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Sunshine Coast Coastal Flood Hazard Mapping

Technical Report to Support Land Use Planning and Climate adaptation

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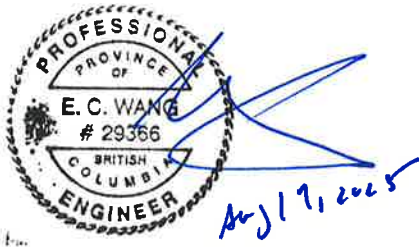
August 18, 2025
Final Report, Rev. 1

NHC Reference No. 3008737

DOCUMENT TRACKING

Date	Revision No.	Reviewer	Issued For
June 23, 2025	0	Edwin Wang	Client Review
August 18, 2025	1	E Wang, P Osborne, D Muir	Final

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1003221

NHC File Path: \\mainfile-van\Projects\Active\3008737 Sunshine Coast Flood Hazard Mapping\97 Reporting\3008737 Coastal Adaptation Mapping Report.R2B.docx

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EXECUTIVE SUMMARY

This report presents the technical findings of the Coastal Flood Hazard Mapping Project completed for the Sunshine Coast Regional District (SCRD), in partnership with the District of Sechelt, Town of Gibsons, and Islands Trust. The project was funded through the Union of BC Municipalities (UBCM) Disaster Risk Reduction Climate Adaptation stream and delivered informational products that provide the foundational support for climate adaptation, land use planning, and infrastructure resilience.

The study assessed present and future coastal flood hazards, including the combined effects of sea level rise, tides, storm surge, and wind-generated waves. Coastal design scenarios were developed based on sea level rise projections and storm return periods consistent with provincial guidance and regional planning needs.

Water levels were estimated using a probabilistic approach combining tide and storm surge with projected sea level rise. Wave conditions were simulated using the SWAN model, and wave run-up was calculated along shoreline transects following the methods described in EurOTop (2018) and by Stockdon et al (2006). A supplementary Coastal Vulnerability Index (CVI) was developed to highlight shoreline areas potentially more sensitive to geomorphic change. Shoreline conditions were characterized using available LiDAR, orthophotos, and targeted field reconnaissance.

Three primary map sets were produced:

- **Inundation Maps** showing projected flood extents under sea level rise scenarios of 0.0, 0.5, 1.0, and 2.0 m (excluding storm effects);
- **Flood Construction Level (FCL) Maps** incorporating sea level rise of 1 m, storm surge, wave run-up, and freeboard;
- **Wave Effects Maps** depicting wave run-up contributions during representative storm events.

All mapping outputs are referenced to CGVD2013 and are intended to inform Official Community Plans (OCPs), Development Permit (DP) areas, emergency planning, and adaptation policy. A complementary engagement process led by EcoPlan International supported local integration of the findings. The results reflect available elevation and shoreline data, present-day shoreline conditions, and current modelling approaches, and are intended for planning-level use. Site-specific assessments by a Qualified Professional are recommended where development is proposed within mapped hazard areas or involves higher-consequence land uses, such as new subdivisions or critical infrastructure. In areas well above mapped hazard extents, additional site-specific review may not be warranted; however, the determination rests with the local government under the Local Government Act.

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ABBREVIATIONS

Acronym / Abbreviation	Definition
AEP	Annual Exceedance Probability
CGVD2013	Canadian Geodetic Vertical Datum of 2013
CVI	Coastal Vulnerability Index
DEM	Digital Elevation Model
DP	Development Permit
FCL	Flood Construction Level
LiDAR	Light Detection and Ranging
OCP	Official Community Plan
R2%	Wave run-up elevation exceeded by 2% of incident waves.
SCRD	Sunshine Coast Regional District
SLR	Sea Level Rise
SWAN	Simulating WAVes Nearshore
UBCM	Union of BC Municipalities

GLOSSARY

Term	Definition
AEP (Annual Exceedance Probability)	The likelihood that a given flood or storm event will be equaled or exceeded in any year. For example, a 0.5% AEP corresponds to a 200-year return period.
CGVD2013 (Canadian Geodetic Vertical Datum of 2013)	The national standard reference for elevation in Canada, used for all vertical data in this study.
CVI (Coastal Vulnerability Index)	A relative measure of the shoreline's potential sensitivity to geomorphic change, based on slope, exposure, and shoreline type.
DEM (Digital Elevation Model)	A gridded dataset representing the earth's surface elevation, typically derived from LiDAR or bathymetric sources.
DP Area (Development Permit Area)	A land use designation in local government planning documents where special conditions apply, often related to hazard mitigation or environmental protection.
EurOtop	A European manual providing empirical methods for estimating wave run-up and overtopping on coastal slopes and structures.
FCL (Flood Construction Level)	A prescribed elevation above which habitable buildings or critical infrastructure must be built to reduce flood risk.
Freeboard	An added vertical buffer above estimated flood levels to account for uncertainty, wave splash, and safety margin.
LiDAR (Light Detection and Ranging)	A remote sensing method using laser pulses to measure elevation with high accuracy. Used to generate topographic data for flood modelling.
Metocean	A combination of meteorological and oceanographic parameters (e.g., wind, wave, tide) used to define coastal design scenarios.
OCP (Official Community Plan)	An official community plan is a statement of objectives and policies to guide decisions on planning and land use management, within the area covered by the plan, respecting the purposes of local government.
R2%	The elevation on the shoreline that is exceeded by 2% of waves during a storm
Run-up	The vertical extent of wave uprush on a slope above still water level. Important for estimating total water levels during storms.

Term	Definition
SLR (Sea Level Rise)	The projected long-term rise in mean sea level due to climate change.
Still Water Level	The water level resulting from the combined effects of tide and storm surge, excluding wave run-up.
Stockdon Method	An empirical formula used to estimate wave run-up on dissipative beaches. Developed by Stockdon et al. (2006).
SWAN (Simulating WAves Nearshore)	A numerical model used to simulate two-dimensional wave propagation and transformation in coastal environments, based on wind input.
Transect	A cross-shore profile extracted from terrain data to represent local slope and shoreline characteristics for use in run-up and wave effect calculations.
UBCM (Union of BC Municipalities)	A provincial association representing BC local governments. The project was funded through UBCM's Disaster Risk Reduction - Climate Adaptation program.

1 INTRODUCTION

This report documents the technical work completed for the Coastal Flood Hazard Mapping Project undertaken on behalf of the Sunshine Coast Regional District (SCRD), in partnership with the District of Sechelt, the Town of Gibsons, and Islands Trust. The study supports regional planning and climate adaptation by identifying areas potentially exposed to future sea level rise, coastal flooding, and wave effects. This report provides an overview of the study area, project scope, objectives, technical assessments, and mapping deliverables

1.1 Site Overview

The study area, illustrated as Figure 1.1, encompasses the coastal shoreline of the lower Sunshine Coast, including lands within the jurisdiction of the SCRД, the District of Sechelt, the Town of Gibsons, and the Islands Trust. Within this figure colour shading indicates population density, red denoting higher density and blue denoting lower density.

The shoreline within the study area includes a range of landforms such as exposed bedrock outcrops, narrow gravel beaches, developed waterfronts, estuarine inlets, and low-lying coastal zones. These diverse landforms influence how flood hazards occur and how communities are exposed to them. Steeper, rocky shorelines tend to be less affected by wave overtopping or erosion, while low-lying or sediment-limited areas are more prone to flooding and shoreline change. Developed waterfronts may experience higher consequences when flooding occurs, as critical infrastructure and residences are directly exposed.

Documented coastal storms have caused localized flooding in several parts of the study area. Figure 1.2 shows conditions near Sunshine Coast Highway at Davis Bay during a storm event, where elevated water levels and wave overtopping impacted the roadway.

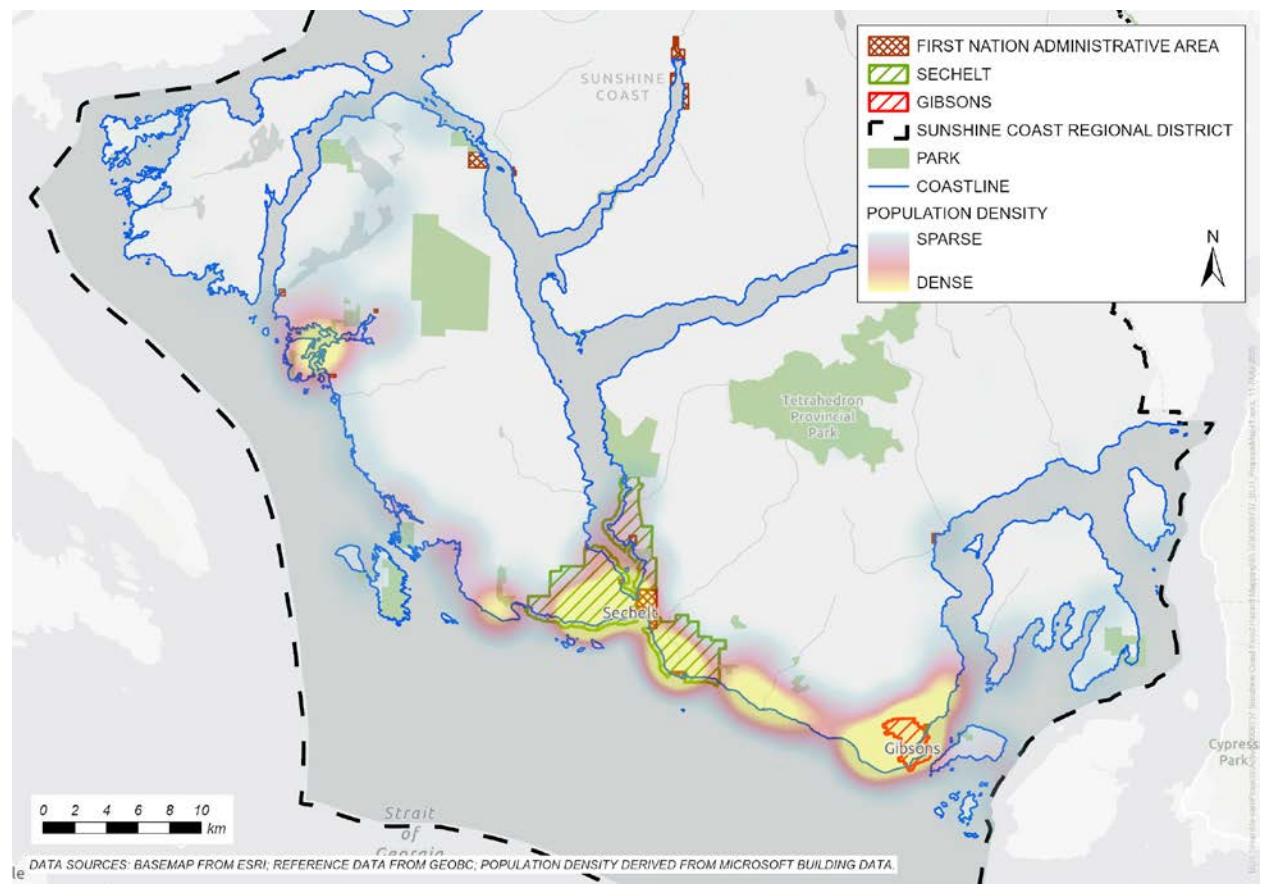


Figure 1.1 Study area, with population density and jurisdictional areas



Figure 1.2 Wave overtopping near Davis Bay during a storm event (January 7, 2022). Elevated water levels and wave run-up caused localized flooding along Sunshine Coast Highway (source: Ian Pipes Bolden).

1.2 Project Scope and Objectives

The project was funded through the Union of BC Municipalities (UBCM) Disaster Risk Reduction Climate Adaptation program and guided by a steering committee with representatives from the Sunshine Coast Regional District, the District of Sechelt, the Town of Gibsons, and Islands Trust. The committee provided direction and feedback throughout to ensure alignment with local climate adaptation and land use planning objectives.

Northwest Hydraulic Consultants Ltd. (NHC), as the prime consultant, was responsible for technical analysis, coastal hazard assessment, and development of the mapping deliverables presented in this report. EcoPlan International (EcoPlan), a sub-consultant, supported project engagement and communications; documented a companion report, Coastal Flood Adaptation Policy and Regulation Considerations (2025).

The study evaluated current and future coastal flood hazards, with emphasis on sea level rise and wave effects, to support the development of flood construction levels (FCLs), planning maps, and adaptation recommendations. A Coastal Vulnerability Index (CVI) was also developed to help identify areas with increased susceptibility to geomorphic change.

The CVI incorporates shoreline exposure, slope, and geomorphic setting, informed by desktop review and targeted field visits. This supplementary assessment helped inform the hazard results and identify shoreline segments where physical change may increase flood-related risk.

The study included the following technical components:

- Field visits to confirm shoreline characteristics and to examine sites identified by the client and partners as areas of interest.
- Metocean analysis to define design water levels and associated wind-wave conditions
- Wave modelling and wave run-up analysis to quantify wave effects at selected shoreline locations
- Coastal vulnerability analysis to develop CVI and classify shoreline segments
- Preparation of technical maps to support adaptation, permitting, and infrastructure planning

Three sets of maps were produced:

- Inundation Maps: Present-day and future sea level rise scenarios (0.0, 0.5, 1.0, and 2.0 m), without storm or wave effects
- FCL Maps: Based on 1.0 m sea level rise, 0.5 % annual exceedance probability (AEP; 1-in-200-year) storm, wave effects, and standard freeboard.
- Wave Effects Maps: Developed for 0.5 m sea level rise and 2 % AEP (1-in-50-year), 1 % AEP (1-in-100-year), and 0.5 % AEP (1-in-200-year) storms.

