TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Lisa Mah, Permitting Specialist	**Date:**	January 23, 2025
c:	Colleen Prather, Technical Advisor Permitting	**Memo No.:**	Hope Bay-2025-001
From:	Jie Liu, M.Sc., EPt., Oceanographer, Coastal and Lake Engineering Group, Vancouver Office Aurelien Hospital, M.Sc., M.Eng., Manager, Coastal and Lake Engineering Group, Vancouver Office	**File:**	704-ENG.ACLE03054-05
Subject:	Hope Bay Project: Summary of 3-D Hydrodynamic Modelling Study of Roberts Bay		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has been retained by Agnico Eagle Mines Limited (Agnico Eagle) to develop and conduct a three-dimensional (3-D) hydrodynamic modelling study of Roberts Bay to quantify effluent concentrations and dilutions at the edge of the mixing zone.

Hope Bay is a gold mining and exploration Project located on a property approximately 20-km × 80-km along the south shore of Melville Sound (called Roberts Bay) in Nunavut, Canada. It continued to be operated by TMAC Resources Inc. (TMAC). On February 2, 2021, TMAC was purchased by Agnico Eagle and became a wholly owned subsidiary of Agnico Eagle. Commercial production began in 2017 and continued until February 18, 2022, when it was announced that the mine would be placed into temporary Care and Maintenance.

Agnico Eagle is planning to restart operations, which includes refinements to the approved Doris and Madrid areas that were previously assessed in the 2017 Final Environmental Impact Statement (FEIS; TMAC 2017) and approved by the Nunavut Impact Review Board (NIRB), to further enhance the Hope Bay Mine plan. The refinements to the operations relevant to this modelling study include:

- Increased generator capacity at Doris and Madrid, to support increased mill rate of 2,400 tonnes per day (tpd) to 8,000 tpd;
- Phased transition from slurry to dry stack/filtered tailings at the Tailings Impoundment Area; and
- Installation of a second diffuser in Roberts Bay for segregation of water.

Tetra Tech Canada Inc.
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

2.0 METHODOLOGY

Roberts Bay 3-D ocean model was developed with Tetra Tech's proprietary 3-D hydrodynamic/coastal model (Stronach et al., 1993; Stronach et al., 2002; Stronach et al., 2015) embedded with the US-EPA Visual Plumes model (Frick, W.E. et al, 2004). The advantage of this modelling framework lies in the fact that it allows to assess both near- and far-field effluent discharge fate and transport over multi-years; therefore, accounting for effluent accumulation over time in Roberts Bay. In other words, it incorporates both the initial mixing and transport associated with the near-field, as well as a defensible far-field behavior in the entire bay driven by environmental conditions and ocean physical processes. Therefore, this modelling approach allows to characterize a more complete view and obtain more accurate results of the effluent transport and mixing in the ocean.

Figure 1 presents the 3-D Roberts Bay model domain and bathymetry. The bathymetry data was provided by Agnico Eagle based on bathymetry survey, and then interpolated onto the 3-D Roberts Bay model domain. The locations of the two diffusers were denoted as green (existing diffuser) and pink (proposed diffuser) dots in Figure 2.1.

A sea ice module has been developed and integrated into the 3-D hydrodynamic modeling framework. Several environmental data and forcings were employed in the 3-D Roberts Bay modelling study:

- Hourly wind and meteorological data at Doris site from 2019 to 2023, representative of the Roberts Bay meteorological conditions as provided by Agnico Eagle;
- Tidal components extracted from TOPEX/Poseidon Global Inversion Solution TPXO Tidal Model Driver (TMD) Database (Egbert and Erofeeva, 2002) to force onto the 3-D Roberts Bay model open boundaries;
- Monthly temperature and salinity profiles extracted from HYCOM Global Ocean Model forecasting system and observed measurements in Roberts Bay provided by Rescan (Rescan, 2010; Rescan 2011; Rescan 2012) to apply onto the open boundaries of the 3-D Roberts Bay model; and
- Daily river flows discharging into Roberts Bay based on measurements from ERM (ERM, 2022; ERM, 2024) – Little Roberts River (2019-2023) and Glenn River (2012-2014, 2019-2023).

