8-E.6: Erosion Management Plan

Updated Plan: *Plan submitted based on NIRB direction. Where historical information previously assessed and approved (as required) under the Type A Water Licence are in place for the Approved Project. This Approved Plan is submitted for ease of regulatory review. Updates were completed to account for Expansion Project activities.*

AGNICO EAGLE

Meadowbank Division

Erosion Management Plan

DECEMBER 2018
VERSION 2_NIRB

EXECUTIVE SUMMARY

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is proposing an expansion to the Whale Tail Pit and Haul Road Project, a Meadowbank satellite deposit located on the Amaruq property. As an expansion to the Approved Project (Nunavut Impact Review Board (NIRB) Project Certificate No. 008 and Nunavut Water Board (NWB) Type A Water License 2AM-WTP1826) Agnico Eagle is proposing to expand and extend the Whale Tail Pit operations to include a larger Whale Tail open pit, development of the IVR open pit, and underground operations while continuing to operate and process ore at the Meadowbank Mine.

This document presents the proposed erosion management plan (the Plan) at the Amaruq property for the development of the Whale Tail Project. The purpose of this Plan is to provide consolidated information on the management and monitoring of potential areas subjected to erosion, by presenting first a review of the potential effects of total suspended solids (TSS) and turbidity, the Federal guidelines and the license requirements, followed by the periods and type of activities subjected to erosion, the specific monitoring and mitigating measures.

General findings on the effects of TSS on fish and fish habitat have been listed, such as sublethal and lethal effects on fish and their eggs. Federal TSS Guidelines have been cited, distinguishing the short-term and long-term exposure thresholds. Turbidity guidelines are also discussed in the present document.

The Plan presents the monitoring and mitigating actions related to three (3) specific periods of activity for the Whale Tail Project: the period of construction and dewatering (during construction and operation), the period of freshet (during construction, operation and closure) and the period of rise in water level in the South Basin of Whale Tail Lake (during operation). The proposed monitoring and mitigating measures are discussed for those periods of activity.

DOCUMENT CONTROL

Version	Date (YM)	Section	Page	Revision
1	June 2018	ALL	-	Comprehensive plan for Whale Tail Project
2	December 2018	ALL	-	Erosion Management Plan as supporting Document submitted to Nunavut Impact Review Board for review and approval as part of Whale Tail Pit – Expansion Project.

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ACRONYMS

Agnico Eagle	Agnico Eagle Mines Limited – Meadowbank Division
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
MMM	Maximum Monthly Mean
NIRB	Nunavut Impact Review Board
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
Plan	Erosion Management Plan
STM	Short Term Maximum
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
WTD	Whale Tail Dike

UNITS

h	hour
km	kilometre
km^2	square kilometre
mg/L	milligram per litre

SECTION 1 • INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is proposing an expansion to the Whale Tail Pit and Haul Road Project, a Meadowbank satellite deposit located on the Amaruq property. As an expansion to the Approved Project (Nunavut Impact Review Board (NIRB) Project Certificate No. 008 and Nunavut Water Board (NWB) Type A Water License 2AM-WTP1826) Agnico Eagle is proposing to expand and extend the Whale Tail Pit operations to include a larger Whale Tail open pit, development of the IVR open pit, and underground operations while continuing to operate and process ore at the Meadowbank Mine.

The Amaruq property is a 408 km2 site located on Inuit Owned Land approximately 150 km north of the Hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as an open pit (i.e., Whale Tail and IVR Pits), and ore will be hauled on the Whale Tail haul road to the approved infrastructure at the Meadowbank Mine for milling.

As presented in Table 1.1, there are four main phases to the development: 1 year of construction; operations will occur from Year 1 to Year 8 (2018 to 2026). Closure will occur from Year 8 (2026) to Year 33 (2051) after the completion of mining and will include removal of the non-essential site infrastructure and flooding of the mined-out open pits and underground mine as well as refilling of Whale Tail Lake (North Basin), Post-closure is expected from Year 34 (2052) forwards. Site and surrounding environment monitoring will start from the beginning of the construction and be completed during the post-closure phase when it is shown that the site and water quality meets the regulatory closure objectives. Table 1.1 summarizes the overview of the timeline and general activities.

Table 1.1 Overview of Timeline and General Activities

Phase	Year	General Activities
Construction	Year -1	• Construct site infrastructure • Develop open pit mine • Stockpile ore
Operations	Year 1 to 7	• Open pits operations • Underground operations • Transport ore to Meadowbank Mine • Stockpile ore • Discharge Tailings in Meadowbank TSF
	Year 8	• Complete transportation of ore to Meadowbank Mine • Complete discharge tailings in Meadowbank TSF
Closure	Year 8 to 33	• Remove non-essential site infrastructure • Flood mined-out open pits and underground operations • Re-establish natural Whale Tail Lake level
Post-Closure	Year 34 forwards	• Site and surrounding environment monitoring

TSF = Tailings Storage Facility

This document presents the Erosion Management Plan (the Plan). The purpose of this Plan is to provide consolidated information on the management and monitoring of potential areas subjected to erosion, by presenting first a review of the potential effects of total suspended solids (TSS) and turbidity, the Federal guidelines and the license requirements, followed by the periods and type of activities subjected to erosion, the specific monitoring and mitigating measures.

