# TECHNICAL MEMORANDUM

**DATE** 28 May 2019 **Project No.** 1789310-240-TM-Rev0

**TO** Michel Groleau and Jamie Quesnel
Agnico Eagle Mines Limited

**CC** Kristina Skeries, Valerie Bertrand

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**EFFLUENT PLUME MODELLING IN WHALE TAIL LAKE (SOUTH BASIN)**

## 1.0 INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) are considering an expansion to the Approved Whale Tail Pit Project (Expansion Project) in Nunavut (see Figure 1). As part of the mine development, treated effluent (from the Water Treatment Plants[1] [WTP]) and captured seepage through the Whale Tail Dike (dike seepage) are planned to be released to Whale Tail Lake (South Basin) during operations. These sources were assessed separately because the captured seepage is anticipated to be pumped to Whale Tail Lake (South Basin) prior to the WTP effluent discharge that begins in June 2021.

The treated effluent and dike seepage water quality and flow rates used in this assessment were forecast based on anticipated site conditions and water management modelled as part of the Site Wide Water Quality Predictions (Golder 2018a). This report summarizes the design of diffusers that will provide the required near-field[2] mixing of discharges in order to meet receiving water quality guidelines in Whale Tail Lake (South Basin).

## 1.1 Objectives

The key objectives for the diffuser design include the following:

- Estimate the dilution factor to meet the receiving water quality limits for specific constituents of interest;
- Design of the diffuser to meet the required dilution factor; and
- Conduct sensitivity analyses for variations in wind and receiving lake current and in discharge rates of treated effluent and dike seepage.

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[1]Water Treatment Plant or WTP in this report refers to any or all water treatment plants at site including the TSS-arsenic Water Treatment Plant (C-WTP, O-WTP) and Salt Water Treatment Plant (S-WTP)

[2] in the mixing zone proximal to the effluent discharge point



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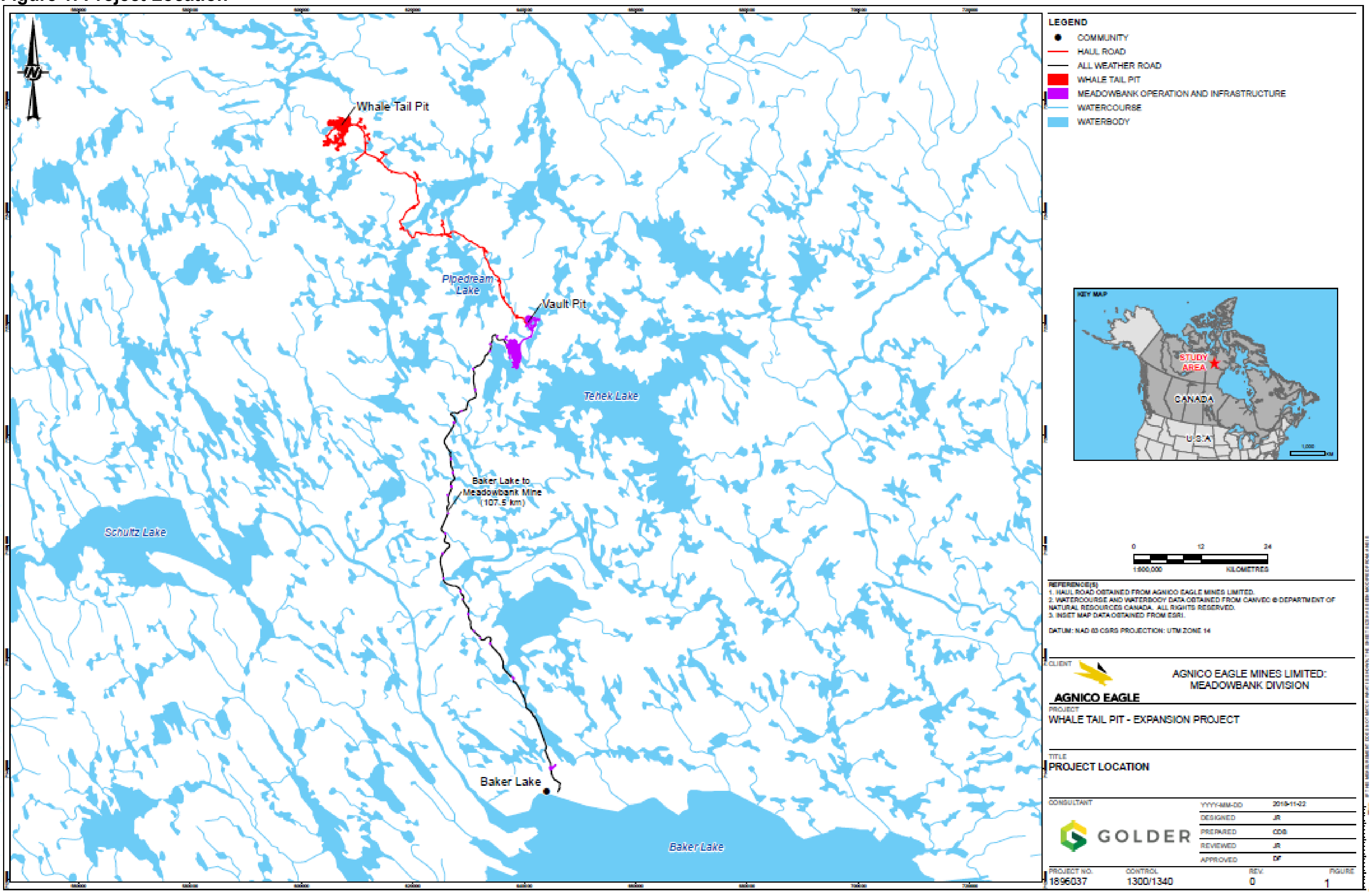
**Figure 1: Project Location**