The existing diffuser is located at (431,965 m E, 7,564,961 m N UTM Zone 13W) at a water depth of 17 m relative to NAD 83 projection datum. The proposed diffuser is expected to follow the same corridor as the existing outfall and is proposed to be located about 350-m northward of the existing diffuser. The coordinates for the proposed diffuser location are (431,967 m E, 7,565,315 m N UTM Zone 13W) located at a water depth of 31 m with respect to NAD 83 projection datum.

Two types of effluent are discharged through the two diffusers: the *Tailings Impoundment Area* (TIA) effluent and the *Saline Pond 1*(SP1) effluent. In this modelling study, the TIA effluent is discharged through the proposed diffuser and SP1 effluent is released from the existing diffuser to Roberts Bay. At present, this discharge configuration is considered optimal however, adjustments to the discharge strategy may be necessary based on further modeling work. Details of the diffuser configurations used in this modelling study are provided in Table 2.1.

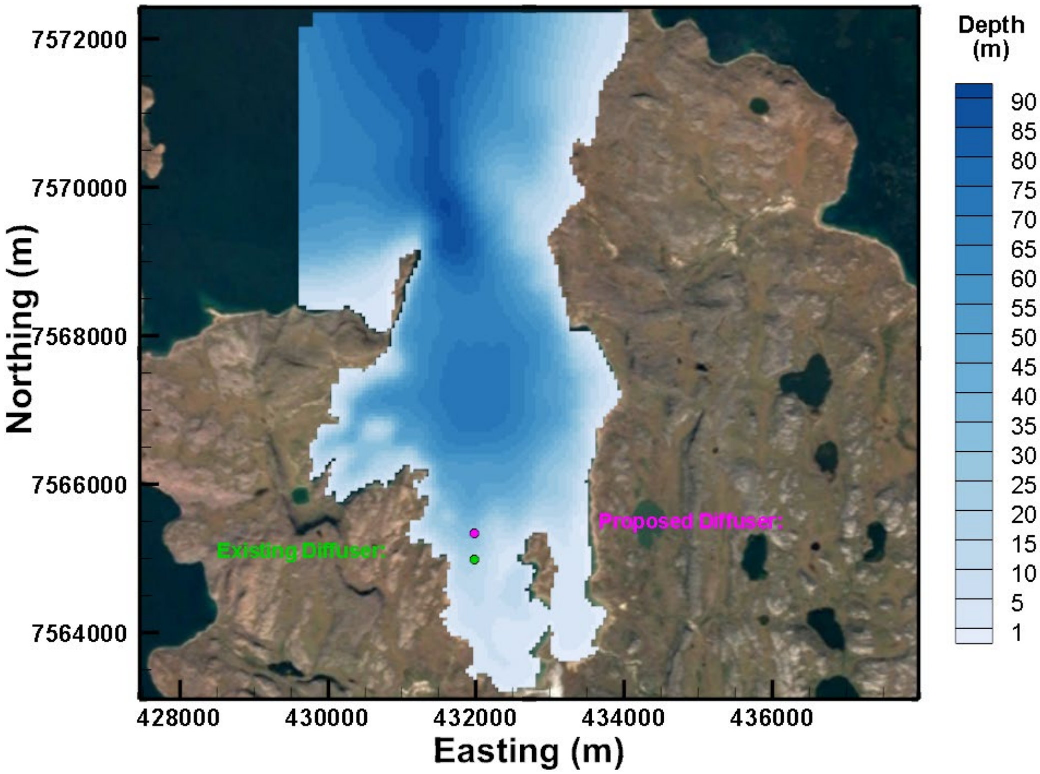

Figure 2.1: 3-D Roberts Bay Model Domain and Bathymetry. Green dot denotes existing diffuser location and pink dot denotes proposed diffuser location.

