REPORT

Water Quality Management and Optimization Plan

Implementation Plan for Total Dissolved Solids

Submitted to:

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Meliadine Mine Operations

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1.0 INTRODUCTION

This report provides a Water Quality Management and Optimization Plan (WQ-MOP) for effluent discharges associated with the Meliadine Mine located in the Kivalliq Region of Nunavut. The objective is to formalize a procedure for management of effluent discharges that follows a systematic and science-based framework for determining acceptable effluent quality conditions.

The WQ-MOP presented herein is focussed on development of interim targets for total dissolved solids (TDS) for effluent discharge and receiving environment conditions at the edge of the mixing zone, but within a framework that can be extended to longer-term management of site water. Although currently specific to the Meliadine Mine, it is intended to align with a process that can be generalized to other Agnico Eagle Mines Limited (Agnico Eagle) projects in Nunavut.

On 24 March 2020, Agnico Eagle submitted an emergency request for an amendment to their Type "A" Water Licence (No. 2AM-MEL-1631), specifically seeking the following amendment:

- Authorization to temporarily discharge water from Containment Pond 1 (CP1) to Meliadine Lake that contains a maximum average TDS concentration up to 3,500 mg/L, which exceeds the current limit described in Part F, Item 3 of the current Water Licence of 1,400 mg/L

The emergency request issued by Agnico Eagle was based on the determination that the water storage capacity of CP1 would be exceeded if dewatering was not conducted prior to or in conjunction with the 2020 spring freshet. If the dewatering was not permitted, and the water storage capacity of CP1 was exceeded, this could represent a significant risk to site infrastructure, as well as human and environmental health. On 29 April 2020, the Nunavut Water Board (NWB 2020) recommended approval of Licence Amendment 1 for Agnico Eagle's Type "A" Water Licence, which permits the following:

- *The time-limited discharge (May 2020 – October 2020) of effluent from the Containment Pond 1 (CP1) into Meliadine Lake through the Meliadine Lake Diffuser (Monitoring Program Station MEL-14) and the Water discharge shall not exceed 3,500 mg/L for the Maximum Average Concentration (MAC) of the Total Dissolved Solids (TDS)*

The NWB's approval of Emergency Amendment 1 is contingent on conditions outlined in NWB's (2020) Reason for Decision. To respond to these conditions and requirements, the following have been addressed in this Updated WQ-MOP:

- **Water Quality Validation Study**—The NWB approval states that *"the Licensee, in addition to the requirement as referred to in Part I, Item 6, during the 2020 discharge, shall undertake the Water Quality Program provided in Table 3 of Schedule I.*" The scope for this study is provided in Section 3.0 of the WQ-MOP (Conduct Validation Study).
- **Plume Delineation Study**—The NWB approval states that "*the Licensee shall provide to the Board for review the 2020 Discharge Plume Delineation Study summary report as soon as all necessary data and results become available."* A detailed study design for the 2020 Discharge Plume Delineation Study has been included in Appendix B of the WQ-MOP, and a summary of program sampling requirements is included in Section 3.3 of the WQ-MOP.
- **Response Plan**—The WQ-MOP now includes adaptive management recommendations. This includes the addition of chemical and toxicological endpoint thresholds that monitoring data collected at the end of pipe or at the edge of the mixing zone can be compared, as well as a list of management actions or protocols that could be implemented in response to non-compliance.

- **Field Contingencies**—The WQ-MOP now includes contingency plans that could be implemented if logistical complications (e.g., safety concerns due to ice-cover or COVID-19) arise during the required 2020 water quality sampling program.

NWBs recommended approval of Amendment 1 received Minister's consent from the Honourable Daniel Vandal, Minister of Northern Affairs on 12 May 2020.

1.1 Site-Specific Benchmark Development Procedure

The guiding principle for the WQ-MOP is that water quality benchmarks should be developed that satisfy the following conditions:

- protective of the environment
- satisfy regulatory requirements
- based on science (rather than strictly on considerations of policy or precedent)
- customized to the site-specific conditions of water quality and quantity

Adoption of fixed numerical benchmarks, either as static discharge limits or generic water quality guidelines, is unlikely to satisfy some parts of the above guiding principle. TDS benchmarks can, however, be developed using a toxicity-based approach that satisfies all the above conditions. TDS represent a "soup" of multiple component ions, and the behavior of this mixture in the environment is influenced by the relative toxicities of the component ions and the ability of some ions (e.g., calcium) to ameliorate the toxicity of others. For effective regulation of TDS, an approach is required that considers the toxicological potential of the mixture, and the point of compliance for different types of responses.

From our communications with Environment and Climate Change Canada (ECCC), a conceptual approach has been developed that is consistent with the guiding principle, and that has three main components in the development of numerical targets:

- Effluent discharges must not result in acute toxicity at the point of release
- Effluent discharges must not result in unacceptable chronic toxicity at the edge of the mixing zone following initial dilution
- Effluent discharges must not exceed the capacity of the receiving environment to accommodate long-term loadings of constituents (i.e., assimilative capacity)

For broader management of TDS in Nunavut, instead of promulgating an uncertain numerical value for TDS or its individual component(s), we recommend development of interim targets for managing TDS in the effluent discharge and receiving environment (to apply at the edge of the mixing zone) that reflect the site-specific mixture of ions, confirmed through standardized toxicity tests and evaluation of assimilative capacity. Much of this information has already been collected for Meliadine Mine, and Agnico Eagle has designed a validation program to validate interim targets and provide data to inform development of effluent quality criterion (EQC) and site-specific water quality objective (SSWQO) benchmarks for long-term application (see Section 3.0). The EQC and site-specific water quality objectives (SSWQO) benchmarks can be applied to guide an adaptive management approach to processing of site water.

1.2 Phasing the Water Quality Management and Optimization Plan

As communicated to NWB by Agnico Eagle, the upcoming 2020 freshet season will result in accumulation of site water that exceeds the water storage capacity of the mine at CP1, requiring a managed release of site water to the environment. In anticipation of this condition, Amendment 1 was approved by NWB for Meliadine Mine's Type "A" Water Licence, allowing Meliadine Mine to dewater CP1 prior to or in conjunction with the 2020 freshet, avoiding "emergency" conditions. This decision received Minister's consent from the Honourable Daniel Vandal, Minister of Northern Affairs, on 12 May 2020.

The operational needs dictate a phased approach to the WQ-MOP, in which short-term needs for monitoring and validation are met, while remaining consistent with the overall WQ-MOP framework.

- **Phase 1: Develop Interim Targets**—Application of the general process described in Section 1.1, entailing review of literature and results of site-relevant toxicity testing, and subsequent establishment of science-based TDS targets, for use on an interim basis.
- **Phase 2: Conduct Validation Study**—In conjunction with the upcoming release of discharge from Meliadine Mine to Meliadine Lake commencing during freshet, Agnico Eagle will conduct supporting studies in 2020 to validate and/or refine the science-based interim targets and produce additional information on receiving environment assimilation. The scope for this study is provided in Section 3.0 of the WQ MOP (Conduct Validation Study).
- **Phase 3: Finalize Meliadine Mine Benchmarks**—Integrate the results of Phase 1 and Phase 2 to formalize the science-based interim targets as EQC and SSWQO benchmarks, with a framework for their implementation (e.g., adaptive management), that is applicable to future conditions at Meliadine Mine. Phase 3 will be submitted as part of the amendment application of the existing Meliadine Water Licence to the Nunavut Water Board.

This document emphasizes Phase 1 (Section 2.0) and Phase 2 (Section 3.0) of the WQ-MOP; sufficient detail is provided for the validation and plume delineation studies to indicate conformance with the Mine's monitoring requirements outlined in the NWB's (2020) Reason for Decision. Additional details of sample collection, handling, and chain-of-custody are being developed separately for use by the field crew and analytical laboratories.

2.0 PHASE 1: DEVELOP INTERIM TARGETS

2.1 Interim TDS Target for Effluent

This section presents the proposed interim target for effluent of 3,500 mg/L calculated TDS for the Meliadine Mine; the target is expressed as a Maximum Average Concentration (MAC). This target is proposed as an interim value, pending implementation of Phase 2 and Phase 3 of the WQ-MOP. The interim target of 3,500 mg/L calculated TDS was proposed following a review of site acute toxicity data collected for Meliadine Mine (Appendix A) and was approved (Amendment 1) on 4 May 2020 as the temporary (May 2020 to October 2020) TDS MAC permitted to be discharged from CP1 into Meliadine Lake at the Meliadine Mine Lake Outfall diffuser (Monitoring Program Station MEL-14).

As discussed in Appendix A, the toxicity of TDS across different site waters varies by ionic composition and the relative proportion of ions in the mixture. Low effect concentrations for acute endpoints (e.g., survival) have been reported in the literature for individual ions for select species, but these tests reflect exposure conditions accounting for a single ion, and not a balanced TDS mixture representative of most field conditions. Considering this, the proposal of an interim target focussed on review of site-specific acute toxicity data collected for site-relevant mixtures (e.g., treated effluent, influent, Collection Pond water; Appendix A, Section A2.0).

The approved interim TDS target for effluent of 3,500 mg/L is supported by:

- No acute toxicity to *D. magna* or Rainbow Trout was observed with influent and effluent TDS concentrations of equal to or less than 5,420 mg/L (measured TDS concentrations of equal to or less than 4,925 mg/L)—details are provided in Appendix A.
- No mortality to other organisms has been observed in tests using Fathead Minnows or *C. dubia* in chronic exposures; as of January 2020, these tests covered calculated TDS concentrations up to 2,357 mg/L (measured TDS concentrations of 2,490 mg/L). Chronic test endpoints are not used in a regulatory context to evaluate the acute toxicity of the effluent, but the lack of mortality in chronic tests provides encouraging information.
- The record of acute toxicity depicted in Appendix A (Table A-4) provides evidence of the lack of acute toxicity even at high TDS concentrations. As of March 2020, nine acute toxicity tests have been conducted with calculated TDS concentrations above 3,500 mg/L. For this reason, some caution is recommended in the development of the interim TDS target for effluent. The no-effect concentration of 5,420 mg/L calculated TDS was therefore reduced by 30% and rounded down to the value of 3,500 mg/L.

Validation of the interim TDS target to demonstrate that the effluent is consistently not acutely lethal will be conducted through monitoring during the discharge period as presented in Section 3.0. Sensitive species that form the basis for the validation would include test species *D. magna* and Rainbow Trout, as these are the species used to assess compliance for acute lethality under the Metal and Diamond Mining Effluent Regulations (MDMER; Government of Canada 2002).

2.2 Interim TDS Target at the Edge of the Mixing Zone

An interim target of 1,000 mg/L (as calculated TDS) to apply in the receiving environment at the edge of the mixing zone is proposed for the protection against chronic toxicity to representative aquatic species. This interim target is intended to evaluate the condition (from Section 1.1) that effluent discharges must not result in unacceptable chronic toxicity at the edge of the mixing zone following initial dilution. The target is proposed as an interim value for use in the short-term, pending implementation of Phase 2 and Phase 3 of the WQ-MOP. The interim target of 1,000 mg/L in the receiving environment at the edge of the mixing zone was supported by the NWB (2020) in their Reasons for Decision related to the approval of Amendment 1 of the Type “A” Water Licence.

The proposed interim target was derived using methods described in Appendix A and summarized below:

- Characterization of the Meliadine TDS profile (Section A1.1)—water chemistry data collected at the Meliadine Mine were used to profile the anticipated water quality in the receiving environment, including composition of major component ions in the TDS mixture.
- Review of water quality benchmarks (Section A1.2)—review of TDS benchmarks developed for locations with a similar TDS composition to Meliadine Mine.
- Literature review (Section A1.3)—review of peer-reviewed literature to determine the threshold for chronic toxicity with a focus on TDS mixtures of similar composition to Meliadine Mine (i.e., dominance of chloride, sodium, and calcium ions).

- Review of site-specific chronic toxicity data (Section A1.4)—review of site toxicity data and corresponding TDS and major ion chemistry of treated effluent and influent samples for Meliadine Mine, as collected during routine and regulatory compliance toxicity testing.
- Weight of Evidence (Section A1.5)—integration of the above information to justify the interim target of 1,000 mg/L TDS to apply at the edge of the mixing zone.

The interim TDS target includes the following assumptions:

- Ambient water hardness should remain within the current range to ameliorate potential chloride toxicity (i.e., through demonstration of non-toxicity of chloride under site-relevant ranges of hardness).
- Additional site-specific validation of the TDS threshold should be conducted to confirm that the mixture of ions represented by the effluent and near-field exposure conditions does not result in acute or chronic toxicity. Such studies are planned, as discussed in Section 3.0.
- Effluent chemistry profiles, particularly with respect to the proportions of major ions, will remain generally consistent in the future.

There is already strong scientific evidence to support the interim target as protective of the aquatic community. The results of toxicity testing do not indicate that an exceedance above 1,000 mg/L TDS will result in harm to aquatic life but provide reasonable certainty of no harm up to 1,000 mg/L. The key lines of evidence are presented in Appendix A, and are supported by the following considerations:

- The Meliadine Mine effluent contains a balance of major ions that is advantageous for limiting the toxic potency of the TDS mixture (Section A1.5.1).
- The Snap Lake site, which applies the same TDS concentration as a SSWQO, provides similar ionic mixtures and biological communities (Section A1.5.2).
- The chronic toxicity data set for Meliadine Mine site water, which includes a battery of four sensitive aquatic species, supports the interim TDS target as a defensible no-effect concentration (Section A1.5.3).
- The ionic balance has been stable in Meliadine Mine water, such that an interim TDS target can be developed without requiring development of targets for individual component ions (Section A1.5.4).

2.3 Assimilation Capacity Evaluation

The ability of the receiving environment to assimilate the concentrations and loading of constituents in effluent is the last component of the WQ-MOP implementation. Consideration of assimilation capacity provides confidence that constituents will not gradually accumulate to concentrations that would degrade the receiving environment.

The approach to TDS management set out in the WQ-MOP is not expected to affect the quality, quantity, or flow of the waters in Meliadine Lake. TDS levels during and after the 2020 discharge will continue to be managed to minimize adverse effects of the licenced deposit of effluent on the aquatic ecosystem of Meliadine Lake, and discharges would continue to meet the stringent requirements set by the MDMER. Confidence in this conclusion comes from plume delineation surveys, preliminary dilution estimates from dispersion models, and consideration of the Meliadine Lake hydrology.

The evidence for sufficient assimilation efficiency in Meliadine Lake to accommodate the interim TDS target for effluent of 3,500 mg/L comes from:

- **Consistency with Previous Impact Assessment Outcomes**—Based on the predictions included in the Final Environmental Impact Statement (FEIS) for the Meliadine Mine Gold Project (Golder 2014), the one-time release of mine wastewater to Meliadine Lake under this amendment would not be expected to result in potential additional project effects. That is, water quality in the receiver and downstream environment would remain within the predictions included in the FEIS. For the FEIS assessment, a Maximum Allowable Concentration (MAC; referred to as the Maximum Allowable Effluent Concentration [MAEC] in the FEIS) of TDS in the discharge of 4,685 mg/L was calculated based on the approach applied in the province of Quebec (MDDEP 2007), where the mixing ratio in a lake is set to a value of 10 to 1. The calculation of the MAC is dependent on the background concentrations (BG) in the lake, the water quality criteria (WQG; the guideline), and the mixing ratio (MR), as established by the following equation:

  $$MAC = MR \times (WQG - BG) + BG.$$

  Where for TDS:

  MR = 10 (as per MDDEP)

  WQG = 500 mg/L (Guidelines for Canadian Drinking Water Quality [GCDWQ; HC 2010], aesthetic objective)

  BG = 35 mg/L

  Therefore:

  $$MAC = 10 \times (500 - 35) + 35 = 4{,}685 \text{ mg/L}$$

  This MAC is well above the proposed interim target of 3,500 mg/L proposed in this amendment.

