CENTRE FOR MARINE APPLIED RESEARCH

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WIND AND WAVE CONDITIONS – ST. MARY'S BAY – REFERENCE SITES 1, 2, 3

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Executive Summary

In support of Centre for Marine Applied Research (CMAR), the following report presents wind and wave conditions at three reference locations in St. Mary's Bay, Nova Scotia, Canada.

In this report, wave and wind conditions are presented for 3 reference locations:

- St. Mary's Bay Reference Site 1: 44° 18.970'N, 66° 12.519'W.
- St. Mary's Bay Reference Site 2: 44° 22.444'N, 66° 9.136'W.
- St. Mary's Bay Reference Site 3: 44° 24.179'N, 66° 7.752'W.

To determine the wave field evolution closer to shore at a specific site, and to determine more accurate 10 and 50 year return period wave data, near shore wave modelling can be used. For the St. Mary's Bay area, STWave was used to model the wave conditions inside the bay. The STWave model results at the three reference locations are determined using wind and wave boundary condition data from the

MSC50 HindCast model of a nearby offshore location. The extreme wave conditions at the reference locations are determined in part by propagating wave from the offshore hindcast model location into the site of interested. As expected, the three locations which are well inside the bay showed significantly reduced wave heights, in comparison to the conditions at the hindcast source point which is located at the southern entrance to the bay due to depth induced energy dissipation (bottom friction, breaking).

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1 Introduction

1.1 Overview

For the reference locations in St. Mary's Bay shown in Figure 1, wind and wave conditions have been estimated. The following presents data on the predicted 10 and 50 year return period extreme wind and wave conditions at these locations.

Figure 1 Three (3) reference site locations at St. Mary's Bay [4]

St. Mary's Bay is overall protected from offshore waves by surrounding lands, including Digby Neck to the North, but is vulnerable to waves from south and southwest which will travel directly into the bay, as can be seen in Figure 2. These waves are expected to lose energy by travelling into shallower waters. Detailed wave modelling is required to determine the amount of energy lost and wave height reduction.

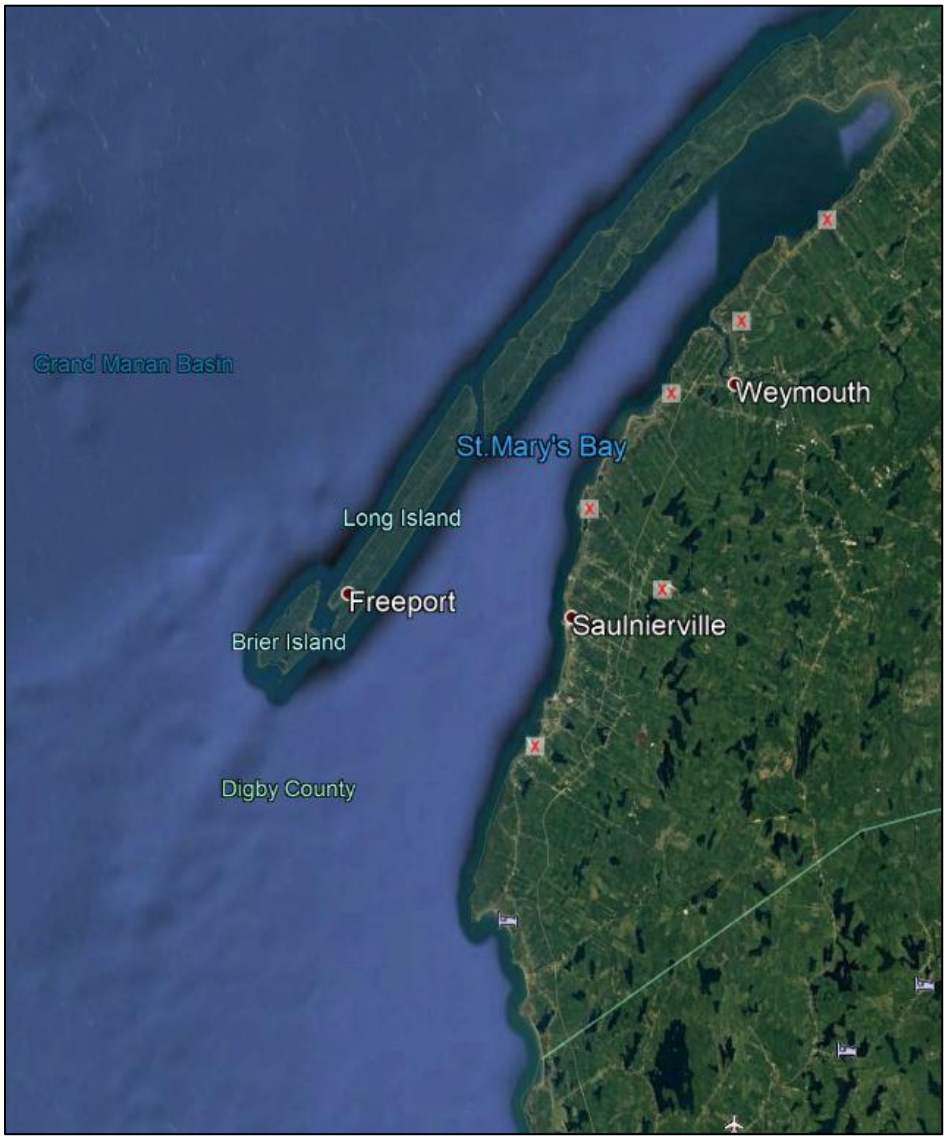

Figure 2 St. Mary's Bay, Nova Scotia, Canada

The context of this project is that extreme wind and wave conditions are needed to select engineering load cases for those wishing to install finfish or shellfish farms in the area. For example, extreme environmental conditions with minimum 10-year and 50-year return periods are required for the design of a marine fish farm site, as per guidance in the Scottish technical standard [2] and NS9415 [3]. While the locations assessed as part of this modeling exercise are not actual aquaculture site locations, the data produced for these locations is useful for understanding the approximate wave climate in the region and can be used to evaluate any proposals for sites in the area. Understanding the wind and wave climates at aquaculture sites is important for mitigating risks.

