



TECHNICAL MEMORANDUM

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TO William Best, P.Eng.
Vice President – Major Projects
Triple Point Resources

FROM Reinier Tromp, Wayne Ingram, Manoj
Gangadharan, Lisa Lee, Sundar Prasad, Helen
Jenkins, Shane Tobin

EMAIL reinier.tromp@wsp.com

CA0058602.1877 TRIPLEPOINT SALT CAVERN PRELIMINARY INTAKE AND OUTFALL DESIGN FCH-FS-ALL-DRW-0004

1. INTRODUCTION

Ports, Marine and Coastal (PMC) was tasked with developing a preliminary intake and outfall structure design for the TriplePoint Salt Cavern, located on the Bay of St. George on the southwest side of Newfoundland (see Figure 1). The project site will be referred to in the remainder of this memorandum as “TriplePoint”.

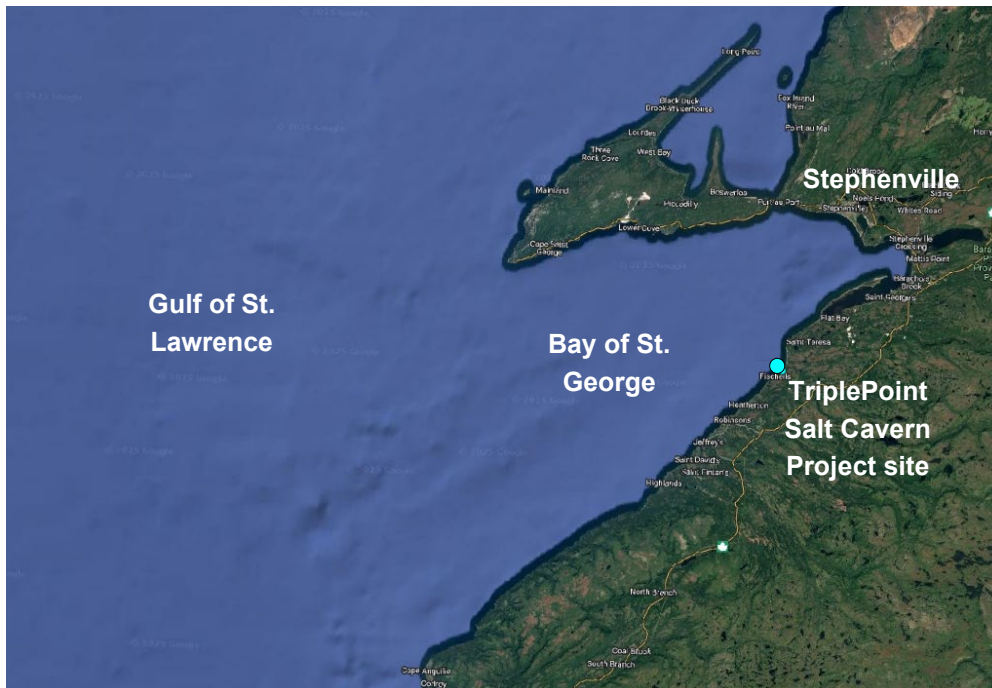


Figure 1: TriplePoint Salt Cavern project site on Bay of St. George.

The proposed salt cavern is assumed to take in seawater from the Bay of St. George through an offshore underwater intake structure, and the outfall will discharge brine back into the bay. The goal of this preliminary study is to determine the following:

1. Intake and outfall locations in the Bay of St. George.
2. Intake structure design and outfall diffuser design.

It should be noted that seabed elevations and water levels mentioned in this memorandum are referenced in meters Chart Datum (CD). The spatial reference system used is WGS84 UTM21N (EPSG 32621). In Section 2, an overview of the available data is provided, followed by the intake and outfall design in Section 3, the recirculation study with the proposed intake and outfall location in Section 4, conclusions in Section 5 and finally a list of references used in this memorandum under Section 6.

2. DATA OVERVIEW

In the upcoming sections, an overview of the available bathymetric and metocean data, and their respective data sources, is provided.

2.1 Bathymetry

Publicly available bathymetric data (NONNA) from the Canadian Hydrographic Service (CHS) was used for the Bay of St. George and part of the Gulf of St. Lawrence (CHS, 2025). Since limited NONNA bathymetric data was available in the vicinity of the proposed TriplePoint Salt Cavern, this data was supplemented with nautical chart data (Nautical Charts, 2025). An overview of the combined bathymetric data sets is provided in Figure 2. The resulting bathymetric dataset is considered adequate for the preliminary design of the TriplePoint intake-outfall system. For more detailed studies though, it is recommended to execute a bathymetric survey.

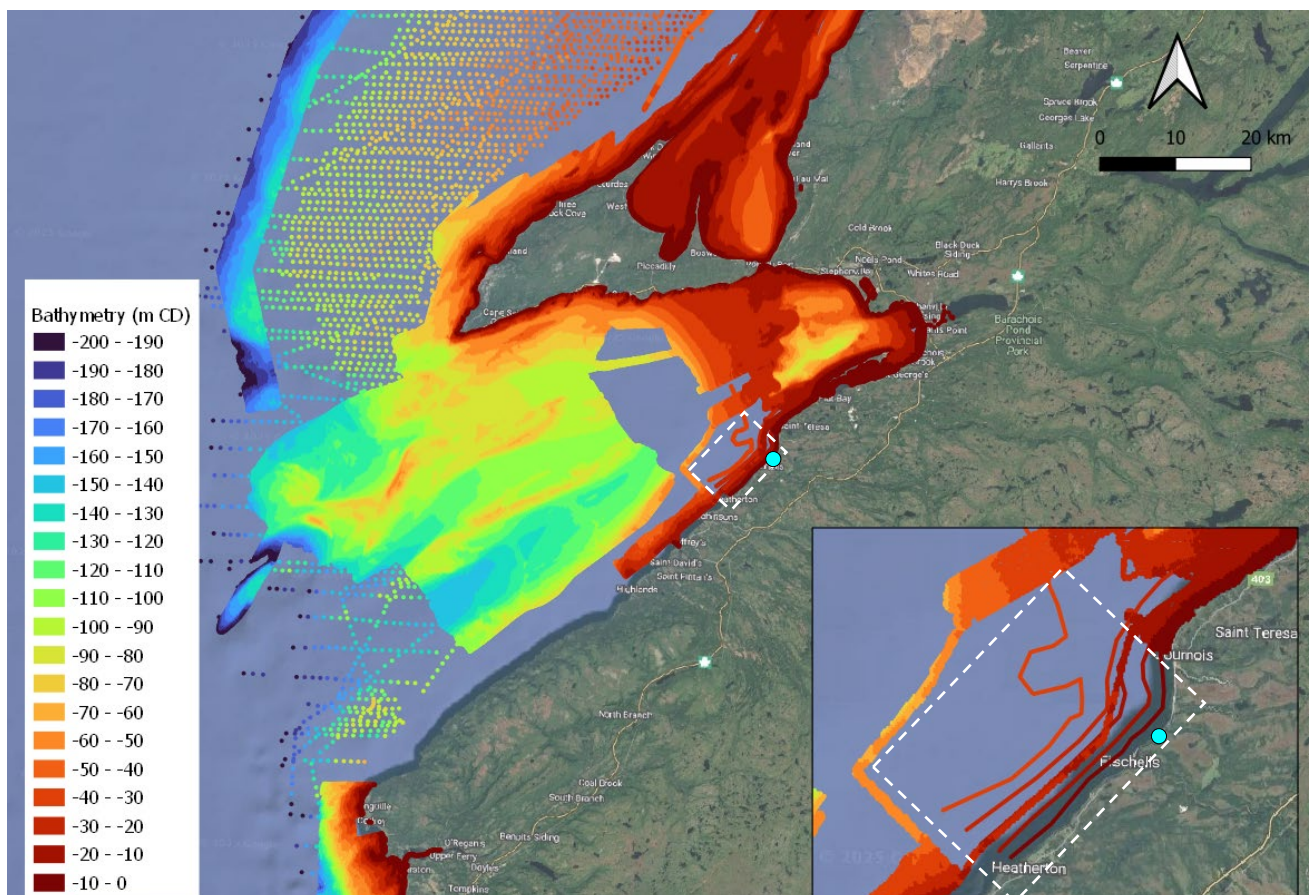


Figure 2: Overview of available bathymetric data. The white dashed box represents the location of the supplemented bathymetric data set originating from nautical charts. The TriplePoint well locations are shown with cyan dots.

2.2 Wind

Several Environment and Climate Change Canada (ECCC) wind measurement stations are present in the vicinity of the project site (ECCC, 2025a). Of these, Stephenville Airport (Stephenville A) was chosen for this study, since it has the longest record of data (1959-2025) and is located close to the Bay of St. George, see Figure 3. It is located approximately 25 km from the project site. Stephenville A has data records between 1959-2014 (station ID 6740) and 2014-2025 (station ID 52759), since in 2014 the measurement station was relocated approximately 1 km north of the earlier location.



Figure 3: Locations of the Stephenville A wind measurement station (yellow), buoy IML-10 (red), and the Mike3 model extraction location for water levels and currents (green). The TriplePoint well locations are shown in cyan.

Hourly-average wind speed and direction data at hourly intervals was downloaded for Stephenville A, see Figure 4. Data gaps less than 12 hr in duration were filled using linear interpolation. Statistics of the post-processed wind data are shown in Figure 5 and Figure 6. It can be observed that the most frequent winds are from the west and west-south-west sectors. The strongest wind events are from the west and east sectors. Highest recorded hourly-average wind speed was 25.8 m/s and approximately 92% of wind speeds were lower than 10 m/s. Wind speeds lower than 0.5 m/s occur less than 0.01% of the time and were designated as calm conditions in this study in accordance with the Beaufort wind scale. Average wind conditions were assessed to be 5 m/s.

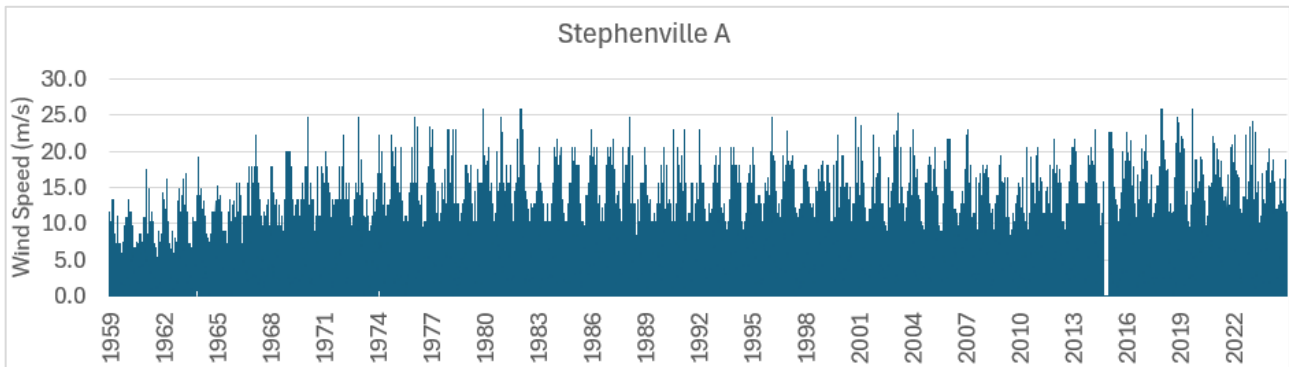


Figure 4: Measured wind data for Stephenville A station.

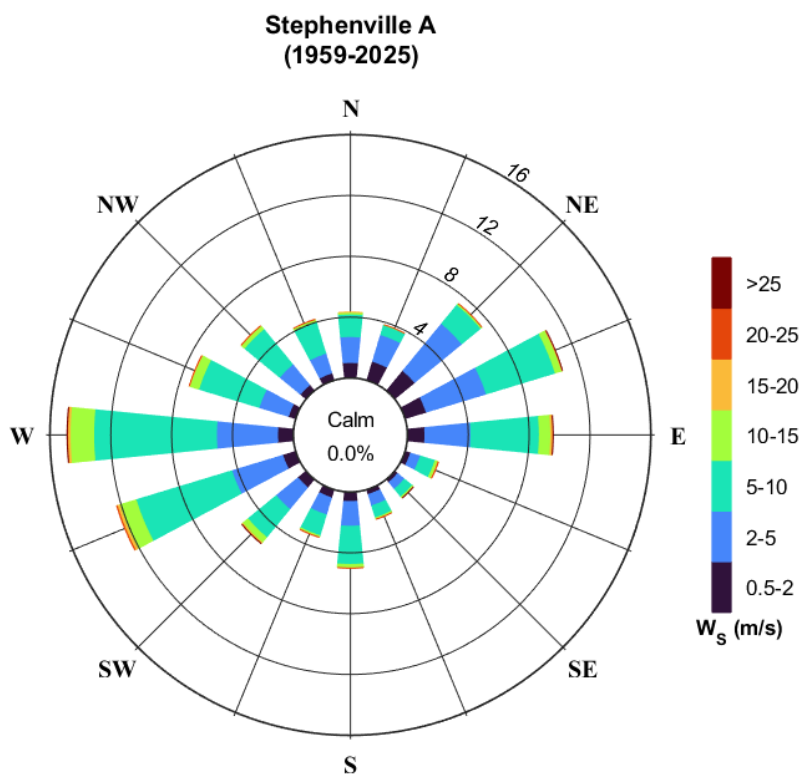


Figure 5: Wind rose for Stephenville A station.

