APPENDIX C – MELIADINE MELVIN BAY DIFFUSER CONCEPTUAL DESIGN – EFFLUENT NEAR FIELD MODELLING (TETRA TECH 2020)

TECHNICAL MEMO

ISSUED FOR USE

To:	Agnico Eagle Mines Ltd.	**Date:**	April 2, 2020
c:		**Memo No.:**	REV 03
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Subject: Meliadine Melvin Bay Diffuser Conceptual Design – Effluent Near Field Modelling

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has been retained by Agnico Eagle Mines Ltd. (Agnico Eagle) to design a new diffuser system in Melvin Bay near Rankin Inlet, Nunavut, as part of the Meliadine Mine operations. Currently, Agnico Eagles operates a diffuser system in Melvin Bay, which discharges treated effluent conveyed by truck from the Meliadine Mine to the nearshore marine environment. Annually, the existing system needs to be decommissioned and removed from the bay at the end of the discharge season, i.e., at the end of the open-water season. To respond to changes in nominal discharge flow rates and requirements for better system operability, Agnico Eagle would like to undertake a redesign of the Melvin Bay diffuser.

The new diffuser would handle nominal flows of 6000 m^3/d to 12,000 m^3/d and as an alternative up to 20,000 m^3/d. The effluent would be conveyed through a pipeline from the Meliadine Mine to a nearshore facility. Thereafter, the effluent would be pumped to the underwater diffuser via a Horizontal Directional Drilling (HDD) pipe. The discharge of the effluent through the underwater diffuser would promote mixing with ambient waters, allowing to meet the water quality criteria within the existing regulatory mixing zone.

Tetra Tech's scope of services for this work is detailed in the proposal submitted to Agnico Eagle in January 2020. This technical memo presents:

- Specification of the final design of the diffuser.
- Modelling study that assessed the fate and behaviour of the discharged effluent in the near-field. The 2D U.S. Environmental Protection Agency (EPA) Visual Plumes (VP) near-field mixing model is employed to help design the diffuser. The VP model simulates dilution of effluent discharged from multiport diffusers and predicts dilution values needed for regulatory compliance.
- Head losses of the outfall pipe and diffuser system, so that the performance of the diffuser can be evaluated with energy loss due to friction being considered. The PlumeHyd and CorHyd models are used to calculate the velocities, head losses and flow rates inside the diffuser pipe and ports.
- Deposition velocity of total suspended sediment (TSS) is calculated as well. The design of the diffuser is optimized for dilutions while achieving pipe velocity well above the TSS deposition velocity.

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2.0 DIFFUSER SYSTEM

2.1 Diffuser Location

The location of the diffuser was selected based on the following factors:

- Possibility to utilize the identified HDD corridor linking the coastal fuel storage facility to the 7 m depth Chart Datum (CD);
- Bathymetry in Melvin Bay based on Canadian Hydrographic Services (CHS) Nautical Chart 5628 "Rankin Inlet Including Melvin Bay and Prairie Bay" Chart 5628, dated 1997;
- Preliminary plume modelling simulations to determine the ideal depth of discharge;
- Estimated tidal current paths based on bathymetry contours;
- Need to enhance mixing once the non-buoyant effluent reaches the seabed;
- Avoidance of archaeological sites, and
- Avoidance of the vessel anchoring area.

Based on the above criteria, an optimal location for the diffuser was selected and is shown on Drawing 1. Drawing 1 shows the entire diffuser system, comprised of:

- The coastal fuel storage facility;
- The portion of the pipe that would be horizontally and directionally drilled to the outfall location at the seabed. This HDD section daylights at 7 m CD at location (545808E / 6963438N) and would connect through a flange with the outfall along the seabed. The battery limit for Tetra Tech starts with the portion of the pipe that is along the seabed, and
- The outfall along the seabed that terminates with a diffuser. At 20 m depth CD, the outfall connects with the diffuser system at location (545780E / 6963370N). The diffuser starts at 20 m depth CD and terminates at depth 21 m CD at the location (545771E / 6963346N).

2.2 Specification of the Diffuser System

Preliminary modelling, velocity assessment in the pipe and at the ports, as well as a sensitivity analysis on the number of ports were conducted, allowing to obtain the final diffuser configuration. The final configuration for the diffuser has the following details:

- Length of outfall from the 7 m CD contour depth down to the flange connection with the diffuser: 75 m;
- Length of diffuser: 25 m;
- Diameter of the outfall pipe and the diffuser pipe: 12'' OD DR-11, corresponding to 305 mm OD and 261 mm ID;
- Diffuser depth: starting at 20 m CD and finishing at 21 m CD (based on CHS Chart 5628 and the bathymetry survey provided by the client);

- Discharge type: multiport;
- Number of ports: 5 ports;
- Port diameter: 100 mm;
- Port spacing: 5 m;
- Port on a 1 m long vertical riser, i.e. 90º bend from diffuser; and
- Type of discharge: open port with no valve.

3.0 NEAR FIELD MODELLING

Near-field effluent mixing performance is a key element in the design of a diffuser system. Dilutions reached within the mixing zone can be simulated, allowing an assessment of effluent concentrations in comparison to water quality criteria. The Visual Plumes (VP) model was selected to conduct the modelling. The performance of the final diffuser design is evaluated with the VP model and presented in this section.

3.1 Model Selection

The Visual Plumes (VP) model is a US-EPA model simulating single and merging submerged plumes in arbitrarily stratified ambient flow and buoyant surface discharges (Frick et al., 2003). Temperature, salinity and current profiles can be input, so as the specifications of the diffuser system and the effluent being discharged. The model is very similar in capabilities to the CORMIX model. Both simulate the behaviour of the discharged effluent in the near-field.

3.2 Ambient and Effluent Conditions

3.2.1 Ambient Conditions

3.2.1.1 Ice Thickness

Ice thickness in Melvin Bay was 1.55 m to 1.92 m according to winter measurements obtained by Golder from March to May 2019 (Golder, 2019b). The maximum ice thickness of 1.92 m was measured on May 19, 2019. For this assessment, the water depth available for effluent mixing was reduced by 1.92 m during ice season. Since the system would operate during the ice-free season, this reduction in depth would represent a conservative factor.

3.2.1.2 Tidal Elevation

Based on predictions of tides at the Rankin Inlet station from Fisheries and Oceans Canada (DFO), water level changes due to tides in 2020 can reach about 4.5 m (http://tides.gc.ca/eng/data/table/2020/wlev_sec/5100). This value is further confirmed by Agnico Eagle: tidal variations in the Melvin Bay is estimated to be about 4 m in the summer, and about 1.5 m in the winter (email communication with Agnico Eagle, January 2020).

This significant change in water depth is not negligible considering the shallow water depths in Melvin Bay. The area of interest, i.e. diffuser location, is in about 20 m CD depth. The water depth varies between 20 m and 24.5 m, depending on the stage and strength of the tide. In other words, the change in water level represents 20% of the water depth, and is thereby important. Hence, considering the system's depth at 20 m CD represents the shallowest depth for potential mixing once the effluent is discharged.

3.2.1.3 Wind and Currents

Winds can generate surface currents, which can then likely enhance effluent mixing with the ambient waters. Open access to numerical forecasts of the currents in Rankin Inlet is limited. The 3D hydrodynamic model HYCOM, operated by the NOAA, provides real-time forecast and hindcast of three-dimensional depiction of the global ocean state at a reasonable spatial resolution of 1/12º, i.e. 4 km to 9 km resolution (https://ncss.hycom.org/thredds/ncss/grid/GLBu0.08_930_MRC/GLBu0.08_930_MRC_best.ncd/dataset.html). While this resolution is adequate in open-ocean, such resolution is too coarse to properly represent the coastal areas of Rankin Inlet and Melvin Bay. Nonetheless, in the absence of other information and for sensitivity analysis purpose, analysis of HYCOM currents were conducted and showed that the maximum current speed is about 0.07 m/s on the cell closest to the Rankin Inlet location, while the maximum current in the waters slightly south of Rankin Inlet reaches about 0.22 m/s. Moreover, the nautical chart of Rankin Inlet (CHS 5628) indicates a 0.25 m/s tidal current in the navigation channel connecting Melvin Bay and Hudson Bay.

Accordingly, information sources indicate that there is a potential for currents to vary between very weak currents and currents up to and potentially over 0.25 m/s. To evaluate the combined effects of wind-driven and tidal currents, a range of currents are evaluated in the near-field modelling study: 0, 0.05, 0.25 and 0.4 m/s. An Acoustic Doppler Current Profile (ADCP) survey (i.e. a characterization of ocean currents with an instrument) combined with a three-dimensional hydrodynamic modelling can confirm the adequacy of these values, and determine the most representative current value.

3.2.1.4 Ambient Water Temperature, Salinity and Density

Water temperature and salinity contribute to water density, and hence influence the behaviour of the discharged effluent.

According to the survey data report of Golder (2018a), the measured mean seawater temperature was about 5.8 °C and was almost uniform throughout the entire water column near the current operational diffuser impact location in Melvin Bay in September 2018. The maximum sea water temperature observed was 8.5 °C from the same survey in Melvin Bay, while salinity was around 30.8 PSU for most survey depths and areas.

Golder (2019b) reports that seawater temperature was about -1.9 °C under-ice during the March, April and May 2019 surveys. To account for the start and end of open water season for discharge, ambient water temperature of 0 °C is used in the VP model simulations, while -1.9 °C is also used to represent near-freezing seawater condition. The Golder (2019b) survey does not report salinity values. HYCOM simulations (described in Section 3.2.1.3) show that the salinity is above 32 PSU in Melvin Bay and its adjacent waters during winter months.

This modelling study uses a salinity of 33 PSU as the representative value of saline seawater in winter (i.e., start and end of open water season for discharge). Sensitivity analysis of density, which is dependent on temperature and salinity, will show that the choice of PSU in the range of 31 to 33 PSU would have minimal effect on the dilution performance of the diffuser (Appendix B).

The ambient water density is calculated based on temperature and salinity values. A summary of the summer and winter ambient water conditions is given in Table 1.

Table 1. Ambient Water Conditions

Temperature (°C)		Salinity (PSU)	Density (kg/m³)
Summer	5.8	30.8	1024.26
	8.5	30.8	1023.91
Winter	-1.9	33.0	1026.56
	0.0	33.0	1026.49

3.2.1.5 Chloride Concentration

Golder (2019a) reported that the chloride concentration was 15,900 mg/L in ambient waters. This chloride concentration value has been used to calculate the target dilution factor in the VP model study (see Section 3.3).

3.2.2 Effluent Conditions

The effluent consists of raw groundwater, which will be treated, combined with surface contact water from the mine's operations.

3.2.2.1 Effluent Temperature, TDS (Total Dissolved Solids) Concentration and Density

Golder (2018b) used an effluent temperature of 20 °C in their temperature sensitivity analysis, which is regarded as the highest possible effluent temperature through their communication with Agnico Eagle in November 2018. To ensure all potential effluent temperatures are assessed, a range of effluent temperatures was tested in the VP modelling study: 5, 10 and 20 °C for summer, and 0 and 2 °C for winter conditions.

Golder (2019a) reported:

- A maximum ambient TDS concentration in Melvin Bay of 36,000 mg/L from the most recent available observation (Golder, 2019b);
- An untreated groundwater TDS concentration of 58,200 mg/L, which is the 95% upper confidence level of the mean from the August 2016 to September 2017 diamond drillhole groundwater data provided by Agnico Eagle, and
- A treated effluent TDS concentration of 39,600 mg/L, which is obtained from the assumption that treatment of the groundwater will achieve a TDS concentration within +/- 10% of the maximum ambient TDS concentration 36,000 mg/L (in line with the BC MOE 2017 guidelines).

The above temperatures and TDS concentrations have been used to calculate the effluent densities in this study. A summary of the effluent conditions is provided in Table 2.

Table 2. Effluent Conditions

Temperature (°C)		TDS Concentration (mg/L)	Density (kg/m³)
Summer	5	39,600	1031.85
	10		1031.69
	20		1031.35
Winter	0		1030.58
	2		1028.30

3.2.2.2 Effluent Chloride Concentration

Golder (2019a) stated that chloride concentration was 33,300 mg/L in the untreated groundwater.

While chloride concentration in the treated effluent is bound to be lower than in the untreated groundwater, in order to provide an upper-bound concentration, the same chloride concentration as found in the untreated groundwater was conservatively assumed for the treated effluent. This value and the ambient chloride concentration from Section 3.2.1.5 have been used to obtain the target dilution factor in Section 3.3.

3.3 Dilution Requirements

Effluent discharge should meet various regulations and guidelines, such as the end of pipe discharge criteria stated in the Metal and Diamond Mining Effluent Regulations (MDMER, Government of Canada, 2018) and the criteria at the edge of a regulatory mixing zone specified by the Canadian Environmental Quality Guidelines — Water Quality Guidelines for the Protection of Aquatic Life (CEQG, CCME, 2003).

The dilution requirements are the followings:

- As in Golder (2019a), the fluctuation of chloride concentration in ambient water after effluent discharge is used as a criterion to obtain the target plume dilution factor. The change in natural chloride concentration due to an effluent discharge should not exceed more than 10% at the edge of the regulatory mixing zone. Since ambient concentration is 15,900 mg/L, an increase of 10% results in a maximum chloride concentration at the edge of the mixing zone of 17,490 mg/L. Since the treated effluent chloride concentration is assumed to have an upper-bound value of 33,300 mg/L (Section 3.2.2.2), a dilution of 11:1 is required to meet this criterion of 17,490 mg/L at the edge of the mixing zone.
- All other effluent constituents would require a dilution lower than 11:1 to reach CCME guideline values.

In conclusion, the dilution factor 11:1 within the regulatory mixing zone is used as the target dilution factor in this modeling study.

3.4 Model Configuration

The VP model requires diffuser design parameters, effluent discharge rate, and ambient water and effluent conditions as inputs. These inputs are discussed in this section, respectively.

3.4.1 Diffuser Design Parameters

The parameters of the final design of the diffuser is provided in Table 3. These parameters are used as input for the VP model simulations.

Table 3. Diffuser Specifications

Parameter	Value
Length of Diffuser	25 m
Depth of Diffuser	20 m and 21 m at the upstream and downstream end
Direction of Diffuser	Perpendicular to bathymetric contour
Vertical Angle of Discharge	90°
Discharge Type	Multiport
Number of Ports	5
Spacing Between Ports	5 m
Port Height Above Seabed	1 m
Outfall Pipe Diameter (ID)	0.261 m
Diameter of Ports	0.102 m

3.4.2 Discharge Configuration

Three constant effluent flow rates have been simulated: 6,000 m^3/d, 12,000 m^3/d and 20,000 m^3/d. The typical discharge for the proposed system will vary between 6,000 m^3/d and 12,000 m^3/d, with a potential increase up to 20,000 m^3/d. Flow speed in outfall pipe and port exit speed are listed in Table 4. Exit velocity is assumed to be the same for all 5 ports in this calculation. The higher exit velocity with the 20,000 m^3/d flow rate is 5.67 m/s, which is getting close to the recommended maximum velocity for a high-density polyethylene (HDPE) system.