- **Plume Delineation Results**—Under operating conditions, a plume delineation survey based on specific conductivity results was conducted in 2018 in the near-field region of Meliadine Lake as part of the Environmental Effects Monitoring (EEM)/Aquatic Effects Monitoring Program (AEMP). The EEM plume delineation study used field surveys of specific conductivity to evaluate effluent dispersion with distance from the diffuser. The study evaluated dilution factors at a series of monitoring stations up to, and extending beyond, 250 m from the diffuser, based on the specific conductivity of the effluent and the measured field values through the water column at each the stations. To account for background values, two scenarios were used:

  - Scenario A: near-field average specific conductivity for 2015 to 2016; and
  - Scenario B: near-field average specific conductivity for 2017

  An observed slight increase in specific conductivity between 2015 to 2016 (pre-construction) and 2017 (construction) was the impetus for considering the two scenarios.

  Observations from the survey indicated a minimum dilution factor of 53 at 50 m away from the diffuser, and a minimum dilution factor range of 56 (Scenario A) and 85 (Scenario B) at the edge of the 100 m mixing zone boundary (Table 1). This study was also useful because it served to validate the performance of the submerged diffuser, which had previously been assessed by Tetra Tech as part of their design (Tetra Tech 2017) and re-assessed in 2018 (Tetra Tech 2018). As part of their reassessment in 2018, Tetra Tech concluded that the predicted minimum dilution of 23:1 was achieved at the edge of the 100 m mixing zone and that water quality criteria were met. The minimum dilution factor was more than twice the mixing ratio of

10:1 that was used to derive the MAC in the 2014 FEIS; it was based on a multi-year modelling scenario[1] where the minimum dilution at 100 m at the end of the first year of discharge was 72:1. The latter ratio is consistent with earlier modelling work to support a conceptual diffuser in 2015 (Agnico Eagle 2015), which indicated that the minimum dilution factor was 65:1.

In summary, the range of dilution factors observed at 100 m distance from the diffuser (representing the edge of the mixing zone) determined from the EEM plume delineation study are greater than the minimum dilution factor (23:1) developed in the performance assessment of the diffuser completed by Tetra Tech in 2018 based on multi-year simulations. The dilution factors remain in broad agreement with Tetra Tech's assessment for the first year of discharge (72:1) and the early work completed by Golder (65:1).

Table 1: Dilution Factors in the Near-field Exposure Area at Meliadine Lake[(a)]

Sampling Station	Maximum Specific Conductivity in 2018 (µS/cm)	Dilution Factor – Scenario A	Dilution Factor – Scenario B
50-01	99.8	63	104
50-03	105.5	53	79
100-01	93.4	80	159
100-03	104	56	85
100-04	102.6	58	90
100-05	98.9	65	109
100-06	88.5	101	266
100-08	96.6	71	125

(a) Listed data represent a portion of the data listed in Table 2.4-10 of Golder (2019)

µS/cm = microsiemens per centimetre

The 2018 EEM plume delineation results suggest that the effluent concentration observed at the 100 m mixing zone boundary was less than 2% of concentrations observed at end of pipe. Furthermore, the survey results showed that the plume remained at depths of roughly between 3 and 7 m, indicating that the receiving water and the effluent discharged had similar densities and/or intense mixing. The measured data from 2018 showed that at the time of the survey, the plume was more distinct to the south-west of the diffuser, which indicates a preferential direction of plume advection during the time of survey. Changes in wind speed and direction including current direction and speed are key factors determining the plume dispersion direction on any given day.

- **Mixing Ratio Calculations**—Preliminary calculations of the MAC have been completed based on standard industry practices as well as the results of the near-field modeling completed by Golder, as shown in Table 2.

[1] The multi-year simulation included annual diffuser discharge to Lake Meliadine over the 14 year construction and operations timeline (Year -3 to Year 11). This scenario was included to assess the effects of water quality constituent build-up in the lake on the dilution factor.

Table 2: Calculations of Maximum Average Concentrations for TDS

Report	Guideline for Canadian Drinking Water Quality for TDS (HC 2010) (mg/L)	Assumed Meliadine Lake Average Background TDS Concentration (mg/L)	Assumed Mixing Factor	Maximum Average Concentration (mg/L)
2014[a]	500 mg/L	35 mg/L	10:1	4,685
2015[b]			65:1	30,260[c]
2018[d]			23:1	10,730[c]
2019[e]			56:1	26,075[c]

Notes:

(a) Golder 2014. Water and Sediment Quality Model – Meliadine Mine Gold Project, Nunavut. Appendix 7.4-A.

(b) Agnico Eagle (2015) (see Appendix E, Water Management Plan).

(c) Concentration of maximum average effluent TDS is conceptual only; effluent would **not** be discharged at TDS concentrations of this magnitude as it could result in acute toxicity at the point of discharge.

(d) Tetra Tech (2018).

(e) Golder. 2019. Appendix G – Field Data in the Near-field Exposure Area at Meliadine Lake Under the Plume Delineation Study, 2018.

For the preliminary calculations, the mixing ratio (MR) was established as:

- 2014—reflects approach applied by the province of Quebec (MDDEP 2007), where the mixing ratio in a lake is set a value of 10:1.
- 2015—reflects minimum mixing factor predicted by near-field modeling.
- 2018—reflects minimum mixing factor as modelled for diffuser design (Tetra Tech 2017, 2018).
- 2019—reflects minimum mixing factor calculated from observations of plume delineation survey at edge of the 100 m mixing zone.

TDS = total dissolved solids; mg/L = milligrams per litre.

Based on the model calculations and the observation of the plume delineation study, it is likely that the discharge of effluent with a TDS concentration at 3,500 mg/L, even at the lowest measured mixing ratio of 72, would result in negligible risk of sublethal toxicity at the edge of the mixing zone. This mixing potential at the edge of the mixing zone boundary limits the potential for a sublethal response.

Beyond the mixing zone, into the near- and far-field in Meliadine Lake, effluent will be carried by currents within the lake and further mixed with ambient water. The location of the effluent outfall diffuser is also within the expected main flow channel of the lake, which will act to convey and further disperse the effluent toward the lake outlet.

The assimilative capacity of the 100 m mixing zone will be validated through a detailed monitoring program, for which a conceptual design is provided in Section 3.0.

3.0 PHASE 2: CONDUCT VALIDATION STUDY

In conjunction with the 2020 releases that are planned to occur prior to or in conjunction with the freshet at Meliadine Mine and that have been approved under Amendment 1 of the Mine's Type "A" Water Licence, supporting studies are required to be conducted in spring/summer 2020 to validate the science-based interim targets and produce additional information on receiving environment assimilation (including plume delineation). This section presents the general conceptual design for the spring/summer 2020 monitoring study required as a condition under Amendment 1. The monitoring study will be undertaken both to assess conditions experienced in Meliadine Lake during the discharge event, and for use as a validation component of the WQ-MOP.

A discharge event to dewater Collection Pond 1 (CP1) has been approved by NWB and will occur at the Mine site in the spring/summer of 2020. TDS concentrations in the effluent will be elevated relative to the receiving environment during this discharge event, presenting an opportunity to conduct site validation for the interim TDS targets for the effluent and for the receiving environment at the edge of the mixing zone. These studies also provide the opportunity to collect additional information for the potential development of TDS EQC and SSWQO benchmarks, for use in adaptive management. The conceptual design for the proposed validation would consist of three components: water quality monitoring (Section 3.1), toxicity testing (Section 3.2), and plume delineation (Section 3.3).

These three components are complimentary and will be conducted with the following primary objectives:

- **Water Quality Monitoring:** The surface water quality monitoring program will be conducted to validate the model predictions that TDS will be diluted to less than 1,000 mg/L at the edge of the mixing zone, to provide detailed chemical characterization of the effluent and receiving environment during the discharge, and to provide information on the ionic composition of water used during the toxicity testing program.
- **Toxicity Testing:** The acute and chronic toxicity testing programs will be conducted to confirm that the ionic composition measured in the effluent and the receiving environment during the surface water quality monitoring program are not at levels that would cause adverse biological effects. As described in detail in Section 3.2 and summarized in Table 3, acute toxicity tests will be conducted on the effluent and a suite of chronic toxicity tests will be conducted on receiving environment samples.
- **Plume Delineation Study**—The plume delineation study will be conducted to assess the vertical and horizontal extent of the effluent plume. This will primarily be assessed through *in situ* specific conductivity profiling of the water column using a handheld meter with a sensor that will be lowered through the water column, with a subset of locations sampled for TDS. The relationship between field measured specific conductivity and laboratory measured TDS will be established to validate the use of specific conductivity as a tracer of TDS in the receiving environment. The information retrieved will be used to confirm model predictions related to effluent dilution and assimilation in the receiving environment, and to confirm that receiving environment monitoring stations are adequately characterizing conditions with respect to surface water chemistry and the potential for adverse biological effects.

An overview of the conceptual design is presented in Table 3 and discussed in detail by component below.

Table 3: Conceptual Design for Proposed Validation of Interim TDS Limits for Effluent and Receiving Environment

Water Quality Monitoring Program			
Sampling Media	**Effluent**	**Mixing Zone**	**Receiving Environment** (beyond mixing zone)
Sample Timing	During effluent discharge and during collection of effluent samples for toxicity testing	During effluent discharge[(a)]	During effluent discharge[(a)]
Sampling Locations	MEL-14	3 stations at the edge of the mixing zone (MEL-01-01, MEL-01-07 and MEL-01-10)[(b)]	4 stations - 1 mid-field (MEL-02-05), 3 references (MEL-03-02, MEL-04-05, and MEL-05-04)
Number of Samples	Per regulatory and operational requirements	1 sample per station	1 sample per station
Frequency of Sampling	Weekly during discharge	Weekly during discharge or as per NWB's direction	Monthly during discharge or as per NWB's direction
Test Parameters	▪ Daily monitoring of effluent flow volumes ▪ Parameters as listed in Schedule I Group 2 of the 2AM-MEL1631 NWB Water Licence[(c)]	▪ Field physico-chemical water column profile measurements (temperature, specific conductivity, pH, DO) ▪ Parameters as listed in Schedule I Group 2 of the 2AM-MEL1631 NWB Water Licence[(c)]	▪ Field physico-chemical water column profile measurements (temperature, specific conductivity, pH, DO) ▪ Parameters as listed in Schedule I Group 2 of the 2AM-MEL1631 NWB Water Licence

Table 3: Conceptual Design for Proposed Validation of Interim TDS Limits for Effluent and Receiving Environment

Toxicity Testing Program			
Sampling Media	**Effluent**	**Mixing Zone**	**Receiving Environment** (beyond mixing zone)
Sample Timing	During effluent discharge	During effluent discharge[a]	During effluent discharge[a]
Sampling Locations	MEL-14	3 stations at the edge of the mixing zone (MEL-01-01, MEL-01-07 and MEL-01-10)[b]	4 stations - 1 mid-field (MEL-02-05), 3 references (MEL-03-02, MEL-04-05, and MEL-05-04)
Number of Samples	Per regulatory and operational requirements	1 composite sample per station	1 composite sample per station
Frequency of Sampling	Weekly during discharge	Monthly during discharge	Monthly during discharge or as per NWB direction
Test Parameters	Acute toxicity tests with: ▪ Rainbow Trout ▪ *Daphnia magna*	Chronic toxicity tests with: ▪ Pelagic crustacean (*Daphnia magna*) ▪ Epibenthic Invertebrate (*Hyalella azteca*) ▪ Macrophyte (duckweed) ▪ ELS fish (Fathead Minnow)	Chronic toxicity tests with: ▪ Pelagic crustacean (*Daphnia magna*) ▪ Epibenthic Invertebrate (*Hyalella azteca*) ▪ Macrophyte (duckweed) ▪ ELS fish (Fathead Minnow)
Plume Delineation Study			
Sampling Media	**Effluent**	**Receiving Environment** (within mixing zone and beyond)	
Sample Timing	During effluent discharge[d]	During effluent discharge[d]	
Sampling Locations	MEL-14	22 survey locations (see Appendix B) at distance intervals of 50 m from the diffuser, 100 m (i.e., edge of mixing zone), 175 m, and 250 m; potentially adjusted to include further afield samples if necessary[e]	
Frequency of Program	1 event during discharge	1 event during discharge	
Test Parameters	▪ TDS and major ions ▪ General parameters[f]	▪ Field physico-chemical water column profile measurements (temperature and specific conductivity) ▪ Water quality samples collected at a subset (a maximum of 10 stations) stations alongside profile measurements and analyzed for TDS, major ions, and general parameters[f]	

Notes:

(a) The timing of sampling for each program is expected to occur continuously during the discharge period as outlined in the sample frequencies listed above for each sample media and test type. However, sample timing will be dependent on safe access to the lake. The period of anticipated discharge will likely coincide with the transition period between ice covered and open water conditions on Meliadine Lake. If samples cannot be collected at the required time due to safety considerations, contingency measures may be implemented, as outlined in Section 3.4.

(b) Parameters as listed in Schedule I Group 2 of the 2AM-MEL1631 NWB Water Licence include Conventional Parameters (bicarbonate alkalinity, chloride, carbonate alkalinity, turbidity, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphate, pH, total alkalinity, TDS, TSS, total cyanide, free cyanide, and weak acid dissociable [WAD] cyanide), Nutrients (ammonia-nitrogen, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, orthophosphate, total phosphorus, total organic carbon, dissolved organic carbon, and reactive silica), and Total and Dissolved Metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc).

(c) Mixing zone stations MEL-01-01 and MEL-01-07 are routinely sampled by the mine during the EEM/AEMP programs. MEL-01-10 represents a new sampling station. Further details on the selected mixing zone sampling stations are provided in Section 3.1.

(d) Sample timing will be dependent on boat access to the lake. The period of anticipated discharge will likely coincide with the transition period between ice covered and open water conditions on Meliadine Lake. Access of the lake will occur as soon as open water conditions permit safe boat access.

(e) The maximum spatial extent of plume delineation monitoring may be extended past 250 m should the proportion of effluent be estimated to contribute >10% of TDS at 250 m (estimated based on field specific conductivity measurements).

(f) General parameters = total and bicarbonate/carbonate alkalinity, turbidity, laboratory specific conductivity, hardness, laboratory pH, and total suspended solids.

ELS = early life-stage; TDS = total dissolved solids.