Wind Speed Distribution

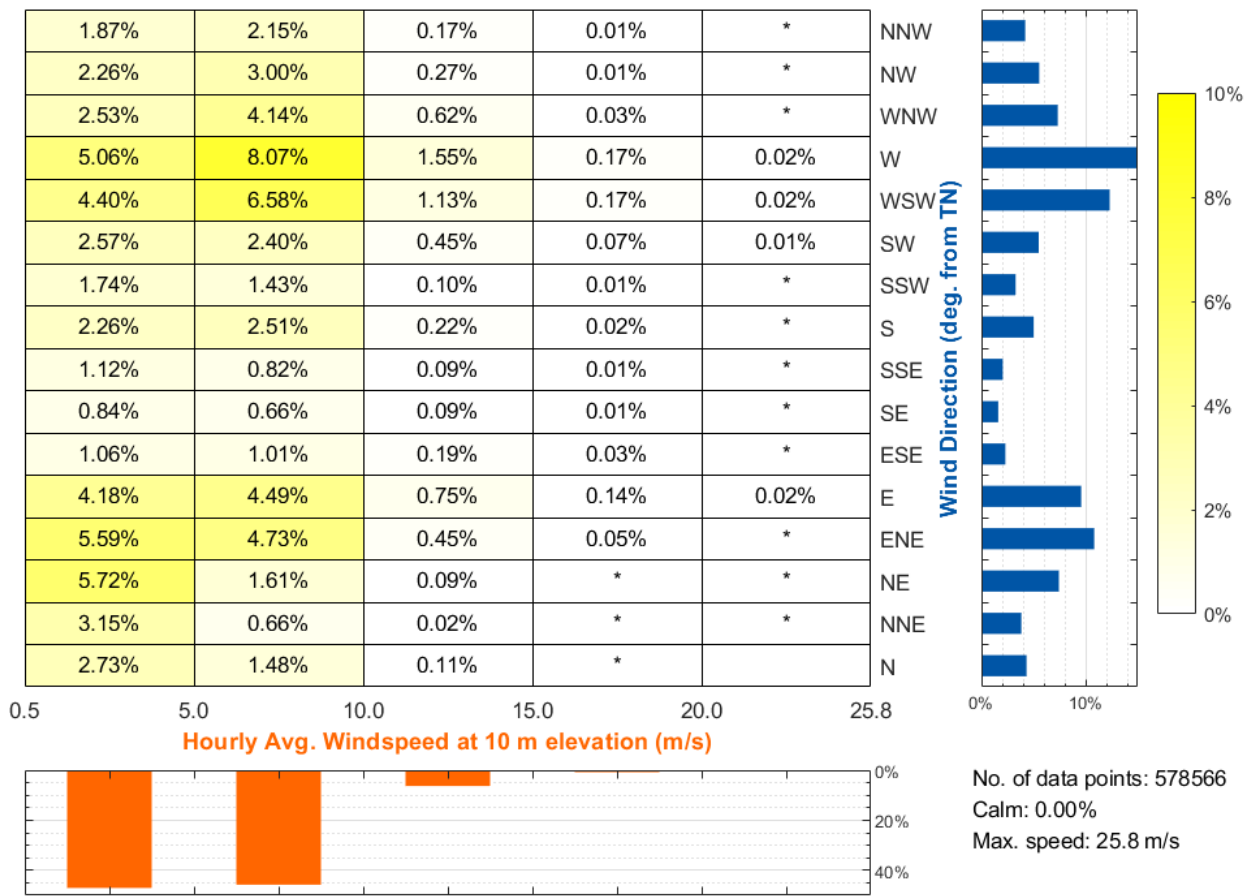


Figure 6: Scatter table showing wind speed and direction at Stephenville A station.

Annual maximum wind speeds were fit to a GEV distribution to estimate the extreme omnidirectional wind speeds for a range of return periods, see Figure 7 and Table 1. The black line in the plot shows the best fit estimate of the extreme wind speeds and the red and green lines show the upper (97.5%) and lower (2.5%) Confidence Intervals (Cis) for the estimates, respectively.

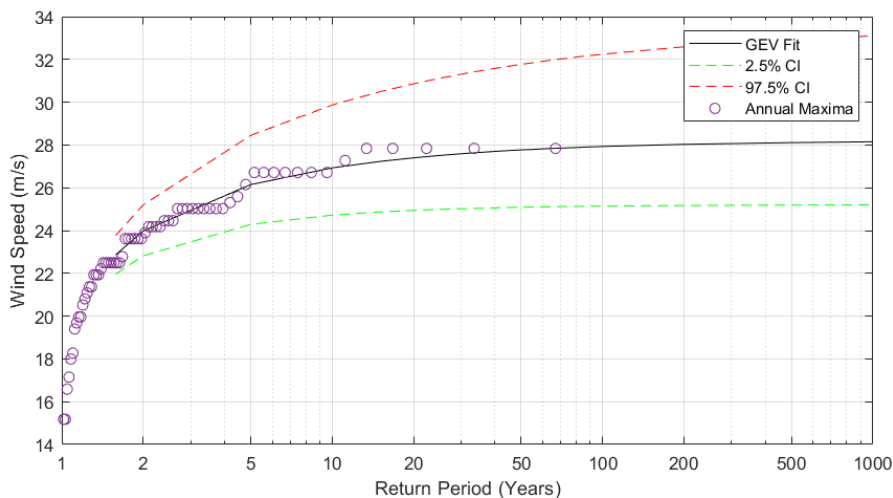


Figure 7: Estimated extreme hourly-average omnidirectional wind speed.

Table 1: Estimated extreme hourly-average omnidirectional wind speed for different return periods.

| Return Period (Year) | Wind Speed (m/s) |
|---------------------------------|-----------------------------|
| 2 | 24.0 |
| 5 | 26.2 |
| 10 | 26.9 |
| 20 | 27.4 |
| 50 | 27.8 |
| 100 | 27.9 |
| 200 | 28.0 |

2.3 Waves

Publicly available wave data from the Meteorological Service of Canada (MSC) was downloaded from the MSC50 wave model (ECCC, 2025b) in the vicinity of the project site. Wave data at three MSC50 grid points was analyzed (locations 013841, 014000, 014001, see Figure 8) for the period 1954 to 2018 (64 years). These MSC50 locations are between 8-11 km from the project site. It should be noted that for the purposes of this preliminary design study this data is considered sufficient for describing the wave climate in the area of interest. It is recommended that the nearshore wave climate be refined further by means of measurements and a numerical wave model (like SWAN or Delft3D-WAVE) for more detailed intake-outfall design studies.

It was determined that the hindcast significant wave heights are highest at location 014000 (see Figure 9). Statistics of the waves at location 014000 are shown in Figure 10 to Figure 12. The most frequent waves are incident from the west (W) and west-south-west (WSW) sectors. The largest waves originate from the west sector. Less than 2.2% of all waves at location 014000 are expected to exceed H_s of 3.1 m and T_p of 6 s. The largest hindcast H_s was 7.7 m with an associated T_p of approximately 12 s. These values were generated during a west-south-westerly storm in December 1972. H_s lower than 0.1 m occur approximately 4% of the time and are designated as calm conditions in this study in accordance with the Douglas Sea Scale.

From the largest hindcasted wave with an H_s of 7.7 m, a maximum wave height H_{max} of 14.6 m was calculated ($H_{max} = 1.9 * H_s$). Assuming a non-linear wave, with a trough that is longer and flatter compared to a linear wave, the trough was calculated to be 5.1 m ($= 0.35 * H_{max}$).



Figure 8: MSC50 output locations (magenta) and the TriplePoint well locations (cyan).

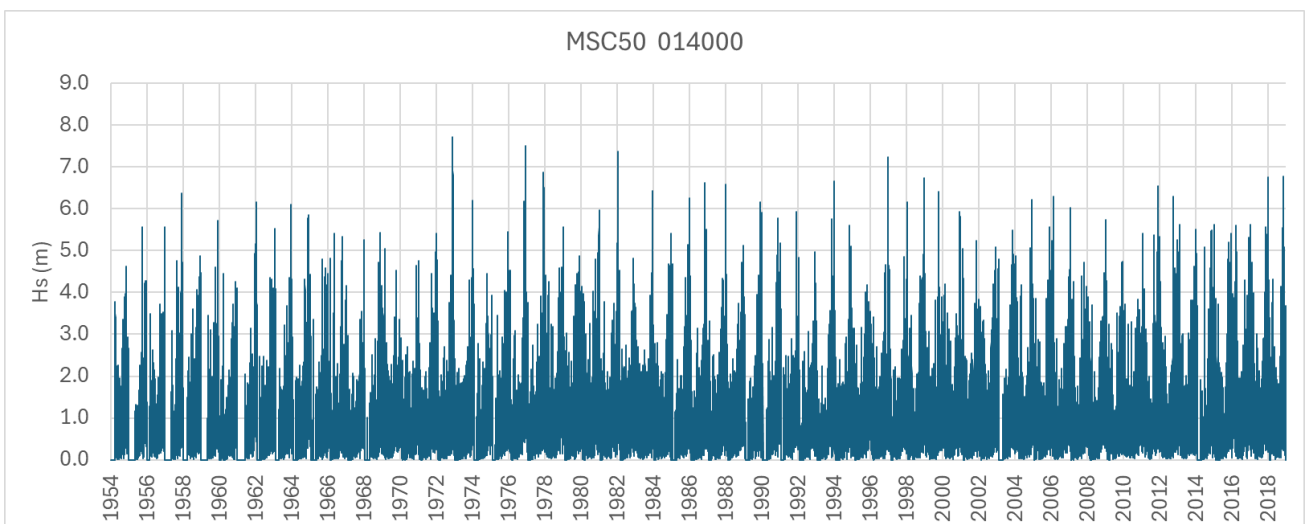


Figure 9: Hindcast wave data for location 014000 originating from the MSC50 model.

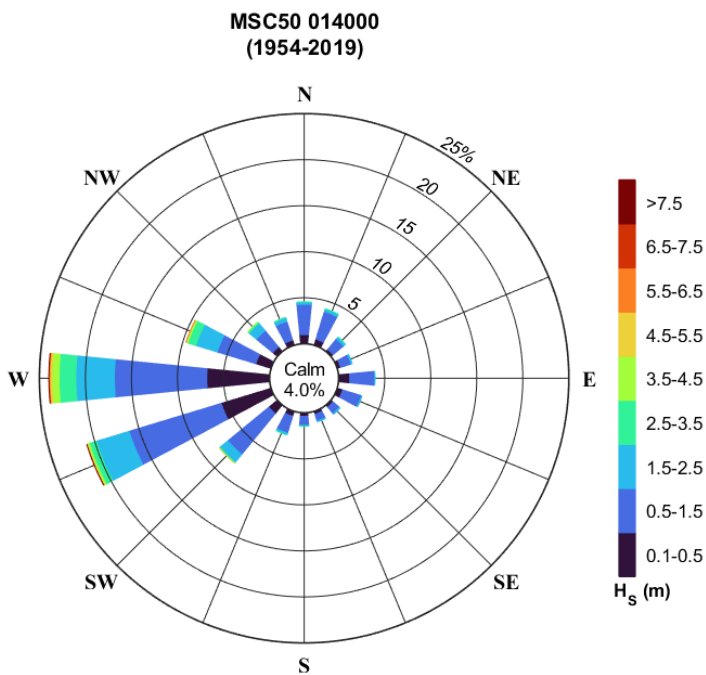


Figure 10: Wave rose of significant wave height for MSC50 location 014000.

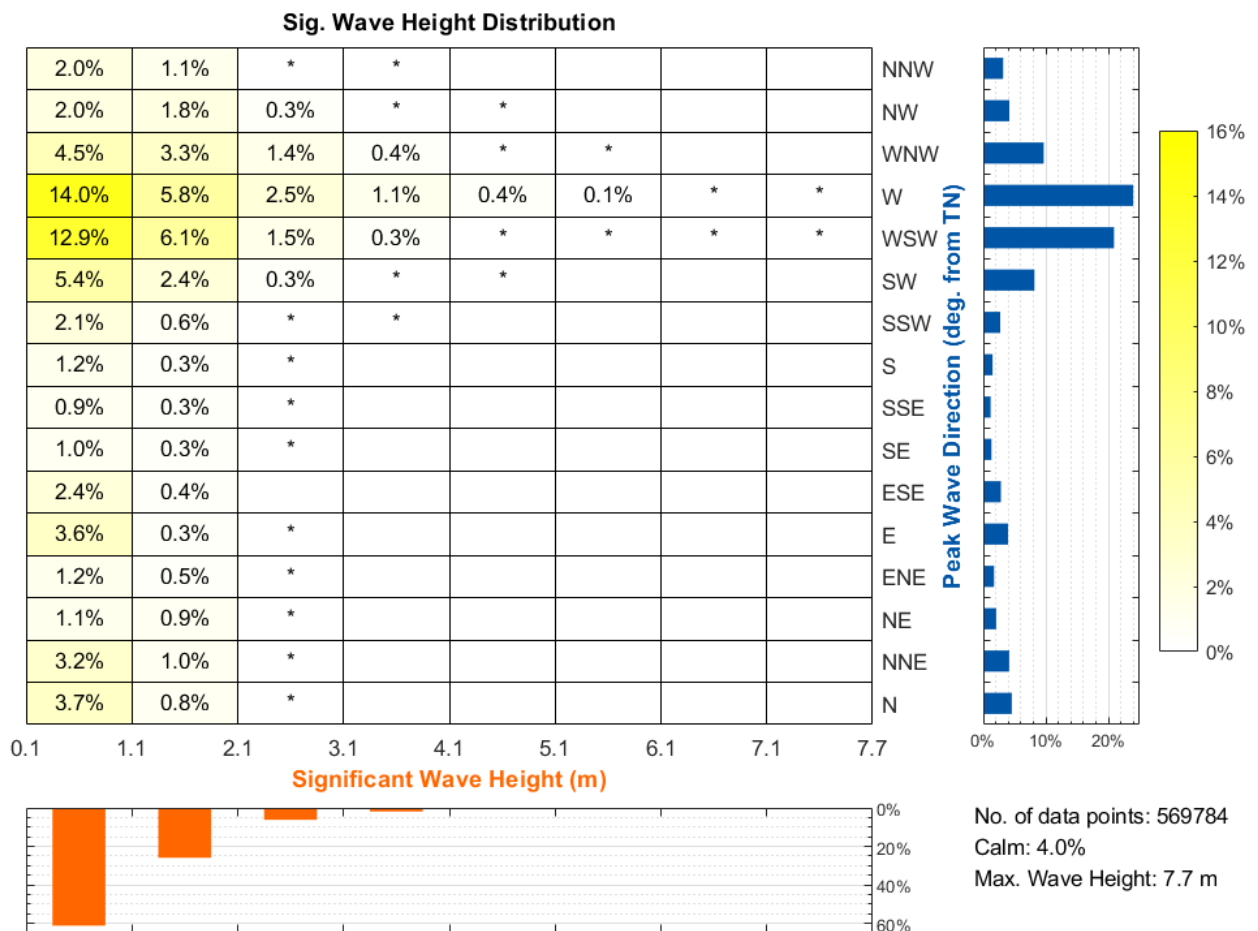


Figure 11: Bivariate distribution of significant wave height and peak wave direction at MSC50 location 014000.

