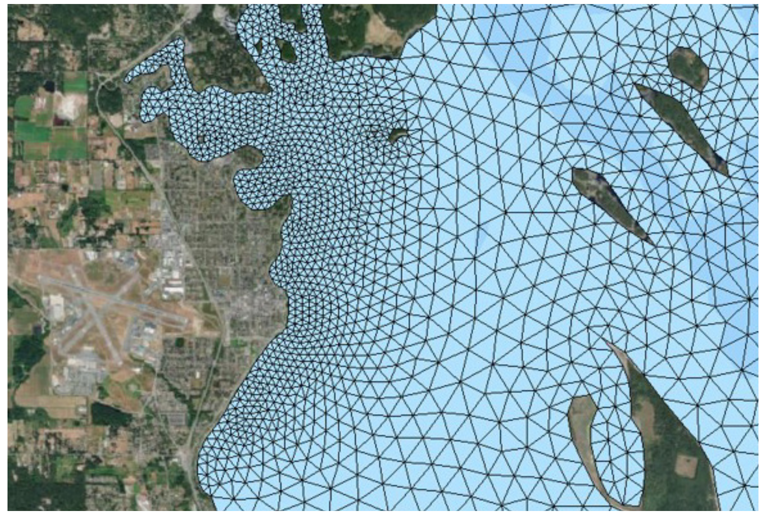
Town of Sidney

FINAL REPORT

Enhanced Flood Inundation Modelling & Mapping

December 2025

Associated Engineering (B.C.) Ltd.
DHI Water and Environment Inc.



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EXECUTIVE SUMMARY

Associated Engineering (Associated) and **DHI Water and Environment Inc.** (DHI), were engaged by the Town of Sidney to prepare the **Enhanced Flood Inundation Modelling & Mapping Project**. This project's objective is to build upon previous floodplain mapping work (i.e. the 2021 Capital Regional District's Coastal Flood Inundation Mapping Project) and focus specifically on the Town of Sidney's coastline. As such, the overarching goals of this contemporary project was to:

- Undertake a site reconnaissance of the Town of Sidney's shoreline; to document and classify the municipality's shoreline.
- Refine an existing spectral wave model of the Salish Sea, concentrating on improving the mesh resolution and fidelity within the offshore and nearshore areas surrounding the Town of Sidney.
- Refine the spectral wave model's input datasets that are used to 'force' the model.
- Estimate present and future coastal flood hazard at approximately 29 locations along Sidney's shoreline.
- Map present and future coastal flood hazard within the Town of Sidney.

The study considered approximately 8.5 km of coastline within the Town's municipal boundary.

As part of this project, three Associated-DHI staff undertook a site reconnaissance visit in August 2023, during low tide. The visit identified priority shoreline locations, assessed signs of sustained erosion and sediment transport, observed surficial substrates and vegetation, and informed the selection of analytical methods for flood hazard mapping and Flood Construction Levels (FCLs).

Recognizing the importance of understanding local wave dynamics, two buoys were deployed off Sidney's coastline to collect wind and wave data over nine months at the northern and southern end of the Town's shoreline.

A project-specific spectral wave model was developed to support the Sidney study, tailored to accurately resolve nearshore wave dynamics along the targeted shoreline. The model was forced using spatially varying atmospheric and oceanographic inputs, derived from available water level and wind datasets within the model domain, to ensure realistic representation of local wave generation and propagation processes. The computational mesh resolution was refined to 80 m, allowing for detailed representation of bathymetric features in the area, which are critical for capturing nuances in wave conditions along the shoreline of interest.

The spectral wave model was calibrated and validated using both offshore and nearshore measurements. Long-term data from the New Dungeness offshore station was used to drive the spectral wave model, while measurements from nearshore buoys at Roberts Bay and Bazan Bay enabled fine-tuning to accurately reproduce local wave transformation processes.

Results show good agreement with observations at both nearshore sites, confirming the model's reliability for the project shoreline. The offshore validation further supports its use for generating the long-term hindcast needed to estimate extreme wave conditions.

The spectral wave model was applied to reconstruct long-term wave conditions (1994–2024) along the Sidney shoreline. Model outputs for the entire study area enabled extreme value analysis which informed the wave runup assessment and subsequent mapping.

Two distinct mapping products were produced from this study: Flood Construction Level Mapping and Flood Extents Mapping. Both map sets are intended to help the Town in guiding planning and emergency management activities.

FLOOD MAPPING CHECKLIST

The following tables provide detailed summaries of key information, as it pertains to the delivery of this project:

Task	Description
Overview	

List of flood maps prepared	• Flood Construction Level Maps
	  ◦ Recommended FCL Map set.
	• Flood Extent Maps
	  ◦ 0.5% AEP Water Levels only; no wave contributions

Overall Approach	
Waterbodies and flood types considered	Town of Sidney waterfront i.e. Salish Sea • Coastal storm flooding only. • Tsunami hazard was not considered.
Primary use	• Land use regulation. • Emergency preparedness and response
Wave Modelling	
Boundary conditions and forcing	**MIKE 21 Spectral Wave Model** • Pacific Ocean to Salish Sea Boundary: DHI's Global Wave Model • Water Levels: 2D time varying water level surface, using regional stations. • Winds: Spatially continuous 2D wind field, using regional stations. • Modelled Hindcast Period: 1994–2024
Key sources of meteorological data (monitoring periods specified in Section 3)	• Patricia Bay (CHS Station 07277) • Sidney (CHS Station 07260) • Saanichton Bay (CHS Station 07255) • Victoria International Airport (1018620) • Kelp Reefs (1013998) • Saturna Island (1017101) • MarineLabs Wave Buoy – Bazan Bay • MarineLabs Wave Buoy – Roberts Bay

Task	Description
Approach to climate change projections	Absolute values of Relative Sea Level Rise were adopted: • 0.5m RSLR • 1.0m RSLR Note: Absolute values listed above are commonly used in coastal engineering practice and were selected to ensure comparability across jurisdictions.
Estimated time horizons	Assuming AR6 SSP5-8.5 (median estimate) projections: • 0.5m RSLR – 2095 • 1.0m RSLR – 2150 Note: These time horizons deviate from time horizons presented in the current Provincial standards[1]. The horizons presented in this report are based on the latest available relative sea level rise projections released by Environment and Climate Change Canada (ECCC). [1](BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development: Flood Hazard Area Land Use Management Guidelines)
Notes on model development, calibration, validation, sensitivity analyses etc.	• Offshore waves were informed by 30-year MIKE 21 SW hindcast. • NOAA New Dungeness (46088) wave buoy was key calibration site for offshore performance. • Nearshore model performance was evaluated using nine (9) months of wave measurements collected in Bazan Bay and Roberts Bay.
Shoreline Geomorphic Hazards	
Is the shoreline composed of erodible or non-erodible material?	Shoreline geomorphic hazard was not investigated. Much of Sidney's shoreline is rocky outcrops and hard infrastructure (e.g. seawalls and revetments).
Is shoreline migration trending to stability / advance / retreat?	Not Investigated
Are there indicators of limited sediment supply?	Not Investigated

Shoreline Wave Effects Summary	
Summary	
Dominant wind direction and design event used	Two dominant wind/wave directions identified and assessed: • North-Easterly (NE); [0°N–90°N] • South-Easterly (SE); [90°N–180°N] In each quadrant, a storm selection process was carried out, identifying 60 significant storm events (on average two events per year) based on the timeseries of wave conditions at the toe of the coastal structure. An extreme value analysis (EVA) was performed for each quadrant to estimate the significant wave height associated with the 0.5% AEP. For subsequent wave runup calculations, the representative mean wave direction was selected by evaluating the range (max/min) of MWD values from the storm list and comparing them against the orientation of the coastal transect. The wave approach angle exhibiting the closest alignment with the transect orientation was selected as the critical direction for each sector. This methodology defined a representative 0.5% AEP extreme wave condition for each directional quadrant.
Description of wave runup analysis	Wave runup computations then carried out for the representative 0.5% AEP extreme wave in both directional quadrants, combined with the 0.5% AEP water level, following the EurOtop (2018) methodology. For each transect, the most critical of the two directional conditions, based on the R2% value, was reported.

Summary of Flood Construction Level		
	Wave Effect Zone	**Beyond Wave Effect Zone**
Present Day Flood Level	2.52 mCGVD2013	2.52 mCGVD2013
+ Relative Sea Level Rise	1.00 m	1.00 m
Design Flood Level	3.52 mCGVD2013	3.52 mCGVD2013
+ Wave Runup	Varies by reach	0.00 m
+ Freeboard	0.60 m	0.60 m
Flood Construction Level (FCL)	Varies by reach (i.e. Foreshore FCL)	4.12 mCGVD2013 (i.e. Backshore FCL)

Freeboard	
Considerations for selecting freeboard	Standard freeboard assumption of 0.60m was applied to account for uncertainty in the underlying data and analysis. This assumption is consistent with Provincial Guidelines.
Selected freeboard	0.60m

Flood Mapping	
Treatment of dikes	Not applicable (there are no Provincially defined flood protection works within the project area).
Datum	• Vertical: CGVD 2013 • Horizontal: CSRS UTM Zone 10N
Key assumptions	• The analysis presented herein assumes 'present-day' shoreline conditions. If there are proposed changes to a foreshore (e.g. removing a seawall), this would result in changes to the estimated FCL values at that location. • Tsunami hazard was not mapped. • The results outlined in this report assume that frequency and intensity of storm surge, winds, and waves do not change as a result of climate change (i.e., 'storminess' does not change due to climate change).
Key limitations	For the purposes of this study, the focus was exclusively on coastal flooding driven by marine sources, including storm surge, tides, waves, and projected sea level rise. Fluvial flooding, stormwater flooding, and pluvial runoff were outside the scope of this modelling effort. The results presented do not account for potential interactions between coastal and inland flood mechanisms. The accuracy of the results and resulting uncertainty is dependent on accuracy of: • LiDAR data • Bathymetry data • Calibration and validation data

ACKNOWLEDGEMENTS

Associated and DHI's project team would like to thank and acknowledge the following individuals for their generous contributions at critical junctures in this project:

Town of Sidney

- Jenn Clary, P.Eng., PMP – Director of Engineering
- Alison Verhagen – Director of Development Services
- Bruce DeMaere – Manager of Engineering
- Corey Newcomb – Director of Community Planning

Associated Engineering (B.C.) Ltd.

- David Forde, M.Eng., P.Eng. – Associated Project Manager and Technical Lead
- Noah Fanos, EIT – Water Resources Project Engineer

DHI Water & Environment Inc.

- Danker Kolijn, M.Sc., P.Eng. – Coastal Engineer and Technical Reviewer
- Méven Huiban, M.Sc. – Coastal Scientist and Modelling Lead
- Pablo Cortes Aguilera, M.Sc. – Coastal and Marine Specialist
- Patrick Joynt, M.Sc., P.Eng. – Coastal Engineer

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GLOSSARY

Associated	**Associated Engineering**	
AEP	**Annual Exceedance Probability**	The probability of a specific event occurring, or being exceeded, in any given year. Approximately equivalent to the concept of 'return period': • 10% AEP = 1:10-year return period • 5% AEP = 1:20-year return period • 2% AEP = 1:50-year return period • 1% AEP = 1:100-year return period • 0.5% AEP = 1:200-year return period
	Bathymetric	Survey to establish elevations of underwater river channel bed or ocean bed surfaces.
CD	**Chart Datum**	A local datum typically used for navigational purposes and oceanographic measurements (e.g. tides) at a specific location, port, or harbour. CD refers to the lowest normal tide, such that water levels rarely fall below it. Tidal predictions and hydrographic charts from the Canadian Hydrographic Service (CHS) reference this datum.
CGVD1928	**Canadian Geodetic Vertical Datum 1928**	Vertical elevation reference system, which is to be superseded by CGVD2013.
CGVD2013	**Canadian Geodetic Vertical Datum 2013**	Vertical elevation reference system, which supersedes CGVD1928.
CHS	**Canadian Hydrographic Service**	
CSRS	**Canadian Spatial Reference System**	
	Climate Change	A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced using fossil fuels.
DEM	**Digital Elevation Model**	A digital representation of relief composed of an array of elevation values referenced to a common vertical datum and corresponding to a regular grid of points on the earth's surface. These elevations can be either ground or reflective surface elevations.

DFL	**Designated Flood Level**	
DHI	**Danish Hydraulic Institute Water & Environment Inc.**	
DTM	**Digital Terrain Model**	
ECCC	**Environment and Climate Change Canada**	
	Flood	A condition in which a watercourse or body of water overtops its natural or artificial confines and covers land not normally under water.
FCL	**Flood Construction Level**	As per Provincial Guidelines, defined as the underside elevation of a wooden floor system, or the top elevation of a concrete slab, for habitable buildings. It is intended to protect habitable living space from flood damage.
	Flood Plain	A flood plain is flat or nearly flat land that is susceptible to flooding from a watercourse, lake, or other body of water.
	Flood Plain Maps/Mapping	Maps (Mapping) that display information related to a flood, such as the estimated extent of flooding, water depths, water velocities, flood duration, or other information.
	Flood Plain Management	Flood plain management includes policies and regulations intended to reduce flood risks associated with land use and development in flood plains and flood hazard areas.
	Freeboard	A vertical distance added to a flood level. The freeboard accounts for uncertainties inherent in the estimation of the flood level including uncertainties in storm intensities, water levels, wave effects, and climate change impacts on these parameters.
GIS	**Geographic Information Systems**	
	Hazard	A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life, injury, property damage, social and economic disruption, or environmental degradation.
HHWLT	**Higher High Water Large Tide**	The average over 19 years of the highest predicted high-water level of each year.

HHWMT	**Higher High Water Mean Tide**	The average from all the higher high waters from an 18.6-year tide cycle.
H_{m0}	**Spectral significant wave height**	The average height of the highest one-third waves, as calculated directly from the wave spectrum (e.g., from spectral wave model results). H_{m0} is determined as four times the square root of the zeroth-order moment of the wave spectrum.
Hs	**Significant wave height**	Significant wave height used in most coastal engineering design applications. Taken as the average height of the highest one-third of waves in a wave record ($H_{1/3}$)
IPCC	**UN Intergovernmental Panel on Climate Change**	
LiDAR	**Light Detection and Ranging**	A surveying method that measures distance to a target by illuminating the target with laser light and measuring the reflected light with a sensor.
	Likelihood	A general concept relating to the chance of an event occurring. Likelihood is generally expressed as a probability or a frequency of a hazard of a given magnitude or severity occurring or being exceeded in any given year. It is based on the average frequency estimated, measured, or extrapolated from records over a large number of years, and is usually expressed as the chance of a particular hazard magnitude being exceeded in any one year (i.e., the Annual Exceedance Probability, AEP).
LLWMT	**Lower Low Water Mean Tide**	The average from all the lower low waters from an 18.6-year tide cycle
LLWLT	**Lower Low Water Large Tide**	The average over a 19-year period of the lowest predicted low water level of each year.
MOF	**BC Ministry of Forests**	
MWD	**Mean wave direction**	
MWL	**Mean Water Level**	The average of all hourly water levels over the available period of record.
NAD83	**North American Datum of 1983**	
NOAA	**National Oceanic and Atmospheric Administration**	

	Probability	In statistics, a measure of the chance of an event or an incident happening. This is directly related to likelihood.
PWD	**Peak wave direction**	
	Regulatory Flood Plain Map	Maps used for regulatory purposes, such as developing flood plain bylaws and informing area plans and official community plans. For Coastal Flood Mapping Projects, the regulatory mapping is generally based on inundation mapping for 0.5% AEP storm events plus a freeboard allowance to establish the flood levels and flood plain limits
RP	**Return Period**	Return period is a way of describing the probability of a storm event. Return period is calculated as one divided by the annual exceedance probability (AEP). For example, for a 10-year return period storm event, there is a 1/10=0.1=10% probability in any given year that the event or a larger event will occur. Return period is not the strict frequency of an event, i.e., if a 10-year return period event occurs this year, there is still a 10% probability that will occur next year as well.
RSLR	**Relative Sea Level Rise**	RSLR is an absolute increase in mean sea level, incorporating the effects of land subsidence or uplift.
	Setback	Withdrawal of a building or siting of a building or landfill from the natural boundary or other reference line to maintain a floodway (room for flooding to occur without damaging structures) and to allow for potential land erosion.
SLR	**Sea Level Rise**	Sea level rise is the increase in mean sea level without incorporating an adjustment due to local land subsidence or uplift.
SWL	**Still Water Level**	Total sea level for a given return period, including sea level rise allowance, tide, and storm surge; analogous to the DFL.
	Topographic	The shape and features of a land surface. In the context of this study, topographic features are those above the water level (as opposed to bathymetric which refer to features below the water level).
T_{02}	**Zero-crossing wave period**	
T_p	**Peak wave period**	
UTM	**Universal Transverse Mercator**	

1 INTRODUCTION

1.1 Project Background

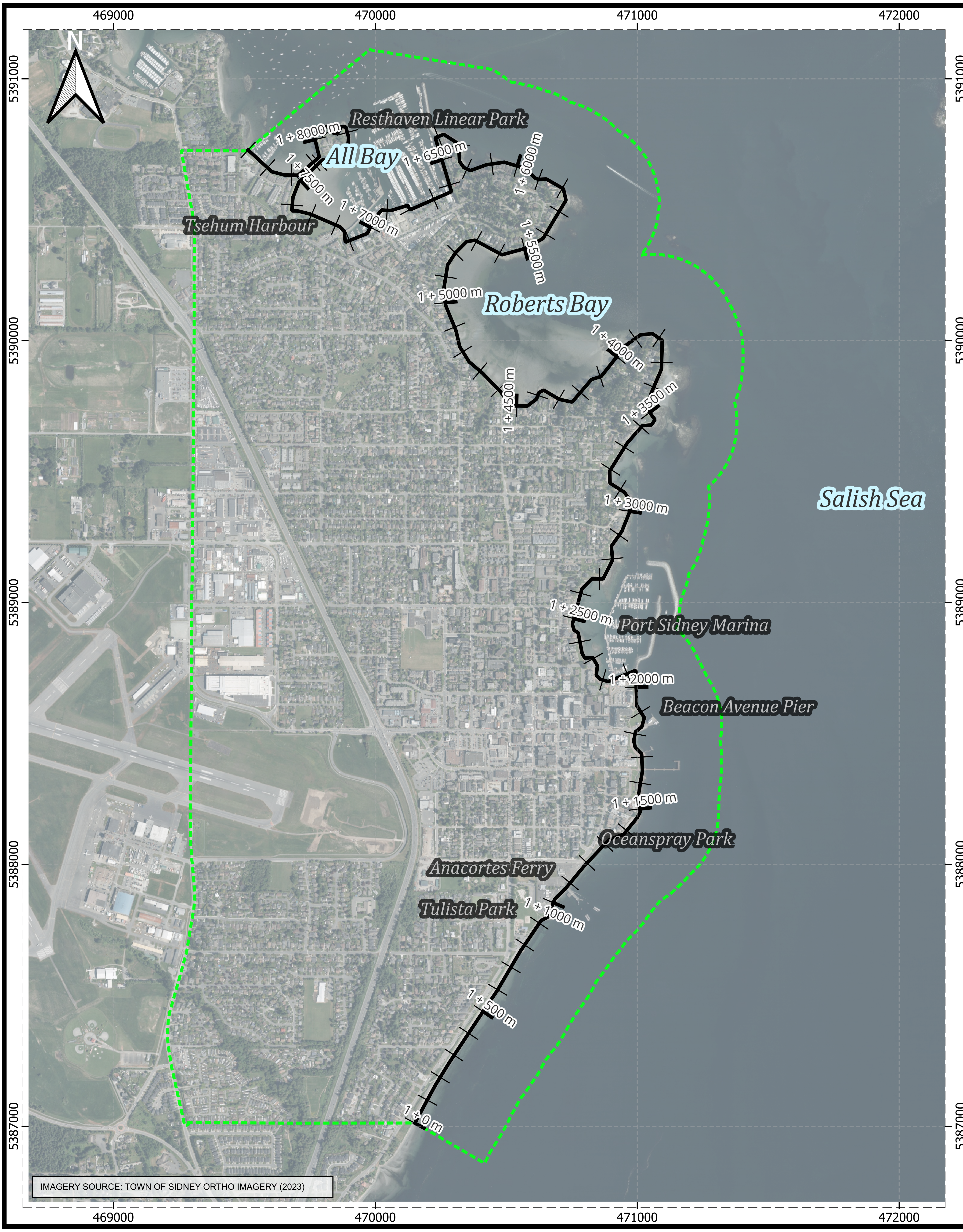
Associated Engineering (Associated) and our project partners, **DHI Water & Environment, Inc**. (DHI), were engaged by the Town of Sidney to complete the **Enhanced Flood Inundation Modelling & Mapping** Project.

The Town of Sidney was included as a participating community in the 2021 CRD *Coastal Flood Inundation Mapping Project* ("2021 CRD Study"). That project's objective was to analyze and map coastal flood hazard for 13 municipalities and three electoral areas within the capital region. First Nations communities within the project area were also invited to use the resultant deliverables.

Given the expansive geographic bounds of the capital region, as well as a tight schedule, the 2021 CRD Study was not able to focus on specific municipalities and their site-specific needs. The analytical procedures had to be spread across the entire CRD coastline at a low resolution (222 transects for approximately 1,300 km of coastline). Nonetheless, the 2021 CRD Coastal Flood Inundation Mapping Project was a necessary and valuable first step in the delineation of coastal flood hazard within the region.

The objective of the **Enhanced Flood Inundation Modelling & Mapping** Project is to build upon the 2021 project, increasing the analytical resolution, and focusing specifically on the Town of Sidney. This study will create Flood Construction Level (FCL) mapping that integrates with existing mapping to enhance flood risk management and emergency planning.

Specific project extents are shown in **Figure 1-1**.



MAP LOCATION

LEGEND

TOWN BOUNDARY

SHORELINE CHAINAGE

0 200 400 600 800 1,000 m

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METERS; Vertical Datum: CGVD 2013

Sidney

FIGURE 1-1

TOWN OF SIDNEY

ENHANCED FLOOD INUNDATION MODELLING & MAPPING PROJECT
OVERVIEW MAP

AE PROJECT No.	2023-2825-00
SCALE	AS SHOWN
APPROVED	D. FORDE
DATE	20251201
REV	A
DESCRIPTION	ISSUED FOR FINAL

Associated Engineering
BEST MANAGED COMPANIES Platinum member
DHI

1.2 Project Scope

The project's scope of work involved the following:

- Review existing data, conditions, and available/previous reports of the area of interest, factoring in climate change conditions such as sea level rise.
- Conduct a field reconnaissance and site inspection.
- Refine the DHI MIKE 21 flexible mesh (FM) spectral wave (SW) model developed as part of the 2021 CRD Study to increase mesh resolution and fidelity within the offshore and nearshore areas surrounding the Town of Sidney.
- Update boundary conditions and forcing of the MIKE 21 SW model.
  - Incorporating additional water level and wind data collected since the commencement of the 2021 CRD Study to extend the simulation period end-year from 2018 to 2024.
  - Adjust the wind sources selected to force the model, allowing for more site-specific selections.
  - Calibrate the model using new site-specific, wave observation data.
- Complete a long-term continuous hindcast simulation using the refined model.
- Estimate present and future coastal flood hazard at approximately 29 transect locations along Sidney's coastline. (For reference, there were nine transects specific to Sidney as part of the 2021 CRD Coastal Flood Inundation Mapping Project).
- Map present and future coastal flood hazard within the Town of Sidney.

To help readers navigate through the report, a brief summary of each ensuing section is provided below:

- **Section 2** (Site Reconnaissance) – Summary of completed site visit at outset of the project.
- **Section 3** (Metocean Conditions) – Outlines work undertaken to characterize the metocean conditions (water levels, winds, waves, and sea level rise) across the study site.
- **Section 4** (Wave Modelling) – Overview of the wave model development used to analyze offshore and nearshore wave conditions.
- **Section 5** (Transect Analysis) – Overview of the methodology used to analyze wave run-up along the shoreline of the project area.
- **Section 6** (Flood Mapping) – Summary of the approach used for flood hazard mapping and guidance for interpreting the maps.
- **Section 7** (Conclusions and Recommendations) – Summary of important conclusions and recommendations arising from this project.

This project assessed both 'blue-water' and 'white-water' coastal flooding.

'Blue-water' flooding is flooding caused by extreme sea levels. The components of blue-water flooding include astronomical tides, storm surge, land uplift/subsidence, and sea level rise.

'White-water' flooding is flooding caused by wave effects (i.e. runup, overtopping, ponding, spray).

Sidney currently experiences, primarily, 'white-water' flooding. As will be demonstrated in subsequent sections, areas of Sidney will become more vulnerable to 'blue-water' flooding in the future due to sea level rise. The graphic presented in **Figure 1-2** summarises the difference between 'blue-water' and 'white-water'. Further information on both types of flooding is provided in ensuing sections.

Figure 1-2 'Blue-water' and 'White-water' components at Oceanspray Park

1.3 Review of Background Data & Previous Studies

Relevant background information and previous studies reviewed and relied upon as part of this project are listed below:

- Task 2, Sea Level Rise Modelling and Mapping Report – Capital Region Coastal Flood Inundation Mapping Project – Version 2.0. (Associated and DHI, 2021).

1.3.1 Existing 'Provincial Guidelines'

The following collection of documents have also been reviewed and leveraged (where appropriate) in the delivery of this project. It is important to note that the following documents, taken collectively, are typically referred to as the 'Provincial Guidelines.' They will be referred to as such throughout this report.

- The Association of Professional Engineers and Geoscientists of British Columbia, Flood Mapping in BC, APEGBC Professional Practice Guidelines, Version 1.0.
- EGBC Legislated Flood Assessments in a Changing Climate in BC, Version 2.1.
- BC Ministry of Environment: Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Draft Policy Discussion Paper, January 2011.

- BC Ministry of Environment: Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use, January 2011.
- BC Ministry of Environment: Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Sea Dike Guidelines, January 2011.
- BC Ministry of Forests, Land and Natural Resource Operations and Rural Development: Amendment to Section 3.5 and 3.6 of the Flood Hazard Land Use Management Guidelines, 2017.
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development: Flood Hazard Area Land Use Management Guidelines, January 2018.

All these documents are inter-related and typically guide coastal engineering practitioners in the delivery of flood hazard and regulatory (i.e. FCL) mapping within British Columbia. Of these information sources, the primary resource for determining a community's flood hazard has been the *Amendment to Section 3.5 and 3.6 of the Flood Hazard Land Use Management Guidelines* (hereafter referred to as 'BC MoE 2017').

The following terms are important to understand the information contained within the Provincial Guidelines: *Designated Storm*, *Designated Flood Level*, *Flood Construction Reference Plane* and *Flood Construction Level*.