Table 4. Outfall and Exit Speeds of the Diffuser at Different Flow Rates

Flow Rate (m^3/d)	Outfall Pipe Diameter (m)	Port Diameter (m)	Speed in Outfall Pipe (m/s)	Exit Speed at Port (m/s)
6,000	0.261	0.102	1.30	1.70
12,000			2.60	3.40
20,000			4.33	5.67

3.4.3 Ambient and Effluent Conditions

Typical summer and winter conditions are investigated first. The typical summer condition corresponds to the scenario, where ambient temperature is 5.8 °C and effluent temperature is assumed to be 10 °C, while the typical winter condition corresponds to the scenario, where ambient temperature is 0 °C and effluent temperature is 2 °C (Tables 1 and 2). Treated effluent under the influence of various ambient currents is studied.

As the effluent mixing behavior is influenced by density difference between ambient water and effluent, sensitivity analysis of this density difference is also conducted. Different combinations of ambient water and effluent conditions listed in Tables 1 and 2 give different density difference values. The scenarios that have the biggest and smallest density differences for summer and winter conditions are simulated respectively.

The water depth of the diffuser is 20 m. The first set of VP runs included tides and indicated that the plume rose as high as 11 m, which is well below the water surface when tidal elevation is considered. Hence the tidal variations do not impact the mixing. Ambient current is a key element in effluent mixing and a range of current is investigated: 0, 0.05, 0.25 and 0.4 m/s. Section 3.2.1.3 describes ocean current conditions. The ambient and effluent condition of all studied scenarios are summarized in Table 5.

Table 5. Typical Summer and Winter Ambient and Effluent Conditions for Modelling Scenarios

Scenario (1)	Ambient Condition			Effluent Condition		
	Current Speed (m/s) (2)	Temperature (°C)	Density (kg/m^3)	Effluent Flow (m^3/s)	Temperature (°C)	Density (kg/m^3)
S01	0	5.8	1024.26	6,000	10.0	1030.58
S02	0.05					
S03	0.25					
S04	0.40					
S05	0	5.8	1024.26	12,000	10.0	1030.58
S06	0.05					
S07	0.25					
S08	0.40					
S09	0	5.8	1024.26	20,000	10.0	1030.58
S10	0.05					
S11	0.25					
S12	0.40					
W01	0	0.0	1,026.49	6,000	2.0	1031.69
W02	0.05					
W03	0.25					
W04	0.40					
W05	0	0.0	1,026.49	12,000	2.0	1031.69
W06	0.05					
W07	0.25					
W08	0.40					
W09	0	0.0	1,026.49	20,000	2.0	1031.69
W10	0.05					
W11	0.25					
W12	0.40					

(1) Scenarios labelled with 'S' are the ones with typical summer conditions, and those with 'W' are with typical winter conditions.
(2) VP model cannot handle current speed of 0 m/s, so 0.00001 m/s current was actually used to study scenarios under no current influence

3.5 Modelling Results

The effluent is discharged through a 1 m riser at a vertical angle of 90°, i.e. facing upward. As the effluent is negatively buoyant, the mixing is dominated by the exit velocity at the ports (plume momentum) and ambient current/density profiles. In general, the discharged plume first rises as it exits the port and then descends to the seabed, since denser than the ambient seawater density. The VP model predicts the plume elevation from the seabed and dilution factor as a distance from the source.

An example of the elevation of the plume and dilutions reached in the ocean environment is presented in Figure 1. The three panels show the same scenario, ambient current of 0.4 m/s, but with different effluent release rate:

- Top panel shows the 6,000 m^3/d W04 Scenario;
- Middle panel shows the 12,000 m^3/d W08 Scenario; and
- Bottom panel shows the 20,000 m^3/d W12 Scenario.

The plume elevation (left panels) shows the depth on the y-axis and the horizontal plume path on the x-axis. It shows that the plume exits the ports, carries upward based on its momentum, and at the same time is deflected by ambient currents, and eventually starts sinking since non-buoyant before hitting the bottom. The dilution factor (right panels) shows dilution vs distance from diffuser. The graph indicates that dilutions increase as the plume is being advected away from its source as expected.

For the top panel (Scenario W04 – 6,000 m^3/d), the plume reaches seabed after about 40 m. Since the dilutions reported by VP after reaching seabed were indicated by the US-EPA to be not reliable, the dilutions achieved when reaching seabed are reported as final result, i.e. 183:1. In the middle (Scenario W08 – 12,000 m^3/d) and bottom panels (Scenario W12 – 20,000 m^3/d), the momentum of the plume results in reaching the bottom further away compared to the top panel (Scenario W04 – 6,000 m^3/d). For the middle panel (Scenario W08 – 12,000 m^3/d), the plume reaches seabed after about 67 m. Dilutions achieved when reaching seabed are 284:1. For the bottom panel (Scenario W12 – 20,000 m^3/d), the plume reaches seabed after about 98 m. Dilutions achieved when reaching seabed are 347:1.

To illustrate the different effluent dilution processes, another example during summer is presented in Figure 2, which correspond to Scenario S07 (flow of 12,000 m^3/d). In this scenario, the seabed is reached after about 34 m and dilutions of 211:1 are reached. A detailed schematic plain view of the plume dilution for Scenario W11 (effluent flow of 20,000 m^3/s and ambient current of 0.25 m/s) is provided in Figure 3.

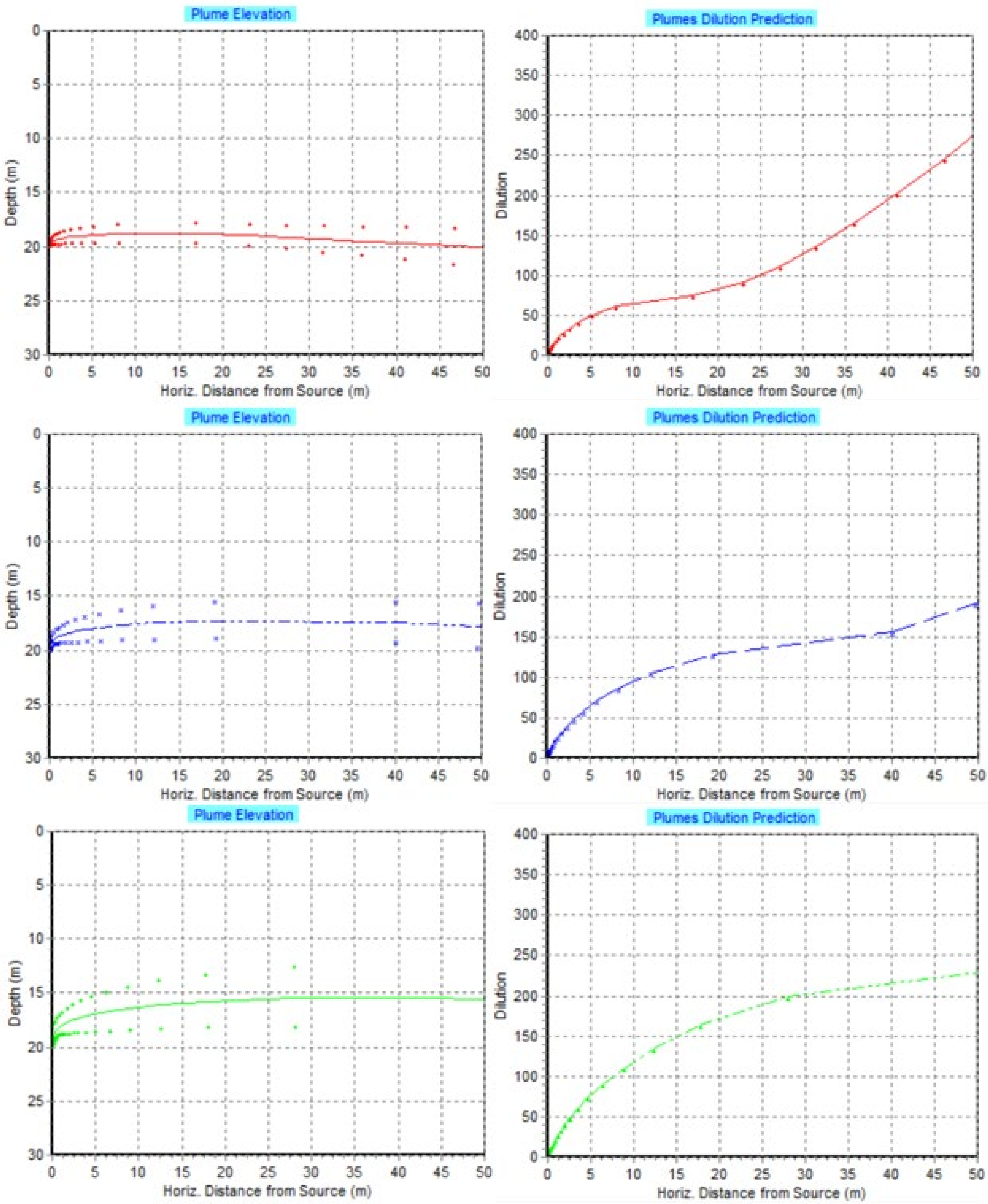

Figure 1. Plume Elevation and Dilution Prediction from the VP Model for Scenario W04 – 6,000 m³/s (top panel), Scenario W08 – 12,000 m³/s (middle panel) and Scenario W12 – 20,000 m³/s (bottom panel)

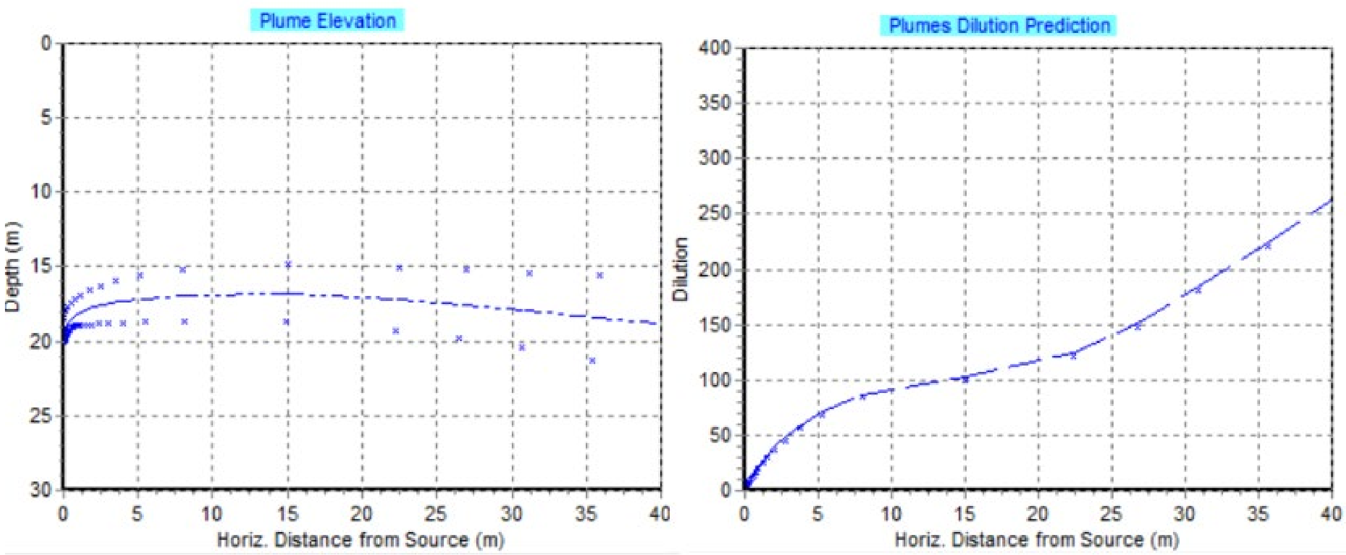

Figure 2. Plume Elevation and Dilution Prediction from the VP model for Scenario S06 (effluent flow of 12,000 m^3/s, ambient current of 0.25 m/s)

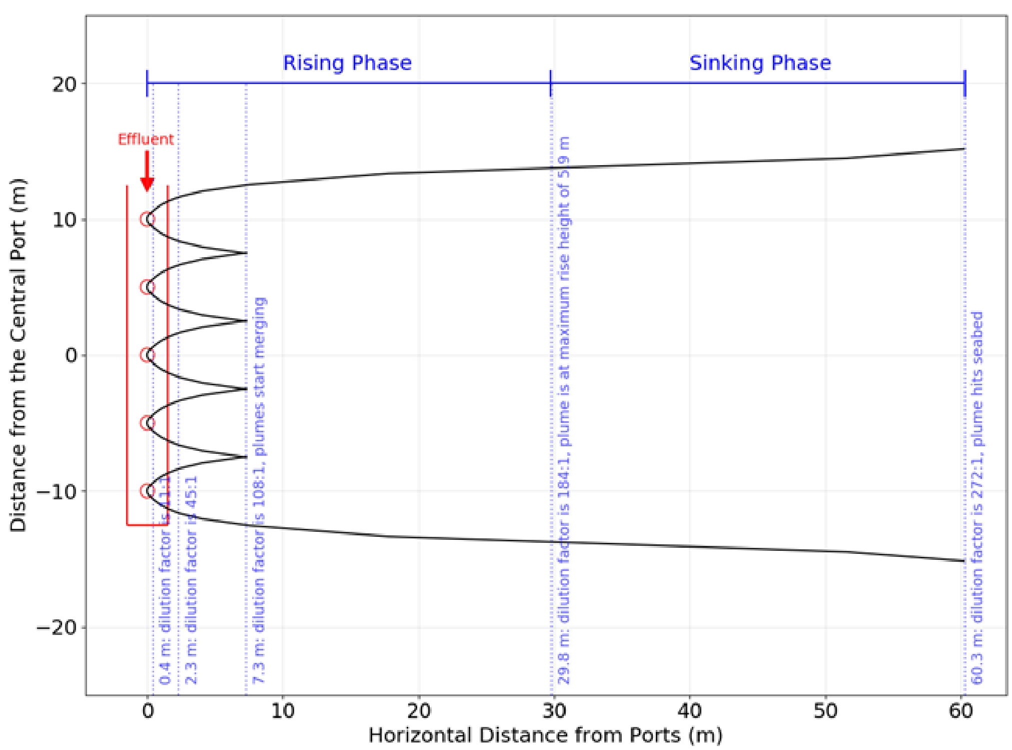

Figure 3. Schematic Plot of the Plume Dilution Process for scenario W11 (effluent flow of 20,000 m^3/s and ambient current of 0.25 m/s). Note that the diffuser pipe and ports are not to scale.

The VP model results of all scenarios are shown in Table 6.