1.2 Objective(s)

- Determine wave/wind conditions at three reference locations in St. Mary's Bay and find the conditions with 10 and 50 year return periods.

2 Abbreviations and acronyms

DSA	Dynamic Systems Analysis Ltd.
SMS	Surface-water Modeling System
CMAR	Centre for Marine Applied Research
CHS	Canadian Hydrographic Services

3 Reference documents and drawings

[1]	Report-DSA-CMAR-19EXM-St. Mary's Bay Wind and Wave Conditions RevB.0.pdf
[2]	Marine Scotland. (2015). A Technical Standard for Scottish Finfish Aquaculture. Ministerial Group for Sustainable Aquaculture's Scottish Technical Standard Steering Group
[3]	Norge, S. (2009). Norwegian Standard NS 9415. E: 2009. Marine Fish Farms—Requirements for Site Survey, Risk Analyses, Design, Dimensioning, Production, Installation and Operation. *Standard Norge, Lysaker*.
[4]	CMAR proposed sites -RevB.kmz

4 Wave conditions

4.1 Overview

SMS version 12.2.13 was used to setup the bathymetric and computational grid. This section provides a description of the grid size, mesh size and offshore environmental conditions. Site bathymetry is provided in Figure 3. Note that a CHS hydrographic chart is used to generate the bathymetric data for wave modeling. More details regarding the wave modeling description, boundary conditions, and the source point are available in St. Mary's Bay wind and wave modeling report [1].

