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Coastal Study of Saint Andrews Market Wharf Replacement

Saint Andrews, New Brunswick

GEMTEC Project: 103099.005

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Submitted to:

Town of Saint Andrews
212 Water Street
Saint Andrews NB
E5B 1B4

Coastal Study of Saint Andrews Market Wharf Replacement

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July 23, 2025
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Hanwell, NB, Canada
E3C 0M7

July 23, 2025

File: 103309.005 – Rev0

Town of Saint Andrews
212 Water Street,
Saint Andrews,
NB E5B 1B4

Attention: Chris Spear, CPA, CGA
Chief Administrative Officer, Treasurer

Re: Coastal Study of Saint Andrews Market Wharf, Saint Andrews, New Brunswick

GEMTEC Consulting Engineers and Scientists Limited is pleased to submit the report for your use and distribution.

We remain available at your convenience to discuss the report or provide additional details you may require.

Regards,

Garth Holder
Senior Civil Technologist

EXECUTIVE SUMMARY

GEMTEC Consulting Engineers and Scientists Limited (GEMTEC) has been engaged by the Town of Saint Andrews (Town) to carry out a coastal study to support the design work related to the Town of Saint Andrews Market Wharf Approach Replacement. The Town is proposing to repair and expand the Market Wharf by adding a 4,545 sq. m rock protected infill area and steel pile supported concrete deck structure to replace the aging inner section of the wharf approach.

In this study, DHI MIKE21 software was applied to simulate wave, hydrodynamics, water exchange and sediment transport in project area. The results of the model indicate the following:

- The Saint Andrews Harbour for the most part is protected from offshore winds and waves by Navy Island and the sand bars that have formed at the two inlets. The waves that form in the harbour are localized and are not influenced from offshore.
- The infill area follows the shoreline and does not protrude far into the water, so therefore has minimal impact on flow patterns within the wharf area. Any influence is limited to high tide conditions and is confined to the immediate vicinity of the expansion structure.
- The module used to assess the water exchange rate in near shore area indicated a slight change to the rate near shore. The water exchange rate of both the existing layout and with the proposed infilling area remain efficient. This efficiency is primarily attributed to the significant tidal range at the site and the complete drying out of nearshore areas during low tide, which promotes rapid water renewal in each tidal cycle
- Longshore sediment transport with the proposed infill indicated that fine sand depositions would likely occur in corners of the infill area (assuming there was available fine sand for the bed material). As the existing seabed consists mainly of gravel and seaweed, there is expected to be no obvious shoreline change with the proposed configuration. The proposed expansion does not affect wave conditions near the existing sand beaches on either side of the infill, so it can also be concluded that the new construction will have no impact on the shorelines.
- The beach profile change indicates potential toe erosion at the revetement based on a sand bottom. Potential revetement toe erosion has been mitigated in the design of the rock protection slope with a 600mm key at the toe of the slope.
- The armour stone size based on the wave climate is 250 kg to 500kg rock size. The proposal calls for 500kg to 1500kg.
- The proposed height of the new work is sufficiently high enough to prevent wave overtopping and flooding with the next 25 years. It is possible at the end of this century sea level rise could lead to flooding of the infill area and wharf deck.

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1.1 Project Background and Objectives

GEMTEC Consulting Engineers and Scientists Limited (GEMTEC) has been engaged by the Town of Saint Andrews (Council) to carry out a coastal study to support the design work related to the Town of Saint Andrews Market Wharf Approach Replacement. The Town is proposing to repair and expand the Market Wharf by adding a 4,545 sq. m rock protected infill area and steel pile supported concrete deck structure to replace the aging inner section of the wharf approach.

To complete the study, GEMTEC created a hydrodynamic coastal model of the Saint Andrews wharf area. The model provides data to support the coastal study, and includes the following:

- simulation of waves and tidal currents in the project area, from which sediment transport can be assessed.
- prediction of the potential wave climate and flooding, considering tidal surges and sea level rise.
- assessment of potential shoreline changes, specifically erosion or accretion, around the infill area.
- evaluation of the water exchange rate on either side of the infill area.

It should be noted that this coastal study deals only with the aspects of the hydrodynamic changes within the study area as a result to the approach reconstruction. Fish and fish habitat loss and disruption has been identified with the Department of Fisheries and Oceans. Impacts to navigation has been submitted to Transport Canada for assessment.

1.2 Existing Site Conditions

St. Andrews Market Approach is located at the foot of King Street at Water Street, considered to be the hub of the downtown core. The Market Wharf extends 260 metres into the Saint Andrews Harbour. The harbour is tucked behind Navy Island, located within Passamaquoddy Bay. The harbour is further protected from offshore waves by significant bars extending from Navy Island and the mainland on both ends of the island.

The tide range at the Saint Andrews Wharf is 8.0 metres.

The structure is a former Government of Canada wharf, divested to the Town of Sta. Andrews in the 1990’s. The approach structure is trestle work and paved deck structure with ballast boxes in alternative bents found near the sea bottom but elevated off the seabed. The structure is aging, and there is a weight restriction imposed on the structure.

The shoreline on both sides of the structure has been changed over the years with a variety of shore protection measures. Immediately to the north of the Market Wharf approach is a narrow slipway leading from King Street to the upper level of the beach. Next to the slipway is King Steet Pier, a tied back full-face timber structure, protruding 37 metres from the historic shoreline and a length of 43 metres perpendicular to the approach. Beyond Kings Pier, there are a combination of vertical faced sea walls, sloped rock revetments and natural coastlines. To the south of the approach, another tied back full-face timber structure exists, 60 m in length, offset from the historic shoreline by about 10m and perpendicular with approach. As is what is found on the north side, shoreline properties to the south have been fortified with vertical seawalls, rock revetments, or left natural.

The harbour is ice-free over the winter.

1.3 Market Wharf Approach Replacement Overview

The Market Wharf located in the downtown area of Saint Andrews, NB, is subject to weight restrictions and is under threat from rising sea levels.

Council approved a proposal by the engineering firm CBCL Engineering and Environmental Design Services (CBCL) in January 2025 to expand Market Square and infill 4535 square metres at the end of King Street and repair sections of the damaged structure beyond the infill. Work specifically includes, but is not limited to:

- Demolition and disposal of the existing timber wharf approach structure and associated infrastructure, including timber cribs, ballast rock, bracing, stringers, decking, curbing, ladders, lights, electrical, water lines, sanitary sewer lines.
- Construction of an infill revetment structure including rockfill, armour rock, filter stone, aggregate base, aggregate subbase and asphalt restoration. The toe of the infill extends seaward 46 metres from the face of the Kings Pier. The infill area is flared at the shoreline to encapsulate the vertical timber structures on either side of the approach.
- A new steel pile supported wharf structure, complete with reinforced concrete pile caps, precast concrete deck, light pole bases, ladders, mooring cleats, wheel guard, timber fender piles.
- Installation of a new water and sanitary force main.
- Removal and replacement of the timber bracing on the existing Intermediate trestle structure.
- Installation of pile wrap corrosion protection on the existing H-piles of the pierhead.
- Supply and placement of granular materials to adjust surrounding grades and incorporate new infill revetment into existing.

- Disconnection and removal of existing electrical equipment and steel poles in the work area, and installation of new electrical service equipment, lighting, and wiring.

Figure 1-1: Project Location in Saint Andrews, New Brunswick

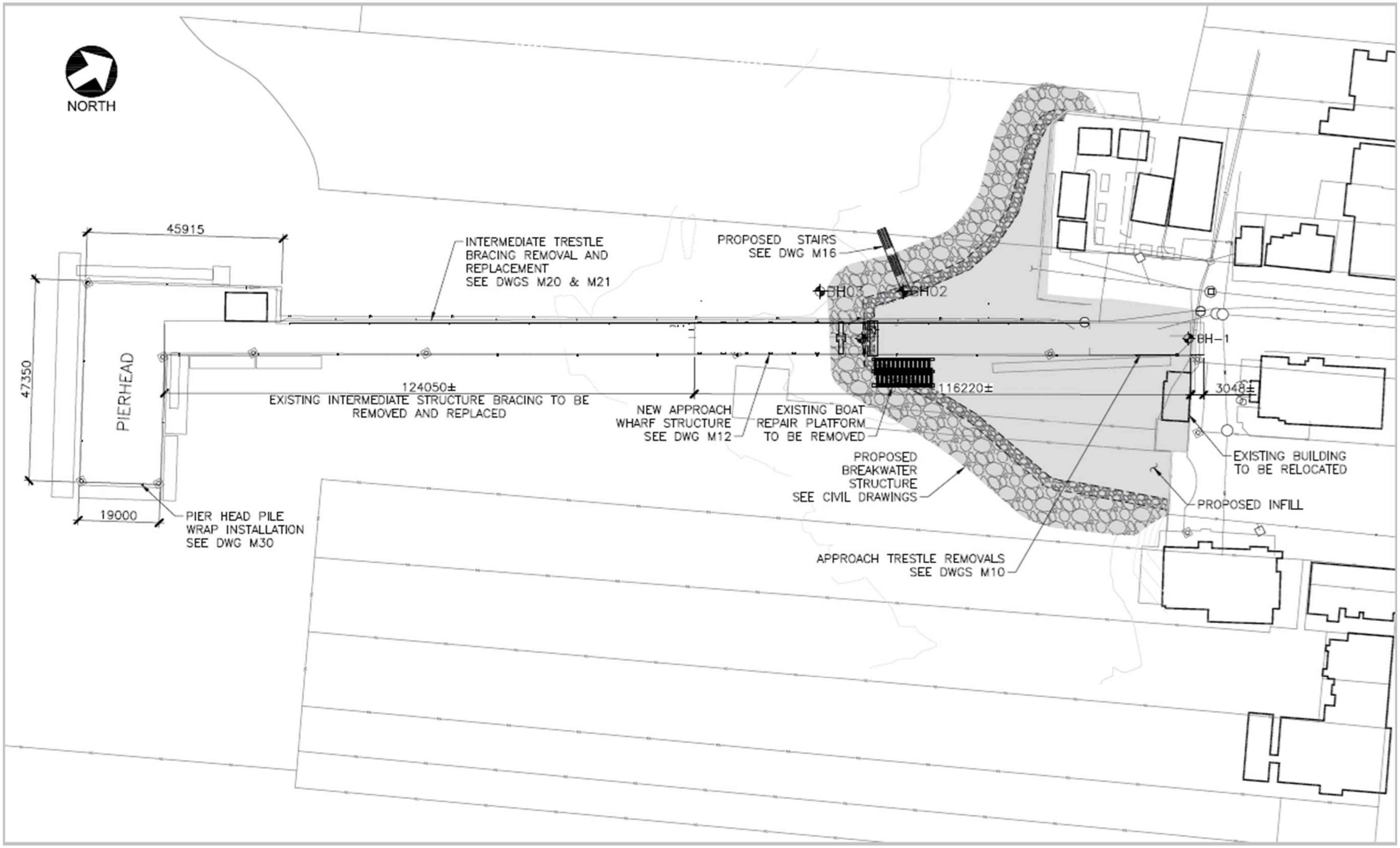

Figure 1-2 Site plan of proposed infill area

1.4 Study Scope

To support and evaluate the design work, coastal modelling will be conducted for the proposed infill area of the shoreline at the Market Wharf. Only the existing configuration and the proposed modifications to the approach are being modelled. The scope of the numerical model study includes:

- Collect and review of available data
- Model setup and calibration using the MIKE2/2 HD software
- Modelling of wave climate in project area
- Modelling of hydrodynamics and water exchange
- Modelling of sediment transport and shoreline change
- Design calculation

The limit of the study area is centered at the approach and initially extends 250 metres on either side of the approach. Should it become evident that the wave and currents have changed at or beyond this limit, the study area will be increased.