# 2.0 DESIGN CRITERIA

## 2.1 Required Dilution

The purpose of the diffuser is to enhance mixing of the piped effluent in the Lake to meet receiving water quality objectives outside the effluent mixing zone. For the treated effluent discharge (from WTP) release, water quality predictions indicate that the highest required dilution is 16.7, which is for phosphorus (P). This dilution ratio must be achieved within the near-field mixing zone (typically 100 m). The reference to 100 m is consistent with the maximum extent (radius) of regulated mixing zone boundaries for many discharges to receiving environments in Canada (e.g., MVLWB/GNWT 2017). For dike seepage, the highest required dilution is 4.1, also for phosphorus (P). Effluent water quality, receiving water quality guidelines and the calculated dilution required to meet the CEQG are provided in Tables A1 and A2 of Appendix A.

## 2.2 Lake Ambient Conditions

It is understood that Agnico Eagle requires year-round discharge of treated effluent and dike seepage. Ambient conditions in Whale Tail Lake (South Basin) are expected to vary over an annual cycle. For example, during winter conditions, Whale Tail Lake (South Basin) is covered by ice whereby the volume of free water is reduced by the ice volume. The lack of wind-driven circulation due to these ice-covered conditions reduces the potential for mixing or in-lake assimilation. Under open water conditions, there is a greater potential for flow-through and wind-driven circulation and the potential for assimilation or mixing of treated effluent discharges is greater than discharge under ice-cover conditions. Both ice-covered and open water conditions were considered for design of diffusers in Whale Tail Lake (South Basin). The ambient conditions in Whale Tail Lake (South Basin) that affect the discharge and mixing of effluents include: bathymetry (water depth), water temperature, the density difference between the effluent and the receiving water in the Lake (measured as total dissolved solids or TDS concentration) and wind driven currents (see Section 5).

# 3.0 METHODOLOGY

The Cornell Mixing Zone Expert System (CORMIX) model (U.S. Environmental Protection Agency 1996), recognized by US EPA for mixing zone analysis, was used to conduct the assessment of effluent discharge and mixing processes and to quantify the dilution and mixing characteristics in the vicinity of the discharge. General hydrodynamic conditions of wind driven currents in Whale Tail Lake (South Basin) were also considered in this near-field region (NFR) dispersion modelling. The NFR is defined as the region where the dispersion of the effluent plume is dominated by discharge momentum and buoyancy forces.

The model requires inputs in the following three areas:

1) Ambient (Lake) condition: water depth at diffuser, temperature, TDS concentration, current speed, and current direction;

2) Effluent data: flow rate, temperature and TDS concentration; and

3) Diffuser design data: diffuser port height, port orientation angle, port diameter, number of ports and port spacing.

# 4.0 EFFLUENT CHARACTERIZATION

The flow rate range and TDS concentration were taken from the site wide water balance model (Golder 2018b), and the discharge temperatures were assumed to be identical to ambient lake water temperatures. Table 2 summarizes the model input data for treated effluent from the WTP and dike seepage water.

**Table 2: Effluent Discharge Data**

| Open Water – Treated Effluent WTP | | | | Ice Covered – Treated Effluent WTP | | | | All year – Seepage Water | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow | | TDS | | Flow | | TDS | | Flow | | TDS | |
| Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| $m^3/h$ | | mg/L | | $m^3/h$ | | mg/L | | $m^3/h$ | | mg/L | |
| 1239* | 214 | 284 | 83 | 146 | 2.5 | 68 | 7 | 15.2 | 15 | 62 | 32 |

Note*:

- Two operation WTPs have the capacity to discharge up to 1600 $m^3/h$ (800 $m^3/h$ each)
- Modelling was conducted for the maximum flow rate of one diffuser at 800 $m^3/h$

It is understood that during the open water season each of the two units of the WTP can discharge up to 800 $m^3/h$ of treated effluent through a dedicated pipeline into Whale Tail Lake (South Basin). The diffuser concept design was developed assuming a discharge line from each unit of the WTP, each equipped with a diffuser on the end of the pipeline. The maximum total discharge flow rate from the WTP during open water season was predicted to be 1239 $m^3/h$, while the maximum discharge from the WTP in winter was predicted to be 146 $m^3/h$ (Golder 2018b). The dike seepage was predicted to be relatively constant year-round, at a maximum flow rate of 15.2 $m^3/h$. A separate diffuser concept was developed to incorporate both the winter flows from the WTP and the dike seepage to efficiently mix the effluent.