These deliverables provide a technical foundation for consistent, region-wide coastal flood risk assessment and adaptation planning.

1.3 Related Work – Partner Contributions

Project sub-consultant EcoPlan supported the project through community outreach, engagement, and land use planning policy review. Their work aimed to better understand community concerns, raise awareness of coastal flood hazards and risks, and identify opportunities to strengthen resilience through land use policy.

EcoPlan's separate report, Coastal Flood Adaptation Policy and Regulation Considerations (2025), summarizes approaches for reducing coastal flood risk through updates to official

community plans, development permit areas, and zoning bylaws, as well as other relevant policies and programs. The report includes a review of existing coastal flood management tools in the project area (that is, within the SCRD, District of Sechelt, Town of Gibsons, and Islands Trust), and outlines opportunities to improve, expand, and consolidate these tools to enhance resilience and public communication of flood risk.

2 APPROACH AND METHODOLOGY

This section outlines the technical approach used to assess coastal flood and wave hazards for the study area. The methodology reflects current guidance in British Columbia and Canada for flood hazard mapping, supported by relevant national standards and best practices.

Key references include:

- Legislated Flood Assessments in a Changing Climate in BC (EGBC, 2018)
- Flood Hazard Area Land Use Management Guidelines (Government of BC, 2018)
- Flood Mapping in BC: Professional Practice Guidelines (APEGBC, 2017)
- Coastal Floodplain Mapping – Guidelines and Specifications (MFLNRO, 2011)

Earlier guidance such as Ausenco-Sandwell (2011) was reviewed for background context but has largely been superseded. Collectively, these documents inform both the technical and planning expectations for flood hazard assessments. For instance, EGBC recommends using a 0.5% AEP (1-in-200 year) and incorporating projected sea level rise (SLR) to 2100 or beyond. This project adopted a probabilistic framework for estimating water levels that jointly considers tides and storm surge.

The methodology included data review, shoreline characterization, scenario definition, technical analysis, and mapping. Each step is summarized below.

2.1 Data Review and Shoreline Characterization

Topographic, bathymetric, and shoreline datasets were compiled and reviewed to establish baseline coastal conditions. Data sources included 2019 provincial and 2009 SCRD LiDAR, Canadian Hydrographic Service NONNA bathymetry, NRCan's medium-resolution digital elevation model (MRDEM), and orthophotos. A desktop review was used to delineate representative shoreline segments based on exposure, geomorphic type, and development.

Targeted field visits were conducted to verify shoreline features at key sites. Observations included slope, sediment type, vegetation, and built infrastructure that may influence local wave

response. These field observations supported interpretation of LiDAR and photo-based mapping and helped confirm shoreline classifications used in run-up and vulnerability assessments.

2.2 Scenario Definition

Hazard scenarios were developed in consultation with project partners and aligned with guidance documents. The scenarios covered multiple SLR values and storm return periods to represent plausible future conditions:

- SLR scenarios: 0.0 m (present), 0.5 m (medium term), 1.0 m (long term), 2.0 m (very long term)
- Storm return periods: 2% AEP (1-in-50-year, frequent), 1% AEP (1-in-100-year, less frequent), 0.5% AEP (1-in-200-year, infrequent, high-impact)

Scenarios were applied based on the type of analysis:

- Inundation Mapping: Used the 0.5% AEP (1-in-200-year) joint tide and storm surge still water level. Wave effects and freeboard were not included.
- FCL Mapping: Applied 1.0 m SLR, 0.5% AEP (1-in-200-year) storm, wave effects, and standard freeboard.
- Wave Effects Mapping: Evaluated 0.5 m sea level rise with 2% AEP (1-in-50-year), 1% AEP (1-in-100-year), and 0.5% AEP (1-in-200-year) storms, including wind-wave generation and run-up.

This structured approach ensures a consistent basis for understanding both current and future coastal hazard exposure. The use of different combinations of SLR and storm conditions across map products establishes the basis for risk analysis and reflects typical planning horizons and policy needs.

2.3 Water Level and Wave Estimation

Still water levels were estimated probabilistically by combining tide and storm surge distributions to calculate a 0.5% AEP (1-in-200-year) joint occurrence. Sea level rise was then added to the scenario-specific baseline.

Wave conditions were simulated using the SWAN (Simulating WAVes Nearshore) model with regional wind data to estimate significant wave height and peak period. Nearshore wave characteristics were extracted from the model for use in empirical wave run-up calculations.

Run-up was estimated along cross-shore transects spaced at approximately 250 m intervals along the shoreline. Each transect calculation incorporated local slope, water depth at the design still water level, beach material, and other site-specific features. Results are expressed as **R2%**, defined as the elevation on the beach face that is exceeded by the highest 2% of incident waves. Two empirical methods were used:

- EurOtop (EurOtop, 2018), suited to natural and engineered shorelines
- Stockdon et al. (2006), suited to natural, dissipative beach conditions

Run-up estimates were added to still water levels to determine total water level. Total water level was projected inland to delineate the inland extent of wave influence. A maximum inland setback of 30 m from still water inundation was applied where the total water level would otherwise project further inland. This approach provides a conservative and consistent spatial representation of wave hazard, while remaining practical for planning applications.

Further technical detail is provided in **Appendix A – Coastal Analysis**.

2.4 Coastal Vulnerability and Geomorphic Review

To support interpretation of static flood mapping, the CVI was developed to highlight areas where shoreline form or processes may increase susceptibility to flood hazards. The CVI considered slope, geomorphic type, and wave exposure.

This desktop assessment was supplemented by field observations at select sites to confirm shoreline types, identify potential instability, and verify the desktop calculation of the CVI. Direct monitoring of shoreline dynamics in the SCRD is limited, so an indicator metric such as the CVI provides an appropriate first step for understanding erosion hazard potential. The CVI incorporates a range of physical attributes and hydro-physical processes known to influence coastal vulnerability and erosion. It is intended both to contextualize flood and run-up results by highlighting areas where shoreline change may alter hazard exposure in the future, and to differentiate shoreline segments that are relatively stable from those that are more susceptible to coastal processes under present conditions.

Results are presented in **Appendix B – Coastal Geomorphic Analysis**.

2.5 Mapping and Interpretation

The following map products were developed to support planning and hazard management:

- Inundation Maps: SLR-only flood extents, no storm or wave effects, and no freeboard

- FCL Maps: Total water levels for 1.0 m SLR, 0.5% AEP (1-in-200-year) storm, wave run-up, and freeboard
- Wave Effects Maps: Additional run-up extent for 0.5 m SLR and storm return periods of 2% (1-in-50-year), 1% (1-in-100-year), and 0.5% AEP (1-in-200-year).

A maximum setback of 30 m inland from the inundation line was applied to delineate wave effect zones, unless constrained by topography. Mapping outputs are described in Section 3 and provided in **Appendices C to E**.

2.6 Vertical Datum

All flood levels and mapping products are referenced to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), which aligns with the provincial LiDAR dataset.

3 APPLICATION OF MAPPING PRODUCTS

The coastal flood mapping products provide a technical basis for a range of local government emergency preparedness, planning, and longer-range policy. Table 3.1 summarizes the primary applications of each product.

Table 3.1 Summary of primary applications for each coastal flood mapping product

Application	Inundation Maps	FCL Maps	Wave Effects Maps
Emergency management and infrastructure planning	✓		
Development Permit (DP) area refinement		✓	✓
Coastal adaptation and risk screening	✓	✓	✓
Official Community Plan (OCP) updates	✓	✓	
Infrastructure siting and resilient design		✓	✓
Near-term adaptation planning	✓		✓

Additional engagement guidance was prepared by EcoPlan International to assist with local implementation.

3.1 Inundation Maps

The inundation maps (Appendix C) illustrate projected flood extents under four SLR scenarios using the 0.5% AEP (1-in-200-year) still water level:

- 0.0 m (present day)
- 0.5 m (medium term)
- 1.0 m (long term)
- 2.0 m (very long term)

These maps exclude wave and freeboard components. They are intended to inform high-level planning and highlight areas where flood exposure increases with sea level. Key applications are summarized in Table 3.1.

Infrastructure features such as roads, bridges, ferry terminals, community facilities, and emergency services were initially considered for overlay on the mapping to support preliminary risk screening. Following discussion with the client, these features were removed from the published mapping to improve visual clarity. Their spatial data remain available within the client's GIS database and can be applied on a case-specific basis to assess potential impacts to specific assets for different end-users.

The table below lists the assets at risk under each scenario. Given the size of the study site, the assessment did not identify or evaluate specific roads that could be affected by inundation. However, four key community areas including Vaucroft Beach waterfront area, Downton Sechelt waterfront area, Davis Bay and Wilson Creek waterfront area, and Gibsons Landing waterfront and marina district are noted as potentially vulnerable locations that may warrant further review by the client.

Table 3.2 Assets Exposed to Flood Hazard, shown by Sea Level Rise Scenarios

Category	Description	0 m SLR	0.5 m SLR	1 m SLR	2 m SLR
Critical Infrastructure	Earls Cove Ferry Terminal		✓	✓	✓
Critical Infrastructure	Pender Harbour Community Police Office			✓	✓
Critical Infrastructure	Square Bay WWTF		✓	✓	✓
Critical Infrastructure	Pender Harbour Fire				✓
Critical Infrastructure	Chapman Creek Bridge		✓	✓	✓
Critical Infrastructure	Chaster House	✓	✓	✓	✓
Facility Point	Hospital Bay	✓	✓	✓	✓

Category	Description	0 m SLR	0.5 m SLR	1 m SLR	2 m SLR
Facility Point	Maderia Park (Pender)	✓	✓	✓	✓
Facility Point	Maderia Park Fire Hall			✓	✓
Facility Point	Maderia Park Ambulance Station 265		✓	✓	✓
Facility Point	Pender Harbour Community Police Office			✓	✓
Facility Point	Pender Harbour Community Hall				
Facility Point	Pender Harbour Pentecostal Church			✓	✓
Facility Point	Secret Cove	✓	✓	✓	✓
Facility Point	Coopers Green Hall		✓	✓	✓
Facility Point	Seaside Centre				✓
Facility Point	Cowrie Medical Clinic				✓
Facility Point	Sechelt Ambulance Station				✓
Facility Point	Sechelt Seniors Activity Centre				✓
Facility Point	Trail Avenue Gate Station		✓	✓	✓
Facility Point	Porpoise Bay	✓	✓	✓	✓
Facility Point	Living Faith Lutheran Church		✓	✓	✓
Facility Point	Langdale Ferry Terminal		✓	✓	✓
Facility Point	Terminal Forest Products			✓	✓
Fortis	Travil Avenue	✓	✓	✓	✓
Fortis	5650 Travil A		✓	✓	✓
Fortis	Old Name Sechelt Meter Station		✓	✓	✓
Lift Station	Wakefield Strata				✓
Lift Station	Wakefield			✓	✓
Lift Station	Sechelt Village Watermark				✓
Lift Station	Mackenzie Marina		✓	✓	✓
Lift Station	Gibsons SN-002		✓	✓	✓
Lift Station	Harbor Way Lift Station			✓	✓

Category	Description	0 m SLR	0.5 m SLR	1 m SLR	2 m SLR
Pump Station	Hill Rd Sewerage PS			✓	✓
Pump Station	Old Ebbside plant	✓	✓	✓	✓
Pump Station	Onni				✓
General	Breakwater, boat launch, dock	✓	✓	✓	✓

3.2 Flood Construction Level Maps

FCL maps (Appendix D) represent projected total water levels for a 1.0 m SLR scenario with a 0.5% AEP (1-in-200-year) storm, wave run-up, and freeboard.

Products include:

- Recommended FCLs, which vary along the shoreline
- Coastal FCL Zones, defined as 30 m inland from the mapped water level or constrained by local topography
- Parcel boundaries, roadways, and jurisdictional boundaries for reference

Key applications are summarized in Table 3.1. Although FCLs reflect current topographic and shoreline conditions, site-specific factors may vary considerably, especially in complex or engineered environments. A Qualified Professional should review development proposals in mapped areas to confirm local elevation and wave effects.

These planning-level elevations are not intended to replace detailed site assessments but offer a consistent regional benchmark for screening and policy development.

Although the FCL mapping for the Sechelt region may appear concerning, the existing shoreline along the Strait of Georgia is generally about 4.0 m, which is close to the design water level for a 1.0 m sea level rise scenario. The mapped inundation and wave effect extents include a 0.6 m freeboard allowance, resulting in a baseline elevation of 4.6 m. On the Sechelt Inlet side, the future design still water level, including 1.0 m sea level rise, is about 3.3 m. In both areas, increasing the shoreline elevation by about 1.0 m could substantially reduce the area shown as affected in the FCL mapping. However, low-lying inland areas would remain susceptible to ponding during overtopping events, and adequate drainage or pumping systems would be required to manage these flows effectively.