As per Nunavut Impact Review Board (NIRB) Whale Tail Project Certificate No.008 Condition 11, the Erosion Management Plan should be developed to prevent or minimize erosion and its resulting effects from project-related land disturbance.

The Plan should be submitted to the NIRB at least 30 days prior to the start of construction, with updates submitted annually thereafter or as may otherwise be required by the NIRB.

This Plan should be consulted in association with the the Whale Tail Pit - Water Quality Monitoring and Management Plan for Dike Construction Dewatering (Agnico Eagle, 2018) and the future Whale Tail Freshet Action Plan.

SECTION 2 • TOTAL SUSPENDED SOLIDS/TURBIDITY EFFECTS, FEDERAL GUIDELINES AND LICENSE REQUIREMENTS

2.1 Effects of Total Suspended Sediments on Fish Habitat

Suspended sediments, and associated effects on water clarity, have the potential to affect fish and fish habitat in a variety of ways, including but not limited to:

- Smothering of deposited eggs or siltation spawning habitats;
- Smothering of benthic invertebrate communities;
- Decreased primary productivity caused by reduced light penetration;
- Reduced visibility, which may decrease feeding efficiency and/or increase predator avoidance; and
- Clogging and abrasion of gills.

Moreover, the general findings for effects of TSS on fish and fish habitat indicate the following:

- Effects of TSS depend on both the concentration of TSS and duration of exposure;
- Effects of TSS can also be influenced by the size and shape of suspended particles;
- Lethal concentration of TSS to fish over acute exposure range from hundreds to hundreds of thousands of mg/L;
- Sublethal effects on fish (reduced growth, changes in blood chemistry, histological changes) associated with chronic exposures tend to be exhibited at TSS concentrations ranging from the tens to hundreds of mg/L;
- There is considerable uncertainty about potential effects of low TSS concentrations over long time periods;
- Overall, the most sensitive group of aquatic organisms to TSS appears to be salmonids, and guidelines are developed to protect this group;
- Adult salmonids are generally more sensitive to short duration, high concentration of suspended sediments than juvenile salmonids; and
- Low suspended sediment levels are known to cause egg mortality (40 %) to rainbow trout at long durations (7 mg/L at 48 days). Guidelines for long-term exposure reflect these findings.

More details can be found in the report from Fisheries and Oceans Canada (DFO) on the effects of sediments on fish and their habitat (Fisheries and Oceans Canada, 1999).

2.2 Federal Guidelines

2.2.1 TSS Guidelines

The Canadian Council of Ministers of the Environment (CCME) specifies separate guidelines for TSS for clear flow and high flow periods. The guidelines are derived primarily from Caux *et al*. (1997), with application intended mainly for British Columbia streams. In the case of application to the Amaruq Project lakes, the clear flow guidelines would be most relevant; even during freshet, one would not expect to see large natural fluctuations in TSS expect in localized areas for short periods.

The guidelines put forth by the CCME recognize that the severity of effects of suspended sediments is a function of both the concentration of suspended sediments and the duration of exposure. Guidelines are intended to protect the most sensitive taxonomic group and the most sensitive life history stages. Table 2.1 summarizes the available guidelines applicable to clear water (CCME) and to mine-related effluent discharges (MDMER).

Table 2.1 Existing Federal TSS Guidelines (after Agnico Eagle, 2016)

Source	Short-Term Exposure	Long-Term Exposure
CCME (1999)	Anthropogenic activities should not increase suspended sediment concentrations by more than 25 mg/L over background levels during any short-term exposure period (e.g., 24-h).	For longer term exposure (e.g., 30 days or more), average suspended sediment concentrations should not be increased by more than 5 mg/L over background levels.
MMER (2002)	Maximum authorized concentration in a composite effluent sample = 22.5 mg/L. Maximum authorized concentration in a grab sample of effluent = 30 mg/L.	Maximum authorized monthly mean effluent concentration = 15 mg/L.

The guidelines mentioned in table 2.1 are based on hundreds of studies in different environments (see Caux *et al*., 1997). Some of the studies may not be particularly relevant to the case of suspended sediment associated with dike construction and dewatering in a lake environment. Consequently, it is worth considering whether all aspects of existing guidelines are applicable for the Amaruq project. There are two particular aspects that warrant discussion.