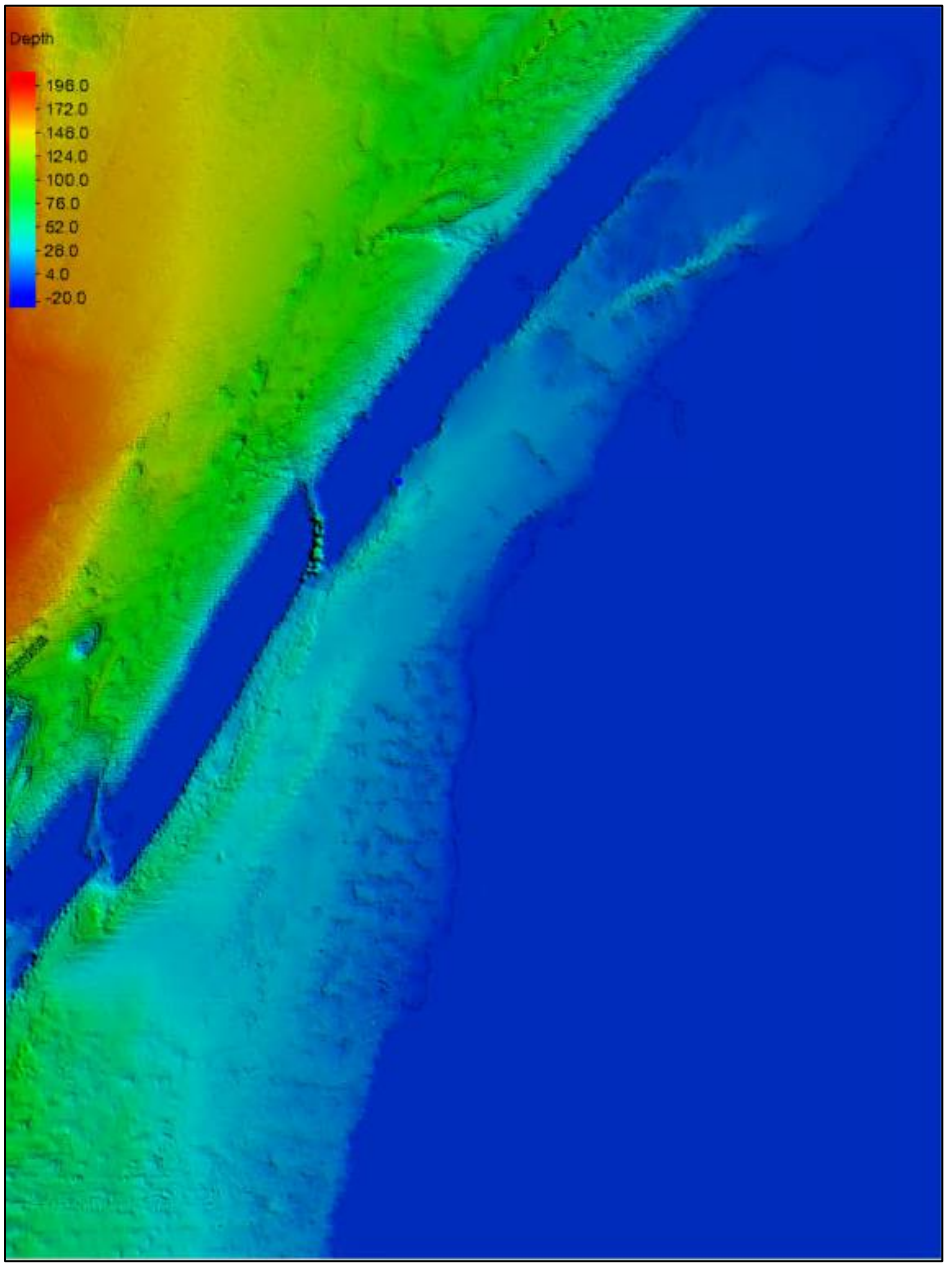

Figure 3 Bathymetry at site on hydrographic charts- Depth reported in meters

The results of the wave modeling at St. Mary's Bay are presented in Figure 4 to Figure 7 for four key wave headings with the highest wave heights. Note that size of the arrows is fixed for all significant wave heights. The orientation of the arrows indicates wave direction.

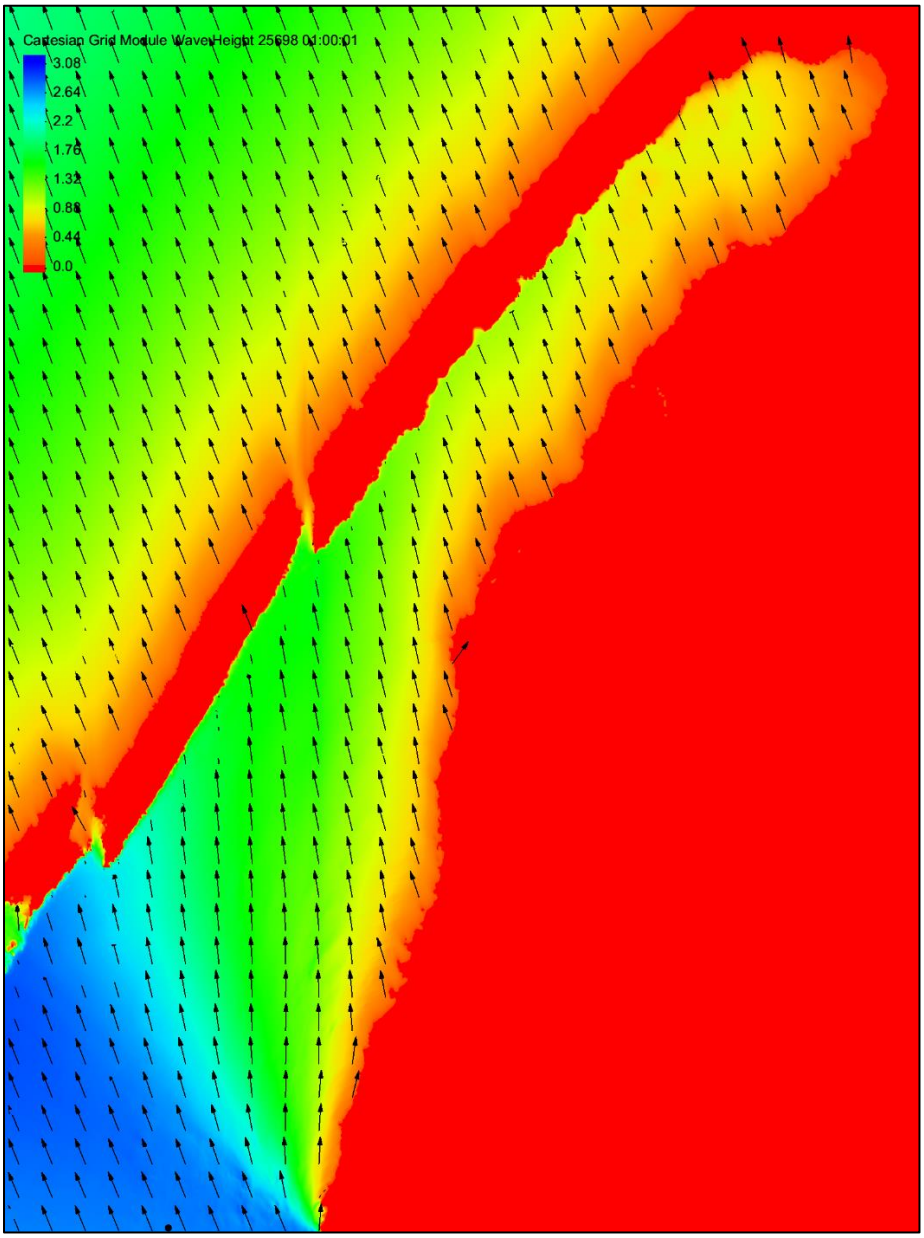

Figure 4 Wave modeling results at St. Mary's Bay for direction [From] 158 deg. Note that arrows are not scaled based on the wave height