3.3 Wave Effects Maps

Wave effects maps (Appendix E) illustrate areas where wave run-up may elevate flood risk under a 0.5 m SLR scenario with storm return periods of:

- 2% AEP (1-in-50-year, frequent)
- 1% AEP (1-in-100-year, less frequent)
- 0.5% AEP (1-in-200-year, infrequent)

Wave conditions were simulated with SWAN. Run-up was estimated following the methods described in EurOTop (2018) and by Stockdon et al (2006).

Key applications are summarized in Table 3.1. These maps identify wave-exposed areas where flood levels may exceed still water conditions.

3.4 Limitations

The mapping reflects terrain conditions based on available data and current methods. Key limitations include:

- Elevation data – LiDAR gaps and vertical errors may affect terrain accuracy, particularly in nearshore, vegetated, or developed areas. In regions without reliable LiDAR, lower-resolution DEMs were used as substitutes.
- Land–water integration – Merging terrestrial LiDAR and marine bathymetric data may introduce elevation artifacts near the shoreline.
- Wind and wave assumptions – In areas without long-term wind records (e.g., Sechart Inlet), regional design values were used and may not fully reflect local exposure conditions.
- Shoreline representation – The analysis assumes a fixed shoreline and does not account for future erosion, sediment transport, or other dynamic coastal processes.
- Transect spacing – Cross-shore transects were established at regular intervals (about 250 m) along most of the shoreline, with additional transects at selected sites of interest. Run-up estimates apply at the transect locations; interpretation and professional judgment are required when applying these results to areas between transects.

FCLs and CVI scores are based on present-day features and assumptions. They are not tied to specific years. Future extreme events or shoreline evolution could reduce their applicability.

Updates are recommended every 25–30 years or following major storms, new LiDAR, or revised sea level rise guidance.

4 COMPARISON WITH SHISHÁLH NATION FLOOD MAPPING

A coastal flood mapping study completed for the shíshálh Nation in 2022 covers portions of the shoreline that overlap with the present study area. As part of the current project scope, a high-level comparison of the two studies has been undertaken to assess general consistency in FCL estimates and to note any substantial differences. The comparison considers vertical datum alignment, overall design water level assumptions, and wave condition treatment, but does not include a detailed review of the shíshálh Nation study inputs or modelling procedures.

The shíshálh Nation (2022) mapping is referenced to CGVD28, whereas the present study is referenced to CGVD2013. The shíshálh Nation study derived a present-day design still water level of 3.0 m CGVD28, equivalent to 2.82 m CGVD2013, which is 0.20 m lower than the 3.02 m CGVD2013 value adopted in the present study for the same area. The shíshálh Nation design water level is based on the Higher High Water Large Tide (HHWLT) plus a 10-year storm surge, whereas the present study applies an extreme event analysis.

For the Trail Bay region, the shíshálh Nation mapping reports FCL values between 6.3 m and 8.9 m CGVD28 (equivalent to 6.12 m and 8.72 m CGVD2013). The present study produces FCL values between 5.5 m and 8.8 m CGVD2013 for the same region. Despite differences in design water level estimation, design wave condition assessment, and foreshore profile transects, the results for this area are broadly comparable.

In the Sechelt Band Lands (Tsawcome No. 1) area, the shíshálh Nation study reports an FCL of 5.3 m CGVD28 (5.12 m CGVD2013). The present study indicates FCL values ranging from approximately 4.8 m to 6.6 m CGVD2013 for the region. The predicted wave effect for this area in the present study is approximately 4.0 m, compared to 1.7 m in the shíshálh Nation study. While the shoreline may not be directly exposed to the primary storm approach direction in the Strait (northwest–southeast), the analysis suggests that large northwest waves could refract into the bay and interact with the shoreline. The basis for the shíshálh Nation wave effect estimates is not available for review; however, differences of up to 2.0 m in FCL are common along the shoreline depending on incident wave direction and foreshore characteristics.

Overall, the results from the two studies are generally aligned, with most differences within the range expected from independent analyses using different wave runup methodologies.

5 CONCLUSIONS AND NEXT STEPS

This report presents technical results from the Coastal Flood Hazard Mapping Project for the lower Sunshine Coast. The mapping products provide a consistent framework to inform flood

planning, policy development, and infrastructure adaptation. They support a range of applications, including emergency management, infrastructure planning, DP area review, OCP updates, and coastal adaptation and risk screening.

Implementation of the mapping should follow the recommendations outlined in the Coastal Flood Adaptation Policy and Regulation Considerations report prepared by EcoPlan (2025). That report provides the primary action plan for integrating the mapping into local government policy and regulatory frameworks, including updates to OCPs, DPAs, zoning bylaws, and hazard communication strategies.

Continued coordination between technical mapping and policy implementation will ensure the products are effectively applied to reduce long-term coastal flood risk and improve community resilience.

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APPENDIX A

COASTAL ANALYSIS



Photo source: Raph Shay (SCRD)

Sunshine Coast Coastal Flood Hazard Mapping

Appendix A – Coastal Analysis

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August 18, 2025
Final Report, Rev. 1

NHC Reference No. 3008737

DOCUMENT TRACKING

Date	Revision No.	Reviewer	Issued For
June 21, 2025	0	Edwin Wang	Client Review
August 2025	1	Phil Osborne	Final

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NHC File Path: \\mainfile-van\Projects\Active\3008737 Sunshine Coast Flood Hazard Mapping\97 Reporting\3008737 SCRD Flood Mapping - Appendix A - Coastal Analysis.R1a.docx

DISCLAIMER

This report has been prepared by Northwest Hydraulic Consultants Ltd. for the benefit of Sunshine Coastal Regional District, District of Sechelt, Town of Gibsons, and Island Trust. The report documents the technical analysis of water levels, waves, and run-up conditions undertaken to support the Sunshine Coast Coastal Flood Hazard Mapping project. The information and data contained herein represent Northwest Hydraulic Consultants Ltd.'s professional judgment in light of the knowledge and information available to Northwest Hydraulic Consultants Ltd. at the time of preparation and were prepared in accordance with generally accepted engineering and geoscience practices.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by Sunshine Coastal Regional District, District of Sechelt, Town of Gibsons, Island Trust, its officers, and employees. Northwest Hydraulic Consultants Ltd. denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss, or damage suffered by such parties arising from their use of or reliance upon this report or any of its contents.

EXECUTIVE SUMMARY

This appendix presents the coastal process analysis undertaken in support of the Sunshine Coast Coastal Flood Hazard Mapping project. The analysis provides the technical foundation for estimating storm-driven water levels, sea level rise allowances, wave run-up, and resulting flood elevations across the lower Sunshine Coast.

Design still water levels were derived from tide and storm surge records at the Point Atkinson gauge and adjusted for local tidal conditions at Blind Bay, Porpoise Bay, and Gibsons. A joint probability approach was used to estimate the 0.5% AEP (200-year) design still water level, which forms the basis of the inundation mapping.

Future sea level rise was incorporated using four scenarios (0.0, 0.5, 1.0, and 2.0 m). The 1.0 m scenario reflects conditions to 2100 and was applied in Flood Construction Level (FCL) mapping, while 0.5 m and 2.0 m scenarios were included for medium- and long-term planning.

Wave modelling was carried out using the SWAN model forced by design wind inputs representative of coastal exposure. Offshore reference data from the Halibut Bank buoy and Pam Rocks station were supplemented by regional design values in areas without long-term wind records. Model results provided nearshore wave conditions that were used to estimate run-up elevations at cross-shore transects spaced approximately 250 m apart. Wave run-up was quantified using $R_2\%$, the elevation exceeded by 2% of incident waves, based on empirical methods (EurOtop, 2018; Stockdon et al., 2006).

Mapping products derived from this analysis include:

- Inundation Maps – Based on design still water levels and sea level rise scenarios, excluding wave effects and freeboard.
- FCL Maps – Incorporating still water level, 1.0 m sea level rise, wave run-up, and freeboard, representing recommended minimum building elevations.
- Wave Effects Maps – Illustrating inland extent of wave run-up under medium-term sea level rise and storm scenarios.

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ABBREVIATIONS

Acronym / Abbreviation	Definition
DEM	Digital Elevation Model
FCL	Flood Construction Level
Hs	Significant Wave Height
LiDAR	Light Detection and Ranging
MRDEM	Medium Resolution Digital Elevation Model
SLR	Sea Level Rise
SWAN	Simulating WAVes Nearshore (numerical wave model)
Rp	Peak Wave Period
R2%	Run-up elevation exceeded by 2% of incident waves

GLOSSARY

Term	Definition
AEP	Annual Exceedance Probability
Flood Construction Level (FCL)	Recommended minimum elevation for buildings and structures in flood-prone coastal areas, defined as total water level plus a freeboard allowance
R ₂ % (Run-up)	The elevation exceeded by 2% of waves during a storm event. Used as a standard measure of wave run-up in coastal engineering.
Significant Wave Height (Hs)	The average height of the highest one-third of waves in a wave record.
Peak Wave Period (Tp)	The wave period corresponding to the peak of the wave energy spectrum
Sea Level Rise (SLR)	Long-term increase in mean sea level due to climate change and other factors.

UNITS AND SYMBOLS

Term	Definition
m	metres
m CGVD2013	metres relative to the Canadian Geodetic Vertical Datum of 2013
m/s	metres per second (wind speed)
S	seconds (wave period)
%	percent (exceedance probability)

1 INTRODUCTION

This appendix documents the coastal process analysis completed in support of the flood hazard mapping project for the lower Sunshine Coast. It provides the technical basis for estimating coastal flood and wave hazard conditions, including the development of still water levels and wave run-up used in inundation, Flood Construction Level (FCL), and wave effects mapping.

Coastal hazard parameters, including tide, storm surge, sea level rise, and waves, were assessed using observational data, empirical methods, and numerical models. These inputs support the mapping products described in the main report. The methods used to develop them are detailed below.

All mapping outputs are referenced to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), consistent with the vertical framework used throughout the project. Coastal design scenarios incorporate probabilistic water levels and sea level rise scenarios of 0.0, 0.5, 1.0, and 2.0 m. The 1.0 m scenario reflects provincial guidance for year 2100. The 0.5 m and 2.0 m scenarios were included to support evaluation across medium- and long-term planning horizons, as described in the main report.

Inundation mapping and wave modelling relied on a high-resolution Digital Elevation Model (DEM) compiled from 2019 provincial LiDAR, 2009 SCRD LiDAR, Canadian Hydrographic Service NONNA10 bathymetry, and the Canadian Medium Resolution DEM (MRDEM). These datasets were merged into a continuous elevation surface referenced to CGVD2013. Minor discontinuities may remain at the land–water interface due to dataset integration.

This appendix complements the main report by documenting the coastal hazard inputs, assumptions, and methods used to develop flood mapping products.

2 COASTAL HAZARD PARAMETERS AND DESIGN BASIS

This section provides detailed methods and assumptions for estimating each coastal hazard component used in flood mapping. These include tidal elevation, storm surge, sea level rise, and wave run-up. Each component was assessed using best-available data, empirical methods, and numerical models. Wind setup was also reviewed but excluded from mapped values due to its relatively minor contribution compared to wave run-up. All elevations are referenced to CGVD2013.

2.1 Still Water Level (Tide and Storm Surge)

Still water level refers to the elevation of the coastal water surface during a storm event, combining the predicted astronomical tide with storm surge. This value represents the baseline coastal water level prior to accounting for sea level rise, wave effects, or freeboard. Accurate estimation of still water level is critical for flood hazard mapping and provides the basis for each of the three mapping products developed in this study.

Tidal conditions in the study area are mixed semi-diurnal, featuring two high and two low tides of unequal amplitude each day. This pattern results from the interaction of multiple tidal constituents and is typical along the British Columbia coast. Mean tidal ranges are generally near 3 m, with spring ranges exceeding 4 m. These values establish the baseline onto which storm surge and wave effects are superimposed. However, tidal characteristics are not uniform across the study area. Variability in tidal amplitude and timing reflects local influences such as inlet geometry, coastal orientation, and bathymetric features, which can amplify or dampen tidal signals. As a result, local adjustments are required when applying regional tide data to site-specific flood mapping.

Storm surge refers to the temporary increase in water level above the predicted tide, caused by low atmospheric pressure and onshore winds during storm events. In the Strait of Georgia, storm surge typically ranges from 0.3 to 0.6 m with extreme events occasionally exceeding 1.0 m. These short-duration surges are superimposed on the tide and vary locally depending on wind direction, coastline geometry, and atmospheric conditions.

The design still water level is a statistical estimate of the still water level (tide plus storm surge) associated with a specified probability of exceedance. It represents the elevation expected to be reached or exceeded during a storm event with a given return period. Design still water levels were derived from historical water level data at the Point Atkinson tide gauge (Station ID: 7795), maintained by the Canadian Hydrographic Service (CHS), a division of Fisheries and Oceans Canada (DFO). This station provides a long-term dataset capturing both tidal variation and storm surge. A joint probability approach was used to estimate the 0.5% AEP (200-year) design still water level, which serves as the baseline for all mapping products in this study.

To apply results across the study area, design levels from Point Atkinson were adjusted at three local tide reference locations: Blind Bay (CHS Station ID07865), Porpoise Bay (CHS Station ID07852), and Gibsons (CHS Station ID07820). Figure 2.1 shows the geographic distribution of the four stations. These adjustments accounted for spatial variation in tidal range and datum, using published tidal datums from Fisheries and Oceans Canada's 2025 Canadian Tide and Current Tables (Volume 5). Offsets between Point Atkinson and the local stations were then applied to ensure regional consistency.