Table 6. Visual Plumes Simulation Results of Typical Summer and Winter Conditions

Scenario	Effluent Flow (m^3/s)	Dilution Factor S (1)	Horizontal Distance to Dilution Factor S (m) (2)	Centerline Maximum Height (m) (3)	Distance to Required Dilution Factor of 11 (m) (4)	Note (5)
S01	6,000	18:1	0.7	3.1	0.8	Bottom hit
S02		55:1	3.9	2.9	0.4	Bottom hit
S03		134:1	19.4	1.5	0.5	Bottom hit
S04		165:1	31.9	1.2	0.4	Bottom hit
S05	12,000	27:1	1.8	6.3	0.6	Bottom hit
S06		93:1	7.6	6.0	0.2	Bottom hit
S07		211:1	34.2	3.3	0.4	Bottom hit
S08		256:1	55.1	2.6	0.4	Bottom hit
S09	20,000	39:1	3.3	10.8	0.3	Maximum rise
S10		109:1	11.8	10.3	0.1	Bottom hit
S11		250:1	50.0	5.6	0.3	Bottom hit
S12		318:1	81.1	4.5	0.4	Bottom hit
W01	6,000	13:1	1.1	3.4	0.7	Bottom hit
W02		65:1	4.8	3.2	0.3	Bottom hit
W03		149:1	23.5	1.6	0.4	Bottom hit
W04		183:1	38.5	1.3	0.4	Bottom hit
W05	12,000	27:1	2.9	7.3	0.6	Maximum rise
W06		100:1	9.1	6.6	0.2	Bottom hit
W07		234:1	41.6	3.5	0.4	Bottom hit
W08		284:1	66.5	2.8	0.4	Bottom hit
W09	20,000	65:1	3.0	10.8	0.6	Bottom hit
W10		118:1	14.2	11.2	0.1	Bottom hit
W11		272:1	60.3	5.9	0.4	Bottom hit
W12		347:1	97.9	4.8	0.4	Bottom hit

(1) The dilution factor and the corresponding horizontal distance for dilution are values when plume reaches maximum height or hits the seabed.
(2) The horizontal distances to reach dilution factor S for the 0 m/s ambient currents cases are the radius of the plumes; otherwise, it is the horizontal distance of the centerline of the plume from the source.
(3) Centerline maximum height is the height above seabed.
(4) Distance required to obtain a dilution of 11:1 corresponds to the horizontal distance between the centerline of the plume and the port.
(5) The VP model reports valid dilution values until the plume reaches maximum height or hits the bottom.

Sensitivity analysis of density difference between ambient water and effluent was conducted and is presented in Appendix B. For each scenario occurring during winter and summer, two additional simulations were conducted, in which the ambient ocean temperature and the effluent temperature slightly varied. These sensitivity analysis scenarios presented in Appendix B are named W01 and W01b for example. The main conclusions of the VP simulations of the typical summer and winter conditions and the sensitivity analysis are:

i. Effluent flow rates of 6,000 m^3/d and 12,000 m^3/d were assessed. A potential maximum discharge of 20,000 m^3/d was also assessed.

ii. The effluent can be effectively diluted to reach the target dilution factor of 11:1 within a horizontal distance of 1 m under all tested conditions.

iii. For effluent flow of 6,000 m^3/d, the greatest height that the plumes can reach, i.e. shallowest water depth, is 3.4 m (Scenario W01 with no ambient current). For effluent flow of 12,000 m^3/d, it is 7.3 m (Scenario W05 with no ambient current). For the potential maximum release case, an effluent flow of 20,000 m^3/d, the greatest height that the plumes can reach is 12.1 m (Scenario W5b with no ambient current presented in

Appendix B). These heights are still well below the water surface even when maximum ice thickness (1.92 m) is present.

iv. Plumes from higher discharge rate can rise to a greater height from the ports, i.e. shallower water depth, than those from lower discharge rate as expected, since a higher discharge rate leads to greater exit velocities from the port (Table 4), hence more momentum.

v. The sensitivity tests (Appendix B) also show that the plumes rise to a higher level when the density difference between ambient and effluent is smaller: this situation occurs when the ambient water are denser than normal conditions, but also especially when the effluent is lighter. Similarly, the plumes don't experience much rising when the density difference between ambient and effluent is large: since the plume is non-buoyant, its rising phase following discharge is limited and quickly followed by its sinking phase towards seabed.

vi. The sensitivity tests show that the horizontal distance required to achieve the target dilution factor almost remains the same. Also, the mixing performance (based on dilution factor when plumes reach the bottom) is better when the density difference between effluent and ocean water is small, and the plume can reach further away from the diffuser before sinking and hitting the seabed.

vii. Though tidal elevations can increase the effective water depth, and associated mixing, they do not affect the VP simulation results, since the diffuser system is at 20 m below CD and the maximum plume height is 12.1 m, hence reaching a depth of 7.9 m below CD. That being said, tide conditions certainly help flushing of the effluent in the long term.

viii. Similarly, the plume is not expected to interact with the ice formation, as the plume cannot reach the bottom of the ice layer. The maximum plume height above the system (located in 20 m of water) is about 12 m. Depending on tidal periods, the effective depth of diffuser varies between 20 m and 25 m. It means that the minimum vertical distance between the plume and the bottom of the ice layer varies between 6 m and 11 m even when the maximum observed ice thickness (1.92 m) is considered.

ix. It should be noted though that a strong temperature difference between effluent and ocean temperature can lead to local changes in temperatures, and potentially alter ice formation right above the discharge that way. To minimize the impact of effluent discharge on the ice cap, best practices include cooling the effluent to a temperature that is close to the observed seawater temperature under-ice (-1.9 °C) before discharge and/or discharging the effluent at selected intervals based on tidal periods so that the effluent can be effectively flushed by ebb and flood tides.

4.0 HEAD LOSS

Energy dissipates as effluent goes through the outfall pipe, diffuser pipe and risers due to friction. This section examines the extent of energy dissipation or head loss through the diffuser system. Different methods (from literatures to software) are used to calculate the head loss in the outfall and diffuser sections.

4.1 Diffuser Head Loss

Three methods were used to calculate the head loss in the diffuser system.

i. PlumeHyd is an internal diffuser hydraulics model developed by the US-EPA. It calculates velocities, head losses and flow rates inside the diffuser pipe and ports.

ii. CorHyd is a module of CORMIX and, similar to PlumeHyd, calculates the losses through the ports and the diffuser pipe.

iii. Tetra Tech's in-house spreadsheet is used to cross-check the results obtained from the two models above.

The scenarios in Table 6 are grouped into 4 cases based on these two key factors: effluent discharge rate and density difference between ambient water and effluent. PlumeHyd, CorHyd and Tetra Tech spreadsheet calculate head loss and velocities in the diffuser pipe and risers for each case. The discharge rate, which drives velocities in the pipe, represents the main parameter for head loss. The results are summarized in Table 7.

Table 7. Head Loss in Diffuser System

Flow (m^3/d)	Diffuser Head Loss (m)			
	PlumeHyd	CorHyd	Tetra Tech	Average
6,000	0.30	0.28	0.26	0.28
12,000	1.18	1.05	1.02	1.08
20,000	3.25	2.89	2.83	2.97

4.2 Outfall Pipe Head Loss

The outfall section starts at 7 m depth CD, where the pipe daylights out of the HDD section onto the seabed. From the 7 m CD depth down to the beginning of the diffuser section at 20 m depth CD, the outfall length is 75.25 m.

It appears that the effluent concentrations that are being considered (10 to 30 mg/L TSS) do not influence the result. The head-loss is dependent on the flow rate, and hence the pipeline velocity.

Table 8. Head Loss in Outfall Pipe

Flow (m^3/d)	Outfall Head Loss (m)			
	Method 1	Method 2	Method 3	Average
6,000	0.46	0.46	0.46	0.46
12,000	1.70	1.66	1.68	1.68
20,000	4.49	4.27	4.43	4.40

Method 1: Streeter and Wylie (1979)
Method 2: Hazen-Williams equation as detailed in Streeter and Wylie (1979)
Method 3: Haaland (1983) equation detailed in Finnemore and Franzini (2002)

4.3 Total Head Loss

The total head loss for the system located on seabed (from the 7m CD depth down to the end of the diffuser) is the following:

Table 9. Total Head Loss for the Outfall and Diffuser System

Effluent Flow Rate (m^3/d)	Diffuser Loss (m)	Outfall Loss (m)	Total Loss (m)
6,000	0.28	0.48	0.74
12,000	1.08	1.79	2.76
20,000	2.97	4.74	7.37

5.0 TOTAL SUSPENDED SOLIDS DEPOSITION VELOCITY

Total Suspended Solids (TSS) can form a moving bed of solid particles on the bottom of the outfall pipe, if the flow speed in the outfall pipe is below a threshold velocity called the deposition velocity. Velocities in the pipe need to be maintained above this deposition velocity in order to prevent deposition of solids and consequently increases in head requirements, hydraulic instabilities and pipeline wear.

The deposition velocity depends on the diffuser geometry and the physical properties of the solids and effluent. Several methods for calculating the deposition velocity exist in literature. It is worth mentioning that most of these methods are for the case of slurry-transport in a straight horizontal pipe (i.e., Durand and Condolios, 1952; Jufin and Lopatin 1966; Wasp et al., 1970; Turian, 1987; Schiller and Herbich, 1991; Shook and Roco, 1991; Wilson et al., 1992; Gillies et al. 2000; Shook et al., 2002; Wilson et al., 2006; Matourek, 2011; Roitto, 2014; Bbosa, 2016). Since the Melvin Bay diffuser system actually goes from the surface down to 25 m depth, the deposition velocities calculated in this section are conservative, and actual deposition velocities should be lower than calculated, due to the pipe downward slope.

The TSS concentration is expected to be below 30 mg/L. A range of concentration has been used for deposition velocity calculation. To calculate the TSS deposition velocity of the effluent, a few assumptions must be made as no particle size distribution and rheology was conducted on these solids:

- TSS solid specific gravity: 2.65;
- Representative size of fine particles: 10 µm to 30 µm; and
- Representative size of coarse particles: 100 µm to 150 µm.

Table 10. TSS Deposition Velocity

TSS Concentration (mg/L)	Representative Size (µm)		Deposition Velocity (m/s) (*)	
	Fine Particle	Coarse Particle	Fine Particle	Coarse Particle
10	10 / 30	100 / 150	0.41 / 0.44	0.51 / 0.59
20			0.44 / 0.48	0.52 / 0.61
30			0.45 / 0.49	0.53 / 0.61

(*) Deposition velocity of fine particles are calculated based on methods from Turian (1987), Shook and Roco (2011) and Roitto (2014); while deposition velocity calculation methods for coarse particles are from Shook and Roco (1991) and Jufin and Lopatin (1966) as discussed in Matourek (2011).

The main conclusions from the results of TSS deposition velocity are the following:

I. The deposition velocity increases slightly, i.e. less than 10%, when the TSS concentration increases from 10 mg/L to 30 mg/L.

II. Larger particles have a larger deposition velocity as expected. Among all cases in Table 10, the largest deposition velocity in a horizontal pipe is 0.61 m/s. Beyond the shoreline, in the sloping portion (-15%) of the outfall pipeline, the expected deposition velocities may be reduced by at least 20% (Wilson, 1992). Therefore, the deposition velocities are well below the design operating velocity in the outfall pipelines (1.30 to 4.33 m/s).

III. Prior to any short-term or extended term shut-down periods, it is recommended to flush the outfall line with seawater: the pumping of seawater through the system will ensure that the pipes are cleared of any deposited solids.

6.0 CONCLUSIONS

Work was conducted to design a new diffuser system in Melvin Bay near Rankin Inlet, Nunavut, as part of the Meliadine Mine operations. The conclusions from this scope are as follows:

- A multiport diffuser is proposed. The diameter of the outfall pipe is 12'' OD DR-11, and the diffuser section has 5 ports with diameter of 100 mm. The diffuser is located at a water depth of 20 m CD.
- The diffuser system is adequate to process effluent discharges from 6,000 m^3/d to 20,000 m^3/d while achieving dilution compliance within the regulated mixing zone.
- The target dilution factor of 11:1 can be reached within a horizontal distance of 1 m for all tested scenarios.
- The effluent plume would not reach the bottom of the ice layer under all conditions considered.
- The total head loss of the system located on seabed (from the 7 m CD depth down to the end of the diffuser) is 0.74 m for an effluent discharge rate of 6,000 m^3/d, 2.76 m for an effluent discharge rate of 12,000 m^3/d and 7.37 m for an effluent discharge rate of 20,000 m^3/d.
- The effluent velocity (1.30 to 4.33 m/s corresponding to effluent flow from 6,000 m^3/d to 20,000 m^3/d) in the outfall pipe is well above the TSS deposition velocities (maximum velocity of 0.61 m/s among all calculated cases) based on a few assumptions of properties of TSS in the effluent (i.e., TSS specific gravity and representative particle sizes). As a result, no deposition issue is expected in the system.

7.0 LIMITATIONS OF REPORT

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8.0 CLOSURE

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Enclosure: Drawings
Appendix A -Limitations on the Use of this Document
Appendix B - Sensitivity Analysis

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DRAWINGS

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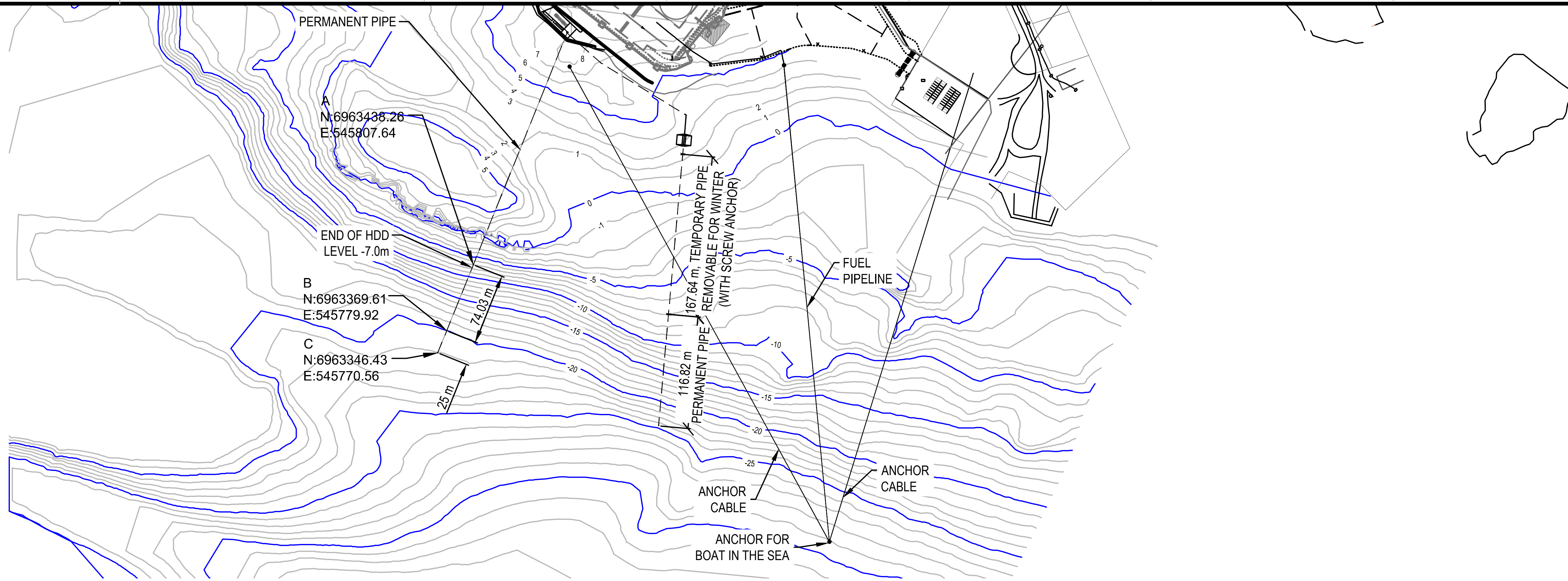