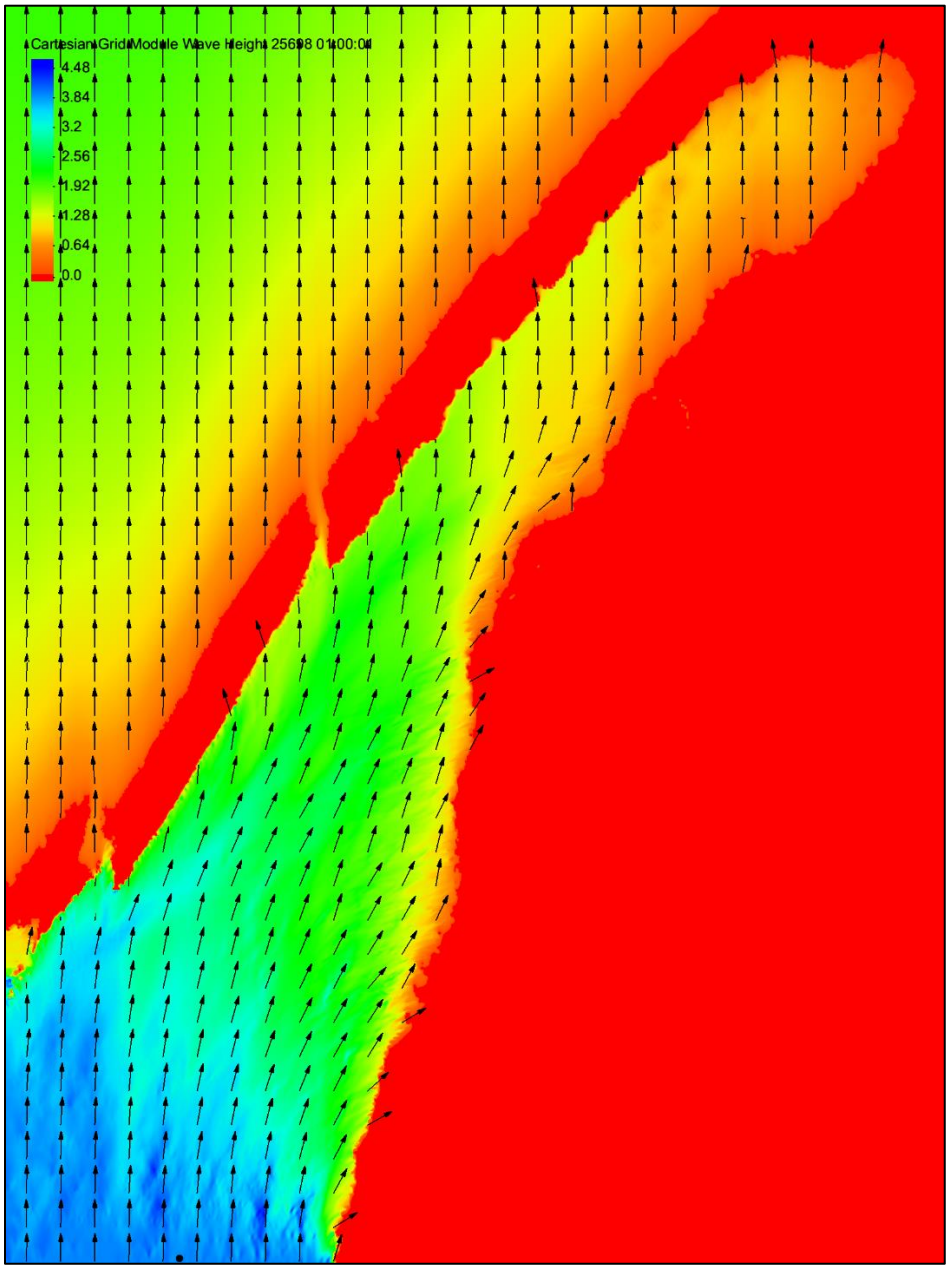

Figure 5 Wave modeling results at St. Mary's Bay for direction [From] 180 deg. Note that arrows are not scaled based on the wave height