This approach allowed design conditions to reflect local tidal influences while maintaining a unified storm surge and sea level rise basis across the region.

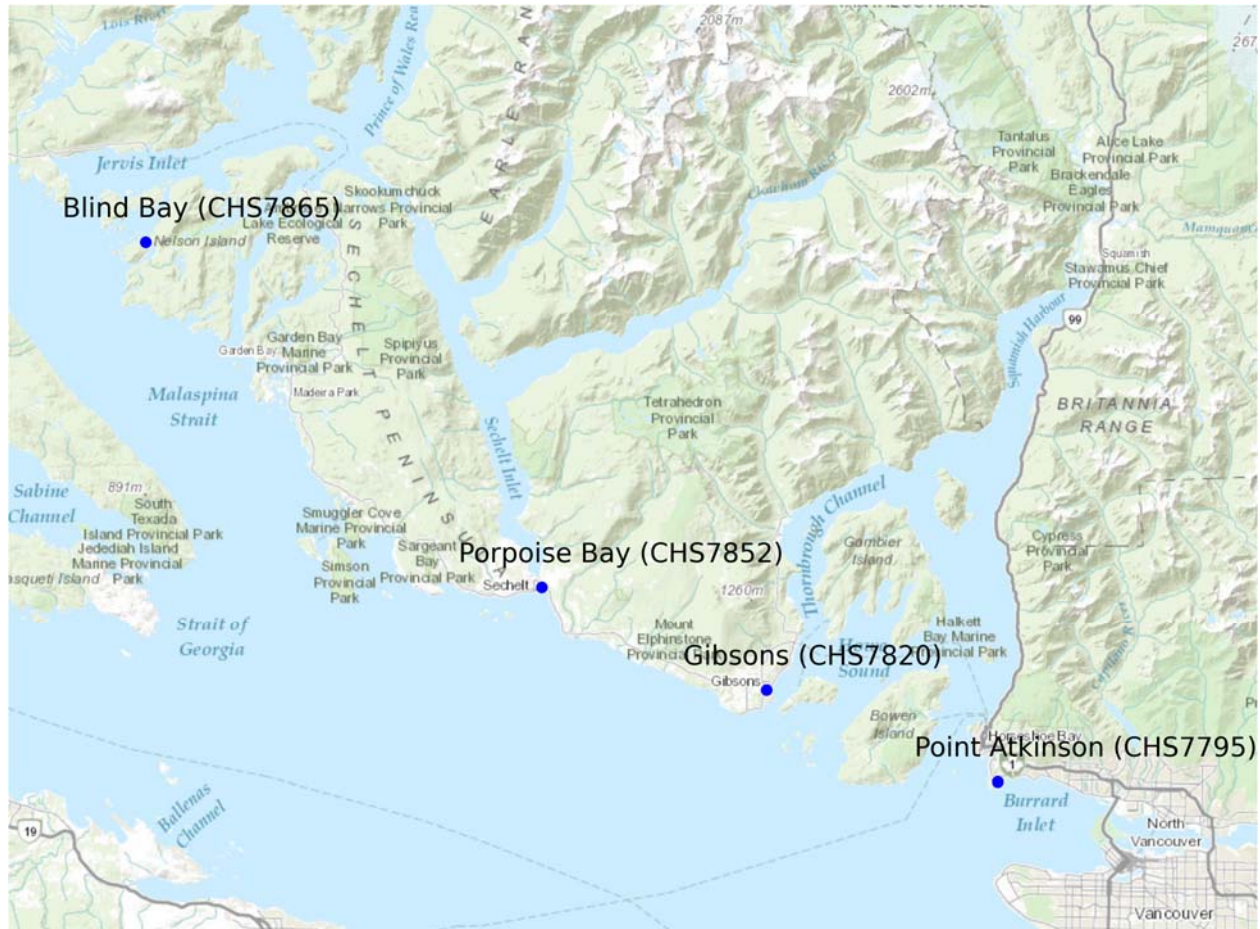


Figure 2.1 Tide reference station locations used for design level adjustment. Basemap source: © Esri.

Table 2.1 summarizes the 0.5% AEP design still water level at each reference location. These values represent present-day conditions, without sea level rise. As noted earlier, tidal ranges vary across the region due to local conditions. The notably lower elevation at Porpoise Bay is consistent with its location within Sechart Inlet, where tidal ranges are generally attenuated relative to more ocean-exposed sites.

Table 2.1 Adjusted 0.5%AEP (200-year) design still water levels at local reference stations (CGVD2013).

Location	0.5% AEP Design Still Water Level (m CGVD2013)	Region Cover
Blind Bay	3.31	Northern shoreline including Jervis Inlet and Egmont
Porpoise Bay	2.30	Sechelt Inlet and adjacent developed shoreline
Gibsons	3.02	Central and eastern shoreline from Gambier Island to just south of Irvine's Landing

2.2 Sea Level Rise

Sea level rise (SLR) scenarios were developed in consultation with the client to reflect a range of long-term planning horizons. Four scenarios were selected to represent plausible future conditions:

- 0.0 m – present day
- 0.5 m – medium term
- 1.0 m – long term
- 2.0 m – very long term

These scenarios are not tied to specific calendar years but are intended to support flexible application across multiple timeframes and policy contexts. The 0.5 m scenario was used in wave effects mapping to represent medium-term conditions and support adaptation planning. The 1.0 m scenario aligns with provincial guidance for planning to the year 2100 and was applied in the FCL mapping. The 2.0 m scenario represents a high-consequence, low-probability outcome intended to inform long-term planning in areas with critical infrastructure or land use decisions with extended design lives. It supports strategic planning beyond the 2100 horizon.

2.3 Design Still Water Levels for Inundation Mapping

The design still water levels used in inundation mapping were calculated by combining the 0.5% AEP still water level (Section 2.1) with each sea level rise scenario defined in Section 2.2.

These values represent projected flood elevations under future sea level conditions, excluding wave effects and freeboard. Table 2.2 summarizes the resulting still water levels at each reference location for the four SLR scenarios.

Table 2.2 Mapped still water levels used for inundation scenarios, based on 0.5% AEP (200-year) design still water levels plus sea level rise scenarios (CGVD2013).

Location	0.5% AEP Design Still Water Level (m CGVD2013)			
	SLR = 0.0 m	SLR = 0.5 m	SLR = 1.0 m	SLR = 2.0 m
Blind Bay	3.31	3.81	4.31	5.31
Porpoise Bay	2.30	2.80	3.30	4.30
Gibsons	3.02	3.52	4.02	5.02

2.4 Wave Effects

Wave effects refer to the contribution of waves to coastal flood hazard, expressed as an scenario above the still water level. These effects include nearshore wave generation, transformation, and wave run-up at the shoreline. When combined with still water level, wave effects contribute to the Total Water Level (TWL) that defines the extent and elevation of coastal flooding. Wave effects are most significant along exposed or steep shorelines, where run-up can substantially increase flood levels relative to the still water surface.

In this study, wave effects were included in two mapping products:

- **FCL Maps**, where wave run-up was added to the still water level and sea level rise, followed by a freeboard allowance. This total represents the recommended minimum building elevation for flood-resilient design.
- **Wave Effects Maps**, which illustrate the spatial extent of wave run-up beyond the inundation line for selected storm scenarios. These maps highlight where wave-driven flooding could impact shoreline areas under medium-term sea level rise conditions.

The following sections describe the input wind data, wave modelling approach, and empirical methods used to estimate wave run-up along the study shoreline.

2.4.1 Wind Input and Wave Modelling

Wind-generated waves are the primary contributor to wave activity in the Strait of Georgia. Local wave conditions are influenced by regional wind patterns, fetch length, nearshore bathymetry, and shoreline orientation. During storm events, persistent onshore winds generate waves that can induce wave run-up and overtopping at the shoreline, potentially leading to flood damage.

To simulate these conditions, wave modelling was carried out using design wind inputs representative of coastal exposure across the study area. For each scenario, a constant wind speed and direction was applied across the Strait of Georgia and Central modelling domains,

based on observed relationships between offshore buoy data and local exposure. The Halibut Bank wave buoy (Environment and Climate Change Canada ID 46146), located offshore in the Strait of Georgia, was the primary reference for most of the study area. For more sheltered portions of Howe Sound, including the area extending from Langdale to McNab Creek via the eastern and western shores of Gambier Island, wind records from Pam Rocks (Environment and Climate Change Canada station ID 10459NN) were reviewed to better reflect local exposure conditions. For northern regions of the study area and portions of Sechelt Inlet, reliable long-term wind data were not available. In these areas, wind speeds were estimated using regional design values from the BC Building Code (BC Ministry of Housing, 2024). The locations of Halibut Bank and Pam Rocks stations are shown in Figure 2.2.

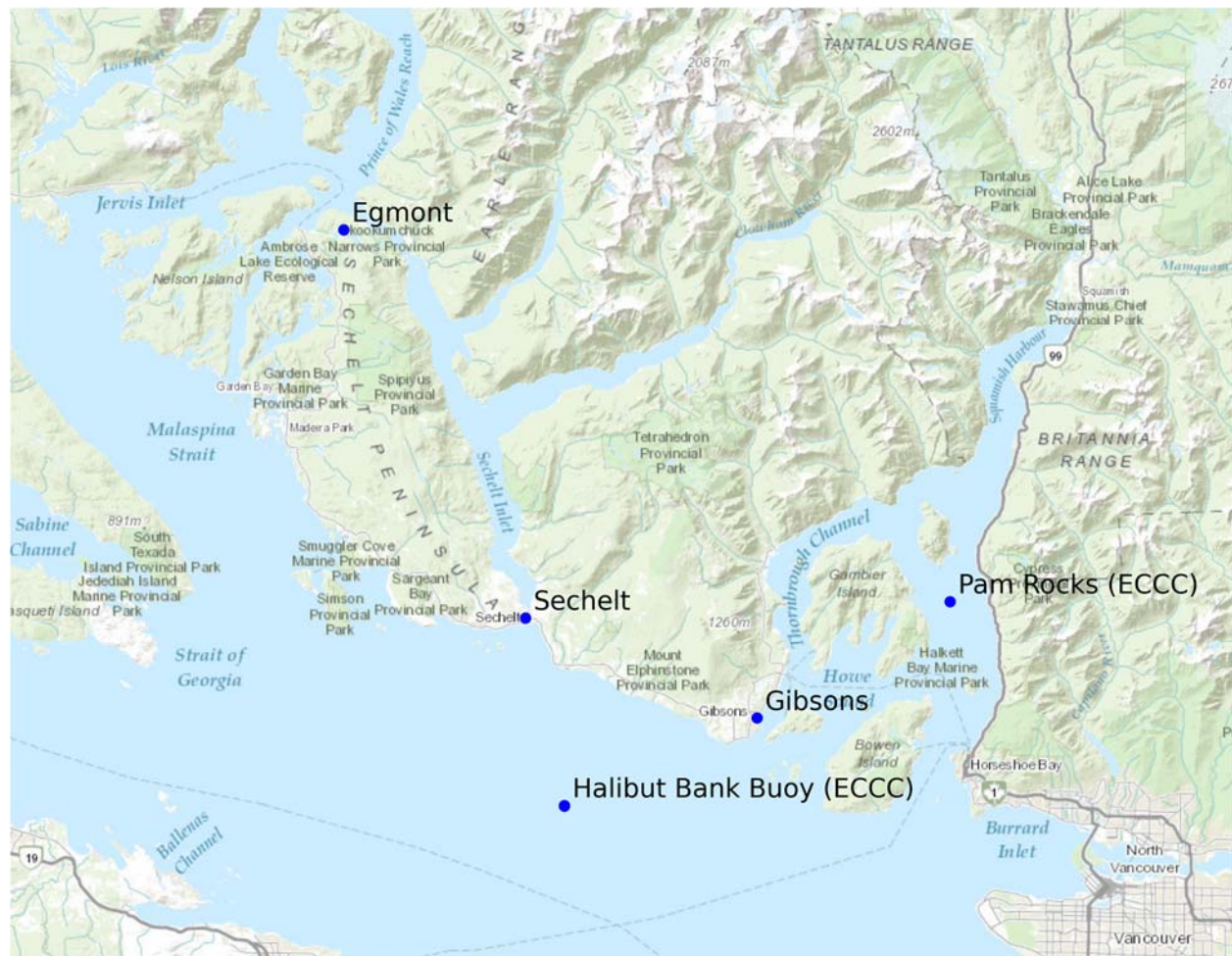


Figure 2.2 Locations of Halibut Bank and Pam Rocks stations. Basemap source: © Esri

Wind records were screened for directionality and storm persistence to define representative scenarios for 2%, 1%, and 0.5% AEP storm events. These design wind conditions were then used

as input to the SWAN (Simulating WAVes Nearshore) model, a numerical model used to simulate wave generation, propagation, and transformation in nearshore environments.

The model domain was developed using a digital elevation model (DEM) based on NONNA10 bathymetric data. Given the large spatial extent of the study area and the complexity of the shoreline, with many sections exposed to winds from multiple directions, simulations were run for a range of wind directions to ensure the largest potential wave conditions were captured.