First, in relation to short-term exposure guidelines, it is important to note that guidance is based on findings for adults and juveniles (which are more sensitive than eggs and larvae over short durations), and that the guidance is based primarily on reviews looking at application to stream environments. In a stream environment, compared to a lake environment, it is difficult for fish to swim away from suspended sediments because the high degree of mixing in the water column facilitates higher uniformity in TSS concentrations. In contrast, in lakes, in particular for sediment plumes associated with construction activities or discharges, high TSS concentrations would generally be expected to be localized, with dilution over distance. In a lake situation, adult and juvenile fish (the most sensitive life stages to short-term exposure) should readily be able to swim away from a sediment plume.

Second, in relation to long-term exposure guidelines, it is important to note that guidance is heavily influenced by findings indicating the sensitivity of eggs to low-level exposure to TSS over long durations. Consequently, the long-term exposure guidelines would be rather conservative if applied during times when eggs are not present, or in areas of a lake or stream that are not spawning habitat.

2.2.2 Turbidity Guidelines

Turbidity guidelines put forth by the CCME (1999) are based on extrapolation from the TSS guidance above, adjusted by a factor of about 3:1 (a typical average ratio for TSS: turbidity). In the case of

turbidity for clear water, CCME (1999) recommends a maximum increase of 8 Nephelometric Turbidity Units (NTU) from background levels for a short-term exposure (e.g., 24-hour period), and a maximum average increase of 2 NTU from background levels for a longer term exposure (e.g., 30-day period).

CCME (1999) notes that in some cases short-term resuspension of sediments and nutrients in the water column can augment primary productivity, and in other cases changes in light penetration may be inconsequential if a system is limited by other factors such as nutrients. The Caux *et al*. (1997) study considered effects of suspended sediment not only on fish but also on algae and zooplankton. In the end, the recommendations put forth by Caux *et al*. (1997) are based mainly on the most sensitive taxonomic group, which is salmonids.

However, research has shown that widespread, chronic turbidity can result in reduced light penetration and subsequent reductions of primary productivity (Fisheries and Oceans Canada, 1999; Canadian Council of Ministers of the Environment, 1999; Lloyd, Koenings, & Laperriere, 1987). Consequently, water clarity is of concern at broader spatial scales and longer timeframes, such as the proposed dewatering activities.

It should be noted that DFO's report on effects of sediment on fish and their habitat (DFO, 1999) endorses the guidelines for TSS put forth by the CCME (1999), but does not recommend following guidelines for turbidity. Rather, turbidity may be used as a surrogate for suspended sediment only when the relationship between the two parameters is established for a particular waterbody.

2.3 License Requirements for the Protection of Fish and Fish Habitat at Whale Tail

The Nunavut Water Board (NWB) Type A Water License for the Whale Tail Project will include the maximum monthly mean (MMM) and short term maximum (STM) TSS concentrations for the dike construction, the dewatering activities and the applicable monitoring stations during operation. These requirements will be included during the erosion monitoring and water quality sampling.

SECTION 3 • EROSION MONITORING AND MITIGATION

The purpose of the Plan is to ensure that Agnico Eagle can monitor signs of erosion and minimize its resulting effects. This plan presents the monitoring and mitigating actions related to three (3) specific periods of activity for Whale Tail Project:

- Period of construction and dewatering – during construction and operation;
- Period of freshet – during construction, operation and closure;
- Period of rise in water level in the South Basin of Whale Tail Lake – during operation.

Monitoring plan and mitigating measures are proposed below for each of these periods of activity.

3.1 Erosion during Construction and Dewatering

The construction of water management infrastructure, especially the WTD, could potentially lead to excess TSS. Dewatering could also require erosion control. A water quality monitoring program and TSS management plan is proposed in the Water Quality Monitoring and Management Plan for Dike Construction and Dewatering (Agnico Eagle, 2018) in order to minimize the effects of the construction of dewatering dikes and subsequent dewatering.

This plan provides details of water quality monitoring and management actions specifically related to the dike construction and dewatering activities. This plan includes the following components:

- Water quality monitoring and management plan for dike construction;
- Water quality and lake level monitoring and management plan for dewatering.

For those specific activities and their respective erosion monitoring and management practices, refer to the Water Quality Monitoring and Management Plan for Dike Construction and Dewatering (Agnico Eagle, 2018).

3.2 Erosion During Freshet

The freshet season at Whale Tail occurs approximately from mid-May until the end of July; however, this period of time can extend up to early fall (mid-October), when re-freezing occurs. Following the construction of the main dewatering dike (the WTD), the hydrogeological regime of the site will change during operations as water from the South Basin of Whale Tail Lake will be rerouted south until it reaches the Mammoth Lake through a newly excavated channel (the South Whale Tail Diversion Channel). Following the site construction, new areas and infrastructures will become potentially vulnerable to excess of water during the freshet season, such as, but not limited to:

- Culverts and other water management infrastructures;
- Newly constructed embankments, such as roads and berms;
- Water diversion ditches and channels.