3.1 Water Quality Sampling

Water quality samples will be collected and analyzed for a suite of parameters (conventional parameters, nutrients, and total and dissolved metals) to characterize water quality conditions of the effluent and the receiving environment of Meliadine Lake. The water quality results will also inform the ionic composition of effluent and receiving environment samples used during toxicity testing for site-specific validation of the interim target established for the edge of the mixing zone (see Section 3.2). The water quality data will also provide confirmation that TDS in water released at sampling station MEL-14 remains within permitted levels established through Amendment 1 (i.e., MAC is ≤3,500 mg/L TDS; edge of mixing zone ≤1,000 mg/L TDS). Samples of effluent for water chemistry analysis should, to the extent possible, be collected on the same day as edge of mixing zone and receiving environment (mid-field and reference locations) samples and analyzed for the same suite of parameters. As described in NWB's (2020) Reasons for Decision document, water quality samples within the discharge period will be collected as follows from monitoring stations routinely sampled during the mine's EEM/AEMP program:

- **Effluent samples:** The effluent (defined as sampling station MEL-14) will be sampled weekly during discharge for conventional parameters, nutrients, and total and dissolved metals.
- **Edge of mixing zone samples:** Three stations located at the edge of the mixing zone will initially be sampled weekly during the discharge for conventional parameters, nutrients, and total and dissolved metals. These edge of mixing zone sampling stations were selected following review of the 2018 plume delineation study results. The stations include MEL-01-01 and MEL-01-07, which are located approximately 100 m northwest and northeast of the diffuser, respectively. These stations are routinely sampled as part of the mine's EEM/AEMP program. To improve spatial coverage surrounding the diffuser, it was determined that a water quality sample should be collected at the edge of the mixing zone towards the southeast of the diffuser. MEL-01-06 represents a station located southeast of the diffuser that is currently monitored under the mine's EEM/AEMP program; however, this station is located outside of the 100 m mixing zone boundary (i.e., ~200 m from the diffuser). As a result, a new station, MEL-01-10, will be monitored at the edge of the mixing zone. MEL-01-10 was selected to provide spatial coverage at the edge of the mixing zone (i.e., 100 m radius surrounding the diffuser) and will correspond with the station 100-04 selected for the plume delineation study described in Appendix B. The UTM coordinates of this station (Easting 542861.3, Northing 6989059.1) are further described in Figure 2 and Table 1 of Appendix B. The specific water depths that will be sampled at each station will be determined in the field based on the specific conductivity profile observed at the time of sampling, to account for changes in plume conditions that could occur over time. As such, the depth sampled at each edge of mixing zone station may change between rounds of sampling. The sampling frequency may also be adjusted during the program based on results and conversations held during the Water Management Working Group review meetings.
- **Receiving environment – mid-field samples:** One mid-field station (MEL-02-05) will initially be sampled monthly during the discharge for conventional parameters, nutrients, and total and dissolved metals. The sampling frequency may be adjusted during the program based on results and conversations held during the Water Management Working Group review meetings.
- **Receiving environment – reference Samples:** Three reference stations (MEL-03-02, MEL-04-05, and MEL-05-04) will initially be sampled monthly during the discharge for conventional parameters, nutrients, and total and dissolved metals. The sampling frequency may be adjusted during the program based on results and conversations held during the Water Management Working Group review meetings.

Physico-chemical profiling of the lake water column will be measured *in situ* using water quality meters (e.g., Hanna, YSI, Eureka or equivalent) equipped with a 20 m or longer cable at each edge of mixing zone and receiving environment sample location. Samples for laboratory water quality analysis will be collected at each location based on the depth determined to have the highest specific conductivity.

Additionally, to facilitate the collection of *in situ* physico-chemical data (i.e., specific conductivity, dissolved oxygen concentrations, temperature, and pH) at the edge of the mixing zone during the period where ice cover transitions to open water across the lake, prohibiting safe lake access, Agnico Eagle will install remote monitoring stations at the edge of the mixing zone prior to the discharge event. This monitoring will collect and log specific conductivity and temperature data at several depths at these stations, which will be recovered once the lake can be safely accessed.

3.2 Sampling for Toxicity Testing

The 2020 discharge event provides an opportunity to evaluate TDS toxicity under site-relevant conditions. During discharge, representative water samples will be collected and tested for laboratory-based toxicity using standardized protocols for aquatic toxicity. The toxicity testing program will include separate test protocols for effluent and receiving water samples.

Effluent samples from sampling station MEL-14 will be collected and tested using the suite of toxicity test species and standard protocols conducted for acute lethality testing and EEM under the MDMER. As outlined in NWB's (2020) Reasons for Decision document, the effluent (sample ID: MEL-14) will be sampled weekly during the discharge and tested for acute toxicity using the following acute toxicity test protocols:

- 96-hour Rainbow Trout survival test using the Environment Canada (2007a) standard biological test method (EPS 1/RM/9)
- 48-hour *Daphnia magna* survival test using the Environment Canada (1996) standard biological test method (EPS 1/RM/11)

As outlined in NWB's (2020) Reasons for Decision document, receiving environment stations will be sampled monthly during the discharge and tested using a suite of chronic toxicity tests that were agreed upon following consultation with the Water Management Working Group. Edge of mixing zone and receiving environment (i.e., mid-field and refence locations) samples will be tested for chronic toxicity using a multi-species approach that uses standardized chronic toxicity test protocols:

- **21-day *Daphnia magna* survival and reproduction test using the ASTM (2007) standard biological test method (Method E1193-97)**—*D. magna* was selected as a chronic test species to evaluate receiving environment water quality, as it is well studied and sensitive pelagic crustacean, and found to be more ecologically relevant to northern lake communities relative to other crustaceans such as *Ceriodaphnia dubia*. The 21-d *D. magna* test was selected over the 7-d *Ceriodaphnia dubia* survival and reproduction test because the former is native to Meliadine Lake, and was recommended by stakeholders in the consultation stage to be preferred as a monitoring species.
- **14-day *Hyalella azteca* water-only survival and growth test using the Environment Canada (2017) standard biological test method (EPS 1/RM/33)**—*H. azteca* was selected as a chronic test species to evaluate receiving environment water quality, as it is a well studied and sensitive invertebrate species. *H. azteca* was selected over the freshwater midge, *Chironomus dilutus,* as *H. azteca* is considered an epibenthic species (i.e., inhabits the microenvironment at the sediment-water interface), whereas *C. dilutus* is a benthic infaunal species that burrows in sediment and would have less direct exposure to receiving

waters. The feeding strategy of *H. azteca*, which derives little nutrition from the sediments, and responds primarily to contaminants in the overlying water column (including water and food; Wang et al. 2004), is well suited to an evaluation of environmental responses associated with effluent discharges. Similarly, the other benthic invertebrate group considered, mayflies, were considered less relevant as the candidate test species tend to prefer either more flowing habitats (e.g., *Centroptilum* representative of Eastern North America streams and rivers), or temperate lakes and streams (e.g., *Hexagenia* representative of slow moving streams and ponds of the Great Lakes), which are less relevant for the northern lentic Meliadine Lake environment. Mayflies are less commonly tested and with lower degree of protocol standardization, such that obtaining representative, reliable, and repeatable results was considered a potential project risk.

- **7-day *Lemna minor* (duckweed) growth test using the Environment Canada (2007b) standard biological test method (EPS 1/RM/37)**—*L. minor* was selected as a chronic test species to evaluate receiving environment water quality, as it is a well studied and sensitive macrophyte species. NWB (2020) approved either the 7-day *Lemna minor* or the 72-h green alga (*Pseudokirchneriella subcapitata*) growth test for evaluating receiving environment water quality with respect to primary producers. *L. minor* was selected for testing as it was identified as the more sensitive of the two species during site-specific testing of CP1 water during the derivation of the proposed interim thresholds (Appendix A).
- **7-day larval Fathead Minnow (*Pimephales promelas*) survival and growth test using the Environment Canada (2011) standard biological test method (EPS 1/RM/22)**—Fathead Minnow were selected as a chronic test species to evaluate receiving environment water quality, as it is a well studied and sensitive early life-stage fish species. NWB (2020) approved either the 7-day Fathead Minnow survival and growth test or the 7-d Rainbow Trout embryo development test for evaluating receiving environment water quality with respect to early life-stage fish. Fathead minnows were selected for testing because the Rainbow Trout embryo development test is contingent on being able to secure viable embryos. Because the testing is expected to occur monthly during the discharge, it was identified that quality Rainbow Trout embryos may not be consistently available throughout the program, which would complicate temporal interpretation of chronic toxicity test results. As a result, the 7-day Fathead Minnow test was selected as the preferred option for early life-stage chronic fish testing.

Three types of samples will be collected from the receiving environment during each monthly sampling event for evaluation using the suite of chronic toxicity tests listed above. These samples include the following:

- **Edge of mixing zone samples**—Three stations located at the edge of the mixing zone (MEL-01-01, MEL-01-07, and MEL-01-10, as described in Section 3.1) will be sampled during each monthly sampling event for chronic toxicity testing. Prior to toxicity testing, physico-chemical water quality profiling of the water column at mixing zone sampling stations will be conducted to identify the samples with the highest specific conductivity (measured *in situ*). Samples will be collected at the depth with the highest conductivity for toxicity testing. Mixing zone stations will be tested for chronic toxicity using a standard dilution approach (i.e., 100%, 50%, 25%, 12.5% and 6.25% volume to volume dilutions) with the suite of chronic toxicity tests identified above. Dilutions will be conducted with laboratory water selected to provide broad comparability to Meliadine Lake.
- **Receiving environment – mid-field samples**—One mid-field station (MEL-02-05) will be sampled during each monthly sampling event for chronic toxicity testing. This mid-field sample will be tested for chronic toxicity using the full-strength sample with no dilution series (i.e., pass/fail test design).
- **Receiving environment – reference samples**—Three reference stations (MEL-03-02, MEL-04-05, and MEL-05-04) will be sampled during each monthly sampling event for chronic toxicity testing. These reference samples will be tested for chronic toxicity using the full-strength sample with no dilution series.

As the primary constituent of concern is TDS (including its component ions), concentrations would not be expected to decrease significantly during storage of a few weeks duration. As a result, a sufficient volume of sample for chronic toxicity testing will be collected at each station once per month. The samples will be collected with minimal headspace and transported under cool dark conditions to the respective toxicology laboratories. Upon arrival at the laboratories, samples will be stored in the dark at 4°C until test initiation. For chronic tests that call for renewals of test solutions during the exposure period, the refresh solution will be obtained from the bulk sample used to supply water at test initiation. The advantage to this approach is that the exposure concentration experienced by the organisms during the test will be held constant and will correspond directly with samples collected for detailed chemistry. The chronic toxicity test protocols require that conductivity be monitored during the tests, which should provide confirmation that TDS exposure concentrations remain relatively constant throughout the exposure duration.

Attempts will be made to conduct toxicity tests within the respective hold time requirements (i.e., 3 days for chronic tests) specified in the test protocols; however, slight deviations from hold time requirements may be unavoidable due to the mine's remote location and due to the current situation surrounding COVID-19. For the purposes of this study, hold time exceedances are not considered to represent a deviation from the test protocol because TDS concentrations are not expected to measurably change during storage. To validate this assumption, if samples are initiated outside the respective hold times, a subset of the stored toxicity samples will be tested for TDS so that comparisons can be made with the samples collected for analytical chemistry in the field.

3.3 Plume Delineation Study

A plume delineation study will be conducted in the near-field area of Meliadine Lake immediately outside of the mixing zone once it is safe to access the lake during effluent discharge to characterize the effluent plume configuration, validate model predictions related to effluent dilution and assimilation in the receiving environment, and to confirm that receiving environment monitoring stations are adequately characterizing edge of mixing zone conditions. Study timing will be dependent on safe lake access. Although discharge will likely commence during ice cover conditions and continue during the transition period between ice cover and open water conditions on Meliadine Lake, boat access to the lake is required to conduct the plume delineation study. Therefore, the plume delineation study will occur once open water conditions permit safe boat access.

Specific conductivity and temperature depth profiling at different spatial intervals from the effluent diffuser (i.e., collected at 50 m, 100 m, 175 m, and 250 m distances at 22 stations around the diffuser; potentially adjusted to include further afield samples if necessary) will be used to depict the dimensions and behaviour of the plume. A subset of the planned sampling stations (i.e., a maximum of 10 of the 22 identified locations) will be sampled for laboratory analysis of TDS, major ions, and other general parameters. Samples selected for more detailed analyses will be selected to encompass the range of specific conductivity measures observed surrounding the outfall. These data from the plume delineation study will provide:

- validation that the water quality at the edge of the mixing zone is consistent with predictions of TDS and major ion concentrations (as estimated using existing water quality from the effluent and modeling of the receiving environment)
- confirmation that the relationship between specific conductivity and water quality is sufficiently reliable for use in future plume delineation
- representation of the rate of effluent dispersion in the near-field region in Meliadine Lake, to address the assimilation capacity portion of the WQ-MOP.

This study would occur over one to two days during the effluent discharge once safe access to the lake is possible. A detailed study plan for the Plume Delineation Study is provided in Appendix B and is similar in scope to plume monitoring conducted during the 2018 Meliadine Mine EEM/AEMP.

3.4 Contingency Planning

Field monitoring and data collection will be conducted by Agnico Eagle Mine personnel, with support from Golder on an as-needed basis. Golder will provide the detailed study design for each component, specific work instructions, program coordination, data analysis, and reporting. Sample collection, chain-of-custody, and health and safety will be the responsibility of Mine staff. Due to the remote location of the Meliadine Mine site, the seasonal lake conditions during ice melt, and the current public health situation surrounding COVID-19, contingency planning for unforeseen complications related to the monitoring program are necessary to provide a framework that can be safely implemented in the event that certain aspects of the proposed monitoring program become unworkable. This section summarizes some of the factors that could influence the need to modify the sampling program, and the measures that will be undertaken to maintain program implementation within the practical and safety constraints.

Following discussions between Agnico Eagle and the Water Management Working Group, NWB (2020) has stipulated that the following contingency measures should be considered in case complications prohibit sampling and analysis as outlined in Table 3:

- *Use of specific conductivity or TDS field measurements as a surrogate for laboratory measured TDS and the contributing ions (development of a statistical relationship between field measurements of specific conductivity and laboratory TDS)*
- *Agnico Eagle should consult with the Water Management Working Group in respect of all monitoring and adaptive management measures* (see Section 3.5) *implemented by Agnico Eagle over the course of the CP1 discharges in 2020*

Where schedule allows, and where adaptations would result in a significant departure from the study design, input will be sought from the Working Group. Therefore, this section emphasizes circumstances that may require revisions to the program with a few days notice, and for which a formal consultation step is not feasible.

3.4.1 Ice Melt

Due to the timing of effluent discharge during freshet, safe access to Meliadine Lake may pose a challenge due to melting ice conditions. It is anticipated that effluent discharge will begin before the lake is completely ice-free to alleviate on-site water storage capacity limitations. Therefore, the edge of mixing zone and receiving environment monitoring conducted as part of this study may not be possible at certain times during the discharge due to safety concerns associated with ice melt. The following outlines contingency measures that could be implemented if the receiving environment is not accessible at the start of the discharge event:

- **Option 1—Delay open-water environment sampling (edge of mixing zone and receiving environment [mid-field and reference locations])**. Depending on the ice cover conditions and the long-term weather forecast at the time of initial discharge, it may be prudent to delay the first round of open-water sampling, to provide improvement in conditions and safety, without any other changes required to the sampling program.
- **Option 2—Temporary replacement of open water sampling with expanded effluent testing using dilutions**. The discharge monitoring station, MEL-14, is located on land and is therefore expected to be accessible when lake ice prohibits receiving environment sampling (both edge of mixing zone samples and receiving environment samples). As a result, if receiving environment samples cannot be sampled during the

first month due to unsafe sampling conditions caused by melting ice on Meliadine Lake, additional whole effluent samples from MEL-14 could be sent to the toxicology laboratory and tested using an extended dilution series that encompasses a larger range of TDS concentrations than would be expected in the receiving environment. These tests would be simulations of water quality and toxicological responses to approximate the field conditions, with a return to direct sampling of field conditions as soon as appropriate. Such chronic toxicity data could then be compared to *in situ* monitoring data that would be collected following ice-free conditions to validate the interim targets established at the edge of the mixing zone. Although this contingency would have uncertainty related to the estimation of effluent dilution in the mixing zone, it has the added benefit of providing site-specific chronic toxicity data at test concentrations greater than those expected at the edge of the mixing zone. These data would be informative for both the short-term monitoring needs, but also to validate longer-term benchmarks for TDS in the effluent (EQC-setting) and receiving environment (SSWQO). Such benchmarks would support a future application for a permanent amendment to these targets under the mine's water licence (i.e., support WQ-MOP Phase 3—long-term management of TDS).