Table 2.1: Diffuser Configurations for Existing and Proposed Diffusers

Diffuser Specifications	Existing Diffuser	Proposed Diffuser
Coordinate of Location	431,965 m E, 7,564,961 m N UTM Zone 13W	431,967 m E, 7,565,315 m N UTM Zone 13W
Discharge Depth of Diffuser (m)	17.2	30.6
Number of Risers	4	2
Spacing Between Risers (m)	8.2	8.2
Number of Ports	8	4
Port Diameter (mm)	101.6	101.6
Port Height (m)	1.25	1.25
Vertical Angle of Port	0°	45°

3.0 MODEL VALIDATION

Model calibration and validation were conducted for the 3-D Roberts Bay modelling framework. A very good agreement was obtained between model results and observations in terms of i) water level, ii) sea ice formation and decay processes as well as ice thickness, iii) temperature and salinity distributions in the water column and their temporal (monthly) variations, and iv) ocean currents strengths and directions at different depths throughout different periods of the year.

4.0 HOPE BAY DISCHARGE SCENARIO DESCRIPTION

The Hope Bay effluent discharge scenario consists of a consecutive multiple-year simulation with year-round effluent discharge conditions at both diffusers (existing and proposed), starting from 2020 and finishing by end of 2041. Table 4.1 provides the summary of the different effluent discharge configurations through two diffusers. The discharge volumes and water quality parameters pertain to untreated effluent provided by SRK's model predictions (SRK, 2024). On average, the TIA effluent exhibits a slightly higher discharge rate with about 127 m^3/hr than the SP1 effluent with 100 m^3/hr. Hence, the TIA effluent was assigned to the proposed diffuser located at a deeper water depth, with a reduced number of ports to reach an optimized exit port velocity. This discharge configuration is currently assumed to be optimal however, adjustments to the discharge strategy may be necessary based on further modeling work.

Table 4.1: Hope Bay Effluent Discharge Configurations for Existing and Proposed Diffusers

	Existing Diffuser	Proposed Diffuser
Effluent Type	SP1	TIA
Effluent Discharge Period	2028 – 2041 year-round	2020 – 2041 year-round
Effluent Discharge Rate (m^3/hr)	Variable, from 78 to 124	Variable, from 0 to 396
Discharged Effluent TDS Concentration (mg/L)	Variable, from 771 to 7,626	Variable, from 60 to 7,135

To visualize, Figure 4.1 presents monthly discharged effluent volume and monthly untreated effluent TDS concentrations of TIA effluent through proposed diffuser over the entire discharge period. It is worth noting that effluent discharge rates from 2020 to 2024 do not reflect realistic past operations of discharge since no actual discharge continued after 2021. This discharge schedule is only a reflection of SRK's model prediction results. Total volume of TIA effluent expected to release over the entire discharge period is approximately 25 Mm^3.

Similarly, Figure 4.2 presents monthly discharged effluent volume and monthly untreated effluent TDS concentrations of SP1 effluent through the existing diffuser. SP1 effluent discharge occurred from year 2028 with a reduced discharge rate. Total volume of SP1 effluent expected to release over the entire discharge period is roughly 12 Mm^3.