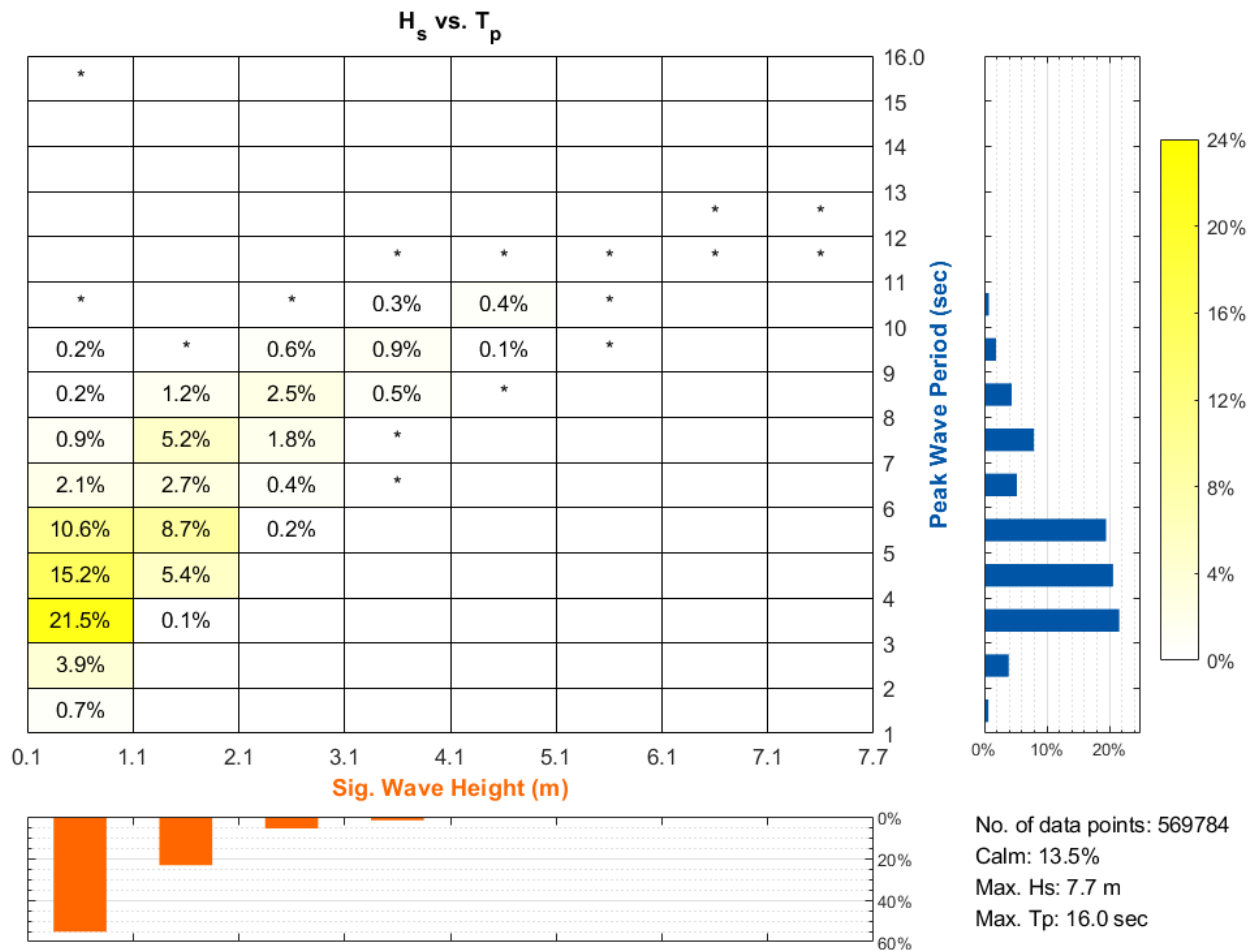


Figure 12: Bivariate distribution of significant wave height and peak wave period at MSC50 location 014000.

Annual significant wave height maxima from the 65 years of hindcast waves were fit to a Generalized Extreme Value (GEV) distribution to estimate extreme wave conditions incident at MSC50 location 014000 (see Figure 13 and Table 3). The black line in the plot shows the best fit estimate of the extreme wave heights and the red and green lines show the upper (97.5%) and lower (2.5%) Confidence Intervals (CIs) for the estimates, respectively.

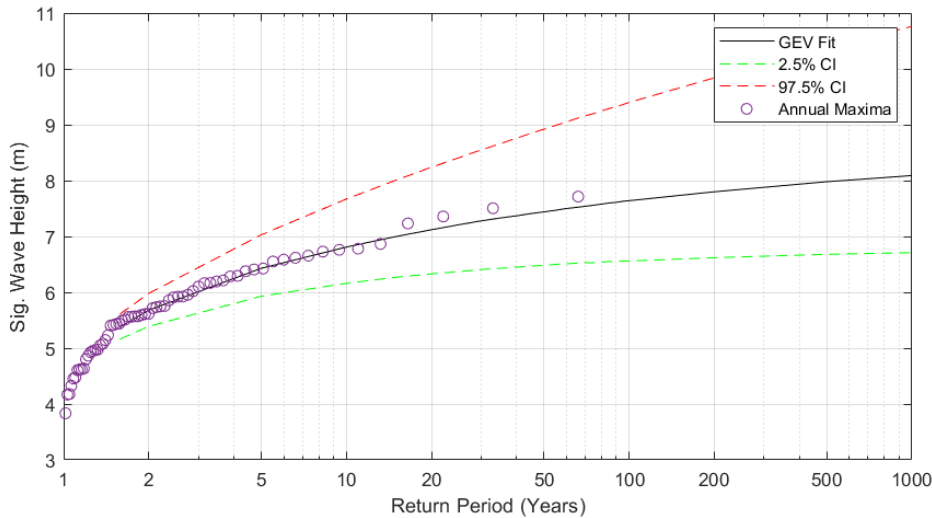


Figure 13: Estimated extreme significant wave height at MSC50 location 0140000.

Table 2: Estimated extreme significant wave heights at MSC50 location 014000.

| Return Period (Year) | Sig. Wave Height (m) | Peak Period (s) |
|----------------------|----------------------|-----------------|
| 2 | 5.6 | 9-12 |
| 5 | 6.4 | 12-13 |
| 10 | 6.8 | |
| 20 | 7.2 | |
| 50 | 7.5 | |
| 100 | 7.7 | |
| 200 | 7.8 | |

2.4 Water level

No tidal level measurements were publicly available in the vicinity of the TriplePoint project site. Tide tables for two locations near the project site with predicted tide levels were available though from the Department of Fisheries and Oceans (DFO) website (DFO, 2025); Crabbes River (ID 02725, located approximately 10 km southwest of the project site) and St George (ID 02720, located approximately 15 km northeast of the project site), see Table 4 below. Using a distance-weighted average, a predicted tide table was determined for the project site. It can be observed that Lowest Astronomical Tide (LAT) is 0.14 m, and Highest Astronomical Tide (HAT) is 1.82 m. The mean tidal range is 0.78 m (difference between Mean High Water and Mean Low Water).

Table 3: DFO tide tables.

| ID | Height (m CD) | | |
|--|-----------------------|---------------------|--------------|
| | Crabbes River (02725) | St. Georges (02720) | Triple Point |
| Highest Astronomical Tide | 1.96 | 1.60 | 1.82 |
| Higher High Water Large Tide | 1.94 | 1.58 | 1.80 |
| Mean Higher High Water (Higher High Water Mean Tide) | 1.60 | 1.32 | 1.49 |
| Mean High Water (High Water Mean Tide) | 1.50 | 1.22 | 1.39 |
| Mean Water Level | 1.10 | 0.82 | 0.99 |
| Mean Low Water (Low Water Mean Tide) | 0.72 | 0.44 | 0.61 |
| Mean Lower Low Water (Lower Low Water Mean Tide) | 0.61 | 0.33 | 0.50 |
| Lower Low Water Large Tide | 0.28 | 0.03 | 0.18 |
| Lowest Astronomical Tide (=CD) | 0.24 | 0.00 | 0.14 |

In addition, water level data in the Bay of St. George was extracted from WSP's calibrated and validated Mike3 model covering the Gulf of St. Lawrence, Gulf of Maine, and part of the Atlantic Ocean. This model takes into account storm surge and atmospheric pressure. Water level data at approximately 1 km from the project site (see Figure 3) in the Bay of St. George was extracted for the period 2015-2019, see Figure 14. It can be observed that water levels range between -0.06 and 2.20 m CD. It can be concluded that the largest difference between LAT and the lowest modeled water level due to meteorological influences (i.e. storm surge and atmospheric pressure) is 0.20 m.

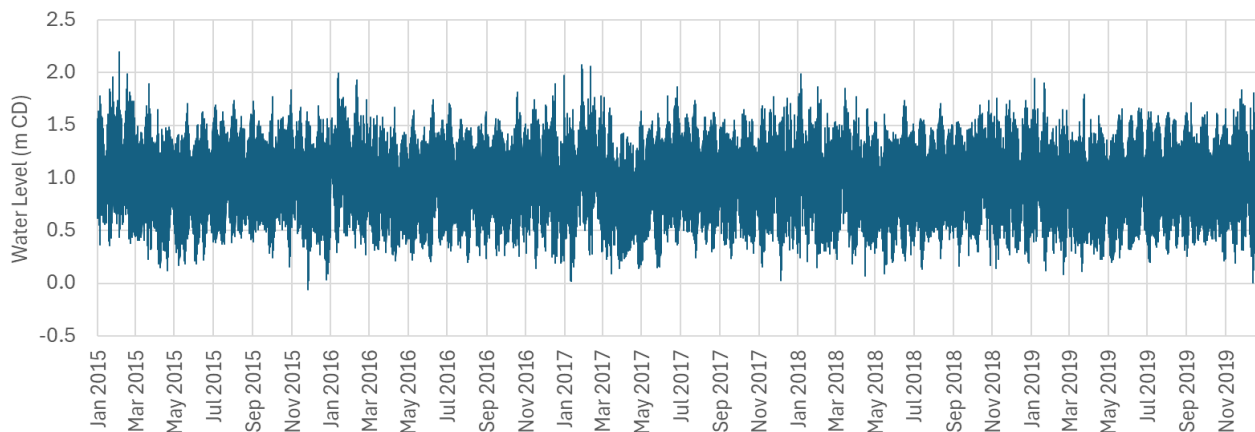


Figure 14: Water level data extracted from WSP's Mike3 model of the Gulf of St. Lawrence, Gulf of Maine and part of the Atlantic Ocean.

2.5 Current

No current data in the vicinity of the project site is publicly available. Therefore, current data near the project site was extracted from WSP's Mike3 model. Current data at approximately 1 km from the project site (see Figure 3) was extracted for the period 2015-2019, see Figure 15. It can be observed that current velocities can reach up to 0.63 m/s. Average current velocities are approximately 0.07 m/s. From the current rose in Figure 16, it can be concluded that currents are moving in alongshore direction (from SW to NE directions), predominantly towards the SW, whereas highest current velocities were modeled in NE direction. It should be noted that the Mike3 model within the Bay of St. George is coarse with a mesh resolution of approximately 6 km, in addition to the fact that the model was not calibrated against water level or current measurements within the Bay of St. George.

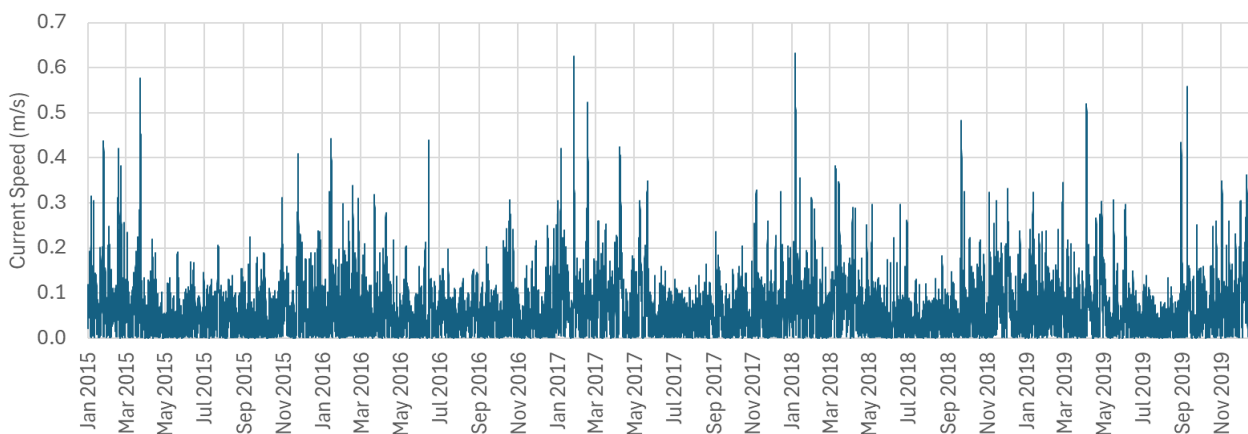


Figure 15: Current data extracted from WSP's Mike3 model at 1 km from project site, see green dot in Figure 3.