# 5.0 AMBIENT CONDITIONS

## 5.1 Lake Bathymetry and Water Depth at Diffuser Location

The bathymetry of the lake is shown in Figure 2. Water levels during the operations phase were considered for the depth calculations. The water elevation in Whale Tail Lake (South Basin) will be increased during operations to 156.1 m. The associated water depth is 9.1 m for the section of Whale Tail Lake (South Basin) south of the Dike Centreline (light and dark blue areas). In winter, it is assumed that at least 2 m ice thickness is covering the lake.

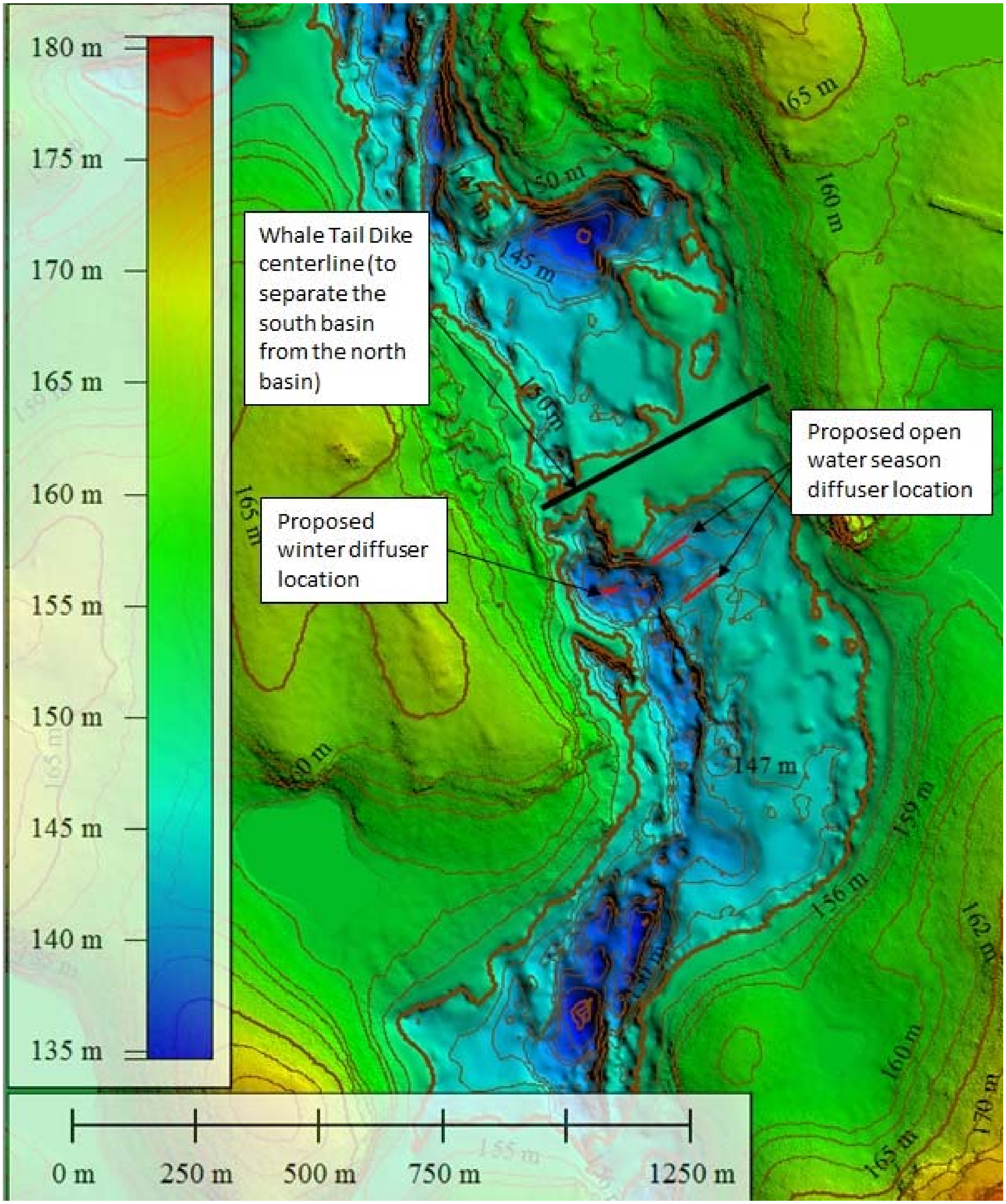



**Figure 2: Whale Tail Lake (South Basin) Bathymetry**

## 5.2 Water Temperature

Daily lake water temperatures were simulated using the Expansion Project water balance (Golder 2018b). The data were used to calculate the average monthly temperatures in June to September. The calculated monthly water temperatures are 2°C, 8°C, 10°C, and 6°C for June, July, August, and September, respectively. These data were assumed to remain unchanged over the period of mine operations. In winter, water temperature of 0°C was assumed (winter water temperatures vary from 0 to 4°C with the chosen value considered to be a conservative assumption).