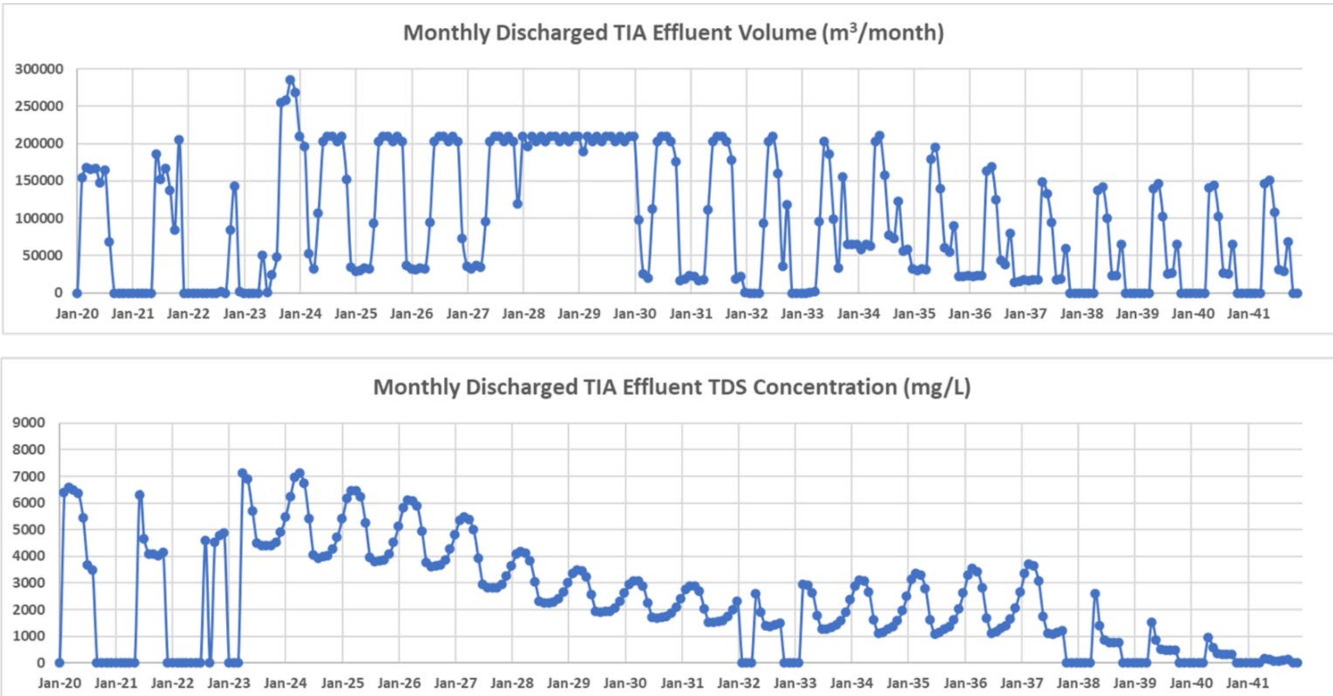

Figure 4.1: Monthly TIA Effluent Discharge Volume (Upper Panel) and Discharged TDS Concentration (Lower Panel) from Year 2020 to 2041 via the Proposed Diffuser