1.5 Numerical Modeling Approach

Numerical models are a valuable design tool in coastal engineering studies. A number of models can be used to investigate existing and projected wave agitation in the study area. Typically, the project requirements and existing wave climate dictate the types of models that are used in a study.

In this study, DHI developed MIKE21 software was applied to simulate wave, hydrodynamics, and sediment transport in project area. MIKE21 is a 2-D model with variables integrated over depth. This model has been widely used in various projects in ocean, coastal, and estuary environments here in Atlantic Canada and worldwide. In this project, the following modules were applied:

- MIKE21 SW was used to calculate waves climate. MIKE21 SW is a spectral wave model, can be used to calculate wind-wave generation, wave transformation from deep water to nearshore, wave-wave interaction, etc.
- MIKE21 HD was used to calculate hydrodynamics in project area.
- MIKE21 ST was applied to calculate sediment transport.

2.0 DATA REVIEW

2.1 Bathymetric Data

To set up the model, bathymetric data for the Saint Andrews area was collected. Canadian Hydrographic Service (CHS) data was used to cover a broad region of the Passamaquoddy Bay. For the nearshore area around Market Wharf, seabed elevations were taken from elevations shown on the contract drawings and measured on site:

- Tide levels were measured from the accessing pier (based on deck elevation 5.0mCGVD28).
- Waterlines were observed and recorded.
- Depth is calculated and the recorded waterlines was defined as depth contours.

In this study, elevations are referred to CGVD28 datum, conversions of Chart Datum to CGVD28 in Saint Andrews are as follows:

- Elevation in Chart Datum = Elevation in CGVD28 -3.84m

Figure 2-1 and Figure 2-2 show images of the east and west sides of the access pier, respectively.

Figure 2-1: Photo of shoreline area on the east side of the access pier

Figure 2-2: Photo of shoreline area on the west side of the access pier

2.2 Tide and Extreme Water Levels

Tide levels were obtained from the Department of Fisheries and Oceans website for Saint Andrews Station 00040 (https://www.tides.gc.ca/en/stations/00040) and shown in Table 2-1 converted to CGVD28 datums. Extreme water levels of various return periods were estimated based on recorded extreme water levels of Saint John (Zhai, 2014), summarized in Table 2-2. Future Sea Level Rise in Saint Andrews was extracted from Canadian Extreme Water Level Adaption Tool (CAN-EWLAT), presented in Table 2-3.

Tide levels were sourced from the Department of Fisheries and Oceans (DFO) website (tides.gc.ca), as shown in Table 2-1. Extreme water levels for various return periods were estimated using recorded data from Saint John (Zhai, 2014), summarized in Table 2-2. Projections for future sea level rise in Saint Andrews were obtained from the Canadian Extreme Water Level Adaptation Tool (CAN-EWLAT) and are presented in Table 2-3. Please note that SSP 2-4.5 is an intermediate greenhouse gas emissions scenario where carbon dioxide emissions continue around current levels until 2050, then decrease but do not reach net zero by 2100.

Table 2-1: Tide Levels of Saint Andrews Sta 00040 (tides.gc.ca)

Tide	Height (mCGVD28)
Highest Astronomical Tide (HAT)	4.18
Higher High Water Large Tide (HHWLT)	4.04
Mean Higher High Water	3.02
Mean High Water (MHW)	2.88
Mean Water Level (MWL)	0.03
Mean Low Water (MLW)	-2.9
Mean Lower Low Water	-3.05
Lower Low Water Large Tide (LLWLT)	-4.09
Lowest Astronomical Tide (LAT)	-4.23

Table 2-2: Estimated extreme water level including tide and storm surge

Return Periods (yrs)	Water Level (WL) (mCGVD28)
2	4.40
5	4.49
10	4.56
25	4.65
50	4.73
100	4.80

Table 2-3: Future Sea Level Rise (CAN-EWLAT)

CAN-EWLAT (Fairhaven)	SSP 2-4.5
2030	0.11
2050	0.26
2070	0.41
2100	0.63

2.3 Offshore Wind and Wave

Offshore wind and wave data were obtained from MSC50, a 50-year long-term wind and wave database maintained by the Environment and Climate Change Canada. The selected data point in the Bay of Fundy is located at Latitude 45°N and Longitude 66.6°W. This is the closest point to the project site and provides conservative but reliable wind and wave conditions for the project. Offshore winds are almost always stronger than what is experienced near shore or on land. Figure 2-1 below presents the offshore wind rose. The length of the rose petal indicates frequency of wind direction. The colour of the petal indicates the wind speed, as per the legend below.

Table 2-4 presents the extreme 100-year wind speed and direction.

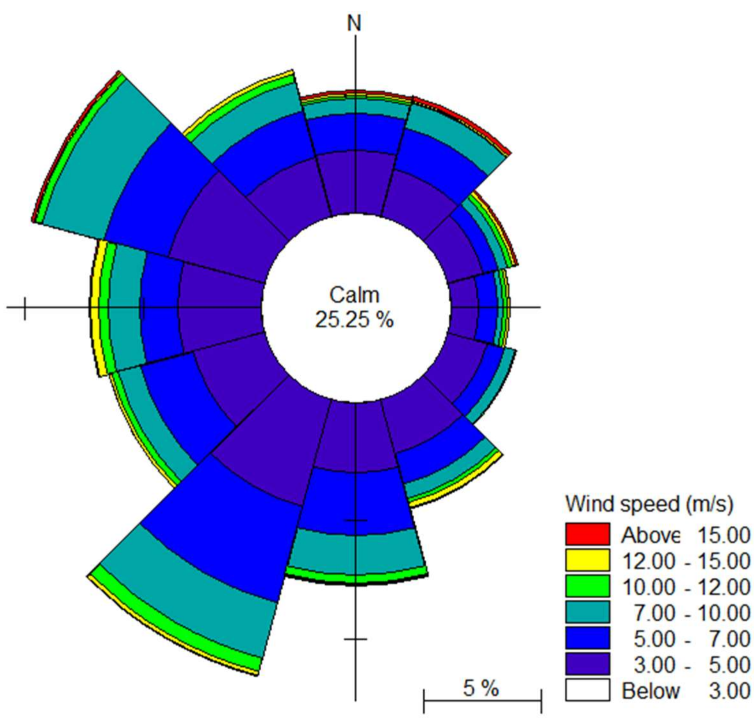

Figure 2-2: Wind Rose for offshore area of Saint Andrews

Table 2-4: 1-100-Year Extreme Wind Parameters from MSC 50 (Latitude 45.0N, Longitude 66.6W)

Wind Direction (Degrees from North)	Wind Speed (m/s)	Wind Speed (km/hr.)
0	28.12	101.23
45	26.18	94.25
90	21.62	77.83
135	22.81	82.12
180	22.06	79.42
225	20.56	74.02
270	23.76	85.54
315	25.15	90.54

2.4 Sea Bottom Samples

Sea bottom samples were collected at low tide during site visit by GEMTEC on June 17, 2025, and returned to the GEMTEC laboratory for grain size analysis. Locations of collected samples are depicted on Figure 2-3. The sea bottom observation at low tide noted only small patches of sand near the shoreline area. Other areas are gravel, rock bed and seaweed. Sand patches are only a small part of the shoreline area.

Figure 2-3: Sand sample locations

Figure 2-4 presents sand sample grain size analysis curves. It shows the particle size of sand samples are between 0.20mm-0.35mm.

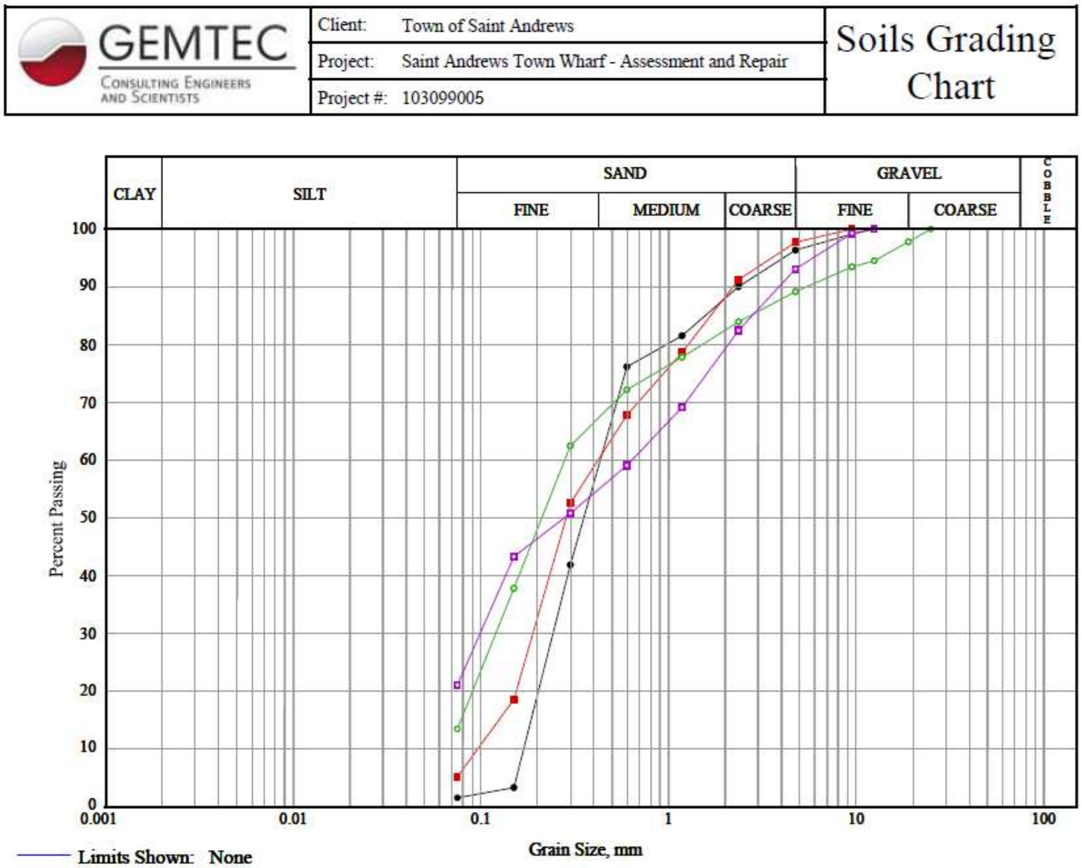

Figure 2-3: Grain size distribution of sand samples

Table 2-1: Sand sample classification and percentage

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt % Clay
black, ●	Soil Sample #1		1		3.7	94.8	1.5
red, ■	Soil Sample #2		2		2.3	92.6	5.2
green, ○	Soil Sample #3		3		10.8	75.7	13.4
purple, □	Soil Sample #4		4		6.9	72.1	21.0