## 5.3 Lake TDS Concentration

The lake TDS concentration was assumed to be 17 mg/L based on site monitoring data from 2014 to 2016. For near-field modelling purposes it was assumed that the lake TDS remain unchanged during the active discharge period.

## 5.4 Lake Current

There is no lake current data for Whale Tail Lake (South Basin). The main phenomena governing lake currents is wind with the average lake current typically in the range of 1 to 3% of average wind speed (Heaps and Jones, 1987). An average value of 2% of wind speed was used to estimate the lake current speed based on the estimated wind speed. The hourly wind speed data were obtained for Baker Lake A Station (2300500) which has coordinates of Latitude of 64°17’56” and Longitude of 96°04’44”, and elevation of 19 m. The station is 126 km to the south-east of the project site. It has 64 years of hourly wind data from 1953 to 2018, and the recent 20 years (1998 to 2017) of data were obtained for analysis. The estimated current speeds in each month are provided in Table 1. This table tabulates the current speeds along the lake axis (north to south) as these have the longest fetch. However, calm conditions occur up to 13% of the time and need to be considered in design of a diffuser at this site. The simulations were conducted using the conservative assumption that the lake conditions were calm (lower ambient current leads to lower dilution).

**Table 1: Lake Current Speed in Each Month (from North)**

| Month | June | July | August | September |
|---|---|---|---|---|
| Probability of calm (%) | 10 | 13 | 6 | 4 |
| Probability of calm more than 6 consecutive hours (%) | 4 | 5 | 2 | 1 |
| Probability of north wind (%) [1] | 30 | 28 | 27 | 24 |
| **% of chance to be exceeded** | **Current speed (m/s)** | | | |
| 1 | 0.28 | 0.26 | 0.27 | 0.27 |
| 50 | 0.12 | 0.11 | 0.11 | 0.11 |
| 95 | 0.022 | 0.022 | 0.033 | 0.033 |
| 99 | 0.006 | 0.006 | 0.006 | 0.011 |

Note 1: wind rose has eight directions, each direction covers a range of 45°. The wind from north covers angles of -22.5° to 22.5°.

# 6.0 DIFFUSER CONCEPTUAL DESIGN

As discussed in Section 4, two diffuser design concepts were developed as follows:

1) A diffuser that would provide mixing for treated effluent from the WTP for the open water season (flow rates of 214 to 800 $m^3$/h) from each pipe. Two diffusers of this type would be required, one for each WTP unit.

2) A diffuser that would provide mixing for year-round discharge of dike seepage and combined winter treated effluent from the WTP (17.5 to 161.2 $m^3$/h). The second diffuser would be smaller than the first, to accommodate lower discharges.

The location of the diffusers needs to be as close to the north edge of the Whale Tail Lake (South Basin) as possible to minimize the pipeline lengths. The target area just south of the Whale Tail dike (see Figure 2) has a depth of approximately 9 m below the operating Whale Tail Lake (South Basin) water level of 156.1 m.

The diffuser conceptual design includes the selection of diffuser port height, port orientation angle, port diameter, number of ports and port spacing.

Part of the overall design approach was to minimize the number of diffusers. Since the winter flows from the WTP and seepage flows were both relatively small these were combined into one diffuser. They could be separated but another diffuser would be required. A separate diffuser could be added for the Dike seepage discharge.

## 6.1 Diffuser Port Height

The diffuser port height or extension into the water column above the diffuser pipeline needs to be sufficiently high to minimize the potential for lake bed erosion during effluent discharge, but short enough to maximize the water depth above the port for mixing. At least 7.3 m depth is required and at the target location for the diffusers (closest to the discharge location), the water depth is about 9 m, providing 8 m of vertical water column for mixing during open water season and up to 7 m during the winter discharge scenario (assuming 2 m maximum ice thickness).

## 6.2 Diffuser Port Orientation Angle

The diffuser ports are designed to be vertical to account for variable directions of lake currents (due to winds).

## 6.3 Diffuser Port Diameter

For a single vertical port, the plume cross section sectional average dilution factor is proportional to the relative distance from the port (Rajaratnam 1976):

$$\bar{S} = \frac{Q}{Q_0} = 0.326\, x/d \qquad (1)$$

where $\bar{S}$ is plume cross sectional average dilution factor, x is distance from port, d is port diameter, $Q_0$ is port discharge, Q is discharge at x. This equation is utilized to obtain an initial estimate of port size, with final details determined using CORMIX modelling results.

For a vertical port, the maximum distance from the port is the water depth. For the initial diffuser design, providing an average dilution of 16.7 when the plume reaches the water surface (i.e., $\bar{S}$ = 16.7 at x = 8.0 m during open water), requires a port diameter of at most 0.156 m. However, the diffuser port diameter needs to also account for the variation in flow rates, balancing the head loss with dilution performance. Typically, lower exit velocities provide lower mixing potential due to a reduction in momentum. The initial port diameter for the low flow of 214 $m^3$/h targeted a low velocity of 3 m/s for the low flow (about 0.062 m), which provides an exit velocity of about 11 m/s under high flow conditions (11 m/s). This results in a much smaller diameter port to provide adequate mixing during lower flows. A standard pipe with inside diameter is 62 mm (2.44”). This initial port diameter was utilized in CORMIX modelling simulations to confirm mixing potential and dilution provided.