To support wave modelling across the region, four model grids were developed. A coarse grid covering the Strait of Georgia at 500 m resolution captured regional wave conditions. Two finer nested grids at 100 m resolution, covering the central and eastern Sunshine Coast, received boundary conditions from the coarse model. Two additional 100 m resolution grids, covering the Sechelt region and the northern shoreline, were developed as standalone models due to their limited exposure to open Strait conditions. The extents of all four grids are shown in Figure 2.3.

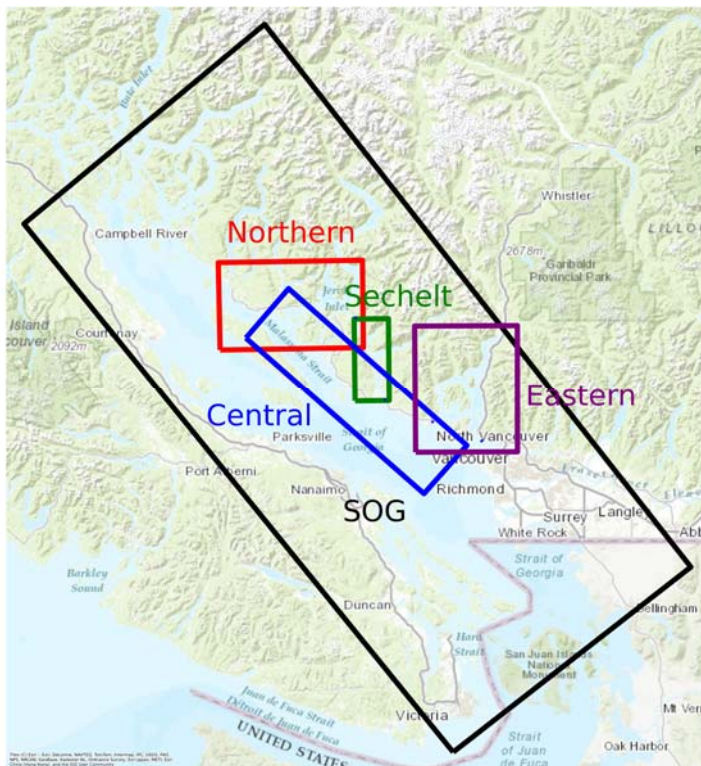


Figure 2.3 SWAN model grid extents, including the 500 m regional grid and four 100 m resolution grids for Northern, Sechelt, Central, and Eastern shoreline regions.

Significant wave height (H_s) and peak wave period (T_p) were extracted from SWAN results at selected cross-shore transects and used as inputs to empirical wave run-up calculations (Section 2.4.2). Figure 2.4 shows a representative example of SWAN model output illustrating spatial

variation in significant wave height across the study area during a northwesterly storm event. Colour contours indicate H_s magnitude, while vectors show wave direction

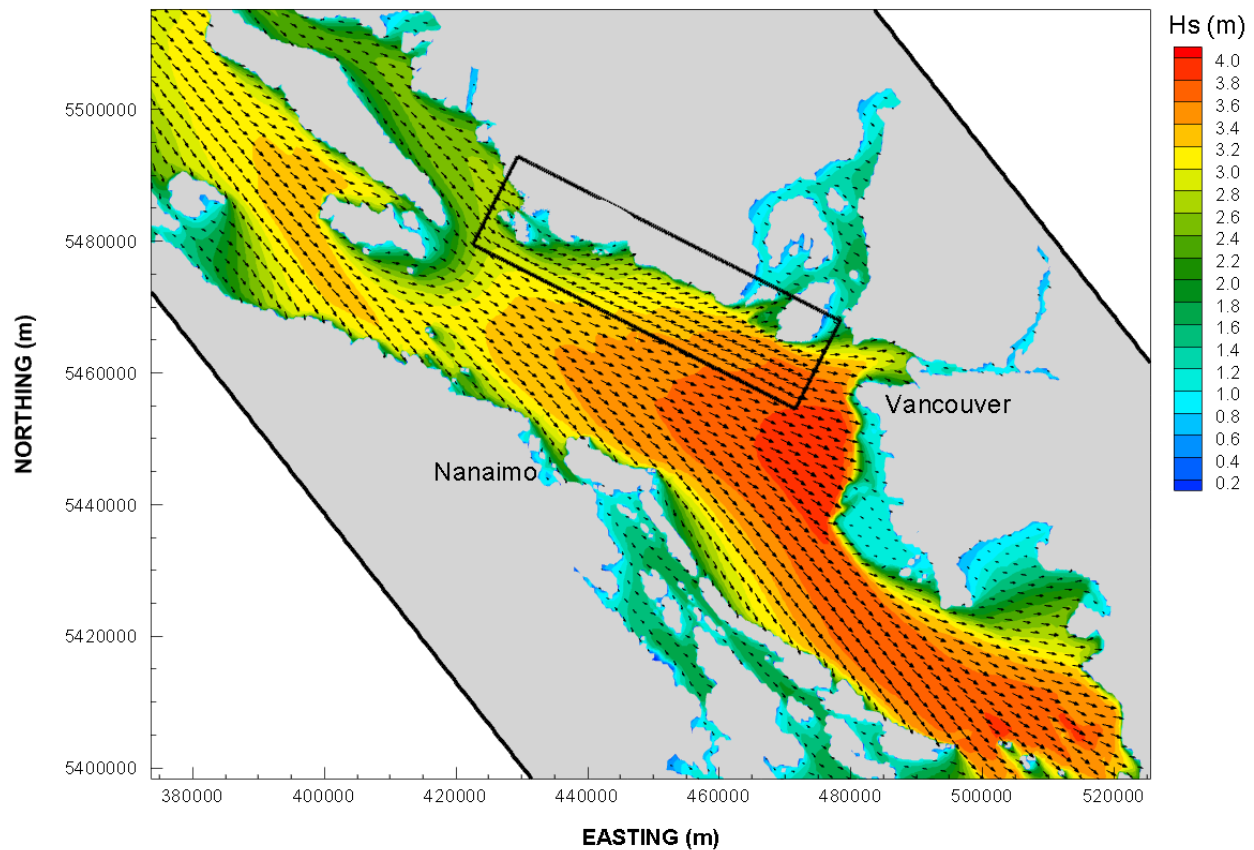


Figure 2.4 Example of SWAN model output showing significant wave height (H_s) distribution across the Sunshine Coast study area.

2.4.2 Wave Run-up Estimation

Wave run-up is the elevation reached by waves on a shoreline or structure above the still water level, resulting from the combined effects of wave set-up and uprush. It can occur with both breaking and non-breaking waves. In this study, run-up is expressed as $R_{2\%}$, the level exceeded by 2% of incident waves, which provides a standard measure of extreme run-up. Wave run-up is an important factor in evaluating coastal flood hazard, particularly along exposed or steep shorelines. While it does not affect the design still water level used in inundation mapping, it is a critical component in estimating total flood levels for wave effects mapping and for establishing FCLs.

Run-up was estimated along cross-shore transects distributed throughout the study area at approximately 250 m spacing. Each transect incorporated local beach slope, shoreline

composition, and nearshore wave conditions derived from SWAN model output. Two empirical methods were used:

- EurOtop (2018) method, suitable for both engineered and natural sloping shorelines.
- Stockdon et al. (2006) method, commonly applied to natural, dissipative sandy beaches.

These methods estimate the two-percent exceedance run-up elevation ($R_2\%$), representing the elevation exceeded by only 2% of incoming waves during a storm event. SWAN output parameters, including H_s and T_p , were used as inputs to the run-up equations, along with beach slope data from each transect.

The resulting $R_2\%$ values were added to the design still water level (plus sea level rise, where applicable) to calculate the Total Water Level (TWL). These combined levels were used to generate the wave effects maps and to develop FCLs.

3 FLOOD CONSTRUCTION LEVEL

The FCL represents the recommended minimum building elevation for coastal areas to reduce the likelihood of damage during extreme water level events. It is defined as the combination of several components that together represent the design coastal flood elevation under future conditions.

The FCL approach is based on the probabilistic method outlined in the Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use (BC Ministry of Environment, 2011) and the 2018 amendment by the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BCMFLNRORD). It is based on a 0.5% AEP (200-year) coastal event, consistent with provincial planning guidance.

As illustrated in Figure 3.1, the FCL is composed of:

- 0.5% AEP still water level, derived from joint tide and storm surge analysis (Section 2.1)
- Sea level rise allowance, with 1.0 m applied for conditions to 2100 (Section 2.2)
- Wave run-up, based on two-percent exceedance estimates from SWAN model outputs (Section 2.4.2)
- Wind setup, reviewed but not included due to minor contribution (Section 2)
- Freeboard, an additional allowance of 0.6 m applied to account for uncertainty and localized effects

Each component was assessed using best-available data and methods, as detailed in Section 2. The resulting FCL values represent total flood levels expected under a 200-year event combined with projected sea level rise and wave effects to the year 2100.

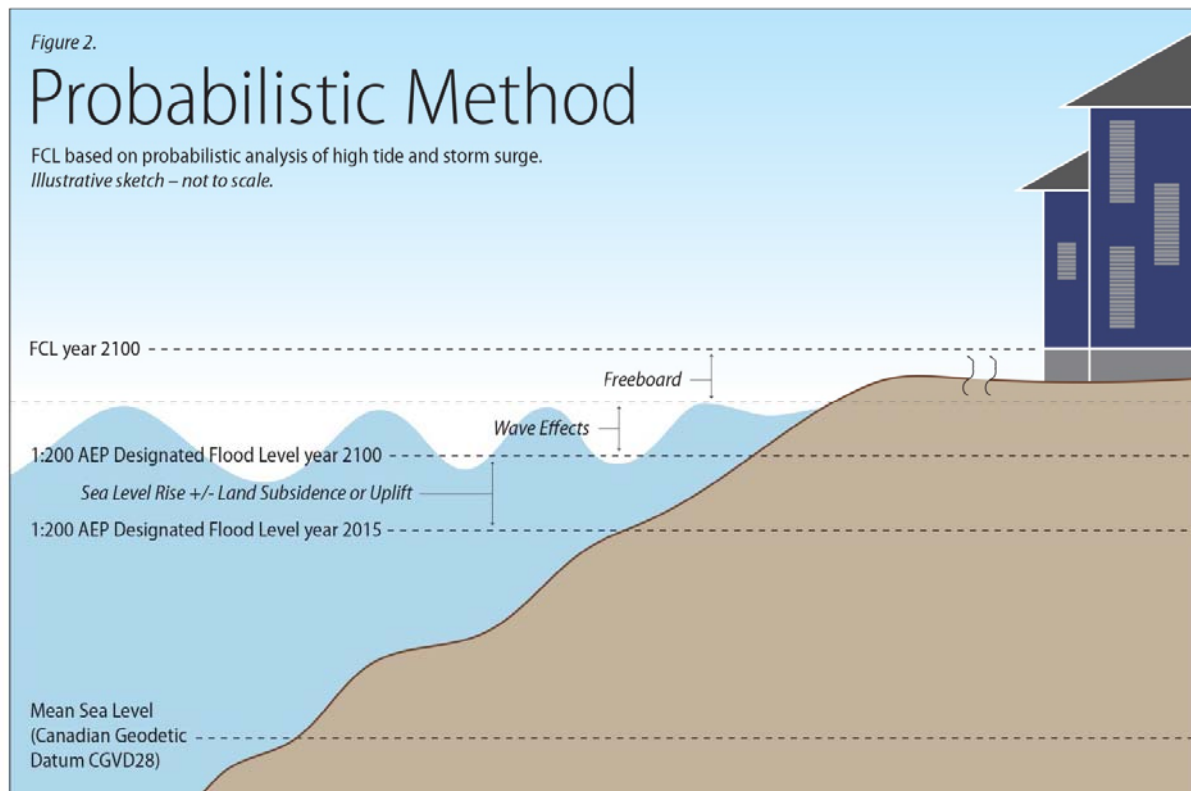


Figure 3.1 Components of FCL (adapted from BCMFLNRORD, 2018)

4 APPLICATION TO MAPPING PRODUCTS

This section summarizes how the coastal hazard parameters described in Section 2 were applied to the three mapping products developed for the study: Inundation Maps, FCL Maps, and Wave Effects Maps. These products are presented in the main report and support land use planning, development regulation, and adaptation planning.

All mapping products were derived using the CGVD2013 vertical datum and relied on a merged digital elevation surface compiled from LiDAR and hydrographic data sources, as described in the introduction.

- **Inundation Maps** show projected flood extents for 0.5% AEP still water levels combined with four sea level rise scenarios (0.0, 0.5, 1.0, and 2.0 m). These maps exclude wave effects and freeboard. See Sections 2.1–2.3 for input assumptions.
- **FCL Maps** identify recommended minimum building elevations. Each FCL includes the 0.5% AEP still water level, a 1.0 m sea level rise allowance, wave run-up, and 0.6 m of freeboard. See Section 3 for a detailed summary of how these were combined.
- **Wave Effects Maps** delineate inland extent of wave run-up for selected storm events under a 0.5 m sea level rise scenario. They represent areas where wave-driven processes may increase flood hazard beyond the still water level. See Section 2.4 for details.

Each mapping product applies specific input combinations to address distinct aspects of coastal flood risk. Further description of the maps and their interpretation is provided in the main report.