3.4.2 Laboratory Testing

The study design has been developed to provide a high level of care and quality management, but laboratory testing always carries some risk of uncontrollable disruption:

- **Shipment Delay**—Due to the remote location of the site, and the multiple legs required for shipment from Nunavut to the Quebec transfer location, and subsequently to the analytical laboratories, there is a possibility of holding time exceedances for chemical or toxicological analyses (these times vary by test type but are generally a few days in duration). The potential for time delays increases during the Covid-19 condition due to the reduced options for alternate shipping routes. In the event of a minor holding time exceedance, we propose to continue with testing of the samples as promptly as can be accommodated by the laboratories, with associated documentation of the necessary protocol deviations. The contaminant types of primary interest in the samples (i.e., major ions and metals) are resistant to rapid sample degradation. Cancellation or rescheduling of the testing program would result in loss of information and associated uncertainty that far outweighs the consideration of holding time. Additional chemical analysis (e.g., both test initiation and termination) can be used to provide confidence in the stability of the chemical mixtures.

- **Test Failure**—A low percentage of toxicity tests result in test failures (i.e., unacceptable performance of negative control media, or other major disqualification, such as a prolonged power outage causing violation of rules for controlled environmental conditions). We have attempted to anticipate potential causes of control failures (e.g., fungal infestation of water samples, essential micronutrient levels of tests). If other unforeseeable factors result in a test failure, the default approach will be to proceed in order of:

  - Consult the laboratory to determine if the cause of failure can be identified
  - Restart the test using additional archived sample, if available
  - If test cannot be repeated with confidence, repeat test with fresh sample in the subsequent monitoring event (with additional water volume provided to support follow-up investigation of cause, if needed)
  - If multiple rounds of testing indicate a systematic problem with test quality, consider replacement testing (e.g., new laboratory, replacement test protocol)

- **Inadequate Sample Volumes**—In the event that water volumes are inadequate (e.g., sample containers compromised or lost in transit), attempts will be made to salvage the testing round through minor adjustments to the design, such as:
  - Replacement of site water with a synthetic water sample designed to mimic the ionic composition of the site water (e.g., laboratory preparation of a simulated Meliadine Lake ambient background water composition)
  - Modification of the dilution series to make efficient use of available sample

The contingency measures provided above represent an initial planning step and are not expected to address all potential complications that could arise during the monitoring program. As a result, these planning steps should be viewed as preliminary measures that are expected to evolve as the program progresses. Golder and Agnico Eagle will work together to identify additional contingency measures where necessary during the program and, where practical, will provide new contingency plans to the Water Management Working Group for comment and discussion prior to implementation.

3.5 Adaptive Management

As described in NWB's (2020) Reason for Decision, adaptive management measures related to the emergency discharge will be discussed on an ongoing basis throughout the discharge event during meetings with the Water Management Working Group comprised of the Kivalliq Inuit Association, Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), Environment and Climate Change Canada (ECCC), and NWB. However, prior to the first Water Management Working Group meeting, which is tentatively scheduled for two weeks following initiation of the discharge, NWB (2020) has stipulated that the following preliminary adaptive management thresholds and triggers be implemented during water quality monitoring of the discharge event:

- *If two consecutive end-of-pipe sampling events identify TDS concentrations equivalent to, or greater than, 3,500 mg/L, Agnico Eagle will increase sampling frequency*
- *If two consecutive edge-of-mixing-zone sampling events identify TDS concentrations equivalent to, or greater than, 75% of the interim target of 1,000 mg/L, Agnico Eagle will increase sampling frequency*

These thresholds and their application based on the respective sample timing at the end of pipe and edge of the mixing zone provides for a high level of responsiveness should monitoring data trigger adaptive management responses. The intent of the adaptive management thresholds and triggers is to initiate a response when there have been two consecutive measurements above the listed TDS thresholds.

The preliminary adaptive management measures (i.e., increase sampling frequency as required) will be implemented if the above referenced management targets are not achieved. NWB will be notified promptly of any adaptive management measures that are implemented throughout the discharge period. Additional adaptive management strategies that may be considered on a case-by-case basis if non-compliance with the above targets are observed, or if the results of the validation studies identify other non-conformances are:

- Decreasing the rate of effluent discharge or temporary cessation of pumping of the discharge could be considered to increase dilution and decrease the overall size of the plume.

- Consideration given to collecting additional edge of the mixing zone sample(s) for exploratory chronic toxicity testing to further validate the proposed interim target at the edge of the mixing zone. These additional samples could be amended with ionic salts in an ionic composition relevant to the edge of mixing zone and tested as a dilution series. The purpose would be to facilitate testing at concentrations both above and below the concentrations measured at the time of sampling, for the purpose of developing a concentration-response curve.
- Consideration given to additional targeted toxicity testing (e.g., validation test, or toxicity identification evaluation to explore the cause for an observed toxicological response), either in response to an acute toxicity outcome (e.g., mortality to crustacean *D. magna*) or for a moderate- to high-magnitude chronic toxicity response. Such toxicity is not anticipated to occur during the program (i.e., the thresholds have been set specifically to avoid such responses); however, if an anomalous response is observed, a TIE could help elucidate the cause.

If additional testing or analysis is conducted, per the second or third bullets above, the data would be useful both as a contingency measure and for longer-term management (i.e., WQ-MOP Step 3). These approaches have been applied at other northern mine sites to better understand the concentration-response and define the lower bound of where TDS may cause chronic toxicity in site-specific mixtures. Multiple chronic toxicity tests have already been conducted in recent years, and these support the proposed interim target at the edge of the mixing zone; additional tests would expand on that knowledge, clarifying the nature of TDS concentration-response, and the influence of modifying factors.

Additional adaptive management strategies, if necessary, would be proposed to the Water Management Working Group in advance of the next scheduled meeting to facilitate discussion and agreement prior to implementation.

4.0 CONCLUSIONS

The application of the WQ-MOP framework provides a basis for management of effluent discharges from Meliadine Mine to Meliadine Lake that:

- Is protective of the environment (both in the mixing zone and broader ecological condition of Meliadine Lake), as demonstrated in this memorandum, which provides Phase 1 and the conceptual elements of Phase 2 of the WQ-MOP
- Will satisfy regulatory requirements for the short-term (Phase 1 and 2) and long-term (Phase 3) management of TDS:
  - interim targets for TDS proposed herein satisfy short-term regulatory requirements for management of TDS during the 2020 discharge, subject to conditions outlined in Emergency Amendment 1, and endorsement of the interim targets for effluent and at the edge of the mixing zone
  - interim targets for TDS proposed herein form the basis for development of TDS targets for effluent (EQC) and receiving environment (SSWQO), following validation monitoring, for future application under an adaptive management framework
- Is based on science, including both site-specific evaluations of toxicity and comparison to other project approvals with similar composition of TDS
- Is customized to the site-specific conditions of water quality and quantity (with revisions as appropriate should these conditions change)

It is acknowledged that the aspects of the interim targets for TDS and, if required, future development of EQC and SSWQO, will benefit from additional confirmatory study. Our revised WQ-MOP provides the technical basis for these studies, and leverages the environmental monitoring of the 2020 discharge, which provides an opportunity to collect the data necessary for both short-term validation (i.e., Phase 2 of the WQ-MOP) and long-term management (i.e., Phase 3 of the WQ-MOP).

Signature Page

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APPENDIX A

Supporting Information for the Interim TDS Targets

APPENDIX A: SUPPORTING INFORMATION FOR INTERIM TDS TARGETS

This Appendix presents the supporting information and rationale for the proposed interim targets of: (a) 1,000 mg/L calculated TDS to apply at the edge of the mixing zone (Section A1.0) and (b) 3,500 mg/L calculated TDS to apply for effluent discharge (Section A2.0).

To prepare the interim targets, Golder Associates Ltd. (Golder) was requested to build from existing work performed on TDS benchmarks (i.e., Golder 2019), including the following:

- Incorporation of site-specific toxicity data.
- Integration with the framework discussed with regulators for developing interim water quality targets for TDS that reflect the site-specific mixture of ions, confirmed through standardized toxicity tests (acute and chronic toxicity testing) and evaluation of assimilative capacity.
- Establishment of a process for validation of interim targets in summer 2020.

The development of interim water quality targets for Agnico Eagle Nunavut operations was discussed with Environment and Climate Change Canada (ECCC) in several recent meetings and associated reviews:

- *Meeting on 9 December 2019 (Agnico Eagle 2019)*. This meeting discussed the technical approach to development of site-specific water quality objectives (SSWQO) for multiple projects (and constituents of interest) in Nunavut.
- *TDS Technical Memorandum (Golder 2019)*. This memorandum was prepared as a draft document to support a technical approach to development of SSWQOs for TDS.
- *Meeting on 9 January 2019 (Agnico Eagle 2020)*. This meeting discussed the technical approach to development of SSWQOs specific to TDS and its components, following from the ECCC review of Golder (2019).
- *Final Public Hearings for the Whale Tail Expansion Project, Baker Lake NU, February 13–14, 2020*. The hearings included contributions from ECCC (as Intervenors), and from Agnico Eagle (in the Proponent's concluding statements) and included areas of general agreement regarding a conceptual approach to regulation of TDS.

A1.0 INTERIM TDS TARGET AT THE EDGE OF THE MIXING ZONE

The benchmark of 1,000 mg/L calculated TDS is proposed as an interim value for use in the short-term, pending implementation of Phase 2 and Phase 3 of the WQ-MOP.

The proposed interim target was derived as summarized below and detailed in the subsequent sections:

- Characterization of the Meliadine TDS profile (Section A1.1)—water chemistry data collected at the Meliadine Mine were used to profile the anticipated water quality in the receiving environment, including composition of major component ions in the TDS mixture.
- Review of water quality benchmarks (Section A1.2)—review of TDS benchmarks developed for locations with a similar TDS composition to Meliadine Mine.
- Literature review (Section A1.3)—review of peer-reviewed literature to determine the threshold for chronic toxicity with a focus on TDS mixtures of similar composition to Meliadine (i.e., dominance of chloride, sodium, and calcium ions).

- Review of site-specific chronic toxicity data (Section A1.4)—review of site toxicity data and corresponding TDS and major ion chemistry for Meliadine treated effluent and influent samples, as collected during routine and regulatory compliance toxicity testing.
- Weight of Evidence (Section A1.5)—integration of the above information to justify an interim target TDS concentration of 1,000 mg/L to apply at the edge of the mixing zone.

A1.1 Characteristics of Total Dissolved Solids

A1.1.1 Definition

The TDS parameter is defined as the sum of the concentrations of all common dissolved ions in freshwaters (e.g., sodium [Na^+], calcium [Ca^{2+}], magnesium [Mg^+], potassium [K^+], sulphate [SO_4^{2-}], bicarbonate [HCO^{3-}], chloride [Cl^-], nitrate [NO^{3-}], fluoride [F^-], and silicate [SiO_3^{2-}]), and is essentially an expression of salinity. TDS can be calculated using the following equation (APHA 2005):

$$TDS_{calculated\ (mg/L)} = \sum[Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, F^-, SO_4^{2-}, SiO_3^{2-}, 4.42 \times NO_3^-\ (as\ N), 0.6 \times total\ alkalinity\ (as\ CaCO_3)]$$

Concentrations of TDS may also be measured gravimetrically by analytical laboratories. However, calculated TDS is used herein as the primary basis for derivation of interim targets for TDS and screening because:

- Laboratory interference can reduce the accuracy of measured TDS (Evaristo-Cordero 2011). In particular, waters with high calcium, magnesium, and chloride concentrations can form hydroscopic residues that absorb water under normal laboratory conditions, potentially biasing the measured TDS higher than actual concentrations (APHA 2005; Evaristo-Cordero 2011). In contrast, calculated TDS is based on the major ions that can measurably contribute to TDS and is therefore, not influenced by any changes that may occur from those ions being taken out of solution.
- Calculated TDS incorporates explicit consideration of the ionic composition, which is important for evaluating the toxicity of the TDS mixture (as discussed below).
- Calculated TDS is forecasted, using predictive modelling, to estimate potential TDS concentrations in effluent and receiving environment under future mine conditions; use of calculated TDS for the interim target provides an equivalence for comparison relative to modelled conditions.

In recent meetings, ECCC expressed a preference that concentrations of TDS be expressed on a measured concentration basis. Agnico Eagle has committed to presenting monitoring results using both methods (calculated and measured).

A1.1.2 General Fate and Effects

Dissolved solids occur naturally in water, with the composition and concentration of individual ion constituents varying by location based on natural factors, such as the geology and soil in the watershed, atmospheric precipitation and the water balance (evaporation-precipitation) (Weber-Scannell and Duffy 2007). Anthropogenic activities can alter the concentration of TDS in the aquatic environment, with effluent from mining or industrial treatment of water identified as common sources of elevated TDS (Soucek 2007; Weber-Scannell and Duffy 2007). Differences in the ratios of calcium to magnesium (Ca:Mg) or relative contribution of sulphate or chloride to the total TDS concentration are common indicators of anthropogenic influence.

The primary toxicity modifying factor for TDS is ionic composition, reflecting the fact that individual ionic components exhibit different potential to exert toxicity. For example, Mount et al. (1997) reported 48-hr LC_{50} values ranging from 390 to >5,610 mg/L in *C. dubia* and 96-hr LC_{50} values ranging from <510 to 7,960 mg/L in the Fathead Minnow exposed to various ion combinations, respectively. In general, a balanced mixture of ions results in lower toxicity than strong dominance by an individual ion, particularly dominance by an individual ion with relatively high toxicity. Mount et al. (1997) reported that the relative ion toxicity to freshwater biota was generally potassium > carbonate ≈ magnesium > chloride > sulphate, with calcium and sodium exhibiting relatively low toxicity. Therefore, the toxicity of a TDS mixture depends largely on the composition of ions within the mixture, rather than the total TDS concentration, which on its own is not an accurate predictor of toxicity. If the mixture is well characterized, and the composition of that mixture is similar to samples for which mixture-based toxicity testing has already been conducted, the confidence in predictions of toxicological potential increases substantially.

A1.1.3 Site-Specific Composition

Monitoring data for Meliadine effluent (MEL-14) were compiled for surface water samples collected between September 2017 and October 2019 and monitoring data for the near-field in Meliadine Lake (MEL-01; stations MEL-01-01 and MEL-01-06 to MEL-01-08) were compiled for surface water samples collected between July 2015 and September 2019. The date range selected for the effluent TDS data begins in 2017 because it coincides with period of increasing effluent TDS concentrations. The near-field TDS composition has been relatively stable over time; data were included for a broader time period to reflect the chronic exposure condition. Summary statistics for major ion chemistry, TDS, and water hardness are presented in Table A-1.