## 6.4 Number of Ports

The number of ports depends on port discharge. For this project, the port velocity is selected to be less than 11 m/s to balance both dilution performance and head loss. Two diffusers were assessed:

1) During the open water season, treated effluent from the WTP discharge ranges from 214 $m^3/h$ to 800 $m^3/h$ from each diffuser. The cross-sectional area of the selected port is 0.00302 $m^2$. The calculated number of ports is 7 which results in port velocity of 2.9 m/s to 10.9 m/s for the range of diffuser discharges.

2) In winter the total discharge from treated effluent from the WTP and seepage water ranges from 17.5 $m^3/h$ to 161 $m^3/h$. The cross-sectional area of the selected port is 0. 00302 $m^2$. The calculated number of ports is 3 which results in a maximum port velocity of 5.1 m/s and minimum velocity of 0.5 m/s (at the lowest flow) for the range of discharge rates considered. At this low velocity adequate dilution is provided for the combined seepage and winter WTP discharge.

## 6.5 Port Spacing

When the port size, port angle and number of ports are selected, plume dilution depends on port spacing; dilution factor increases with port spacing. The minimum spacing must be determined by analyzing the results of the CORMIX model simulations such that the design criteria are met over the range of discharge conditions.

## 6.6 Modelling Results for Open Water Season

Open water season (June to September) treated effluent from the WTP discharge modelling was conducted for the range of discharges and TDS concentrations. The modelling results are provided in Table 3. The results can be summarized as follows:

- The treated effluent from the WTP is consistently heavier than the ambient Whale Tail Lake (South Basin) conditions and behaves as a negatively buoyant plume when discharged from the diffuser. The plume exits the ports vertically towards the lake surface under the influence of plume momentum. The plume is affected by lake currents with stronger currents elongating the plume away from the diffuser and provided increased mixing.
- A number of diffuser arrangements were tested, with only the modelling results for the final arrangement provided for clarity.
- The model results show that a dilution of 16.7 is provided by the proposed diffuser design within as short as 14 m from the diffuser during low discharges and as much as 52 m distance from the diffuser during higher discharges. The results could reduce the distance between diffusers but since the regulatory NFR is usually 100 m, we recommend 100 m separation between diffusers.
- Simulations were conducted using very low ambient lake currents. Dilution is expected to be higher during high wind/current events.
- A variety of port spacings were assessed; the port spacing of 14 m is required to achieve the required dilution.

- Following sensitivity analysis, at least 7.3 m water depth is required to achieve the required dilution during the open water season.

A schematic of the proposed diffuser for the treated effluent from the WTP discharge during open water season is provided in Figure 3.

**Table 3: CORMIX Simulations for Open Water Season – Treated Effluent from the WTP**

| Scenarios | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | June | | July | | August | | September | |
| Effluent TDS (mg/L) | 120 | 83 | 262 | 225 | 284 | 244 | 168 | 139 |
| Effluent Density (kg/m³) | 1000.06 | 1000.04 | 1000.08 | 1000.06 | 999.95 | 999.92 | 1000.10 | 1000.08 |
| Ambient Density (kg/m³) | 999.98 | 999.98 | 999.89 | 999.89 | 999.74 | 999.74 | 999.98 | 999.98 |
| Distance (m) from diffuser to meet required dilution of 16.7 for Effluent discharge of 800 m³/h | **48** | **52** | **35** | **37** | **35** | **37** | **42** | **44** |
| Distance (m) from diffuser to meet required dilution of 16.7 for Effluent discharge of 214 m³/h | **18** | **20** | **14** | **15** | **14** | **14** | **16** | **17** |

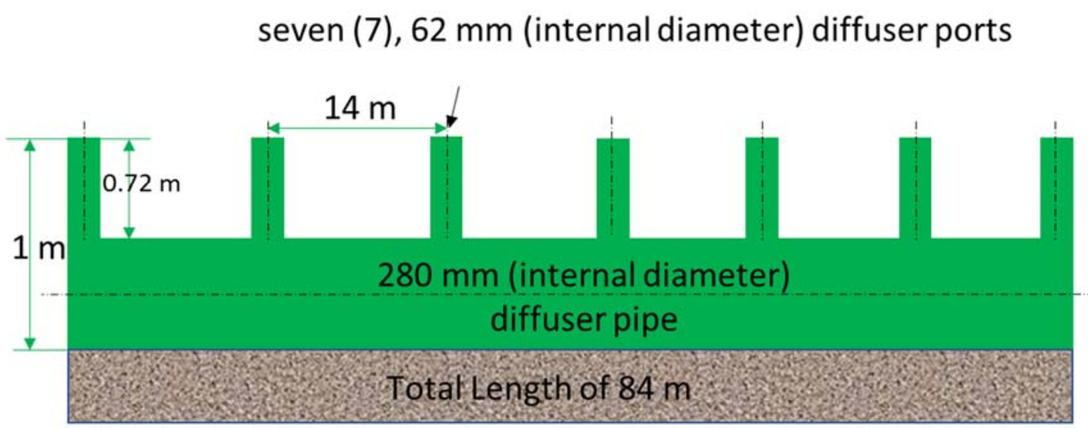



**Figure 3: Conceptual Design of Diffuser for Treated Effluent Discharge from the WTP in Open Water Season (not to scale)**