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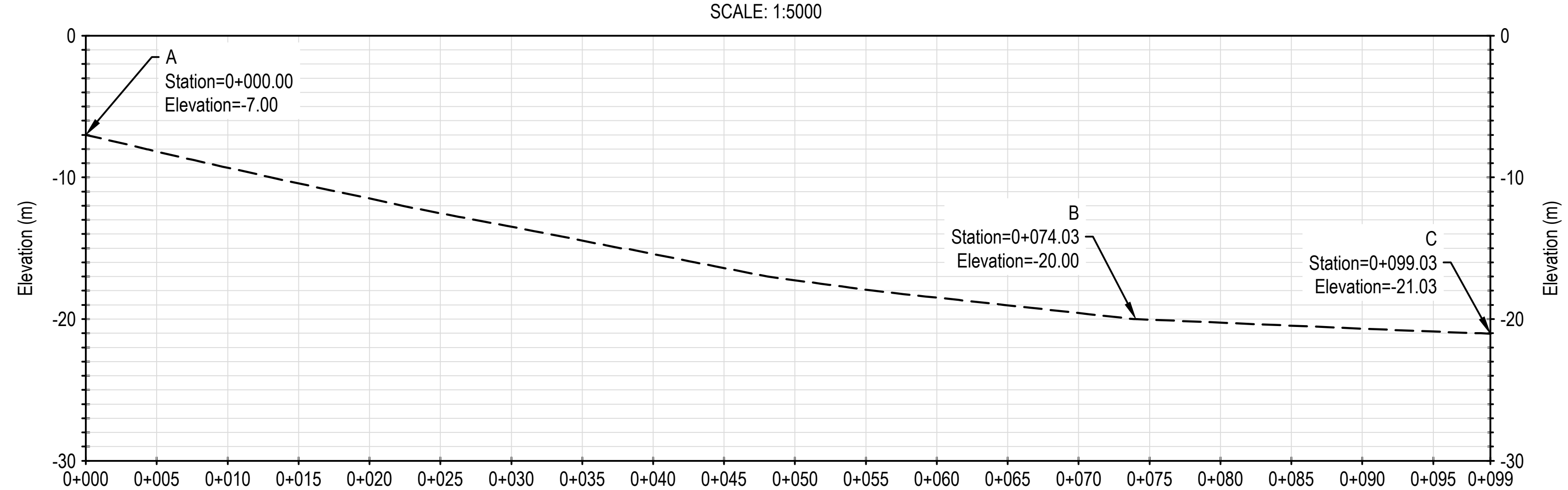

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DATE	March 12, 2020	

TITRE / TITLE
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DIFFUSER
PLAN AND PROFILE

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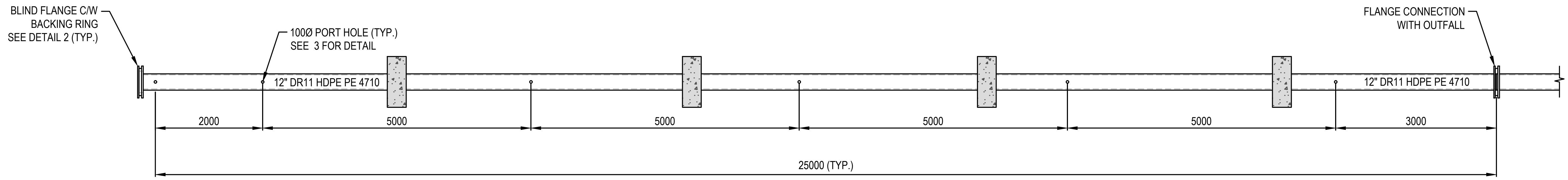

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12" DR11 HDPE PE 4710	
O.D.	I.D.
305 mm	261 mm

NOTE:

1. DEPENDING ON THE MANUFACTURER, THE PIPE DIAMETER AND WALL THICKNESS MAY VARY SLIGHTLY. CONTRACTOR TO CONFIRM AND COORDINATE SUPPLY AND INSTALLATION.
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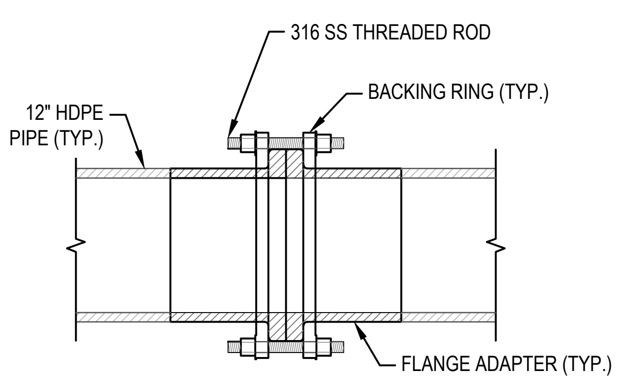

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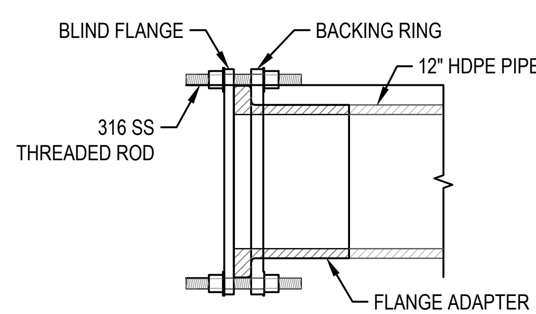

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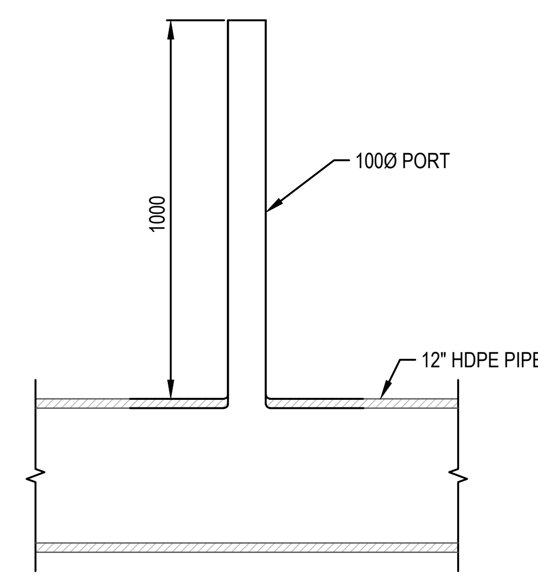

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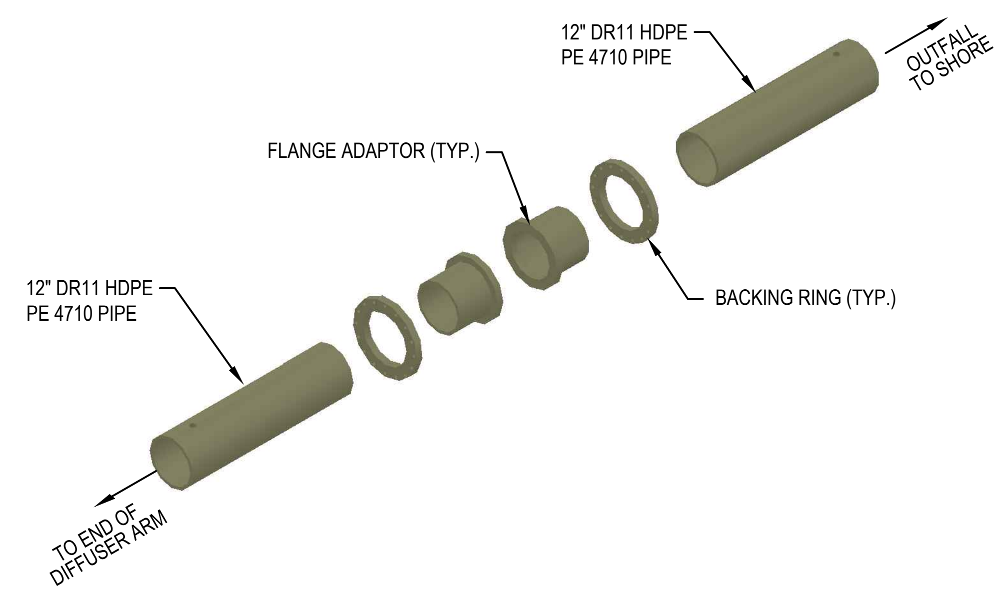

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APPENDIX A

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LIMITATIONS ON USE OF THIS DOCUMENT

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APPENDIX B

SENSITIVITY ANALYSIS

This section presents sensitivity analysis of density difference between ambient water and effluent. The cases of the smallest and largest density differences for both summer and winter are studied. The upper and lower bounds of effluent flow rates 6,000 and 20,000 m^3/s are used in this study. The sensitivity analysis of summer conditions is presented in Section B1 and the one of winter conditions in Section B2. Conclusions of these two parts are given in Section 2.5.

B1. SENSITIVITY ANALYSIS OF DENSITY DIFFERENCE OF SUMMER CONDITIONS

This section presents sensitivity analysis of density differences of summer conditions. Table B1 shows the model input conditions and Table B2 shows the model results. Scenarios S1a through S8a are cases where the density difference between the effluent and ambient water is the smallest (4.40 kg/m3), while Scenarios S1b through S8b are cases with the greatest density difference (7.44 kg/m3).

Table B1. Summer Conditions Corresponding to the Smallest and Largest Density Differences

Scenario (1)	Ambient Condition			Effluent Condition		
	Current Speed (m/s) (2)	Temperature (°C)	Density (kg/m^3)	Effluent Flow (m^3/s)	Temperature (°C)	Density (kg/m^3)
S1a	0	5.8	1024.26	6,000	20.0	1028.30
S2a	0.05					
S3a	0.25					
S4a	0.40					
S5a	0			20,000		
S6a	0.05					
S7a	0.25					
S8a	0.40					
S1b	0	8.5	1023.91	6,000	5.0	1031.35
S2b	0.05					
S3b	0.25					
S4b	0.40					
S5b	0			20,000		
S6b	0.05					
S7b	0.25					
S8b	0.40					

(1) Scenarios with labels ending with ‘a’ are the ones with the smallest density differences, and those with ‘b’ are the largest density differences.
(2) VP model cannot handle current speed of 0 m/s, so 0.00001 m/s current is used to study scenarios under no current influence

Table B2. Visual Plumes Results of Sensitivity Analysis of Summer Conditions

Scenario	Dilution Factor S (1)	Horizontal Distance to Dilution Factor S (m) (2)	Centerline Maximum Height (m) (3)	Distance to Required Dilution Factor of 11 (m) (4)	Note (5)
S1a	30:1	1.2	3.4	0.7	Maximum rise
S2a	65:1	4.8	3.1	0.3	Bottom hit
S3a	149:1	23.4	1.6	0.4	Bottom hit
S4a	183:1	38.3	1.3	0.4	Bottom hit
S5a	67:1	3.1	10.0	0.6	Maximum rise
S6a	119:1	14.2	11.2	0.1	Bottom hit
S7a	266:1	58.7	5.9	0.4	Bottom hit
S8a	346:1	96.9	4.8	0.4	Bottom hit
S1b	24:1	1.0	2.1	1.0	Maximum rise
S2b	50:1	3.4	2.7	0.3	Bottom hit
S3b	126:1	17.3	1.4	0.4	Bottom hit
S4b	155:1	28.3	1.1	0.4	Bottom hit
S5b	36:1	2.7	9.5	0.6	Maximum rise
S6b	105:1	10.5	9.7	0.1	Bottom hit
S7b	236:1	44.2	5.3	0.4	Bottom hit
S8b	305:1	72.7	4.3	0.4	Bottom hit

(1) The dilution factor and the corresponding horizontal distance for dilution are values when plume reaches maximum height or hits the seabed.
(2) The horizontal distances to reach dilution factor S for the 0 m/s ambient currents cases are the radius of the plumes; otherwise, it is the horizontal distance of the centerline of the plume from the source.
(3) Centerline maximum height is the height above seabed.
(4) Distance required to obtain a dilution of 11:1 corresponds to the horizontal distance between the centerline of the plume and the port
(5) The VP model reports valid dilution values until the plume reaches maximum height or hits the bottom.

B2. SENSITIVITY ANALYSIS OF DENSITY OF WINTER CONDITIONS

This section presents sensitivity analysis of density differences of winter conditions. Table B3 shows the model input conditions and Table B4 shows the model results. Scenarios W1a through W8a are cases where the density difference between the effluent and ambient water is the smallest (5.13 kg/m^3), while Scenarios W1b through W8b are cases with the greatest density difference (5.36 kg/m^3).

Table B3. Winter Conditions Corresponding to the Smallest and Largest Density Differences

Scenario (1)	Ambient Condition			Effluent Condition		
	Current Speed (m/s) (2)	Temperature (°C)	Density (kg/m^3)	Effluent Flow (m^3/s)	Temperature (°C)	Density (kg/m^3)
W1a	0	-1.9	1026.56	6,000	2.0	1031.69
W2a	0.05					
W3a	0.25					
W4a	0.40					
W5a	0			20,000		
W6a	0.05					
W7a	0.25					
W8a	0.40					
W1b	0	0.0	1026.49	6,000	5.0	1031.85
W2b	0.05					
W3b	0.25					
W4b	0.40					
W5b	0			20,000		
W6b	0.05					
W7b	0.25					
W8b	0.40					

(1) Scenarios with labels ending with 'a' are the ones with the smallest density differences, and those with 'b' are the largest density differences.
(2) VP model cannot handle current speed of 0 m/s, so 0.00001 m/s current is used to study scenarios under no current influence.

Table B4. Visual Plumes Results of Sensitivity Analysis of Winter Conditions

Scenario	Dilution Factor S (1)	Horizontal Distance to Dilution Factor S (m) (2)	Centerline Maximum Height (m) (3)	Distance to Required Dilution Factor of 11 (m) (4)	Note (5)
W1a	18:1	0.8	2.2	0.7	Bottom hit
W2a	64:1	4.7	3.2	0.3	Bottom hit
W3a	148:1	23.4	1.6	0.4	Bottom hit
W4a	183:1	38.3	1.3	0.4	Bottom hit
W5a	64:1	3.0	7.6	0.6	Bottom hit
W6a	119:1	14.2	11.2	0.1	Bottom hit
W7a	266:1	58.8	5.9	0.4	Bottom hit
W8a	225:1	44.6	4.8	0.4	Bottom hit
W1b	29:1	1.1	3.3	0.7	Bottom hit
W2b	64:1	4.7	3.1	0.3	Bottom hit
W3b	149:1	23.3	1.6	0.4	Bottom hit
W4b	179:1	37.7	1.3	0.4	Bottom hit
W5b	43:1	4.4	12.1	0.6	Maximum rise
W6b	118:1	14.1	11.1	0.1	Bottom hit
W7b	266:1	58.5	5.9	0.4	Bottom hit
W8b	339:1	95.1	4.8	0.4	Bottom hit

(1) The dilution factor and the corresponding horizontal distance for dilution are values when plume reaches maximum height or hits the seabed.
(2) The horizontal distances to reach dilution factor S for the 0 m/s ambient currents cases are the radius of the plumes; otherwise, it is the horizontal distance of the centerline of the plume from the source.
(3) Centerline maximum height is the height above seabed.
(4) Distance required to obtain a dilution of 11:1 corresponds to the horizontal distance between the centerline of the plume and the port
(5) The VP model reports valid dilution values until the plume reaches maximum height or hits the bottom.

APPENDIX D – 2026 SHELLFISH HARVEST MONITORING PLAN

MELIADINE MINE

2026 SHELLFISH HARVEST MONITORING PLAN

Prepared By: Nunavut Environmental Consulting Ltd.

Prepared For: Agnico Eagle Mines ltd.