The interim target was developed considering that the ionic composition would fall within the bounds of the ionic composition of the effluent and near-field receiving water. In other words, the effluent and near-field receiving environment samples bracket the range of mixture types expected for future samples of water upon initial mixing. Average measured TDS in the effluent was approximately 930 mg/L and consisted predominantly of chloride (470 mg/L; 52% of TDS), sodium (167 mg/L; 18% of TDS), calcium (125 mg/L; 13% of TDS), sulphate (56 mg/L; 6% of TDS), carbonate (20 mg/L; 2% of TDS), and relatively low concentrations of magnesium, potassium, fluoride, nitrate, and reactive silica (combined 9% of TDS; Figure A-1). Average measured TDS in the near-field receiving environment (MEL-01) was lower (44 mg/L) with a broadly similar ionic composition to the effluent but with a higher overall proportion of carbonate and lower proportion of chloride, sodium, and calcium. TDS in the near-field consisted predominantly of chloride (12 mg/L; 28% of TDS), carbonate (18 mg/L; 24% of TDS), sodium (5.8 mg/L; 13% of TDS), calcium (7.7 mg/L; 18% of TDS), sulphate (4.5 mg/L; 10% of TDS), and relatively low concentrations of magnesium, potassium, fluoride, nitrate, and reactive silica (combined 6% of TDS; Figure A-2). On a site-wide basis, TDS composition relevant to the Meliadine interim TDS target is an ionic composition dominated by chloride, sodium, and calcium (from highest to lowest concentration), with lower contribution from carbonate. It is anticipated that, should TDS increase in the receiving environment relative to current conditions, the relative proportion of carbonate would decline as the relative proportions of chloride, sodium and calcium increase. Dominant ions of chloride, sodium, and calcium represent the lower range of toxicity potential relative to potassium, carbonate, and magnesium (Mount et al. 1997).

From November 2019 to March 2020, ten water quality samples were collected in Containment Pond 1 (CP1). The ionic composition of these samples were consistent with the ionic composition reported above for MEL-14 and MEL-01; average measured TDS in CP1 from November 2019 to March 2020 was approximately 4,403 mg/L and consisted predominantly of chloride (2,160 mg/L; 51% of TDS), sodium (806 mg/L; 19% of TDS), calcium

(483 mg/L; 11% of TDS), sulphate (349 mg/L; 8% of TDS), carbonate (87 mg/L; 2% of TDS), and relatively low concentrations of magnesium, potassium, fluoride, nitrate, and reactive silica (combined 9% of TDS).

Hardness may modify ion-specific toxicity, thereby ameliorating the toxicity of a mixture by reducing the toxicity of individual ions (Kennedy et al. 2005). For example, calcium has been identified as a specific component of hardness that ameliorates sulphate toxicity (Davies and Hall 2007; Mount et al. 2016). Hardness is not considered a toxicity modifying factor in the case of TDS, because hardness is a component of the TDS mixture and is therefore not an independent factor distinct from ionic composition. However, hardness can be considered for the evaluation of ion-specific toxicity, given that some ions (e.g., chloride, sulphate) are less toxic in hard water. Water hardness was calculated as calcium carbonate ($CaCO_3$) using the following equation:

$$[CaCO_3] = 2.5 \times [Ca^{2+}] + 4.1 \times [Mg^{2+}]$$

Average calculated water hardness in the effluent was 408 mg/L as $CaCO_3$ (i.e., very hard water), compared to 25 mg/L (i.e., soft water) in the near-field receiving environment.

Table A-1: Water chemistry results for TDS and associated constituents in Meliadine Mine effluent (MEL-14) collected between September 2017 to October 2019 and near-field (MEL-01) collected between July 2015 and September 2019

Parameter (mg/L)	MEL-14					MEL-01[(a)]				
	Median	Average	Maximum	Minimum	Sample Count	Median	Average	Maximum	Minimum	Sample Count
Calculated TDS	923	930	1,213	634	28	42	44	69	33	43
Measured TDS	1,185	1,203	1,760	860	28	52	54	94	25	43
Carbonate[(b)]	20	20	34	4	28	10	11	17	8	43
Chloride	470	487	660	300	28	12	12	19	8	43
Sodium	167	165	236	94	28	5.6	5.8	9.4	4.1	43
Calcium	125	122	220	17	28	7.3	7.7	13	5.8	43
Sulphate	53	56	90	7	28	4.3	4.5	6.6	3.4	43
Magnesium	26	25	36	4	28	1.3	1.4	2.4	1.0	43
Potassium	14	14	17	10	28	1.0	1.0	1.7	0.8	43
Fluoride	—[(c)]	—[(c)]	—[(c)]	—[(c)]	0	0.03	0.03	0.03	0.02	43
Nitrate (as N)	11	9	15	3	28	0.01	0.01	0.08	0.01	43
Reactive Silica	0.73	0.79	3.60	0.05	28	—[(d)]	—[(d)]	—[(d)]	—[(d)]	1
Calculated Water Hardness (as $CaCO_3$)[(e)]	407	408	698	59	28	24	25	41	19	43

Notes:

All concentrations expressed in milligrams per litre.

(a) MEL-01 measurements are from near-field stations MEL-01-01, MEL-01-06, MEL-01-07, MEL-01-08, and MEL-01-09.

(b) Calculated from total alkalinity as total alkalinity (as $CaCO_3$) × 0.6

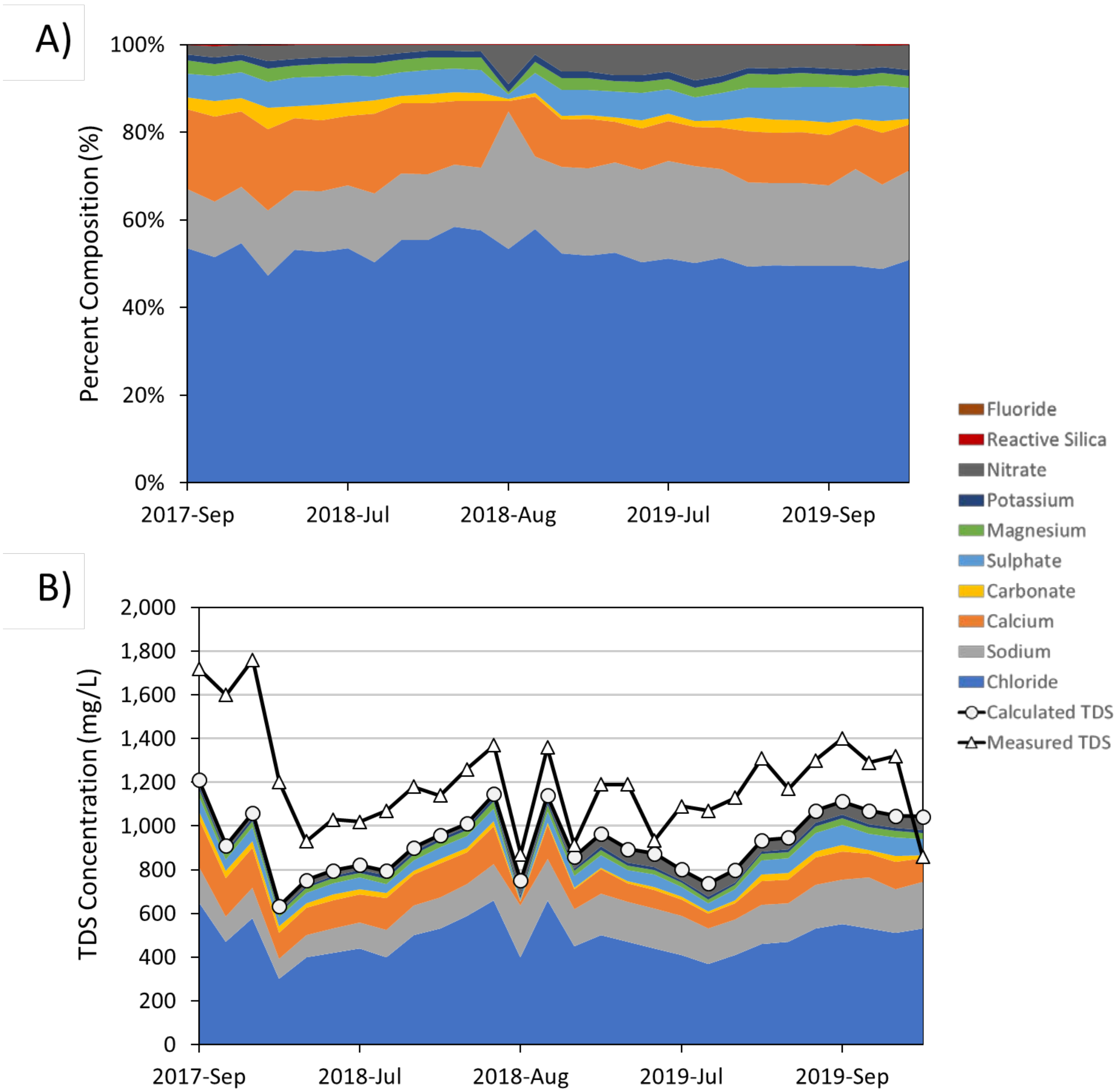
(c) Fluoride was not measured for data collected between September 2017 and October 2019, which precluded the calculation of summary statistics. However, these data would not result in significant changes to the understanding of ionic composition, given that fluoride provides only a trace component of both halides and TDS in Meliadine water samples.

(d) Reactive silica was only measured in one sample for data collected between September 2017 and October 2019, which precluded the calculation of summary statistics.

(e) Calculated as $(2.5 \times [Ca^{2+}]) + (4.1 \times [Mg^{2+}])$

mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; N = Nitrogen; — = not measured.

Figure A-1: Percent composition of TDS (%) (Panel A) and TDS concentration (mg/L) (Panel B) at station MEL-14 (treated effluent) for samples collected between September 2017 and October 2019 at Meliadine Mine.

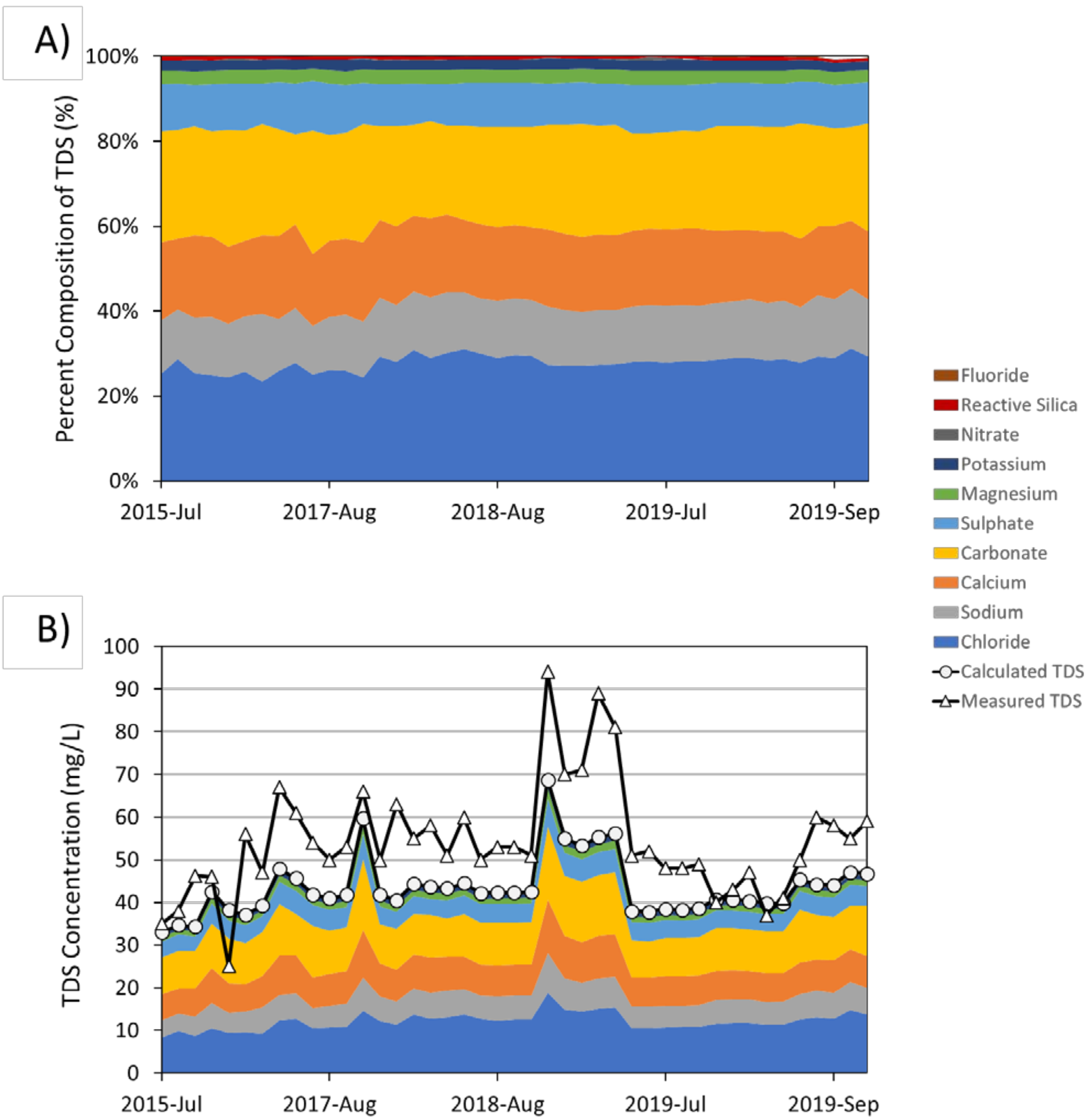


Notes:

Ionic composition was calculated as: $TDS_{calculated\ (mg/L)} = \sum[Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, F^-, SO_4^{2-}, SiO_3^{2-}, 4.42 \times NO_3^-\ (as\ N), 0.6 \times total\ alkalinity\ (as\ CaCO_3)]$.

Data for ionic composition from effluent (MEL-14) was collected between September 2017 and October 2019.

Figure A-2: Percent composition of TDS (%) (Panel A) and TDS concentration (mg/L) (Panel B) at station MEL-01 (near-field) for samples collected between July 2015 and September 2019 at Meliadine Mine.



Notes:

Ionic composition was calculated as: $TDS_{calculated\ (mg/L)} = \sum[Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, F^-, SO_4^{2-}, SiO_3^{2-}, 4.42 \times NO_3^-\ (as\ N), 0.6 \times total\ alkalinity\ (as\ CaCO_3)]$.

Data for ionic composition from near-field (MEL-01) was collected from stations MEL-01-01, MEL-01-06, MEL-01-07, and MEL-01-08 between July 2015 and September 2019.

A1.2 Benchmarks from Other Sites

Currently, there is no federal, Provincial or Territorial water quality guideline for TDS in Canada. Several US States have developed state or site-specific TDS criteria focussed on the protection of aquatic life. In Alaska, TDS criteria range from 500 to 1,500 mg/L (ADEC 2009), depending on the TDS composition and whether the receiving environment is potential salmon spawning habitat. Permits are required for discharges to receiving water that result in an increase in TDS concentration in the waterbody between 500 and 1,000 mg/L. Chapman et al. (2000) reported that studies conducted for Coeur Alaska's Kensington Mine site resulted in the first site-specific TDS permit in Alaska. The permit states that TDS may not exceed 1,000 mg/L in Sherman Creek, the receiving waterbody of Kensington Mine effluent (ADEC 2017). Alaska also granted a site-specific permit for Red Dog Mine effluent (ADEC 2013; Brix et al. 2010). Concentrations of TDS up to 1,500 mg/L are permitted during periods when salmonids are not spawning, provided calcium is greater than 50% by weight of the total cations (ADEC 2013; Brix et al. 2010). During spawning periods, the limit was set at 500 mg/L (Brix et al. 2010). However, the studies used to establish the Alaskan TDS water quality criterion were based on ionic compositions dominated by calcium sulphate, whereas the Meliadine effluent and near-field TDS is predominantly sodium chloride and calcium chloride (Chapman et al. 2000; Brix et al. 2010). Therefore, these benchmarks are not directly applicable to Meliadine Mine.