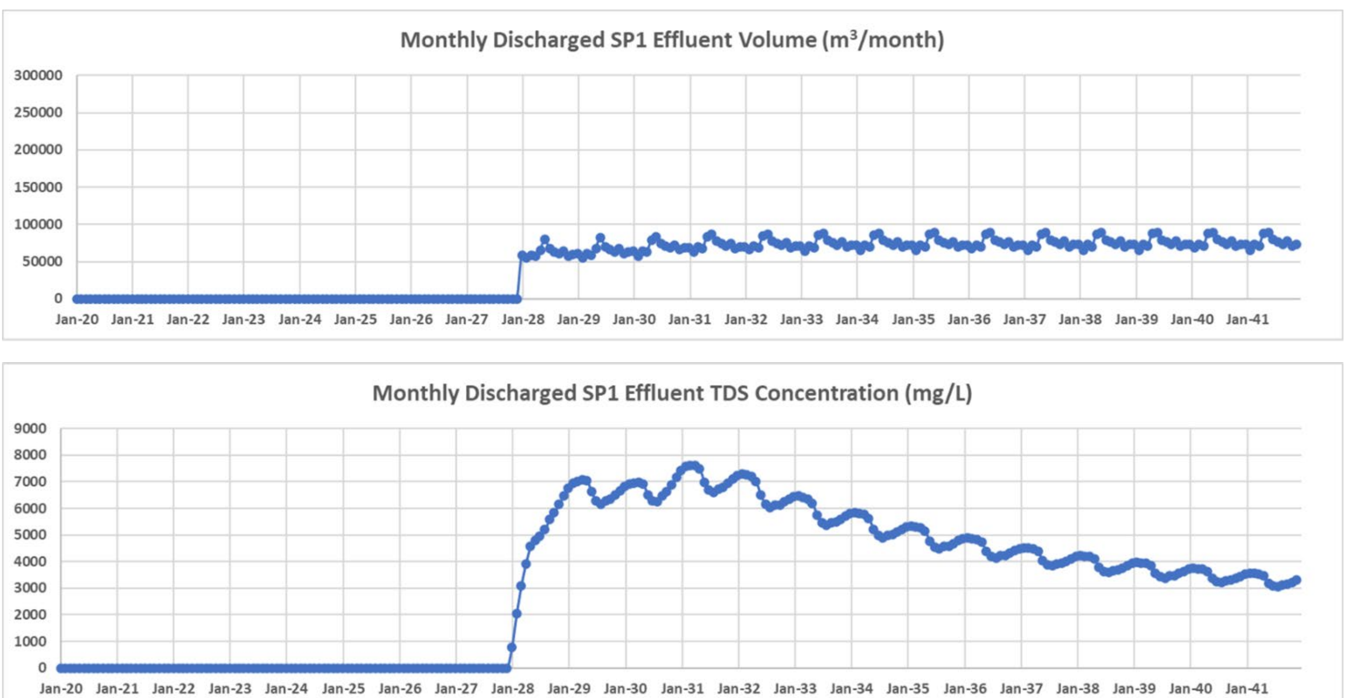

Figure 4.2: Monthly SP1 Effluent Discharge Volume (Upper Panel) and Discharged TDS Concentration (Lower Panel) from Year 2028 to 2041 via the Existing Diffuser

Table 4.1 presents monthly effluent temperature, based on empirical estimate from operations.

Table 4.1: Effluent Monthly Discharge Temperature

Month	Effluent Temperature (°C)
January	2
February	2
March	2
April	2
May	2
June	4
July	10
August	10
September	4
October	2
November	2
December	2

5.0 HOPE BAY SCENARIO MODELLING DILUTION RESULTS

Table 6.1 provides the statistics of modelled minimum and average dilution obtained at the MZB of the existing diffuser discharging SP1 effluent for each simulated year. **A conservative minimum dilution of 147:1 was reached at the MZB of the existing diffuser over the 22-year simulation**.

Table 6.1: Statistics of Minimum and Average Dilution Reached at the MZB of the Existing Diffuser with SP1 Discharge for Each Year

Simulated Year	Minimum Dilution Predicted at the MZB	Average Dilution Predicted at the MZB
2020	284:1	>10,000:1
2021	265:1	>40,000:1
2022	401:1	>200,000:1
2023	**147:1**	>100,000:1
2024	179:1	5,071:1
2025	189:1	6,084:1
2026	151:1	12,735:1
2027	262:1	5,946:1
2028	170:1	1,707:1
2029	151:1	1,266:1

Simulated Year	Minimum Dilution Predicted at the MZB	Average Dilution Predicted at the MZB
2030	155:1	1,626:1
2031	219:1	1,977:1
2032	316:1	2,190:1
2033	207:1	2169:1
2034	241:1	1,805:1
2035	280:1	1,919:1
2036	291:1	2,237:1
2037	284:1	2,736:1
2038	303:1	2,552:1
2039	282:1	2,132:1
2040	301:1	2,209:1
2041	259:1	2,562:1