29 MARCH 2026

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List of Acronyms

ASP	Amnesic Shellfish Poisoning
CFIA	Canadian Food Inspection Agency
CSSP	Canadian Shellfish Sanitation Program
DDT	Dichlorodiphenyltrichloroethane
DSP	Diarrhetic Shellfish Poisoning
GN	Government of Nunavut
HAB	Harmful Algal Bloom
HHA	Human Health Assessment
HHS	Hunter Harvest Study
IQ	Inuit Qaujimajatuqangit
KEAC	Kivalliq Elders Advisory Committee
KHTO	Kangiqliniq Hunters and Trappers Organization
KIA	Kivalliq Inuit Association
KWB	Kivalliq Wildlife Board
NCRI	Nunavut Coastal Resource Inventory
NEC	Nunavut Environmental Consulting Ltd.
NRC	National Research Council
NWHS	Nunavut Wildlife Harvest Study
NWMB	Nunavut Wildlife Management Board
NIRB	Nunavut Impact Review Board
ODMP	Ocean Discharge Monitoring Plan
PCP	Polychlorinated Biphenyl
PSP	Paralytic Shellfish Poisoning
PTX	Pectenotoxins
QEL	Quamajuq Environmental Ltd.
SHMP	Shellfish Harvest Monitoring Plan
TK	Traditional Knowledge

EXECUTIVE SUMMARY

Under a recent amendment to Nunavut Impact Review Board Project Certificate No. 006 for the Meliadine Project [March 2, 2022], the new Term and Condition No. 133 (i.e., New Condition for the Waterline Proposal) requires Agnico Eagle Mines Ltd., Meliadine Division (Agnico Eagle) to update its Ocean Discharge Monitoring Plan (ODMP). The updated ODMP needs to include a community-based shellfish monitoring program developed and implemented by Agnico Eagle in partnership with the Kivalliq Wildlife Board (KWB) and Rankin Inlet community members. Although the Human Health Assessment did not predict detrimental effects on shellfish consumption, Agnico Eagle committed to the KWB to conduct a community-based shellfish harvest monitoring program, which would include contaminant analysis of samples from areas used to harvest shellfish by Rankin Inlet residents.

Community-based monitoring is a primary goal of the monitoring approach; therefore, community input and involvement is an essential component of all stages of the monitoring program, from identifying sampling locations to organizing local events. The approach for 2025, the first year of shellfish harvest monitoring, included a reconnaissance of shellfish harvest areas, shellfish and water sample collections by Quamajuq Environmental Ltd. (QEL) and Agnico Eagle personnel over two sampling periods, and water (fecal coliform) and shellfish tissue (metals) analyses. Details of the 2025 program are provided in the 2025 annual report.

In 2026, water and tissue sampling will continue at five locations over three sampling periods. A community event is planned, which will likely consist of a community harvest event in September or October, where the goals of the monitoring program can be reiterated, where food, including shellfish, are shared, and community input to guide long-term monitoring is solicited.

The 2026 monitoring program will be coordinated by Nunavut Environmental Consulting Ltd. and implemented by QEL and Agnico Eagle.

SECTION 1 • OVERVIEW & PURPOSE

1.1 BACKGROUND

Under a recent amendment to Nunavut Impact Review Board (NIRB) Project Certificate No. 006 for the Meliadine Project [March 2, 2022], the new Term and Condition No. 133 (i.e., New Condition for the Waterline Proposal) requires Agnico Eagle Mines Ltd., Meliadine Division (Agnico Eagle) to update its Ocean Discharge Monitoring Plan (ODMP). The updated ODMP needs to include a community-based shellfish monitoring program developed and implemented by Agnico Eagle in partnership with the Kivalliq Wildlife Board (KWB) and Rankin Inlet community members. Although the Human Health Assessment (HHA) did not predict detrimental effects on these activities, Agnico Eagle committed to the KWB to conduct a community-based shellfish harvest monitoring program, which would include contaminant analysis of samples from areas used to harvest shellfish by Rankin Inlet residents (Agnico Eagle 2020).

Nunavut Environmental Consulting Ltd. (NEC) was tasked with advancing an earlier report, 'A Framework for a Community-Based Shellfish Monitoring Program', developed by ERM Consultants Canada Ltd. (2022). NEC is collaborating with Agnico Eagle, KWB, Quamajuq Environmental Ltd. (QEL), an Inuit-owned consulting firm based in Rankin Inlet, and community members in developing this current version of the Shellfish Harvest Monitoring Plan (SHMP).

1.2 GUIDING PRINCIPLES & KEY FEATURES

The guiding principles of the SHMP include:

- **Inuit Qaujimajatuqangit (IQ)** - Driven by Inuit culture, values, and traditional knowledge (TK);
- **Community Involvement** - Led by Inuit communities for the benefit of Inuit Kivalliq communities;
- **Collaboration** - Developed in partnership with the KWB and with input from the community; and
- **Capacity Building** - Provides training and skills development for community members.

The SHMP will also adhere to the following NIRB IQ principles, as set out by the Government of Nunavut (GN):

- **Inuuqatigiitsiarniq** - Respecting others, relationships, and caring for people;
- **Tunnganarniq** - Fostering good spirit by being open, welcoming, and inclusive;
- **Pijitsirniq** - Serving and providing for family and/or community;
- **Aajiiqatigiinniq** - Making decisions through discussion and consensus;
- **Pilimmaksarniq** - Developing skills through observation, mentoring, practice, and effort;
- **Ikajuqtigiinniq** - Working together for a common cause;
- **Qanuqtuurniq** - Being innovative and resourceful; and
- **Avatittinnki Kamatsiarniq** - Respecting and caring for the land, animals and environment.

Key features of the SHMP include:

- **Monitoring Shellfish Health** – The program is looking at the productivity of shellfish populations over time by documenting the size and age of collected specimens. The presence of contaminants are being assessed in Melvin Bay and other known harvesting areas through the collection and testing of water and shellfish tissue samples. Sampling locations are selected based on community input and include known prime shellfish harvesting areas;
- **Adaptation of a Federal Program** – The program builds upon existing Canadian Shellfish Sanitation Program (CSSP) principles; and
- **Community Engagement** – Engagement will include shellfish harvest events, and ongoing communication with community members through regular community meetings and social media.

SECTION 2 • PURPOSE

To continue northern traditional lifestyles and economies dependent on hunting and fishing, there is a need to assess the health of waterbodies and their biological communities. This assessment can best be achieved through meaningful collaboration between Inuit organizations and communities, federal/territorial governments and institutions (e.g., GN, KWB), and Hunters and Trappers Organizations (HTOs).

The proposed community-based SHMP would track shellfish health in Melvin Bay near the Meliadine Mine effluent discharge, along shorelines in Rankin Inlet (e.g., Johnston Cove), and at other areas determined to be important shellfish harvesting areas near the community of Rankin Inlet. The SHMP will be facilitated by Agnico Eagle and carried out by Inuit for the benefit and use of Inuit Kivalliq communities.

Community-based monitoring fosters a wide range of capacity building for all parties involved, including increased awareness of water stewardship issues, improved TK collection and application, expanded information-sharing opportunities, and direct community involvement. Studies from other Arctic regions have determined that community-level participation and leadership is essential for the long-term success of resource monitoring programs (Johnson et al. 2016; Gérin-Lajoie et al. 2018; Etiendem et al. 2020; Rashidi et al. 2021; Wilson et al. 2024). Residents have a unique knowledge and understanding that add immense value to long-term monitoring projects.

Agnico Eagle is committed to developing a SHMP in partnership with KWB and aligning the program with the CSSP, although the CSSP has not yet been implemented in Nunavut (GN 2016). The Department of Environment Fisheries Strategy 2016-2020 (2016) indicates that “Lobbying for the implementation of the Canadian Shellfish Sanitation Program in Nunavut”, is a top priority. The purpose of the CSSP is to minimize the potential health risks associated with consuming bivalve molluscan shellfish and to protect public health. While the CSSP is designed with the goal of ensuring the safety of commercially harvested shellfish, the principles of the monitoring program can be adapted for monitoring country food safety.

This document provides a technical and social framework for ongoing development of the program.

SECTION 3 • OBJECTIVES

The primary objectives of the SHMP are to:

1. Document historical and existing shellfish harvesting patterns (e.g., location, species, number of harvesters) in Rankin Inlet based on:
    a. The Nunavut Wildlife Management Board's (NWMB) Nunavut Wildlife Harvest Study (NWHS; NWMB 2004);
    b. The Nunavut Coastal Resource Inventory (NCRI) – Rankin Inlet (GN 2018);
    c. The ongoing Rankin Inlet Hunter Harvest Study (HHS); and
    d. IQ and TK gathered at community meetings (e.g., June 04, 2024, November 15, 2024, and November 11, 2025).
2. Outline the monitoring approach for 2026, the second year of the monitoring program, including:
    a. Undertaking water and shellfish collections at five (5) locations over three (3) time periods (i.e., ice-off – early July, mid August, and late September);
    b. Analysing shellfish tissues for metals, fecal coliforms, and biotoxins; and
    c. Organizing a community meeting or event where program results and food, including shellfish, can be shared.
3. Recommend a long-term monitoring approach (i.e., 2027 and beyond), which includes community involvement and events.

SECTION 4 • EXISTING SHELLFISH HARVEST INFORMATION

4.1 NUNAVUT WILDLIFE HARVEST STUDY (NWHS)

The NWHS (NWMB 2004) was mandated by the *Nunavut Lands Claim Agreement* and carried out under the direction of the NWMB. Harvest data were collected monthly from Inuit hunters in Nunavut for five years covering the harvest months from June 1996 to May 2001. The purpose of the NWMB study was to determine current harvesting levels and patterns of Inuit use of wildlife resources. Results were to be used by the NWMB to aid in the management of Nunavut wildlife resources.

Interviewees in the community of Rankin Inlet did not indicate any shellfish harvest but other communities in Nunavut reported harvests of clams and Blue Mussel (*Mytilus edulis*). The absence of data from the NWMB study for Rankin Inlet does not necessarily indicate that shellfish harvest is not important to some community members, as there may have been differences in approach and interview questions between communities.

4.2 NUNAVUT COASTAL RESOURCE INVENTORY (NCRI)

The NCRI for Rankin Inlet (GN 2018) documented key shellfish harvesting areas and provided comments by participants in the study. A summary of participant observations included:

Blue Mussel (*Mytilus edulis*)

- Mussels occur all along the shore at low tide and around rivers and areas with current.
- Old shells can be seen at Second Landing Lake and in the Wager Bay area in areas that are not too rocky.
- Observed off cliffs and on reefs at very low tide, and shallow areas where there is seaweed (Qikiuq).
- Found from Baird Bay south and at Marble Island.

Truncate Softshell Clam (*Mya truncata*)

- There are usually lots of clams where Walrus (*Odobenus rosmarus*) are found. Walruses eat a lot of these and fresh ones from the walrus stomach can be rinsed and eaten (Aumumaiju).
- Lots of shells can be found on island shores so live clams likely occur in deeper waters around the islands.
- Can be found on island near Itivia and in the Wager Bay area in areas that are not too rocky.
- Generally found at low tide in shallow muddy areas along the coast.
- Clams tend to be small around Rankin Inlet with bigger ones occurring in colder water.

Northern Horsemussel (***Modiolus modiolus***)

- Horsemussel can be found along the shore at low tide.
- Flatter horsemussels can be found along the south shore of Bibby Island and in the Wager Bay area in areas that are not too rocky.
- Found at low tide in shallow and muddy areas, including channels, often where seaweed (Qikiuq) is found.
- Occur around Rankin Inlet where they are eaten. Also found behind the airport, from Baird Bay south, and Marble Island.

Key shellfish areas of occurrence in the Rankin Inlet area, as described on figures in the NCRI, are depicted in **Figure 4.1**. Blue Mussel can be found in Melvin Bay, in the Broken Islands area south of Rankin Inlet, at the northern end of the Barrier Islands west of Rankin Inlet, and between Rabbit Island and Baird Bay east of Rankin Inlet. Truncate Softshell Clam appears to occur most commonly in several shoreline areas immediately west and east of Rankin Inlet, including the base of the Barrier Islands, at the north end of Prairie Bay, the shallow areas east of Thomson Island, and near Cape Jones. Northern Horsemussel occurrence has been documented at the north end of the Barrier Islands, in Melvin and Prairie bays, and a point of land on the mainland just west of Rabbit Island.

4.3 RANKIN INLET HUNTER HARVEST STUDY (HHS)

Prior to 2024, questions on shellfish harvesting were not part of the regular Rankin Inlet HHS but individual participants reported harvesting 816 mussels in 2022 and 51 mussels in 2024. No shellfish harvests were reported in 2023.

In 2024, the HHS was expanded to include specific questions on shellfish harvest and to add participants that were regular shellfish harvesters. Conversations with hunters, harvesters, wildlife managers, cultural interpreters, Kangiqliniq Hunters and Trappers Organization (KHTO) staff, and other community members were held between June 25 and July 3, 2024, and November 9 to 13, 2024. Many of the discussions about shellfish harvesting were with current participants of the HHS. Based on recommendations and introductions from friends and colleagues in the community of Rankin Inlet, conversations with additional shellfish harvesters (outside of the HHS) were also undertaken.

Interviewees expressed interest in learning more about shellfish monitoring programs, including sending specimens off for testing. The KHTO and the GN’s Department of Environment wildlife office expressed a willingness to help amplify information about shellfish collection and testing programs that may come online.

With launching of the shellfish monitoring program in 2025, questions related to shellfish harvesting were not included in the 2025 or 2026 HHS.