Designated Storm

The Designated Storm (DS) is defined as a storm that, in any given year, has a magnitude equivalent to one with the specified annual exceedance probability (AEP). BC MoE 2017 recommends adopting either the 0.5% AEP (i.e. 200-year) or 0.2% AEP (i.e. 500-year) storms. The choice of AEP directly influences the corresponding Designated Flood Level and Flood Construction Reference Plane.

Designated Flood Level

The Designated Flood Level (DFL) is the design water level, accounting for tide, storm surge, and sea level rise (but not wave effects). The DFL is analogous to 'blue-water' flooding.

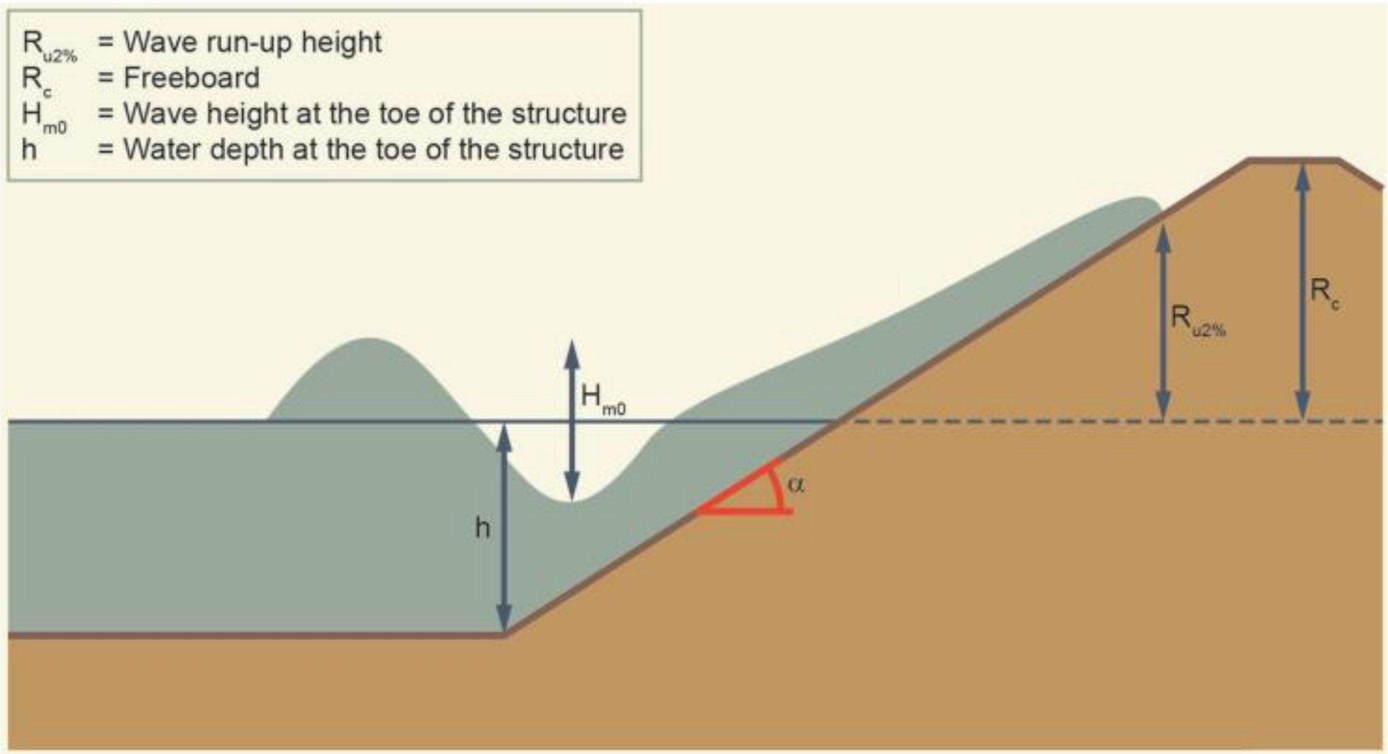
In the Provincial Guidelines' Probabilistic Method (see **Figure 1-4**), the DFL is derived using either a 0.5% AEP or 0.2% AEP estimate of tide and storm surge (the joint-probability aspect of tide and storm surge is inherent in a tide gauge's record), as well as an allowance for RSLR (either as an absolute value or tied to a particular time horizon). Estimation of the DFL is discussed in greater detail in **Section 3**.

Wave Runup and Wave Effects

Wave runup is defined as the vertical elevation that waves reach as they travel up a beach, coastal structure, or shoreline above the still water level. The typical wave runup parameter used in FCL mapping in BC is $R_{2\%}$. $R_{2\%}$ is defined as the vertical distance, measured from the still water line, which is exceeded by only 2% of the number of incident waves. The following figure[1] illustrates the concept of $R_{2\%}$.

[1] *Image Credit: EurOtop Manual.*

Figure 1-3 Runup at a Typical Coastal Cross Section (EurOtop, 2018)



'Wave effects' is a term used in the existing 'Provincial Guidelines,' it refers to the elevation and area affected by dynamic wave action as waves travel onshore during the Designated Storm.

Flood Construction Reference Plane

The Flood Construction Reference Plane (FCRP) is the sum of the Designated Flood Level and the Estimated Wave Effect.

In summary, the FCRP is the elevation of combining 'blue-water' and 'white-water' flooding. The FCRP plus an allowance for freeboard yields the Flood Construction Level (FCL)

Freeboard

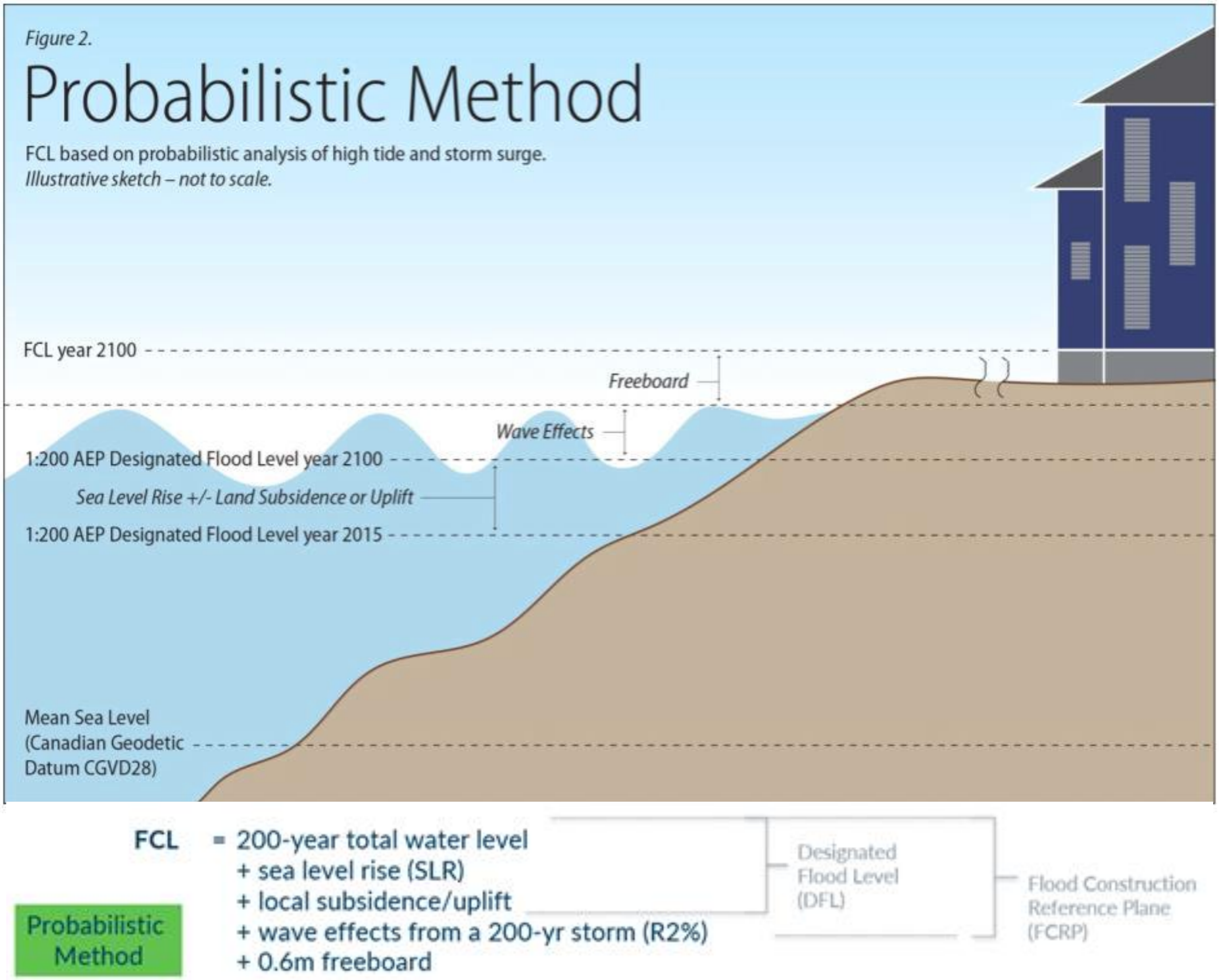
Freeboard is a vertical distance, typically 600 mm, added to the FCRP, to derive the Flood Construction Level. The purpose of the freeboard value is to account for uncertainty in the underlying data and analysis.

Flood Construction Level

The Flood Construction Level (FCL), as defined by the existing Provincial Guidelines, is the FCRP plus an allowance for freeboard. The FCL can be estimated for either 0.5% AEP or 0.2% AEP events, depending on the intended application, consequences, and uncertainty in the analysis.

For this project, the selected level of service was 0.5% AEP, with a corresponding 600 mm freeboard.

Figure 1-4 Existing Provincial Guidelines Probabilistic Method for Derivation of Flood Construction Levels



1.3.2 Upcoming 'Provincial Guidelines'

During the completion of this project, the team became aware of the existence of unpublished, upcoming Provincial Guidelines, which includes substantive updates to the methodology used for mapping coastal flood hazards in British Columbia. This added information source was made available by Fraser Basin Council, who are administering the Flood Hazard Identification and Mapping Program (FHIMP), on behalf of the provincial government, in BC. FHIMP aims to develop high quality, standardized, consistent flood plain mapping for higher-risk communities in BC that lack recent flood maps. Using standardized and reputable methods to produce flood maps, this initiative helps communities identify flood hazard areas and assess potential impacts to people, critical infrastructure, and other assets and values.

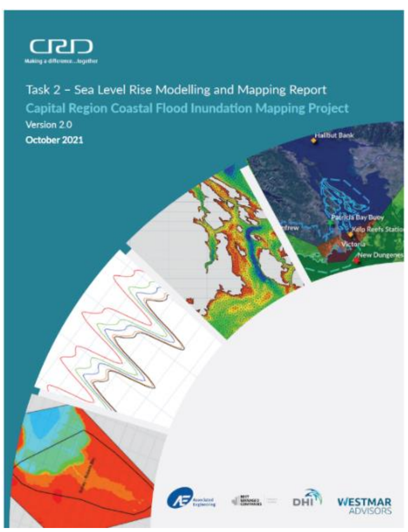
The Fraser Basin Council provided an un-released draft document, titled *FHIMP in BC* – Technical Approach and Requirements, which has been developed "to provide clear expectations on the level of study, type, and format of mapping products expected of professionals conducting floodplain mapping studies and producing floodplain maps for land use planning and regulation within the Province of BC." As such, the project team considered it prudent to account for the forthcoming guidance.

Many of the requirements and concepts of the Existing Provincial Guidelines have been carried forward to these 'Upcoming Provincial Guidelines.' Some updated requirements and/or key recommendations are as follows:

- There is an allowance for relaxation of FCLs landward of the 'Wave Runup Zone.' This recognises that wave effects are usually confined to the foreshore corridor.
- It is recommended to consider a 15 m setback from the estimated future natural boundary.
- A larger setback should be considered on shorelines where geomorphic processes could cause changes to the shoreline position.

Our team's experience working within the FHIMP program, as well as review of the 'Upcoming Provincial Guidelines' has informed the development of our resulting FCL maps (**Appendix C**). However, it must be noted that the 'Upcoming Provincial Guidelines' only became available late in this particular project. The team have endeavoured to incorporate as much of the guidance contained therein into this project's deliverable. As such, while the project team has made efforts to incorporate the relevant guidance into the deliverables, the mapping products presented herein may not fully reflect all elements of the finalized provincial standards. Future updates to the maps may be warranted once the guidelines are officially published and fully adopted by the province.

1.3.3 Capital Region Coastal Flood Inundation Mapping Project



In 2021, Associated, DHI and Westmar Advisors completed the *Capital Region Coastal Flood Inundation Mapping Project* for the Capital Regional District. The purpose of that project was to evaluate the potential inundation hazards associated with sea level rise along the capital region coastline (13 municipalities and three electoral areas). The report also provided potential FCLs at select locations to inform future planning and policy development. In addition, the report included a qualitative assessment of the potential impacts of sea level rise on intertidal areas, with particular attention to the associated risks to local ecosystems and culturally significant sites. The study evaluated four scenarios of Relative Sea Level Rise (RSLR): 0.0 m, 0.5 m, 1.0 m, and 2.0 m. While this was a valuable assessment at the time, advancements in coastal data collection and modelling techniques have since provided a more refined understanding of sea level rise, wave effects, and associated flood construction levels. It is also important to note that this study was completed using the original provincial guidelines available at the time and therefore does not reflect the most recent 'Upcoming Provincial Guidelines.' Nevertheless, much of the information, methodology, and findings from this study remain applicable and can be carried forward to align with future guidance.

The 2021 CRD study provides the baseline spectral wave model, which was adapted and modified to meet the specific requirements of this project. Further information is presented in **Section 4**.

1.4 Coordinate Reference System and Vertical Datum

All GIS and mapping deliverables produced for this study assume the following:

- **Coordinate System:** Universal Transverse Mercator (UTM) 10N is the horizontal coordinate reference system used for this study.
- **Elevations:** Referenced to Canadian Geodetic Vertical Datum, 2013 (CGVD2013), unless otherwise stated. The following formulae were used to convert elevations referenced to the Canadian Geodetic Vertical Datum of 1928 (CGVD28)[2] and Chart Datum (CD)[3] at the project site:

$$Z_{CGVD2013} = Z_{CGVD28} + 0.13\text{m}$$
$$Z_{CGVD2013} = Z_{CD} - 2.11\text{ m}$$

Where Z is the elevation, in metres, above the reference datum.

For users' information, most record drawings and older surveying deliverables are referenced to CGVD28.

1.5 Topographic Data

The Town of Sidney provided LiDAR data for this project. This LiDAR data was collected in 2023. The coverage extends through the entire project area along Sidney's shoreline. The project team used the delivered LAS files to develop a bare-earth 0.5-metre resolution Digital Elevation Model (DEM), which was subsequently used for analysis. All elevation data is referenced to the datums listed in **Section 1.4**.

Table 1-1 Metadata Summary of Project Topo Data

Metadata Summary		
Sources	Town of Sidney	Government of British Columbia
Data Provider		LiDAR BC
Year	2023	2023
Horizontal Datum	NAD83(CSRS)	NAD83(CSRS)
Vertical Datum	CGVD2013	CGVD2013
Units	Metres	Metres

The Town's LiDAR data was utilized for model development, wave run-up analysis, and flood hazard mapping. LiDAR BC data was utilized to supplement coastal wave modelling and analysis along the Town's shoreline.

[2] *CGVD28 on Vancouver Island is based on: NAD83 (CSRS), HT2 hybrid geoid model, Epoch 2010.*
[3] *Chart datum refers to the lowest normal tide, such that water levels rarely fall below it. Tidal predictions and hydrographic charts from the Canadian Hydrographic Service (CHS) reference this datum.*

1.6 Bathymetric Data

Bathymetric data for this study was primarily derived from the Canadian Hydrographic Service Non-Navigational (CHS-NONNA) Data Portal and was used to support the modelling analysis (see **Section 4**). The bathymetric data for the project area is ten metre resolution. It is important to note that the data is initially provided in Chart Datum, so it was converted to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013) to remain consistent with provincial mapping guidelines and recent studies that have been completed in the project area. This conversion involved applying a local adjustment of 2.11 metres (Z_{CD} – 2.11 = $Z_{CGVD2013}$).

1.7 Environmental Data

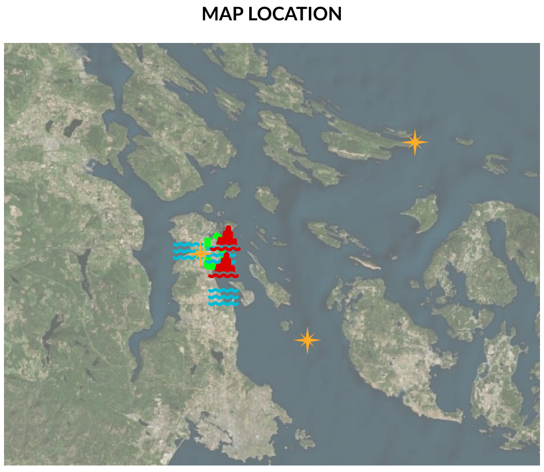
Available water levels, winds, and wave measurements were considered in this project. **Figure 1-5** depicts the different stations with measured data in the environs of Sidney. The various data sources are summarised and tabulated in **Table 1-2** for clarity. Further details on each data source are provided in **Section 3**. Additional sources of environmental data were used to force the entire spectral wave model domain and will be summarised in ensuing sections.

Table 1-2 Summary of Data Sources and Reasons for Use

Data Source	Data Availability	Data Use	Comment
Patricia Bay (CHS Station 07277)	1976 – Present	Tidal (water level) data	Tide gauge was used to develop statistics on extreme water levels. Extreme water levels were used as inputs in wave modelling and to inform mapping.
Sidney (CHS Station 07260)	1953 – 2023	Tidal (water level) data	Local tide gauge within the study area, providing tidal levels at Sidney.
Saanichton Bay (CHS Station 07255)	Predictions only	Tidal (water level) data	Tidal data in the vicinity of the project site, used as a supplementary reference for local tidal levels.
Victoria International Airport (1018620)	1940 – 2013	Wind data	Wind data was analyzed using wind roses to assess directional variability and identify prevailing wind directions relevant to local wave generation and modelling.
Kelp Reefs (1013998)	1997 – 2025	Wind data	Wind data was analyzed using wind roses to assess directional variability and identify prevailing wind

Data Source	Data Availability	Data Use	Comment
			directions relevant to local wave generation and modelling.
Saturna Island (1017101)	1994 – 2025	Wind data	Wind data was analyzed using wind roses to assess directional variability and identify prevailing wind directions relevant to local wave generation and modeling.
MarineLabs Wave Buoy – Bazan Bay	2023 – 2024 (9 months)	Wind and wave data	Constitutes a valuable record for calibration and validation of the spectral wave model developed for the project.
MarineLabs Wave Buoy – Roberts Bay	2023 – 2024 (9 months)	Wind and wave data	Constitutes a valuable record for calibration and validation of the spectral wave model developed for the project.

MAP LOCATION



LEGEND

TOWN BOUNDARY

ENVIRONMENTAL STATIONS

TIDE STATION

WAVE BUOY

WIND SOURCE

0 2,000 4,000 6,000 8,000 10,000 m

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METERS; Vertical Datum: CGVD 2013

Sidney

FIGURE 1-5

TOWN OF SIDNEY

ENHANCED FLOOD INUNDATION MODELLING & MAPPING PROJECT
METOCEAN DATA SOURCES

AE PROJECT No.	2023-2825-00
SCALE	AS SHOWN
APPROVED	D. FORDE
DATE	20251201
REV	A
DESCRIPTION	ISSUED FOR FINAL

1.8 History of Coastal Flooding

Sidney has experienced several notable coastal flooding events in recent years, primarily driven by storm surges, king tides, and high-energy winter storms. Vulnerability assessments and coastal flood mapping have identified southern Sidney and Roberts Bay as particularly at risk.

Significant events include king tide flooding in December 2022, which caused overtopping at Glass Beach and Beacon Avenue Pier, and a series of atmospheric river and windstorm events in late 2023 and December 2024[4] that resulted in widespread wave overtopping, road closures, power outages, and infrastructure damage along the waterfront.

The Town has also reported wave-induced flooding in Oceanspray Park and Tulista Park, where residential properties have been impacted and debris removal has been required following major storm events. Additionally, online reports indicate that Waterfront Walkway (Diver's Point) is vulnerable and has sustained damage from storm-driven debris, lifted bricks and extended closures post-storms.

There are quite a variety of videos from previous storm events in Sidney available for review on YouTube (A table of relevant links is provided below). Review of the videos and other online media suggests the following:

- Sidney is vulnerable to coastal flooding on a relatively frequent basis (almost annual).
- The primary source of flooding along Sidney's coastline is, presently, 'white-water.' Waves are running up on the shoreline and result in overtopping, ponding and spray. Water levels during these storms, while elevated, do not seem to presently inundate the crest of the foreshore. This is consistent with the water level analysis completed in **Section 3**.
- 'Blue-water' flooding will become a more frequent flood mechanism as sea levels continue to rise.
- Debris mobilisation during coastal storms is a persistent challenge. Many of the photos and videos reviewed show large woody debris strewn across the crest of the foreshore.
- Acutely vulnerable areas seem to be:
    - Tulista Park and Tulista Boat Launch
    - The Anacortes Ferry foreshore area
    - Oceanspray Park and First Street
    - Waterfront Walkway
    - Bevan Fishing Pier
    - Diver's Point and Glass Beach
    - Beacon Avenue Pier and Park

[4] *https://victoriabuzz.com/2024/12/10-captures-of-the-aftermath-of-waterfront-storm-damaged-in-sidney-photos-videos/*

Table 1-3 A selection of YouTube footage of coastal storms in Sidney, BC

Approximate (Assumed) Storm Date	Link
December 23, 2010	https://www.youtube.com/watch?v=kOVphsbqjLw
March, 2012	https://www.youtube.com/watch?v=5zMr8BxO2HY https://www.youtube.com/watch?v=arPtDQNDtk0
December 12, 2015	https://www.youtube.com/watch?v=eZO8ML_i_kU https://www.youtube.com/watch?v=olVJuOkomf4 https://www.youtube.com/watch?v=PXkfm_hOS_0
March, 2018	https://www.youtube.com/watch?v=mzeYF7635uM

2 SITE RECONNAISSANCE

2.1 Overview

In support of this project, three Associated-DHI staff undertook a site reconnaissance visit on August 1, 2023. The site visit was conducted at low tide. The project team were accompanied on our site visit by representatives from the Town of Sidney. The intent of the site visit was to complete the following:

- Meet with the Town of Sidney to discuss priority locations along the municipality's shoreline.
- Complete a visual assessment of any evidence of sustained erosion, including possible sediment transport pathways, sources, and sinks at areas that appear to be susceptible to shoreline damage.
- Conduct qualitative observations of surficial substrate materials and shoreline vegetation types.
- Select appropriate analytical methods for the derivation of the eventual flood hazard mapping and FCLs.

2.2 Key Observations from Site Reconnaissance

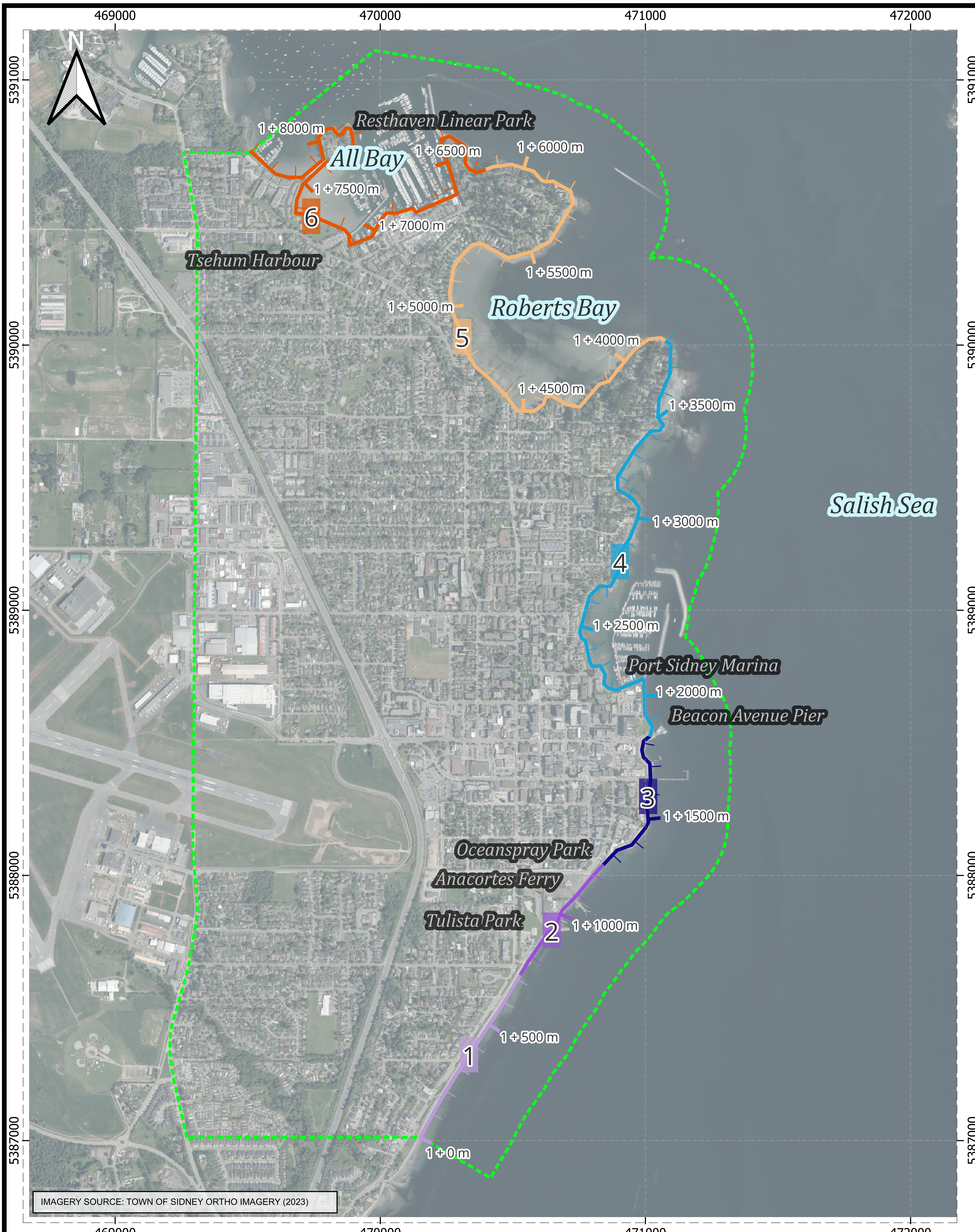
A summary of key background information provided by the client and observations made by the team during the site reconnaissance trip in August 2023 are documented within this section. There are a handful of particularly vulnerable, low-lying areas in Sidney:

- Tulista Park/Annacortes Ferry
- Beacon Park
- A corridor surrounding Mermaid Creek, in Roberts Bay
- Portions of Tsehum Harbour and Resthaven Park

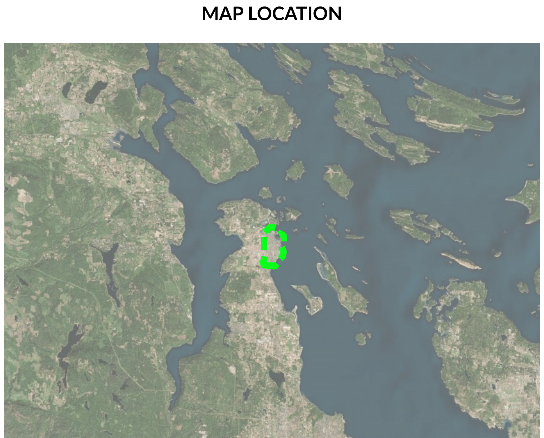
The Town's shoreline is generally comprised of a mix of sandy beaches, rocky outcrops, seawalls and developed waterfronts. There was evidence of woody debris accumulation at the top of the intertidal zone on most shoreline reaches.