In 2004, the Iowa Department of Natural Resources (IDNR) adopted an interim TDS standard of 1,000 mg/L in receiving streams; the standard was used as a screening value to determine whether site-specific toxicity testing was required (IDNR 2009). However, IDNR since recommended replacing the TDS standard with numerical sulphate and chloride criteria (IDNR 2009) under the assumption that the individual ions provide a more defensible basis for evaluating toxicity relative to the sum of the ions.

The Snap Lake Mine in the Northwest Territories currently has a site-specific water quality objective (SSWQO) for TDS of 1,000 mg/L (Golder 2014; Chapman and McPherson 2015). The SSWQO was derived following toxicity testing with multiple receptor groups (fish, invertebrates, and plants) using a TDS ionic composition specific to Snap Lake Mine dominated by chloride, calcium, and sodium. The typical composition of Snap Lake water includes ~45% to 47% chloride, 20% to 21% calcium, 10% to 11% sodium, 9% sulphate, 5% to 7% carbonate, 4% nitrate, and 2% to 3% magnesium, with minor contributions from potassium and fluoride. This composition is broadly similar to that of Meliadine effluent. The test species and effects endpoints for the TDS SSWQO dataset, as reported by Chapman and McPherson (2015) and discussed in detail in Golder (2014), are presented in Table A-2. Additional testing was also conducted with the non-resident water flea, *Ceriodaphnia dubia*. As discussed by Chapman (2014a) the results from multiple rounds of testing with *C. dubia* were highly variable (potentially confounded by laboratory artifacts) and could not be relied upon to derive a protective SSWQO for Snap Lake Mine. Because species of the genus *Ceriodaphnia* do not reside in Snap Lake, species of the genus *Daphnia* are observed in Snap Lake, the chronic reproduction *D. magna* results were considered more representative of daphnids in Snap Lake. Following a resident taxa approach for deriving a SSWQO using the dataset in Table A-2, the TDS SSWQO for Snap Lake was set as 1,000 mg/L. The SSWQO was considered protective of aquatic life, and "if not exceeded, will avoid harm to the Snap Lake ecosystem" (Chapman 2014a, p.5). As discussed by Chapman (2014c), the results of toxicity testing do not indicate that an exceedance above 1,000 mg/L TDS will result in harm to aquatic life but provide "reasonable certainty of no harm up to 1,000 mg/L" (Chapman 2014a, p.5).

Table A-2: Chronic toxicity testing dataset for Snap Lake TDS SSWQO as summarized by Chapman and McPherson (2015)

Test Species	Common Name	Life stage	Test Duration	Endpoint	Test Statistic[(a)]	Result (mg/L TDS)	Reference
Salvelinus namaycush	Lake Trout	early life-stage		dry fertilization survival	LC_{20}	990	Baker et al. 2015
				dry fertilization growth	IC_{20}	>1,490	
				wet fertilization survival	LC_{20}	>1,480	
				wet fertilization growth	IC_{20}	>1,480	
Daphnia magna	water flea	<24 hr	21-d	reproduction	IC_{20}	>1,100	Chapman 2014b
Brachionus calyciflorus	rotifer		48-hr	population	IC_{10}	>1,330	Chapman 2014c
Chironomus dilutus	chironomid		10-d	growth	IC_{10}	>1,390	Chapman 2014c
Thymallus arcticus	Arctic Grayling	early life-stage		dry fertilization survival	LC_{20}	>1,420	Baker et al. 2015
				dry fertilization growth	IC_{20}	>1,420	
				wet fertilization survival	LC_{20}	>1,410	
				wet fertilization growth	IC_{20}	>1,410	
Pseudokirchneriella subcapitata	green alga	population	72-h	growth	IC_{10}	>1,470	Chapman 2014c
Navicula pelliculosa	diatom	population	120-h	growth	IC_{10}	>1,490	Chapman 2014c
Cyclops vernalis	copepod		20-d	growth	IC_{20}	>1,510	Marus et al. 2015; Chapman 2014c; Chapman 2014a
Pimephales promelas	Fathead Minnow	early life-stage	32-d	hatching, survival and growth	IC_{20}	>2,200	Chapman 2014c

Notes:

(a) As reported in Chapman and McPherson (2015) for the "*lowest reliable, technically defensible endpoint for each test*." A discussion of the selection of endpoints is provided in Golder (2014).

mg/L = milligrams per litre; TDS = total dissolved solids; LC_X = lethal concentration causing a lethal effect to x% of the test population; IC_X = inhibitory concentration that causes an x% inhibitory effect in the sublethal endpoint being measured.

The Snap Lake SSWQO validation excluded test results for the water flea, *C. dubia,* because multiple rounds of testing produced highly variable effect concentrations that were not reliable. Variability in the reproductive endpoint for *C. dubia* was attributed to confounding factors associated with the testing laboratory (e.g., dilution and acclimation water), and such variations have also been reported elsewhere (Lasier et al. 2006; Pacholski et al. 2016; Mount et al. 2016). Golder (2011; 2014) and Chapman and McPherson (2015) concluded that *D. magna* are more relevant surrogate for resident cladoceran species in Snap Lake mine because zooplankton surveys in Snap Lake reported the genus *Daphnia* but not the genus *Ceriodaphnia*. The same logic would apply for Meliadine Lake, where zooplankton surveys conducted as part of Aquatic Effects Monitoring in 2015, 2016, and 2017 reported *Daphnia* presence but not *Ceriodaphnia* (Golder 2019).

A1.3 Review of Chronic Toxicity Literature

Golder (2011; 2014) conducted an extensive literature review for total dissolved solids that was updated by Chapman and McPherson (2015); the literature review is presented in Appendix A of Golder (2011; 2014) and summarized in Chapman and McPherson (2015). This literature is separate from the values derived from site-specific toxicity testing at Snap Lake Mine as reported in Table A-2. Golder (2011; 2014) and Chapman and McPherson (2015) concluded that the toxicity of TDS was highly dependent on the ionic composition, the species tested, and the life stage; they identified the following trends for generic TDS mixtures:

- Phytoplankton—overall high tolerance of phytoplankton to TDS toxicity with effect concentrations higher than 1,000 mg/L.
- Benthic invertebrates—in general, adverse effect concentrations were above 1,000 mg/L, with the following exceptions. Relatively high sensitivity was reported for oligochaete worms (96-hour immobilization EC_{50} of 281 mg/L calcium chloride to the oligochaete worm *Tubifex*; Khangarot 1991), and the glochidia of a freshwater mussel (48-hour EC_{50} of 560 mg/L sodium chloride to glochidia of *Lampsilis fasciola*; Bringolf et al. 2007). Lower effect concentrations were also reported for the fingernail clam (*Sphaerium simile*; 96-hour survival LC_{50} of 740 mg/L; GLEC and INHS 2008; Soucek et al. 2011) but these represented individual ion exposure, which may not accurately predict chloride toxicity under mixture conditions.
- Zooplankton—cladoceran species were generally the most sensitive to TDS. Effect concentrations for calcium chloride salts ranged from 600 to 7,000 mg/L. A review of the chronic dataset presented by Golder (2011; 2014) indicated that effect concentrations for sodium chloride generally ranged from 750 mg/L (7-d reproduction no-effect concentration (NOEC) for *C. dubia*; Cooney et al. 1992) to 2,400 mg/L (7-d survival lowest effect concentration for *C. dubia*; Cooney et al. 1992).
- Fish—the sensitivity of fish to TDS toxicity varied by life-stage, with fertilization and egg-hardening life stages identified as the most sensitive toxicological endpoints. Fish were also generally less sensitive to TDS toxicity than zooplankton, with effect concentrations for calcium chloride ranging from 4,600 mg/L to greater than 15,000 mg/L. A review of the chronic dataset presented by Golder (2011; 2014) indicated that effect concentrations for sodium chloride generally ranged from 800 mg/L (8-d NOEC *Oncorhynchus mykiss*; Camargo and Tarazona 1991) to 8,000 mg/L (7-d NOEC *Pimephales promelas*; Pickering et al. 1996).

Lower effect concentrations have been reported for individual ions for select species, but these tests reflect exposure conditions accounting for a single ion, and not a balanced TDS mixture representative of most field conditions. A review of the literature indicates that when accounting for toxicity for TDS the following observations apply as summarized by Chapman and McPherson (2015):

- TDS toxicity is lower with the presence of more than one cation.
- Hardness may ameliorate TDS toxicity and the toxicity of individual ions (e.g., chloride and sulphate).
- The relative ratios of ions within the TDS mixture may affect TDS toxicity (e.g., Ca^{2+}:Mg^{2+}).

More recent research by Mount et al. (2016) support the conclusions by Chapman and McPherson (2015). Following extensive toxicity testing exposing *C. dubia* to different salt mixtures, Mount et al. (2016) concluded that inferring toxicity from individual ions is difficult due in part to interdependence among ions. Buchwalter et al. (2013) concluded that TDS toxicity is complicated by the findings that:

1) individual ions vary in toxicity;

2) some ions in solution can modify the toxicity of other ions; and

3) relative toxicities of ions are not consistent across species.

The results from Mount et al. (2016) also support the conclusion that toxicity of TDS mixtures varies by ionic composition, and that the characteristics of the TDS mixture influence the toxicity of other ions in the mixture.

A1.4 Site-Specific Chronic Toxicity Data

The information from the literature discussed in Section A1.3, particularly for Snap Lake, provides an indication of chronic exposure levels for TDS that are protective of aquatic life in a northern freshwater ecosystem. However, the identified importance of ionic composition means that site-specific results should carry the greatest weight in the interpretation of biological and ecological significance.

Chronic toxicity testing data and corresponding water chemistry data have been collected by Agnico Eagle as part of routine and regulatory monitoring at stations MEL-14 (treated effluent), and MEL-12 (influent from the water treatment plant). Chronic toxicity tests performed (all standard Environment Canada test protocols commonly applied in the Canadian environmental effects monitoring framework) were:

- Biological Test Method: Test of Reproduction and Survival Using the Cladoceran, *Ceriodaphnia dubia* (EC 2007a)
- Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows (EC 2011)
- Biological Test Method: Growth Inhibition Test Using a Freshwater Alga (EC 2007b)
- Biological Test Method: Test for Measuring the Inhibition of Growth Using the Freshwater Macrophyte, *Lemna minor* (EC 2007c)

Chronic toxicity test results and corresponding water chemistry data for calculated TDS (and measured) and chloride are presented in Table A-3. The results of the chronic testing indicate:

- No effects to *C. dubia* survival at TDS concentrations up to and including 2,357 mg/L (measured TDS of 2,450 mg/L). Reduced *C. dubia* reproduction was observed at TDS concentrations between 1,140 mg/L to 2,202 mg/L (measured TDS of 1,360 to 2,490 mg/L).
- No effects to Fathead Minnow survival or growth at TDS concentrations up to and including 2,357 mg/L (measured TDS of 2,450 mg/L).
- Growth inhibition to *P. subcapitata* was observed in two samples collected in September and October 2019 at TDS concentrations of 2,202 mg/L and 2,357 mg/L, respectively (measured TDS of 2,490 mg/L and 2,450 mg/L, respectively). However, follow up testing conducted in October indicated no effect to growth inhibition at a TDS concentration of 2,350 mg/L (measured TDS of 2,370 mg/L). No effect to growth inhibition was observed in remaining samples at TDS concentrations up to and including 1,140 mg/L (measured TDS of 1,360 mg/L).
- Effects to *L. minor* frond count were observed at TDS concentrations between 2,202 mg/L to 2,357 mg/L (measured TDS of 2,490 mg/L to 2,450 mg/L). Although effects to *L. minor* frond count were occasionally observed at TDS concentrations of approximately 1,000 mg/L the effect was not consistently observed. For example, no effect to frond count (IC_{25} >97% vol/vol) was observed on three occasions at TDS

concentrations ranging between 800 to 1,140 mg/L (measured TDS of 1,130 to 1,360 mg/L). Effects to *L. minor* biomass were observed in two of eight samples at TDS concentrations of 1,011 mg/L and 2,357 mg/L (measured TDS 1,260 mg/L to 2,450 mg/L). No effects to *L. minor* biomass were observed in six of eight samples at TDS concentrations of 800 to 2,350 mg/L (measured TDS of 1,130 mg/L to 2,370 mg/L).

In summary, multiple rounds of chronic toxicity testing indicate no effects to survival of fish or crustaceans across a wide range of TDS concentrations (i.e., unbounded no-effect level of 2,357 mg/L), and no reliable indications of sublethal toxicity have been observed at 1,000 mg/L. Moderate to high magnitude sublethal responses to *C. dubia* and aquatic plants/algae are evident at calculated TDS concentrations that exceed 2,000 mg/L. Collectively, these results provide evidence that the interim TDS target for Snap Lake of 1,000 mg/L remains protective for Meliadine Lake. A higher threshold TDS concentration protective of aquatic life may be supportable once the validation study (Phase 2 of WQ-MOP) is complete.

Table A-3: Chronic toxicity data for MEL-14 and MEL-12 samples collected between 2018 to 2019 with corresponding total dissolved solids and chloride concentrations

Sample Location	Sample Date	Chronic Toxicity							Water Chemistry (mg/L)		
		Water flea *Ceriodaphnia dubia*		Fathead minnow *Pimephales promelas*		Green alga *P. subcapitata*	Duckweed *Lemna minor*				
		3-brood Survival LC_{50} (% vol/vol)	3-brood Reproduction IC_{25} (% vol/vol)	7-d Survival LC_{50} (% vol/vol)	7-d Growth IC_{25} (% vol/vol)	72-hr Cell Inhibition IC_{25} (% vol/vol)	7-d Frond Count IC_{25} (% vol/vol)	7-d Biomass IC_{25} (% vol/vol)	Measured TDS	Calculated TDS	Chloride
MEL-14	07 August 2018	>100	>100	>100	>100	>90.9	72.3	>97	1,140[(a)]	958[(a)]	530[(a)]
	13 August 2018	—	—	>100	>100	>90.9	38.2	42	1,260	1,011	590
	3 September 2018	>100	90.1	>100	>100	>90.9	>97	>97	1,360	1,140	660
	9 July 2019	—	—	—	—	—	>97	>97	1,190	965	500
	13 August 2019	—	—	—	—	—	>97	>97	1,130	800	410
MEL-12	24 September 2019	>100	24.3	>100	>100	60.8	26.3	>97	2,490	2,202	1,100
	1 October 2019	>100	58.8	>100	>100	88.2	29.4	66.2	2,450	2,357	1,200
	8 October 2019	>100	20.1	>100	>100	>90.9	59	>97	2,370	2,350	1,200

Notes:

(a) Corresponding water chemistry data was not collected for this sample. However, a sample collected on 5 August 2018 from the same location is reported here for comparison.

mg/L = milligrams per litre; vol/vol = volume per volume; TDS = total dissolved solids; LC_X = lethal concentration causing a lethal effect to x% of the test population; IC_X = inhibitory concentration that causes a x% inhibitory effect in the sublethal endpoint being measured.

A1.5 Weight of Evidence Summary for Proposed Site-Specific Water Quality Objective

An interim TDS target of 1,000 mg/L to apply at the edge of the mixing zone was proposed following integration of information obtained through characterization of the Meliadine TDS profile (Section A1.1), review of water quality benchmarks for TDS developed for similar mixtures (Section A1.2), a literature review of TDS toxicity (Section A1.3), and a review of site-specific chronic toxicity data for Meliadine treated effluent and influent samples (Section A1.4). Sections A1.5.1 to 1.5.4 summarize the weight of evidence behind the proposed interim TDS target.