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75μm
black, ●	Sand , trace gravel, trace silt	SP	0.169	0.185	0.24	0.35	0.43	1.57	---
red, ■	Sand , trace gravel, trace silt	N/A	0.096	0.125	0.19	0.28	0.42	1.67	---
green, ○	Sand , some gravel, some silt	N/A	---	0.078	0.12	0.21	0.28	2.72	---
purple, □	Silty sand , trace gravel	N/A	---	---	0.10	0.28	0.64	2.79	---

3.0 MODEL METHODOLOGY

A numerical model was developed for the project site, with the model domain illustrated in Figure 3-1. Figure 3-2 presents the refined mesh system within the harbour area, where a higher resolution is required for a detailed analysis.

The model includes two open boundaries connecting to the Bay of Fundy. For wave modeling, wind data from the MSC50 dataset are applied across the entire model domain. The offshore wave conditions are imposed at the open boundaries to represent incoming waves from the Bay of Fundy. For hydrodynamic, water exchange, and sediment transport modeling, tidal levels from nearby tidal stations are applied at the open boundaries.

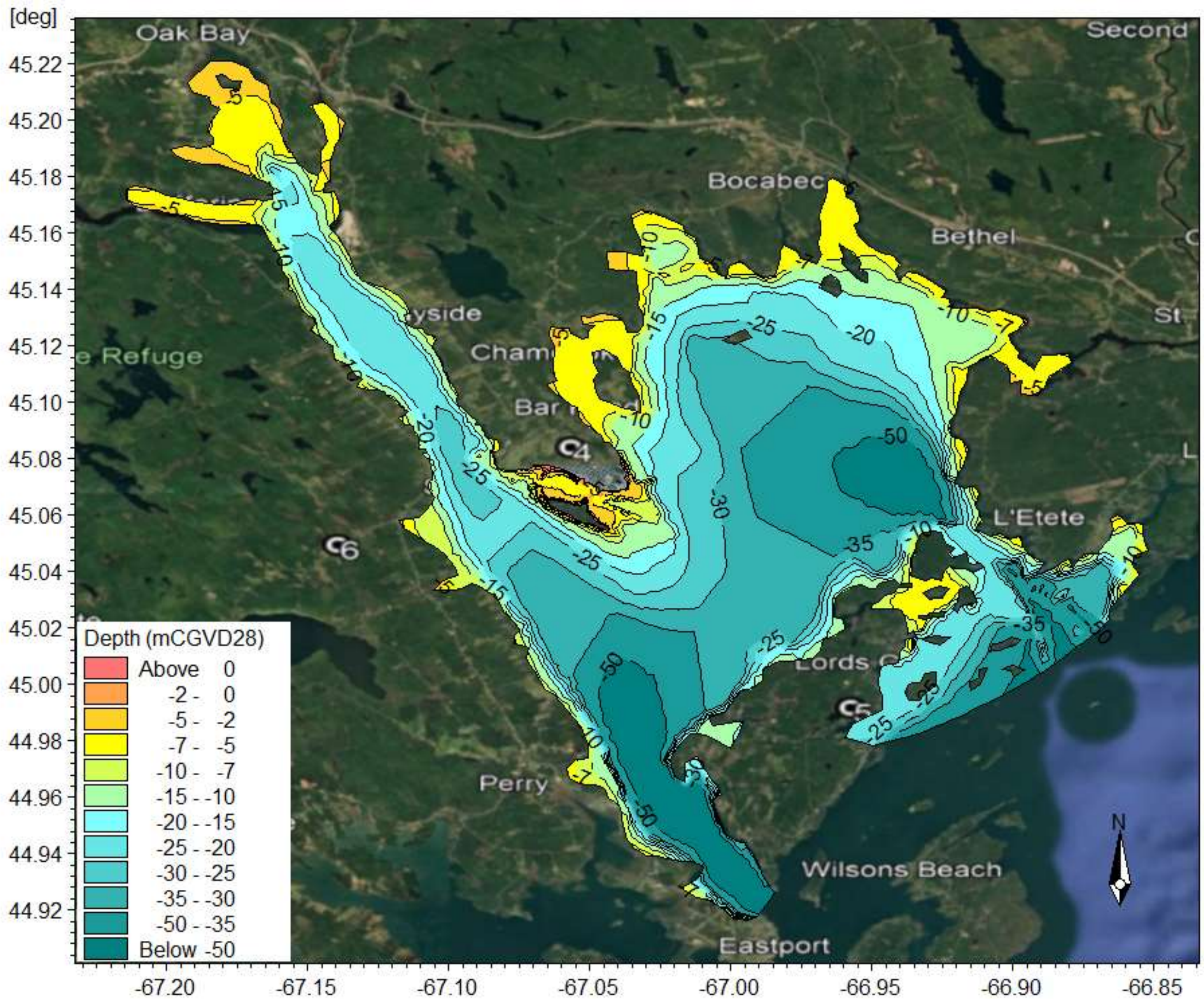

Figure 3-1: Model domain and bathymetry

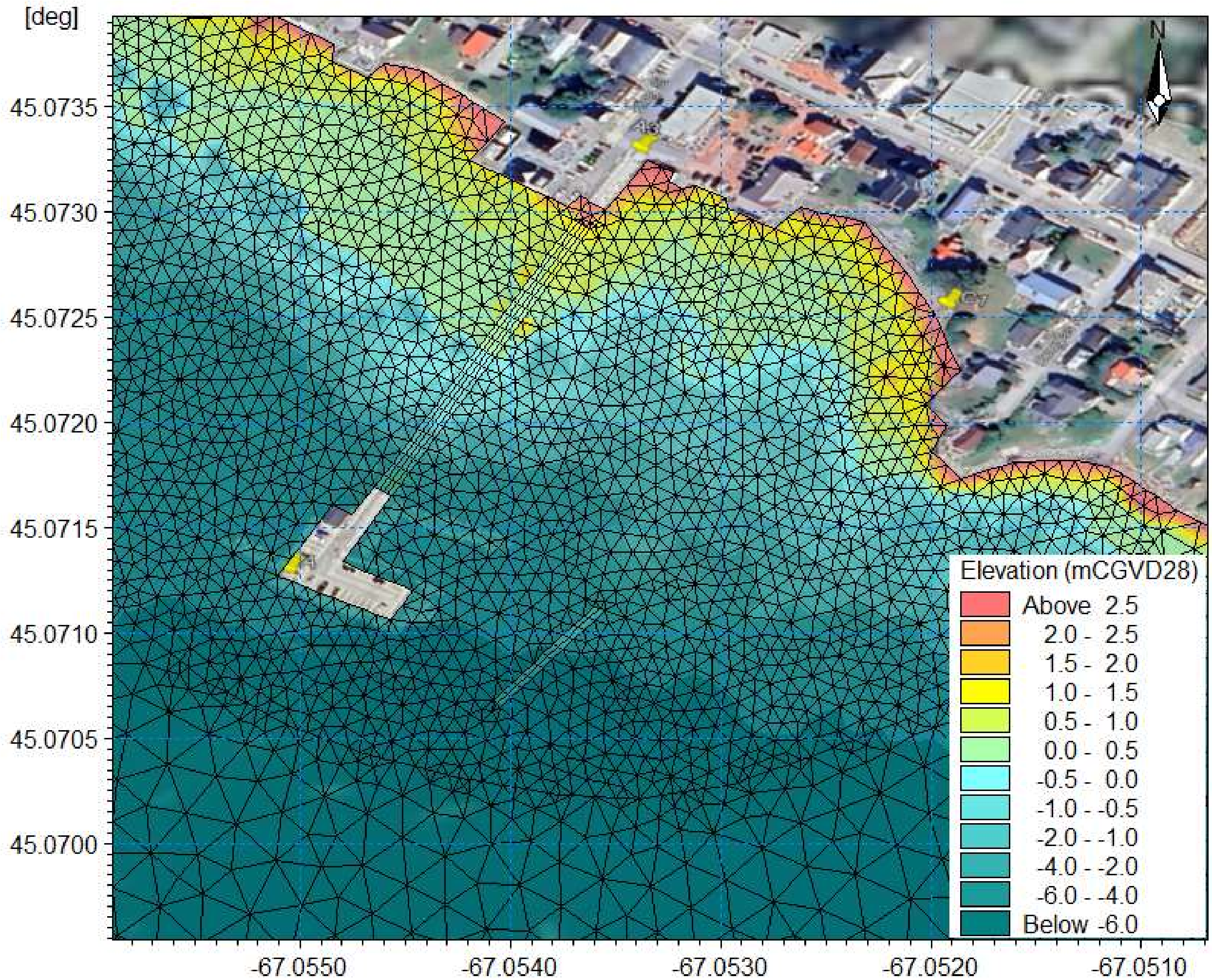

Figure 3-2: Refined mesh system in project area

4.0 MODEL RESULT

4.1 Wave Model

4.1.1 Nearshore wave climate

A wave model was conducted to simulate wind wave generation and wave transformation from offshore to nearshore area. Model result demonstrates that waves in Saint Andrews area are local wind-generated waves. Waves from the Bay of Fundy cannot fully penetrate/transfer to Saint Andrews harbour area and Navy Island provides good protection so waves in the nearshore area can be significantly reduced. Figure 4-1 demonstrates wave height in Saint Andrews harbour with a 100-year storm from the SSE.