There is a variety of existing flood and erosion control measures along the coast, most of which seem to be in adequate condition. However, it must be noted that a structural condition assessment of the Town's coastal infrastructure was outside the scope of this current project. It is recommended that regular inspections of coastal infrastructure such as piers, breakwaters, seawalls, and revetments be undertaken by a suitably qualified marine structural engineer.

We have grouped site observations into six areas, due to similarities in the characteristics observed within each area. These areas are shown in **Figure 2-1** for reference.



MAP LOCATION



LEGEND

- TOWN BOUNDARY
- SHORELINE CHAINAGE
- 1 SITE RECONNAISSANCE AREA

0 200 400 600 800 1,000 m

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METERS; Vertical Datum: CGVD 2013

Sidney

FIGURE 2-1

TOWN OF SIDNEY

ENHANCED FLOOD INUNDATION MODELLING & MAPPING PROJECT
SITE RECONNAISSANCE MAP

AE PROJECT No.	2023-2825-00
SCALE	AS SHOWN
APPROVED	D. FORDE
DATE	20251201
REV	A
DESCRIPTION	ISSUED FOR FINAL

Associated Engineering
BEST MANAGED COMPANIES Platinum member
DHI

2.2.1 Area 1 (Approximately STA 1 + 0 m to STA 1 + 700 m)

Area 1 corresponds to the stretch of shoreline extending from the Town's southern boundary northward to Tulista Park's vehicular entrance at the intersection with Weiler Avenue. This section of the coast is relatively elevated, with Lochside Drive running parallel to the shoreline. Key locations include Lochside Waterfront Park, a narrow, linear park situated between the road and the ocean, and adjacent parking lots providing beach access. Staircases/ramping connect the upper level to the beach below.

The shoreline is relatively straight, facing southeast, and the beach exhibits a gentle, gradual slope. It is composed of loose coarse material, primarily gravel and cobbles, with logs and driftwood distributed along the entire stretch. Some armouring is present: riprap is installed at the southern end, while a relatively low lock-block wall from approximately STA1 + 200 m to STA 1 + 900 m (in Area 2) is positioned directly on the beach and supports a pedestrian path. Several localized drainage outfalls are also observed within the armored sections.

The combination of coarse sediments, natural debris, and existing armouring indicates that this shoreline is exposed to relatively dynamic wave conditions and storm energy.

A selection of images of this area is presented in the ensuing figures.

Figure 2-2 STA 1 + 120 m

Figure 2-3 STA 1 + 280 m

Figure 2-4 STA 1 + 180 m

Figure 2-5 STA 1 + 350 m

2.2.2 Area 2 (Approximately STA 1 + 700 m to STA 1 + 1250 m)

Area 2 extends from the vehicular entrance of Tulista Park northward to Oceanspray Park. The shoreline orientation continues from Area 1 with no significant directional change, facing generally southeast. This section is completely engineered, hosting several key coastal assets, including the Anacortes Ferry Terminal and the Tulista Boat Launch. Some forms of shoreline protection extend along the entire area shoreline. The seawall from Area 1 continues northward through this section to the ferry terminal, reinforced with riprap in several locations. The Tulista Boat Launch jetty is sheltered by a breakwater/groyne approximately 60 m in length, extending eastward from the ramp to protect the structure.

The area is relatively low-lying, with a narrow crest elevation, and contains multiple parking lots and road infrastructure supporting ferry and boating operations. In some locations, the landward areas lie lower than the foreshore crest, creating susceptibility to ponding and localized flooding. According to the Town of Sidney, and corroborated by video footage from March 2018, Tulista Park is prone to storm-related flooding, with woody debris overtopping the lock-block wall and accumulating in the park.

The beach material consists mainly of coarse gravel and cobbles, with mobilized riprap and driftwood observed along the foreshore. Additional features include:

- Riprap extending from the upper beach slope into the intertidal zone south of the boat launch.
- Larger riprap structures protecting a drainage outfall.
- A stormwater outfall at Tulista that remains submerged year-round, with a secondary pipe equipped with a flap gate.
- Woody debris collected at the top of the beach slope.

A selection of images of this area is presented in the ensuing figures.

Figure 2-6 STA 1 + 830 m

Figure 2-7 STA 1 + 895 m

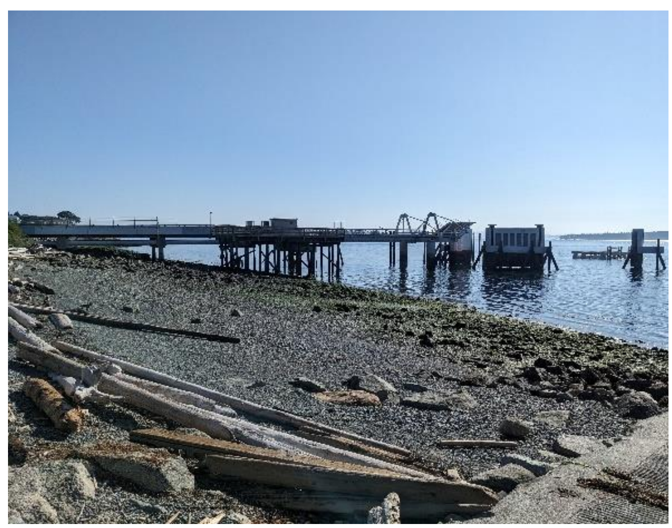


Figure 2-8 STA 1 + 1000 m

Figure 2-9 STA 1 + 1115 m

2.2.3 Area 3 (Approximately STA 1 + 1250 m to STA 1 + 1850 m)

Area 3 extends from Oceanspray Park to the Beacon Avenue Pier, covering approximately 600 m of shoreline. Key features include Eastview Park and the adjacent Bevan Fishing Pier, a 150 m long structure extending eastward into the ocean.

The shoreline in this reach is characterized by a series of pocket beaches interspersed with exposed bedrock outcrops. A distinct change in shoreline orientation occurs between STA 1+1 300 m and STA 1+1 500 m, shifting from a southeast-facing alignment in the south to a more easterly orientation toward the north. At this transition point, the intertidal zone consists of a gravel beach and rock slope fronting a relatively tall (3–5 m) concrete seawall. Immediately landward, private waterfront properties are situated behind a pedestrian path, with the seawall providing the primary protection. The foreshore commonly exhibits accumulations of logs, driftwood, and mobilized riprap.

The seawall extends along much of this shoreline, fronting both private properties and public areas, and shows evidence of localized cracking, surface deterioration, and undermining. South of Eastview Park, the profile transitions from gravel beach and rock slope to a vegetated backshore. North of Bevan Fishing Pier lies “Glass Beach,” located between the pier fronting the Sidney Waterfront Inn and Suites and the Beacon Avenue Pier. This section consists of a gravel beach fronted by a vertical seawall.

Overall, sediments in Area 3 range from cobbles to gravel, with driftwood accumulations and occasional mobilized riprap scattered along the foreshore. The Beacon Avenue Pier marks the northern limit of this reach and forms a prominent feature of Sidney’s downtown waterfront.

A selection of images of this area is presented in the ensuing figures.

Figure 2-10 STA 1 + 1455 m

Figure 2-11 STA 1 + 1550 m

Figure 2-12 STA 1 + 1370 m

Figure 2-13 STA 1 + 1745 m

2.2.4 Area 4 (Approximately STA 1 + 1850 m to STA 1 + 3800 m)

Area 4 encompasses approximately 2,000 m of shoreline, extending from the Beacon Avenue Pier in the south to the end of Beaufort Road in the north. Notable features include Beacon Park, the Port Sidney Marina, and a series of private waterfront properties situated immediately adjacent to the shore. Majority of this shoreline is reinforced with riprap and seawalls, with additional retaining walls and landscaped edges in various locations.

The Port Sidney Marina occupies a central portion of this area, spanning 700 m between STA 1+2,100 m and STA 1+2,800 m. The marina basin is enclosed by two breakwaters that provide shelter from wave action. Within the basin, an unhealthy salt marsh is present, and past dredging activities have been reported by the Town of Sidney.

North of the marina, the shoreline transitions to more natural features, including several offshore bedrock formations and relatively gentle, sloping beaches. These beaches consist primarily of sandy clay interspersed with cobbles and occasional bedrock exposures. Scattered driftwood and debris are also observed.

Adjacent land uses include private residences, parks, and public beach access points. In several locations, walkways and backshore areas are protected by riprap, while some sections feature discontinuous retaining walls.

A selection of images of this area is presented in the ensuing figures.

Figure 2-14 STA 1 + 1865m

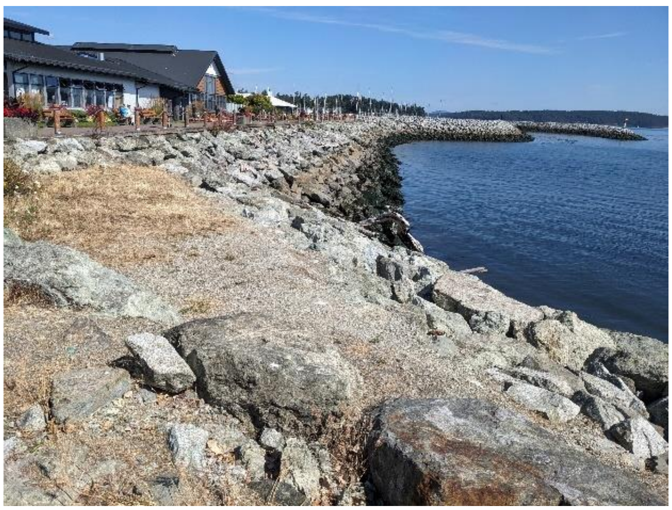


Figure 2-15 STA 1 + 2050 m

Figure 2-16 STA 1 + 2300 m

Figure 2-17 STA 1 + 3195 m

2.2.5 Area 5 (Approximately STA 1 + 3800 m to STA 1 + 6150 m)

Area 5 extends from the Beaufort Viewpoint to approximately 400 m west of the Allbay Viewpoint, terminating at the Harbour Road viewpoint. This section encompasses Roberts Bay, a semi-enclosed embayment oriented towards the northeast, with an opening of approximately 500 m between the two viewpoints. The bay also contains the estuary of Mermaid Creek, which drains through a relatively low-lying backshore area. The foreshore is fronted by low-density residential properties, interspersed with small public access points such as Ardwell Avenue and Resthaven Drive.

The shoreline is characterized by broad intertidal mudflats and sandflats that extend well offshore and are exposed extensively at low tide. These are interspersed with localized pockets of sandy and gravel beaches, with sandy-pebble materials forming much of the foreshore. Driftwood deposits are scattered along the beach, and vegetated areas are present along the bay margins. The backshore is predominantly low-lying, with limited vertical relief separating the shoreline from adjacent residential areas. In certain locations, small retaining structures have been constructed to provide localized protection.

Roberts Bay is more sheltered than adjacent shoreline reaches, with wave exposure limited by its enclosed orientation. Coastal flooding considerations are elevated in this area due to the combination of shallow nearshore bathymetry and low-lying backshore. The estuary of Mermaid Creek further increases the sensitivity of this shoreline to flooding and stormwater impacts.

A selection of images of this area is presented in the ensuing figures.

Figure 2-18 STA 1 + 4560 m

Figure 2-19 STA 1 + 4605 m

Figure 2-20 STA 1 + 4560 m

Figure 2-21 STA 1 + 4690 m

2.2.6 Area 6 (Approximately STA 1 + 6150 m to STA 1 + 8400 m)

Area 6 extends from the Harbour Road Viewpoint to the northern limit of the Town. Most of the area is mostly occupied by Tsehum Harbour, where the Van Isle Marina is sheltered by a 200 m long breakwater. Another notable feature is Resthaven Linear Park, which loops around Resthaven Island within the harbour and connects to the mainland via a vehicle and pedestrian bridge.

The foreshore areas are generally populated by harbour infrastructure, including marina facilities, floating docks, and mooring structures that provide sheltered moorage for recreational and commercial vessels. The backshore is dominated by marine-oriented land uses and residential properties.

The shoreline is generally, naturally rocky and interspersed with armouring, with narrow strips of sand, gravel, and cobble occurring in isolated locations. Vegetation occurs along the slope crest, although some signs of erosion and localized slope movement are evident. A large intertidal zone is exposed at low tide, and debris is occasionally present along the foreshore.

This section is sheltered from wave exposure due to the enclosed harbour configuration. Coastal processes are primarily influenced by tidal fluctuations and vessel activity. The low-lying backshore and limited relief between the shoreline and adjacent developments increase sensitivity to sea level rise and elevated water levels. Homes are located close to the shoreline with minimal setback, and the foreshore consists of coarse materials such as cobbles and boulders.

A selection of images of this area is presented in the ensuing figures.

Figure 2-22 STA 7325 m

Figure 2-23 STA 7325 m

Figure 2-24 STA 1 + 7375 m

Figure 2-25 STA 1 + 7810 m

2.3 Site Reconnaissance Conclusions

The site reconnaissance provided valuable information about current shoreline conditions along the Town of Sidney's waterfront. Observations across all six areas revealed a range of shoreline types, existing protection measures, and erosion conditions. Key findings are summarized below:

- **Shoreline Protection:** Most vulnerable areas have existing coastal structures and erosion control such as riprap, seawalls, or retaining structures. These are generally in fair condition, though some areas show signs of deterioration or damage (e.g., seawall cracking, slumping slopes).
- **Foreshore Conditions:** The shoreline consists of a mix of materials, including gravels, cobbles, boulders, sand, and bedrock. Many areas show debris accumulation.
- **Vegetation and Slopes:** Vegetation varies by area, with some slopes well vegetated and others showing exposed soils or signs of erosion. Slopes range from gently sloping beaches to high vertical walls with little setback to existing development/infrastructure.

This information will help guide the selection of transects for analysis; as well as the wave run-up calculations for subsequent FCL mapping.

3 METOCEAN CONDITIONS

Analysis of meteorological and oceanographic (metocean) conditions (including analysis of extreme water levels, winds, and waves) was completed to inform the understanding of shoreline vulnerability to flooding, and to inform subsequent FCL mapping. This section outlines work undertaken to characterize the metocean conditions across the study site.

3.1 Water Levels

Water levels in Sidney vary due to a combination of astronomical tides, atmospheric conditions, and long-term sea level trends. Some of the primary drivers influencing total water level along Sidney include, but are not limited to:

- **Tide**: Sidney experiences mixed semi-diurnal tides, meaning two high and two low tides of varying heights occurring daily.
- **Storm Surge**: Short-term fluctuations in water levels are driven by weather systems, such as low-pressure events and strong winds, which can raise sea levels during storm conditions.
- **Long-term Sea Level Rise**: long-term increase in the average level of the world's oceans, driven primarily by processes linked to climate change.

The Canadian Hydrographic Service (CHS) maintains water level gauging stations across Canada[5]. The closest, long-term gauging station is in **Patricia Bay (07277),** which provides high-resolution water level measurements (including surge residual) from 1976 to present. Additional stations were installed in the area: one in **Sidney (07260)** and one in **Saanichton Bay (07255)**, as illustrated in **Figure 1-5**

3.1.1 Astronomic Tide Levels

Table 3-1 presents key tide levels derived from the long-term measurements at Patricia Bay (07277) and shorter-term historic measurements at Sidney (07260) and Saanichton Bay (07255). These tables were compiled using CHS tides and water levels data archive.

At Sidney (07260) and Saanichton Bay (07255), the Highest Astronomical Tide (HAT) measures approximately 1.53 mCVGD2013 and 1.61 mCGVD2013, respectively. It is also noted that at Patricia Bay, located west of Sidney in the Saanich Inlet, the HAT reaches 1.66 mCGVD2013.

[5] https://tides.gc.ca/en/stations

Table 3-1 Tide levels at Patricia Bay (07277), Sidney (07260) and Saanichton Bay (07255) CHS Stations.

Tidal Height	Patricia Bay (m, CD)	Patricia Bay (m, CGVD2013)	Sidney (m, CD)	Sidney (m, CGVD2013)	Saanichton Bay (m, CD)	Saanichton Bay (m, CGVD2013)
Highest Astronomical Tide (HAT)	3.77	1.66	3.53	1.53	3.55	1.61
Higher High Water Large Tide (HHWLT)	3.73	1.62	3.47	1.47	3.50	1.56
Mean Higher High Water (HHWMT)	3.28	1.17	3.05	1.05	3.13	1.19
Mean High Water (MHW)	3.06	0.95	2.85	0.85	2.94	1.00
Mean Water Level (MWL)	2.26	0.15	2.09	0.09	2.19	0.25
Mean Low Water (MLW)	1.58	-0.53	1.47	-0.53	1.58	-0.36
Mean Lower Low Water (LLWMT)	0.83	-1.28	0.74	-1.26	0.87	-1.07
Lower Low Water Large Tide (LLWLT)	-0.11	-2.22	-0.22	-2.22	-0.08	-2.02
Lowest Astronomical Tide (LAT)	-0.29	-2.4	-0.43	-2.43	-0.28	-2.22

3.1.2 Total Water Level for Flood Mapping

Extreme values with associated long return periods are estimated by fitting a probability distribution to historical data. The main objective in determining an appropriate extreme distribution function is to derive estimates of extreme conditions at desired return periods. Often the data must be extrapolated to probabilities beyond the record length to match design return periods (USACE, 2006)[6]. There are large uncertainties associated with extreme value analyses, and the uncertainties generally increase for higher return periods. Ideally, time series that are long compared to the desired return periods should be available to reliably extract extreme values. In practice, however, the opposite is true and return values corresponding to return periods much longer than the length of recorded data are needed. Intuitively, the further away from the data one has to extrapolate, the larger the uncertainties of the resulting estimates will be.

As a rule of thumb, for example, the ISO standard ISO 19901-1 (ISO, 2020)[7] recommends not using return periods more than a factor of three to four times beyond the length of the data set when deriving return values for design (Vanem, 2015)[8]. Therefore, for the assessment of a 0.5% AEP, one would need a continuous time series of over 50-65 years.

Water level records at Sidney (07260) and Saanichton Bay (07255) are characterized by data gaps and limited temporal coverage, reducing their reliability for extreme value analysis. Consequently, the long-term, continuous dataset from the Patricia Bay (07277) station was utilized to characterize extreme total water levels at Sidney.

To determine the annual exceedance probability (AEP) for total water levels for a 200-year event (0.5% AEP), an extreme value analysis (EVA[9]) of 45-year historical total water level at Patricia Bay was completed. The results for the central fit at some of these points are depicted in **Figure 3-1** and **Table 3-2**.

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[6] *USACE. (2006). Coastal Engineering Manual. Washington, D.C.: U.S. Army Corps of Engineers.*
[7] *ISO. (2020). 29400:2020 Ships and marine technology — Offshore wind energy — Port and marine operations. Switzerland: ISO*
[8] *Vanem, E. (2015). Uncertainties in Extreme Value Modelling of Wave Data in a Climate Change Perspective. Journal of Ocean Engineering and Marine Energy 1 (4), 339-359*
[9] *The Extreme Value Analysis (EVA) is a fit of data to predict extreme events reoccurrence.*

Figure 3-1 Total Water Level Extreme Value Analysis at Patricia Bay (07277) – 1979-2024

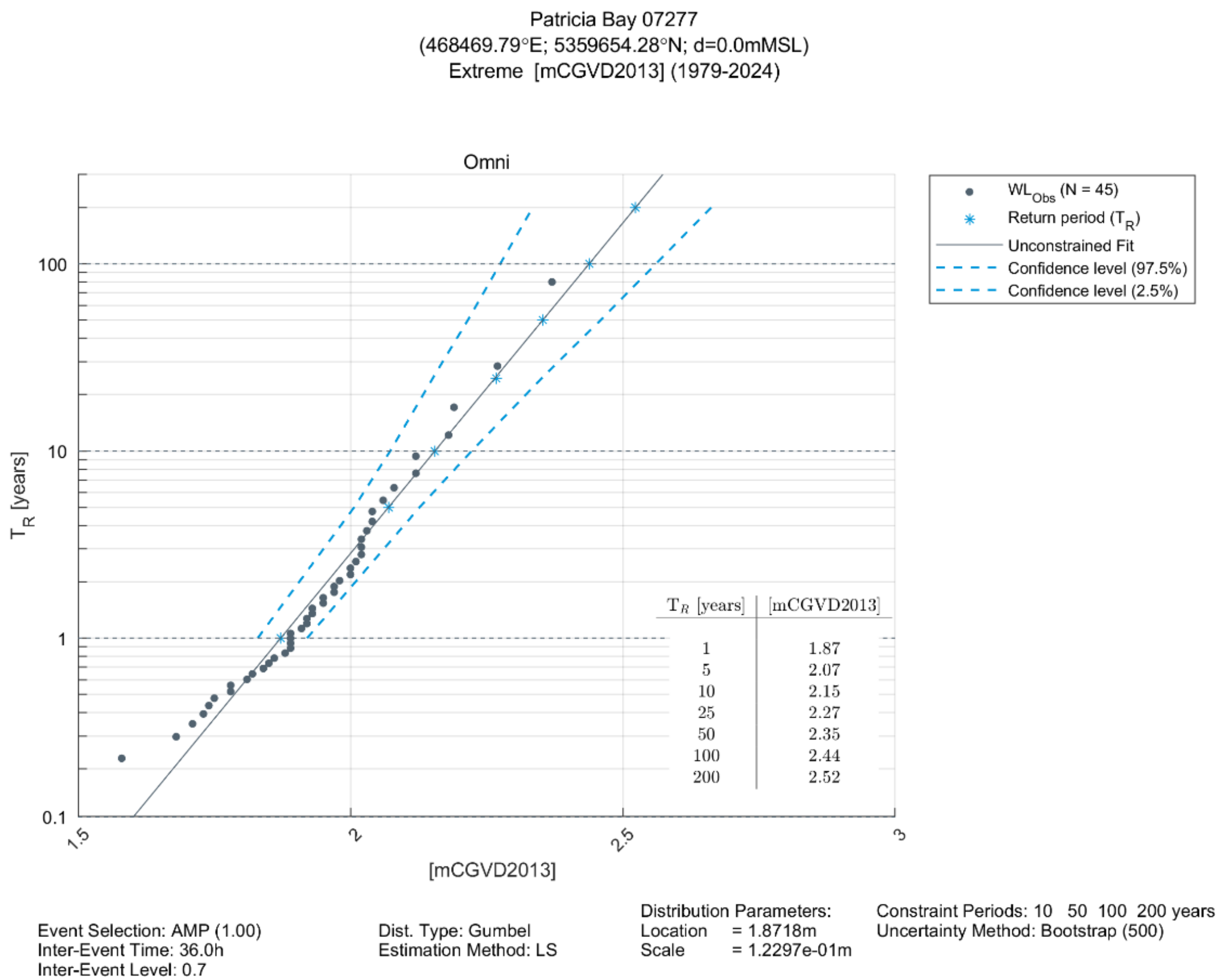


Table 3-2 AEPs for Total Water Level at Patricia Bay (07277) – Central Estimate

Annual Exceedance Probability (AEP)	Total Water level (m CGVD2013)
100% Annual	1.87
20% (1-in-5 years)	2.07
10% (1-in-10 years)	2.15
4% (1-in-25 years)	2.27
2% (1-in-50 years)	2.35
1% (1-in-100 years)	2.44
0.5% (1-in-200 years)	**2.52**

Per the results of this analysis, we propose the following for application to the FCL assessment at Sidney:

- 0.5% AEP Total Water level: 2.52 mCGVD2013.
- This is applied for the project in the wave run-up assessment (see **Section 5**).