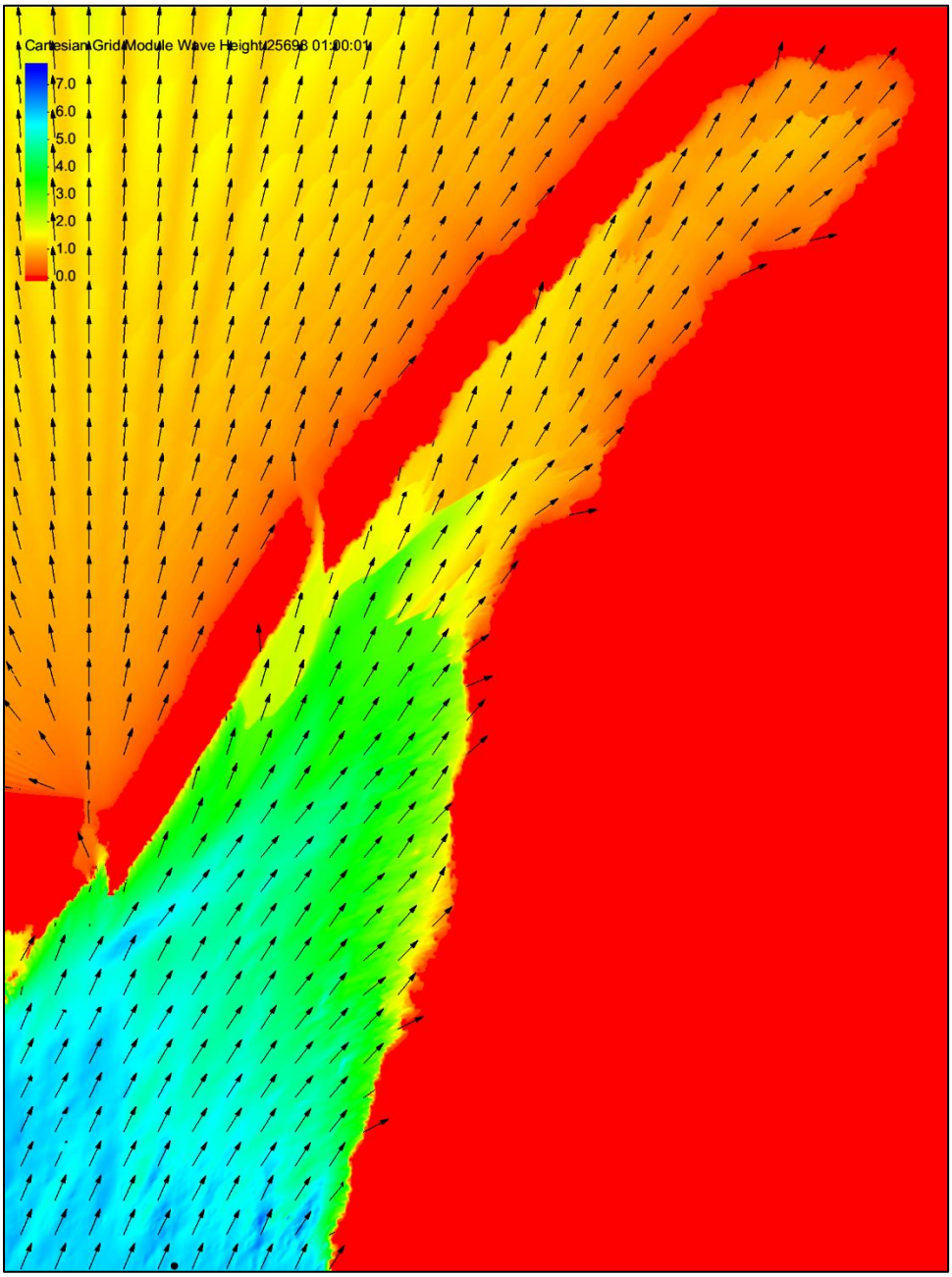

Figure 6 Wave modeling results at St. Mary's Bay for direction [From] 203 deg. Note that arrows are not scaled based on the wave height

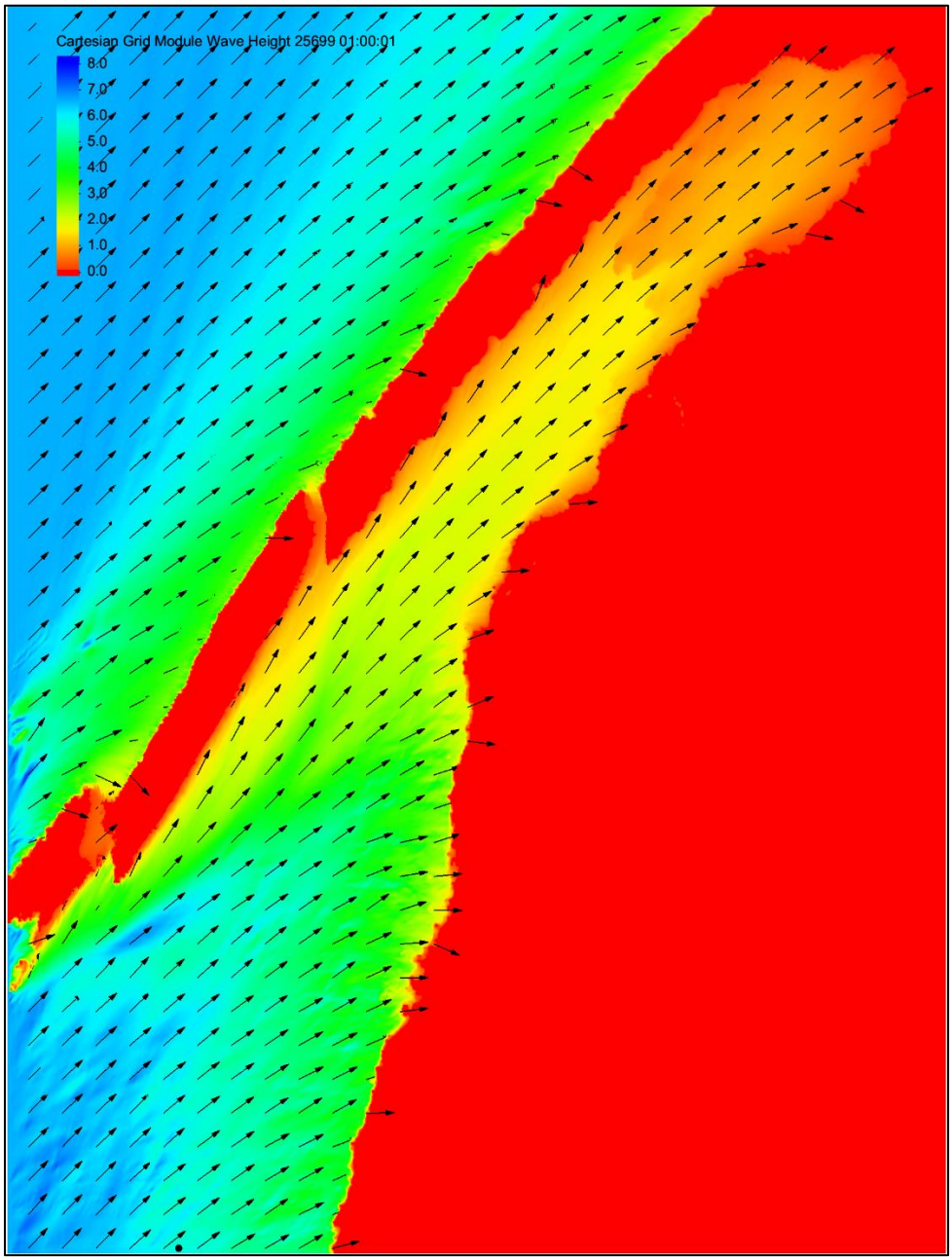

Figure 7 Wave modeling results at St. Mary's Bay for direction [From] 225 deg. Note that arrows are not scaled based on the wave height

The location of reference sites at the St. Mary's Bay are presented in Figure 1. The estimated wave and wind conditions for each site based on the STWave modeling are presented in the following sections.