Open water season (June to September) seepage water discharge modelling was conducted for the range of effluent discharge rates and effluent TDS concentrations. A smaller diffuser is proposed for the dike seepage discharge due to the much lower flow rate. The modelling results are provided in Table 4. The results can be summarized as follows:

- The dike seepage discharge has a similar density to the ambient Whale Tail Lake (South Basin) conditions and behaves as a neutrally buoyant plume. The plume exits the port vertically towards the lake surface under the influence of plume momentum. The plume is affected by lake currents with stronger currents elongating the plume away from the diffuser and provided increased mixing.
- A number of diffuser arrangements were tested, with only the modelling results for the final arrangement provided for clarity.
- The model results show that a minimum dilution of 4.1 is provided by the proposed diffuser design within as short as 1 m from the diffuser.
- A variety of port spacings were assessed with the final port spacing required to achieve the required dilution of 14 m.
- Following sensitivity analysis, at least 7.3 m water depth is required to achieve the required dilution during the open water season.

A schematic of the proposed diffuser for the seepage water discharge during open water season is provided in Figure 4. The concept was to utilize the same diffuser configuration for discharge of seepage during open water season and for the winter season (see Section 6.7).

**Table 4: CORMIX Simulation Results for Open Water Season – Dike Seepage Water**

| Scenarios | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | June | | July | | August | | September | |
| Depth (m) | 9 | | | | | | | |
| Effluent Discharge (m³/h) | 15 | | | | | | | |
| Effluent TDS (mg/L) | 62 | 32 | 62 | 32 | 62 | 32 | 62 | 32 |
| Effluent Density (kg/m³) | 1000.01 | 999.99 | 999.93 | 999.90 | 999.78 | 999.75 | 1000.02 | 999.99 |
| Ambient Density (kg/m³) | 999.98 | 999.98 | 999.89 | 999.89 | 999.74 | 999.74 | 999.98 | 999.98 |
| Dilution Factor Required | **4.1** | | | | | | | |
| Distance from diffuser meeting dilution (m) | **1** | | | | | | | |

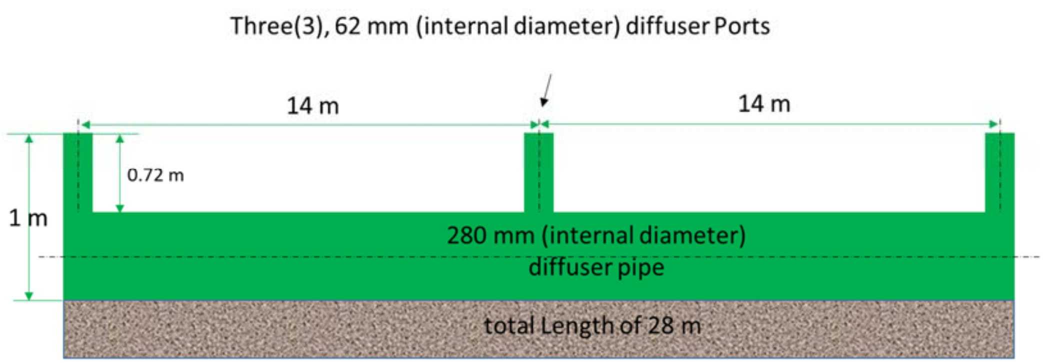



**Figure 4: Conceptual Design of Diffuser for Year-Round Discharge of Dike Seepage (not to scale)**

## 6.7 Modelling Results for Winter

As previously noted, the 3-port diffuser would provide mixing for year round seepage water and combined winter treated effluent from the WTP and seepage water flows (17.5 to 161.2 $m^3$/h). Open water season (June to September) seepage water discharge modelling for the 3-port diffuser is presented in Section 6.6. Discharge modelling for the combined winter treated effluent from the WTP and dike seepage was conducted for the range of discharges flow rates and TDS concentrations over the winter period. The modelling results are provided in Table 5. The results can be summarized as follows:

- The combined discharge has a similar density to the ambient Whale Tail Lake (South Basin) conditions and behaves as a neutrally buoyant plume. The plume exits the port vertically towards the bottom of ice under the influence of plume momentum.
- The model results show that a minimum dilution of 16.7 is provided by the proposed diffuser design within 86 m from the diffuser (86 m mixing zone).
- A variety of port spacings were assessed; a port spacing of 14 m is deemed necessary to achieve the required dilution.
- Following sensitivity analysis, at least 4.0 m depth under ice (6 m total depth assuming 2 m thick ice) is required to achieve the required dilution during winter.

A schematic of the proposed diffuser for the combined dike seepage and winter WTP discharge is provided in Figure 4.