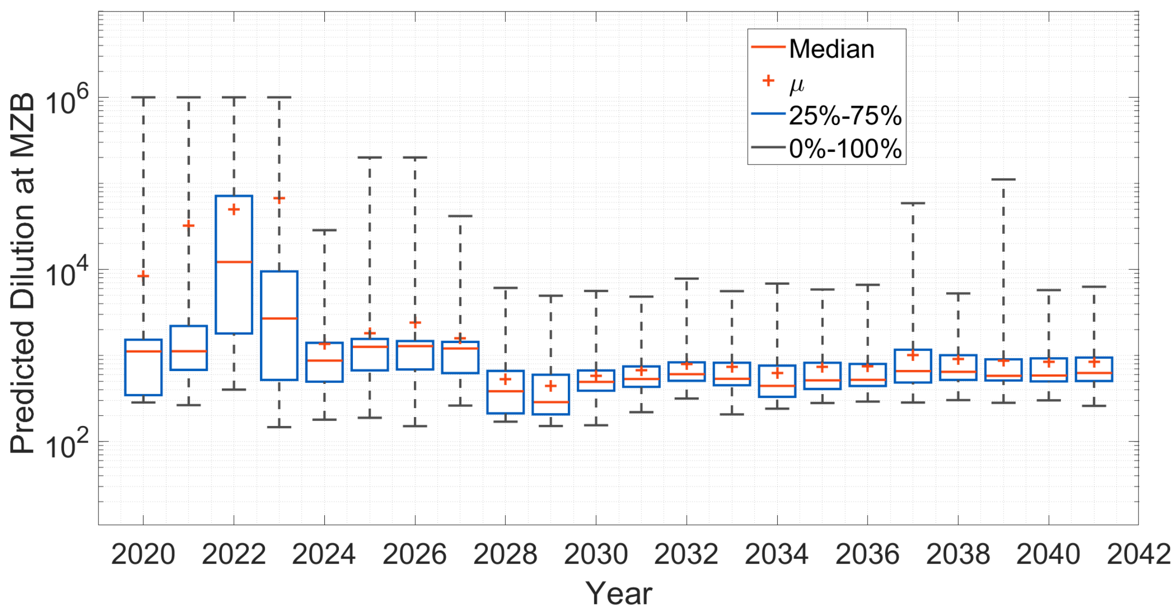

Figure 6.1: Box and Whisker Plot of Range of Minimum Dilutions Achieved at the MZB of Existing Diffuser from 2020 to 2041.

Figure 6.1 assembles the range of minimum dilutions obtained at the MZB of the existing diffuser discharging SP1 effluent in the form of box and whisker, including statistics of median, average, range of 25th-75th percentile and range of minimum and maximum of minimum dilutions of each year. A few findings were summarized below:

- From 2020 to 2027, much higher dilutions were obtained at the MZB due to the absence of SP1 effluent discharge and transport of TIA effluent carried by ocean currents; and

TETRA TECH

- From 2028 when SP1 effluent discharge kicks off, dilutions start to drop down (i.e. concentrations are increasing), reflecting a combined impact from both diffusers. Dilutions showed similar variability pattern during 2028-2041 discharge years, and the average dilution throughout each year fluctuated around a similar level at about 600:1.

Table 6.2 provides the statistics of modelled minimum and average dilution obtained at the MZB of the proposed diffuser discharging TIA effluent for each simulated year. **A conservative minimum dilution of 117:1 was reached at the MZB of the proposed diffuser over the 22-year simulation.**

Table 6.2: Statistics of Minimum and Average Dilution Reached at the MZB of the Proposed Diffuser with TIA Discharge for Each Year