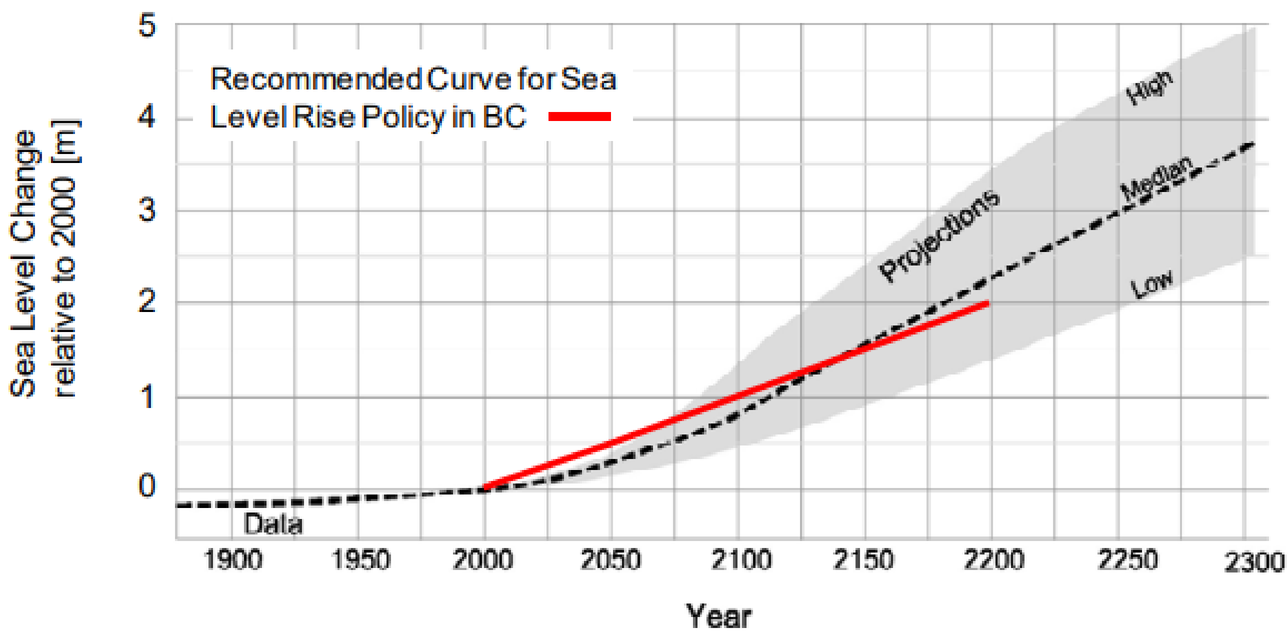
3.2 Sea Level Rise

In British Columbia, it is standard practice to apply guidance regarding sea level rise projections from the 2011 Policy Discussion Paper - Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use, as prepared by Ausenco Sandwell for the British Columbia Ministry of Environment (Ausenco Sandwell, 2011a)[10]. Since the release of this document, there have been no definitive updates on guidance related to sea level rise, and therefore it is still considered one of the primary guiding documents for practitioners for the purposes of flood hazard mapping. The document provides the following guidance regarding the establishment of policy for climate change adaptation in the coastal waters of British Columbia (Ausenco Sandwell, 2011a):

- Sea level rise (SLR) in the future is expected to be both faster and higher than previously anticipated (as of 2011). A large degree of the related uncertainty can be eliminated by recognizing that it seems likely that sea level will rise but the rate at which it rises, and therefore the particular sea level rise on a given date, carries the most uncertainty.
- For planning purposes, it is recommended that the rates and trends reflected in **Figure 3-2** should be used (reference to 2011).
- The choice of appropriate response options or adaptation measures is so site-specific that their identification and adoption must be the responsibility of local governments, with guidelines and other support provided by the province.
- As of 2011, scientific information on the expected changes in storms approaching British Columbia coastal waters and their characteristics, specifically on the intensity of the storms, their related wave conditions, and the associated storm surges in the future, is only starting to emerge. Based on the available information it appears reasonable to conclude that no significant change is expected in coastal BC waters; however, further investigations are warranted to fully assess the regional implications and to further assess future trends.
- The present recommended rates and trends for SLR have significant implications for British Columbia coastal communities.

[10] *Ausenco Sandwell. (2011a). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use Draft Policy Discussion Paper. Vancouver: BC Ministry of Environment.*

Figure 3-2 Recommended Global Sea Level Rise Curve for Planning and Design in BC



Additional guidance for the application of global sea level rise scenarios for various development and land-use timeframe is provided in **Table 3-3** (Ausenco Sandwell, 2011a).

Table 3-3 Sea Level Rise Recommendations and Their Application for BC Sea Dike and Coastal Flooded Land Management Guidelines

Development/ Land Use Timeframe	Global SLR	Regional SLR	Application	Comment
For short to medium term - life of 25 to 50 years	0.5 m	To be developed on a site-specific basis.	Evaluation of existing structures (sea dikes)	This estimate is slightly higher than suggested by the present range of SLR estimates and planning curves and anticipates revision soon (circa 2014).
For longer term - life of up to 2100	1.0 m		Definition of requirements for permanent structures (sea dikes) that can be expected to be upgraded again in the future as science and knowledge increases	This is consistent with the present "extreme high" estimates in BC Sea Level Report 2008.

Development/ Land Use Timeframe	Global SLR	Regional SLR	Application	Comment
For issues with long life (> 100 years), and as a sensitivity example	2.0 m		Consideration of long-term land use and planning issues having very long-term implications – especially where decisions may be made that allow or encourage concentration of high value or high population density uses.	This value is a balance between the current often stated upper limit of ~ 2 m for updated accounting of ice sheet mass loss by 2100 and potential increases identified by others.

The global sea level rise projections from 2011 (**Figure 3-2**) are, at the time of writing this report, over 14 years old. Since these projections were published, significant advancements have been made with regards to global sea level rise projections, and local understanding of land subsidence, thereby resulting in significant changes to both global and local relative sea level rise projections. Nonetheless, the principles outlined in **Table 3-3** remain valid and should be considered within the present study.

Local relative sea level rise (RSLR) is a combination of both global sea level changes due to climate change and local vertical land movements. Global SLR is the result of changes in glacier and ice-sheet mass loss, changing ocean circulation conditions, thermal expansion of the oceans, and human caused changes in land water storage. Local vertical land movements are the result of tectonic uplift or subsidence, isostatic rebound due to glacial retreat, and sediment consolidation. Local relative SLR is therefore the change in ocean height relative to land and is the apparent sea-level change experienced by coastal communities and ecosystems. Local relative SLR (i.e. RSLR) is also the parameter adopted for design purposes.

AR5[11] and AR6A[12] projections are available through the CAN-EWLAT[13] online tool (Greenan, 2022)[14] for small craft harbours and tide gauge locations. **Table 3-4** presents the latest AR6 RSLR projection in the vicinity of the project site, extracted from the tool, for the SSP5-8.5[15] scenario (median estimate). For the Sidney Beacon Small Craft Harbour (6167), CAN-EWLAT provides a projection of 0.59 m in 2100 m and 1.00 m in 2150 relative to year 2010 which is approximately analogous to the AR5 RCP8.5 mean projection.

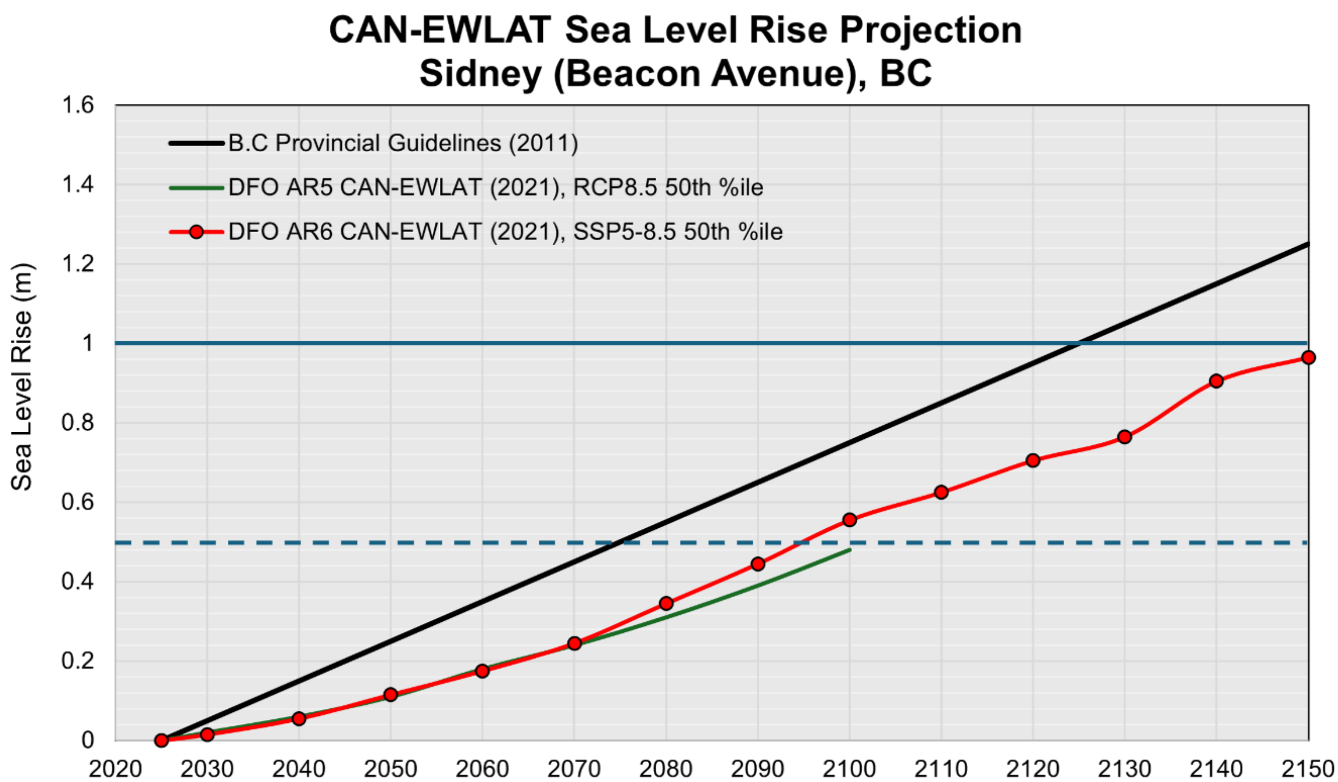
11 Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)
12 Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)
13 https://gisp.dfo-mpo.gc.ca/portal/apps/experiencebuilder/experience/?id=760c4e0033ef4023ba395127a406d3a7&locale=en
14 Greenan. (2022). Canadian Extreme Water Level Adaptation Tool (CAN-EWLAT) Published June 2022. Dartmouth: Oceans Ecosystems Science Division, Fisheries and Oceans Canada
15 SSP5-8.5 is a Shared Socioeconomic Pathway (SSP) scenario that represents a high-end scenario for future climate change, due to significant greenhouse gas emissions.

Table 3-4 Projected Relative Sea Level Rise extracted from CAN-EWLAT portal in the vicinity of the project site

Year	Projected Relative Sea Level Rise relative to 2010 (m)		
	Patricia Bay AR6 SSP5-8.5	Sidney (Beacon Avenue) AR6 SSP5-8.5	Tsehum, Harbour (Shoal Harbour) AR6 SSP5-8.5
2020	0.02	0.02	0.02
2030	0.05	0.05	0.05
2040	0.09	0.09	0.09
2050	0.14	0.15	0.15
2060	0.2	0.21	0.21
2070	0.28	0.28	0.28
2080	0.37	0.38	0.38
2090	0.47	0.48	0.48
2100	0.58	0.59	0.59
2110	0.65	0.66	0.67
2120	0.73	0.74	0.74
2130	0.79	0.8	0.8
2140	0.93	0.94	0.95
2150	0.98	1.00	0.99

To compare the various sea level rise scenarios, from the earliest 2011 Provincial Guidelines to the most recent AR6 projections, the relative sea level rise projections for Sidney are adjusted to a common reference point of 2025 as depicted in **Figure 3-3**. It should be noted that all projections are RSLR projections and thus include local annual land subsidence/uplift. It is noted that the 2011 Provincial Guidelines are seemingly conservative relative to the latest IPCC scientific projections.

Figure 3-3 Comparison of Local Sea Level Rise projections in Sidney



Given that the latest scientific models and projections indicate a relative sea level rise at Sidney of no more than 0.6 m by 2100, and a relative sea level rise less than 1.0 m by 2150, it is proposed to adopt future relative sea level rise scenarios for the purposes of mapping for **0.50 meters** and **1.0 meters only**. These recommendations are aligned with guidance in **Table 3-3** which indicates that a 0.50-meter SLR allowance is appropriate for short to medium term - life of 25 to 50 years, and 1.0-meter SLR allowance is appropriate for longer term - life of up to 2100.

As sea level rise science and projections continue to evolve, the guidance offered by mapping 0.50 meter and 1.0- meter sea level rise estimates can be used relative to the latest scientific consensus, to provide a robust basis for informed planning decisions along Sidney. Currently, a 2.0-meter increase in relative SLR is unlikely to occur by 2100 and is likely to fall well outside the long-term planning timelines of Town of Sidney. A 2.0-meter relative SLR projection is therefore discarded as part of this assessment. If required, this SLR scenario can be considered for future study and mapping projects.

It must also be mentioned that the unreleased 'Provincial Guidelines' recommend that AR6 SSP5-8.5 83rd projections be adopted for coastal environments. This would result in global sea level rise values of 0.3 m by 2050, 1.0 m by 2100 and 1.9 m by 2150, respectively. This reinforces our study's decision to adopt absolute RSLR values of 0.5 m and 1.0 m respectively, instead of tying the analyses to specific time-horizons.

3.3 Wind Observations

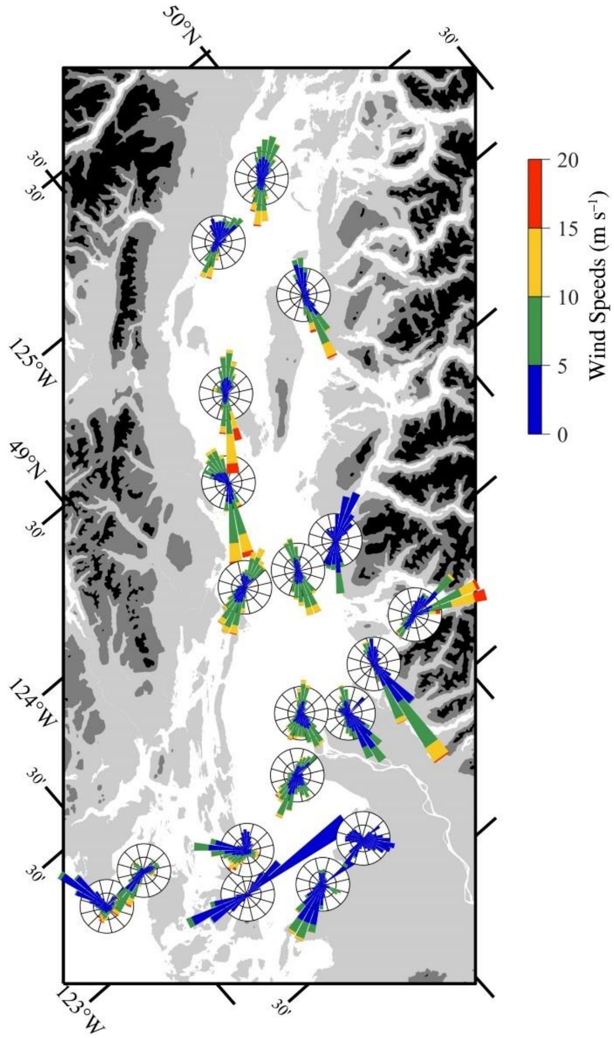
Local wave conditions in the Haro Strait and along the Sidney shoreline are influenced by local atmospheric conditions. Wind conditions in the area are influenced by a variety of factors, including local geography and complex topography, and broader regional atmospheric circulations, significantly impacting wind patterns and intensity in the area.

Numerous land and water-based meteorological stations are maintained throughout the region, most of them maintained and operated by ECCC and MSC, and accessible via the Government of Canada data portal[16]. The closest, relevant weather meteorological stations with long-term data are Victoria International Airport (1018620), Kelp Reefs (1013998), and Saturna Island (1017101); as shown on **Figure 1-5**. **Figure 3-5** presents wind roses at the three stations and highlights the high directional variability of the wind conditions in the area. The spatial variability in the area is illustrated in **Figure 4-3** below, which is sourced from the applied research paper *Wind Waves in the Strait of Georgia* [17] (2020). In this figure we note that wind directions are generally aligned with the orientation of the Strait, with the exception of the Gulf Islands, where prevailing wind directions are more locally focused and variable. This is consistent with local observations at Sidney.

[16] *https://climate.weather.gc.ca/*

[17] *Gemmrich, J., & Pawlowicz, R. (2020). Wind Waves in the Strait of Georgia. Atmosphere-Ocean, 58(2), 79–97. https://doi.org/10.1080/07055900.2020.1735989*

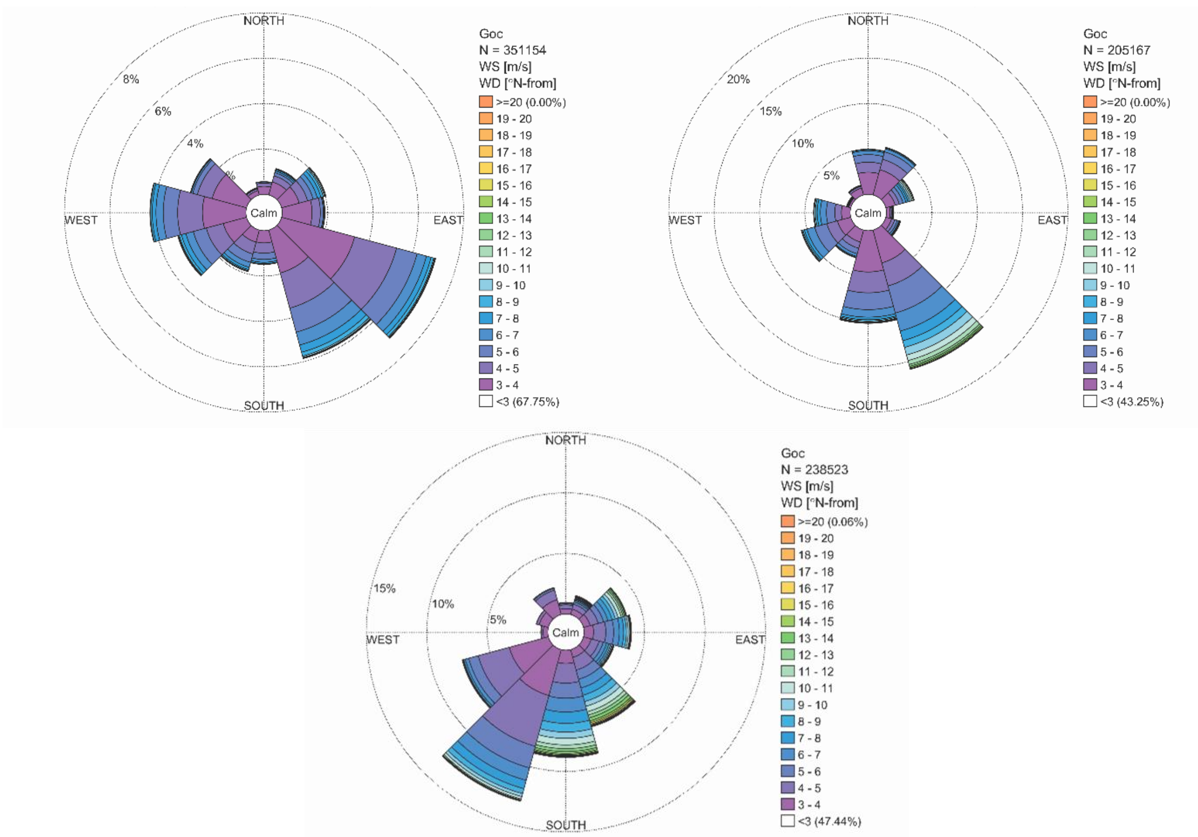
Figure 3-4 Illustration of wind spatial variability in the Strait of Georgia



At the three monitoring stations, wind speeds reach approximately 20 m/s and originate from a range of directions, with a higher frequency observed from the south-east and south-west quadrants. This high directional variability is a key consideration for wave modelling, as wind forcing plays an important role in wave generation and transformation processes. Wind rose analyses indicate that wind-generated waves can propagate from any direction, provided the fetch length is sufficient to support wave development.

Given the local shoreline orientation at Sidney, winds originating from the north-east to south-east sectors are expected to have the greatest impact on local wave development, due to their alignment with the predominant fetch direction.

Figure 3-5 Wind measurements captured at Victoria International Airport (top left), Kelp Reefs (top right) and Saturna Island (bottom)



3.4 Wave Observations at Sidney

Sidney is subject to a moderate wave climate, primarily influenced by its relatively sheltered location on the Saanich Peninsula, within the Salish Sea. Wave exposure is further limited by the presence of the surrounding Gulf Islands, which limit fetch length and constrain incident wave directions along the Town's shoreline.

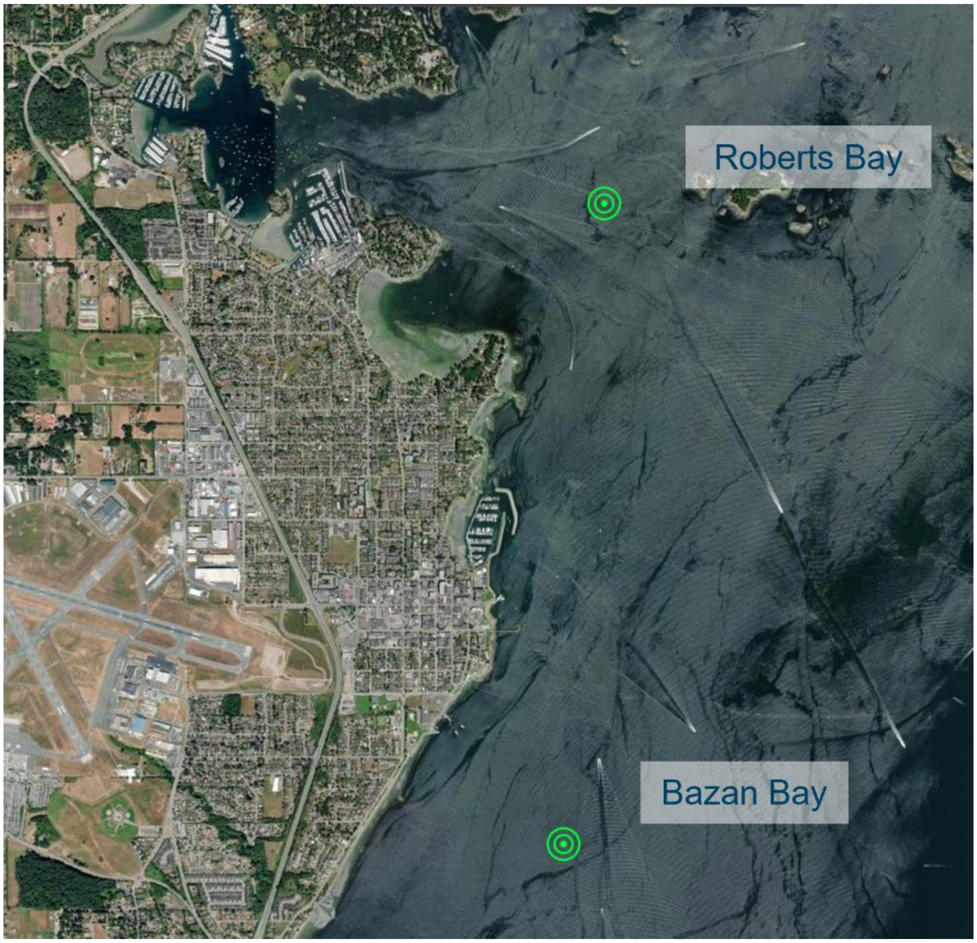
Under typical conditions, wave heights remain relatively low throughout the year due to this natural protection from open ocean forcing. However, during winter months, the passage of intense regional storm systems can generate elevated wave conditions, increasing the potential for coastal erosion and localized inundation. Long term records at Sidney are unfortunately not available to support the long-term characterization of the wave conditions at the shoreline.

Recognizing the importance of understanding local wave dynamics, two buoys were deployed off Sidney's coastline to collect wind and wave data over nine months at the northern and southern end of the Town's shoreline. The locations of the two buoys deployed along Sidney's shoreline are provided in **Table 3-5** and illustrated in **Figure 3-6**.

Table 3-5 Location of the wave buoys deployed in Roberts Bay and Bazan Bay

Wave Buoy Location	Easting (m UTM 10)	Northing (m UTM 10)	Depth (m CGVD2013)
Roberts Bay	471654	5390743	-37
Bazan Bay	471407	5387176	-23

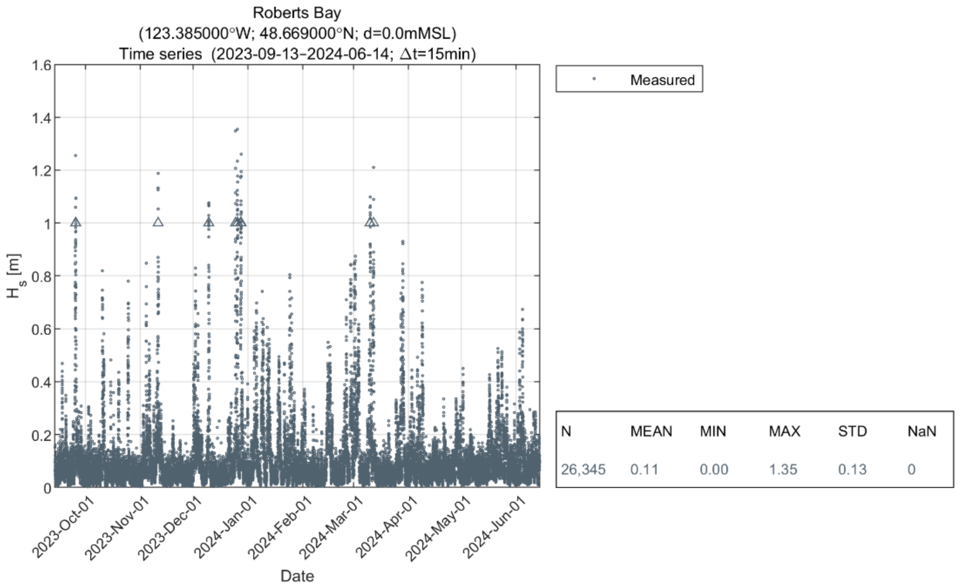
Figure 3-6 Location of the Bazan Bay and Roberts Bay buoys deployed for the purpose of the project



The two buoys were deployed from 2023-09-13 to 2024-06-18, providing nine (9) months of wave measurements informing the wave climate along Sidney's shoreline and covering an entire winter period, during which wave conditions were expected to be more energetic.

Figure 3-7 and **Figure 3-8** present the wave conditions recorded, at Roberts Bay and Bazan Bay respectively, during the measurement period.