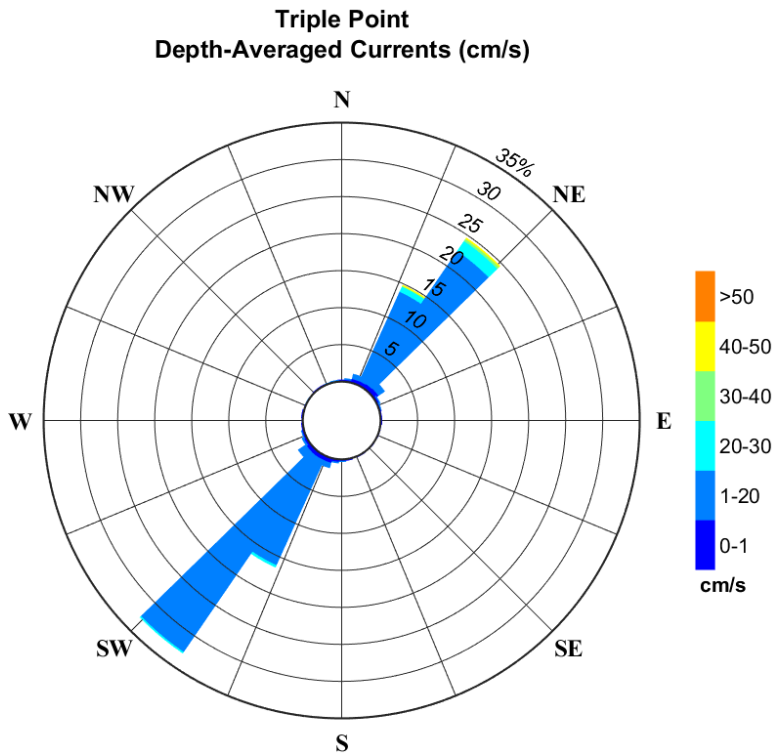


Figure 16: Current rose for TriplePoint location (values in cm/s).

2.6 Temperature & Salinity

Publicly available water surface temperature and salinity data from DFO's IML-10 buoy (see Figure 3) was downloaded and processed for the period 2015-2018 (OGSL, 2025). IML-10 is located approximately 120 km from the project site. It should be noted that for the purposes of this preliminary design study, this data is considered sufficient. It is recommended that water temperature and salinity measurements within the Bay of St. George are collected for more detailed intake-outfall design studies.

From the processed data, it can be inferred that surface seawater temperatures range between 4-23 °C, with highest water temperatures in July and August, see Figure 17. Salinity values typically range between 28-32 ppt, though some outliers can be observed in 2016 and 2018, see Figure 18. It can be observed that between October and May/June, no measurements tend to be collected for buoy IML-10 since they buoys are removed because of ice.

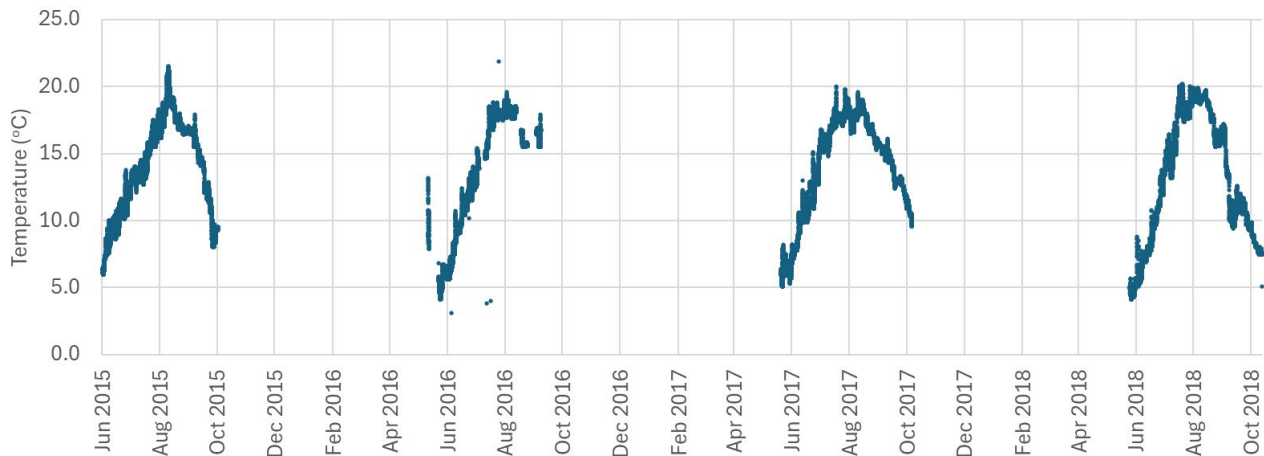


Figure 17: Temperature measurements in top of water column for 2015-2018 for buoy IML-10.

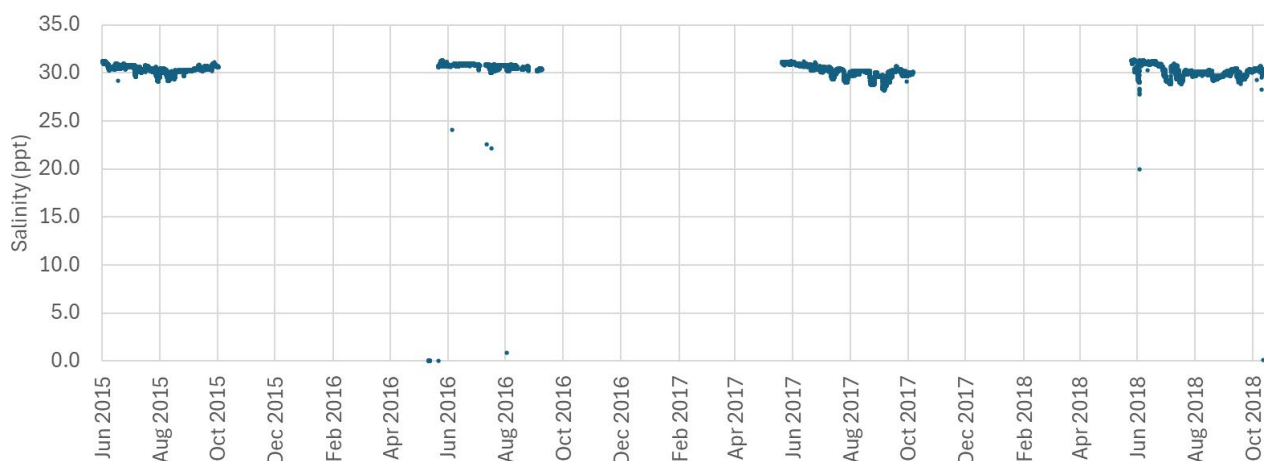


Figure 18: Salinity measurements in top of water column for 2015-2018 for buoy IML-10.

3. PRELIMINARY INTAKE & OUTFALL DESIGN

For the preliminary intake and outfall structure design, different engineering and environmental constraints were identified. Based on the identified constraints, the preliminary structure designs and location are determined. Both the intake and outfall are assumed to be offshore submerged structures.

3.1 Engineering constraints

The following engineering constraints were identified for the design of the intake and outfall structures:

- The depth of water over the intake should be sufficient to avoid air being drawn into the intake at design low water levels.
- The depth of water over the intake and outfall should be sufficient to avoid exposure in troughs of very large waves that could result in wave slam forces.
- The outfall diffuser should be designed to mitigate the environmental impact of the brine discharge.
- The intake and outfall locations should avoid recirculation of brine. Operating limits to avoid inflow of brine are specified as either average recirculation values of less than 0.2 ppt or maximum recirculation values of less than 0.3 ppt (Pita et al, 2022).
- The intake location should avoid the presence of steep slopes on the seabed where instability could result in slides; it should avoid the presence of depressions in the seabed that could collect debris; it should avoid areas with a highly mobile substrate that could result in significant entrainment of suspended sediment and consequently sediment accretion within the system; and it should avoid existing infrastructure or obstructions that may distort the ambient flow regime significantly.
- The intake or outfall location should avoid becoming a navigational or fishing hazard (i.e. interfering with anchorage, or risk entanglement of gear).

It should be noted that at this preliminary design stage, navigation and fishing have not been considered in the determination of the intake and outfall location and design. In addition, the available bathymetric data is insufficient to identify the presence of steep slopes and depressions, and no information with respect to sediment transport and existing infrastructure or obstructions was available.

3.2 Environmental constraints

The following environmental constraints were identified for the outfall with respect to salinity and temperature, originating from the Canadian Council of Ministers of the Environment (CCME, 2025):

- **Salinity:** Human activities should not cause salinity of marine and estuarine waters to fluctuate by more than 10% of the natural level expected at that time and depth.

-
- **Temperature:** Human activities should not cause changes in ambient temperature of marine and estuarine water to exceed ± 1 °C at any time, location or depth. The natural temperature cycle characteristic of the site should not be altered in amplitude or frequency by human activities. The maximum rate of any human-induced temperature change should not exceed 0.5 °C per hour.

For this preliminary design study, it is assumed that the water quality guidelines mentioned above must be met at the edge of the initial dilution zone (IDZ), identified as a three-dimensional area around an outfall where effluent mixes with receiving water. The IDZ typically may extend up to a maximum of 100 m from the point of discharge (ECCC, 2019) and is therefore assumed to be 100 m for this preliminary study. For future detailed design studies, it is recommended that a more in-depth assessment of environmental constraints is performed (e.g. DO and TSS constraints, marine mammals, sensitive aquatic habitats/species, fish impingement or entrainment at the intake structure, ornithological diving species, zoobenthos, plankton, macroalgae, ichthyofaunal communities, and bathing waters).

3.3 Preliminary Intake Design

Average current velocities (see section 2.5) near the project site were determined to be approximately 0.07 m/s and can therefore be assessed as relatively weak. Generally, in areas where the prevailing tidal currents are weak, contemporary design of offshore submerged intake structures tends to be capped radial flow structures that project above the seabed without permanent access for maintenance (Pita, E. et al, 2022). For the purposes of this preliminary study, the capped radial flow intake structure is assumed to have a structure height of 8.0 m. This height was chosen based on similar previously constructed intake structures (Chie and Wahab, 2020).

Assuming an intake structure height of 7.0 m, a margin of safety for meteorological effects of 0.20 m (see Section 2.4), a non-linear wave with a H_{max} of 14.6 m and a wave trough of 5.1 m (see section 2.3), it can be concluded that a minimum water depth of approximately 12.3 m is required for the intake structure to avoid the intake structure to be exposed to wave slamming forces or draw in air.

3.4 Preliminary Intake and Outfall Location

In general terms, it is desirable to place an intake structure at a deeper location than the outfall diffuser, since water quality is usually better in deeper waters, there is less exposure to waves, there is more distance to the sea surface (avoiding growth of marine micro organisms), a larger distance to the seabed can be created to avoid sediment ingress into the intake structure, and a lower velocity at the water intake windows can be obtained (Pita, E. et al, 2022).

Since the available local bathymetric data near the project site indicates a relatively small slope, and to avoid the dense brine flowing from the outfall to the intake structure due to gravity, at this preliminary design stage the outfall structure was located further offshore than the intake structure. An advantage of this is that the cost of pipe construction will decrease, since a smaller intake pipeline length is achieved, assuming higher diameters for the intake pipelines compared to the outfall pipelines (Pita, E. et al, 2022).

An overview of the intake and outfall location characteristics is provided in Table 5. In Figure 19, both locations are visualized as well. It should be noted that the water depths and distances from shore should be considerate approximates, and that these are based on limited available bathymetric data. It should be noted that potentially in future more detailed studies, the pipe layout could be optimized by orienting it further southwest. Thereby, pipe lengths could be decreased while still reaching desired water depths. More detailed bathymetry should be available for this.

Table 4: General intake and outfall location information

| Parameter | Intake | Outfall |
|---------------------|-----------|-----------|
| X Location | 373437 m | 372934 m |
| Y Location | 5355066 m | 5355669 m |
| Water depth | 12.3 m | 16.0 m |
| Distance from shore | 1,200 m | 2,000 m |

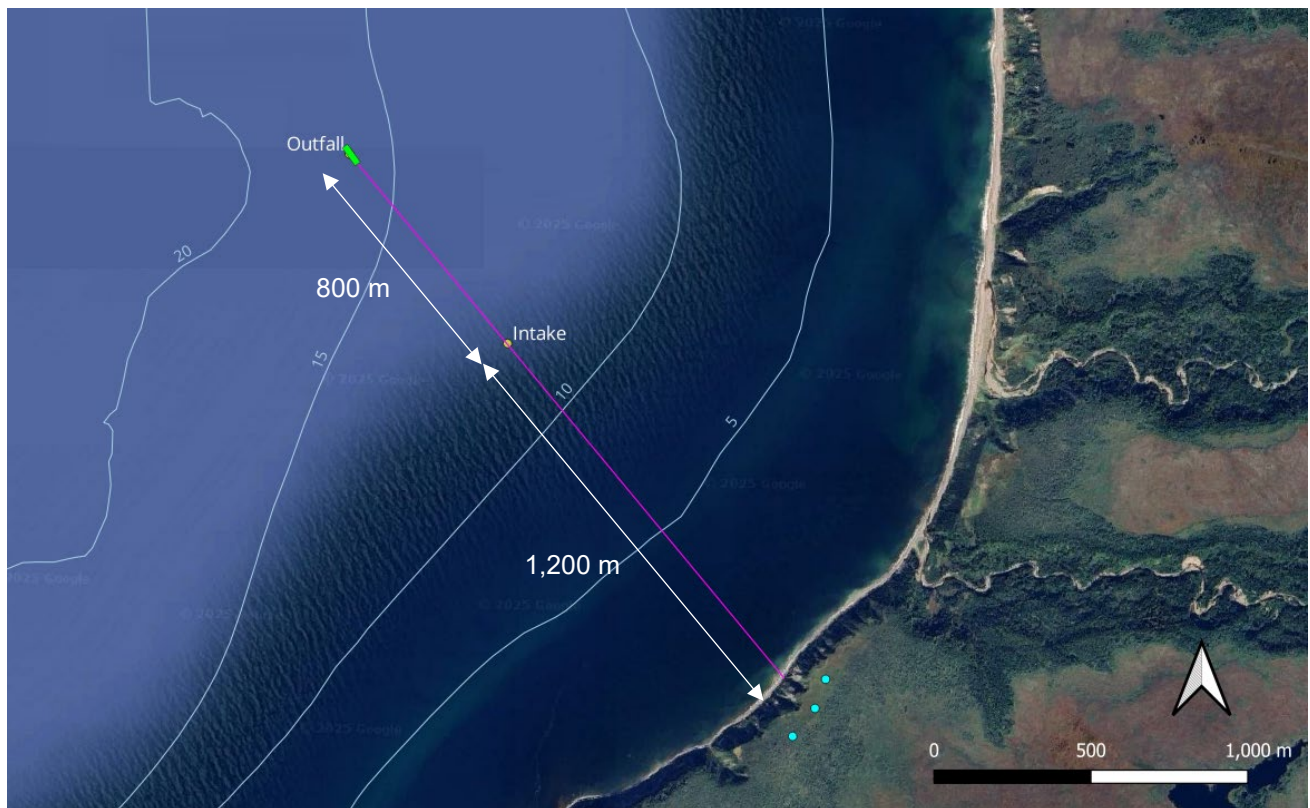


Figure 19: Preliminary intake and outfall locations. Approximate pipe trajectory is shown in magenta, outfall diffuser orientation is shown in green (not to scale). TriplePoint well locations are shown in cyan. Depth contours provided in grey (m CD).