A monitoring program and mitigating measures are proposed in the next sections.

3.2.1 Proposed Monitoring

In order to monitor the potential erosion during freshet, smaller water management infrastructures such as culverts, cross drains and ditches should be inspected on a regular basis and after significant rain events. Bigger culverts and bridges should be inspected more often if they represent a risk for daily operations, for the receiving environment or for the health and safety of workers. More specifically, the following aspects, but not limited to, should be monitored during visual inspections:

- Accumulation of debris near the inlet of the crossings, impeding the free flow of water at those locations;
- Bed erosion upstream and downstream of watercourse crossing structures;
- Scour under bridge abutments and abutment foundations;
- Erosion along cut slopes and fill slopes of embankments (rill and gully erosion), etc.

Newly excavated channels should be inspected on a regular basis and after significant rain events as well. Erosion signs along the channel flow path should be monitored. Inspections should be carried out during the spring when surficial ice moves towards the inlet of the diversion channels to ensure that no ice blockage cause water buildup upstream of the channel, which could lead to subsequent erosion problems.

The frequency of water grab samples and turbidity should follow the Type A Water License requirements and could be increased in required during the freshet season, if the TSS contents gets near or exceed the maximum allowed value as per the license.

Monitoring will be documented with site photographs and inspection forms.

3.2.2 Mitigating Measures

The following mitigation measures could be used if applicable and required to reduce risks associated with erosion:

- Riprap or clean non-acid generating/non-metal leaching rockfill could be used to armor shorelines, bridge abutments, culverts inlets and outlets and toe berms;
- Ditches managing high volumes of water could be armored for erosion control and reduce the speed of water flow;
- Sedimentation basins could be constructed at sensitive locations to allow settlement of finer sediments;
- Ditches, culverts and other water crossing structures should be maintained free of debris to allow free flow of runoff water;
- Installation of erosion control material such as turbidity barriers, silt curtains or straw booms.

Site-specific erosion issues may arise during the mine operation that require specific local corrective actions.

3.3 Erosion Due to the Rise of Water Level

The Whale Tail Dike (WTD) is an important dewatering dike that is required to enable mining of the open pit located in the north part of Whale Tail Lake. This dike is located on a shallow plateau of the

lake floor with an approximate 2 m depth of water. Once in operation, the downstream side of the dike will be dewatered and the upstream side of the dike will allow a 3.5 m raise of the water level prior to being discharged by gravity towards Mammoth Lake.

The 3.5 m rise of water level following the construction of the WTD is a potential source of erosion, specifically along the shorelines located on both shores of the Whale Tail Lake from the South Basin up until the South Whale Tail Diversion Channel.

Gradation curves obtained from samples collected at both abutments of the WTD showed that the esker located at the west shore is composed of coarser material (sand and gravel), whereas the soil near the east shore is mostly silty sand with some gravel and clay (SNC-Lavalin, 2018b). Erosion hazard varies with soil type and slope along the shorelines. These factors will be taken into account for the monitoring and mitigation presented below.

Dewatering of the Lake A53 for the construction of the IVR Attenuation pond could also be a source of erosion.

3.3.1 Proposed Monitoring

According to the water balance of the Whale Tail Lake, it is expected that the water level in South Whale Tail Lake will reach its final elevation of 156.0 m approximately two (2) years after the construction of the WTD, during the summer of 2020 (SNC-Lavalin, 2018a). Visual inspection of the shoreline stability and of the water quality on a regular basis during open water season will be required to ensure that erosion along the new banks will not mobilize excess TSS in the Whale Tail Lake, especially during the first years following construction while the water level is rising. Shorelines instability will be noted, along with signs of permafrost degradation such as ground ice melting, gully and fissuring.

The frequency of grab water samples and turbidity should follow the Type A Water License requirements and could be increased in required during the freshet season, if the TSS contents gets near or exceed the maximum allowed value as per the license.

Monitoring will be documented with site photographs and inspection forms.

3.3.2 Mitigating Measures

Because erosion of the shorelines is a rather specific problem, the installation of riprap, clean non-acid generating/non-metal leaching rockfill on the affected banks could be considered in most cases if erosion-related issues are observed. Installation of erosion control material such as turbidity barriers, silt curtains or straw booms could be done if required.

If severe erosion problems occur following the rise of the water level in the South Basin, additional site specific mitigating measures such will be developed according to the site conditions.

SECTION 4 • REFERENCES

Agnico Eagle Mines Ltd. (2018). Whale Tail Pit - Water Quality Monitoring and Management Plan for Dike Construction Dewatering.

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