Figure 3-7 Timeseries of Significant Wave Height (upper) and Wave rose (lower) of recorded wave conditions at Roberts Bay from 2023-09-14 to 2024-05-31



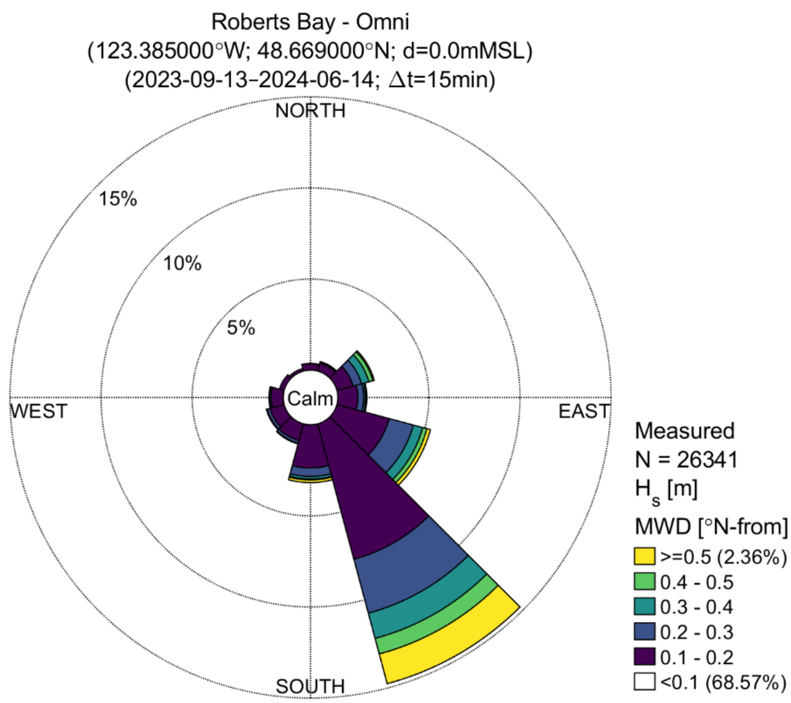
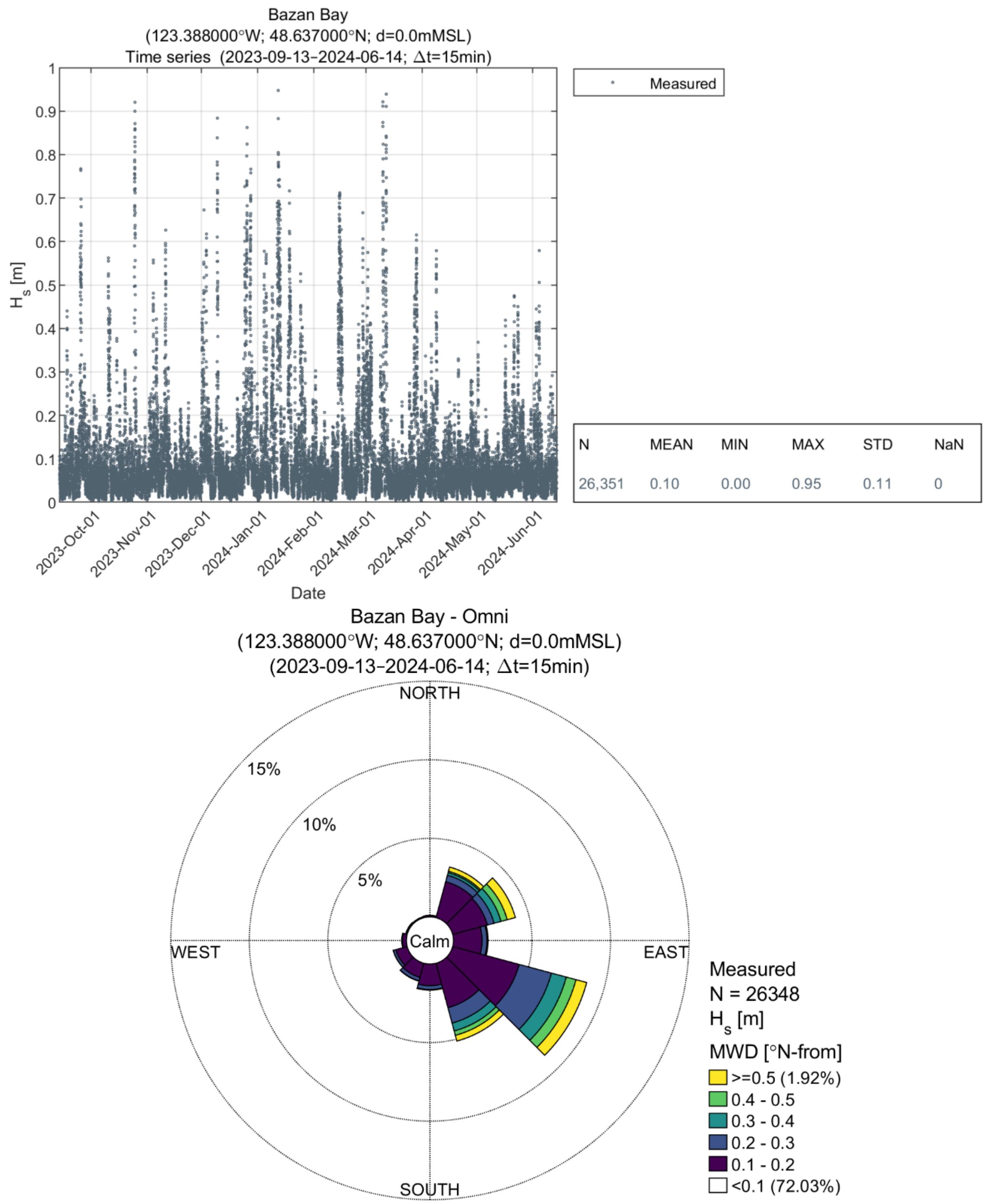


Figure 3-8 Timeseries of Significant Wave Height (upper) and Wave rose (lower) of recorded wave conditions at Bazan Bay from 2023-09-14 to 2024-05-31



As shown in the two figures, wave conditions during the monitoring period were relatively mild. The maximum significant wave heights (H_s) recorded were 1.35 m at Roberts Bay and 0.95 m at Bazan Bay, respectively.
The wave roses indicate that the predominant wave direction at Sidney is from the southeast quadrant, which also corresponds to the most energetic wave events. These waves are primarily generated in Haro Strait, where the longest fetch supports greater wave development. Additionally, Bazan Bay is exposed to a higher proportion of wave energy arriving from the northeast quadrant compared to Roberts Bay. This directional variation is likely influenced by localized factors such as nearshore bathymetry and shoreline orientation.

This dataset constitutes a valuable record for the calibration and validation of the spectral wave model developed for the project and presented in **Section 4**.

4 WAVE MODELLING

A reliable characterization of the nearshore wave climate is essential for identifying and differentiating areas that could be exposed to risks during storm events. Given the complexity of the area, and the availability of the local wave measurements, a dedicated Spectral Wave model was setup for the assessment at Sidney.

To characterize the wave climate, the state-of-the-art numerical model MIKE21 SW model is used to simulate offshore and nearshore wave conditions. MIKE 21 SW includes the following physical phenomena:

- Wave growth by action of wind.
- Non-linear wave-wave interaction.
- Dissipation due to white capping.
- Dissipation due to bottom friction.
- Dissipation due to depth-induced wave breaking.
- Refraction and shoaling due to depth variations.

The model is developed specifically for the Sidney project and focused on accurately resolving local wave conditions along the shoreline of interest. Some areas in the model domain are represented at coarser resolution due to their limited influence on wave dynamics at Sidney, allowing computational resources to be prioritized where they are most impactful to project outcomes.

4.1 Model Domain and Computational Mesh

The model domain encompasses the entire Salish Sea to capture both swell conditions propagating through the Strait of Juan de Fuca and locally generated waves within the Salish Sea itself. The numerical model is built on an unstructured flexible mesh, enabling spatially variable resolution. This approach allows for finer mesh refinement in areas of particular interest (such as nearshore zones and complex coastal geometries) while coarsening the mesh in offshore or less sensitive regions. This strategy improves model accuracy where it is most critical, while maintaining computational efficiency and reducing overall simulation runtimes.

Special attention was given to the accurate representation of the intricate island systems and coastal landforms in the region, as these features significantly influence wave transformation processes. As confirmed by measured data, there are notable directional differences in wave exposure along the northern and southern extents of the study shoreline, underscoring the importance of resolving local geomorphology in the model setup.

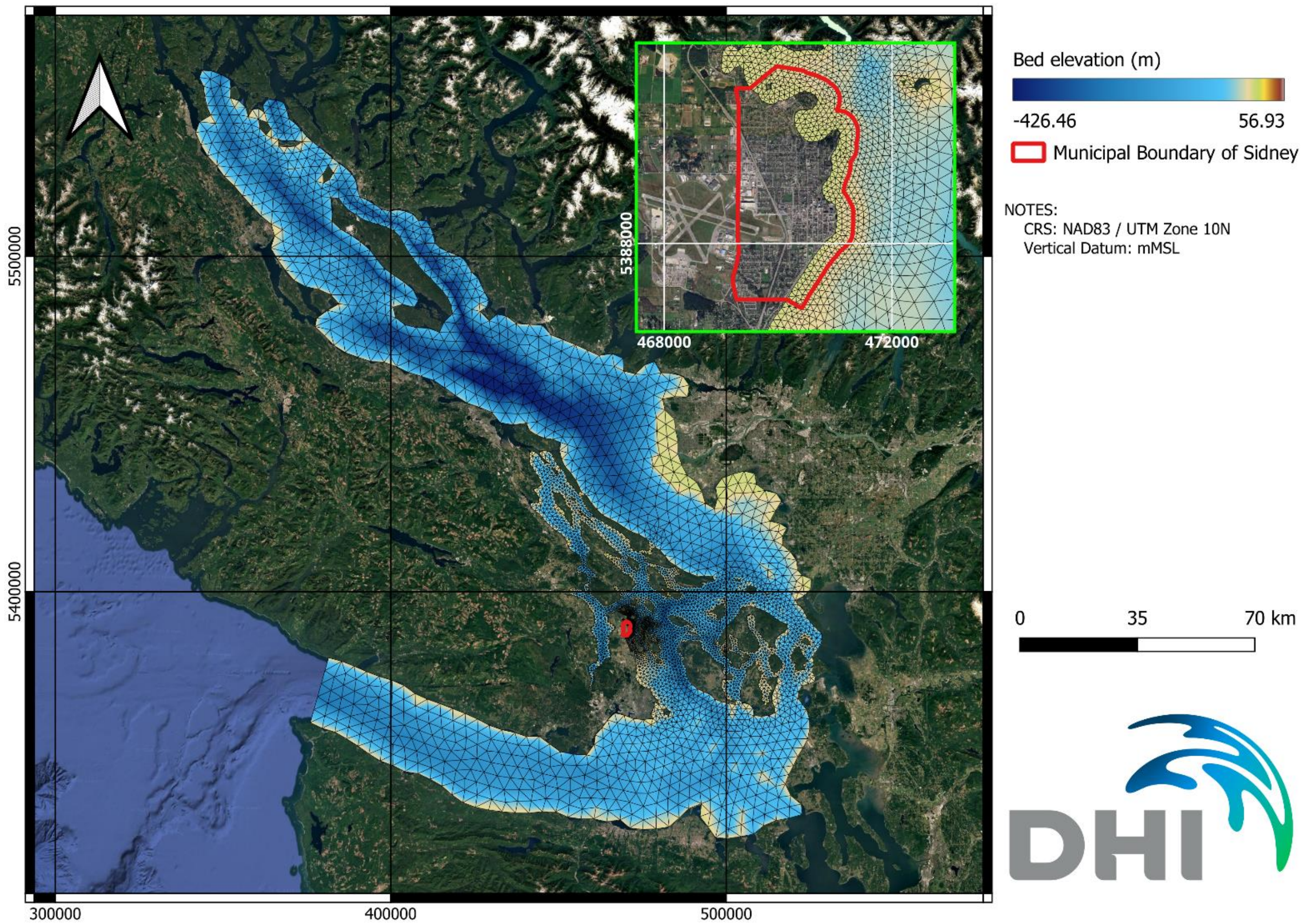
Bathymetric inputs were primarily derived from the Canadian Hydrographic Service Non-Navigational (CHS-NONNA) Data Portal[18]. This high-resolution dataset offers full spatial coverage of the study area and ensures consistent, quality-assured topographic and bathymetric representation throughout the model domain.

As shown in **Figure 4-1**, the final mesh resolution varies from approximately 3 km in the deeper offshore areas to 80 m meters in the nearshore and coastal zones of interest. It is worth noting that the Port Sidney Marina breakwater is not explicitly resolved within the mesh, its presence is accounted for through parameterization within the model setup.

[18] *https://data.chs-shc.ca/login*

This ensures its influence on wave attenuation is appropriately represented without the need for direct geometric inclusion, which would significantly increase mesh complexity and computational cost.

Figure 4-1 Overview of the model extent and computational mesh for the Spectral Wave model. Coordinates are indicated in UTM Zone10 and depth is relative to Mean Sea Level (MSL)



4.2 Model Forcing

Spatially varying atmospheric and oceanographic forcing was developed to drive the spectral wave model. A key challenge in preparing this long-term hindcast was the alignment and completeness of water level and wind data across the full spatial extent of the model domain.

Spatial interpolation was applied to both water level and wind measurements to ensure spatial coverage for the model input. Given the availability and quality of the measurement data, especially for wind observations, the simulation period was set to 1994–2024. While this differs from the 1979–2018 hindcast period used in the 2021 CRD Study, the shorter period is tailored to this project site, making use of spatially varying wind fields and validation against local measurements. This approach leverages site-specific forcing datasets to strengthen the accuracy of the wave hindcast near Sidney and enhance confidence in the run-up and extreme value analyses. While the hindcast period used for extreme wave statistics is shorter than in some broader regional studies, such as the 2021 CRD project, the use of locally targeted datasets offers advantages for this site-specific assessment. **Section 4.3** demonstrates how this calibration approach improves model performance for conditions relevant to Sidney's coastline. The following sections present a detailed overview of the water level and wind measurements used to develop the spatially and temporally-varying forcing datasets applied in the model.

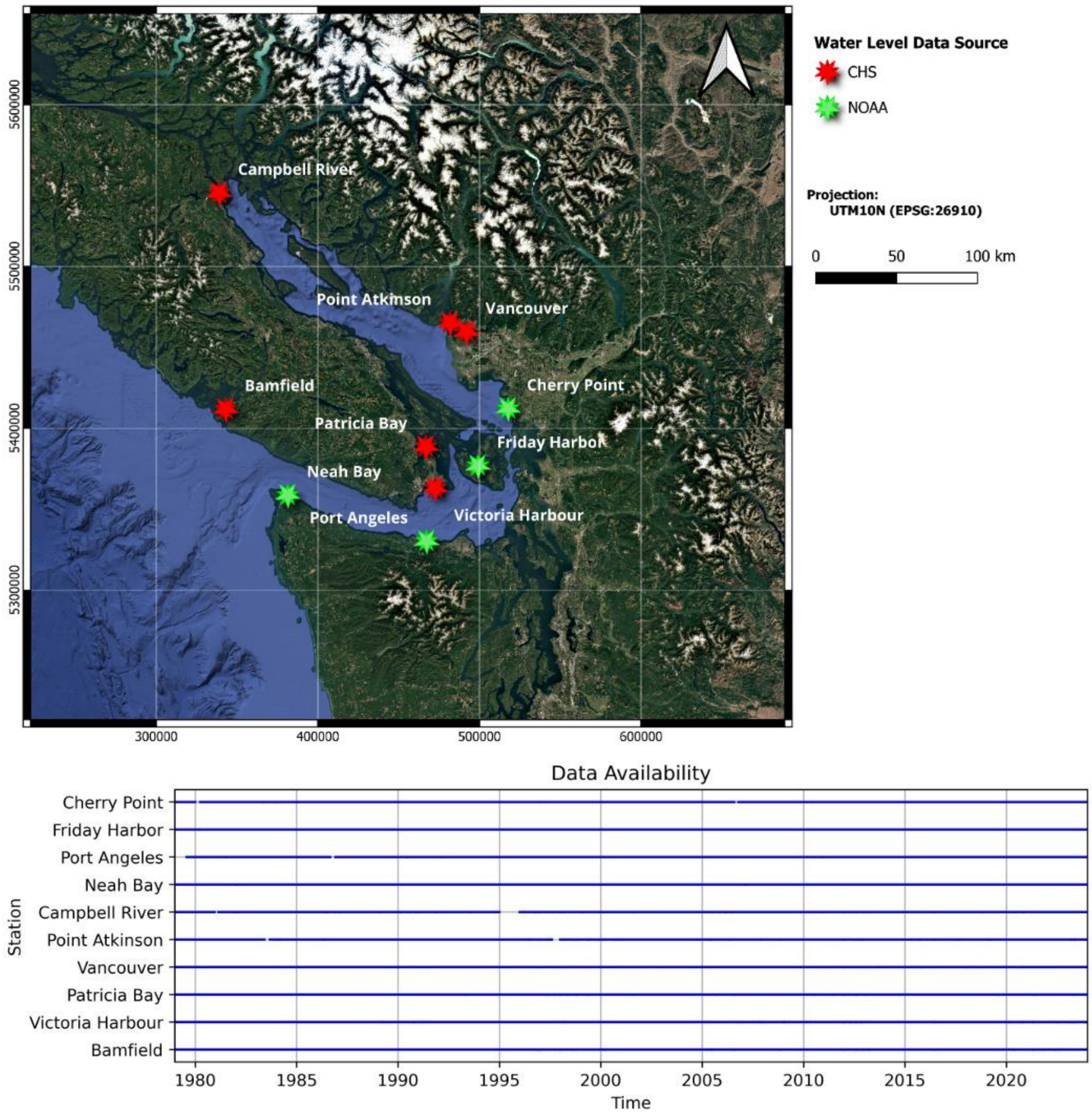
4.2.1 Water Levels

Accurate representation of water level variations is necessary for capturing wave transformations, particularly within shallow and morphologically complex areas of the model domain. To support this, a methodology was developed to spatially interpolate long-term water level observations across the domain, providing two-dimensional total water level variation for input to the spectral wave model. The key advantage of using historical water level measurements lies in their ability to incorporate both tidal fluctuations and storm surge components.

Water level monitoring stations within the model domain, maintained by CHS in Canada and NOAA[19] in the US, were used to generate the 2D time-varying water level surface. The station selection process prioritized spatial coverage across the model domain and sufficient temporal data availability and the stations retained for the interpolation are presented in **Figure 4-2**.

[19] https://www.tidesandcurrents.noaa.gov/

Figure 4-2 Overview of the selected stations used for the preparation of the 2D varying total water levels supporting wave model.



Both Point Atkinson and Vancouver water level records were considered; however, to minimize redundancy during interpolation, priority was given to the Point Atkinson dataset. The Vancouver record was used as a secondary source to infill gaps in the Point Atkinson time series. At Campbell River, the data gaps were filled with tidal signals generated using the Web Tide Tidal Prediction Model[20] from the Bedford Institute of Oceanography.

The 2D interpolation approach employs a weighted method, assigning areas of influence to each station to ensure full domain coverage.

[20] *WebTide Tidal Prediction Model*

Due to its proximity to the project site, the observed water levels at Patricia Bay serve as the primary reference for local water levels within the study area and are the most critical data source for determining hourly water levels along the shoreline of interest.

For the purpose of driving the spectral wave model, a regional network of interpolated water level observations was applied across the broader model domain. It is recognized that this approach does not capture the finer-scale variability that can occur within small coves, inlets, or other highly localized settings within such a large domain. However, at Sidney, this limitation is not significant because the local water levels are effectively governed by the measured record at Patricia Bay, which accurately reflects the conditions influencing the study site.

As a result, the nearshore wave effects at Sidney are reliably represented since they are based on directly measured water levels rather than interpolated estimates. At the same time, the deeper-water waves generated across the regional domain that propagate toward Sidney are also accurately captured, as shallow-water transformations have negligible influence on regional wave setup in this area. Taken together, this means that while the regional water level interpolation does not account for small-scale variability elsewhere, it provides an appropriate and sufficiently accurate representation for the conditions at Sidney.

The outcome of the interpolation is a spatially continuous, 2D total water level variation field that covers the entire model domain for the full duration of the spectral wave hindcast period, spanning from 1994 to 2024, at an hourly timestep.

4.2.2 Wind Forcing

To accurately represent wave dynamics within the model domain, spatially varying wind forcing is required. Wind plays a critical role in wave generation and transformation, and its appropriate representation is important to ensure the accuracy of the simulated wave fields across the study area.

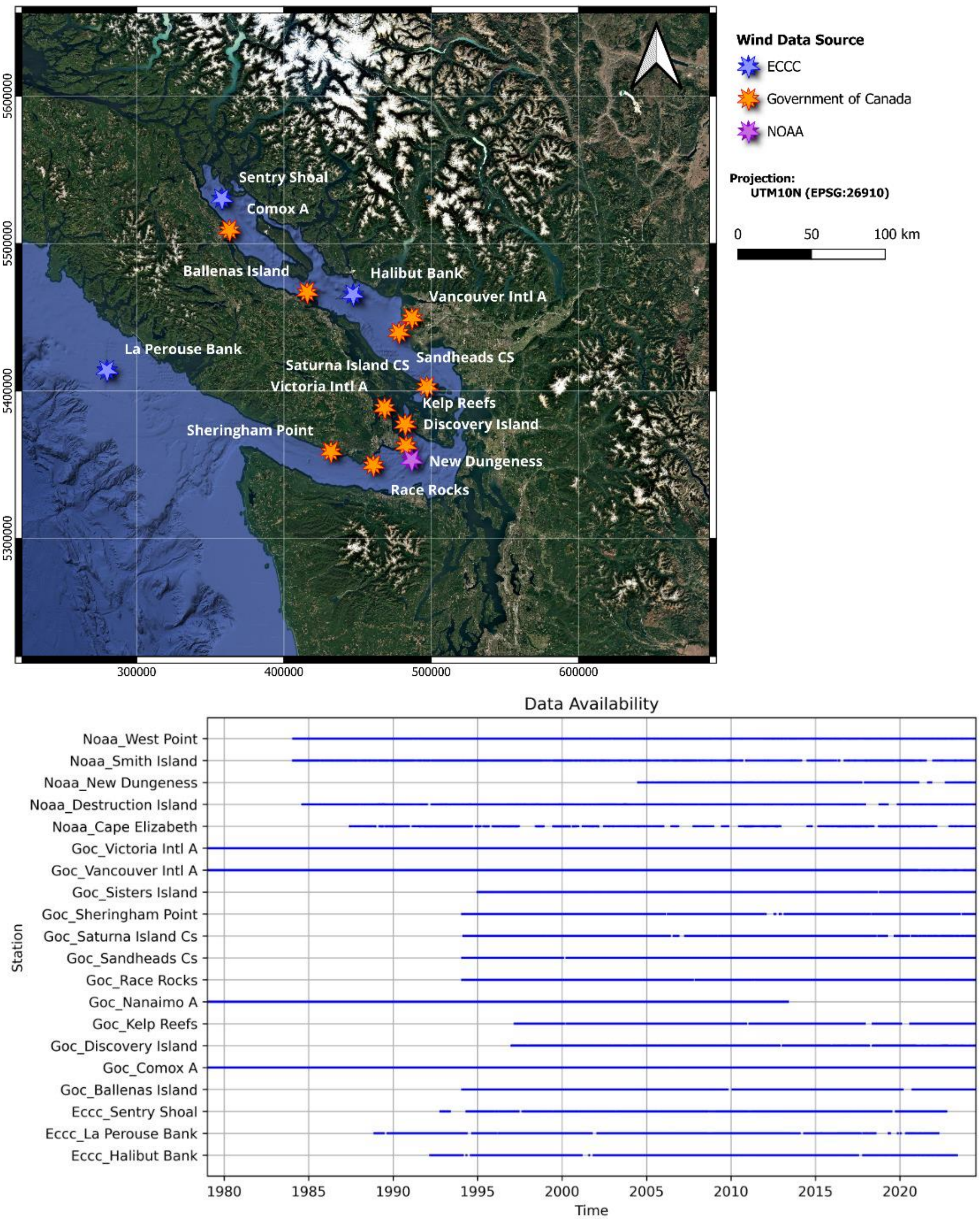
Given the spatial extent of the domain and the complex topography of the Salish Sea, characterized by highly variable and often terrain-driven wind patterns, it was determined that the use of long-term, in-situ, wind measurements from meteorological stations would be more appropriate than relying solely on global or regional hindcast wind products. Hindcast datasets, while useful, may not adequately resolve the localized wind variability induced by the mountainous terrain surrounding the region.

Meteorological stations from Environment and Climate Change Canada (ECCC), CHS and NOAA were utilized and recorded wind data from these stations were downloaded, quality-controlled, and assessed for their suitability in supporting the development of spatially distributed wind forcing for wave modeling.

Figure 4-3 presents a map of the selected wind stations, and their temporal coverage, used for the generation of the spatially varying wind forcing. Due to limited wind data availability prior to 1994, the modelling period was constrained to 1994–2024, which provides a more consistent dataset for hindcast simulation purposes.

Since the primary purpose of the wind field is to drive the spectral wave model, the effects of the interpolation method are directly reflected in the wave model calibration results (see **Section 4.3**). The successful reproduction of observed wave conditions along the Sidney shoreline indicates that the wind fields are sufficiently accurate to drive wave transformation processes and support reliable simulation of wind-driven sea states in the project area.

Figure 4-3 Overview of the selected stations used for the preparation of the 2D varying wind field supporting wave model



A comprehensive review of the wind data available for the 1994-2024 period was conducted, with a focus on data quality, completeness, and spatial applicability. It was observed that many of the datasets include substantial gaps, particularly in the earlier years. To support the generation of a continuous two-dimensional wind field suitable for numerical modelling, data infilling techniques were employed to mitigate the effects of missing data and improve spatial coverage.

The gap filling procedure followed several steps involving:

- Linear interpolation between timesteps for gaps shorter than two hours.
- Gap filling using nearest neighboring stations with data available to fill in the gaps.

These steps were reproduced several times, to build usable timeseries with limited gaps for selected key stations:

- Halibut Bank
- La Perouse Bank
- Sentry Shoal
- Discovery Island
- Race Rocks
- Sand Heads CS
- Saturna Island CS
- Sheringham Point
- Victoria International Airport

Once the preparation of the timeseries was completed for these stations, the 2D interpolation was applied in a similar way to the water level interpolation, i.e. using weighted areas of influence for each station to cover the entire domain and ensure smooth transitions within the generated wind fields.

The outcome of the interpolation is a spatially continuous 2D wind field that covers the entire model domain for the full duration of the spectral wave hindcast period, spanning from 1994 to 2024, at an hourly timestep.

4.2.3 Boundary Conditions

Only one marine boundary in the model domain was applied and was done so at the entrance of the Juan de Fuca Strait. The boundary conditions were extracted from DHI's Global Wave Model. This boundary condition was applied to simulate wave conditions coming into the Juan de Fuca Strait from the Pacific Ocean. Details on the Global Wave Model and the validation report can be found on the metocean-on-demand data portal[21].

4.3 Model Calibration and Validation

The calibration of the numerical model was carried out through an iterative process. This involved the progressive adjustment of key model parameters to enhance agreement between simulated and observed data at selected measurement stations. The final calibrated model results are presented in the following section.

[21] https://www.metocean-on-demand.com/metadata/waterdata-dataset-Global_SW_ERA5_v2

4.3.1 Offshore Results

Given the significance of South-Easterly wave conditions observed at Sidney, the NOAA wave buoy at New Dungeness (46088) was selected as a key calibration station. This site offers a long-term and reliable wave record, making it suitable for calibrating the model over an extended period.

Table 4-1 Location and temporal coverage of the New Dungeness (46088) wave buoy.