Several considerations, summarized in Sections A1.5.1 through A1.5.4, provide confidence in the application of the interim TDS target and also bode well for outcomes of the Phase 2 validation studies. The literature and site-specific data review provide a basis to propose an interim target for TDS; implementation of Phase 2 validation studies will provide increased precision and reliability in the interim target.

A1.5.1 Ionic Balance is Favorable

Effect concentrations reported in the Snap Lake dataset were derived from exposures using a balanced TDS mixture, whereas effect concentrations from the literature are generally derived from exposures using single salt mixtures (e.g., sodium chloride or calcium chloride) that do not consider TDS mixture effects. Meliadine TDS ionic composition resembles the ionic composition evaluated during the validation of the Snap Lake TDS SSWQO of 1,000 mg/L. As indicated in Section A1.0, Meliadine TDS contains a high relative proportion of calcium and sodium ions (on average 31% of TDS); these dominant ions are among the least toxic according to Mount et al. (1997), and have been identified as key components of TDS that ameliorate toxicity of other ions (Davies and Hall 2007, Mount et al. 2016, Soucek et al. 2018, Scheibener et al. 2017). Concentrations of the relatively toxic potassium and magnesium ions are predicted to remain low in Meliadine effluent; potassium and magnesium ions make up approximately 4% to 5% of TDS in effluent and the near-field. The information from the ionic composition analysis (Section A1.0), and comparison to the Snap Lake TDS SSWQO dataset (Section A2.0), although not conclusive, suggests that the Meliadine TDS mixture would not exhibit chronic toxicity from TDS components at concentrations of TDS below approximately 1,000 mg/L. Some literature studies indicate toxicity to select invertebrate species at concentrations below 1,000 mg/L TDS, but these toxicity tests are limited to test solutions that contain predominantly one or two ions, which do not apply to the complex mixture conditions of Meliadine TDS, nor incorporate the beneficial effect of calcium and sodium for ameliorating toxicity of other ions in these mixtures.

A1.5.2 Comparability to Well-Validated Snap Lake

Effect concentrations derived from extensive validation of the SSWQO at Snap Lake mine indicated no effects to site-resident or relevant surrogate species below 1,100 mg/L TDS. The effect concentration for *D. magna*, the most sensitive species in the dataset, was unbounded indicating no effects at the highest tested TDS concentration. Unbounded effect concentrations were also reported for all other test species in the Snap Lake dataset. Therefore, concentrations of TDS above 1,000 mg/L may pose no risk to aquatic life but there is uncertainty in proposing an interim TDS target to apply at the edge of the mixing zone of higher than 1,000 mg/L because exposure concentrations used in the Snap Lake dataset did not reach toxicity thresholds for the species tested.

A1.5.3 Available Site-Specific Toxicity Data Support the Benchmark

The chronic toxicity data tested with Meliadine mixtures supports the proposed interim target to apply at the edge of the mixing zone of 1,000 mg/L (Section A4.0). During routine and regulatory chronic toxicity testing with

MEL-14 and MEL-12 samples, no chronic effects to *C. dubia* survival, early life-stage Fathead Minnow survival or growth, or growth of the green alga *P. subcapitata* were observed at TDS concentrations of approximately 1,140 mg/L (measured TDS of 1,360 mg/L). The reduction of *C. dubia* reproduction at 1,140 mg/L (measured TDS of 1,360 mg/L) was not large (IC_{25} for reproduction of 90.1% vol/vol at TDS concentrations of 1,140 mg/L). Overall, these results support the proposed interim TDS target of 1,000 mg/L to apply at the edge of the mixing zone, but site-specific validation is necessary to verify these results and develop a TDS SSWQO for long-term application.

A1.5.4 Ionic Balance is Stable

The stable ionic balance over several years of monitoring (Figure 2) is suited to development of a single benchmark for TDS, without requiring development of individual benchmarks for component ions. The TDS interim target incorporates contributions from chloride and sulphate (along with other ionic components) and it is not recommended at this time that separate benchmarks be developed for chloride and sulphate as individual ions. However, the concentrations of individuals ions can be prorated from the recommended TDS interim target of 1,000 mg/L. For Meliadine TDS, the relative proportion of chloride at the recommended interim target of 1,000 mg/L would range between 280 to 520 mg/L, depending on the ionic composition. The upper bound of chloride proportion is based on an ionic composition derived from TDS in the effluent; it is anticipated that the ionic composition for TDS in the receiving environment would not have as high a proportion of chloride as effluent. For comparison, Snap Lake TDS including chloride of up to approximately 450 to 470 mg/L demonstrated negligible toxicity.

The proposed TDS interim target to apply at the edge of the mixing zone was derived from the anticipated ion composition for Meliadine based on monitoring data for effluent and near-field. Modelled chemistry data are not available for the ionic composition anticipated under future discharge conditions at Meliadine, requiring confirmation that ionic mixtures are expected to remain consistent in terms of proportions of major ions. If future effluent quality with respect to TDS constituents is markedly different, then re-evaluation of the proposed TDS threshold may be warranted.

A2.0 INTERIM TDS TARGET FOR EFFLUENT—SITE-SPECIFIC ACUTE TOXICITY RESULTS

Acute toxicity testing data and corresponding water chemistry data were collected by Agnico Eagle as part of routine and regulatory monitoring at stations MEL-14 (treated effluent), MEL-12 (influent from the water treatment plant), and CP1 (Collection Pond 1). Acute toxicity tests performed were:

- Biological Test Method: Reference Method for Determining Acute Lethality of Effluent to *Daphnia magna* (EC 2000a).
- Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout (EC 2000b).
- Biological Test Method: Acute Lethality Test Using Threespine Stickleback (*Gastrosteus aculeatus*) (ECCC 2017).

Acute toxicity test species include the standard protocols (*D. magna* and Rainbow Trout) used to assess compliance for acute lethality under the Metal and Diamond Mining Effluent Regulations (Government of Canada 2002). Two additional tests were conducted with Threespine Stickleback in November and December 2019. The Threespine Stickleback results were included for comparative purposes, although this species is currently not a required standard test species for regulatory testing related to discharge of effluent to Meliadine Lake. Acute toxicity test results and corresponding water chemistry data for TDS (measured and calculated) and chloride are presented in Table A-4.

Acute toxicity testing conducted between 2017 to 2020 with influent (MEL-12 and CP1) and effluent (MEL-14) has indicated no acute toxicity (i.e., LC_{50} >100% vol/vol) to *D. magna* or Rainbow Trout survival with TDS concentrations of up to and including 5,420 mg/L (measured TDS concentrations of up to 4,925 mg/L). Reduced survival (60% in full-strength sample) in Rainbow Trout was observed in a CP1 sample collected 17 December 2017 at TDS concentration of 3,150 mg/L. However, mortality did not exceed 50%, and since 2017 several samples have been tested with measured and TDS concentrations greater than 3,150 mg/L, all of which indicated no acutely toxic effects to Rainbow Trout.

Threespine Stickleback were tested on two occasions in November and December 2019 with CP1 sample. Measured TDS concentrations of up to and including 3,410 mg/L did not result in acutely toxic effects in Threespine Stickleback.

Table A-4: Acute toxicity data for MEL-14, MEL-12, and CP1 samples collected between 2017 to 2020 with corresponding total dissolved solids and chloride concentrations

Sample Location	Sample Date	Acute Toxicity			Water Chemistry (mg/L)		
		Daphnia magna	Rainbow Trout *Oncorhynchus mykiss*	Threespine Stickleback *Gastrosteus aculeatus*	Measured TDS	Calculated TDS	Chloride
		48-hour Survival LC_{50} (% vol/vol)	96-hour Survival LC_{50} (% vol/vol)	96-hour Survival LC_{50} (% vol/vol)			
MEL-14	9 August 2017	>100	>100	—	1,600	911	470
	27 August 2017	>100	>100	—	1,760	1,061	580
	24 June 2018	>100	>100	—	1,200	634	300
	1 July 2018	>100	>100	—	930	752	400
	5 August 2018	>100	>100	—	1,140	958	530
	3 September 2018	>100	>100	—	1,360	1,140	660
	24 June 2019	>100	>100	—	915	859	450
	9 July 2019	>100	>100	—	1,190	965	500
	3 September 2019	>100	>100	—	1,300	1,070	530
CP1	21 June 2017	>100	>100	—	1,190	575	290
	12 July 2017	>100	>100	—	908	707	350
	05 November 2017	—	>100	—	2,230	— (b)	— (b)
	11 November 2017	>100	>100	—	2,791	— (b)	— (b)
	19 November 2017	>100	>100	—	— (c)	— (b)	— (b)
	17 December 2017	>100	NC (60% survival)(d)	—	3,150	— (b)	— (b)
	10 June 2018	>100	>100	—	685	477	210
	17 June 2018	>100	>100	—	540	281	180
	25 November 2019	—	—	>100	2,960	3,055	1,500
	15 December 2019	—	—	>100	3,410	— (b)	— (b)
	05 January 2020	>100	>100	—	4,830	4,465	2,400
	12 January 2020	>100	>100	—	4,150	3,815	1,900

Sample Location	Sample Date	Acute Toxicity			Water Chemistry (mg/L)		
		Daphnia magna	Rainbow Trout *Oncorhynchus mykiss*	Threespine Stickleback *Gastrosteus aculeatus*	Measured TDS	Calculated TDS	Chloride
		48-hour Survival LC_{50} (% vol/vol)	96-hour Survival LC_{50} (% vol/vol)	96-hour Survival LC_{50} (% vol/vol)			
	26 January 2020	>100	>100	—	4,160	3,659	1,900
	02 February 2020	>100	>100	—	4,080	4,263	2,100
	09 February 2020	>100	>100	—	4,330	4,219	2,100
	16 February 2020	>100	>100	—	4,880	4,352	2,300
	01 March 2020	>100	>100	—	5,350	4,946	2,500
	08 March 2020	>100	>100	—	4,870	4,816	2,400
	15 March 2020	>100	>100	—	5,420	4,925	2,500
MEL-12	24 September 2019	>100	>100	—	2,490	2,202	1,100
	01 October 2019	— (e)	>100	—	2,450	2,357	1200
	08 October 2019	>100	>100	—	2,370	2,350	1,200

Notes:

(a) Test was conducted with full-strength sample (100% vol/vol) and laboratory control.

(b) Corresponding major ion chemistry data were not measured in this sample; therefore, calculated TDS could not be determined.

(c) Corresponding water chemistry data were not collected for this sample.

(d) A 96-hour LC_{50} could not be calculated because this test was conducted as a screening (pass/fail) test, whereby full-strength (100% vol/vol effluent) sample was tested with a laboratory control. To estimate the LC_{50} a multi-concentration dilution series must be conducted. The result reported here in brackets is percent survival in the full-strength effluent sample.

(e) Due to a laboratory error during testing with *Daphnia magna* the results of the 1 October 2019 test were invalidated and were not reported by the laboratory.

TDS = total dissolved solids; MEL-14 = treated effluent; MEL-12 = untreated influent; CP1 = Containment Pond 1; mg/L = milligrams per litre; LC_X = lethal concentration causing a lethal effect to x% of the test population; vol/vol = volume per volume; NC = not calculable.

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APPENDIX B

Plume Delineation Study Design

B.1 INTRODUCTION

The Meliadine Gold Mine (Mine) is located in the Kivalliq District of Nunavut near the western shore of Hudson Bay, in Northern Canada (Figure 1). The nearest community is Rankin Inlet (coordinates: 62°48’35’’N;092°05’58’’W), approximately 25 km south of the Tiriganiaq deposit (coordinates: 63°01’03’’N, 92°12’03’’W). The Mine is located within the Meliadine Lake watershed of the Wilson Water Management Area (Nunavut Water Regulations Schedule 4).

As communicated to the Nunavut Water Board (NWB) by Agnico Eagle Mines Limited (Agnico Eagle), the 2020 freshet season will result in accumulation of site water that exceeds the water storage capacity of the mine at containment pond 1 (CP1), requiring a managed release of site water to the environment. In anticipation of this condition, Amendment 1 was approved by NWB for the Meliadine Mine Type “A” Water Licence (No. 2AM-MEL-1631), allowing Meliadine to dewater CP1 prior to freshet, avoiding “emergency” conditions. Specifically, Amendment 1 permits the following:

- *The time-limited discharge (May 2020 – October 2020) of effluent from the Containment Pond 1 (CP1) into Meliadine Lake through the Meliadine Lake Diffuser (Monitoring Program Station MEL-14) and the Water discharge shall not exceed 3,500 mg/L for the Maximum Average Concentration (MAC) of the Total Dissolved Solids (TDS)*

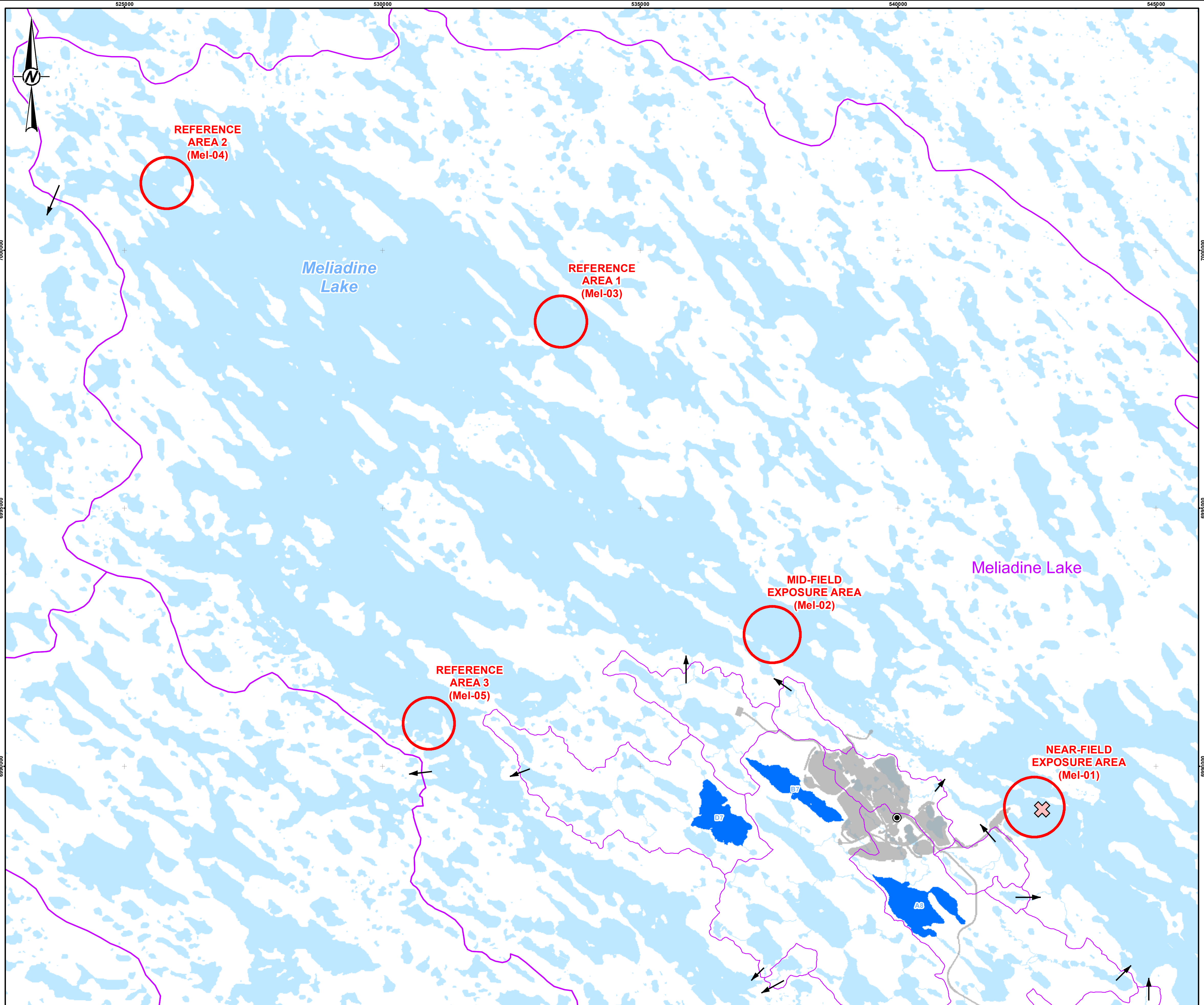
The NWB approval is contingent on several conditions outlined in NWB’s (2020) Reason for Decision. Among these conditions is the requirement for Agnico Eagle to conduct a Plume Delineation Study during the discharge event to characterize plume dispersion in the receiving environment of Meliadine Lake. The purpose of the Plume Delineation Study is to provide confidence that the dispersion of the CP1 discharge will follow the anticipated pattern of flow and mixing in the receiving environment, such that environmental protection objectives at the edge of the mixing zone will be satisfied.