5 LIMITATIONS AND USE CONSIDERATIONS

The inundation, FCL and wave effects mapping results are subject to the following limitations:

- **Transect representation:** Cross-shore transects were selected to represent typical shoreline conditions across the study area. However, foreshore characteristics can vary between transects. Interpretation is required when applying run-up estimates to properties located between mapped segments.
- **Wind data uncertainty:** In the northern region and Sechelt Inlet, long-term site-specific wind data were not available. Wind inputs in these areas were based on regional design values, which may not fully reflect local exposure conditions.
- **LiDAR coverage and accuracy:** Gaps in LiDAR coverage exist, particularly in nearshore and vegetated areas. In regions without reliable LiDAR, the Canadian Medium Resolution DEM (MRDEM) was used as a substitute, which may reduce elevation accuracy. Additionally, vertical errors in LiDAR can affect terrain representation and run-up estimates.
- **DEM integration artifacts:** Merging of terrestrial LiDAR and marine bathymetric data may result in elevation discontinuities at the land–water interface.
- **Static shoreline assumption:** The analysis assumes a fixed shoreline and does not account for future erosion, sediment transport, or other dynamic coastal processes that could affect flood exposure over time.

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APPENDIX B

COASTAL GEOMORPHIC ASSESSMENT





Photo source: Northwest Hydraulic Consultants

Sunshine Coast Coastal Flood Hazard Mapping

Appendix B – Coastal Geomorphic Assessment

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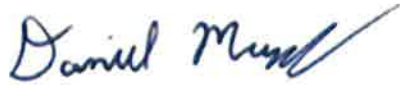
August 18, 2025
Final Report, Rev. R1

NHC Reference No. 3008737

DOCUMENT TRACKING

Date	Revision No.	Reviewer	Issued For
May 2025	R0	P Osborne	Draft
August 2025	R1	P Osborne	Final

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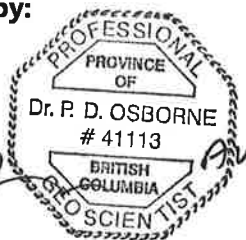


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DISCLAIMER

This report has been prepared by Northwest Hydraulic Consultants Ltd. for the benefit of Sunshine Coast Regional District, District of Sechelt, Town of Gibsons, and Island Trust. The report documents the geomorphological assessment and development of a Coastal Vulnerability Index (CVI), undertaken to support the Sunshine Coast Coastal Flood Hazard Mapping project. The information and data contained herein represent Northwest Hydraulic Consultants Ltd.'s professional judgment in light of the knowledge and information available to Northwest Hydraulic Consultants Ltd. at the time of preparation and were prepared in accordance with generally accepted engineering and geoscience practices.

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ABBREVIATIONS

Acronym / Abbreviation	Definition
CVI	Coastal Vulnerability Index
Lidar	Light Detection and Ranging
NHC	Northwest Hydraulic Consultants
SCRD	Sunshine Coast Regional District

GLOSSARY

Term	Definition
ArcGIS Pro	Geographic information software developed by ESRI to visualize, analyze and compile spatial data.
Backshore	The beach zone above high tide, typically supratidal, experiences runup only during storms.
Bluff	Hill with steep shoreline slope made up of compacted soil or sedimentary rock.
Coastal Accretion	Accumulation of sediment on the beach due to continuous net deposition, resulting in a (vertical or horizontal) buildup of the beach zone.
Coastal Erosion	The loss or displacement of land, or the long-term removal of sediment and rocks along the coastline due to the action of waves, currents, tides, waterborne ice, or impacts of storms.
Deposition	The process by which sediment settles, or is added to a beach and its surroundings.
Erosion	Breakdown and transport of soil and rock by water, wind, or ice (Ministry of Water, Lands and Resource Stewardship, 2024).
Foreshore	The beach zone below high tide, typically intertidal and is inundated at high tide.
Geomorphic processes	In the context of coastal geomorphology, these are any processes that influence beach morphology, primarily including erosion and deposition.
Geomorphology	The study of landforms and the processes that cause and alter landforms.

Term	Definition
Hazard	A process or phenomenon that may cause adverse environmental, social and economic impacts. Hazards can be characterized by their location, intensity or magnitude, frequency and probability (UNDRR, 2017).
Hydro-physical processes	Hydrologically-driven processes that influence coastal geomorphology.
Longshore Transport	The movement of beach sediment, specifically sand, downcoast due to nearshore waves moving at oblique angles to the shoreline (Kahl et al., 2024).
Nearshore	The beach zone that extends from where waves break to low water level, experiencing most of the breaking waves.
Offshore	The area seaward and beyond where waves break.
Pocket beach	Isolated beach with headlands on each extent and curved planform with little to no sediment exchange with adjacent shorelines.
Risk	The potential adverse impacts of an event or process on society, or factors of human settlement, including life and infrastructure, in a specific period of time. Risk is determined probabilistically as a function of hazard, exposure, vulnerability and capacity (UNDRR, 2017).
Shoreline	General term for the boundary between land and ocean, commonly defined at the high-water mark.
Stream magnitude	The number of tributaries that contribute to a stream.
Surf parameter	Dimensionless parameter used to describe breaking wave types on beaches and coastal structures as spilling (<0.5), plunging (0.5 - 2.5) or collapsing/surging (>2.5).
Tributary	A river or stream flowing into a larger river or lake.
Vulnerability	Conditions that increase the susceptibility of an individual, community, asset or system to the impacts of hazards. Vulnerability can be influenced by physical, social, economic and environmental factors or processes (UNDRR, 2017).

1 INTRODUCTION

This report presents the geomorphic assessment and Coastal Vulnerability Index (CVI) mapping performed as part of the coastal flood mapping project for the Sunshine Coast Regional District (SCRD). The geomorphic assessment includes a review of the sediment and bedrock as well as rivers in the project area, observations from the field visit, and CVI classification methods and results.

There is limited direct monitoring of coastal change in the SCRD. In such cases, it is appropriate to use an indicator metric such as the CVI to provide initial insight regarding erosion hazard potential. The CVI was used as a tool to assess the coastal erosion hazard and highlight areas where shoreline sensitivity or potential instability may influence long-term exposure to coastal hazards. This desktop-based assessment was supported by a limited field visit to verify shoreline characteristics in priority areas. The CVI combines selected physical attributes, such as beach composition and slope, with hydro-physical processes, such as exposure to wave energy to provide a relative measure of the erosion hazard along the coast. This assessment focuses on the analysis of the erosion hazard for the study area and not erosion risk.

The final product of this assessment is an assigned CVI rank of low, moderate, or high for each mapped segment of shoreline. Section 5 provides field examples of each of these rankings within the project area, and statistics on the occurrence of different shoreline conditions.

2 BACKGROUND REVIEW AND DATA COLLECTION

The background review includes data from existing studies, including surveys, maps, lidar and air photos. Additional data and site observations for this study were collected during a site survey conducted by NHC on September 16, 2024.

A number of public and private data sources were compiled and reviewed as part of this background review. These data sources were used as part of the coastal erosion and flood hazard assessment. The data sources include:

- Topographic Data from the GeoBC Data Portal. Specifically, the LiDAR data which was collected between 2018 and 2019 (Government of British Columbia, 2019).
- Topographic Data from a 2009 Lidar survey provided by SCRD.
- Orthoimagery collected in 2014, 2018 and 2021 provided by SCRD.
- Oblique Imagery collected by Shore Zone in 2020 (Shore Zone, 2004).
- Delineated shoreline from the BC Freshwater Atlas provided by SCRD for the purpose of the CVI mapping.

3 METHODOLOGY

A coastal vulnerability index (CVI) accounts for a range of physical attributes and hydro-physical processes known to influence coastal vulnerability and erosion. CVI's are used in cases where shoreline change from direct monitoring of coastal change is limited, as it can function as an indicator metric to provide initial insight regarding erosion hazard potential (VanZomeren and Acevedo-Mackey, 2019) and shoreline dynamics in response to storms. CVI assessments can also include social, cultural, and economic indicators; however, a physically-based vulnerability index is suitable for an erosion hazard assessment.

This section presents the criteria used to assess each variable that was included in the coastal vulnerability index mapping. NHC assigned each of the physical and hydro-physical variables a CVI score according to their relative erosion vulnerability – 0 for low vulnerability, 1 for moderate vulnerability, and 2 for high vulnerability. The assigned vulnerabilities are based on associative understandings of geomorphic processes, rather than well-defined empirical relationships between the variables and hazard scores. The total CVI rank is the sum of each variable score for that distinct segment of shoreline.

3.1 Physical attributes

Beach composition, shoreline morphology, shoreline protection, and foreshore slope are assessed as physical attributes influencing coastal vulnerability. For the purpose of this assessment, backshore refers to attributes located landward of the high tide level and foreshore refers to the beach zone below the high tide level (Figure 3.1). Table 3.1 describes the CVI scores assigned to the physical attribute variables to indicate their relative erosion vulnerability. Beach composition, shoreline morphology and shoreline protection were mapped using available imagery and topographic lidar data. Foreshore slope was computed during flood modelling completed by NHC.

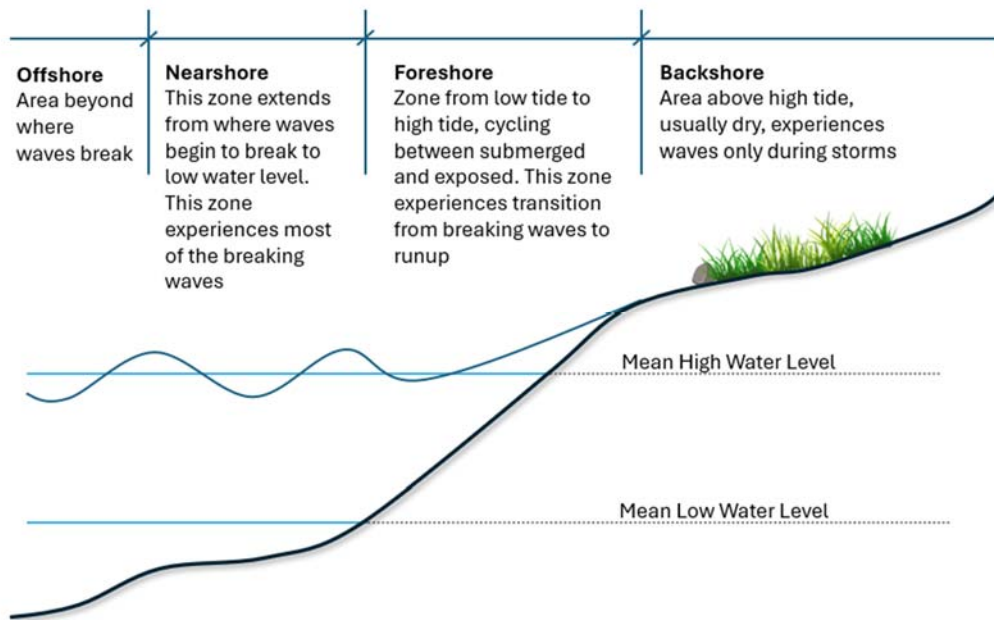


Figure 3.1 Definition sketch of beach zones (NHC, 2025).

Table 3.1 CVI scoring of coastal physical attributes.

Physical Attribute	CVI Score	Assessment Characteristics
Beach composition	0	Beach material is predominately comprised of bedrock or has been engineered.
	1	Beach material is predominately comprised of coarse sediments, including shallow discontinuous bedrock, boulders and cobbles, though minor components of gravel and sand may be present.
	2	Beach material is predominately comprised of fine sediments, including sand and gravel, though cobbles and boulders may be scattered.
Shoreline protection	0	Shoreline is protected by a continuous seawall, revetment, or riprap.
	1	Shoreline is protected by a discontinuous seawall, revetment, timber wall, or riprap.
	2	Shoreline is natural with no anthropogenic protection.
Shoreline morphology	0	Shoreline is composed of bedrock or an anthropogenic structure (e.g., ferry terminal, lumber processing facility, jetty, etc.).
	1	Shoreline exhibits a backshore bluff, pocket beach (foreshore), lagoon (foreshore), mixed bedrock or a has a steep backshore
	2	Shoreline is characterized by a foreshore tidal flat, delta or a low slope backshore.
Foreshore slope	0	Foreshore slope is greater than 50% (2H:1V, or steeper)
	1	Foreshore slope is between 20% and 50% (2H:1V to 5H:1V)
	2	Foreshore slope is less than 20% (less than 5H:1V)

3.1.1 Beach composition

Beach composition influences resistance to erosion. Igneous and metamorphic bedrock are relatively resistant to erosion - with variations depending on lithology and relative mineral hardness – while unconsolidated sediments are more vulnerable to erosion. Fine sediments are the most easily weathered (VanZomerén and Acevedo-Mackey, 2019). Beach composition is divided into three classes of increasing vulnerability: bedrock and engineered, coarse sediment, and fine sediment. Coarse sediment refers to shallow discontinuous bedrock, boulders and cobbles, though some gravel and sand may be present. Fine sediment refers to sand and gravel, though cobbles and boulders may be scattered.

3.1.2 Shoreline protection

Similar to beach composition, anthropogenic shoreline protection features can influence a shoreline's resistance to erosion. For present day and near-future conditions protected shorelines may erode slower than natural shorelines located in areas of high erosion potential. However, shoreline protection requires routine maintenance and upgrades for continued protection. NHC classified shoreline protection as continuous, discontinuous, or unprotected which generally refers to a natural shoreline.