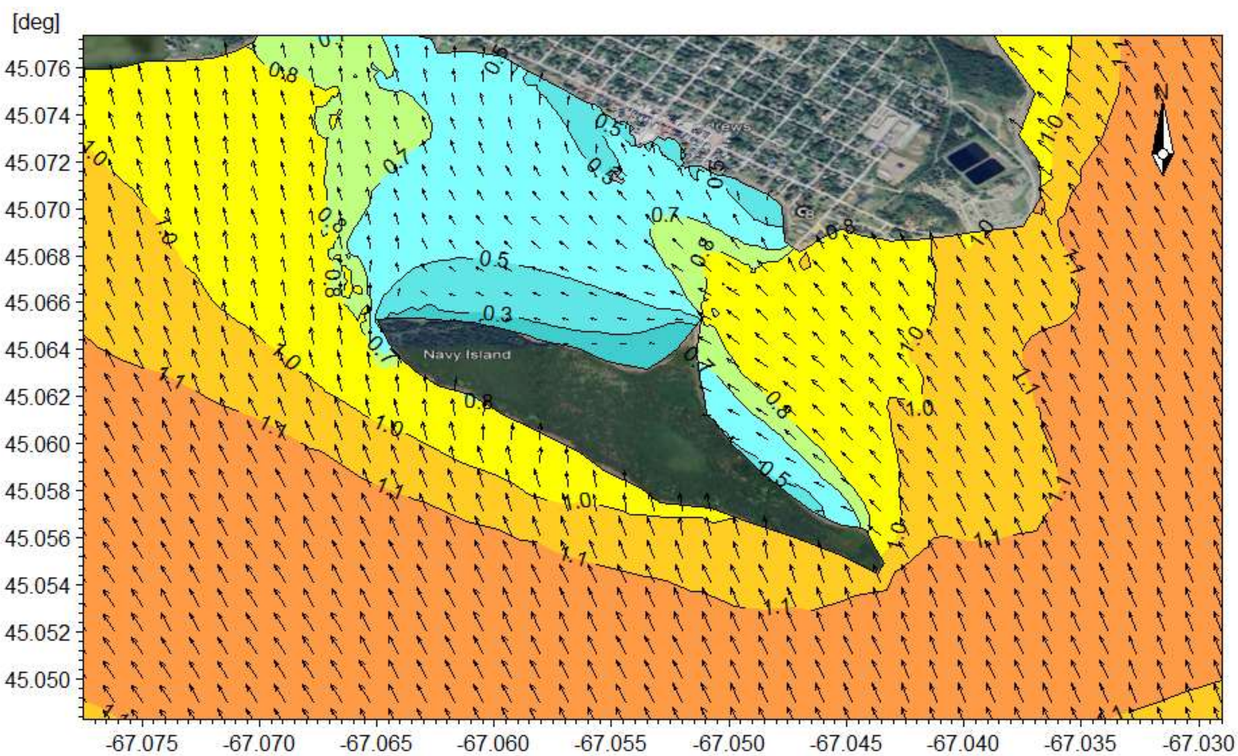

Figure 4-1: Wave height in Saint Andrews and surrounding area with 100-year windstorm from SSE

Figure 4-2 presents the wave roses for the nearshore areas on west side and east side of the accessing pier. It shows that on west side, waves are mainly from W to WSW, while on east side, waves are mainly from SSE.

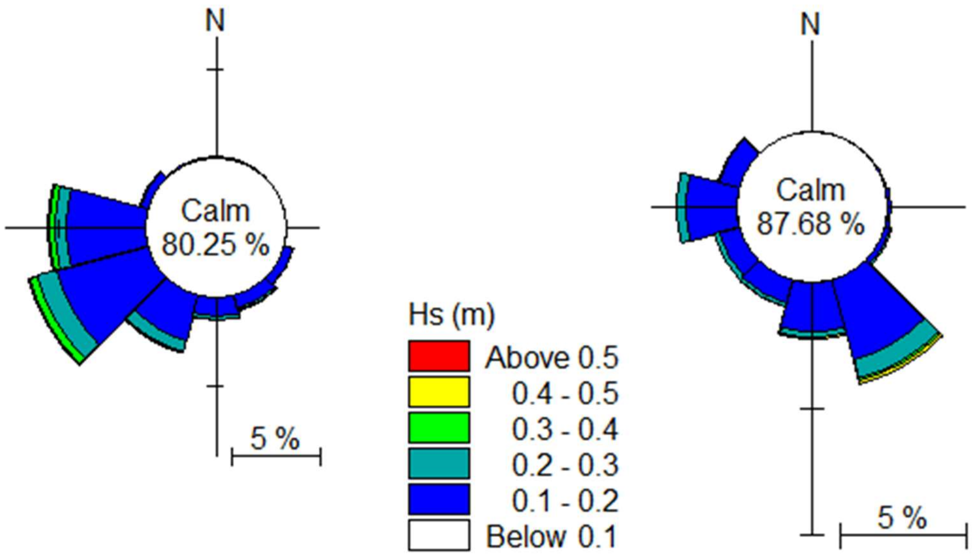

Figure 4-2: Wave roses near project area (west side and east side of the accessing pier)

4.1.2 Extreme Waves in Shoreline Area

The 100-year extreme wave heights in the project area were extracted from the model results and summarized in Table 4-1 below.

Table 4-1: Extreme wave in project area

Location	Hs (m)*	Tp (s)**	D (deg N)***
West side	0.65	5.2	225
East Side	0.60	5.2	165

*Hs = wave height, wave measured in metres
**Tp = wave period, measured in seconds
***D = wave direction, measured from N being 0°

4.2 Tidal Flow

Figure 4-2 presents a Google Earth image showing Saint Andrews Harbour and surrounding area. The harbour is situated within a semi-enclosed bay, sheltered to the south by Navy Island. Prominent sandbars are also present to the west and east, providing additional natural protection. Flow through the western entrance is dominant due to the lower elevation of the sandbar on that side. In contrast, the eastern sandbar, with an elevation of 2.0 metres or higher, significantly limits water exchange into the harbour.

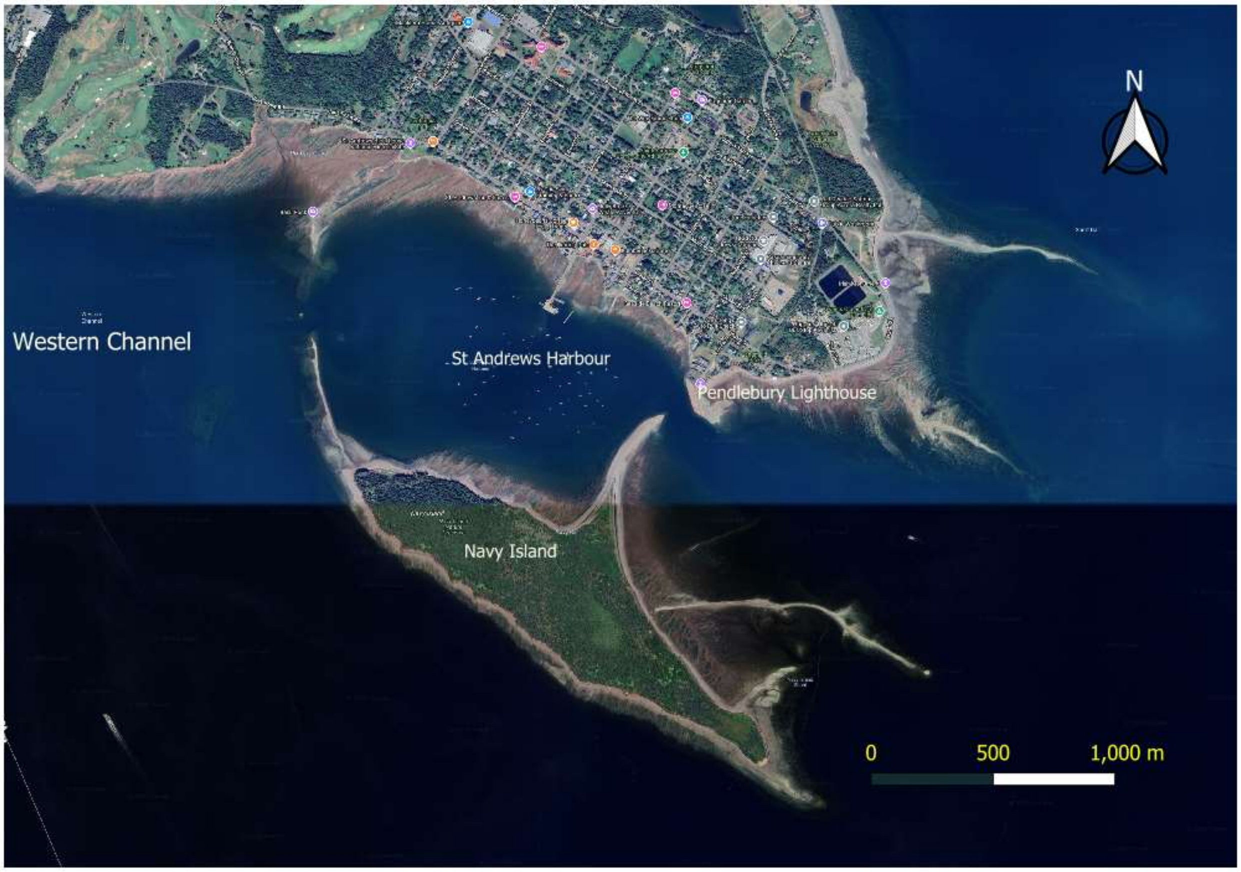

Figure 4-2: Satellite image of Saint Andrews Harbour and surrounding area

Figure 4-2 and Figure 4-3 demonstrate flow patterns in Saint Andrews and surrounding area. Flow speed outside of Navy Island can be greater than 0.5m/s. Flow near the harbour area is much smaller. In the Market Wharf area, maximum flow speed can be 0.3m/s, while nearshore area flow speed is much smaller, usually 0-0.1m/s.

Figure 4-4 and Figure 4-5 present snapshot of flow patterns of existing shoreline and with future proposed shoreline expansion. Since the expansion follows the shoreline and does not protrude far into the water, it has minimal impact on flow patterns within the wharf area. Any influence is limited to high tide conditions and is confined to the immediate vicinity of the expansion structure.

The flow patterns at the study limit (250m from Market Wharf) are unchanged when the infill area is introduced, and it is concluded that the limit of study area is sufficient.