Wave Buoy Location	Easting (m UTM 10)	Northing (m UTM 10)	Available period
New Dungeness (46088)	486933	5353217	2004-Present

Figure 4-4 presents comparison of measured and modelled significant wave height at New Dungeness (46088) for the period 2004-2024, in the form of wave rose, timeseries comparison and scatter plots. The timeseries comparison and scatter plots highlight a strong correlation between the measured and modelled significant wave height, with a model BIAS of +0.09 m and a RMSE of 0.28 m. The model accurately replicates storm events captured by the buoy, with a slight tendency to overestimate peak wave heights.

Figure 4-5 presents the final calibration results for the mean wave period, indicating a model BIAS of -0.07 s and a RMSE of 0.98 s.

The wave rose plots indicate that the model demonstrates strong performance in replicating the dominant wave directions observed at the buoy location. It accurately captures both the longer-period waves entering from the Pacific Ocean via the Juan de Fuca Strait and the shorter-period, wind-driven waves generated locally from the southeast. The latter's directional component is especially relevant for this study, as south-easterly waves have been observed at the Sidney shoreline in wave records from Roberts Bay and Bazan Bay.

Overall, model performance at New Dungeness (46088) is robust, with good agreement between simulated and observed significant wave heights and mean wave directions. The model successfully simulates wave energy contributions from both the western and south-eastern sectors, providing a reliable characterization of offshore wave conditions. These outputs form a solid basis for subsequent near-shore wave transformation toward the Sidney shoreline.

Figure 4-4 Comparison between measured and simulated significant wave height at New Dungeness (46088) for the period 2004-2024 (included), in the form of Hs/MWD wave rose (top), timeseries (middle) and scatter plot (bottom). Minimum wave cut-off for the comparison: 0.25 m

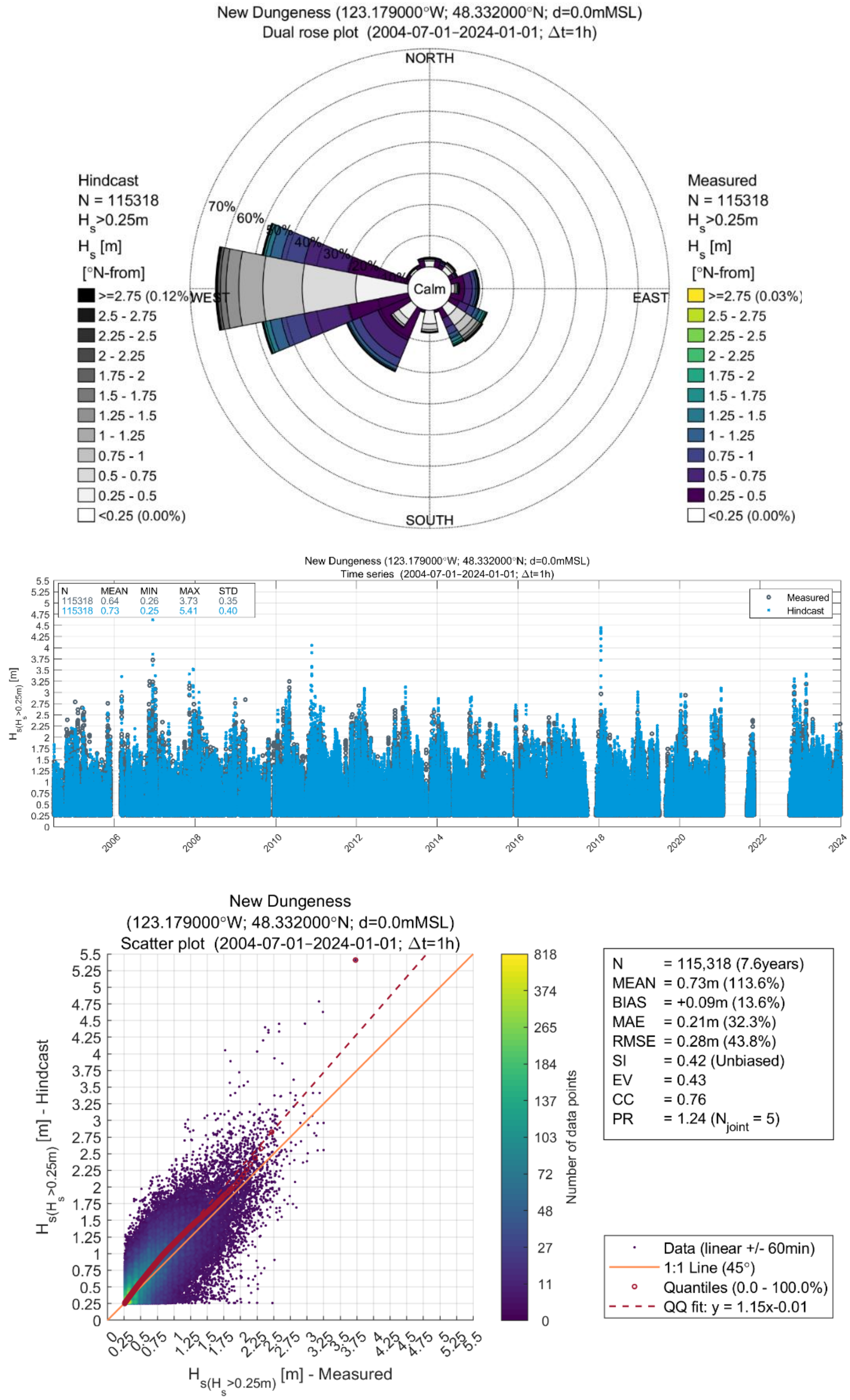
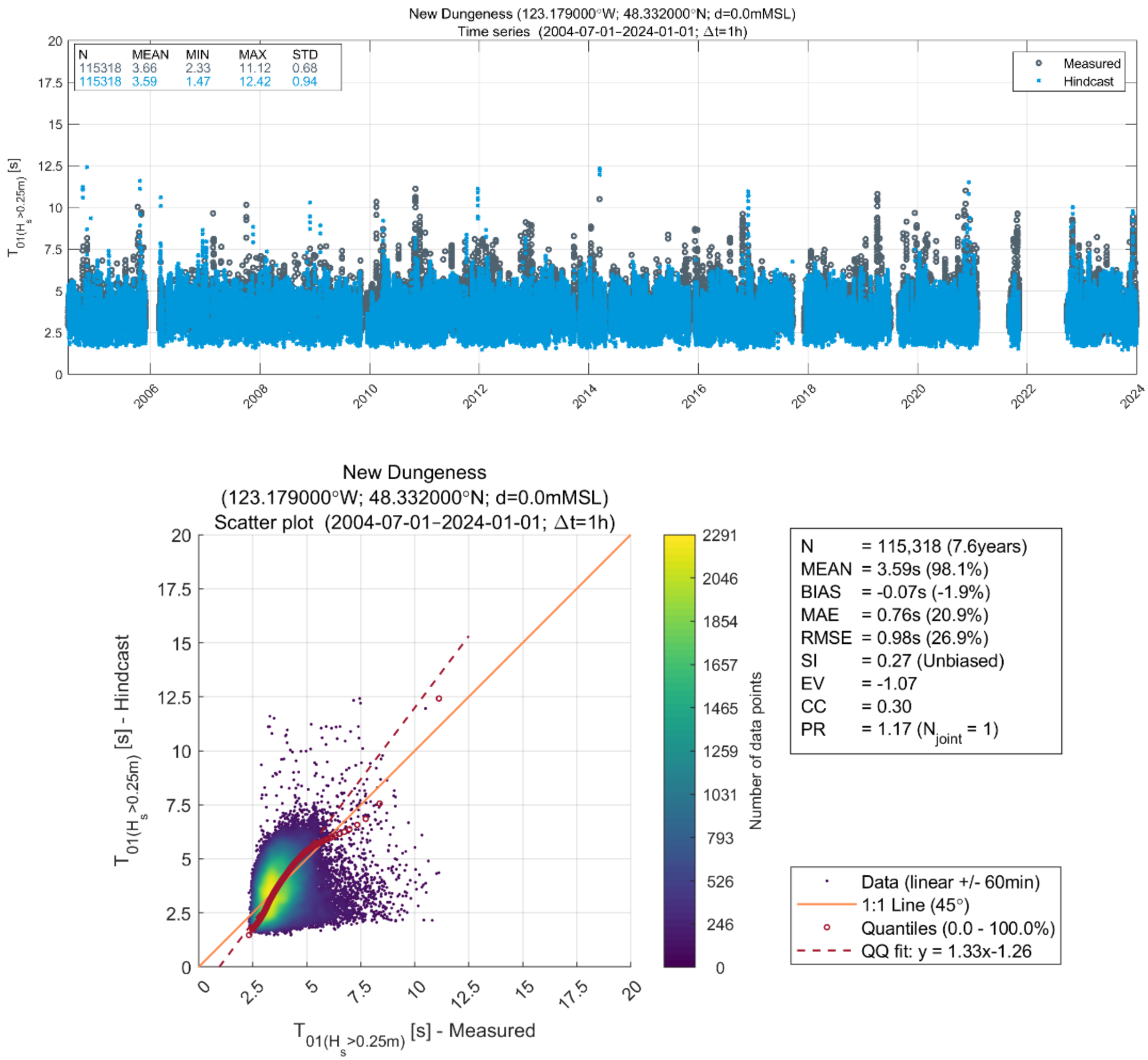


Figure 4-5 Comparison between measured and simulated mean wave period at New Dungeness (46088) for the period 2004-2024 (included), in the form of T01/MWD wave rose (top), timeseries (middle) and scatter plot (bottom). Minimum wave cut-off for the comparison: 0.25 m



4.3.2 Nearshore Results

To assess the performance of the model in nearshore areas, the model results were compared to the measurements recorded by the two wave buoys at Roberts Bay and Bazan Bay. **Figure 4-6** and **Figure 4-7** present an overview of the model performance at Roberts Bay, in the form of wave rose, timeseries and scatter plot for significant wave height and peak wave period, respectively.

Overall, the comparison between measured and simulated wave parameters shows a good agreement, with a mean BIAS of +0.01 m and a RMSE of 0.13 m for significant wave height and a BIAS of -0.11 s and RMSE of 1.27s for the peak wave period.

The directional wave distribution is well-reproduced, with the dominant south-easterly wave components accurately captured. The model shows a tendency to overrepresent wave conditions from the east and slightly underrepresent contributions from the south. This bias in the model results is conservative for future calculations of wave runup, considering the shoreline orientation in Sidney, which faces east. In this context, waves approaching from the south are typically aligned with the shoreline and are anticipated to be less critical for the determination of the FCL.

Figure 4-6 Comparison between measured and simulated significant wave height at Roberts Bay for the available period of measurements. Minimum wave cut-off for the comparison: 0.10 m.

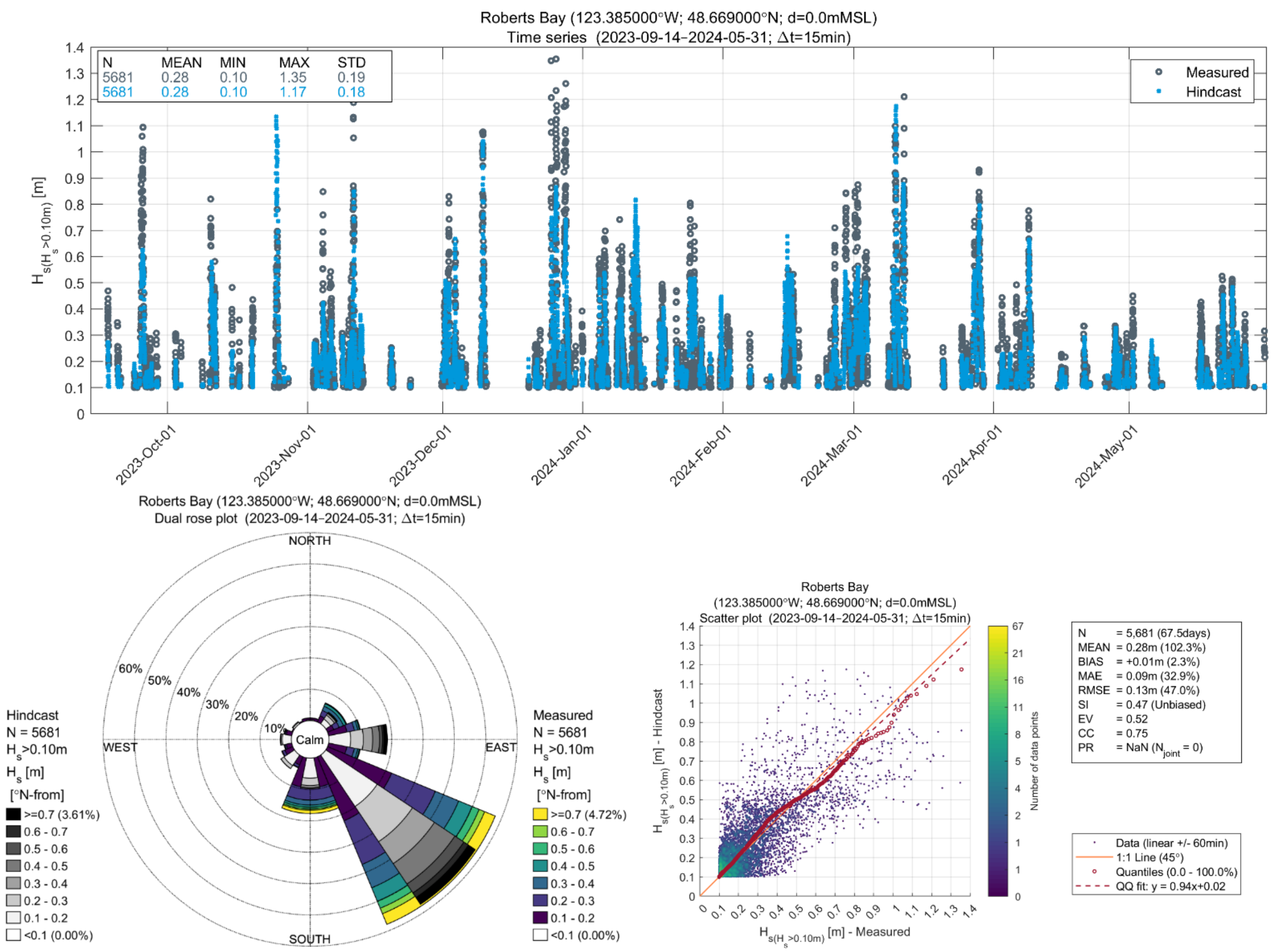
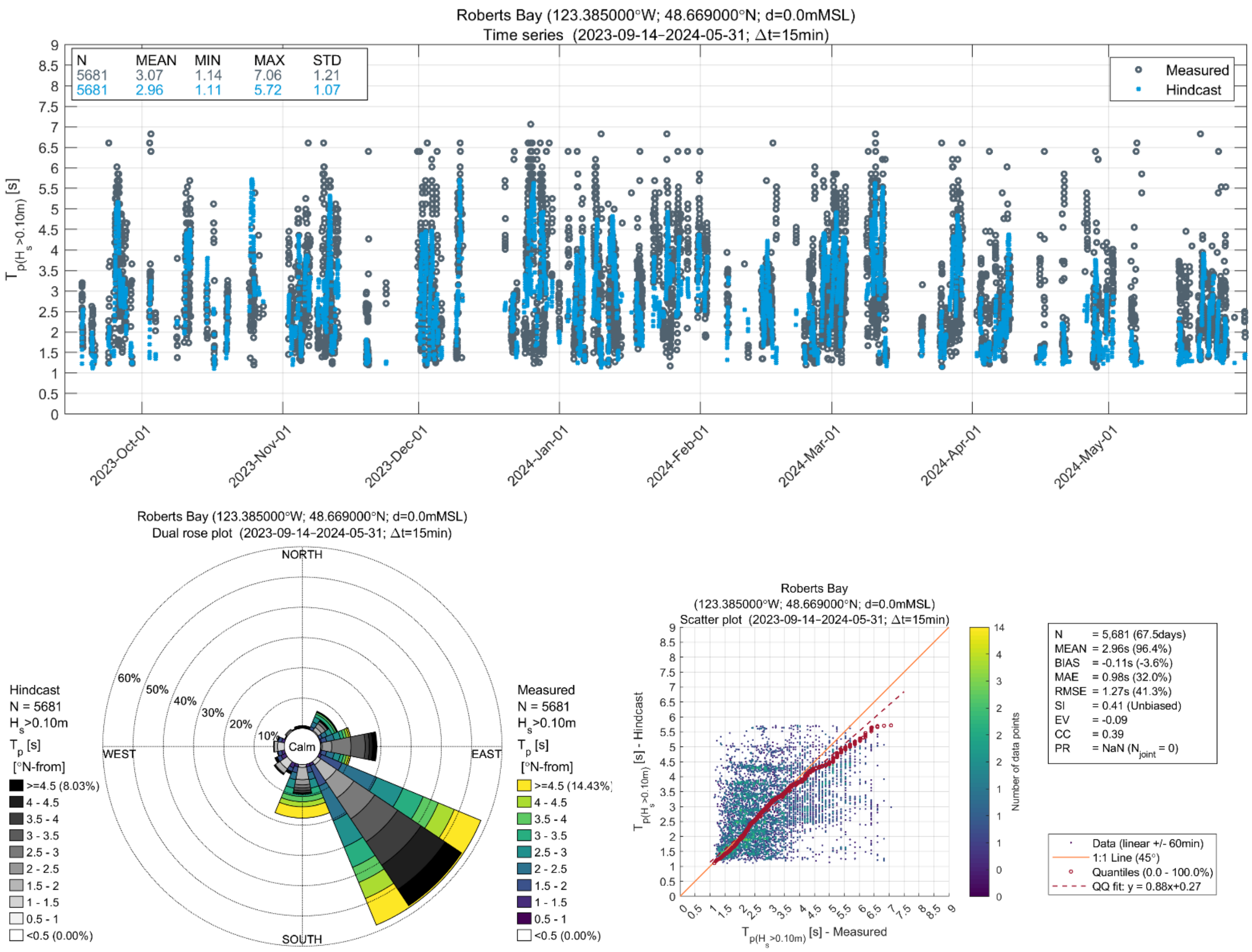


Figure 4-7 Comparison between measured and simulated peak wave period at Roberts Bay for the available period of measurements. Minimum wave cut-off for the comparison: 0.10 m.



Similar comparisons are presented to validate the model results at Bazan Bay in **Figure 4-8** for significant wave height and **Figure 4-9** for Peak Wave Period.

The assessment at Bazan Bay yields model performance metrics consistent with those obtained at Roberts Bay. The simulated significant wave height exhibits a BIAS of −0.02 m and an RMSE of 0.09 m, while the peak wave period shows a BIAS of −0.03 s and an RMSE of 1.18 s.

Furthermore, the model successfully captures the larger proportion of north-easterly waves observed at Bazan Bay, demonstrating its ability to reproduce the directional variability of incident waves along Sidney's shoreline at the evaluated two locations.

Figure 4-8 Comparison between measured and simulated significant wave height at Bazan Bay for the available period of measurements. Minimum wave cut-off for the comparison: 0.10 m.

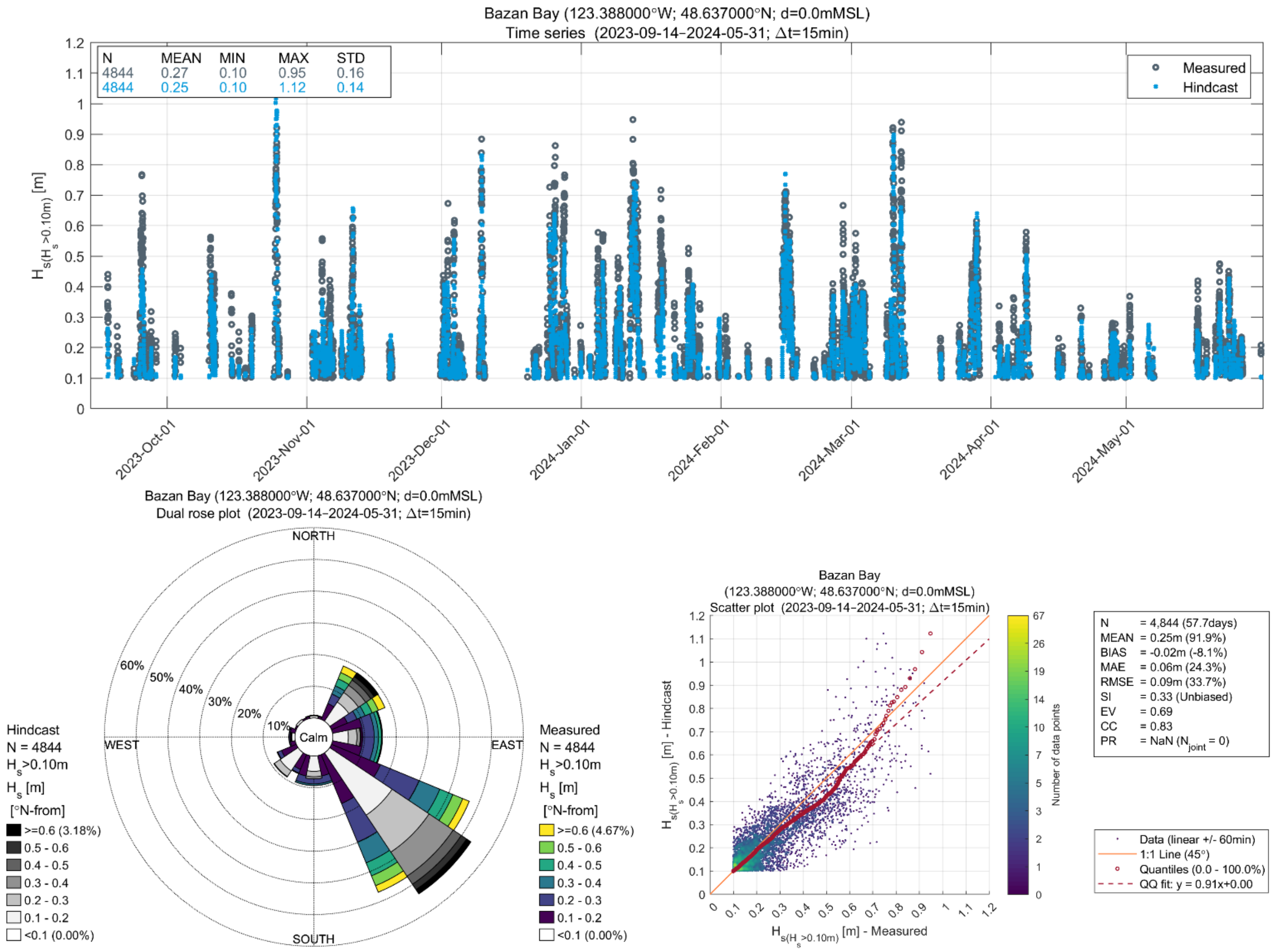
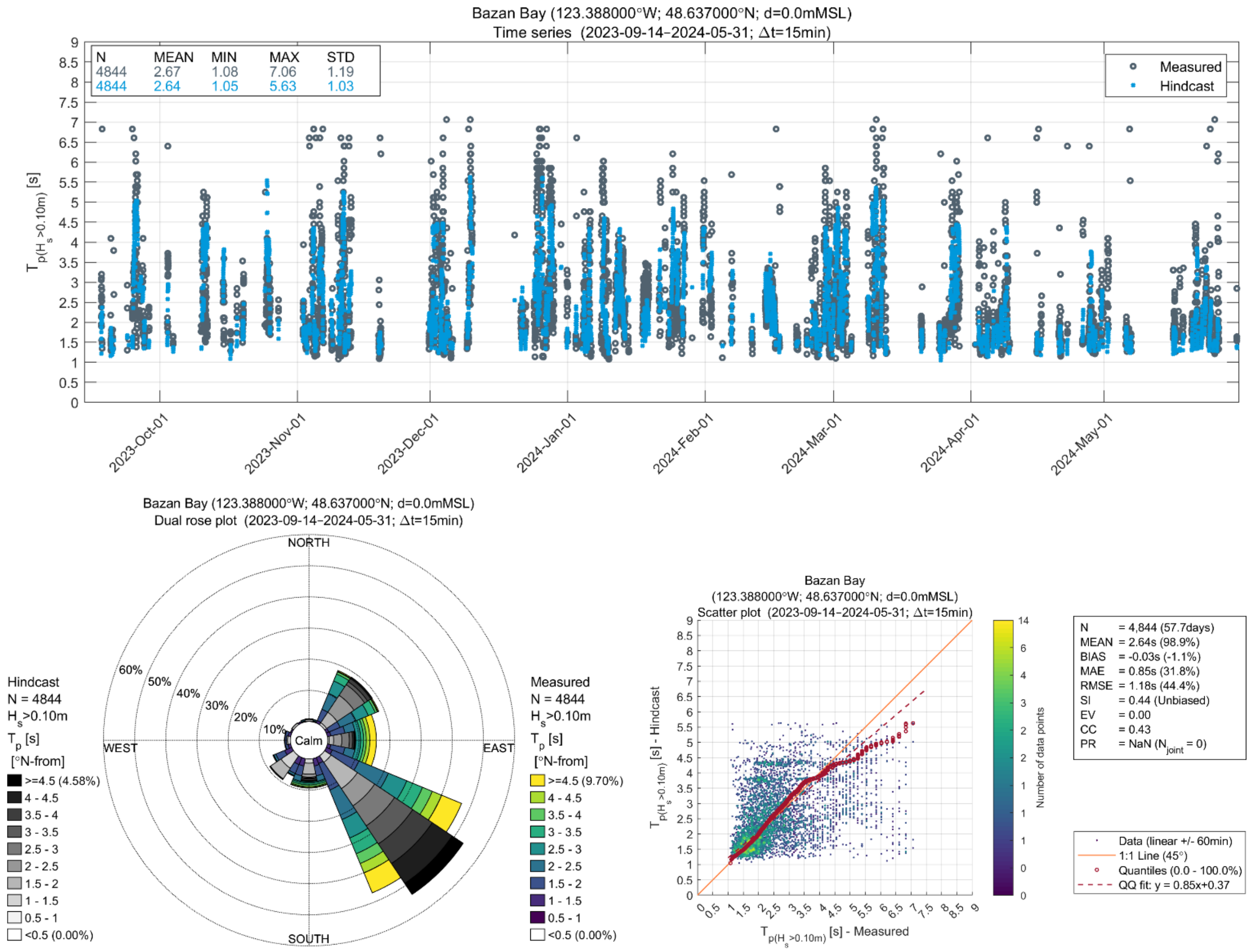


Figure 4-9 **Comparison between measured and simulated peak wave period at Bazan Bay for the available period of measurements. Minimum wave cut-off for the comparison: 0.10 m.**



4.3.3 Calibration Summary

The spectral wave model developed for this project demonstrates strong performance in reproducing wave conditions locally along the shoreline of Sidney, as validated against measurements from the temporary Roberts Bay and Bazan Bay wave buoys. The offshore validation, supported by a longer observational record, further reinforces confidence in the model's reliability. Overall, the model accurately represents wave conditions and effectively captures key wave characteristics, including directionality and peak wave period.