3.5 Preliminary Outfall Design

As mentioned in Section 3.1, the outfall diffuser should be designed to mitigate the environmental impact of the brine discharge. An overview of the assumed data for the brine discharge is provided in Table 6.

Table 5: Brine discharge data overview.

| Parameter | Data | Comments |
|--|---|---|
| Discharge of brine | 14,500 m ³ /day or 0.167 m ³ /s | The maximum discharge of 14,500 m ³ /day or 0.167 m ³ /s is used however the conservative nature of this analysis would accommodate up to 2x these values. |
| Temperature increase of intake sea water | 5 °C | The intake sea water is expected to be heated 10-15 °C during the salt extraction process, but the brine discharge is expected to cool towards the outfall diffuser to an overall temperature increase of 5 °C. |
| Salinity increase of intake sea water | 130 – 260 ppt | The maximum increase of 260 ppt is used representing more conservative conditions for outfall design. |

For the preliminary design of the outfall diffuser, the modeling software CORMIX (Cornell Mixing Zone Expert System) was used. CORMIX is a water quality modeling and decision support system used to assess the environmental impact of wastewater discharges into water bodies. It is a model that is developed by MixZon Inc., and is capable of simulating the mixing zone, predicting the geometry and dilution of a plume from a point source, and is used for regulatory and design purposes. CORMIX was used for optimization of the outfall diffuser design through a sensitivity analysis.

Average ambient water conditions were used for the CORMIX modeling: a water temperature of 15 °C and salinity of 31 ppt. A current velocity of 0.07 m/s was used, representing average flow conditions. For the bottom friction, a Darcy-Weisbach coefficient of 0.02 was used. It was assumed that the outfall is located in approximately 16.0 m of water depth, approximately 2 km from shore.

The IDZ in CORMIX was specified as 100 m, see section 3.2. The environmental constraints to be met by the outfall diffuser at the edge of the IDZ are a temperature excess of 0.5 °C and a salinity concentration excess of 10%. Assuming an ambient salinity of 31 ppt, the salinity excess concentration can be 3.1 ppt.

Sensitivity tests were conducted with respect to effluent density, diffuser length, diameter, number of ports/risers and their respective diameters, and port velocity and orientation. In general, a denser effluent, higher port velocity, shorter diffuser lengths, increased number of ports, and diffuser orientation in the current direction resulted in higher dilution rates. In Table 7, an overview is provided of the preliminary outfall design components that were determined to meet the identified environmental constraints. In Figure 20, the preliminary design parameters of the outfall diffuser have been provided. A dilution of 76 was reached with this outfall diffuser configuration at the IDZ, with salinity concentrations dropping from 260 ppt at the nozzle head to 34.0 ppt at the IDZ, and temperatures dropping from 20 °C at the diffuser to 15.1 °C at the IDZ. It can be concluded that salinity excess concentrations of 3.0 ppt and 0.1 °C fall within the environmental constraints at the IDZ of 3.1 ppt and 0.5 °C respectively.

As mentioned previously, it should be noted that at this preliminary design stage, navigation and fishing have not been considered in the determination of the outfall location and design. If navigation/fishing hazard in subsequent detailed design phases turns out to be of concern, the outfall design can be further optimized to mitigate these hazards.

Table 6: Preliminary design parameters outfall diffuser.

| Parameter | Value |
|-----------------------------|-----------------------------|
| Water depth | 16.0 m |
| Distance from shore | 2 km |
| Total Diffuser Length | 20 m |
| Diffuser Diameter | 0.21 m |
| Number of Risers | 14 |
| Riser Diameter | 0.17 m |
| Number of Ports | 14 ports (1 port per riser) |
| Port Diameter | 0.06 m |
| Port Velocity | 8.48 m/s |
| Port Orientation Vertical | 60° |
| Port Orientation Horizontal | In direction of flow |

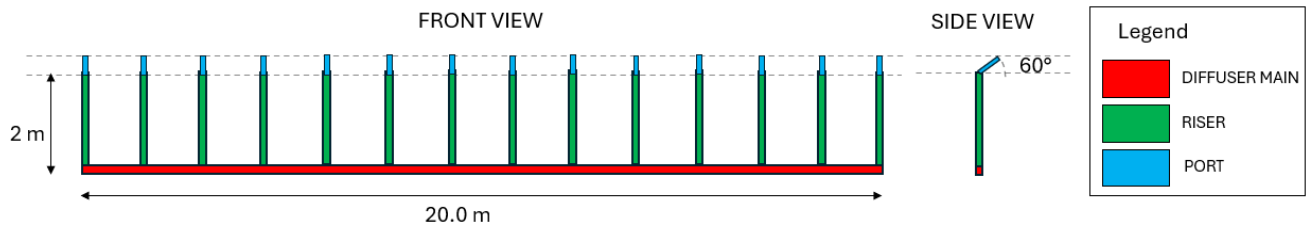


Figure 20: Outfall diffuser preliminary design front view and side view.

3.6 Constructability Considerations

The 24" HDPE intake and 16" outfall pipelines are conceptually buried along the first 500 m from the shoreline, to protect from the anticipated waves. Beyond this, the remaining length of the pipelines are weighted down using concrete collars. Further, the intake screen is mounted 2 m above the ocean floor, on a concrete support structure. Rock protection and support structures to be finalized during detailed design. Similarly, navigation and fishing considerations to be further detailed.

4. RECIRCULATION MODELING

To investigate recirculation of brine from the outfall to the intake location, a three-dimensional Delft3D model was developed for the Bay of St. George and part of the Gulf of St. Lawrence, using 10 equally spaced sigma layers. Delft3D is an integrated modeling suite developed by Deltares for simulating hydrodynamics, sediment transport, waves, and water quality in coastal, estuarine, and river environments. For the purposes of this preliminary model study, with both intake and outfall structures being located in deep water with limited wave interaction, waves were excluded from the Delft3D model.

4.1 Grid & Bathymetry

A curvilinear grid using the bathymetric datasets outlined in section 2.1 was developed covering the Bay of St. George and part of the Gulf of St. Lawrence, see Figure 21. The grid resolution is 100 m in the vicinity of the proposed intake and outfall locations, and 300 m otherwise. Three model boundaries were used: a western water level boundary and a northern and southern Neumann boundary. Bathymetry near the boundaries was set to a uniform value of -200 m to avoid model instabilities.

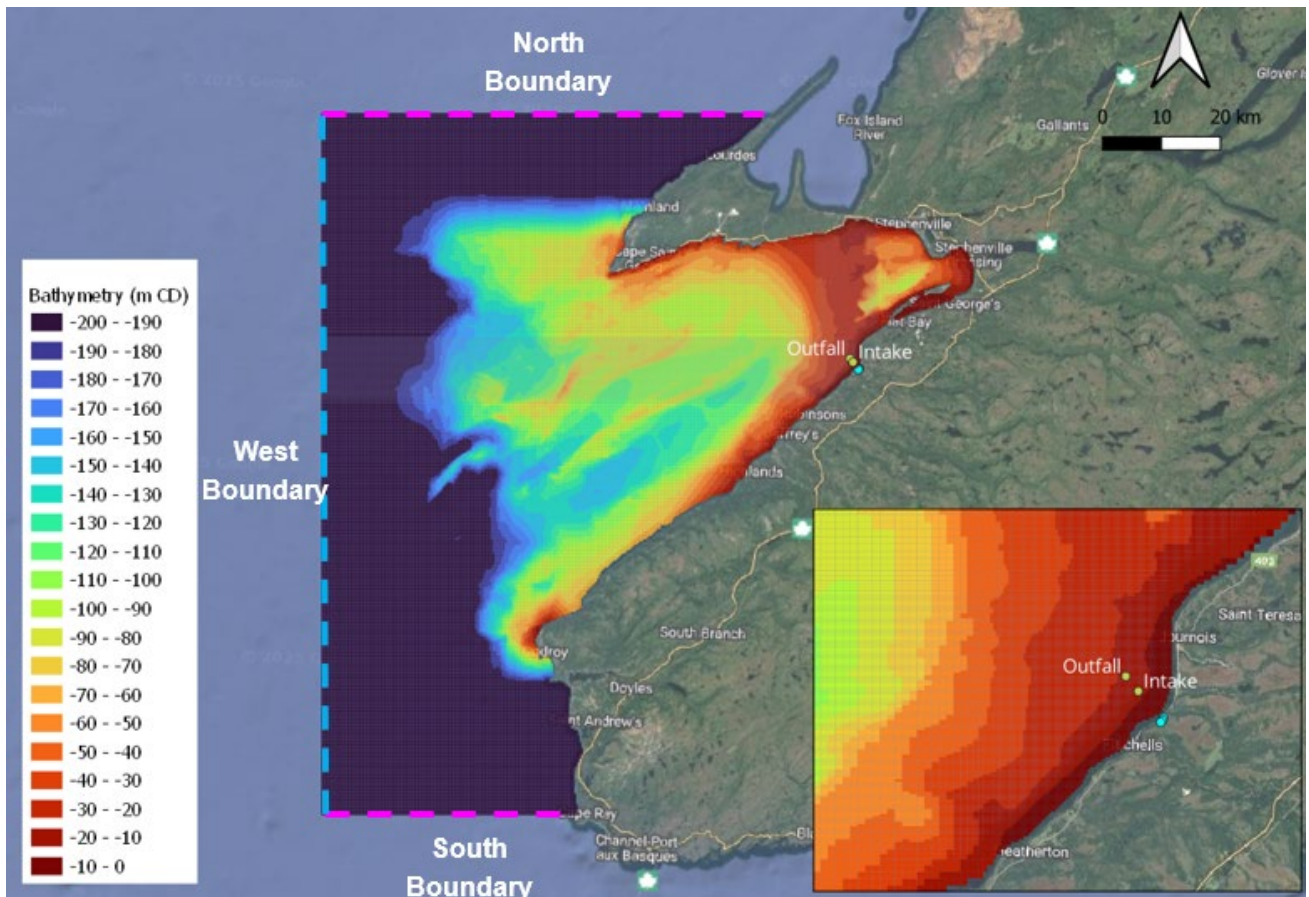


Figure 21: Delft3D curvilinear grid extents and bathymetry. Intake and outfall locations are shown in yellow. The TriplePoint well locations are shown in cyan. Western water level boundary (blue dashed line) and northern/southern Neumann boundaries (magenta dashed lines) are shown.

4.2 Forcing & Model scenarios

The Delft3D model was forced using water levels originating from WSP's Mike3 model. To assess recirculation of brine discharge between the intake and outfall, the period of Jul 20-Aug 20, 2016 was chosen as a conservative model period due to the low flow velocities in the vicinity of the outfall location (see Figure 22) and consequently lower brine dilution rates. Different model scenarios were chosen using different wind scenarios based on the analysis performed in section 2.2. In Table 8, an overview is given of the different model scenarios. A constant ambient water temperature of 15 °C and salinity of 31 ppt was assumed, representing typical conditions based on the measurements at buoy IML-10 as presented in section 2.6. For all scenarios, the outfall is constantly discharging maximum volumes as previously specified in Table 6, i.e. 29,000 m³/day, with a temperature of 5 °C above ambient and salinity of 260 ppt. The CORMIX brine dilution results at the end of the nearfield zone are introduced in the Delft3D model using 10 discharge sources placed in the bottom layer of the Delft3D model, with each source discharging 2,900 m³/day. For scenarios 2 to 5, the model is hot started on Aug 13 using the scenario 1 (no wind) model output. Scenarios 2 to 5 were chosen to determine the impact of average wind and storm conditions on the brine plume and represent scenarios in which brine is potentially pushed towards the intake by the increased current velocities.

For the Delft3D modeling, no atmospheric heat flux was used, corresponding with a more conservative assumption for the outfall modeling with respect to water temperatures. In addition, no atmospheric pressure was incorporated in the model.

Table 7: Estimated Extreme Hourly-Averaged Omnidirectional Wind Speed for Different Return Periods.

| Model Scenario | Period | Duration | Wind conditions |
|-----------------------------|-----------------------|----------|-------------------------------|
| 1 – No wind | Jul 20 – Aug 20, 2016 | 1 month | No wind |
| 2 – Average wind from West | Aug 13-16, 2016 | 3 days | 5 m/s from West for 37 hours |
| 3 – Average wind from North | Aug 13-16, 2016 | 3 days | 5 m/s from North for 37 hours |
| 4 – Storm from West | Aug 13-16, 2016 | 3 days | 28 m/s from West for 6 hours |
| 5 – Storm from North | Aug 13-16, 2016 | 3 days | 28 m/s from North for 6 hours |

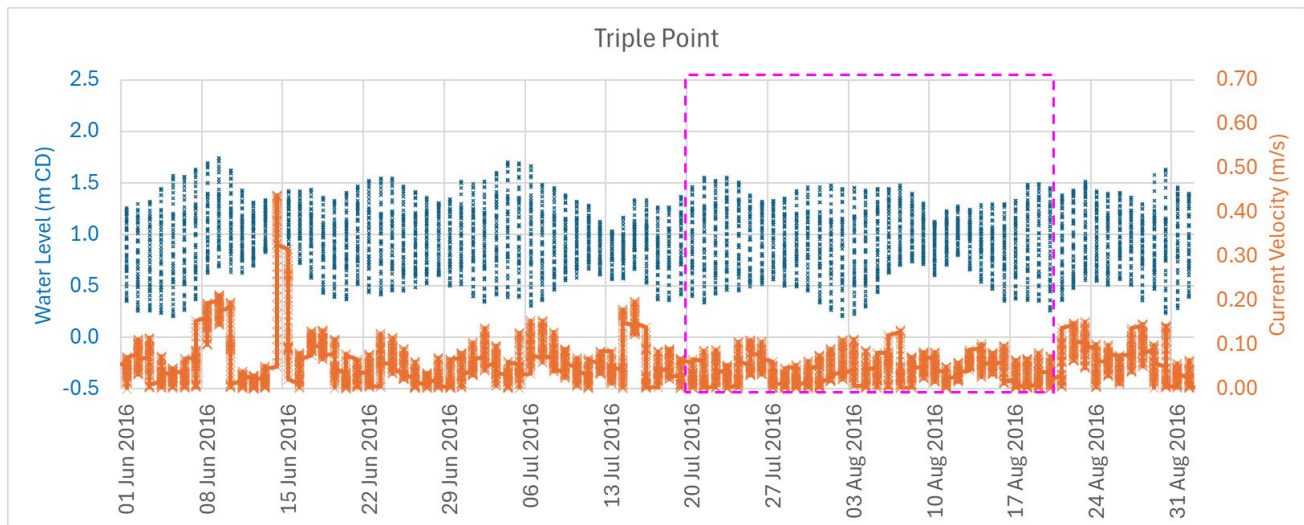


Figure 22: Water level and depth-averaged current velocities near the project site between Jun-Aug 2016, originating from WSP’s Mike3 model. Model period of time with low current velocities is indicated with the dash magenta square.