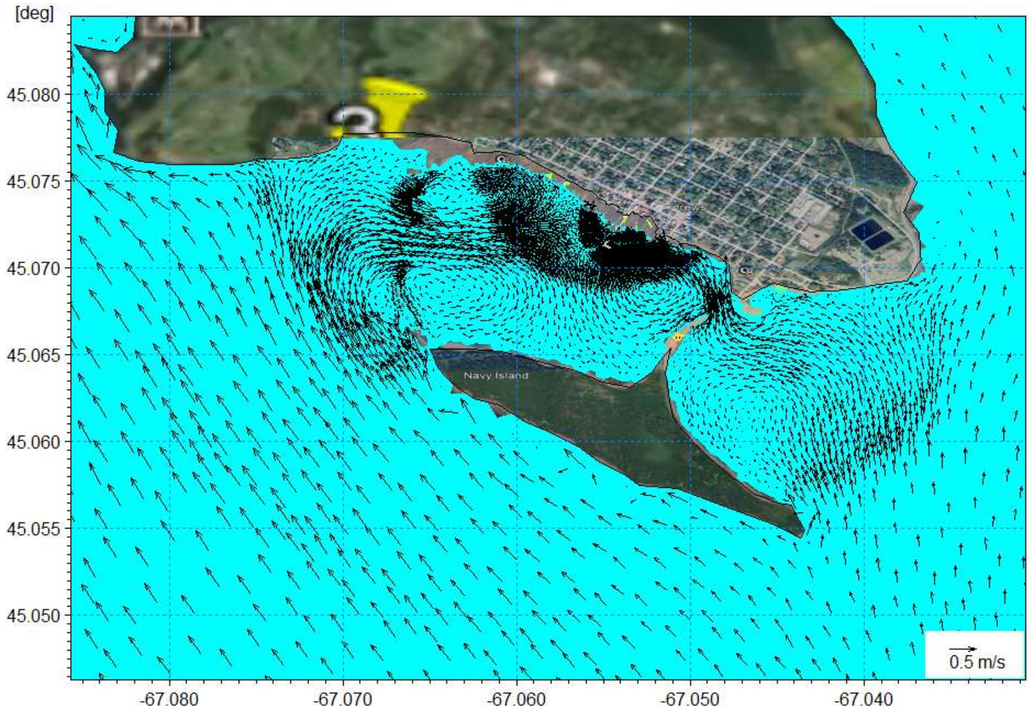

Figure 4-2: Snapshot of flow pattern of rising tide in Saint Andrews and surrounding area

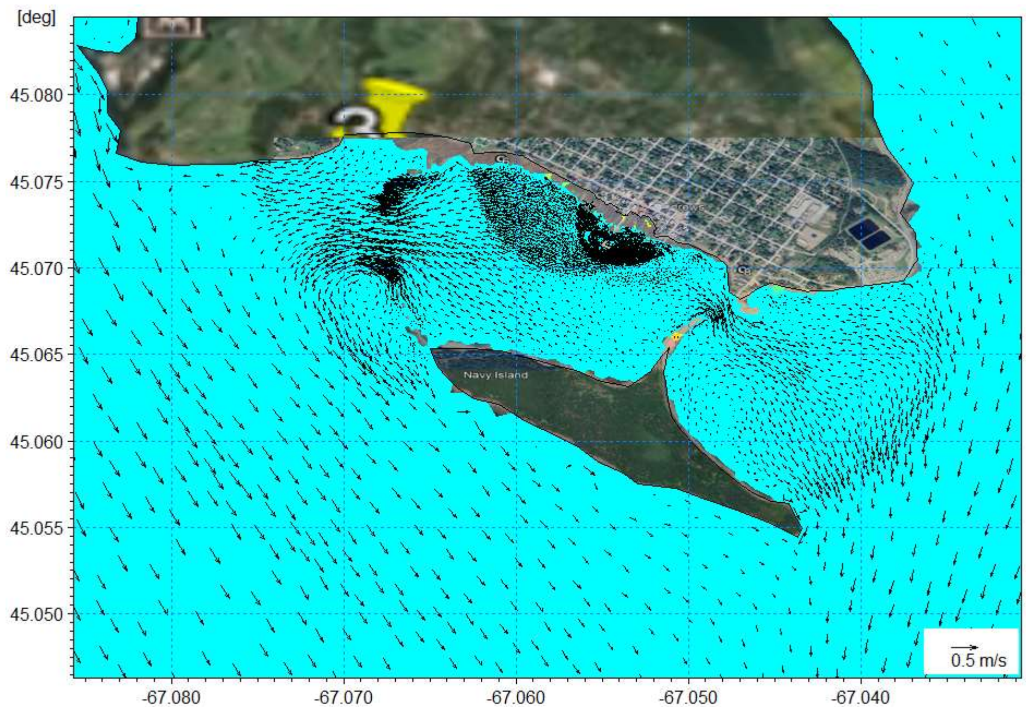

Figure 4-3: Snapshot of flow pattern of falling tide in Saint Andrews and surrounding area

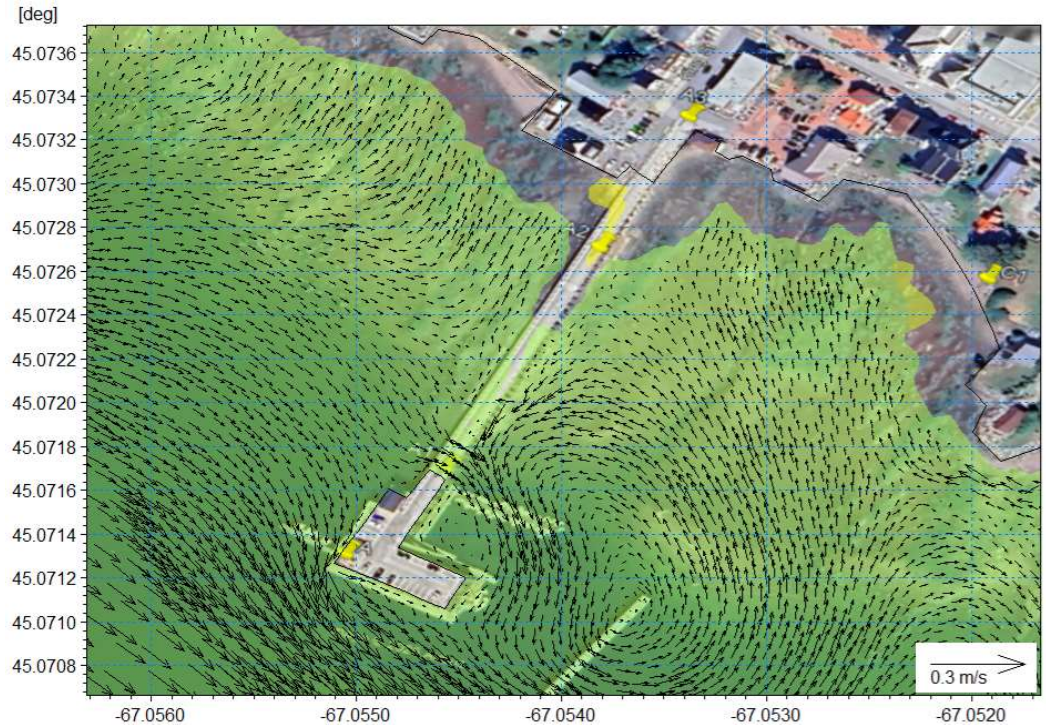

Figure 4-4: Snapshot of flow pattern during rising tide -existing shoreline

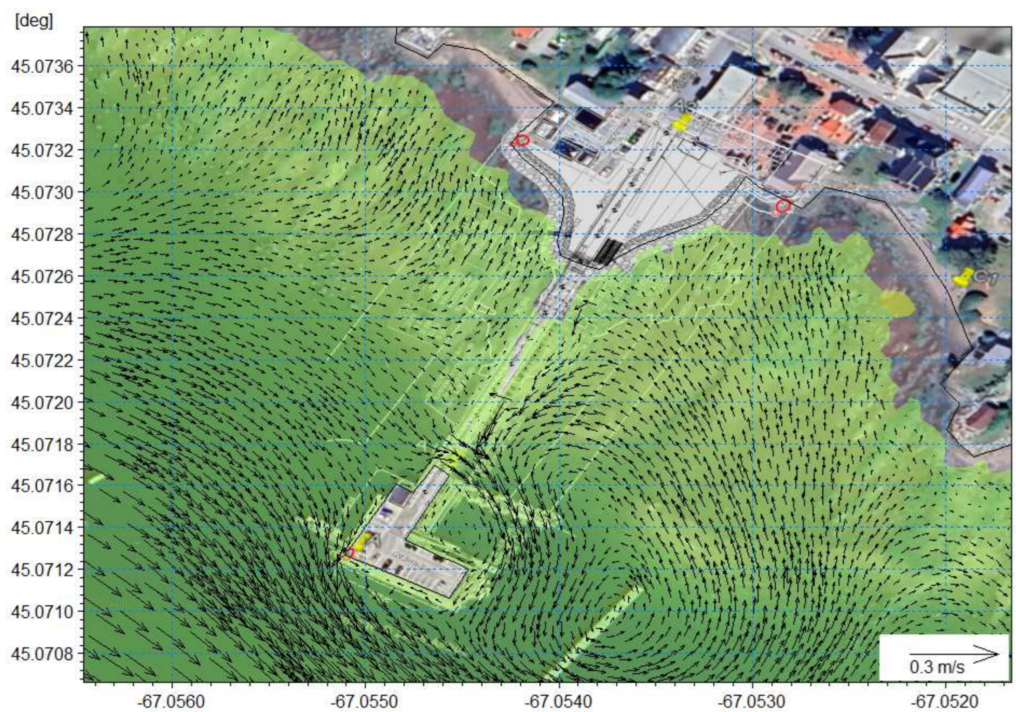

Figure 4-5: Snapshot of flow pattern during rising tide – including proposed shoreline expansion

4.3 Water Exchange

To evaluate the water exchange rate in the study area, a “pollutant” of a concentration of 100% was assigned to the harbour area, as illustrated in Figure 4-6. The dispersion of this concentration is measured over a number of tidal cycles. Remaining concentrations of the introduced substance after a number of tidal cycles is extracted at the points shown in Figure 4-6 to assess the water exchange rate.

The use of this module is effective to assess the exchange rate of the water in the study area. The rapid dispersion is primarily attributed to the significant tidal range and the complete drying out of the nearshore areas during each low tide. There is no opportunity for water to become stagnate as the near shore drains completely. The residual concentrations measured assumes a percentage of the introduced pollutant returns each tide.