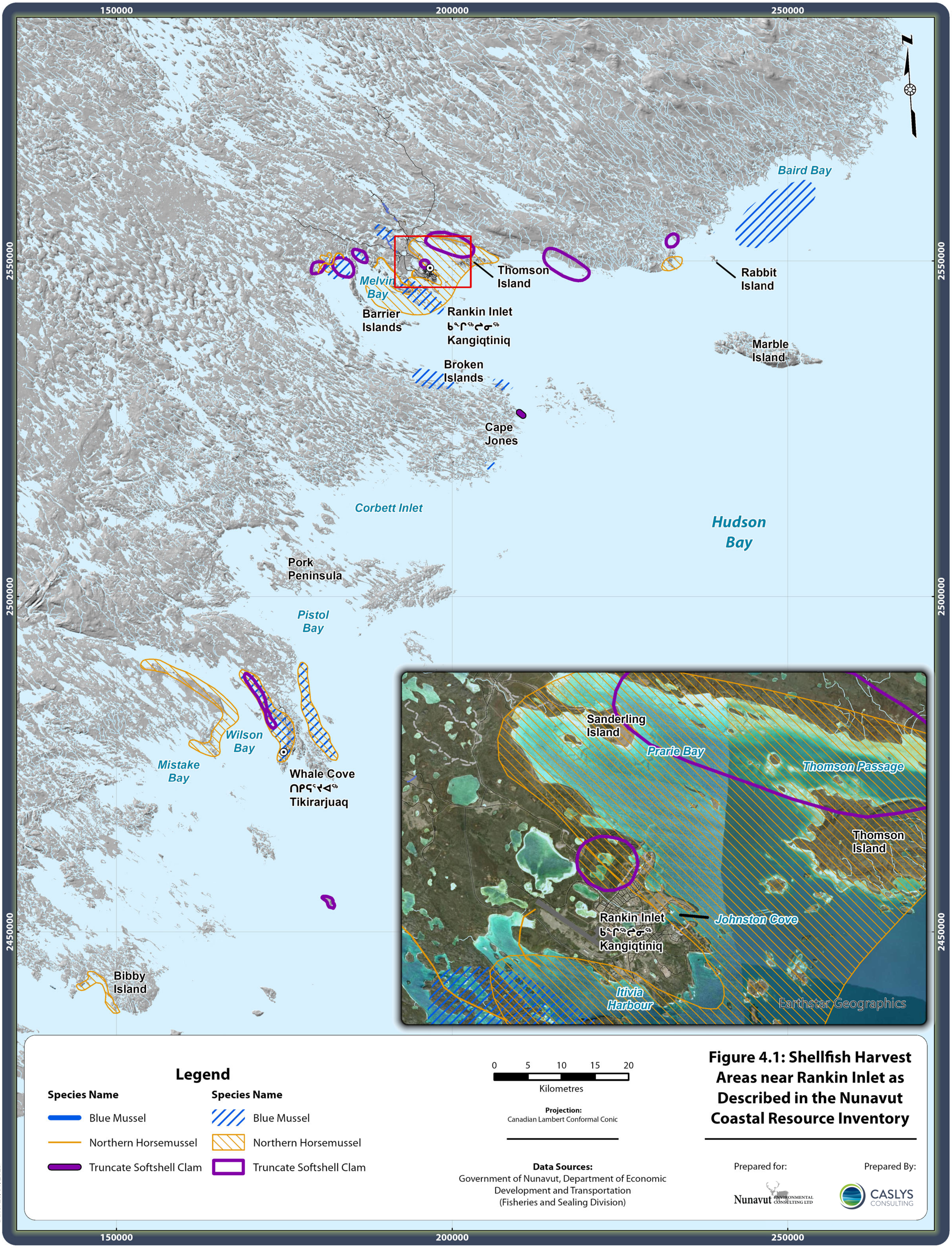

Figure 4.1: Shellfish Harvest Areas near Rankin Inlet as Described in the Nunavut Coastal Resource Inventory

The three species of edible shellfish identified as occurring commonly in the region included Blue Mussel, Truncate Softshell Clam, and Northern Horsemussel. By far, the most harvested species in Rankin Inlet is the Blue Mussel, while Truncate Softshell Clam was also harvested (although in small quantities) from shallow sandy coastal flats such as Dry Bay (**Figure 4.2**). Northern Horsemussel harvesting in the area is unconfirmed, but possible. Lastly, an unknown species referred to by one person as “razor clam” may occur to the north in Naujaat. At present, no matching shellfish species could be determined from literature review, but razor clam may be a localized name for the Truncate Softshell Clam.

Near Rankin Inlet, most shellfish are harvested in late August, September, and October - “When the first snow falls, it’s a good time to collect mussels”. The fall timing allows the mussels or clams a full growing season, resulting in a larger size and preferred flavour. Some mussels are harvested shortly after ice-off (late June and early July). Shellfish harvesting from islands and areas perceived as cleaner or more remote are preferred. Some people consider mussels a treat or delicacy as they are only available for a limited period of the year.

Mussel harvesting is often undertaken in conjunction with late summer and early fall coastal hunts for seals, Walrus, or whales. In some cases, it was fondly remembered as a childhood activity: harvesting mussels while the adults were hunting. Walrus, which is a benthic invertebrate specialist, eats large quantities of shellfish. Pre-digested shellfish (especially Truncate Softshell Clam) can occasionally be recovered from a harvested Walrus stomach, rinsed, and eaten. This method was described by one person as “pre-cooked” and is a sought-after delicacy for shellfish harvesters.

Mussels are collected by waiting for low tide at known mussel areas or exposed coastlines where seaweed is present. Mussels are pulled by hand from the shore or, more often, from a boat and placed into buckets filled with saltwater. If consumed right away, the mussels are often unpleasantly full of sand, silts, and other sediments; therefore, harvested mussels are left in saltwater buckets for several hours at a minimum, and sometimes overnight, to allow for the expulsion of sand. Some harvesters change the saltwater several times to maximize this cleaning process. Preparation of the mussels varies, but most of our interviews described boiling as the preferred technique.

Shellfish harvesting is primarily done outside of town; however, several people also described harvesting nearer to Rankin Inlet and indicated that historic shellfish harvesting occurred directly adjacent to the modern townsite (**Figure 4.2**). Some shellfish collection adjacent to town may only have occurred until very recently. One person described the existence – within the past decade – of a “shellfish harvesting warning sign” near the current location of the Agnico Eagle dock. Most interviewees said that town pollution, dust, and sewage have discouraged shellfish harvesting directly adjacent to the town.

Figure 4.2 depicts preliminary findings of preferred shellfish harvest areas; however, it seems that Blue Mussel is ubiquitous and harvested from most coastal habitat of the region including many areas not shown on these maps.

Legend

- Current Blue Mussel Harvest Area
- Historic Blue Mussel Harvest Area
- Current Softshell Clam Harvest Area

0 5 10 15
Kilometres

Projection:
Canadian Lambert Conformal Conic

Data Sources:
Agnico Eagle
Nunavut Environmental Consulting Ltd.

Figure 4.2: Shellfish Harvest Locations in the Rankin Inlet Area based on the Rankin Inlet Hunter Harvest Study

Prepared for: Nunavut Environmental Consulting Ltd

Prepared By: CASLYS Consulting

Date: 23/01/2025

4.4 COMMUNITY MEETINGS

Three meetings were held in 2024 and one meeting was held in 2025 that focused on presenting the framework of a community-based shellfish monitoring program, gathering information on shellfish harvests in the community, and soliciting input to the monitoring approach. Summary outcomes of the meetings are below, while minutes are provided in **Appendix A**.

February 28, 2024 – Kivalliq Wildlife Board

Maria Kasaluak (KWB) and Kyle Conway (Agnico Eagle) met at the KWB office in the community of Rankin Inlet to discuss the framework of a community-based shellfish monitoring program. Topics discussed included who should participate in the program, development of a detailed monitoring design, community meetings to present the program, and collection of IQ/TK.

June 04, 2024 – Kivalliq Elders Advisory Committee

A meeting was held in Baker Lake with the Kivalliq Elders Advisory Committee (KEAC) to present the framework of a community-based shellfish monitoring program. The meeting was open to questions, comments, and input from the committee. Topics discussed included details of the monitoring program, shellfish harvesting locations, contamination, Agnico Eagle's water discharge plans, climate change, and community involvement.

November 15, 2024 – Rankin Inlet Community Members

A community meeting was held at on November 15, 2024, in the 'Stand-by' room located near the Rankin Inlet Airport. Approximately 10 members of the community were in attendance. The proposed shellfish monitoring program was presented and the floor was opened to comments and questions. Topics discussed included shellfish harvest locations, the importance of shellfish as a food, and how shellfish are prepared and eaten. Attendees marked up a map indicating shellfish harvest locations, which is illustrated in **Figure 4.3**.

November 11, 2025 – Kivalliq Elders Advisory Committee

A community meeting was held at on November 11, 2025. The proposed community-based shellfish monitoring program was presented with an update on the monitoring program to date. Topics discussed included shellfish harvest locations (e.g., Marble Island), the importance of traditional food sources, and the possibility of including high school students in monitoring activities.

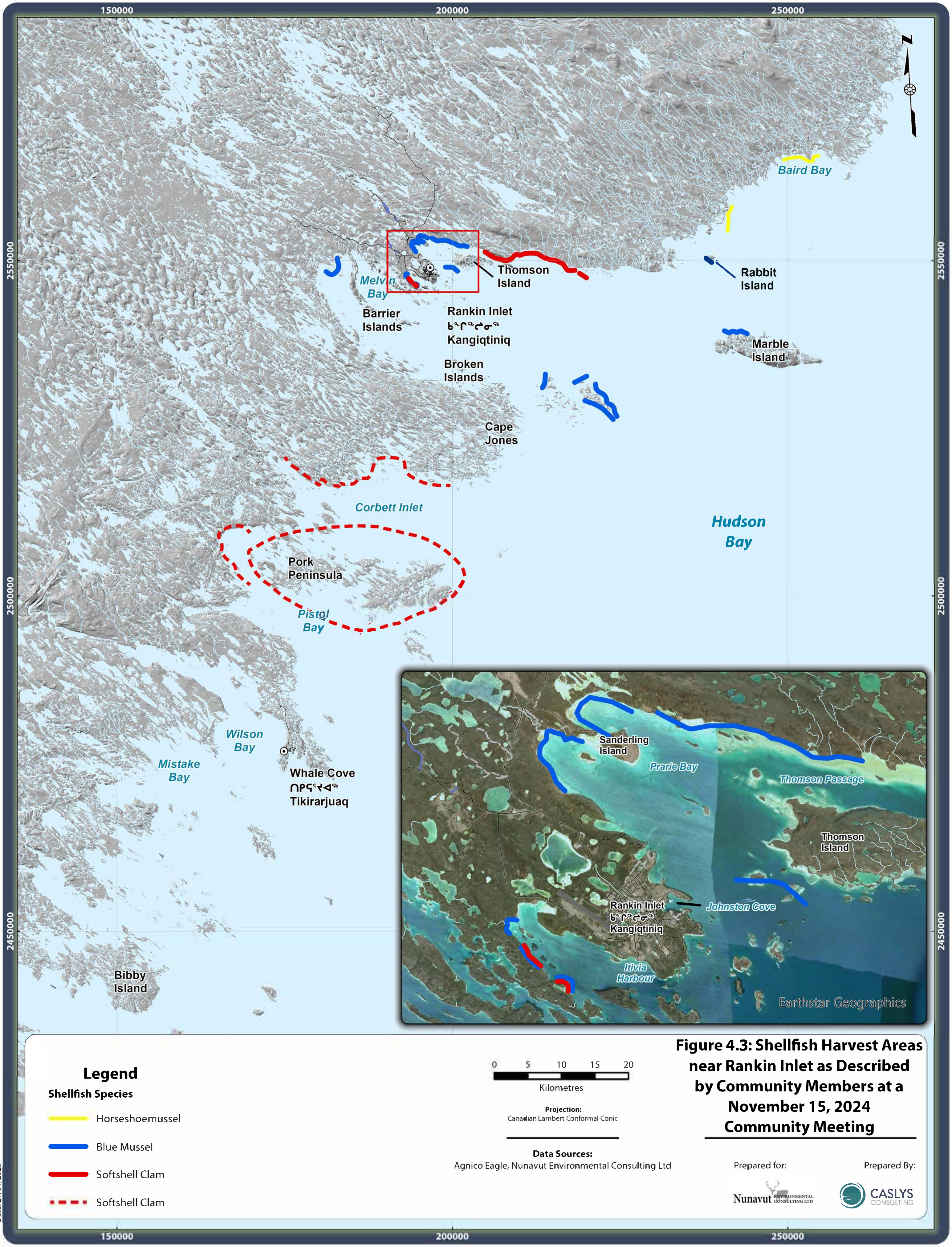

Figure 4.3: Shellfish Harvest Areas near Rankin Inlet as Described by Community Members at a November 15, 2024 Community Meeting

Data Sources:
Agnico Eagle, Nunavut Environmental Consulting Ltd

Prepared for: Nunavut Environmental Consulting Ltd

Prepared By: CASLYS Consulting

Date: 21/01/2025

SECTION 5 • MONITORING APPROACH FOR 2026

5.1 OVERVIEW

Section 5 outlines the monitoring approach for 2026, including plans for community engagement and participation, capacity building, and implementation of the community shellfish harvest monitoring program.

5.2 COMMUNITY ENGAGEMENT & PARTICIPATION

Residents have a deep knowledge and understanding of the surrounding environment and wildlife, which makes their expertise essential for planning and executing long-term monitoring projects. Regular community meetings (where IQ/TK can be gathered), discussions with HHS participants, and community events in the field (e.g., shellfish harvest and feast) are important for ensuring the monitoring program is supported and run by the community. Community members are the best people to provide local expertise and IQ/TK on current shellfish harvest locations, areas that people avoid harvesting in and why, the best times to harvest, historical shellfish harvesting information, and concerns about eating shellfish from the Rankin Inlet area (e.g., size, health, taste, texture, or colour of shellfish).

Information collected from community meetings and analytical results from baseline tissue collections can be shared at community meetings and in an annual report. Use of a dedicated cellphone app could be used to facilitate recording of shellfish harvest information (e.g., harvest location, species and number harvested, quality of food etc.). Those harvesting shellfish could provide data by sending photos of their harvest through the app, and GPS location data and sample timing could be automatically collected. Identification and measurement of shellfish collected can be done from images of collected shellfish. The sampler could provide information on the number and types of shellfish collected for any personal harvest. In the absence of an app, data could also be collected by requesting that the community members submit all the shucked shells from their harvest. In this case, QEL could collect, identify, store, and dispose of the shells, and summarize all information.

A community event in 2026 would focus on bringing interested members of the community, particularly Elders, together to provide information about the monitoring plan, allow community members to share stories, collect shellfish, and have a cookout. Agnico Eagle is also committed to developing a process to identify traditional names of harvest areas. To encourage participation, incentives such as prizes for contributing samples could significantly enhance data collection.

Co-development and discussions of the monitoring program with the KWB is important. Discussions with the KWB will allow KWB and Agnico Eagle to tailor and design a program in response to the unique conditions in Melvin Bay and the specific concerns and interests of the KWB and the Inuit community.

5.3 CAPACITY BUILDING

Capacity building and skills development for Inuit community members is a foundational aspect of the Program. Agnico Eagle is committed to working with the KWB to develop approaches to the monitoring program that incorporates opportunities to train Inuit monitors and build in a process for gathering and sharing IQ and TK (see **Section 5.2** above). In a November 11, 2025 meeting with the KEAC (**Appendix A**), elders expressed their interest in involving high school students in the monitoring program as part of capacity building.

The program will continue providing training to community members (i.e., QEL) to execute the SHMP, including: a) managing the program; b) identifying shellfish species and age; c) collecting, storing, and sending water and tissue samples; d) conducting in-situ biotoxin testing using rapid test kits and readers; e) creating and maintaining community communication channels; and f) interpreting laboratory results for community members. The Standard Operating Procedures document developed by NEC and regular conference calls with QEL will facilitate the training process.

5.4 COMMUNICATION

Communication between stakeholders in the SHMP will be essential to its success. Communication tools that will be implemented may include an app for sharing information, regular community meetings, and yearly shellfish cook-outs (in late September/early October), social media notifications, radio announcements, and the annual report. The most promising app for sharing information is SIKU, The Indigenous Knowledge Social Network (https://siku.org/). The website and app may be developed and implemented in 2026.

Communication methods will be determined through ongoing consultation with the KWB and preferences of the community.

The health of shellfish harvest areas (i.e., based on analytical results) will be communicated to community members using the CSSP notification system. The CSSP uses a green/red notification system is indicated below.

Green areas are **approved (suitable)** for harvesting of all species of bivalve molluscs.

Red areas are **closed (contaminated)** for all species of bivalve molluscs.

Red hatching are areas where harvesting of some species of bivalve molluscs is **closed (contaminated).**

Blue indicates that areas are unmonitored. Shellfish **should not** be harvested in these areas.

5.5 PERSONNEL TRAINING FOR 2026

Shellfish tissue and water sample collection will be conducted by QEL and Agnico Eagle, who employ Rankin Inlet community members. Prior to the first collection period (i.e., ice-off in early July 2025), new QEL and Agnico eagle staff will be trained by NEC and Sensoreal (i.e., biotoxin testing expertise) to: a) manage the tissue collections; b) identify shellfish species and age; c) collect, store, and ship tissue samples to analytical labs; d) analyze tissues for biotoxins using rapid test kits and readers; and e) interpret laboratory results for community members.