4.3 Calibration & Sensitivity

Generally, default model parameter settings were used for the Delft3D model runs. Since no water level and current measurement data near the project site was available, no calibration was performed for water levels and currents. In addition, no sensitivity testing was conducted. Therefore, model results present in this memorandum can only be used qualitatively. It is recommended that for detailed intake-outfall design studies, water level and current velocity measurements in the vicinity of the project site are conducted to calibrate and validate the Delft3D model.

4.4 Recirculation results

Maximum salinity excess concentration plots were created (Figure 23 to Figure 32), showing the maximum salinity concentrations over the full simulation duration and throughout the entire water column, while subtracting the ambient salinity concentration of 31 ppt. Maximum temperature excess plots are not presented in this report, since excess temperatures were concluded to be insignificant with respect to recirculation for all different scenarios.

In Table 9, an overview is created of the conclusions for the different scenarios with respect to recirculation of brine. In the salinity excess figures (Figure 23 to Figure 32), it should be noted that salinity concentration excess values of lower than 0.02 ppt were omitted from the results. A magenta contour of salinity

concentration excess values of 0.3 ppt is plotted in each figure. Recirculation was determined to be present when this magenta contour overlapped the intake structure location.

From all scenarios, it was concluded that the magenta contour did not overlap with the intake structure, and therefore no recirculation was present. The magenta contour remains for all scenarios approximately 500 m away from the intake location. It was concluded that average wind as well as storm conditions do not significantly impact mixing of the brine with the ambient water, since the brine plume is mostly dispersing in the bottom layers due to its higher density, and wind is predominantly affecting current velocities in the upper layers of the water column.

Table 8: Recirculation conclusions of salinity excess concentrations.

| Model Scenario | Figure | Recirculation conclusions |
|-----------------------------|-----------------------|---|
| 1 – No wind | Figure 23 - Figure 24 | No recirculation of brine from the outfall to intake structure is observed. |
| 2 – Average wind from West | Figure 25 - Figure 26 | No recirculation of brine from the outfall to intake structure is observed. |
| 3 – Average wind from North | Figure 27 - Figure 28 | No recirculation of brine from the outfall to intake structure is observed. |
| 4 – Storm from West | Figure 29 - Figure 30 | No recirculation of brine from the outfall to intake structure is observed. |
| 5 – Storm from North | Figure 31 - Figure 32 | No recirculation of brine from the outfall to intake structure is observed. |

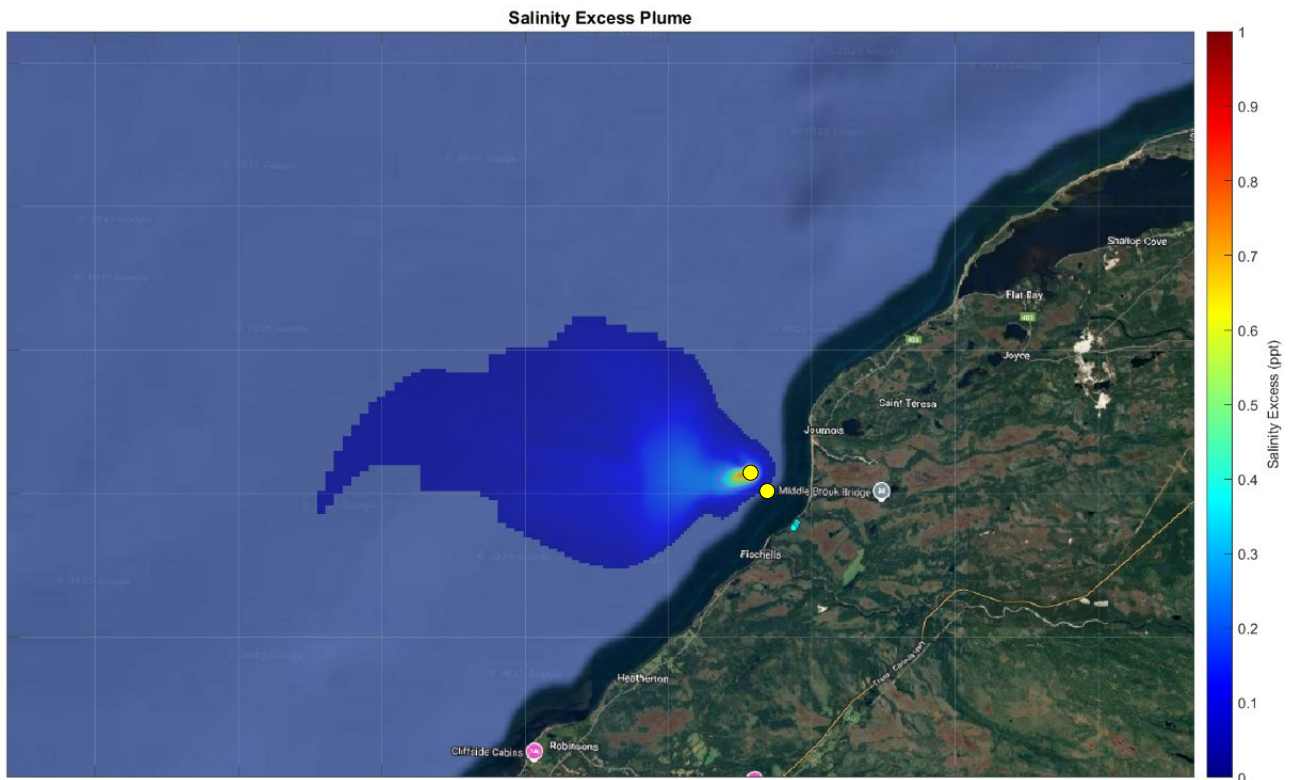


Figure 23: Salinity excess results Scenario 1 (no wind). The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

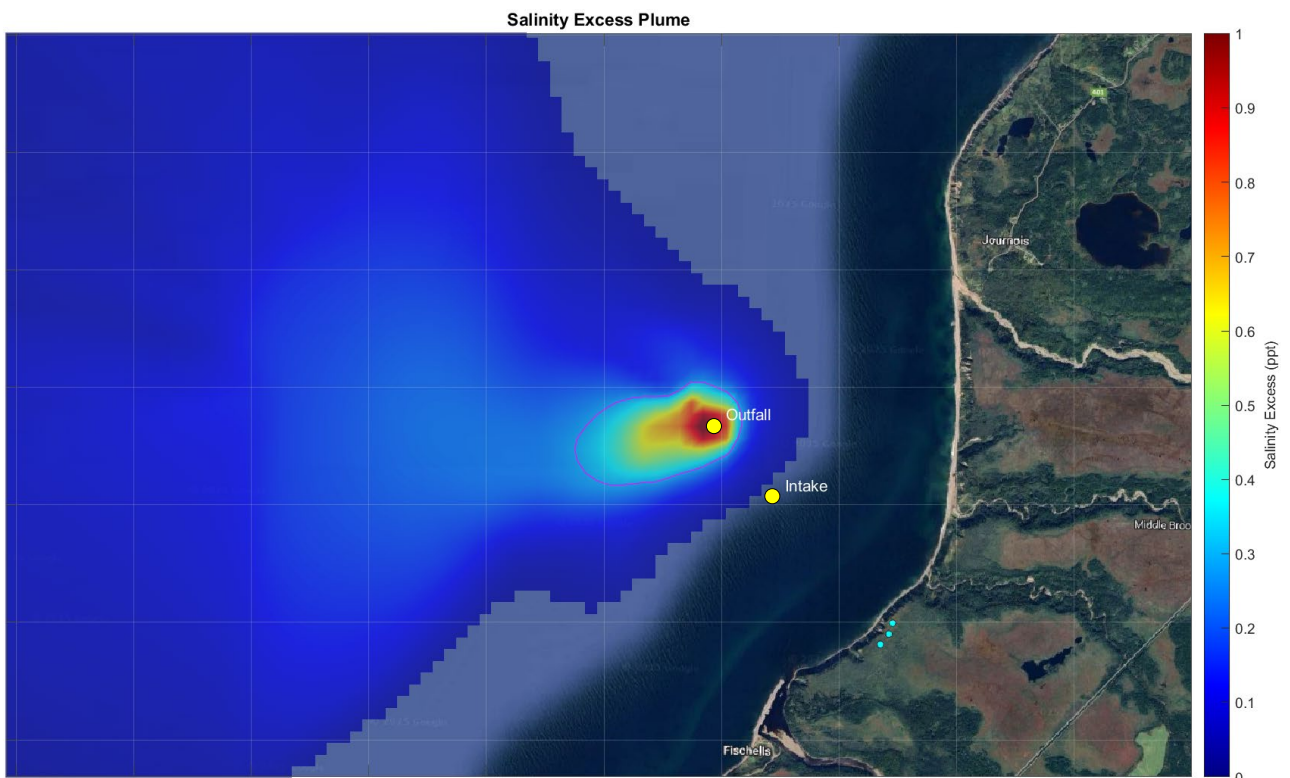


Figure 24: Salinity excess results Scenario 1 (no wind) zoomed in. The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

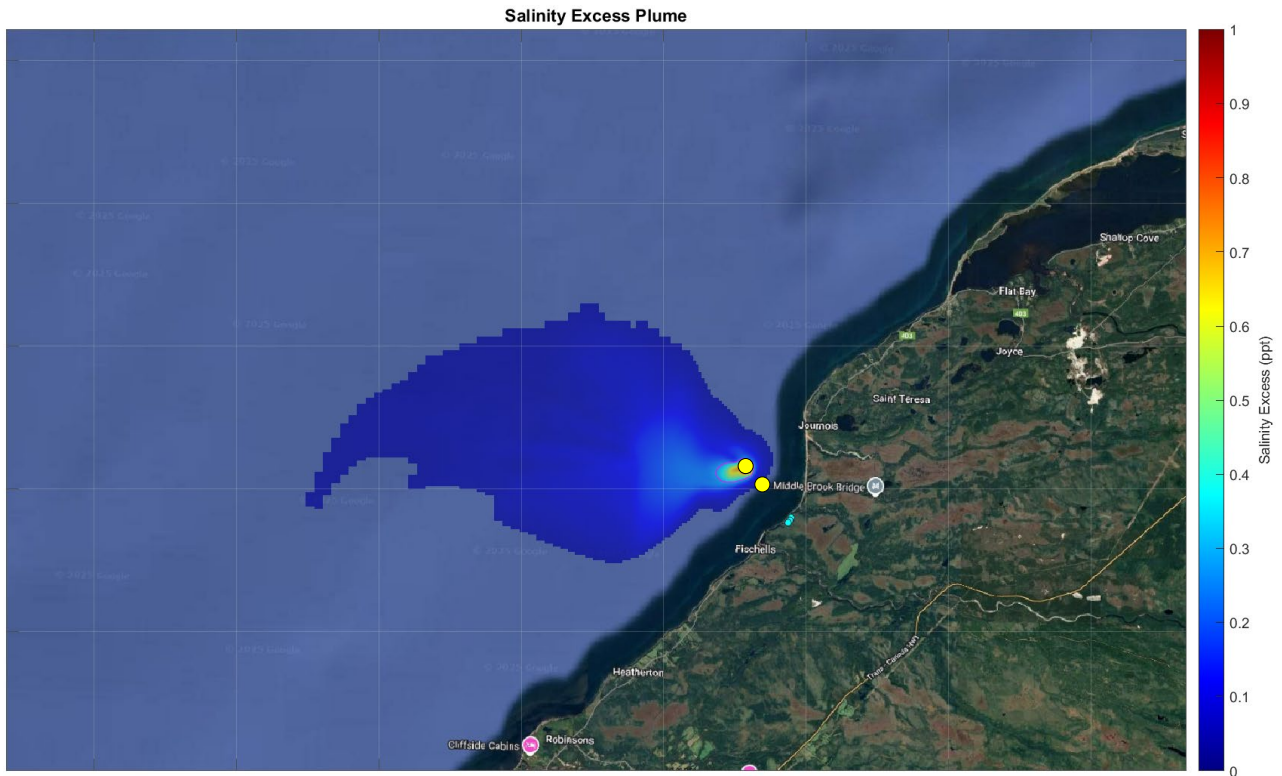


Figure 25: Salinity excess results Scenario 2 (ave. wind from West). The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