4.2 Wave/wind conditions for St. Mary's Bay – Reference Site 1

The wave and wind results from the STWave model, for the St. Mary's Bay – Reference Site 1, are summarized in Table 1. Note that the results in Table 1 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 44° 18.970'N, 66° 12.519'W.

Table 1 Estimated wave and wind design conditions for St. Mary's Bay – Reference Site 1

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	20.39	1.03	3.17
	23	NNE	20.99	1.21	4
	45	NE	22.17	1.5	3.63
	68	ENE	21.69	1.15	3.22
	90	E	23.39	1.21	3.26
	113	ESE	19.88	0.72	2.87
	135	SE	19.45	0.93	4.46
	158	SSE	19.97	1.47	4.9
	180	S	19.91	1.74	4.22
	203	SSW	19.75	3.79	8.7
	225	SW	18.8	3	8.75
	248	WSW	19.6	0.97	2.86
	270	W	19.56	0.8	2.67
	293	WNW	20.5	0.6	2.5
	315	NW	19.99	0.68	3.54
	338	NNW	19.67	0.8	3.15
50yr wave/wind	*0*	N	24.33	1.26	3.43
	23	NNE	25.18	1.48	4.32
	45	NE	27.13	1.9	4
	68	ENE	27.33	1.51	3.57
	90	E	25.03	1.32	3.63
	113	ESE	24.22	0.91	3.14
	135	SE	23.26	1.12	4.82
	158	SSE	24.06	1.7	5
	180	S	23.48	2.1	4.53
	203	SSW	23.29	3.98	8.13
	225	SW	21.88	3.1	8.42
	248	WSW	23.15	1.18	3.1

	270	W	23.1	0.96	2.9
	293	WNW	24.2	0.74	2.7
	315	NW	23.39	0.82	3.8
	338	NNW	23.34	0.97	3.4

It should be noted that the return periods indicated for each wave parameter in Table 1 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 8 and Figure 9.

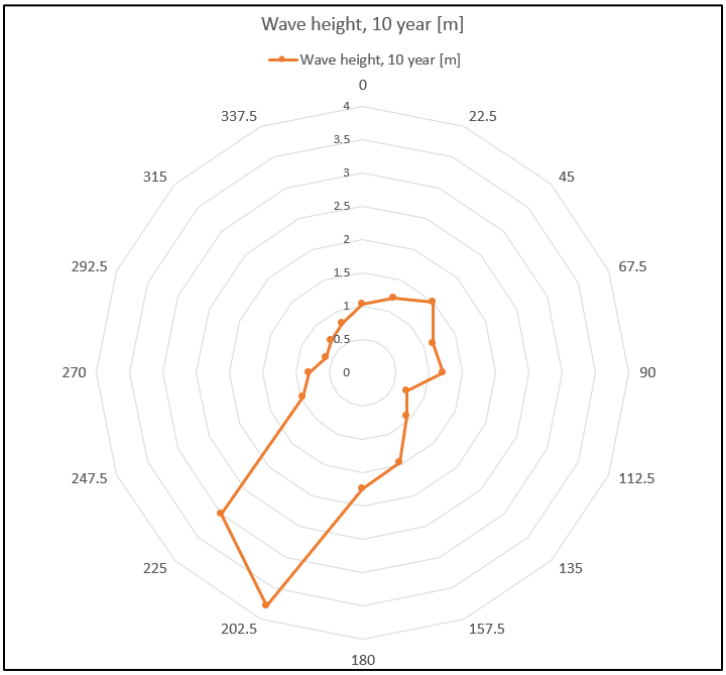

Figure 8 Maximum wave height at 10 year return period and direction [from]- St. Mary's Bay – Reference Site 1

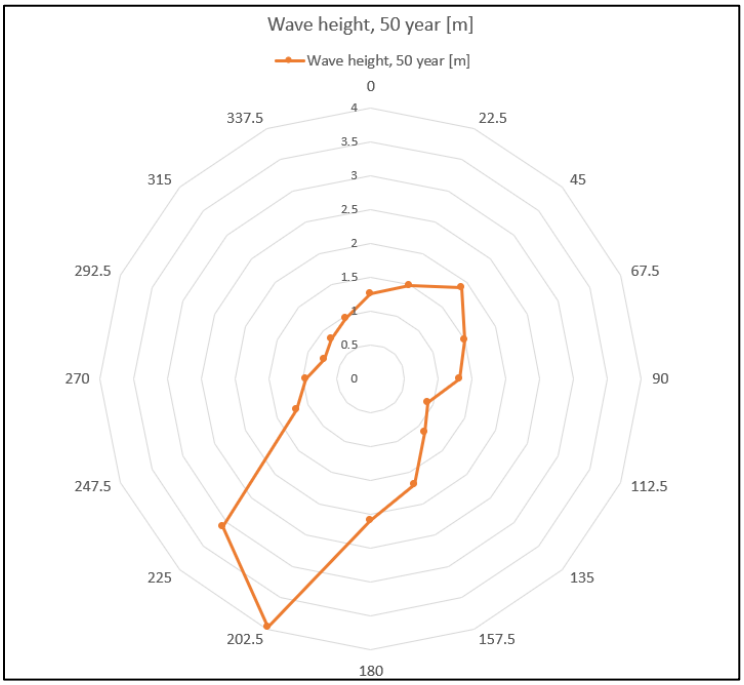

Figure 9 Maximum wave height at 50 year return period and direction [from]- St. Mary's Bay – Reference Site 1