Following the calibration of the model, the production runs covering the 1994-2024 period were completed. The output of this model provides hourly wave parameters within the entire model domain and yields a good foundation to support the transect analysis presented in **Section 5**.

5 TRANSECT ANALYSIS

5.1 Approach

5.1.1 Reaches and Transects Delineation

The delineation of shoreline reaches and the placement of transects within each reach to assess wave run-up requires a detailed interpretation of the Sidney shoreline and its exposure to wave and water level hazards.

As previously described, water levels and wave conditions exhibit spatial variability along the Sidney shoreline. The delineation of coastal reaches and corresponding transects was strategically developed to capture this variability and to ensure accurate representation of site-specific forcing conditions for localized wave runup computations.

The Sidney shoreline was discretized into 29 reaches, as depicted in **Figure 5-1**, using visual evidence collected from the site visit (**Section 2**), combined with interpretation of the available DTM and bathymetry, shoreline classification, and prevailing wave conditions. The extent and position of each reach was determined using the following key considerations:

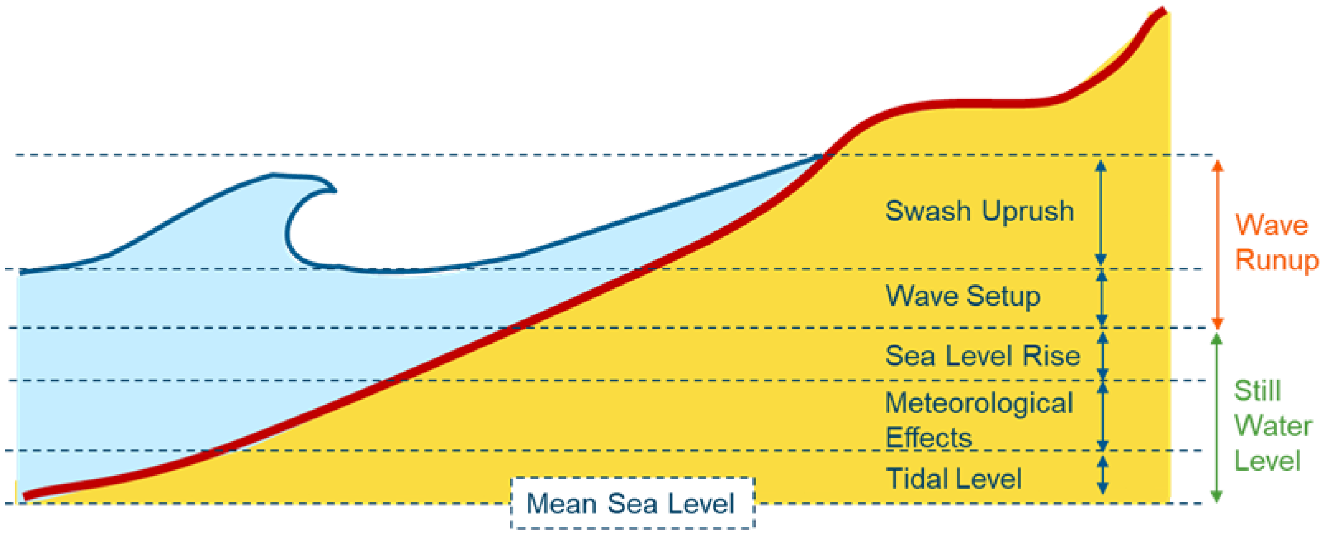
- The shoreline type and composition.
- Wave exposure and open fetch along the reach extent.
- Topographic and bathymetric features.
- Ability to extract a profile for the wave run-up assessment within the reach which is representative of that reach.
- Presence of critical municipal assets or infrastructure within the reach.
- Vulnerability of private properties and residences within the reach.

Figure 5-1 Overview of the transects and reaches discretizing the Sidney shoreline for the wave run-up assessment

5.1.2 Wave Run-up Characterization

Wave induced runup corresponds to the maximum onshore elevation generated by the waves, relative to the total "still" water level (tide, surge, wind setup, sea level rise, etc.; i.e. 'blue-water' flood level). It includes both the wave set-up[22] and the swash uprush[23]. **Figure 5-2** outlines the components of wave runup and other relevant water levels that contribute to wave runup, which were considered as part of this study.

Figure 5-2 Schematic Figure of Wave Runup



Runup is a complex phenomenon that depends on the incident wave characteristics and its transformation to the nearshore, the local water depths, the bathymetric profile, and the characteristics of coastal structures, if present. The most used parameters to describe wave runup are R_{mean}, R_{max}, and $R_{2\%}$, where:

- R_{mean} is the mean runup elevation. It is calculated by averaging all individual runup events.
- R_{max} is the largest elevation obtained by a single runup event.
- $R_{2\%}$ is a statistical measure of the elevation that is exceeded by only 2% of the incoming waves.

The 2% wave runup ($R_{2\%}$) will be used in this investigation, as it has historically been considered the most suitable parameter for describing the whole runup series and is the most commonly applied metric for describing wave runup. Additionally, $R_{2\%}$ is cited for use in the existing 'Provincial Guidelines'. The $R_{2\%}$ parameter has an origin from experiments in physical models conducted in the Netherlands (see EurOtop 2018, section 5.2.1), with the idea that if only 2% of the wave runup reached the crest of coastal defenses, such as dikes or embankments, this defense would need minimal protection measures (EurOtop 2018, section 5.2.2). The value of $R_{2\%}$ has widely been adopted as the wave runup parameter to be used for flood hazard studies covering not only coastal structures but also natural beaches, shoreline, and municipal infrastructure.

[22] *Elevation of the mean water level at the shoreline due to wave breaking in the surf zone.*
[23] *Up and down propagation of bores formed after the collapse of waves on the beach. Swash is the decelerating uprush phase and backwash is the accelerating down-rush phase.*

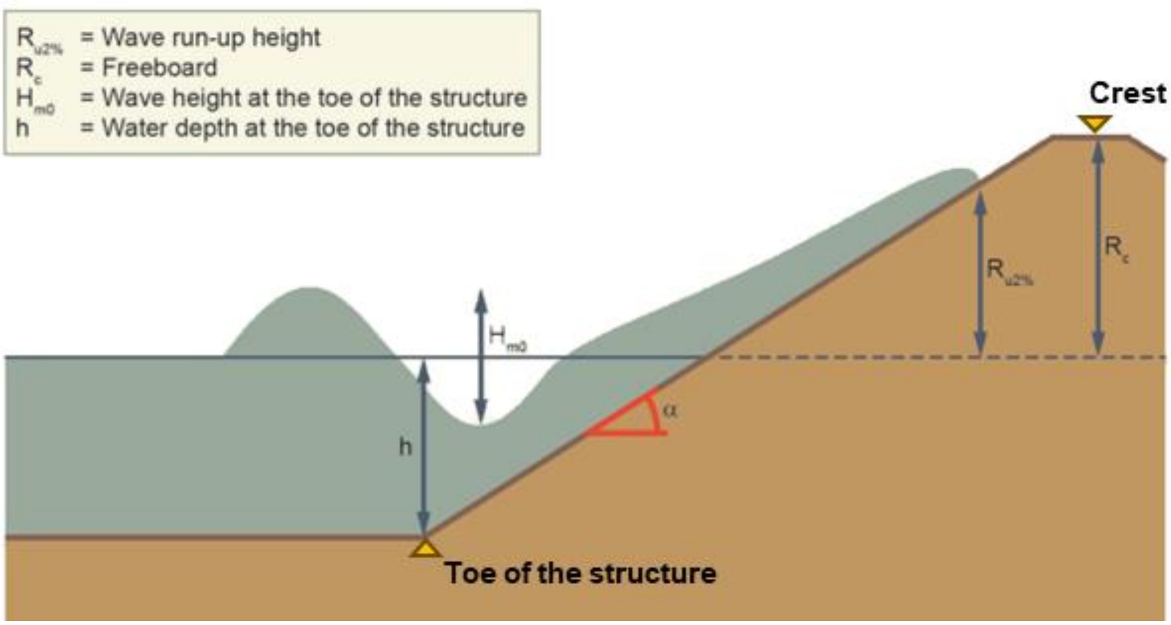
5.1.3 Calculation Methodology

EurOtop (2018) provides guidance on analysis and/or prediction of wave runup and overtopping for flood defenses subject to wave action. It is regarded as an industry standard when performing assessments for coastal structures and some natural coastal features. Moreover, in 2023 EurOtop (2018) became an accepted methodology within the FEMA Coastal Flood Hazard Guidelines (FEMA, 2023).

The manual includes a series of workflows specifically tailored for different coastal structures and shoreline types subject to a variety of wave characteristics. Each workflow provides a series of empirical formulae, which are based on measurements conducted in wave flumes, where structures and bathymetry are idealized and modelled at scale. The application of these empirical formulations to real-world cases requires extensive analysis and schematization of site-specific profiles in addition to careful consideration of the local wave conditions.

A key concept used in the EurOtop (2018) methodology is the idea of the “toe of the structure”, which corresponds to the location of the separation between the gently sloping sea bottom and the coastal structure or feature (see **Figure 5-3**).

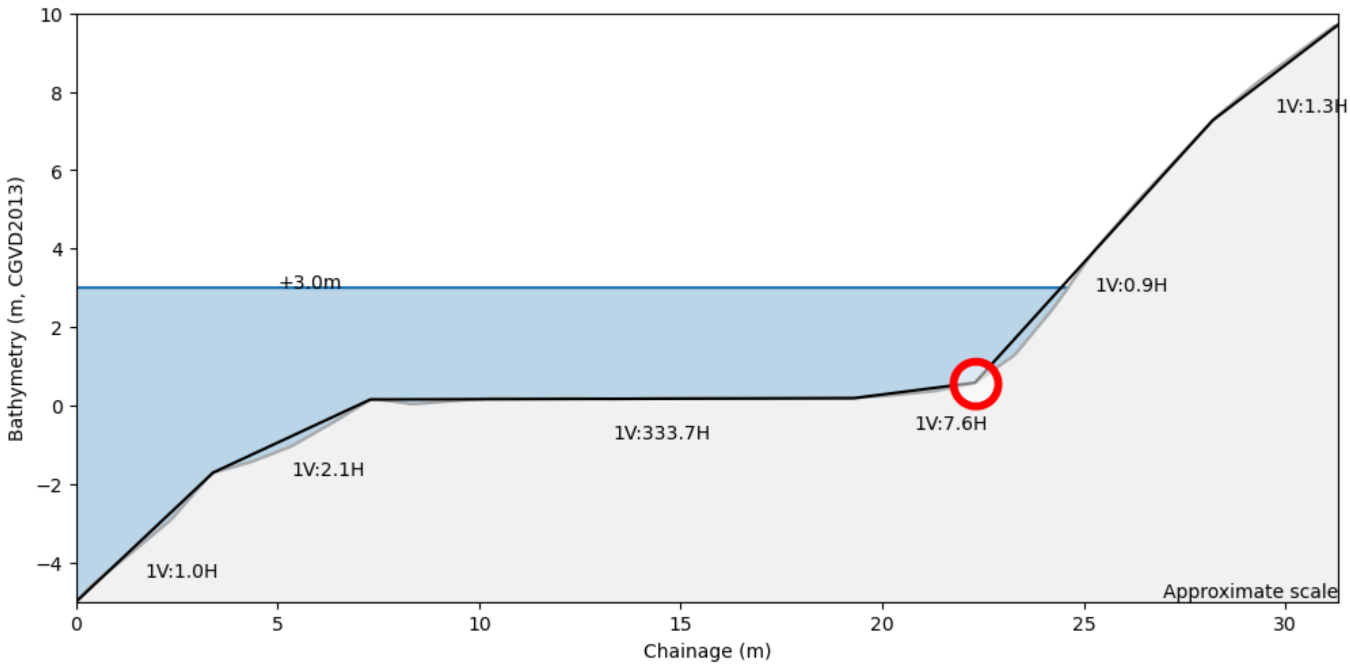
Figure 5-3 Schematic Profile Outlining Key EurOtop Features (Modified from EurOtop, 2018)



EurOtop (2018) requires wave conditions to be determined at the toe of the structure, prior to their use of the formulae for runup. Other relevant concepts include the crest level, which could be represented by the crest of a coastal structure or a location at a natural crest along the shoreline profile, and the profile slope. As the empirical formulae in EurOtop (2018) are developed from measurements conducted in wave flumes, the bathymetric profiles used to derive the formulae are generally idealized with simple slopes and are limited in their capabilities of representing complex geometries.

For each individual transect and to support the calculation of the wave runup, the complex geometry of the slope was simplified into a series of straight lines as demonstrated in **Figure 5-4**. The toe of the structure was carefully defined for each profile by identifying points where sudden changes from very gentle (usually less than 1:10) to steeper slopes are observed (see for example the circled point in red in **Figure 5-4**).

Figure 5-4 Example Profile Simplification



5.2 Wave Runup Computation

5.2.1 Wave Conditions

The 29 shoreline reaches were individually evaluated through a detailed analysis, utilizing the spectral wave model results along the Sidney coastline over the 1994–2024 period (as described in **Section 4**). For each transect, wave parameters were extracted from the spectral wave model hindcast and processed through the following workflow:

- Transects were extended seaward to the second or third row of computational mesh elements to ensure optimal utilization of the spectral wave (SW) model outputs and minimize nearshore interpolation uncertainties.
- Key wave parameters required for EurOtop assessments were extracted at 29 designated offshore points along each transect. These included significant wave height (H_s), mean wave period ($T_{m-1,0}$), and mean wave direction (MWD).
- Extraction points were screened to confirm the absence of wave breaking at the extraction point.
- Wave transformation from the offshore extraction points to the toe of the coastal structure was carried out using the Goda's method. To ensure physical validity and alignment with expected nearshore wave behavior, the resulting wave heights were benchmarked against theoretical depth-limited wave height constraints.

The output of this workflow is a long-term timeseries of wave conditions at the toe of the coastal structure for each transect. These time series were then analysed to identify the 0.5% AEP wave condition, subsequently informing the wave run-up assessment.

As presented in **Section 4**, wave energy incident along the Sidney coastline is predominantly associated with two principal directional sectors: North-East (NE) and South-East (SE). Given that both wave approach directions have the potential to induce significant wave runup along different reaches of the coastline, a structured methodology was adopted to assess the effect of these dominant wave conditions. The following steps were implemented to ensure both directional sectors were considered in the analysis:

- Two primary wave direction sectors were considered in the Extreme Value Analysis (EVA), corresponding to the dominant incident wave directions: [0°N–90°N] and [90°N–180°N]. In each quadrant, a storm selection process was carried out, identifying 60 significant storm events (in average two events per year) based on the timeseries of wave conditions at the toe of the coastal structure.
- An EVA was performed for each quadrant to estimate the significant wave height associated with the 0.5% AEP. For subsequent wave runup calculations, the representative mean wave direction was selected by evaluating the range (max/min) of MWD values from the storm list and comparing them against the orientation of the coastal transect. The wave approach angle exhibiting the closest alignment with the transect orientation was selected as the critical direction for each sector.

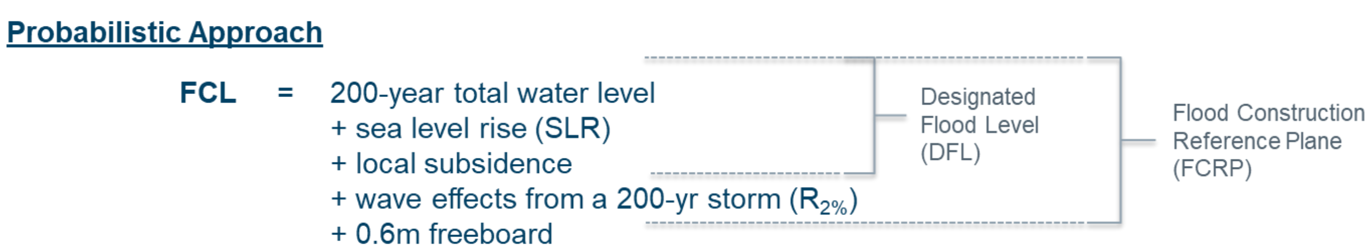
This methodology defined a representative 0.5% AEP extreme wave condition for each directional quadrant. Wave runup computations were then carried out for these two conditions, using the 0.5% AEP water level, and the most critical condition in terms of $R_{2\%}$ value was reported.

The resulting waves used for the wave runup calculations are summarised in **Appendix A**.

5.2.2 Wave Runup and Flood Construction Levels

In British Columbia, the Provincial Guidelines exist to offer practitioners guidance on establishing the DFL and FCL for coastal regions of British Columbia. The probabilistic approach adopted in this study is shown in **Figure 5-5**.

Figure 5-5 Probabilistic Approach to define the FCL, DFL and FCRP including key components of each



Definitions for the DFL, FCRP and FCL are given in **Section 1.** For each of the 29 reaches defined along the shoreline of Sidney, a FCL is defined for the 0 m (current conditions), the 0.5 m and 1.0 m RSLR scenario, referenced to CGVD2013. For each transect, the DFL, FCRP, and FCL, as well as the individual components used in their calculation, are presented in **Appendix B**.

6 FLOOD MAPPING

To consolidate the analysis presented in **Sections 3 to 5**, multiple sets of flood maps were developed for the Town. These maps are intended to support the Town's planning and development processes in the coming years. The co-existence of both 'existing' and 'upcoming' Provincial Guidelines complicated the production of the eventual map sets (given in **Appendix C**). The project team have endeavoured to produce deliverables in keeping with the spirit of both Guidelines publications.

The following sections detail the methods used to derive the flood maps applicable to this project.

6.1 Flood Construction Level Mapping Methodology

Coastal flood construction level (FCL) mapping delineates areas that are vulnerable to coastal flooding and provides pertinent information intended to be used for shoreline and coastal community planning. FCLs represent the design flood elevation, including freeboard. As per Provincial Guidelines, a FCL informs the underside elevation of a wooden floor system, or the top elevation of a concrete slab, for habitable buildings.

As previously described in this report, coastal flood hazard is comprised of both 'blue-water' flooding and 'white-water flooding.'

'Blue-water' flooding is analogous to the Designated Flood Level (DFL). This is the extreme baseline water level used for floodplain mapping near your shoreline of interest. This baseline water level will increase due to sea level rise. This can be plotted on maps as a contour line, as the ocean is anticipated to inundate to this elevation, during the design event (i.e. 0.5% AEP). The 'upcoming' Provincial Guidelines swap the Designated Flood Level term for the Design Flood Level; but are essentially describing the same phenomenon.

'White-water' flooding must also be accounted for in FCL mapping. As previously described, this is accounting for wave effects. Wave effects vary spatially from transect to transect, reach to reach. Very steep natural shorelines or manmade structures can result in considerable wave runup, thereby yielding an exceptionally large FCL elevation. Conversely, a gently-sloping beach can result in a smaller wave runup contribution, thereby yielding a lower FCL elevation.

6.1.1 Wave Effects Zone

The 'upcoming' Provincial Guidelines require that coastal FCL mapping delineate a Wave Effects Zone. This is the area where wave effects lead to higher flood levels, increased erosion risk or physical impacts, compared to areas further inland. The zone is typically a narrow section along the shoreline, extending inland. The extent of the zone is governed by factors such as foreshore slope, vegetation, geometry, roughness, and the energy of the incoming waves. The analyses presented in **Section 5** estimated the increase in vertical elevation as a result of wave runup; however, it did not estimate the horizontal/plan distance that wave effects would extend inland.

In the absence of additional calculations, the 'upcoming' Provincial Guidelines state that the Wave Runup Zone[24] should extend at least 30m inland from where the DFL intersects the shoreline (**Figure 6-1**)[25]; unless the shoreline elevation exceeds the FCL value (**Figure 6-2**).

Figure 6-1 Excerpt from 'Upcoming' Provincial Guidelines, showing wave runup zone extending 30 m inland

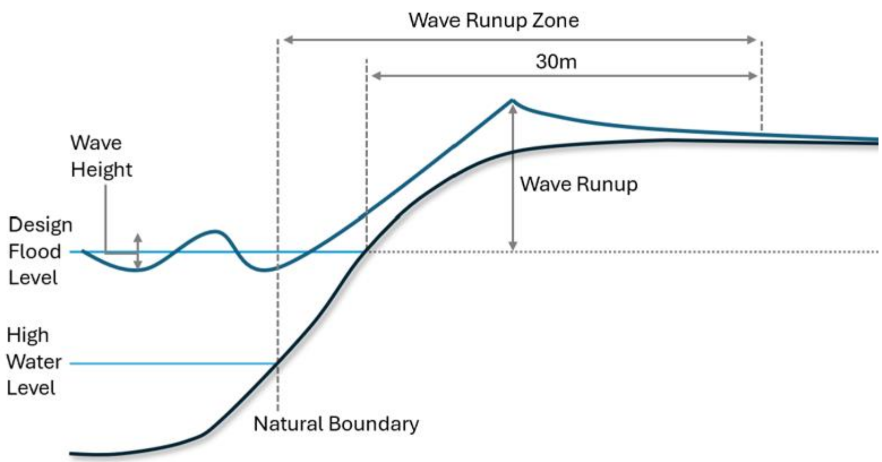
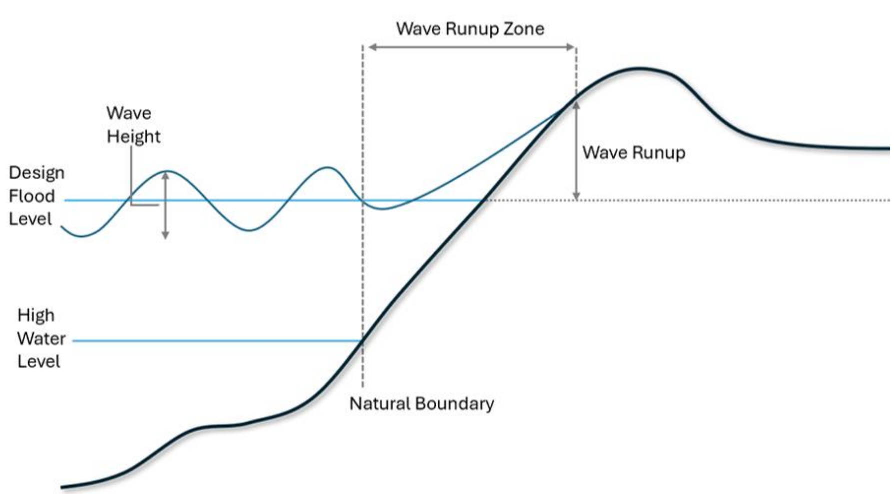


Figure 6-2 Excerpt from 'Upcoming' Provincial Guidelines, showing wave runup zone limited by shoreline elevation



In summary, the Wave Effects Zone is the strip of land in which wave effects would apply. Landward of the Wave Runup Zone, FCLs could be relaxed to DFL plus freeboard; as has been done in this study.

[24] *Please note that our team have seen Wave Effects Zone and Wave Runup Zone used in different iterations of upcoming Guidelines. It is our understanding that these terms are being used to describe the same criterion.*
[25] *FHIMP in BC – Technical Approach and Requirements. Fraser Basin Council. 2025.*

It is important to note that the delineation of the Wave Effects Zone in this project is based on municipal-scale modeling and policy guidance. While this provides a robust and defensible basis for planning, more detailed site-specific analyses—such as high-resolution 3D or CFD numerical wave run-up modeling or physical model testing—could refine the estimate of the landward extent of the Wave Effects Zone. Such work would provide communities with greater confidence in localized FCLs and may help optimize floodplain management decisions. However, undertaking these more advanced analyses was outside the scope of the present study.

6.1.2 FCL Map Interpretation

Following on from the information presented in the preceding sub-section, this study has produced FCL mapping with two distinct FCL values on each map:

- **Foreshore FCL**: FCL values are derived using the Probabilistic Approach, as defined in **Section 5.2.2.**, and are applicable to their specific Wave Effect Zone. Wave Effect Zones are delineated on each map; based on a 30m buffer inland from where the 0.5% AEP 1m RSLR DFL intersects the shoreline.
- **Backshore FCL**: Backshore FCL values are equal to the 0.5% AEP 1m RSLR DFL plus freeboard (0.6 m) and are applicable for coastal areas outside of defined Wave Effect Zones.

As the project team progressed through the transect analyses and subsequent FCL mapping, Sidney's topography yielded a number of nuanced problems that needed to be addressed, to deliver a sensible mapping solution:

Tulista Park/Anacortes Ferry Terminal Floodplain

As previously highlighted, the Tulista Park and Anacortes Ferry Terminal environs are lower than many areas along Sidney's shoreline. This means that the 0.5% AEP 1m RSLR DFL inundates quite considerably into the backshore here, extending as far as the Ocean Ave – Fifth Street roundabout. Therefore, under the design mapping conditions there would be approximately 0.7 m of water depth in the floodplain, from 'blue-water flooding.' However, it would be technically incorrect to state that waves can penetrate all the way inland to the Ocean Ave – Fifth Street roundabout. It's unlikely that the depth of the water column in the floodplain here would be able to support the design wave heights (approximately H_{m0} of 1.8 m along this reach). Waves would likely break and spill at the foreshore i.e. the foreshore would almost behave like a submerged breakwater. Wave effects are unlikely to penetrate into the backshore. Therefore, the project team have delineated the Wave Effect Zone in this area as a 30 m buffer landward of the foreshore crest.

This particular, nuanced problem would be best resolved using more detailed numerical analyses (e.g. a MIKE 3 Wave FM model). However, this was beyond the scope of the current project.

Coastal Setbacks

Setbacks are required in coastal floodplain mapping, to help manage additional sources of risk, that would not be mitigated through the use of FCLs alone. Additional sources of risk can include:

- Debris, such as timber logs, can be transported up the shoreline. Sidney has experienced this on many occasions during recent coastal storm events (as outlined in **Section 1.8**).
- Wave breaking during storm events can generate significant volumes of spray, that blow towards adjacent properties. This spray can result in property damage. Again, Sidney is acutely vulnerable to this hazard, as evidenced in recent storm events.

- In more erodible shorelines, coastal storms can actually undermine and erode the foreshore, thereby leading to coastline retreat.