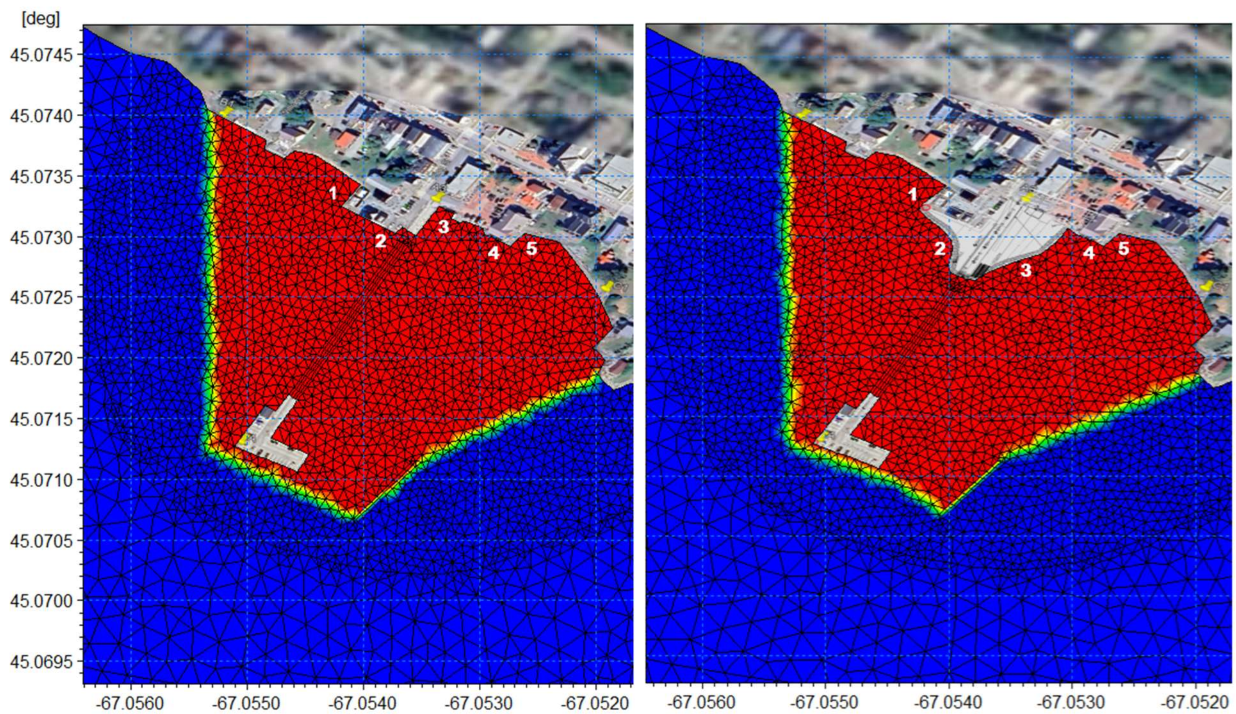

Figure 4-6: Initial concentration (Red area-100%) and point locations to extract remaining concentration (Left image: Existing Wharf Approach. Right image: Proposed shoreline expansion)

Figures 4-7 and 4-8 illustrate the remaining pollutant concentration in the existing scenario after 3 and 5 tidal cycles, respectively. Figures 4-9 and 4-10 present the corresponding results for the proposed shoreline expansion scenario. Results show that the proposed construction may slightly reduce the water exchange rate in near shore area, however, the remaining pollutant concentration can be reduced to less than 1% (of original concentration) within 5 tides. This means that water exchanges of both existing layout and with the proposed infilling area are efficient. Again, this efficiency is primarily attributed to the significant tidal range and the drying out of nearshore areas during low tide, which promotes rapid water renewal in each tidal cycle.

Figure 4-11 and Figure 4-12 present results of remaining concentration of selected points, shown in Figure 4-6. It shows that remaining concentrations with proposed expansion are slightly higher than existing case, but concentrations are quickly reduced. This means both in both cases the water exchanges are efficient.

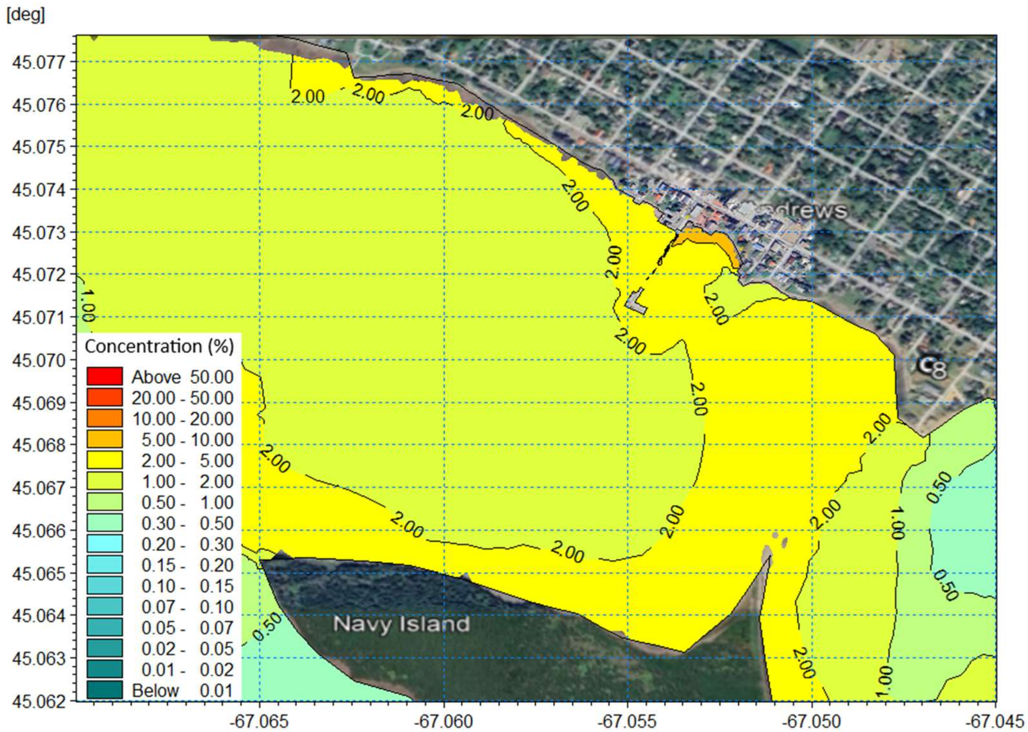

Figure 4-7: Remaining concentration after 3 tidal cycles – Existing Shoreline

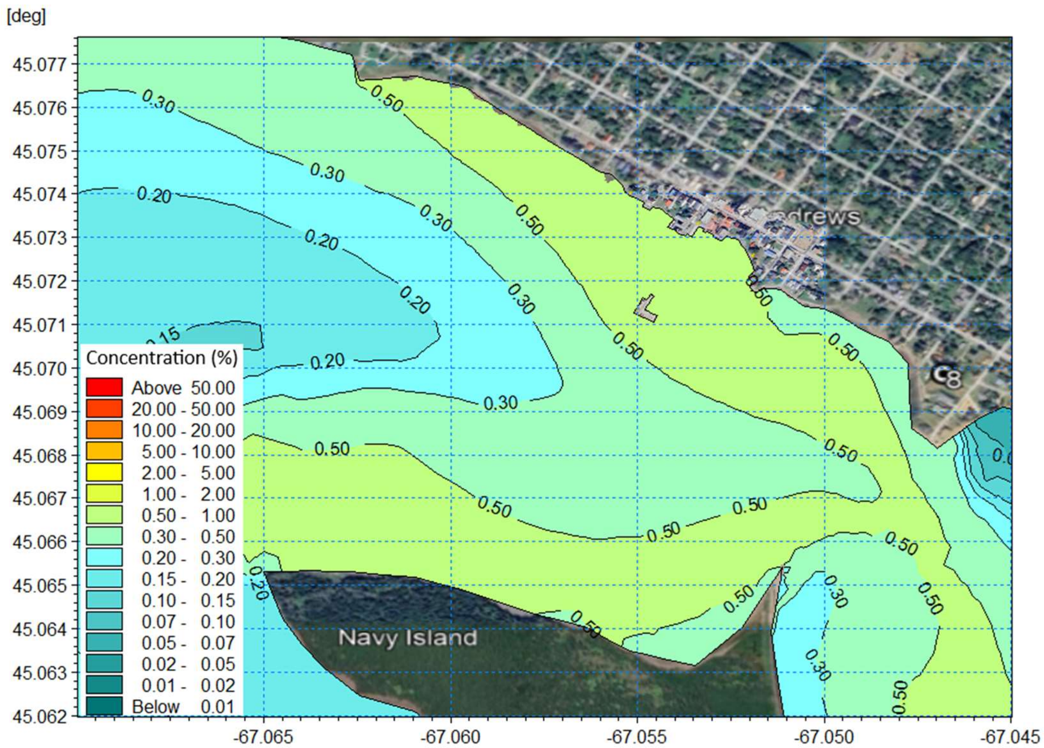

Figure 4-8: Remaining concentration after 5 tidal cycles – Existing Shoreline

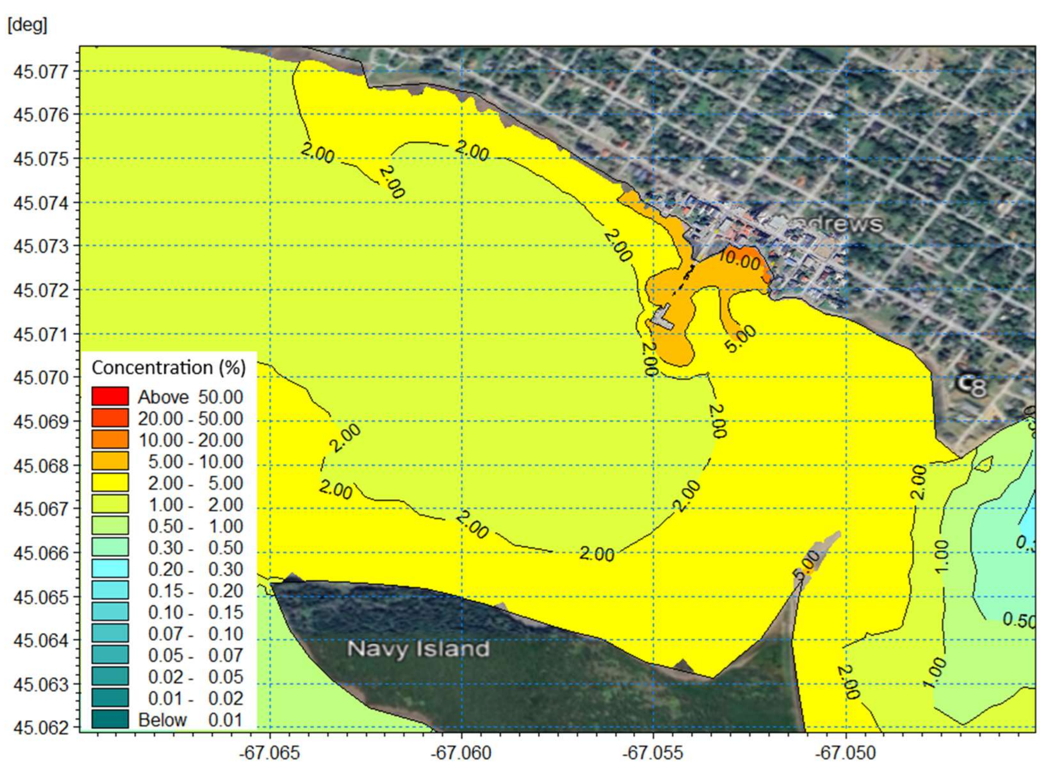

Figure 4-9: Remaining concentration after 3 tidal cycles – With Proposed expansion