4.3 Wave/wind conditions for St. Mary's Bay – Reference Site 2

The wave and wind results from the STWave model, for the St. Mary's Bay – Reference Site 2, are summarized in Table 2. Note that the results in Table 2 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 44° 22.444'N, 66° 9.136'W.

Table 2 Estimated wave and wind design conditions for St. Mary's Bay – Reference Site 2

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	20.39	0.92	2.9
	23	NNE	20.99	1.12	3.77
	45	NE	22.17	1.44	3.47
	68	ENE	21.69	1.1	3
	90	E	23.39	0.95	2.84
	113	ESE	19.88	0.55	2.43
	135	SE	19.45	0.64	4.23
	158	SSE	19.97	1.02	4.1
	180	S	19.91	1.6	4.03
	203	SSW	19.75	2	5.9
	225	SW	18.8	1.94	5.6

	248	WSW	19.6	1	2.91
	270	W	19.56	0.8	2.66
	293	WNW	20.5	0.52	2.35
	315	NW	19.99	0.6	3.17
	338	NNW	19.67	0.71	2.88
50yr wave/wind	*0*	N	24.33	1.13	3.12
	23	NNE	25.18	1.38	4.1
	45	NE	27.13	1.83	3.8
	68	ENE	27.33	1.44	3.3
	90	E	25.03	1.02	2.93
	113	ESE	24.22	0.71	2.66
	135	SE	23.26	0.8	4.6
	158	SSE	24.06	1.23	4.31
	180	S	23.48	1.92	4.32
	203	SSW	23.29	1.2	4.32
	225	SW	21.88	2.1	5.3
	248	WSW	23.15	1.22	3.13
	270	W	23.1	0.97	2.86
	293	WNW	24.2	0.65	2.54
	315	NW	23.39	0.72	3.4
	338	NNW	23.34	0.87	3.1

It should be noted that the return periods indicated for each wave parameter in Table 2 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 10 and Figure 11.

Figure 10 Maximum wave height at 10 year return period and direction [from]- St. Mary's Bay – Reference Site 2

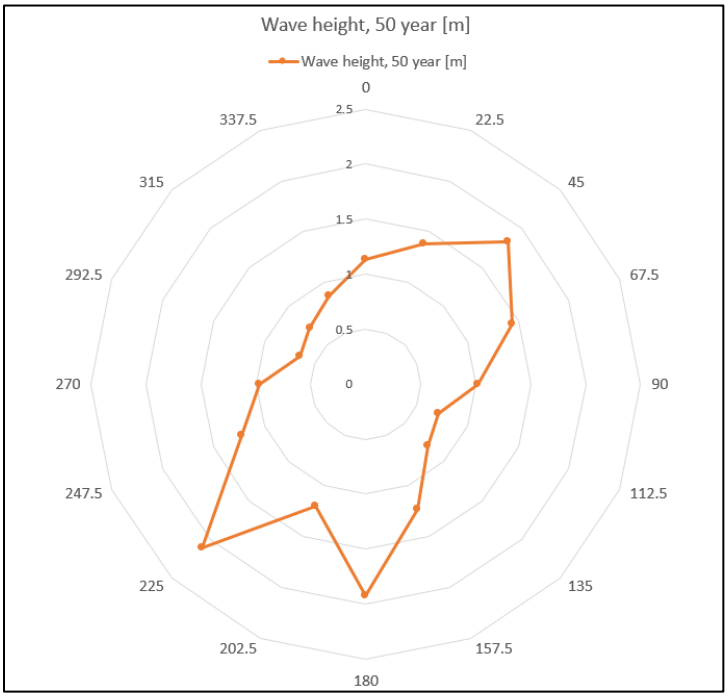

Figure 11 Maximum wave height at 50 year return period and direction [from]- St. Mary's Bay – Reference Site 2

4.4 Wave/wind conditions for St. Mary's Bay – Reference Site 3

The wave and wind results from the STWave model, for the St. Mary's Bay – Reference Site 3, are summarized in Table 3. Note that the results in Table 3 indicate significant wave height (Hs) and peak period (T_P) for the selected site. These represent the extreme wave conditions at this coordinate: 44° 24.179'N, 66° 7.752'W.