5.6 SAMPLING LOCATIONS & TIMING

In all aspects of sampling proposed, shellfish species, sizes, and sampling technique should be consistent with the traditional harvesting practices and treatment of shellfish meat by harvesters. The specific concerns of the community will dictate the ultimate framework of the sampling program as it suits their needs.

Based on data summarized in **Sections 4.1** to **4.4**, and particularly community input, as well as lessons learned during sampling in 2025, five (5) fixed, readily accessible sampling locations used as historical or current harvest areas are proposed for preliminary baseline shellfish (focus on Blue Mussel in 2025; Beyer et al. 2017) tissue collections. The five locations are: 1) Itivia Harbour/Melvin Bay, the location where Meliadine Mine waterline discharge station is located; 2) Johnston Cove, within the Rankin Inlet townsite and close to the old nickel mine; 3) the north end of Prairie Bay between Sanderling Island and Thomson Passage; 4) the mainland shoreline area just south of the Barrier Islands; and 5) a far field location on the mainland east of Thomson Island (see **Figure 5.1**; note that Location 5 replaces the Rabbit Island site accessed in 2025). Fixed sampling locations align with the requirements of the CSSP and provide sufficient understanding of conditions in shellfish beds over a broad range, including potential influence of discharges from the waterline diffuser and historical contamination (e.g., old nickel mine), and varying climate conditions. Proposed sampling locations should be reviewed by Rankin Inlet community members to ensure genuine support and increased likelihood of adoption.

Proposed sampling locations were based on several criteria including: a) known areas of historical and/or current shellfish occurrence; b) historical or current issues (e.g., Johnston Cove); b) site accessibility; and d) representative of shellfish harvest sites in general.

Water and tissue samples will be collected during three periods: a) ice-off – early July; b) mid August; and 3) late September, the period when harvesters have indicated that most shellfish are harvested.

In future years, to broaden the study area and to include more community members in the sampling program, collection of shellfish tissues from harvesters will be considered. This approach would be outside of the more formal tissue collection process described above.

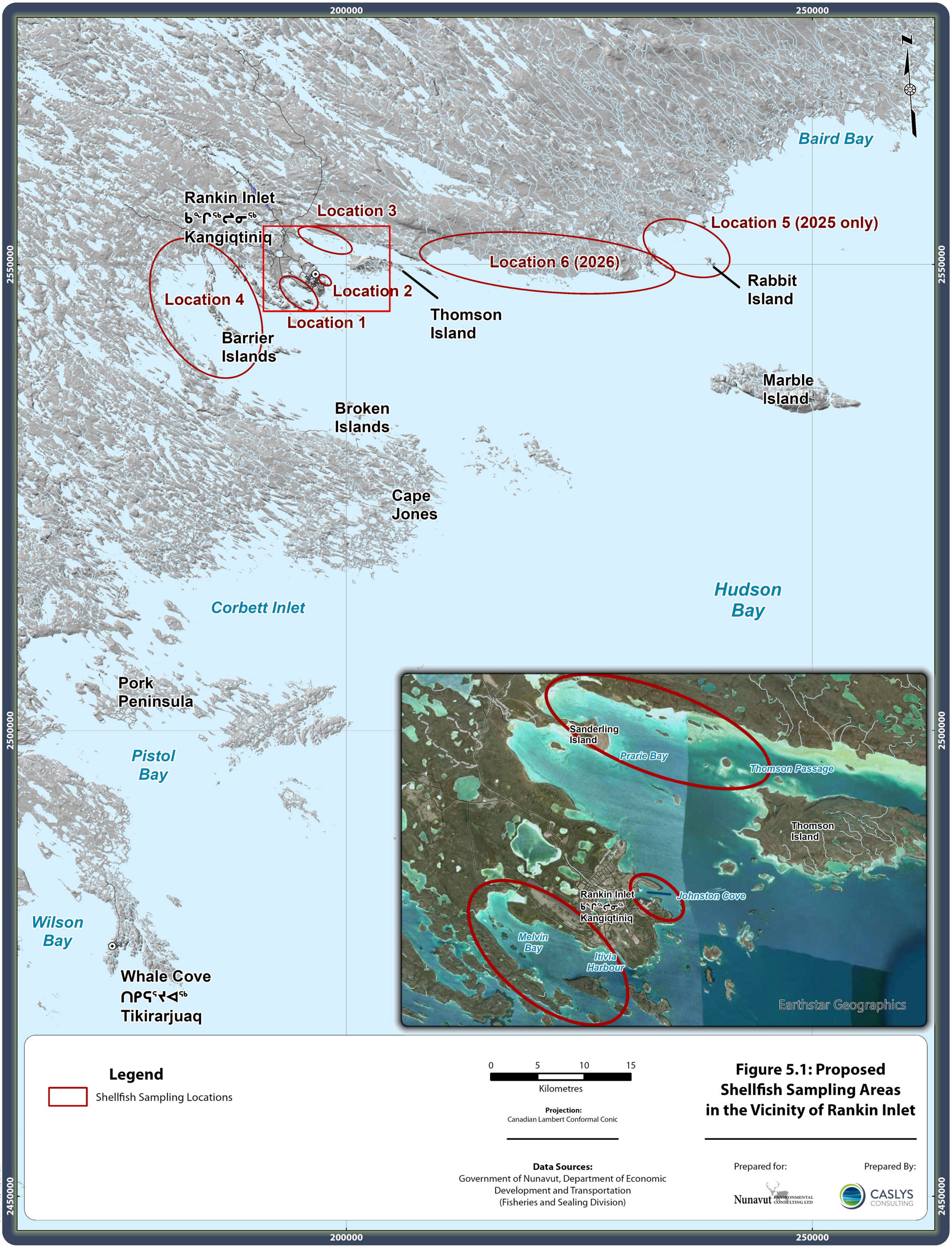

Figure 5.1: Proposed Shellfish Sampling Areas in the Vicinity of Rankin Inlet

5.7 DATA COLLECTION DETAILS

Key data that need to be collected are described below. To guide QEL and Agnico Eagle staff, a Standard Operating Procedure, which includes a Job Hazard Analysis, will be updated by NEC prior to the 2026 tissue sampling period.

5.7.1 Shellfish Tissue Sampling

The primary focus of tissue sampling in 2026 is to gather baseline information on shellfish (focus on Blue Mussel; Beyer et al. 2017) tissue health at five (5) fixed locations (see **Section 5.6**). Tissue samples will consist of **five (5) to 40 individual mussels** (see paragraph below), depending on the contaminant being tested and the size of the mussels. Mussels need to be shucked on site, rinsed, drained, and handled/stored as per laboratory requirements. Collection of Blue Mussel samples will mirror traditional harvest methods.

For **metals** testing, one (1) Blue Mussel tissue sample will be collected from each of the five (5) sites within each of the five (5) locations. Each tissue sample will consist of five (5) individual mussels. Sampling will be conducted three (3) times per year (see **Section 5.6**), resulting in a total of 75 tissue samples (375 mussels) annually.

For **fecal coliform** testing, two (2) water samples will be collected from different sites within each of the five (5) locations. Sampling will occur three (3) times per year (see **Section 5.6**), resulting in a total of 30 water samples annually.

For **biotoxin testing**, one (1) Blue Mussel tissue sample will be collected near the centre of each of the five (5) locations. Each tissue sample will consist of 20 to 40 individual mussels, depending on size. Sampling will occur three (3) times during the year (see **Section 5.6**), resulting in a total of 15 tissue samples (approximately 300 to 600 mussels) annually.

5.7.2 Catch-per-Unit-Effort

Catch-per-unit-effort is a semi-quantitative estimate of the relative size of the populations of shellfish species. The assumption is that if the population size and sampling method has not changed, then it should be possible to collect the same (or similar) numbers of shellfish for the same amount of time invested in collecting them. Tracking this statistic over time provides information on whether the population is increasing or decreasing.

Key data to collect are: a) time spent collecting samples; b) sampling methods; and c) number of people involved in the collections.

5.7.3 Shellfish Community Composition

The shellfish community composition involves estimates of the relative proportions of various species within the shellfish community at each collection site. Changes in composition are further evidence of changing population sizes but also will provide information on the effects of possible introductions of invasive species, changing habitats, and climate conditions.

Key data to collect are: a) species identification; and b) counts or relative percentage of each species.

5.7.4 Age Structure & Growth Rates

Changes in the relative numbers of older/larger and smaller/younger individuals of mussels, and the relative age for the size of shellfish, can indicate changes in the health of the population, and the potential for over-harvesting.

Key data to collect are: a) counts of annuli (rings) on shells; b) shape characteristics (i.e., length, width, depth); and c) weight. The age of collected mussels will likely be placed within defined age categories.

5.8 SAMPLE PRESERVATION AND SHIPPING

All 75 Blue Mussel tissue samples collected over the course of 2026 for metals testing need to be stored on ice immediately and shipped in a cooler to a designated analytical lab. Chain of Custody forms or similar forms, which will be provided by the selected analytical lab, need to be completed for each sample so that analytical results can be tracked carefully. Water samples collected for fecal coliform analyses need to be shipped at around 5^{0}C and ideally arrive at the testing lab within 24 to 48 hours. For biotoxins, in-situ testing will be conducted; therefore, freezing samples will likely not be necessary. If an option for laboratory testing is confirmed for biotoxins, sample preservation and shipping will be similar to samples collected for metals testing.

The tissue sampling team (e.g., QEL), with the support of Agnico Eagle and NEC, will need to coordinate details with an accredited laboratory, prepare sample labels, complete Chain of Custody forms, securely package samples for transport, secure and seal coolers, coordinate transport and courier/cargo pickup, and follow-up with the analytical lab following shipping.

5.9 ANALYTICAL APPROACH

5.9.1 Overview

Under the CSSP program, Environment and Climate Change Canada is responsible for measuring sanitary components (e.g., fecal coliforms) while the Canadian Food Inspection Agency (CFIA) measures the level of marine biotoxin levels (e.g., paralytic shellfish poisoning [PSP]). Understanding the contaminants in shellfish, as they would be consumed by community members, is of greatest importance. Since Blue Mussel is the most harvested shellfish species in the Rankin Inlet, and because it has been identified as a good bio-indicator of contamination (Beyer et al. 2017), tissues from this species will be sampled again in 2026.

The basic framework of the CSSP provides guidance with regards to sampling water and shellfish meat for monitoring for contaminants and toxins. The purpose of the CSSP is to provide reasonable assurance that shellfish are safe for consumption as food within the tidal waters of Canada. This section intends to describe the main components of the CSSP and contaminants of concern that should be assessed for the Meliadine SHMP.

5.9.2 Bacteriological (Fecal Coliform) Contamination

Bacterial contamination of the aquatic environment occurs through the release of untreated or insufficiently treated sewage. When a shellfish bed is contaminated by fecal bacteria, shellfish can filter concentrate these bacteria in their gut. Fecal bacteria have no effect on shellfish survival or growth, but they can make them unsuitable for human consumption. Bacteriological examination of shellfish can help determine the extent of bacterial contamination and can contribute quantitative data for the classification of harvest waters within the context of the CSSP.

Issues related to bacteriological contamination have been identified in the Arctic (Daley et al. 2018, 2022), including Rankin Inlet (Johnson et al. 2017) and Iqaluit (Schaefer et al. 2021).

Components to Analyze: Fecal Coliform (e.g., *Escherichia coli* [*E. coli*])

5.9.3 Marine Biotoxins

Harmful algal blooms (HABs) are naturally occurring phenomena caused by the overgrowth of certain phytoplankton species that produce biotoxins. These HABs are increasing in frequency and geographic distribution due to rising ocean temperatures, increasing cultural eutrophication (i.e., increasing nutrient inputs), and ballast water transportation of algae to new environments (Maso and Garcés 2006; Smayda 2007; McCarthy et al. 2015; Káradóottir 2024). Historically, the Canadian Arctic was considered not to be conducive for HABs, but recent studies suggest that the risk is increasing (Pućko et al. 2019, 2023; Lefebvre 2022; Káradóottir 2024). As well, the presence of salinity gradients in coastal areas can inhibit water column mixing, which can result in warmer surface water that would normally be cooled by mixing with colder deeper water.

As with bacterial contamination, shellfish are filter feeders that can concentrate marine biotoxin-producing algal species from the water column. The toxins produced by some algae are accumulated in the gut and/or meat of shellfish, and when ingested by humans can cause illness. These toxins are resistant to cooking or processing and cannot be detected by taste. Toxicity is dependent on concentration in the shellfish.

Types of marine biotoxins include: a) PSP (saxitoxin equivalents); b) Amnesic Shellfish Poisoning (ASP) (domoic acid), Diarrhetic Shellfish Poisoning (DSP) (okadaic acid and/or dinophysis toxins [DTX-1, DTX-2, and DTX-3], singly or in combination); and d) Pectenotoxins (PTX) (sum of PTX-1, PTX-2, PTX-3, PTX-4, PTX-6, AND PTX-11) (Cetinkaya and Elal Mus 2012; Murk et al. 2019).

Because the risk of harmful biotoxins is increasing in the Arctic, testing for marine biotoxin levels is proposed for 2026.

Currently, the CFIA has the only accredited laboratory in Canada with marine biotoxin testing methods within their scope of accreditation. Although Canadian businesses and organizations can request marine biotoxin testing for shellfish from CFIA laboratories, the facilities have limited capacity and are unlikely to respond to most requests. Recently, the CFIA has been working with the National Research Council (NRC), which has been mandated to develop the methodology and business case for private sector biotoxin testing. Discussions with NRC indicate that accreditation may occur in 2026. Because of the limited capacity of the CFIA and uncertainty around NRC accreditation, the primary approach for biotoxin testing in Rankin Inlet in 2026 will be to conduct rapid in-situ testing using test kits and readers developed by Sensoreal (https://sensoreal.com/), in collaboration with the CFIA. If NRC receives accreditation, options to conduct external laboratory analysis of biotoxins to coincide with in-situ testing will be explored.

Components to Analyze: Analysis of PSP, ASP, and DSP.

5.9.4 Trace Metals & Organochlorines

Consumption of fish and seafood are regarded as some of the main food sources responsible for chronic human exposure to some heavy metals, including arsenic, cadmium, mercury, and lead (Welfinger-Smith et al. 2012; Bosch et al 2016). These metals can accumulate in animal tissues and are widely distributed in marine environments. Higher levels of some heavy metals in shellfish can occur because of point source discharges (e.g., old nickel mine in Rankin Inlet) but can also occur due to altered food web structure due to altered nutrient cycling, invasive species, and global climate change. While it is not predicted that saline water discharges from the waterline project would contain notable amounts of these metals, mercury is a widespread concern for the safety of country foods from aquatic ecosystems in the North (Braune et al. 2005; Rigét et al. 2011; Morris et al. 2023).

Organochlorine compounds, including Dichlorodiphenyltrichloroethane (DDT), Polychlorinated Biphenyls (PCB), dioxin, and mirex, are also known to occur in the Arctic and may bioaccumulate in shellfish (Braune et al. 2005; Kuzyk et al. 2005; Hardell et al. 2010; Welfinger-Smith et al. 2012); however, the focus in 2025 will be to analyze a suite of metals in shellfish tissues.

Components to Analyze: Mercury, lead, nickel, other trace metals.