Simulated Year	Minimum Dilution Predicted at the MZB	Average Dilution Predicted at the MZB
2020	237:1	>10,000:1
2021	170:1	>20,000:1
2022	280:1	>100,000:1
2023	**117:1**	>90,000:1
2024	129:1	2,976:1
2025	146:1	3,805:1
2026	128:1	3,728:1
2027	170:1	3,604:1
2028	134:1	1,483:1
2029	135:1	1,259:1
2030	137:1	2,079:1
2031	166:1	2,399:1
2032	343:1	3,273:1
2033	177:1	2,943:1
2034	242:1	2,813:1
2035	261:1	2,679:1
2036	310:1	3,177:1
2037	288:1	4,594:1
2038	316:1	4,031:1
2039	303:1	3,527:1
2040	322:1	3,573:1
2041	254:1	3,901:1

Figure 6.2 assembles the range of minimum dilutions obtained at the MZB of the proposed diffuser with TIA effluent discharge in the form of box and whisker, including statistics of median, average, range of 25th-75th percentile and range of minimum and maximum of minimum dilutions of each year. Several findings were described below:

- Much higher dilutions were predicted during year 2020-2023, due to a low volume of discharge with relatively sparse discharge frequency;
- Overall dilutions decreased in 2024 due to a significant increase in discharge volume from 0.8 Mm^3 to 1.8 Mm^3, which also resulted in a less intra-annual variability of dilution range;
- High volume of consecutive monthly discharge in 2029 considerably limited the dilutions, leading to the least dilution variability (i.e., from 135:1 to 1,615:1) compared to rest of the years; and
- Dilutions started to rise from 2030 and stabilized near 1,000:1 on average until the end of the simulation year of 2041, primarily due to the reduction of discharge volume over these years.

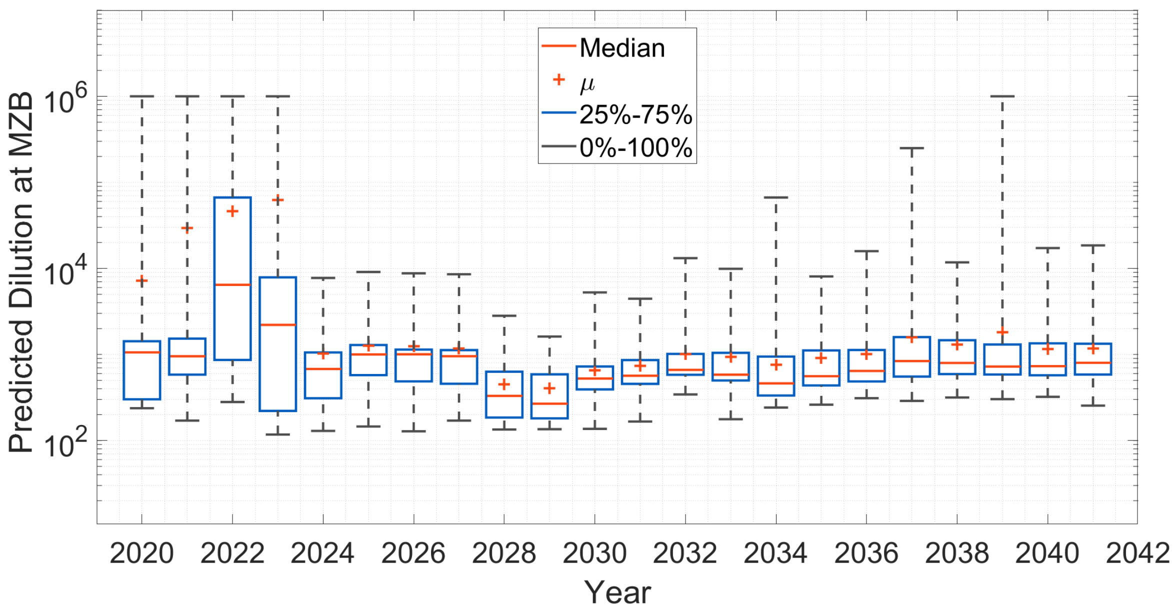

Figure 6.2: Box and Whisker Plot of Range of Minimum Dilutions Achieved at the MZB of Proposed Diffuser from 2020 to 2041.