3.1.3 Shoreline morphology

Coastal landforms have varying erodibility potential, determined by the composition and shape of the landform (VanZomerén and Acevedo-Mackey, 2019). NHC mapped shoreline morphology as bedrock, anthropogenic (e.g., ferry terminal, lumber processing facility, jetty, etc.), bluff, pocket beach, lagoon, mixed bedrock, delta, tidal flat. Hardened morphologies such as bedrock or anthropogenic structures are interpreted to be the least vulnerable to erosion, while more dynamic morphologies such as deltas and tidal flats are interpreted to be the most vulnerable. When a shoreline segment did not fit any of the outlined morphologies above, the backshore gradient was observed using aerial imagery and available lidar to differentiate between a steep or low backshore area. For the purpose of this study, low backshores were interpreted to be more vulnerable to erosion.

3.1.4 Slope

Low slope coastal regions are typically considered a higher hazard for inundation and land loss than high slope regions such as bluffs (VanZomerén and Acevedo-Mackey, 2019). Sea level rise has the potential to cover more lateral distance on a low slope shoreline than a high slope shoreline. As such, steep shorelines are considered as relatively lower vulnerability when considering the lateral shoreline migration potential and erosion hazard. NHC calculated foreshore slope along shore perpendicular transects within the wave effect zone. This length of transect is on average sufficient to characterize the foreshore slope. Slopes were classified based

on the percent grade of the foreshore with the following bins ranking from low to high vulnerability: greater than 50%; 20% to 50%; less than 20%.

3.2 Hydro-physical processes

Incident wave height and surf parameter are assessed as hydro-physical processes influencing coastal erosion vulnerability. Table 3.2 describes the CVI scores assigned to the hydro-physical process variables based on their relative erosion vulnerability. The wave height and surf parameters are based on the flood modelling completed by NHC (see Appendix A).

Table 3.2 CVI scoring of coastal hydro-physical processes.

Hydro-physical Process	CVI Score	Assessment Characteristics
Incident Wave Height	0	Incident wave height is between 0 m and 1 m
	1	Incident wave height is between 1 m and 1.5 m
	2	Incident wave height is greater than 1.5 m
Surf Parameter	0	A surf parameter is less than 0.5, represents spilling
	1	A surf parameter is between 0.5 and 2.5, represents plunging
	2	A surf parameter is greater than 2.5, represents collapsing/surging

3.2.1 Wave height

Wave height is a proxy for wave energy – the driving force for sediment mobilization, governing erosion and deposition (VanZomeren and Acevedo-Mackey, 2019). NHC assigned modelled significant wave height point values to each shoreline segment. To assign a significant wave height to each shoreline segment a search for the closest model point within 250 m of each shoreline segment was completed and the maximum significant wave height was assigned to the shoreline segment. Due to the arrangement of the significant wave height point data, there were some shoreline segments that required a wave height to be manually assigned following the same rationale outlined above. Significant wave heights were binned and assigned a CVI score as follows: low - 0 to 1 m; moderate - 1 to 1.5 m; high greater than 1.5 m.

3.2.2 Surf parameter

Similar to wave heights, NHC assigned modelled surf parameter point values to each shoreline segment. To assign a surf parameter to each shoreline segment, a search for the closest point within 250 m of each segment was completed, and the maximum surf parameter was assigned to the shoreline segment. Due to the arrangement of the surf parameter point data, there were some shoreline segments that required a surf parameter to be manually assigned following the same rationale outlined above. Surf parameter values were binned from low to high CVI as follows: spilling - less than 0.5; plunging - 0.5 and 2.5; collapsing/surging - greater than 2.5.

4 COASTAL GEOMORPHIC ASSESSMENT

In Section 4, NHC characterizes Sunshine Coast surficial sediment and bedrock geology (Section 4.1) and presents the findings of the geomorphic site assessment based on the site survey that was performed in 2024 (Section 4.2), and a qualitative assessment of river and coast interactions based on the available orthoimagery within the project area (Section 4.3).

4.1 Sediment and Bedrock Characterization

The study area is situated in the Georgia Lowland, which was shaped by glacial ice during the periods of glaciation throughout the Pleistocene (McCammon, 1977). Bedrock geology on the Sunshine Coast is generally composed of intrusive igneous rocks with smaller areas of volcanic and sedimentary rocks present (Cui et al., 2019). Offshore, north and south Thormanby Islands are entirely composed of basaltic volcanic rocks (Figure 4.1). To the north, northeast of Gibsons on the mainland Sunshine Coast and offshore, Keats and Gambier Islands, are composed of sedimentary rocks (Figure 4.1).

During the Holocene, as glacial ice retreated, isostatic adjustments resulted in local land and sea level fluctuations. As a result, sea levels on the Sunshine Coast are estimated to have been up to 180 meters above the present day level as indicated by marine deposits and deltas (McCammon, 1977). However, following isostatic adjustments, sea levels stabilized and reached levels similar to present approximately 6,000 years ago (Earle, 2002).

Surficial geology of the lower Sunshine Coast shoreline is generally composed of Capilano fluvial deposits and Salish sediments as mapped by McCammon (1977). Capilano fluvial deposits were deposited during the Holocene following glacial retreat, under a different hydrologic regime, and are composed of sands and gravels which form alluvial fans such as the relic Chapman Creek fan (McCammon, 1977). Salish sediments are materials that have deposited since sea levels stabilized approximately 6,000 years ago (Earle, 2002). These sediments include silt, sand and gravel found in modern stream channels and deltas, and sand-gravel deposits found on modern beaches (McCammon, 1977). Frequent bedrock rock exposures along the mainland coast suggest that the surficial sediment deposits are shallow (McCammon, 1977).

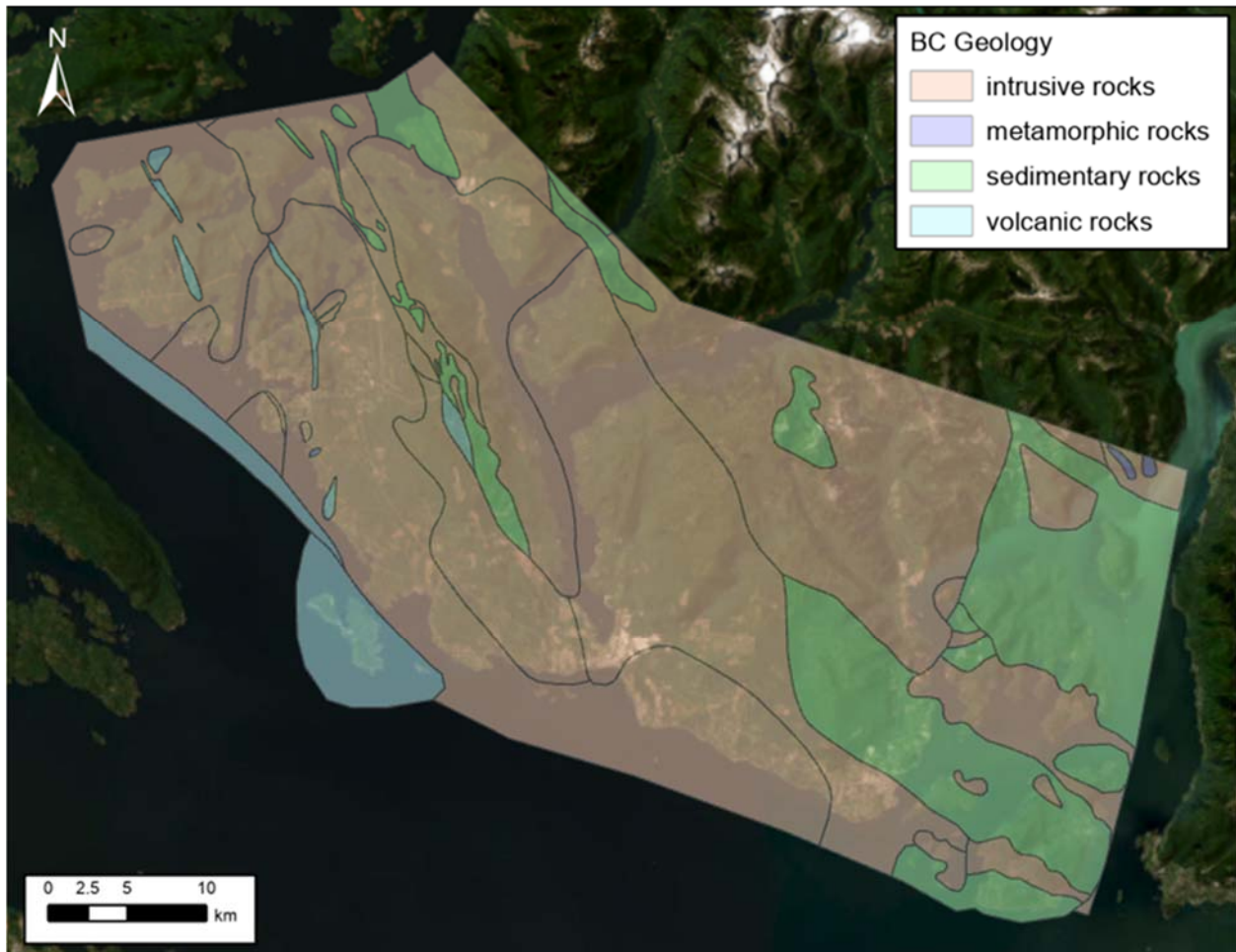


Figure 4.1 Bedrock geology of the Sunshine Coast.

4.2 Geomorphic Site Assessment

An interpretive geomorphic assessment was conducted by NHC on September 16, 2024. The assessment covered six sites within the project area (Figure 4.2). These sites were selected based on input from SCRD and an initial desktop review of the existing datasets. During the site surveys, photos and observations were collected and key areas of the site were mapped using high precision Real Time Kinematic (RTK) GPS equipment to confirm beach profiles.

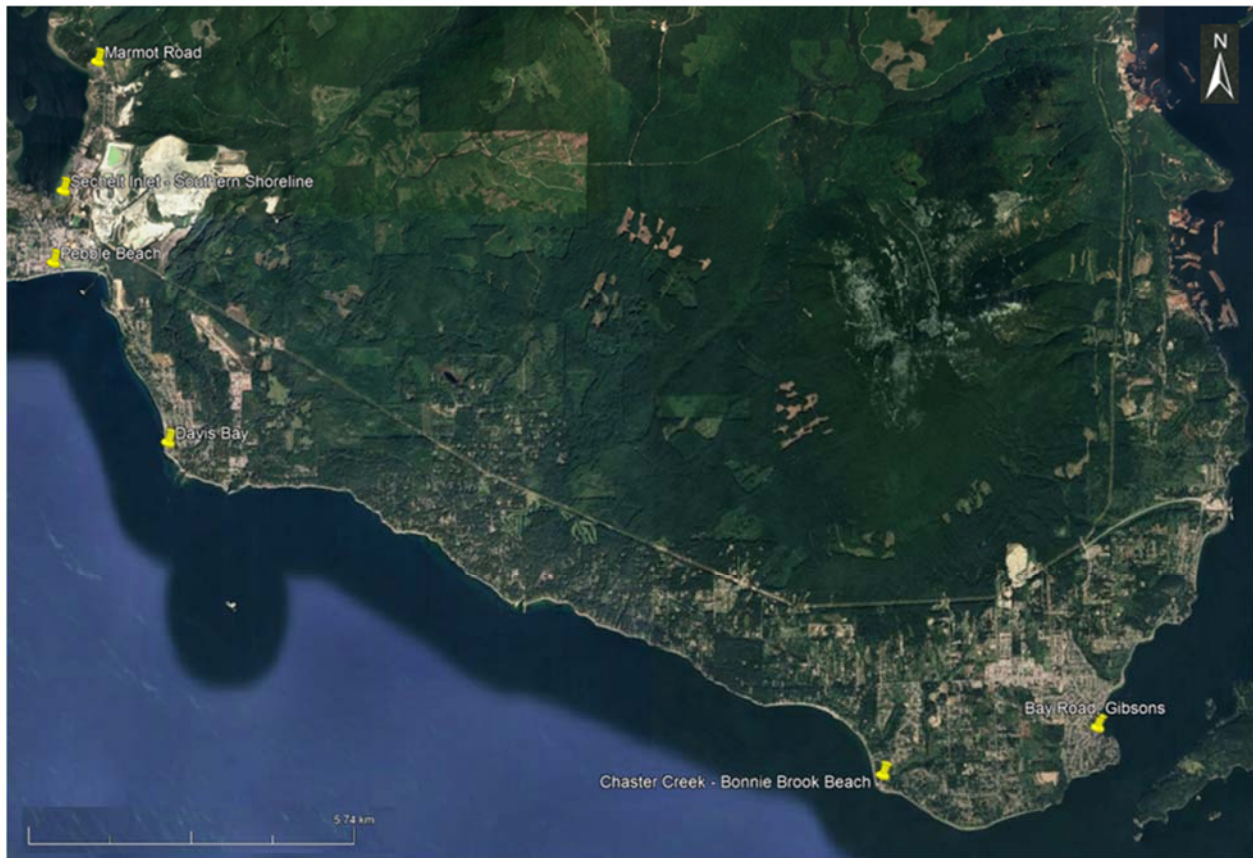


Figure 4.2 Site visit locations. Imagery source: Google Earth.