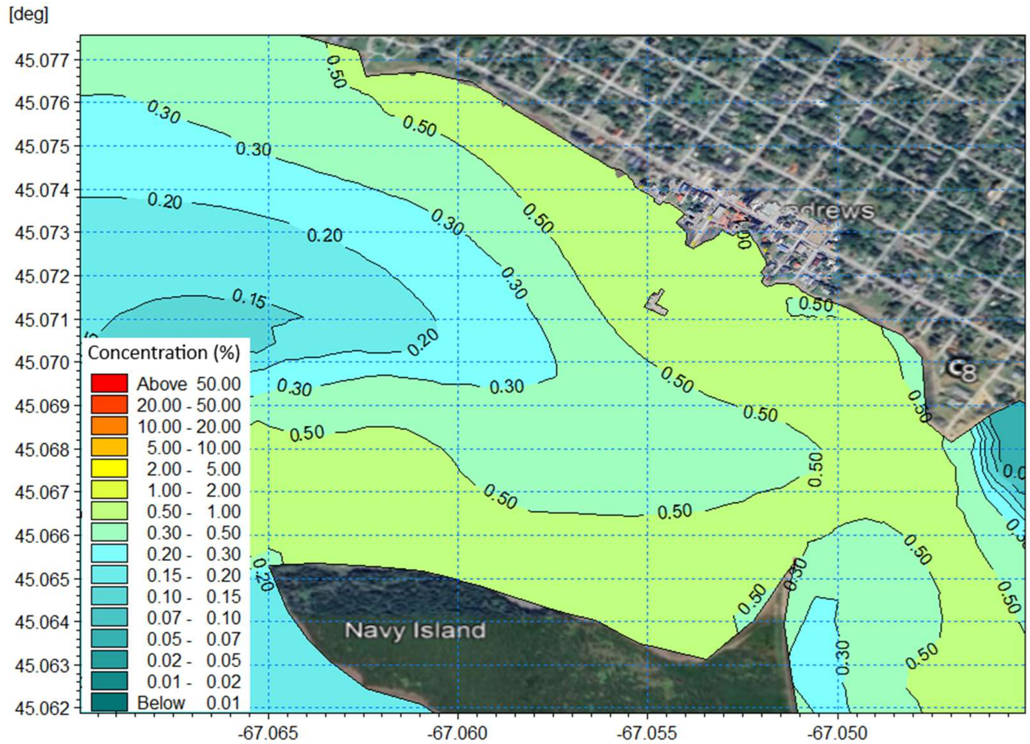

Figure 4-10: Remaining concentration after 5 tidal cycles – With Proposed expansion

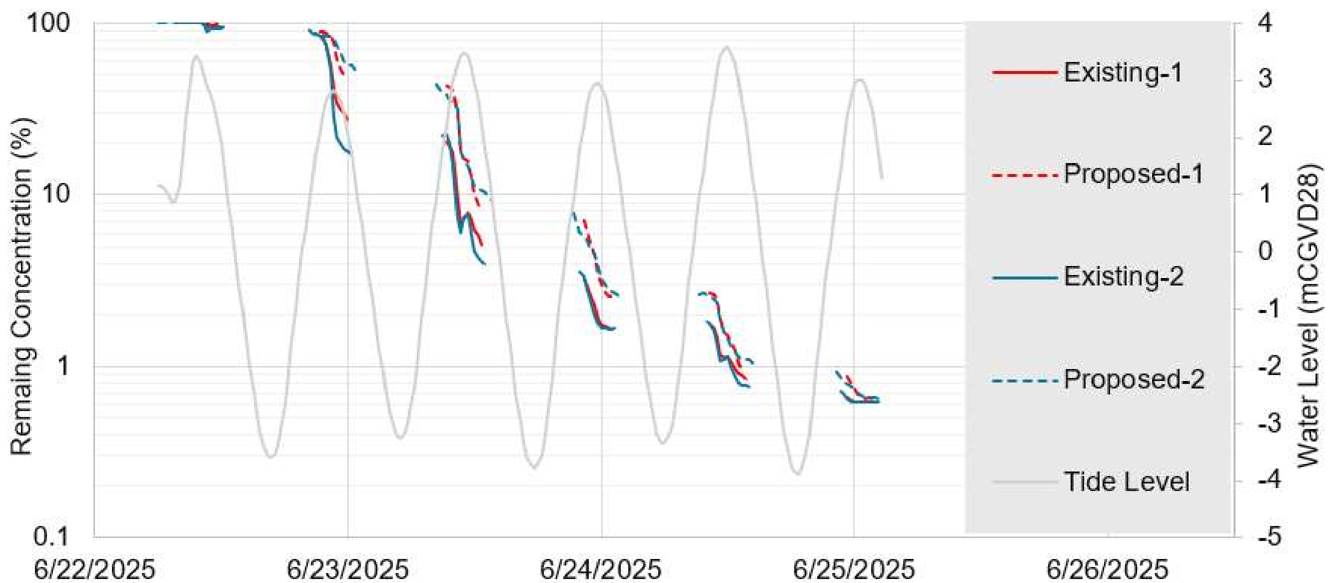

Figure 4-11: Change of remaining concentrations, west side points

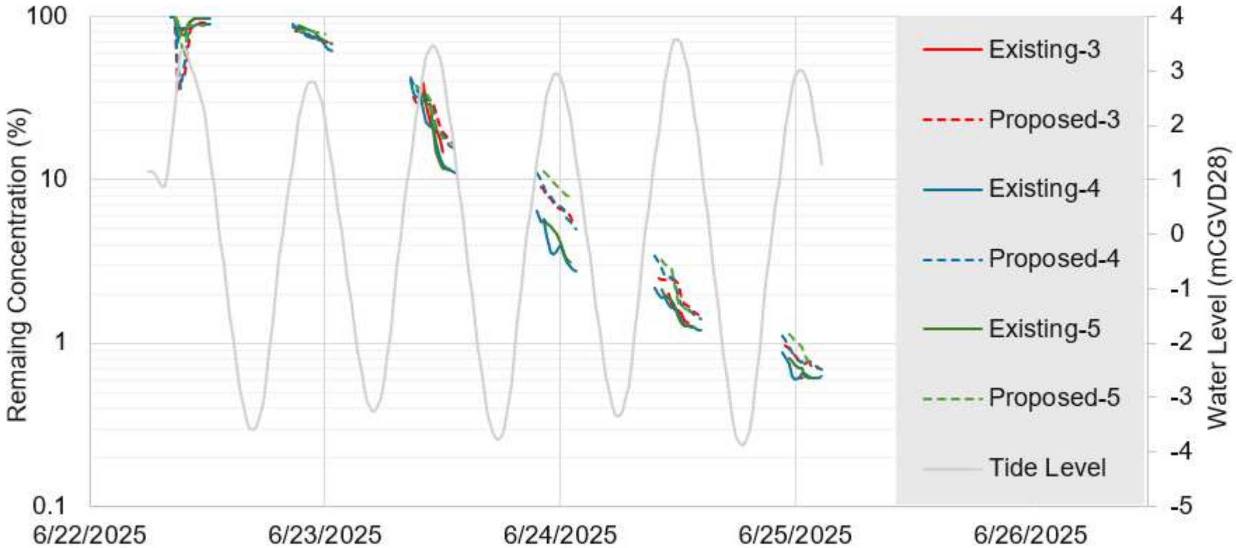

Figure 4-12: Change of remaining concentrations, east side points

4.4 Sediment Transport

4.4.1 Sediment Transport in Nearshore Area

Wave calculation shows that the proposed shoreline expansion does not have any impact on the nearshore wave climate and has no obvious impact on flow patterns. As a result, sediment transport in nearshore area remains the same.

4.4.2 Shoreline Change

Longshore sediment transport was modelled for the existing and proposed scenarios. As the tidal flow speed is minimal, and the wave height is small (0m - 0.5m), sediment transport is also limited to finer particles. The model indicates, shown in Figure 4-13, that the potential longshore sediment transport using the existing configuration would tend to converge toward the corners on both sides of the access pier. No evidence of significant deposition is found at the site. The transport rate is very low and is likely balanced by the natural upslope formation toward the corners.

Figure 4-14 shows the longshore transport with the proposed infill area. Fine sand depositions likely occur in the tight corners of the infill areas, shown circled in the figure. In both scenarios, the potential longshore transport rate is only 100-200cubic metres/year (assuming there was available fine sand for the bed material). As the existing seabed consists mainly of gravel and seaweed, there is expected to be no obvious shoreline change with the proposed configuration.

Structures introduced into the coastal setting may result in changes to how waves travel along the reconfigured shoreline. Vertical and smooth structures can have negative impacts to shorelines, such as increased erosion in adjacent unprotected areas or potential damage from wave reflection. The introduction of the proposed sloped rock revetment mitigates these concerns. The wave energy is consumed on the side slope and within the voids of the rock protection. Adjacent properties are at less risk of erosion than with the current seawall.

The model predicts that the proposed expansion does not affect wave conditions (direction of flow remains the same near shore, Figure 4.5) near the existing sand beaches at Points 1 and 4 in Figure 4-13. It can also be concluded that the new construction will have no impact on the small beaches. Seasonal variations in beach morphology are expected to remain consistent with current conditions.