A submerged diffuser was installed in Meliadine Lake in August 2017 to disperse the water discharged from containment ponds 1 and 5 (CP1 and CP5). The diffuser is 30 m long, 400 mm diameter, with a nearly north-south orientation, and connected to the pipelines through a T-connection. Ten 51 mm ports are evenly spaced at every 3 m along the diffuser (Tetra Tech 2017).

This document provides details on the proposed plume delineation study (e.g., sampling design and methods) to evaluate plume dispersion dynamics during the planned release of effluent from CP1. This plan has been designed to address reporting requirements under Amendment 1 for a Plume Delineation Study, as outlined in Insert Item 25, Part I of NWB’s (2020) Reasons for Decision. The period of anticipated discharge is expected to commence during ice cover on Lake Meliadine and continue through the transition period between ice cover and open water conditions, and into open water conditions on Meliadine Lake. Safe boat access to the lake is required to successfully conduct the plume delineation study. Therefore, the detailed plume delineation study will be conducted over 1 to 2 days as soon as open water conditions permit safe boat access.

B.2 BACKGROUND INFORMATION

Turbulent mixing caused by the diffusers results in an initial effluent plume adjacent to the diffusers. The term “plume” in this report refers to the mixture of effluent and lake water that is chemically distinguishable from the surrounding ambient lake water.



LEGEND

- DIFFUSER
- MINE FOOTPRINT
- WATERSHED BOUNDARY
- WATERCOURSE
- WATERBODY

DRAFT

0 1.5 3

1:75,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. DATUM: NAD83 PROJECTION UTM ZONE 15

CLIENT

AGNICO EAGLE MINES LIMITED

PROJECT

MELIADINE GOLD PROJECT
NUNAVUT

TITLE

SITE LOCATION

CONSULTANT

GOLDER

YYYY-MM-DD	2018-07-04
DESIGNED	ER
PREPARED	MH
REVIEWED	
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1787610	5000/5010	A	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

The diffuser in Meliadine Lake is oriented on a nearly north-south alignment, forming a “T” at the end of the pipe (Tetra Tech 2018; Figure 1). The constructed diffuser differed from the original project design (see Tetra Tech 2017) in terms of its horizontal position and depth of diffuser system at T-connection (42 m horizontal shift and a 3.2 m shallower depth). Therefore, the performance of the diffuser system was reassessed by Tetra Tech (2018). Despite the deviations from the original design, the predicted minimum dilution of 23:1 was achieved at the edge of the mixing zone, and water quality criteria were met (Tetra Tech 2018).

Based on previous experience in low conductivity sub-arctic lakes, specific conductivity was considered an appropriate tracer to delineate the effluent plume in Meliadine Lake, because effluent conductivity (i.e., specific conductance, temperature-corrected to 25°C) is higher than the specific conductivity of natural lake water. Specific conductivity measurements are a rapid, inexpensive, and reliable way of measuring the ionic content in a solution; the main constituents of interest in Meliadine Lake discharge are ionic parameters (e.g., chloride and other components of total dissolved solids). Specific conductivity in CP1 ranged from 5,300 to 9,000 microsiemens per litre (µS/cm) between November 2019 and March 2020 (Appendix A), whereas specific conductivity in Meliadine Lake (Near-field exposure area) ranged from 49 to 99 µS/cm in 2017 (Golder 2018c). This gradient in specific conductivity provides a reliable basis for tracing the direction and intensity of the plume during the release event, with chemical measurements from samples collected at select monitoring stations used to confirm the water quality details.

B.3 METHODS

B.3.1 Sampling Design

The sampling design selected for the plume delineation in Meliadine Lake is a nearly radial model that allows measurement of plume dispersion in all directions. According to the *MVLWB/GNWT Guidelines for Effluent Mixing Zones* (GNWT 2017), the regulated mixing zone is defined as an area where concentrations of some substances may not comply with site-specific water quality objectives for the receiving environment, but is nevertheless suitable for reducing constituent concentrations from full strength discharges to those that provide protection against chronic effects to aquatic life. For lakes in the Mackenzie Valley, regulated mixing zones commonly have a maximum of 100 m radius from the discharge point (GNWT 2017). In contrast, site characterization under the MDMER/MMER (GC 2017) requires a description of the manner in which the effluent mixes within the exposure area at 250 m from each final discharge point. Using these distances as a basis for monitoring design, a modified radial grid containing 22 sampling stations was developed (Figure 2). Coordinates of sampling stations are provided in Table 1.

Table 1: Coordinates of plume delineation study sampling stations

Sample ID	UTM Coordinates (NAD 83, Zone 15V)	
	Easting	Northing
50-01	542803.3	6989212.3
50-02	542847.2	6989144.7
50-03	542792.6	6989085.7
50-04	542748.4	6989153.2
100-01	542807.5	6989262.1
100-02	542875.5	6989226.9
100-03	542897.3	6989140.6
100-04	542861.3	6989059.1

Sample ID	UTM Coordinates (NAD 83, Zone 15V)	
	Easting	Northing
100-05	542788.4	6989035.9
100-06	542719.9	6989070.2
100-07	542699.0	6989157.3
100-08	542728.6	6989233.4
175-01	542813.8	6989336.8
175-02	542971.8	6989134.3
175-03	542782.1	6988961.1
175-04	542624.1	6989163.6
250-01	543046.7	6989128.0
250-02	542958.1	6988944.5
250-03	542775.8	6988886.4
250-04	542605.4	6988972.9
250-05	542549.2	6989170.0
250-06	542622.9	6989339.8

Two central markers are depicted in Figure 2 that outline the north and south ends of the diffuser, which is approximately 30 m in length. From each of these central markers, semicircles of 50, 100, 175, and 250 m were drawn, and within each arc, sampling stations have been placed along up to eight transects radiating from the diffuser (Figure 2). The number of stations at each distance varied, with the larger station numbers applied to the 100 m and 250 m distances. Some of the candidate sampling stations along transects were removed from the design as they were located on islands or shallow areas of Meliadine Lake.

The distances from sampling stations to central markers (i.e., diffuser ends) were selected to provide higher resolution close to the diffusers and to characterize the edge of the mixing zone per the GNWT and MDMER frameworks.

B.3.2 Field Work Instructions

As described by Golder (2018a), the method selected for plume delineation relies on vertical profiles of specific conductivity in near-field exposure areas of Meliadine Lake. Vertical profiles of the lake water column will be measured using water quality meters (e.g., Hanna, YSI, Eureka, or equivalent) equipped with a 20 m or longer cable. Before commencing the profile, the water quality sensor will be placed in lake water for at least one minute to allow readings to stabilize. If, following extended submersion (beyond one minute if necessary), the equipment is not providing stable readings, measurements will be taken using a different meter.

At each sampling station, profile measurements will be taken from surface (i.e., 0.3 m) and at 1-m water depth intervals, starting from 1 m below surface to 1 m above the lake bottom. Temperature and specific conductivity (and if possible, dissolved oxygen concentration, dissolved oxygen saturation, and pH) will be entered on field data sheets. If possible, wind direction and speed will be estimated and recorded.

A maximum of ten water samples will be collected from a subset of the planned sampling stations for laboratory analysis of TDS, major ions, and general parameters (i.e., total and bicarbonate/carbonate alkalinity, turbidity, laboratory specific conductivity, hardness, laboratory pH, and total suspended solids). These samples will be collected from the depth of highest specific conductivity through the water volume at these stations, as determined from the specific conductivity water column profile. Samples identified for more detailed analyses will be selected to encompass the range of specific conductivity measures observed surrounding the diffuser. These data will be used to validate the assumption that TDS concentrations in the receiving environment can be adequately traced using specific conductivity.

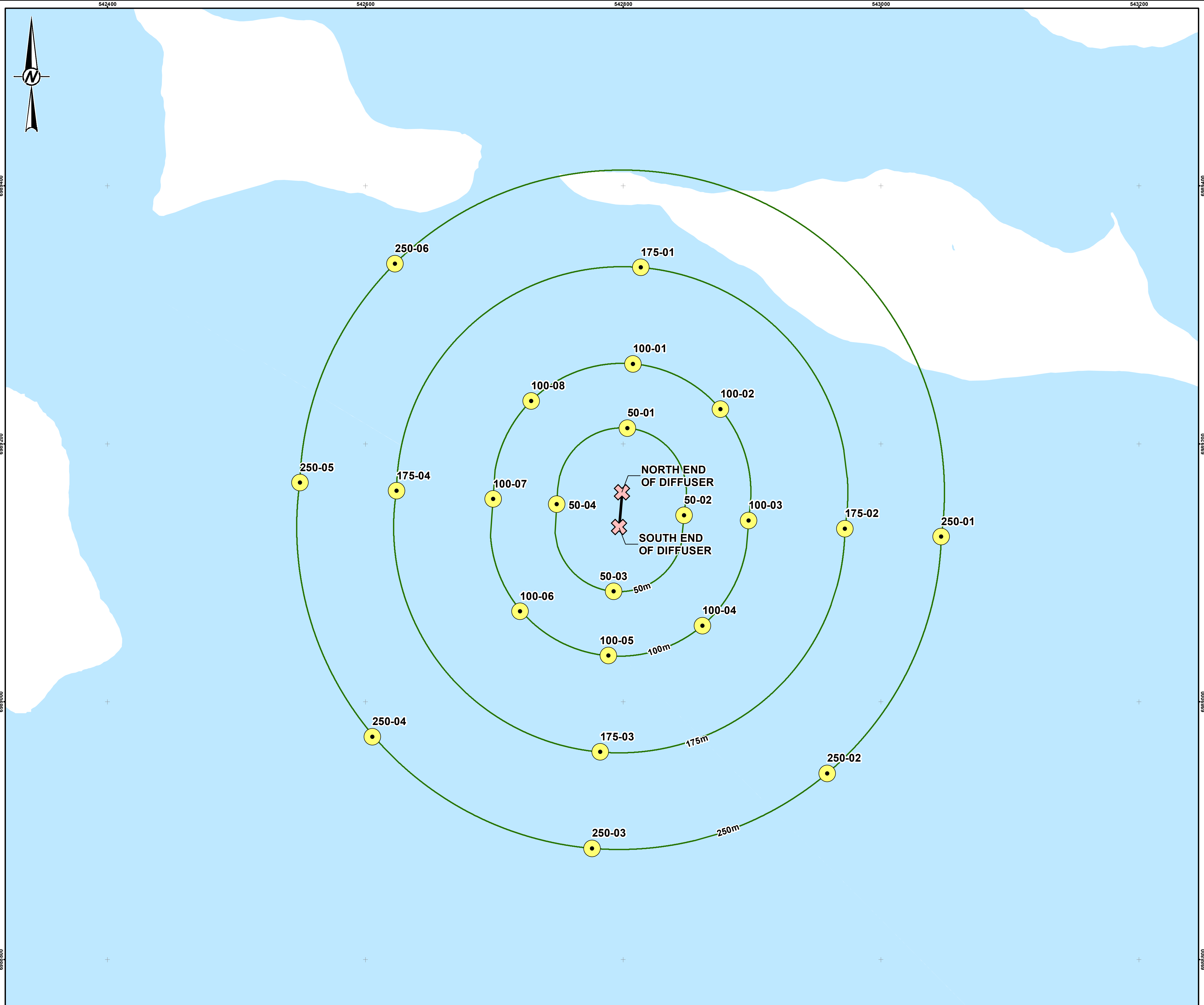
Field work for this study will commence as soon as open water conditions are present on Meliadine Lake, and there is safe access to the sampling locations by boat. Field work will be completed within a timely manner to avoid influence of confounding factors associated with weather conditions and discharge variability. Although it is expected that it will take one full day of work for a two-person field crew to complete the field program, additional days might be required depending on weather conditions. The program will be conducted during discharge to satisfy reporting requirement under Amendment 1 for a plume delineation study, as outlined in Insert Item 25, Part I of NWB's (2020) Reasons for Decision. In addition, a corresponding sample of the discharge from MEL-14 is required to be collected for the program. Therefore, the timing of the field work for this study should be planned around the weekly MEL-14 sampling schedule.

Quality assurance and quality control (QA/QC) procedures will be undertaken to obtain accurate data. QA/QC will include field staff training, routine calibration of field equipment, and documentation. Meter calibration will be re-checked at least once during each day of field work. In case the field staff notice that results are deviating from the expected range of values, a new check with calibration standards will be performed at a sampling station and, if necessary, the probe will be recalibrated. Calibration checks or re-calibration will be documented in the field book.

B.3.3. Data Analysis and Reporting

Following field work, data will be reviewed, and summary tables and figures will be prepared for presentation and discussion during the next available Water Management Working Group meeting. The plume will be described in terms of its size, shape, and vertical distribution. The relationship between field measured specific conductivity and laboratory measured TDS and calculated TDS (from the sum of major ions, where these data are available for each of the selected substations) will be established to validate the use of specific conductivity as a tracer of TDS in the receiving environment. The information retrieved will be used to confirm model predictions related to effluent dilution and assimilation in the receiving environment, and to confirm that receiving environment monitoring stations are adequately characterizing conditions with respect to surface water chemistry and toxicity testing (Sections 3.1 and 3.2 of the main body of the report, respectively).

Results from the plume delineation study will be presented as a stand-alone report, including spatial delineation of the plume and estimated dilution factors at each sampling station. This report will be submitted for review by the Water Management Working Group.



LEGEND

DIFFUSER

SAMPLING LOCATION

FINAL DISCHARGE BUFFER

AS-BUILT DIFFUSER

0 60 120

1:3,000 METRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. DATUM: NAD83 PROJECTION UTM ZONE 15

CLIENT

AGNICO EAGLE MINES LIMITED

PROJECT

MELIADINE GOLD PROJECT
NUNAVUT

TITLE

SAMPLING DESIGN FOR PLUME DELINEATION STUDY AT MELIADINE LAKE NEAR-FIELD EXPOSURE AREA

CONSULTANT

GOLDER

YYYY-MM-DD	2018-07-04
DESIGNED	ER
PREPARED	MH
REVIEWED	
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1787610	5000/5010	A	2

APPENDIX B REFERENCES

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Tetra Tech 2018. Effluent Discharge Modelling for the As-Built Diffuser at the Meliadine Gold Project, Nunavut. Prepared for Agnico Eagle Mines Limited. May 2018.

golder.com