Table 3 Estimated wave and wind design conditions for St. Mary's Bay – Reference Site 3

Wave/Wind conditions	Direction [from] [°]		Wind (m/s)	Hs (m)	Tp (s)
10yr wave/wind	*0*	N	20.39	0.85	2.77
	23	NNE	20.99	0.98	3.52
	45	NE	22.17	1.45	3.56
	68	ENE	21.69	1.22	3.23
	90	E	23.39	1.13	3.15
	113	ESE	19.88	0.58	2.43
	135	SE	19.45	0.65	3.55
	158	SSE	19.97	0.87	3.57
	180	S	19.91	1.44	3.76
	203	SSW	19.75	0.98	3.81
	225	SW	18.8	1.8	5.31
	248	WSW	19.6	0.87	2.65
	270	W	19.56	0.67	2.42
	293	WNW	20.5	0.5	2.26
	315	NW	19.99	0.55	2.95
	338	NNW	19.67	0.64	2.75
50yr wave/wind	*0*	N	24.33	1.05	3
	23	NNE	25.18	1.2	3.83
	45	NE	27.13	1.8	3.9
	68	ENE	27.33	1.6	3.6
	90	E	25.03	1.22	3.25
	113	ESE	24.22	0.73	2.66
	135	SE	23.26	0.8	3.85
	158	SSE	24.06	1.06	3.74
	180	S	23.48	1.73	4.03
	203	SSW	23.29	0.99	3.3
	225	SW	21.88	1.95	5.03
	248	WSW	23.15	1.05	2.84

	270	W	23.1	0.81	2.6
	293	WNW	24.2	0.61	2.43
	315	NW	23.39	0.67	3.17
	338	NNW	23.34	0.78	2.97

It should be noted that the return periods indicated for each wave parameter in Table 3 are representative of the boundary condition used to derive that value, not the value itself. Polar plots for maximum wave heights are presented in Figure 12 and Figure 13.

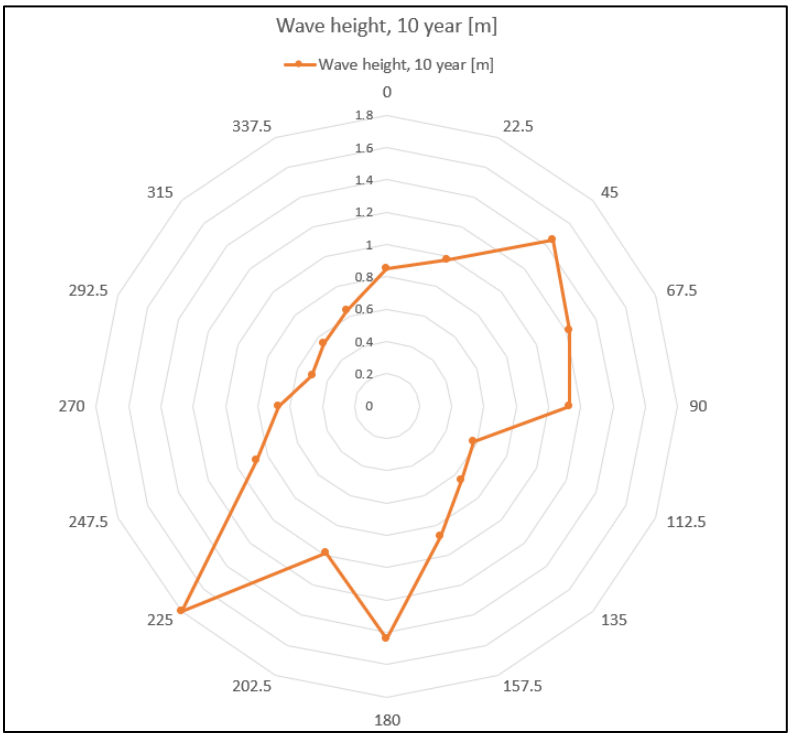

Figure 12 Maximum wave height at 10 year return period and direction [from]- St. Mary's Bay – Reference Site 3

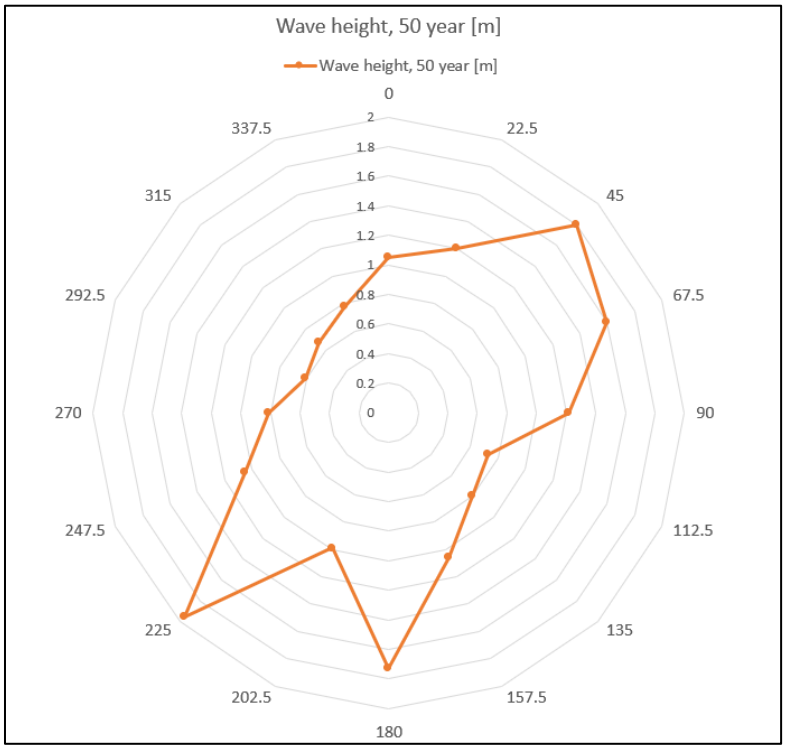

Figure 13 Maximum wave height at 50 year return period and direction [from]- St. Mary's Bay – Reference Site 3