5.10 ANALYTICAL LABS

To follow CSSP protocols, all laboratories performing CSSP testing for regulatory purposes must use approved reference methods and be accredited to the international standard ISO/IEC 17025 "General Requirements for the Competence of Testing and Calibration Laboratories" by a recognized Canadian accrediting body. The laboratory's scope of accreditation must include methods specified by the CSSP.

The appropriate analytical labs for conducting metals and fecal coliform testing in 2026 are provided below. Discussions with these labs will confirm collection, storage, and tracking protocol, analytical tests required, costs, and reporting.

Metals (tissue samples)
Animal Health Laboratory
Laboratory Services Division
University of Guelph
Attn: Specimen Reception
Building 89, 419 Gordon St.
NW Corner Gordon/McGilvray
Guelph, ON N1G 2W1

Fecal Coliforms (water samples)
Mérieux NutriSciences
90 Gough Road
Markham, Ontario L3R 5V5

Biotoxins (tissue samples)
Possibly National Research Council

SECTION 6 • LONG-TERM MONITORING APPROACH

The intent of the SHMP is to develop a long-term community-run monitoring approach for shellfish health and shellfish harvesting in the Rankin Inlet area. A long-term strategy will be developed following further community engagement with the local community, and discussions between Agnico Eagle, KWB, and other municipal (KHTO) and territorial organizations like the Kivalliq Inuit Association (KIA). Components of a long-term monitoring approach may include:

- Monitoring shellfish catch-per-unit-effort over time to track population trends, impacts of invasive species, and/or changing habitats;
- Monitoring shellfish community composition, age structure, and growth rates over time;
- Collecting consistent datasets;
- Conducting regular contaminant monitoring;
- Facilitating information sharing with the community of Rankin Inlet (e.g., website, app etc.);
- Holding regular community meetings and promoting community involvement (e.g., fall cook-out);
- Regularly evaluating the program approach and outcomes; and
- Determining when the program can be fully supported by the community of Rankin Inlet.

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APPENDIX A

Minutes from Community Meetings

February 28, 2024

Location:

Kivalliq Wildlife Board (KWB) office in the community of Rankin Inlet

Participants:

Maria Kasaluak (KWB)

Kyle Conway (Agnico Eagle)

Minutes:

The objective of the meeting was to provide regulatory context (PC T&C 133), have a general discussion on the program, and answer the following questions:

- Who should be involved in the program design?;
- Who should be involved in the initial implementation?; and
- Who could eventually support the program within the community?

A PowerPoint presentation was reviewed and discussed. As Maria is new to the position, additional context was provided on the Meliadine water management philosophy and why the waterline is required.

A discussion on who should be involved in the program design and implementation included:

- KWB is currently works with ArctiConnexion, who have trained a community member to take water samples (winter/summer) and maintain a local lab. Maria was not too sure of what they do but thought the company could be involved in either the program design or implementation.
- Maria stated that she and her partner recently graduated from the Environmental Technician program at Arctic College and would like to be involved. As KWB has minimal resources, KWB does not want to lead the program. Maria advised that the program is an Agnico Eagle obligation, and that development and implementation will be Agnico Eagle's responsibility. The KWB can be involved in any capacity that can be afforded (consulting or advisory role).
- Maria thought that the best way to get input on the program design would be to hold community consultation that targets:
    - Elders;
    - The KHTO;
    - Highschool students;
    - Interested community members;
    - Fisheries and Oceans Canada, as subject matter experts; and
    - ArctiConnexion.

- Maria stated that she recently attended the Technical Advisory Group (TAG) meetings and really liked the meeting format. She suggested that eventually a committee for this program could be formed with KWB acting as an advisor and providing input.
- Maria asked if there was any requirement for the KWB to provide any information to the NIRB and reiterated that Agnico Eagle is obligated to report on the program annually.
- Maria stated that the summer is very busy for community members (hunting, fishing, berry picking) and suggested having the consultation in October or November.
- Maria stated it would be of value to emphasize the food chain aspect. Not all people harvest shellfish, but they do harvest animals that eat shellfish. The community might be more interested in that aspect.
- Maria stated the program name should be changed from shellfish to Uviluq (mussels). She couldn't recall the Inuktitut word for clams.
- Maria asked about logistics, equipment, and funding. Kyle advised that this would be supported in large part by Agnico Eagle and that these items can be discussed before the program is rolled out.
- Maria generally supported and liked the idea of the program. We reviewed the CSSP and proposed that the program framework could be based on this program.

Next Steps:

- Maria stated it would be good to have a conceptual program design to present again to the KWB for review and receive input before the community consultation.
- Once the program design is conceptualized, it could be presented to the community for IQ/TK in the fall.
    - Maria put great emphasis on the value of IQ/TK. She stated that it is better that IQ/TK inform science programs than science inform IQ/TK. There are generations of knowledge, while a scientific understanding of the land in the area is young. Information gathered is of great value to Inuit, and Maria emphasized the need to ensure that information collected is not used for the benefit of others who are not Inuit.
    - Maria suggested bringing lots of food and refreshments to community meetings as some Inuit don't know where their next meal might come from.

June 04, 2024

Location:

Community of Rankin Inlet

Participants:

Kivalliq Elders Advisory Committee (KEAC) and Agnico Eagle staff

Minutes:

Question: Where did you guys find shellfish in Rankin or somewhere in south?

Response: Program has not yet been implemented so we don't know where shellfish exist yet, but the focus is on Rankin Inlet and Melvin Bay.

Question: Can you clarify what organisms you are talking about?

Response: Blue Mussels and clams will be targeted but maybe there are other shellfish or species that you would be interested in

Question You said you were looking around Rankin Area but what area in the sea are you looking at?

Response: Kyle has a map to look at but in general we are looking at the Itivia Harbour and Melvin Bay areas. We have a permit commitment to look at shellfish, and during discussions with the KWB, they suggested we look at shellfish because we are already looking at fish with other programs. We thought KHTO should be involved as well and not sure who else. We would like to know if the community feels like it's something worth pursuing.

Comment from Community member: Been wondering if contaminated shellfish would affect other sea life or organisms that would eat the shellfish.

Response: Originally, we intended the shellfish monitoring to be focused on Human Health but if there is interest in ecological health and food chain effects, we could look at that as well.

Question: Has the discharge impacted saltwater presence in Meliadine Lake?

Response: All our monitoring programs are focusing on Meliadine Lake and other lakes around. We monitor water, sediment, benthic organisms, and fish health within the Aquatic Effects Monitoring Program program, which is captured within the annual reports. We do not monitor shellfish in Melvin Bay.

No saltwater gets discharged to Meliadine Lake or any of the lakes around Meliadine that is why we are building a discharge line for saltwater discharge to Melvin Bay.

Question: In reference to the pipe, I am aware that it was not going to Meliadine Lake but what about downstream effects on nature from the marine discharge? What will be the scientific updates and who will be informing us of these updates if nature has been affected?

Response: We are creating this shellfish monitoring program to help determine whether these changes occur naturally (natural cycles or climate change) or because of the mine. The KIA also monitors to understand the impacts to water and fish. One item that was identified is monitoring other components of the environment, and that is why we suggested shellfish.

Question: I wanted to ask if the organisms that fish feed on (bugs and invertebrates), will they also get impacted by exposure to mine effluent and do they eat the same food as the shellfish?

Response: No, mussels and clams are filter feeders meaning they filter food that passes through their open mouths. They do not eat bugs or aquatic organisms in the sediment.

Question: Why are you suddenly studying these shellfish - just curious if you were aware that others were doing a similar practice in Arviat?

Response: Not aware of other studies going on in Arviat but this came up during the permitting process. It is not a requirement but something we would like to do and see the community take over and continue to monitor.

Question: In the mid-80's, there were studies conducted on scallops. They found it to be an opportunity to study and get baseline results. They found the scallops to be healthy, but the KHTO committee had concerns and kept requesting for scallops to be investigated further. That's why we wanted to get a better idea. Shellfish are slightly different than scallops. Please be aware of these differences and that the federal government KIA, University of Winnipeg, and other people do arrive at the communities to have a closer look at all kinds of things, including studying the conditions, movement, and salt concentration. Everything is changing and being studied.

Response: Those are the pieces of information that we need. If the program needs to be changed, we can do so and can talk to our consultant and change it.

Question: I just wanted to add to the seashell topic for Rankin Inlet. Mussels are more in numbers in Rankin Inlet. As for the scallops, they are a little harder to catch. Because of that, mussels are easier to access. Community members like to go out and collect mussels. But the first mine that existed in Rankin destroyed an area. The environment was impacted and the mussels in the area were not edible anymore because of the impact of the mine. The mussels in the Itivia area are probably impacted now. I haven't seen it myself, but there are impacts through chemicals along the shore. We are aware because it has been seen and it has been mentioned. We are not aware if these impacts are negative to the mussels, but I wanted to make sure to mention that the nickel mine outside of Rankin Inlet definitely had an impact on mussels.

Response: This is the kind of information that we would like to have from the community as Agnico Eagle has only been operating there for a short period of time. A monitoring program allows us to monitor the impacts today (baseline) and what the impact may be in the future.

Question: As soon as you get reports of what is being collected, please share with community right away?

Response: That is the spirit of the program depending on how much harvesting is done and if people are willing to contribute and tell us which area they got the shellfish from. We would like to map out and identify the areas where shellfish are good or bad, and as soon as the results come in we can share information with the community. We hope to determine if it is a natural change or a mine change, so if it is related to the mine, we can make changes right away.

Question: As I am starting to hear this, it's becoming interesting to me as the mine extended west. Back in 1992, we sat around with our regional health board and said fish from lake were contaminated with mercury. At the time, we didn't ask a lot of questions and today we're more involved. How does the mercury in fish get made in Peter Lake? A cousin got diagnosed with mercury poisoning from eating mercury fish and Peter Lake had high mercury.

Response: There is a Natural Resources Canada study going on now. A naturally occurring thing is happening where mercury is increasing due to climate change because temperatures are increasing, the permafrost is melting, and mercury and other things are getting into the lakes. The federal program is looking at that and not Agnico Eagle, so we cannot comment on levels in Peter Lake.

Question: Just wanted to ask about phenomenon of the Elders having a craving, especially when not well, for aged Beluga (*Delphinapterus leucas*), Walrus or fish from lakes. I was wondering if you were aware of the edible (country) food assessments from there to now (i.e., difference between historical and current quality of meat from lakes)? Our Elders also have specific preferences for different wildlife/fish from different parts of the lake and different depths.

Response: Those types of studies are not being conducted by Agnico Eagle.

Question: When snow starts to melt, there used to be water and now it seems to evaporate now and not flow. Are there any studies about snow melt?

Response: Agnico Eagle has a weather station that monitors snowfall, but it does not monitor evaporation or overland flow and compare it to the past.

Question: Why would we see more evaporation now to the past?

Response: I am not sure, as it is not something that Agnico Eagle monitors.

Question from Kyle: Is there a window of when we should be harvesting shellfish?

Response from Community Member: Usually around fall time is the best time to start hunting and fishing. Harvesting in spring is not the best; not too familiar with spring season but the healthiest time is the fall season.

Comment from Community Member: I just wanted to add that wildlife during the fall time tends to be healthier and fatter, and that is when we would go to collect mussels.

Response: Thank you, that is the information we need regarding harvesting shellfish, which will inform when to do the sampling.

Question from Kyle: Would anyone be interested in coming out to the site to show us where to harvest shellfish in Melvin Bay/Itivia Harbour and to talk about the locations to avoid?

Response: Yes, a few Elders would be interested in supporting with that.

Additional Comment at Break: Community member notices that the (anadromous) fish (Arctic Char; *Salvelinus alpinus*) at the outlet of the rivers into the ocean have thin skin in the spring and as they acclimate to the salt water by moving in and out of the saline water, their skin changes and becomes tougher and thicker and then they can swim in the ocean.

November 15, 2024

Location:

Standby room at the Rankin Inlet airport.

Participants:

Community members from Rankin Inlet (10 individuals), Kyle Conway (Agnico Eagle), Edward Malindzak (Agnico Eagle), and Derek Irwin (Quamajuq Environmental Ltd.; QEL).

Minutes:

Three maps were placed on a table in the center of the room, one the coastal area of the Kivalliq extending from Whale Cove to Chesterfield Inlet, another showing the greater Rankin Inlet region, and the last a closeup of Rankin Inlet, Melvin Bay, and surrounding areas.

Agnico Eagle started with an introduction and a brief slide presentation. Derek Irwin (QEL) introduced himself and provided some background on himself and his environmental consulting firm.

Agnico Eagle presented three shellfish species of interest (Blue Mussel, Truncate Softshell Clam, and Northern Horsemussel) and asked attendees a series of questions:

- Do they or anyone they know harvest these mussels?;
- What time of year do they harvest?; and
- How do they prepare the mussels to eat?

Agnico Eagle then asked participants to mark on the maps where they harvested mussels and what type of mussels were harvested in those locations. The following is a summary of the comments participants made during this exercise.

- I don't pay attention to the species. I just eat them.
- Softshell mussels are not collected much.
- Harvest is typically during the fall when the mussels are larger.
- Some harvesters ride their All-Terrain Vehicles to the shore and wait for low tide to harvest mussels.
- One spot just past Tent City (uncertain name) has been harvested in the past.
- Nobody flushes mussels in a bucket of salt water prior to consuming them.
- Mussels taken from a Walrus stomach are good (Daniel).
- Sometimes mussels are eaten right away, either raw or boiled.
- Mussel harvesting is not done close to town; it must be far away.
- One man's grandmother eats the softshell mussels, but not him.
- They don't collect mussels near town because of the old nickel mine and sewage.
- Yes, they collect Blue Mussels and Northern Horsemussels, often filling three or four large Northern Store shopping bags at a time.
- They collect larger mussels and leave the smaller ones to grow.

- Some harvest closer to town, but not any of the participants.
- Shellfish collected near town are smaller and will make you sick.
- Shellfish collection is better where there is seaweed.
- It's bingo night, we should not plan these events on bingo night.
- Softshell mussels are collected at Repulse Bay (Daniel).

Meeting participants were asked to mark up a map to identify known and potential shellfish harvesting areas. Blue Mussel was identified as occurring in Prairie Bay, south of the Barrier Islands, along the shorelines of Crane and Mirage islands, and the northeast end of Marble Island. The mainland shoreline east of Thomson Island and shorelines of Melvin Bay were identified as locations where Truncate Softshell Clam could be found as were shoreline areas around Park Peninsula and Corbett Inlet. Mainland areas north of Rabbit Island were identified as being areas where Northern Horsemussel could be found.

November 11, 2025

Location:

Community of Rankin Inlet.

Participants:

Kivalliq Elders Advisory Committee (KEAC) and Agnico Eagle staff

Minutes:

Agnico Eagle staff provided an update on the mussel monitoring program, which checks for contamination and overall health of shellfish. Staff explained that the program aims to expand with more community involvement and could create opportunities for Inuit to collect samples. Marble Island was identified as a potential monitoring site for next year. Plans to engage youth through school programs as part of capacity building was also discussed.

Elders' responses and key insights:

- Expressed appreciation for programs that protect traditional food sources, noting it shows respect for Inuit lifestyle;
- Highlighted the cultural importance of mussels as a food source and supported monitoring at Marble Island; and
- Welcomed the idea of involving high school students in environmental monitoring to strengthen intergenerational knowledge sharing.