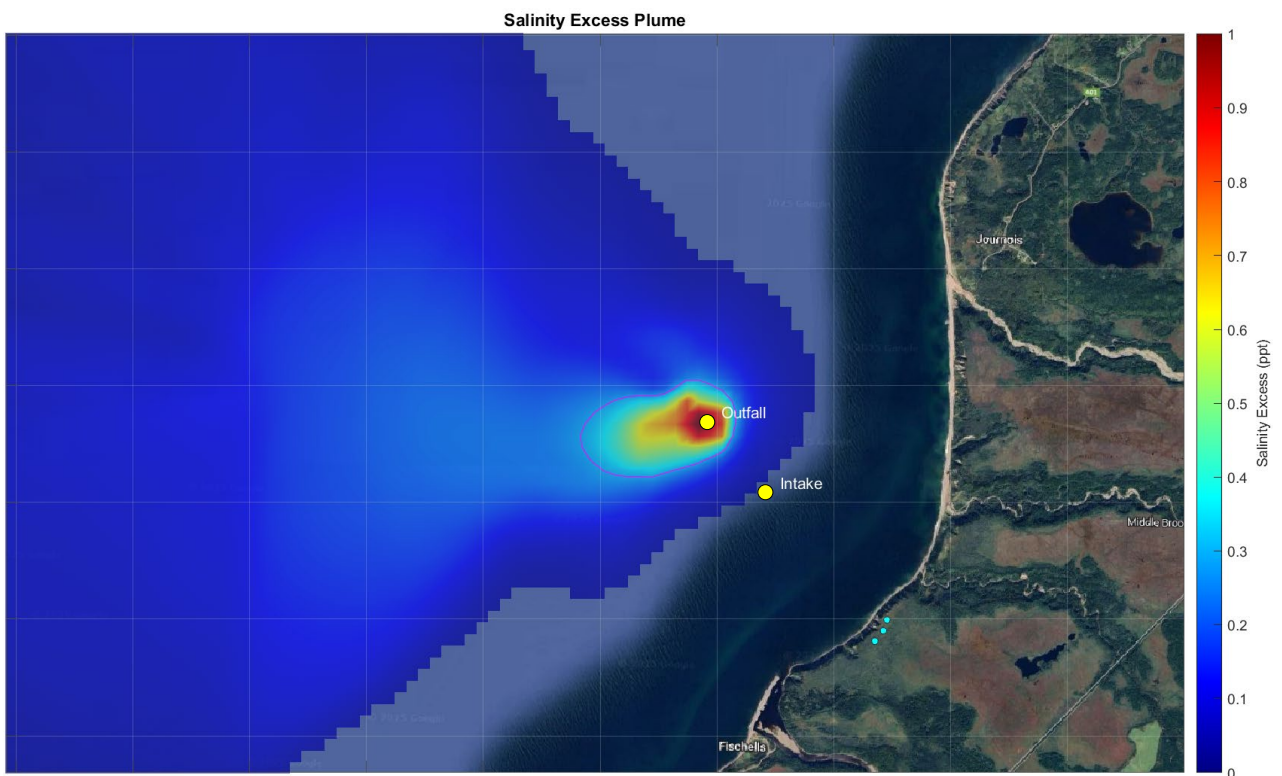


Figure 26: Salinity excess results Scenario 2 (ave. wind from West) zoomed in. The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

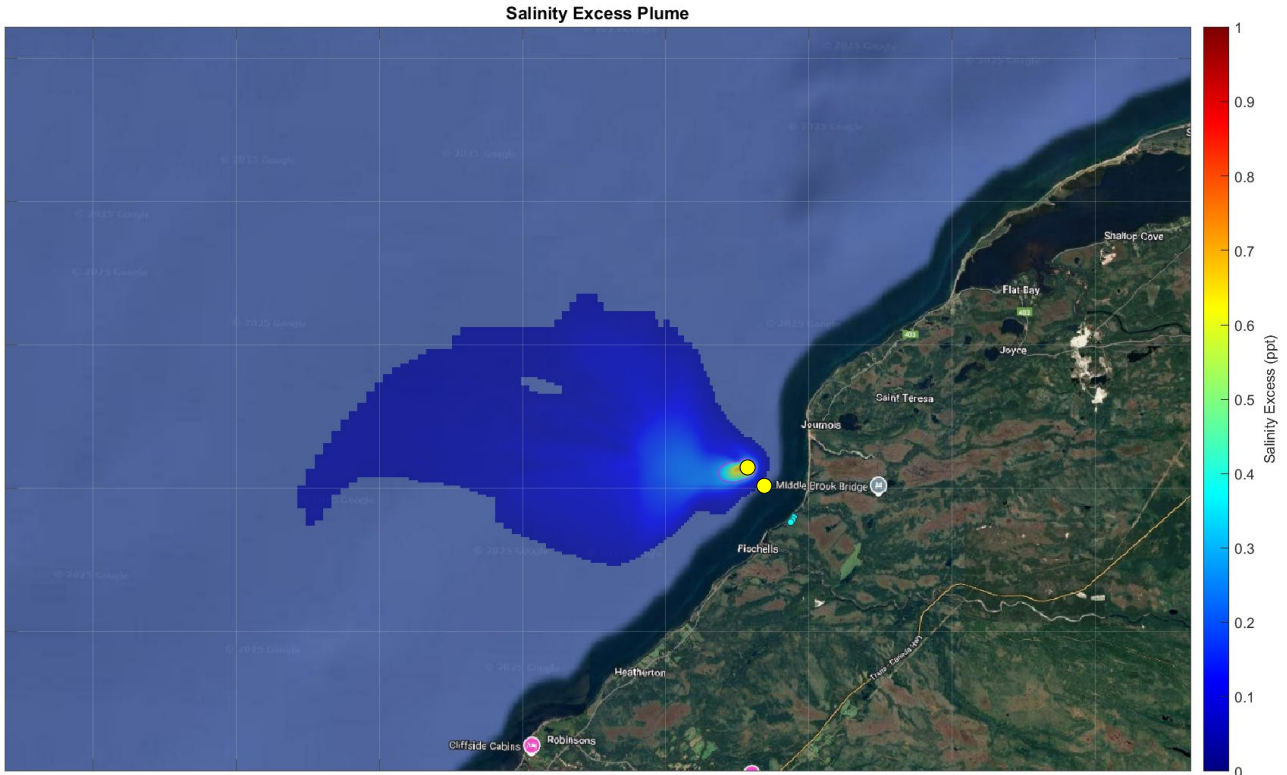


Figure 27: Salinity excess results Scenario 3 (ave. wind from North). The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

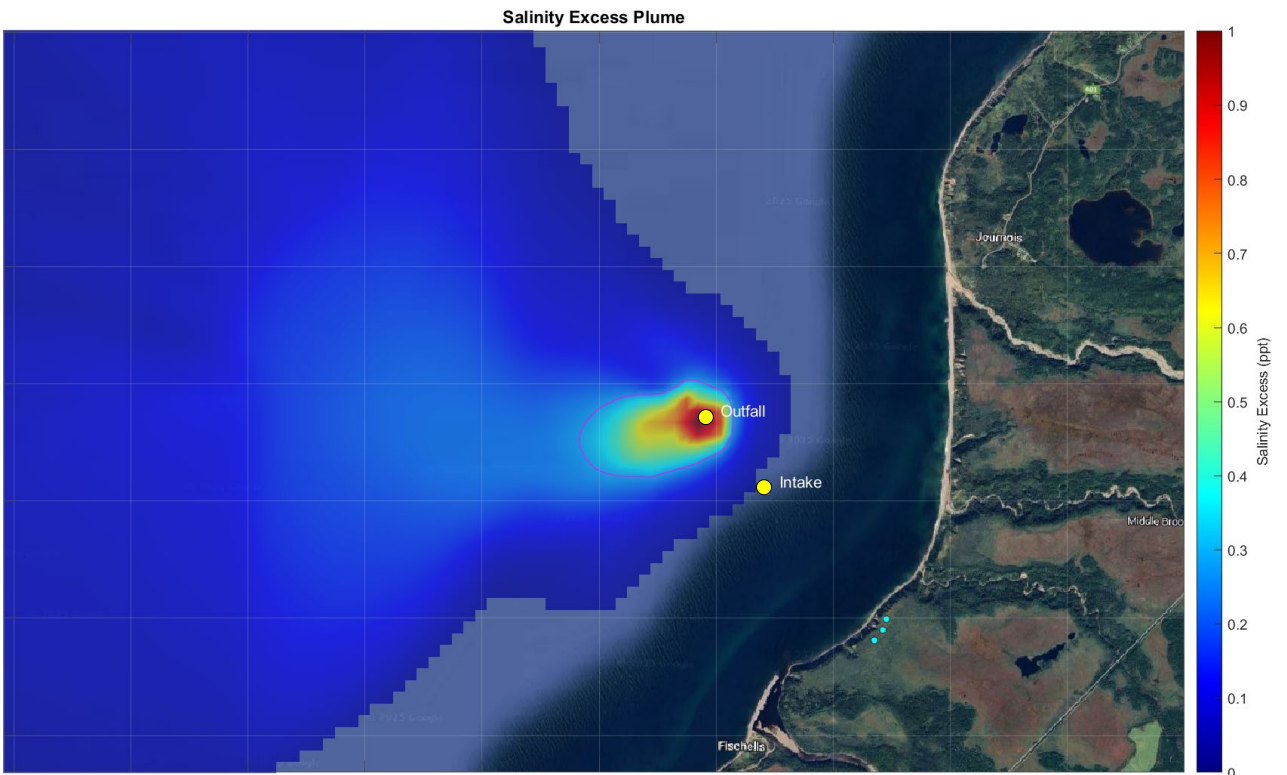


Figure 28: Salinity excess results Scenario 3 (ave. Wind from North) zoomed in. The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

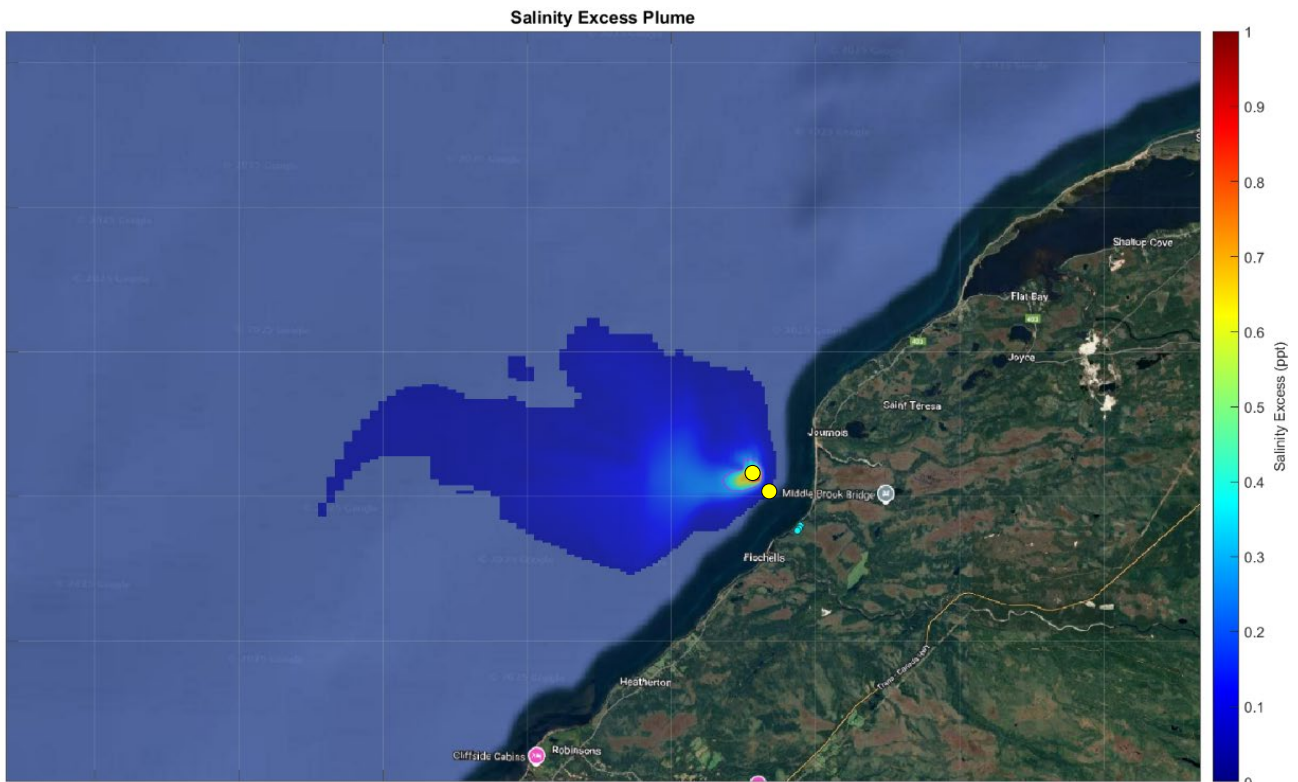


Figure 29: Salinity excess results Scenario 4 (storm from West). The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

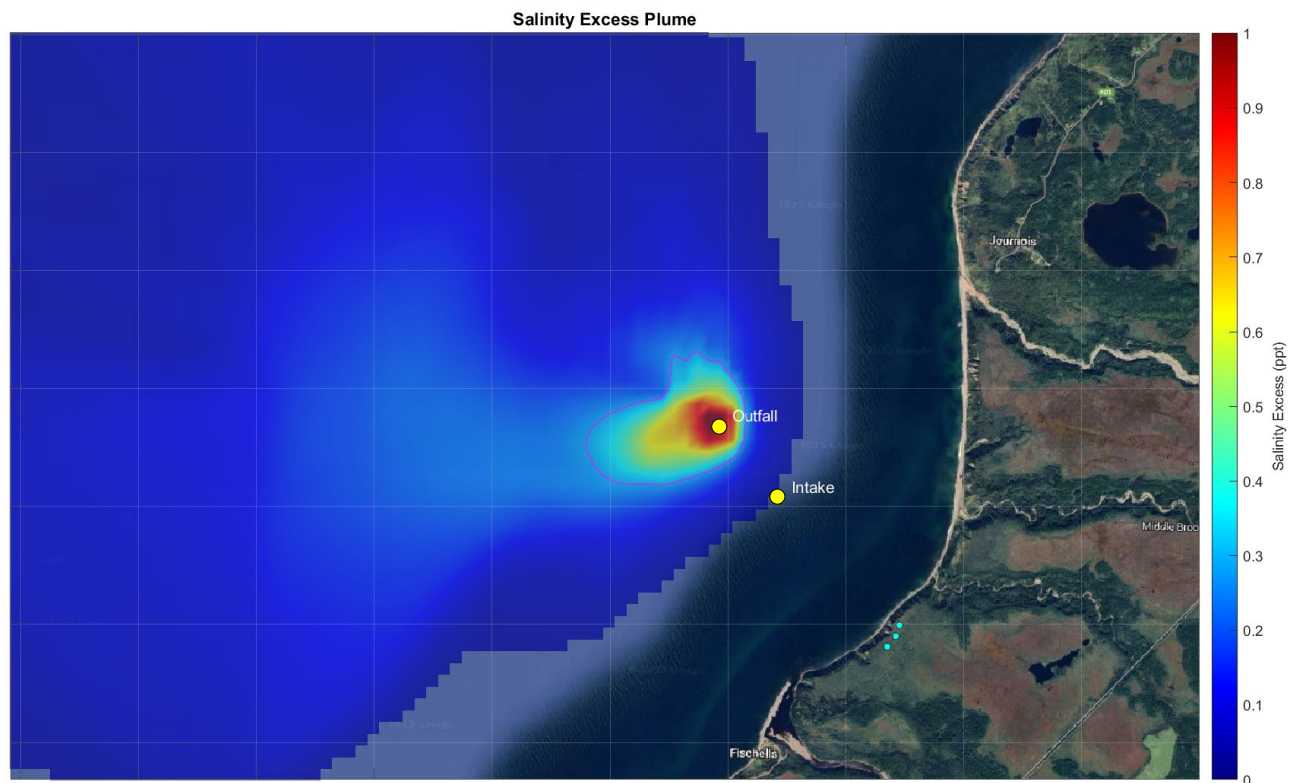


Figure 30: Salinity excess results Scenario 4 (storm from West) zoomed in. The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