6.0 CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL CONCERN

Through the 3-D hydrodynamic model for Roberts Bay, predictions were made regarding the dilution of effluent upon reaching the mixing zone. Additionally, a comprehensive set of constituents was forecasted and utilized as input to the Human Health and Ecological Risk Assessment (HHERA) for the Hope Bay Operational Update (WSP 2025).

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Agnico Eagle and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Agnico Eagle, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

8.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

Prepared by:
Jie Liu, M.Sc., EPt.
Oceanographer
Coastal and Lake Engineering Group
Direct Line: 604.238.3562
Jie.Liu@tetratech.com

Reviewed by:
Aurelien Hospital, M.Sc., M.Eng.
Senior Oceanographer/Manager
Coastal and Lake Engineering Group
Direct Line: 778.945.5847
Aurelien.Hopital@tetratech.com

/JL/AH

REFERENCES

Egbert, G. D., & Erofeeva, S. Y., 2002. Efficient Inverse Modeling of Barotropic Ocean Tides. Journal of Atmospheric and Oceanic Technology, 19, 183-204. https://doi.org/10.1175/1520-0426(2002)019<0183:eimobo>2.0.co;2

ERM, 2022. Hope Bay Project: 2021 Aquatic Effects Monitoring Program Report.

ERM, 2024. Hope Bay Project: 2023 Hydrology Compliance Monitoring Summary.

Frick, W.E., 2004. Visual Plumes Mixing Zone Modelling Software. Environmental Modelling & Software 19 (7-8), 645-654.

Minnow, 2024. Agnico Eagle Hope Bay Mine Phase 2 Environmental Effects Monitoring Program Study Design.

Rescan. 2010. Hope Bay Belt Project: 2009 Marine Baseline Report.

Rescan. 2011. Hope Bay Belt Project: 2010 Regional Marine Baseline Report.

Rescan. 2011. Hope Bay Project: 2010 Hydrology Baseline Report.

Rescan. 2011. Doris North Gold Mine Project: 2011 Aquatic Effects Monitoring Program (AEMP) Marine Expansion Baseline Report.

Rescan. 2012. Doris North Gold Mine Project: 2011 Roberts Bay Physical Oceanography Baseline Report.

SRK, 2024. HopeBay_SP1Results_PRELIMINARY_CAPR003305_20241112_nf.xlsx.

SRK, 2024. HopeBay_TIAResults_PRELIMINARY_CAPR003305_20241105_nf.xlsx

Stronach, J.A., J.O. Backhaus, and T.S. Murty. 1993. An update on the numerical simulation of oceanographic processes in the waters between Vancouver Island and the mainland: the GF8 model, Oceanography and Marine Biology Annual Review, 31:1-86.

Stronach, J.A., R.P. Mulligan, H. Soderholm, R. Draho, D Degen. 2002. Okanagan Lake Limnology: Helping to Improve Water Quality and Safety. Innovation, Journal of the Association of Professional Engineers and Geoscientists of B.C.

Stronach, J.A., J. Rogers, A. Hospital and A. Oveisy. 2015. A Validated 3-D Hydrodynamic Model to Simulate the Fate of Dissolved Hydrocarbons. Proceedings of the Canadian Water Resources Association - BC Conference, Richmond, BC.

TMAC Resources Inc. 2017. Madrid-Boston Project Final Environmental Impact Statement

WSP, 2025. Human Health and Ecological Risk Assessment Hope Bay Update - 2025 Mine Plan Operational Update

LIMITATIONS ON USE OF THIS DOCUMENT

HYDROTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless expressly agreed to in the Services Agreement, TETRA TECH was not retained to explore, address or consider, and has not explored, addressed or considered any environmental or regulatory issues associated with the project.

1.8 LEVEL OF RISK

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the hydrotechnical information that was reasonably acquired to facilitate completion of the design.