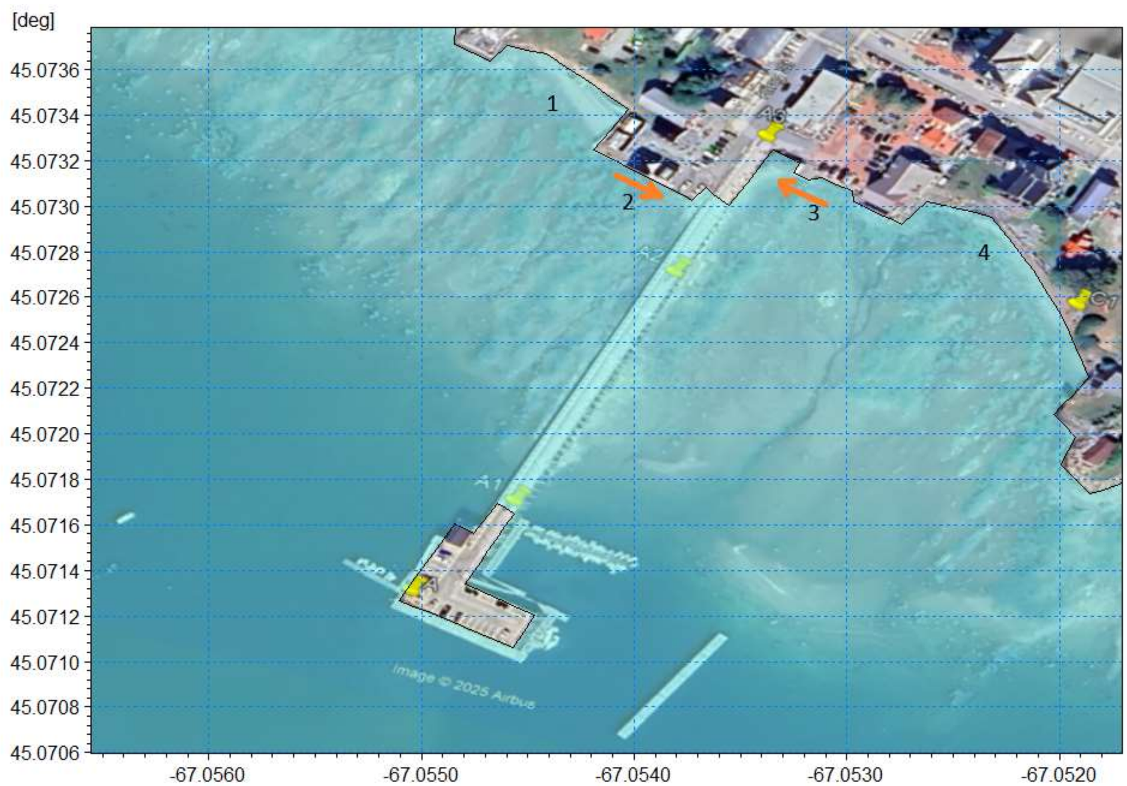

Figure 4-13: Longshore sediment transport in existing shoreline area

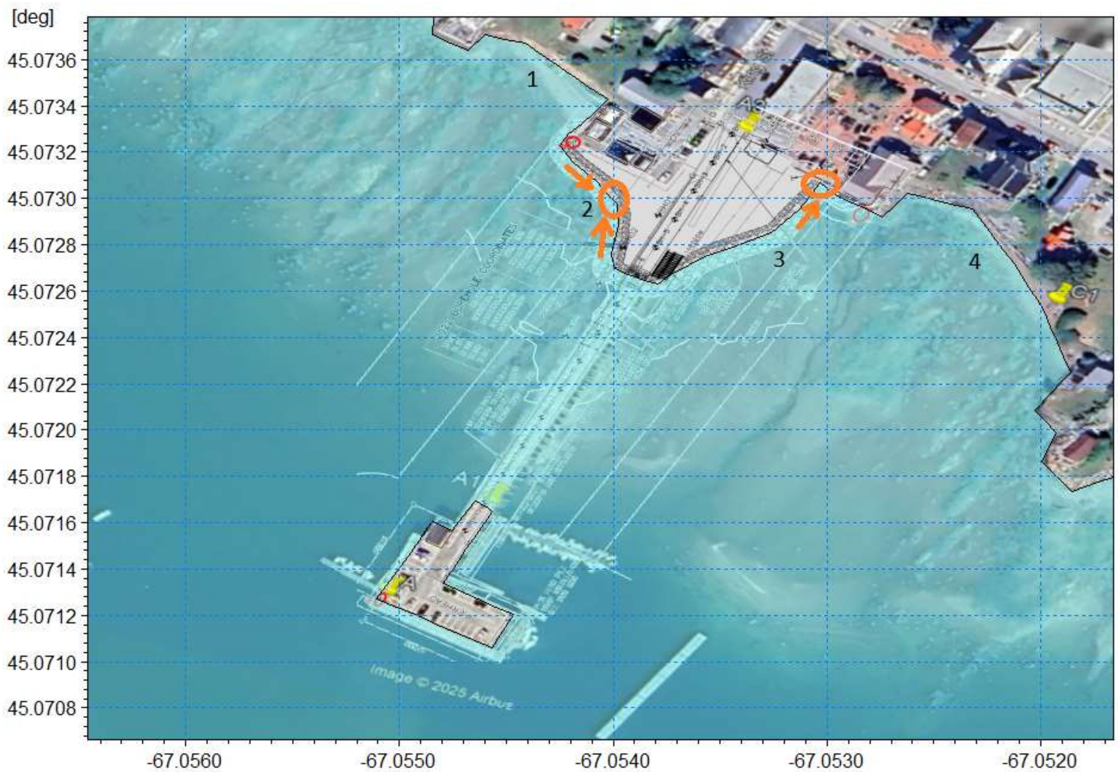

Figure 4-14: Beach profile (change) with proposed shoreline expansion

4.4.3 Beach Profile Change

Beach profile change was examined using 100-year wave storm shown in Table 4-1. Figure 4-15 presents the model result of the beach profile change after several storms. It shows the potential toe erosion at the revetement could be a magnitude of 0.20m - 0.30m. In this model study, a fine sand (D=0.20mm) was assumed, therefore, the predicted toe erosion is a very conservative estimate.

Potential revetement toe erosion has been mitigated in the design of the rock protection slope with a 600mm key at the toe of the slope.

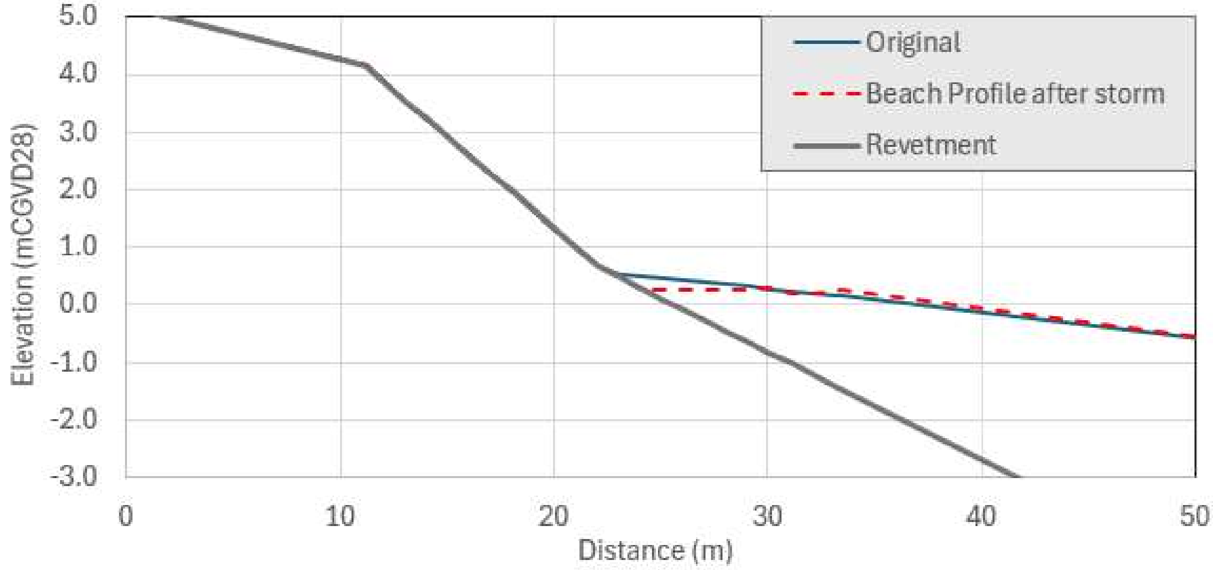

Figure 4-15: Beach profile change after storms

5.0 DESIGN CALCULATION

5.1 Rock Armour Protection

The armour rock size is calculated using the 100-year wave data from Table 4-1 and applying both Hudson and Van de Meer formulas to confirm the appropriate sizing for the wave energy. The results are summarized in Table 5-1. There is no reason to consider oversizing the rock for ice damage (plucking, pushing) as the Passamaquoddy Bay is ice free.

The grading sizes used to specify the rock are from Table 608-1 of the New Brunswick Department of Transportation and Infrastructure Standard Specification. R250 armour rock is a is 250 kg to 500kg rock size. The proposal calls for 500kg to 1500kg, which is R500 armour rock.

Table 5-1: Armour rock size

Hs (m)	Tp (s)	Hudson (kg)	Van de Meer (kg)	Proposed Armour Rock
0.7	5.2	165	120-170	R250
0.6	5.2	100	70-100	R250

*Hs = wave height, wave measured in metres
**Tp = wave period, measured in seconds

5.2 Wave Overtopping and Crest Level

Wave overtopping and flooding of the proposed work is predicted using the Table 2-2: estimated extreme water found in Table 2.2 and applying the wave height predictions from the 100-year storm found in Table 4-1.

Over the next 25 years, the extreme water height and tide surge is estimated not to exceed 4.65m. This height, plus a generated storm wave of 0.65m will produce a flood height of 5.3m. The new infill and deck elevation of the proposed work is 5.50m. At the end of this century, sea level rise will likely cause flooding of the infill area.

6.0 CONCLUSION AND RECOMMENDATIONS

The following concludes and summarizes the results of the modelling of the Town of Saint Andrews Market Wharf Approach replacement.

- The Saint Andrews Harbour for the most part is protected from offshore winds and waves by Navy Island and the sand bars that have formed at two inlets. The waves that form are localized and are not influenced from offshore.
- The infill area follows the shoreline and does not protrude far into the water, so therefore has minimal impact on flow patterns within the wharf area. Any influence is limited to high tide conditions and is confined to the immediate vicinity of the expansion structure.
- The module used to assess the water exchange rate in near shore area indicated a slight change to the rate near shore. The water exchange rate of both existing layout and with the proposed infilling area remain efficient. This efficiency is primarily attributed to the significant tidal range at the site and the complete drying out of nearshore areas during low tide, which promotes rapid water renewal in each tidal cycle
- Longshore sediment transport with the proposed infill indicated that fine sand depositions would likely occur in corners of the infill area (assuming there was available fine sand for the bed material). As the existing seabed consists mainly of gravel and seaweed, there is expected to be no obvious shoreline change with the proposed configuration. The proposed expansion does not affect wave conditions near the existing sand beaches on either side of the infill, so it can also be concluded that the new construction will have no impact on the shorelines.
- The beach profile change indicates potential toe erosion at the revetement based on a sand bottom. Potential revetement toe erosion has been mitigated in the design of the rock protection slope with a 600mm key at the toe of the slope.
- The armour stone size based on the wave climate is 250 kg to 500kg rock size. The proposal calls for 500kg to 1500kg.
- The proposed height of the new work is sufficiently high enough to prevent wave overtopping and flooding with the next 25 years. It is possible at the end of this century sea level rise could lead to flooding of the infill area and wharf deck.

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geotechnical	géotechnique
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structural	structures
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

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