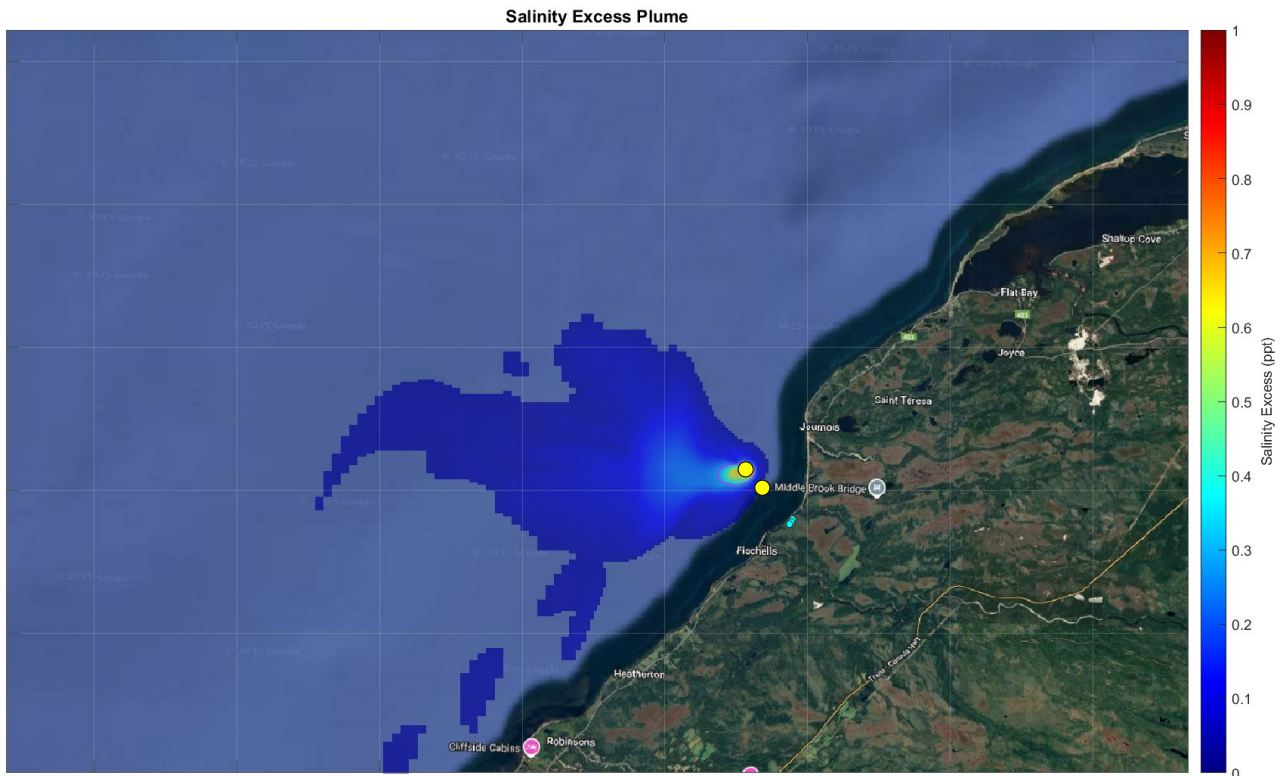


Figure 31: Salinity excess results Scenario 5 (storm from North). The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

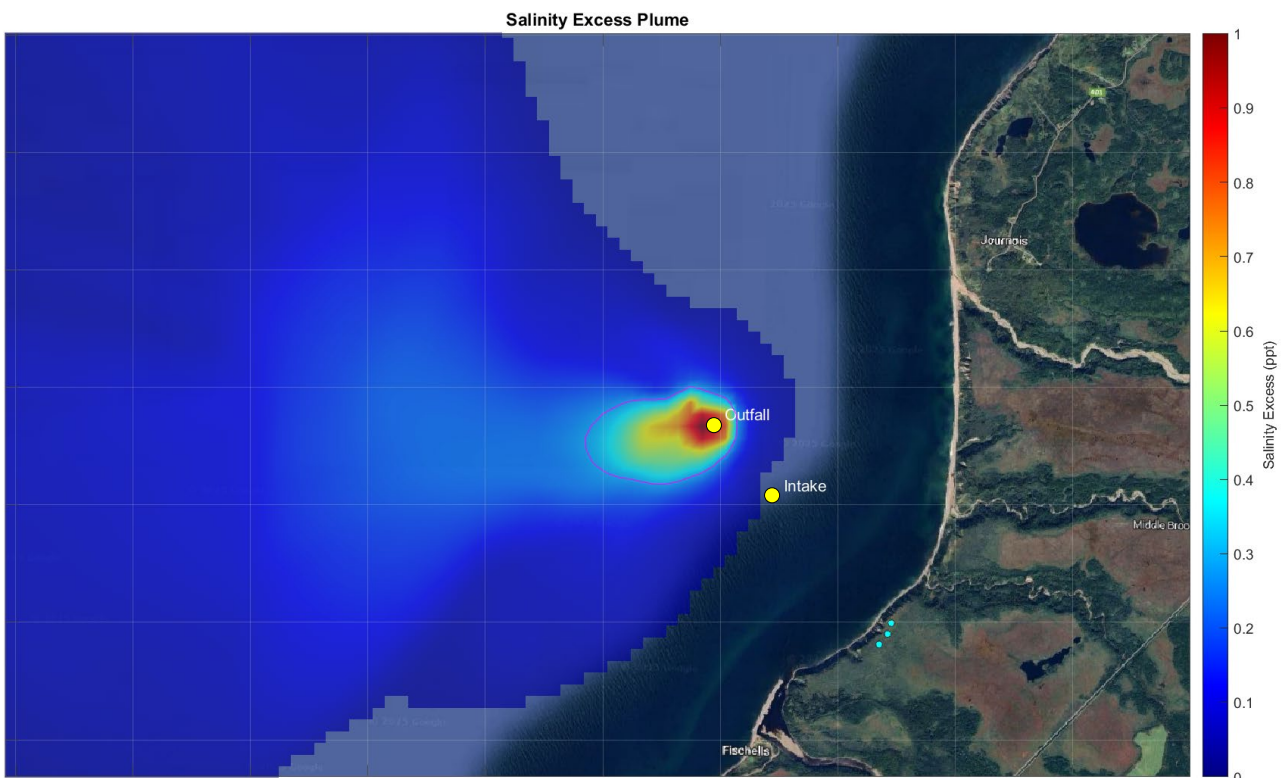


Figure 32: Salinity excess results Scenario 5 (storm from North) zoomed in. The magenta contour indicates the max. allowable excess value of 0.3 ppt. The intake/outfall structure are shown with yellow dots.

5. CONCLUSIONS

Based on the study performed for the TriplePoint Salt Cavern, located on the Bay of St. George on the southwest side of Newfoundland, the following conclusions could be drawn:

1. Wind data between 1959-2025 for location Stephenville A showed highest recorded hourly-average wind speeds of 25.8 m/s and approximately 92% of wind speeds were lower than 10 m/s. Average wind conditions were assessed to be 5 m/s. Different return period winds were determined by means of an Extreme Value Analysis (EVA), and wind speeds with a 200-year return period were determined to be 28.0 m/s.
2. Hindcast wave data between 1954-2018 from the MSC50 wave model for location 014000, approximately 11 km from the project site, showed largest hindcast H_s of 7.7 m with an associated T_p of approximately 12 s during a west-south-westerly storm in December 1972. H_{max} was concluded to be 14.6 m, with a wave trough of 5.1 m. Different return period waves were determined by means of an Extreme Value Analysis (EVA), and H_s with a 200-year return period was determined to be 7.8 m with an associated T_p of 12-13 s. It should be noted that for the purposes of this preliminary design study this data is considered sufficient, yet it is recommended to investigate the nearshore wave climate by means of measurements and a numerical wave model (like SWAN or Delft3D-WAVE) for more detailed intake-outfall design studies.
3. No tidal water level or current measurements are publicly available in the vicinity of the TriplePoint project site. Analysis of DFO tide tables for Crabbes River and St Georges resulted in Lowest Astronomical Tide (LAT) at 0.14 m and Highest Astronomical Tide (HAT) at 1.82 m relative to CD. The mean tidal range is 0.78 m. Water level and current data from WSP's calibrated and validated Mike3 model covering the Gulf of St. Lawrence was extracted for 2015-2019. Modeled water levels showed that the largest difference with LAT was 0.20 m, which can be contributed to meteorological effects like storm surge and atmospheric pressure. Modeled current data showed currents to move in alongshore direction with maximum current velocities of 0.63 m/s and average velocities of 0.07 m/s. It should be noted that WSP's Mike3 model within the Bay of St. George is coarse with a mesh resolution of approximately 6 km, in addition to the fact that this model was not calibrated against measurements within the Bay of St. George.
4. Salinity and water temperature measurements between 2015-2019 from buoy IML-10, located approximately 120 km from the project site, showed salinity concentrations at the water surface range between 28-32 ppt and water temperatures range between 4-23 °C, with highest temperatures in July and August.
5. Large gaps in bathymetric data were present in the Bay of St. George, which were filled using nautical charts data and interpolation methods. No sensitivity testing was conducted with respect to the chosen bathymetry values for the areas where large gaps were present. The resulting bathymetric dataset is considered adequate for the preliminary design of an intake-outfall system, though for more detailed studies, it is recommended to execute a bathymetric survey in the vicinity of the project site.
6. Engineering constraints were identified for the intake and outfall structure design. Navigation and fishing were not considered in the determination of the outfall location and design in this preliminary design phase though. Various options can be looked into focused on mitigating navigation and fishing hazards in subsequent detailed design phases. Additionally, the available bathymetric data is insufficient to identify the presence of steep slopes and depressions, and no information with respect to sediment transport and existing infrastructure or obstructions was available.
7. Environmental constraints were identified for the outfall with respect to salinity and temperature (CCME, 2025). For future detailed intake and outfall design studies, it is recommended that a more in-depth assessment of environmental constraints is performed that could influence design (e.g. DO and TSS constraints, marine mammals, sensitive aquatic habitats/species, fish impingement or entrainment at the

intake structure, ornithological diving species, zoobenthos, plankton, macroalgae, ichthyofaunal communities, and bathing waters).

8. Assuming an intake structure height of 7.0 m, a margin of safety for meteorological effects of 0.20 m, a wave through of 5.1 m, it was concluded that a minimum water depth of approximately 12.3 m is required for the intake structure to avoid the intake structure to be exposed to wave slamming forces or draw in air. The preliminary intake XY location was determined to be: 373437,5355066 (m WGS84 UTM21N). This location is in approximately 12.3 m of water depth and is 1,200 m from shore. Since the available local bathymetric data near the project site indicates a relatively small slope, and to avoid the dense brine flowing from the outfall to the intake structure due to gravity, at this preliminary design stage the outfall structure was located further offshore than the intake structure. The outfall diffuser XY location was determined to be: 372934, 5355669 (m WGS84 UTM21N). This location is in 16.0 m of water depth and is approximately 2,000 m from shore. It should be noted that potentially in future more detailed studies, the pipe layout could be optimized by orienting it further southwest resulting in decreased pipe lengths, though more detailed bathymetry is needed.
9. The preliminary outfall diffuser design was developed using CORMIX. Based on sensitivity tests conducted, it was concluded that in general a denser effluent, higher port velocity, shorter diffuser lengths, increased number of ports, and diffuser orientation in the current direction resulted in higher dilution rates. It was also concluded that an outfall diffuser with a diffuser length of 20 m oriented in the direction of flow, a diffuser diameter of 0.21 m, the number of risers and ports of 14, a riser diameter of 0.17 m and port diameter of 0.06 m, a vertical port orientation of 60° meets the environmental requirements with respect to salinity and temperature. This outfall diffuser design results in a dilution of 76 at the edge of the IDZ, with salinity excess concentrations of 3.0 ppt and 0.1 °C staying within the environmental constraints of 3.1 ppt and 0.5 °C respectively. It should be noted that at this preliminary design stage, navigation and fishing have not been considered in the determination of the outfall location and design. If navigation/fishing hazard in subsequent detailed design phases turns out to be of concern, the outfall design can be further optimized to mitigate these hazards.
10. Recirculation of brine between the preliminary proposed outfall and intake structure was assessed using a three-dimensional Delft3D circulation model. Since no measurements of water levels or currents were available, the numerical model was not calibrated/validated and no sensitivity testing was conducted. Waves were excluded from this numerical model representing a more conservative approach with respect to brine mixing. It was concluded that no recirculation of brine occurred for the different modeled scenarios, i.e. no wind conditions, average wind conditions and storm wind conditions. Additionally, it was concluded that average wind conditions as well as storm conditions do not significantly impact mixing of the brine with the ambient water, since the brine plume is mostly dispersing in the bottom layers due to its higher density, and wind is predominantly affecting current velocities in the upper layers of the water column. Since no calibration/validation was performed, model results presented in this memorandum should be used qualitatively.

WSP Canada Inc.



Reinier Tromp, P.Eng, M.Sc., PMP, ir.

Coastal Engineering Project Manager

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