**Table 5: CORMIX Simulation Results for Winter – WTP and Seepage**

| Scenarios | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Depth (m) | 4 | | | |
| Effluent Discharge (m³/h) | 161 | 161 | 17.5 | 17.5 |
| Effluent TDS (mg/L) | 67.4 | 9.4 | 62.9 | 28.4 |
| Effluent Density (kg/m³) | 999.92 | 999.88 | 999.92 | 999.89 |
| Ambient Density (kg/m³) | 999.88 | 999.88 | 999.88 | 999.88 |
| Dilution Factor Required | **16.7** | | | |
| Distance from diffuser meeting dilution (m) | **86** | **29** | **7** | **12** |

## 7.0 INSTALLATION

It is understood that Agnico Eagle's preference is to utilize 3-inch diameter pipe (I.D.) for fabrication of the diffuser ports. This will provide similar dilution performance as long as a steel reducer is welded onto the end of each port to reduce the port diameter to 62 mm (I.D.).

## 8.0 SUMMARY

The following can be concluded from this study:

- Required Dilution in the near-field mixing zone: For WTP treated effluent discharge, the highest required dilution is 16.7, which is for phosphorus (P). The required dilution for dike seepage is 4.1, also for phosphorus (P).
- Three diffusers are proposed to be placed in Whale Tail Lake (South Basin) to provide the required dilution for the treated effluent from the WTP and seepage water discharges as follows:
  - Two parallel 7-port diffusers for discharging treated effluent from the WTP during the open water season. The diffusers should be located at least 7.3 m below the water surface and be separated by at least 100 m. Each diffuser should be 84 m long and have seven vertical ports with a port height of 1 m above the lake bed, port diameter of 0.061m, and the port spacing of 14 m. For the modelled combinations of predicted temperature, effluent TDS concentration, effluent discharge rate, and calm conditions, the simulations indicated that the required dilution criteria of 16.7 can be achieved within a distance of than 52 m from the diffuser.
  - A third diffuser is proposed for year-round dike seepage discharge and winter (ice covered) discharge of treated effluent from the WTP. This diffuser has 3 ports and a length of 28 m. The required dilution of 4.1 for seepage water in open water season can be achieved in less than 1 m from the diffuser port. However, the required dilution of 16.7 during the ice-covered scenario requires a distance of 86 m to meet dilution criteria. The minimum water depth is 7.3 m and needs to be 100 m away from the other diffusers. Since the summer and winter diffusers are not operated at the same time the distance between diffusers could be reduced. However, since the regulatory NFR is usually 100 m, this separation distance is recommended.
  - A separate diffuser could be added for the dike seepage discharge.

## 9.0 CLOSURE

This memorandum is prepared and reviewed by the undersigned.

**Golder Associates Ltd.**

Parnian Hosseini, PhD
*Warer Resources EIT*

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*Principal, Senior Water Resources Engineer*

REGISTERED PROFESSIONAL ENGINEER
K. B. DEAN
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28 May 2019

Attachments: Appendix A - Dilution Requirements

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Signature
Date 28 MAY 2019
PERMIT NUMBER: P 049
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## REFERENCES

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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project.

**APPENDIX A**

# Dilution Requirements

**Table A1: Required dilution for different parameters - WTP**

| | Water Treatment Plant (WTP) | | | | Required Dilution | |
|---|---|---|---|---|---|---|
| Parameter | Amaruq Effluent Quality Criteria | CEQG aquatic life (mg/L) | Maximum Predicted Effluent Concentration[1] | Ambient Concentration | Amaruq Effluent Quality Criteria | CEQG aquatic life (mg/L) |
| TDS | - | - | 781 | 17.78 | **0.55** | |
| Acidity | - | - | 76 | | | |
| Alkalinity | - | - | 90 | 4.5 | | |
| SO4 | - | - | 68 | 1.4 | | |
| Ca | - | - | 238 | 2.1 | | |
| Cl | - | 120 | 448 | 2.6 | | **3.8** |
| F | - | 0.12 | 0.45 | 0.026 | | **4.5** |
| Hg | - | 0.000026 | 0.000051 | 0.000005 | | **2.2** |
| Ag | - | 0.0001 | 0.0002 | 0.00001 | | **2.1** |
| Al | 0.5 | 0.1 | 0.1 | 0.0053 | **0.19** | **1.0** |
| As | 0.1 | 0.025 | 0.1 | 0.00015 | **1.0** | **4.0** |
| Ba | - | - | 0.079 | 0.0041 | | |
| Be | - | - | 0.00011 | 0.00002 | | |
| B | - | 1.5 | 0.61 | 0.01 | | **0.4** |
| Bi | - | - | 0.0012 | 0.00005 | | |
| Cd | 0.002 | 0.00004 | 0.000077 | 0.000005 | **0.036** | **2.1** |
| Co | - | - | 0.0043 | 0.0001 | | |
| Cr | 0.02 | 0.001 | 0.0072 | 0.0001 | **0.35** | **7.8** |
| Cu | 0.1 | 0.002 | 0.014 | 0.00048 | **0.13** | **8.7** |
| Fe | 1 | 0.3 | 0.3 | 0.015 | **0.29** | **1.0** |
| K | - | - | 17 | 0.4 | | |
| Li | - | - | 0.011 | 0.001 | | |
| Mg | - | - | 13 | 0.72 | | |
| Mn | - | - | 0.61 | 0.0015 | | |
| Mo | - | 0.073 | 0.012 | 0.00005 | | **0.17** |
| Ni | 0.25 | 0.038 | 0.05 | 0.00063 | **0.2** | **1.3** |
| P | 0.3 | 0.01 | 0.13 | 0.0021 | **0.44** | **16.7** |
| Pb | 0.05 | 0.001 | 0.0023 | 0.000054 | **0.045** | **2.4** |
| Sb | - | - | 0.011 | 0.0001 | | |
| Se | - | 0.001 | 0.0029 | 0.00005 | | **3.0** |
| Sr | - | - | 0.27 | 0.014 | | |
| Sn | - | - | 0.00049 | 0.0001 | | |
| Tl | - | 0.0008 | 0.000074 | 0.00001 | | **0.082** |
| U | - | 0.015 | 0.004 | 0.000031 | | **0.26** |
| V | - | - | 0.0066 | 0.0005 | | |
| Zn | 0.1 | 0.03 | 0.015 | 0.0011 | **0.14** | **0.47** |
| NO3 | - | 2.93 | 10 | 0.001 | | **3.4** |
| Na | - | - | 39 | 0.55 | | |
| NH3 | 16 | - | 2.4 | 0.0061 | **0.15** | |