Much of Sidney's shoreline consists of rocky outcrops and/or heavily modified and hardened shoreline (e.g. seawalls, revetments), which reduces the likelihood of widespread erosion, apart from a few localized vulnerable locations observed during the site visit. Therefore, much of Sidney's shoreline is unlikely to recede or erode due to storm events (as long as the coastal structures are properly monitored and managed) within the time horizons considered in this project. Given this coastal typology, coastal setbacks would primarily assist to manage coastal debris and spray. These phenomena are difficult to model and detailed analyses are thus outside the scope of this current project.
Coastal setbacks should be established, intending to limit the risk to proposed development from debris, wave breaking, coastal erosion and risk transference to adjacent properties. It is recommended that site-specific analyses be undertaken, with regard to setback, for any proposed development within the Wave Effect Zone. For the purposes of this project, our mapping does recommend a minimum setback distance of 15m horizontal distance, measured landward from the HHWLT + 1m RSLR contour.

Future shoreline change is uncertain and cannot be reliably assessed without a more detailed sediment budget study. Such work was not within the scope of the current project but could be considered as a valuable next step if there is interest in better understanding long-term shoreline dynamics.

Relative Sea Level Rise Scenarios

Three relative sea level rise (RSLR) scenarios were considered in our analysis: 0 m, 0.5 m, and 1 m. Further information on sea level rise and associated, estimated time horizons attached to the relative sea level rise values can be found in **Section 3.2**. For some reaches within the study area, the highest FCL value does not correspond to the highest RSLR scenario due to complex wave dynamics. As a result, the produced FCL mapping only shows the largest FCL value for that particular reach that can occur across all three RSLR scenarios.

A backshore FCL value of 4.12 mCGVD2013 is applicable for all reaches within the study area and corresponds to the 0.5% AEP water level plus 1 m RSLR scenario. Considering wave effect (wave run-up) calculations are not included in backshore FCL calculations, the DFL is consistent for the entire study area and the 1 m RSLR scenario governs as the largest value.

Areas with Negligible Wave Effects

Some coastal reaches are located behind or within the shadow of a protective coastal feature (e.g. a breakwater). The spectral wave modelling results confirm that incident wave heights in these locations are negligible. Accordingly, the FCL maps have been adjusted to remove the Wave Effect Zone from these protected reaches. The Backshore FCL would be sufficient for application in these locations, so long as the protective features remain in place and are in appropriate condition. The specific locations are as follows:

- Transect/Reach 15
- Transect/Reach 27

6.2 Flood Extents Mapping

The project team have also produced 'blue-water' coastal flood extents maps. These maps are intended to show areas within Sidney most-acutely aware of sea level rise. Please note that these maps were derived by projecting anticipated, extreme sea levels landward. Flood extents were not hydraulically modelled and are approximate only.

For further specific details on this map set, please refer to **Appendix C**.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary of Key Findings

The **Enhanced Flood Inundation Modelling & Mapping Project** conducted for the Town of Sidney provides a comprehensive assessment of current and future coastal flood hazards under a range of scenarios, including present-day conditions and projected relative sea level rise (RSLR) scenarios. The RSLR scenarios considered were 0.5m and 1.0m, relative to present-day.

Primary Flooding Mechanism

The coastal processes assessment evaluated the 0.5% AEP conditions for total water level (tide plus storm surge) and extreme offshore wave climate across the study area shoreline. Wave runup was assessed by combining the 0.5% AEP total water level (plus potential RSLR) with the 0.5% AEP offshore wave conditions.

Present-Day Conditions

Results confirm that the dominant coastal flooding mechanism in Sidney is wave-driven overtopping (“white-water” flooding), where incident storm waves propagate across the foreshore and wave effects exceed shoreline crest elevations. Temporary wave buoys deployed in Roberts Bay and Bazan Bay show that prevailing storm-wave energy arrives predominantly from the northeast and southeast, consistent with regional exposure to storm-generated seas.

This finding reflects the relatively high backshore elevations, which currently limit the extent of “blue-water” (still-water) flooding.

Certain topographic depressions along the shoreline influence local flooding dynamics. In the area from Tulista Park to Oceanspray Park, overtopped water can accumulate in low-lying terrain, leading to ponding and potentially extended inundation.

It is noted that this assessment is limited to coastal flood mechanisms. Other processes such as pluvial flooding (rainfall-driven runoff), which could contribute to water accumulation in local ponding depressions, have not been considered within the scope of this study.

Future Conditions with Relative Sea-Level Rise (RSLR)

With progressive relative sea-level rise, the extent of shoreline and low-lying areas susceptible to still-water flooding is expected to increase. Analyses undertaken for +0.5 m and +1.0 m RSLR scenarios indicate:

- **+0.5 m RSLR scenario**: Most of the Town remains primarily exposed to wave-driven overtopping. However, in some locations the computed still-water level (tide + surge + RSLR, without wave effects) approaches the elevation of existing coastal defenses, indicating the onset of blue-water flood risk.
- **+1.0 m RSLR scenario**: Several areas of the Town are projected to fall below the DFL associated with tide, storm surge, and RSLR alone. In these cases, still-water flooding becomes the dominant driver, even without wave contributions. The Tulista Park, Anacortes Ferry Terminal, Oceanspray Park and Port Sidney Marina areas are particularly vulnerable, as is the northern section near Mermaid Creek.

In areas already inundated by still-water flooding under SLR scenarios, wave-effect estimates carry higher uncertainty because wave transformation into inland flooded areas was not modelled in detail. Nonetheless, as these areas are projected to be inundated by tide and surge alone, adaptation strategies will necessarily need to account for these impacts directly.

Finally, it is important to acknowledge that uncertainty persists regarding the timing of future flood pathways due to variability in regional SLR projections. It is therefore recommended that this assessment be periodically updated in line with new sea-level projections and advances in local flood science, ensuring that long-term adaptation planning remains consistent with best available information.

7.2 Analyses Confidence and Limitations

While the coastal modelling presented in this report is based on best-available data and established methodologies, it is important to acknowledge the inherent uncertainties and limitations associated with any predictive analysis. The following section outlines key factors influencing analytical performance and areas where caution should be applied.

Uncertainty in Long-Term SLR Projections

As previously highlighted, sea level rise is a critical driver of future coastal flood risk. However, there is considerable uncertainty in sea level rise projections. This project adopted absolute Relative Sea Level Rise values of 0.5m and 1.0m, respectively. Therefore, these values are not 'pegged' to specific years. Per the AR6 SSP5-8.5 median trajectory, these values might be applicable at 2100 and 2150, respectively. We must emphasize, however, these time horizons should not be adopted as definitive.

Given the inherent uncertainty, it is recommended that Sidney adopt a flexible and adaptive planning approach, incorporating low-regret strategies and periodic updates to flood hazard/risk assessments as new data and guidance become available.

Assumed Stationarity in Storm Surges and Wind Directions/Intensities

The results outlined in this report assume that frequency and intensity of storm surge, winds, and waves do not change as a result of climate change (i.e., 'storminess' does not change due to climate change). Such an assumption has been regularly made in prior local flood hazard and coastal design assessments. There is still some uncertainty in how frequency and magnitude of storm events could change in British Columbia. There are still variability and uncertainty across climate model ensembles and improved and expanded regional climate model projections are needed to improve projections of extreme storm surges and waves for specific locations like Sidney. This type of analysis and research (i.e., downscaling GCMs and applying regional impact models) is in its infancy in a local context. Given the uncertainty in climate change projections over longer time-horizons; we recommend that this analysis be revisited at regular intervals (e.g., every 5 - 10 years) to reflect the latest climate change-related knowledge, improvements in modelling methodology, and updated shoreline profile sections and elevations.

Changes in Foreshore Geometry or Form

The analysis presented herein assumes 'present-day' shoreline conditions. If there are proposed changes to a foreshore (e.g. removing a seawall), this would result in changes to the estimated FCL values at that location. Any proposed development applications should be assessed against the potential to change the Foreshore FCL values presented herein.

Limited Site-Specific Calibration Data

As previously highlighted, two temporary wave buoys were specially deployed for this project in Bazan Bay and Roberts Bay, respectively. Each buoy was able to capture nine months of data, over a winter period. The team are confident in the spectral wave's performance in replicating the local wave climate, particularly in the areas just offshore of Sidney. However, this deployment period did not include any extremely large storm event. The team, therefore, were limited to comparing the resultant extreme value analyses against video and photo records of what had already been experienced in Sidney during previous extreme storms.

Compound Flooding Events

Compound flooding refers to situations where multiple flood drivers—such as storm surge, high tides, heavy rainfall, and riverine inflows—occur simultaneously or in close succession, amplifying overall flood impacts. These events can significantly increase flood severity, particularly in low-lying coastal communities like Sidney, where stormwater systems may be overwhelmed during high tide or storm surge conditions (i.e. stormwater outfalls become 'tide-locked').

For the purposes of this study, the focus was exclusively on coastal flooding driven by marine sources, including storm surge, tides, waves, and projected sea level rise. Stormwater flooding and pluvial runoff were outside the scope of this modelling effort. Furthermore, fluvial flooding along Mermaid Creek was similarly outside the scope of this project. As such, the results presented do not account for potential interactions between coastal and inland flood mechanisms.

While this approach allows for a clear assessment of coastal-driven flood hazards, it is important to recognize that compound events may pose additional risks not captured in this analysis. Future studies should consider integrated modelling approaches that combine coastal, fluvial and stormwater systems to better understand the full spectrum of flood risk in Sidney.

Tsunami Hazard Excluded

As outlined in the 2021 *Capital Region Coastal Flood Inundation Mapping Project* for the Capital Regional District, Sidney is vulnerable to tsunami events: albeit to a lesser degree than more exposed locations on Vancouver Island like Tofino or Port Renfrew. This current project focused on coastal flooding primarily driven by sea level rise, storm surge, and wave run-up. Tsunami hazard has not been considered within the scope of this assessment and is therefore not reflected in the mapped flood extents. Future updates may incorporate tsunami scenarios, subject to regional hazard assessments and available data. Readers should be aware that even with adoption of the FCLs presented herein, developments could still be exposed to residual risk of tsunami inundation and damage.

7.3 Overview of Comparison with 2021 CRD Study

It is important to note that the results presented in this particular project differ to those delivered during the 2021 CRD Study. The following bullets, while not exhaustive, have been provided below to help summarise the main technical differences.

- **Area of Interest:** The 2021 Capital Region Coastal Flood Inundation Mapping Project had a larger geographic area of interest (i.e. 13 municipalities and three electoral areas). The 2025 Enhanced Flood Inundation Modelling & Mapping Project focusses solely on Sidney's coastline. The underlying wave model development and calibration has been targeted to Sidney's coastline only. This overarching difference in scope is the primary difference between projects; many other methodological choices flow from this initial difference.
- **Spectral Wave Modelling Approach:** The 2021 Capital Region Coastal Flood Inundation Mapping Project required that the spectral wave model be able to accurately replicate incident wave conditions across a much larger area of interest. The 2025 Enhanced Flood Inundation Modelling & Mapping Project focusses solely on Sidney's coastline; thereby allowing for a finer model resolution. This more targeted area of interest allowed

the team to shorten the hindcast period for this project (1994-2024), minimising the presence of data gaps wherever possible.

- **Number of Transects and Reaches**: In the 2021 CRD Study, project scope and schedule limited the number of transects within the Town's coastline to nine distinct transects (i.e. nine analytical cross-sections through the shoreline). The 2025 Enhanced Flood Inundation Modelling & Mapping Project has analysed 29 different transects within the Town's municipal boundary. This has increased the analytical resolution and allowed the project team to split the coastline into smaller reaches. This increased resolution can ultimately lead to greater accuracy in the derived results.
- **Local Coastal Structures:** As the number of transects have been increased in the 2025 Enhanced Flood Inundation Modelling & Mapping Project, this has allowed for more site-specific adjustments to reach lengths and positioning. Some reach lengths have been expressly influenced by the presence of breakwaters and protective structures.
- **Offshore Calibration Data:** The 2021 CRD Study did not have the benefit of wave buoy results within the Haro Strait, which could be used to calibrate its spectral wave model. The 2025 Enhanced Flood Inundation Modelling & Mapping Project specifically tasked two wave buoys within Bazan Bay and Roberts Bay for a nine-month period. This project-specific data collection exercise allowed our project team to fine-tune the spectral wave model just offshore of Sidney, thereby enhancing the confidence in our eventual results.
- **Designated Flood Level value:** The 2021 CRD Study estimated a 0.5% AEP 1m RSLR water level of 3.26 mCGVD2013 at Sidney. The 2025 Enhanced Flood Inundation Modelling & Mapping Project has estimated a 0.5% AEP 1m RSLR water level of 3.52 mCGVD2013 at Sidney. Both estimates are based on extreme value analysis of the Patricia Bay (07277) station; the primary difference being that today's project had six additional years of data in the record.

7.4 Recommendations for Future Work

The coastal flood modelling and mapping conducted for Sidney provides a robust foundation for understanding current and future flood risks. However, addressing the evolving nature of coastal hazards, particularly in the context of climate change and sea level rise, requires ongoing effort. The following recommendations outline key areas for future work that will enhance flood resilience, support informed decision-making, and ensure that Sidney remains proactive in managing its coastal vulnerabilities.

Formalised Data Collection

To support ongoing flood risk assessment and adaptation planning, the Town of Sidney could establish a formalised data collection program focused on coastal hazards and flood impacts. Reliable, consistent, and locally relevant data is essential for improving model accuracy, validating projections, and informing evidence-based decision-making. A structured data collection initiative could include some or all of the following:

- **Offshore wave buoy deployment**: The Town could attempt to redeploy wave buoys offshore in the Bazan Bay and Roberts Bay areas. The project team have found the previously collected 9 months of data invaluable in validating our spectral wave model's performance. Any additional, prolonged data collection period would simply add to the confidence in future modelling work and would help detect any trends in the local sea state.
- **Wave runup and overtopping observations**: Capturing data and information regarding how waves runup and overtop would be critical in validating future analyses. Local newspapers and residents have informally done this. However, the Town could also implement a more formalised collection process during storm events by tasking one or more staff members to visit sections of the shoreline. This would build a library of information

that could be leveraged in future work. Another option could be the installation of a real-time webcam at say, Oceanspray Park or Beacon Wharf.

- **'Citizen Science' and crowdsourcing initiatives**: A related concept would be to 'outsource' this data collection during storm events to local residents. Data could be tagged to the Town's social media accounts (involving active downloading) or uploaded to a dedicated mobile app or online portal.
- **Economic Impact Data Collection**: Another beneficial exercise after a coastal flood event is to estimate the cost of recovery and clean-up. For example, is there a financial cost associated with road closures, debris clean-up, damage to infrastructure, private sector damages etc.? Any information collected can be used to build a 'damages profile' for a particular return period. This can then be used to help estimate the Return on Investment associated with any preventative measures. This is extremely useful in helping strengthen grant fund applications.

Sea Level Rise Adaptation Planning

A potential next step after this project would be for the Town to pursue the development of a comprehensive Sea Level Rise Adaptation Plan to guide long-term resilience efforts. This plan could build upon the findings of the current modelling and mapping project and align with provincial guidance and best practices in climate adaptation. The adaptation plan could serve as a strategic framework to:

- Identify vulnerable assets, infrastructure, and populations.
- Evaluate adaptation options across physical, ecological and policy domains.
- Prioritise actions based on risk, feasibility, and community values.
- Establish timelines and funding strategies for implementation.

Recommended elements of the plan would include:

- **Risk Assessment**: Integrate updated flood hazard mapping with asset inventories to assess exposure and sensitivity.
- **Adaptation Pathways**: Develop flexible strategies that allow for phased implementation and adjustment over time (e.g., protect, accommodate, retreat).
- **Nature-Based Solutions**: Explore opportunities for living shorelines, wetland restoration, and other ecological approaches that provide co-benefits.
- **Community Engagement**: Involve residents, businesses, and Indigenous partners in co-developing adaptation priorities and actions.
- **Policy Integration**: Align adaptation measures with updates to the Official Community Plan, zoning bylaws, and infrastructure planning.

By initiating a Sea Level Rise Adaptation Plan, Sidney can continue to take a proactive and structured approach to managing future coastal risks, ensuring the long-term safety, sustainability, and livability of its waterfront and community.

Update Official Community Plan (OCP) and Zoning Bylaws

The results of this coastal flood modelling study highlight the need for proactive land use planning to manage future flood risks in Sidney. As sea level rises and coastal flooding exposure increases, it is essential that the Town's planning framework evolves to reflect updated flood hazard information.

The OCP serves as Sidney's long-term vision for growth, development, and environmental stewardship. To enhance resilience to coastal flooding, future updates to the OCP could:

- Integrate updated flood hazard mapping into land use designations and development policies.
- Identify flood-prone areas as special planning zones with tailored policies for risk mitigation, infrastructure adaptation, and emergency preparedness.
- Promote climate-resilient development by encouraging elevation of structures, use of flood-resistant materials, and incorporation of green infrastructure.
- Support managed retreat or land use transition in areas where long-term flood risk is incompatible with continued development.

With respect to Zoning Bylaw amendments, the Town could also consider:

- Restricting high-density or critical infrastructure in areas identified as vulnerable to coastal flooding.
- Incentivizing adaptive design through zoning flexibility for flood-resilient building forms and site layouts.
- Establishing development permit areas (DPAs) for coastal flood hazard zones, requiring site-specific assessments and mitigation measures.

CLOSURE

This report was prepared for the Town of Sidney as part of a project to provide detailed coastal flood modelling and mapping information.

The information and data contained herein represent our team's best professional judgment in light of the knowledge and information available to our team at the time of preparation and were prepared in accordance with generally accepted engineering and geoscience practices. The services provided by Associated Engineering (B.C.) Ltd. and DHI Water and Environment, Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,

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APPENDIX A – WAVE CONDITIONS FOR WAVE RUNUP CALCULATIONS

	Waves from 1st Quadrant [0-90degN]			Waves from 2nd Quadrant [90-180deg.N]		
Profile N°	Hm_0	Tm10	Selected MWD	Hm_0	Tm10	Selected MWD
P01	1.3	3.8	78.5	1.72	4.1	119
P02	1.28	3.8	80.8	1.71	4.1	118.9
P03	1.33	3.9	89.8	1.75	4.1	113.9
P04	1.34	3.8	89.9	1.77	4.1	114.4
P05	1.35	3.8	89.8	1.8	4.1	118.7
P06	1.4	3.9	80.6	1.81	4.2	119.8
P07	1.41	3.9	77.9	1.84	4.2	122.6
P08	1.46	4.1	76.3	1.86	4.3	122.7
P09	1.56	4.1	88.2	1.89	4.3	117.8
P10	1.54	4.1	87.8	1.93	4.4	118.1
P11	1.55	4.1	87.1	1.93	4.3	117.1
P12	1.59	4.2	86	1.92	4.3	115.7
P13	1.59	4.1	71.2	1.93	4.3	111.4
P14	1.58	4.2	84	1.91	4.3	110.9
P15	0.47	2.9	87.3	0.86	3.7	133.6
P16	1.55	4.3	85.6	1.79	4.5	106.4
P17	1.51	4.3	89.9	1.83	4.5	116
P18	1.51	4.2	88.2	1.87	4.5	112.7
P19	1.44	4.2	64.5	1.85	4.6	102.1
P20	1.2	4.2	36.4	0.43	2.9	90
P21	1.16	4.1	64	0.43	2.8	90.1

	Waves from 1st Quadrant [0-90degN]			Waves from 2nd Quadrant [90-180deg.N]		
P22	1.12	4	77.6	0.6	3.1	90.1
P23	1.02	4.1	89.7	1.04	4.2	99.3
P24	1.38	4.1	89.4	1.51	4.5	111
P25	1.49	4.2	77.6	1.67	4.4	99.9
P26	1.59	4.3	71.7	1.66	4.3	93.9
P27	0.56	2.9	45.2	0.49	3.1	90.2
P28	0.83	3.5	63.9	0.59	3.2	90.1
P29	0.7	3.3	9.7	0.45	3.2	90.1

APPENDIX B - FLOOD CONSTRUCTION LEVELS

Note: All elevations are reported in m CGVD2013.

Profile / Transect No.	Profile Type	SWL	RSLR [m]	DFL	Runup 2% [m]	FCRP	FCL
P01	Gravel Beach to Revetment	2.52	0	2.52	2.14	4.66	5.26
		2.52	0.5	3.02	2.5	5.52	6.12
		2.52	1	3.52	2.54	6.06	6.66
P02	Gravel Beach to Concrete Step and Vegetation Slope	2.52	0	2.52	2.31	4.83	5.43
		2.52	0.5	3.02	3.02	6.04	6.64
		2.52	1	3.52	2.91	6.43	7.03
P03	Gravel Beach to Concrete Wall	2.52	0	2.52	0.56	3.08	3.68
		2.52	0.5	3.02	1.89	4.91	5.51
		2.52	1	3.52	N/A	3.52	4.12
P04	Gravel Beach to Revetment/Rubble	2.52	0	2.52	3.32	5.84	6.44
		2.52	0.5	3.02	4.09	7.11	7.71
		2.52	1	3.52	4.79	8.31	8.91
P05	Gravel Beach to Vegetation Slope	2.52	0	2.52	2.11	4.63	5.23
		2.52	0.5	3.02	2.21	5.23	5.83
		2.52	1	3.52	N/A	3.52	4.12
P06	Gravel to Revetment and Seawall	2.52	0	2.52	3.37	5.89	6.49
		2.52	0.5	3.02	4.14	7.16	7.76
		2.52	1	3.52	4.8	8.32	8.92
P07	Gravel Beach to Revetment	2.52	0	2.52	3.97	6.49	7.09
		2.52	0.5	3.02	4.73	7.75	8.35
		2.52	1	3.52	4.35	7.87	8.47
P08	Gravel Beach to Concrete Wall	2.52	0	2.52	2.29	4.81	5.41
		2.52	0.5	3.02	2.88	5.9	6.5

Profile / Transect No.	Profile Type	SWL	RSLR [m]	DFL	Runup 2% [m]	FCRP	FCL
		2.52	1	3.52	N/A	3.52	4.12
P09	Gravel Beach/Rock Slope to Concrete Wall	2.52	0	2.52	2.15	4.67	5.27
		2.52	0.5	3.02	3.38	6.4	7
		2.52	1	3.52	4.63	8.15	8.75
P10	Gravel Beach/Rock Slope to Vegetation Slope	2.52	0	2.52	4.15	6.67	7.27
		2.52	0.5	3.02	5.12	8.14	8.74
		2.52	1	3.52	5.25	8.77	9.37
P11	Rock Slope to Concrete Wall	2.52	0	2.52	2.1	4.62	5.22
		2.52	0.5	3.02	2.95	5.97	6.57
		2.52	1	3.52	3.8	7.32	7.92
P12	Gravel Beach to Concrete Wall	2.52	0	2.52	1.04	3.56	4.16
		2.52	0.5	3.02	2.4	5.42	6.02
		2.52	1	3.52	2.06	5.58	6.18
P13	Revetment	2.52	0	2.52	5.56	8.08	8.68
		2.52	0.5	3.02	5.59	8.61	9.21
		2.52	1	3.52	5.58	9.1	9.7
P14	Revetment	2.52	0	2.52	1.57	4.09	4.69
		2.52	0.5	3.02	2.2	5.22	5.82
		2.52	1	3.52	3.21	6.73	7.33
P15	Gravel Beach to Vertical Structures	2.52	0	2.52	N/A	2.52	3.12
		2.52	0.5	3.02	N/A	3.02	3.62
		2.52	1	3.52	N/A	3.52	4.12
P16	Rock Slope to Vertical Wall	2.52	0	2.52	2.15	4.67	5.27
		2.52	0.5	3.02	2.79	5.81	6.41
		2.52	1	3.52	3.42	6.94	7.54
P17	Grave Beach to Concrete Wall	2.52	0	2.52	2.98	5.5	6.1
		2.52	0.5	3.02	3.69	6.71	7.31

Profile / Transect No.	Profile Type	SWL	RSLR [m]	DFL	Runup 2% [m]	FCRP	FCL
		2.52	1	3.52	4.39	7.91	8.51
P18	Gravel Beach to Rock Slope	2.52	0	2.52	1.96	4.48	5.08
		2.52	0.5	3.02	2.93	5.95	6.55
		2.52	1	3.52	3.69	7.21	7.81
P19	Rock Slope	2.52	0	2.52	3.3	5.82	6.42
		2.52	0.5	3.02	4.34	7.36	7.96
		2.52	1	3.52	4.43	7.95	8.55
P20	Gravel Beach to Wall	2.52	0	2.52	2.53	5.05	5.65
		2.52	0.5	3.02	3.3	6.32	6.92
		2.52	1	3.52	3.43	6.95	7.55
P21	Gravel Flats to Concrete Wall	2.52	0	2.52	3.1	5.62	6.22
		2.52	0.5	3.02	3.35	6.37	6.97
		2.52	1	3.52	3.34	6.86	7.46
P22	Gravel Flats to Gravel/Vegetation Slope	2.52	0	2.52	2	4.52	5.12
		2.52	0.5	3.02	2.21	5.23	5.83
		2.52	1	3.52	2.16	5.68	6.28
P23	Gravel Flats to Gravel/Vegetation Slope	2.52	0	2.52	1.48	4	4.6
		2.52	0.5	3.02	2.39	5.41	6.01
		2.52	1	3.52	3.3	6.82	7.42
P24	Rock Slope covered with Gravel	2.52	0	2.52	3.76	6.28	6.88
		2.52	0.5	3.02	4.83	7.85	8.45
		2.52	1	3.52	4.8	8.32	8.92
P25	Vertical Rock	2.52	0	2.52	1.99	4.51	5.11
		2.52	0.5	3.02	1.92	4.94	5.54
		2.52	1	3.52	2.75	6.27	6.87
P26	Vertical Rock	2.52	0	2.52	2.16	4.68	5.28
		2.52	0.5	3.02	3.01	6.03	6.63

Profile / Transect No.	Profile Type	SWL	RSLR [m]	DFL	Runup 2% [m]	FCRP	FCL
		2.52	1	3.52	3.49	7.01	7.61
P27	Very Shallow Foreshore to Vegetation	2.52	0	2.52	0.13	2.65	3.25
		2.52	0.5	3.02	0.04	3.06	3.66
		2.52	1	3.52	N/A	3.52	4.12
P28	Gravel Beach to Rubble	2.52	0	2.52	2.21	4.73	5.33
		2.52	0.5	3.02	2.19	5.21	5.81
		2.52	1	3.52	2.18	5.7	6.3
P29	Gravel Beach to Vegetation slope	2.52	0	2.52	1.55	4.07	4.67
		2.52	0.5	3.02	1.51	4.53	5.13
		2.52	1	3.52	0.25	3.77	4.37

APPENDIX C - FLOOD MAPPING