[1] Golder 2018a

**Table 2A: Required dilution for different parameters - seepage**

| | Seepage | | | | Required Dilution | |
|---|---|---|---|---|---|---|
| Parameter | Amaruq Effluent Quality Criteria | CEQG aquatic life (mg/L) | Maximum Predicted Seepage Concentration[1] | Ambient Concentration | Amaruq Effluent Quality Criteria | CEQG aquatic life (mg/L) |
| TDS | 1400 | - | 93 | 17.78 | **0.05** | |
| Acidity | - | - | 2 | | | |
| Alkalinity | - | - | 20 | 4.5 | | |
| SO4 | - | - | 9 | 1.4 | | |
| Ca | - | - | 13 | 2.1 | | |
| Cl | - | 120 | 42 | 2.6 | | **0.3** |
| F | - | 0.12 | 0.08 | 0.026 | | **0.6** |
| Hg | - | 0.000026 | 0.000011 | 0.000005 | | **0.3** |
| Ag | - | 0.0001 | 0.00003 | 0.00001 | | **0.2** |
| Al | 0.5 | 0.1 | 0.01 | 0.0053 | **0.01** | **0.0** |
| As | 0.1 | 0.025 | 0.03 | 0.00015 | **0.3** | **1.1** |
| Ba | - | - | 0.023 | 0.0041 | | |
| Be | - | - | 0.00004 | 0.00002 | | |
| B | - | 1.5 | 0.08 | 0.01 | | **0.05** |
| Bi | - | - | 0.0001 | 0.00005 | | |
| Cd | 0.002 | 0.00004 | 0.000023 | 0.000005 | **0.009** | **0.5** |
| Co | - | - | 0.0007 | 0.0001 | | |
| Cr | 0.02 | 0.001 | 0.0007 | 0.0001 | **0.03** | **0.7** |
| Cu | 0.1 | 0.002 | 0.002 | 0.00048 | **0.01** | **0.8** |
| Fe | 1 | 0.3 | 0.05 | 0.015 | **0.03** | **0.1** |
| K | - | - | 2 | 0.4 | | |
| Li | - | - | 0.004 | 0.001 | | |
| Mg | - | - | 5 | 0.72 | | |
| Mn | - | - | 0.13 | 0.0015 | | |
| Mo | - | 0.073 | 0.004 | 0.00005 | | **0.06** |
| Ni | 0.25 | 0.038 | 0.009 | 0.00063 | **0.03** | **0.2** |
| P | 0.3 | 0.01 | 0.03 | 0.0021 | **0.11** | **4.08** |
| Pb | 0.05 | 0.001 | 0.0003 | 0.000054 | **0.005** | **0.3** |
| Sb | - | - | 0.001 | 0.0001 | | |
| Se | - | 0.001 | 0.0004 | 0.00005 | | **0.4** |
| Sr | - | - | 0.11 | 0.014 | | |
| Sn | - | - | 0.00016 | 0.0001 | | |
| Tl | - | 0.0008 | 0.000019 | 0.00001 | | **0.011** |
| U | - | 0.015 | 0.0012 | 0.000031 | | **0.08** |
| V | - | - | 0.0012 | 0.0005 | | |
| Zn | 0.1 | 0.03 | 0.003 | 0.0011 | **0.02** | **0.07** |
| NO3 | - | 2.93 | 3 | 0.001 | | **1.1** |
| Na | - | - | 9 | 0.55 | | |
| NH3 | 16 | - | 0.5 | 0.0061 | **0.03** | |

[1] Golder 2018a