4.2.1 Sechelt Inlet: Marmot Road

Marmot Road Bay is situated on the eastern shoreline of Sechelt Inlet approximately 2.5 km to the northeast of the southern inlet extent. A small tributary drains onto a low gradient tidal flat to the North of a spit feature (Photo 1). To the south of the spit, a similar shoreline morphology is observed with numerous drainage channels on a mudflat. Residential shoreline protection features (e.g., seawall, rip rap) were observed on the margin of numerous residential properties along and to the south of Marmot Road (Photo 2).



Photo 1 Shallow sloping mudflats present on the eastern shoreline of Sechelt Inlet near Marmot Road.



Photo 2 Shoreline protection features observed near Marmot Road.

4.2.2 Sechelt Inlet: Southern Shoreline

The southern shoreline of the Sechelt Inlet from Halfmoon Sea Kayaks to Sechelt Marsh was assessed during the site visit. During the site visit no apparent signs of shoreline erosion were observed. Shoreline protection was present along numerous sections in this area, examples are the riprap and revetments shown in Photo 3. On the tidal flat northeast of Sechelt Marsh, a drainage channel originating from the marsh flows across a low-gradient tidal flat. Sechelt Marsh is likely prone to inundation with sea level rise. Vegetation is generally absent from the shoreline.



Photo 3 Shoreline protection features on the southern shoreline of Sechelt Inlet.

4.2.3 Sechelt Ocean: Pebble Beach

Pebble Beach is situated on the Strait of Georgia at the southern extent of Sechelt. There is a revetment and lock-block seawall along the Pebble Beach shoreline (Photo 4). The revetment and seawall and boardwalk are elevated above the foreshore and slope down towards the north. The backshore is developed with commercial and residential properties and as a result there is little vegetation/forest cover present. At the base of the seawall there is substantial woody debris accumulation (Photo 4). The beach slope reduces from west to east along the shoreline based on the elevation points collected during the site survey (Photo 4). Consistent with the change in slope, a change in grain size from gravel to sand and gravel was observed from west to east on the beach (Photo 4).



Photo 4 The western (left) and eastern (right) extents of Pebble Beach.

4.2.4 Davis Bay

Davis Bay is situated approximately 4 km to the southeast of Sechelt. The Chapman Creek river mouth and prograding delta are a distinguishing characteristic of this location. The Sunshine Coast Highway runs parallel to the shoreline, which is lined with a revetment (Photo 5). Residential and commercial infrastructure is adjacent to the highway on the east. At the base of the seawall there is riprap in place (Photo 5). In some locations, the riprap appears to have been displaced, likely due to wave action at high water levels (Photo 5). Large woody debris is also present along the toe of the seawall (Photo 5).



Photo 5 Davis Bay seawall and displaced riprap, indicative of high wave exposure. (left).

4.2.5 Chaster Park – Bonnie Brook Beach

Bonnie Brook beach is situated approximately 4 km to the west-southwest of Gibsons. There is generally an upward cross-shore fining trend in grain-size where cobble-gravel sized material is found on the lower foreshore which grades to sand-gravel in the upper foreshore (Photo 6). Woody debris accumulation is present along the shoreline (Photo 6). The backshore of the beach rapidly changes from coastal vegetation to forest. Residential establishments are close to the vegetated shoreline. Chaster Creek river mouth and delta protrudes into the Strait of Georgia similar to Davis Bay, but on a smaller scale. At the time of the site visit Chaster Creek had two channels that incised across the delta. Shoreline erosion was observed at the mouth of Chaster Creek (Photo 7). Aerial imagery suggests this erosion is a result of fluvial erosion (Figure 4.5).



Photo 6 Bonnie Beach shoreline.



Photo 7 Chaster Creek northern outlet channel (left) and shoreline erosion (right).

4.2.6 Bay Road, Gibsons

Gibsons Bay is characterized as a low-energy environment sheltered by jetties (Photo 8). There were no observations of shoreline erosion but localized residential shoreline protection was observed near Bay Road (Photo 8). The beach slope was shallow, and the composition was observed to be sand-gravel (Photo 9). In the vicinity of Bay Road, a thin buffer of shoreline vegetation was observed (Photo 9).



Photo 8 Gibsons Bay shoreline protection features near Bay Road.



Photo 9 **Gibsons Bay shoreline sediment and vegetation.**

4.3 River-Coast Interactions

The Sunshine Coast has a dense stream network with the largest rivers originating from Tetrahedron Provincial Park where elevations reach up to 1700 m (Figure 4.3). Major rivers that intersect the lower Sunshine Coast within the study reach include: Rainy River, McNair and Dakota Creeks which enter Thornborough Channel at Port Mellon; Gray Creek which flows into Sechelt inlet; Chapman Creek at Sechelt; and a number of smaller creeks.

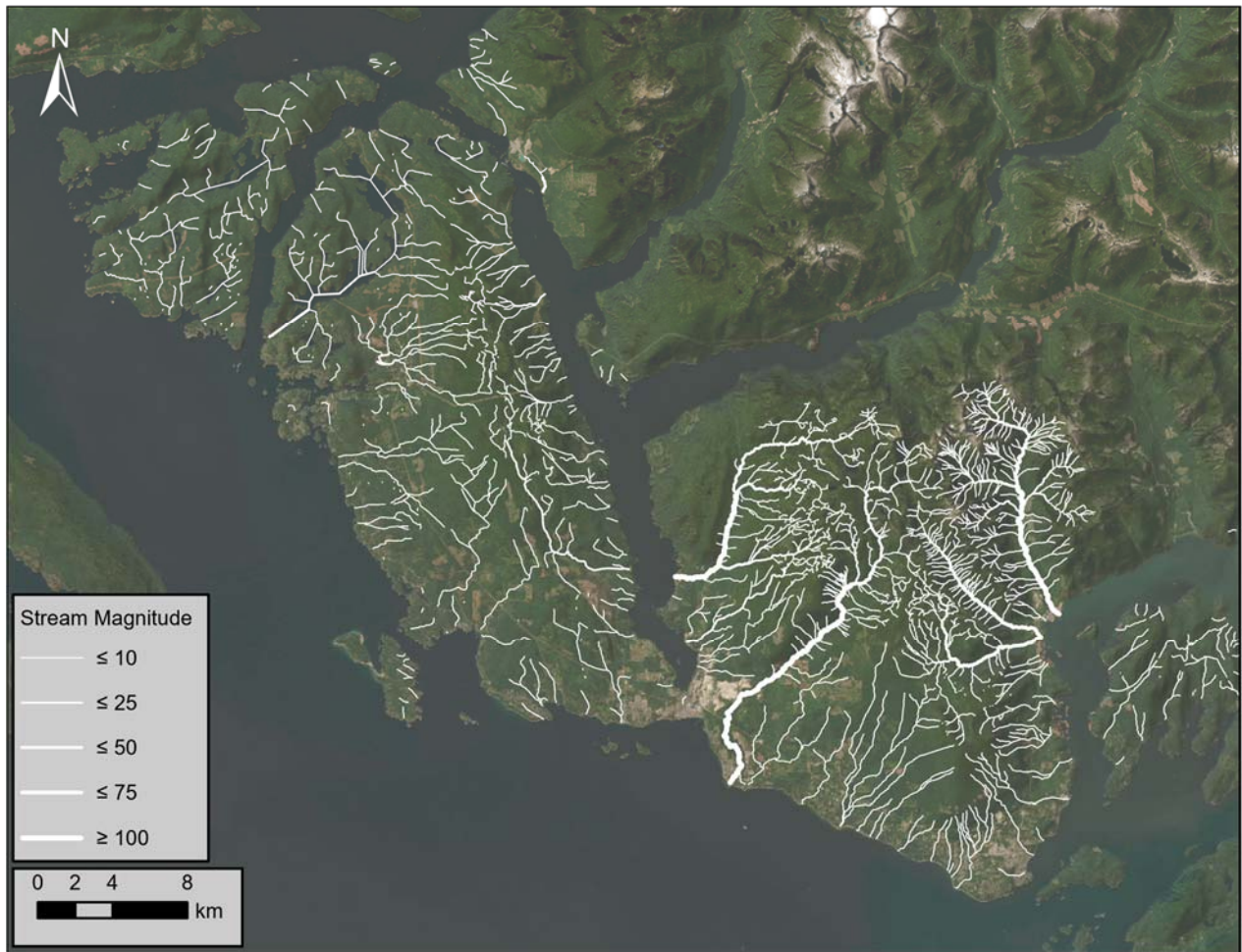


Figure 4.3 Sunshine Coast watershed map (BC Forests, Lands and Natural Resources, 2008).

Along their course, rivers transport hillslope and bank sediment to the ocean where fluvial sediment is deposited. If the rate of sediment deposition is greater than the rate of sea level rise and tectonic uplift, then a delta will form at the river mouth. Delta material is then reworked through coastal processes (e.g., wave action and tidal forces). Prograded deltas, such as Chapman Creek, can act as storm barriers buffering the shoreline from wind and wave energy. Delta form can vary depending on the availability of sediment to be transported in a watershed and the flood history. For example, Chapman and Chaster Creek along the lower Sunshine Coast have both prograded into the Strait of Georgia.

Comparison of aerial imagery from 2014 and 2021 allows a qualitative assessment of change on a sub-decadal scale. In both 2014 and 2021 Chapman Creek maintains a straight channel as it flows across its prograding delta into the Strait of Georgia. The form of Chapman Creek's delta is wave-dominated with an arcuate shape representative of a normal wave incidence. At the mouth of the Chapman Creek there is some deposition observed on river right and erosion on

river left between 2014 and 2021. The shoreline here has been heavily protected by seawalls and other shoreline protection features.

Similar to Chapman Creek, Chaster Creek delta is characterized by a wave-dominated form. Chaster Creek's delta shape and orientation is characteristic of an oblique wave incidence. Between 2014 and 2021 Chaster Creek's outlet channel has shifted to the North, resulting in localized shoreline erosion. This observation is supported by field observations during the site visit (Photo 7). For more detailed shoreline and delta change detection, a minimum of two low tide Lidar datasets are required or a set of aerial images which spans several decades allowing for detailed shoreline mapping through time.



Figure 4.4 Orthoimagery of Chapman Creek delta from 2014 (top) and 2021 (bottom). Imagery source: SCRD.



Figure 4.5 Orthoimagery of Chaster Creek delta from 2014 (top) and 2021 (bottom). Imagery source: SCRD.

5 COASTAL VULNERABILITY INDEX

The coastal erosion hazard was assessed with the use of a coastal vulnerability index (CVI) - a ranking of coastal vulnerability based on mapped and calculated metrics of coastal hazard. NHC assessed approximately 560 km of shoreline for the CVI analysis. The shoreline was divided into 842 segments based on the physical attributes and hydro-physical processes. The resulting CVI ranks range from 0 to 12. NHC binned these ranks into three categories: low (0 to 4), moderate (5 to 8), and high (9 to 12) vulnerability. Mapping results suggest that 64% of the shoreline was mapped as low, 28% as moderate and 9% as high (Table 5.1). Refer to Appendix D to see the resulting CVI maps.

Table 5.1 CVI results.

CVI Rank	Length of Shoreline (km)	Percent of Total Shoreline (%)
Low	360	64%
Moderate	160	28%
High	50	9%

5.1 Physical Attributes

The following sections present descriptive statistics of the CVI rank for each physical attribute used in CVI calculation. The division of coastal vulnerability by each physical variable can be used to understand the overall erosion hazard along the SCRD shoreline and provide insights into the most common shoreline types within the SCRD.

5.1.1 Beach composition

Of the total mapped shoreline, 63% was classified as bedrock and engineered beaches, of which 62% were ranked as low vulnerability. Coarse beaches made up 20% of the mapped shoreline, with 19% ranked as moderate vulnerability. Fine beaches represented approximately 16% of the total mapped shoreline, with 8% ranked as moderate and high vulnerability, respectively (Table 5.2).

Table 5.2 CVI rank by beach composition.

CVI rank	Beach composition as percent of shoreline (%)			
	Bedrock	Engineered	Coarse	Fine
Low	62.5%	0.9%	0.2%	0.0%
Moderate	0.8%	0.1%	19.1%	7.6%
High	0.0%	0.0%	0.7%	8.2%
Total percent of shoreline (%)	63%	1%	20%	16%

5.1.2 Shoreline protection

Approximately 4% of the total mapped shoreline was classified as continuous shoreline protection, of which 2% was ranked as moderate vulnerability. Discontinuous protection made up about 3% of the mapped shoreline, with 3% ranked as moderate vulnerability. Unprotected beaches represented approximately 93% of the total mapped shoreline with 63% ranked as low and 22% as moderate vulnerability, respectively (Table 5.3). Protected beaches are associated with local shoreline conditions that generally score higher, such as fine beach composition, higher foreshore slopes, and more erosion prone morphologies. Therefore, anthropogenic development generally involves the installation of shoreline protection to help mitigate the associated impacts of a more erosion prone shoreline.

To better visualize CVI results for shoreline protection, the statistics were recomputed without bedrock composition shorelines which represents 63% of the total mapped shoreline and in most cases had a shoreline protection score of unprotected. Approximately 11% of the non-bedrock composition shorelines was classified as continuous shoreline protection, of which 7% was ranked as moderate vulnerability. Discontinuous beaches made up about 8% of the mapped shoreline, with 6% ranked as moderate vulnerability. Unprotected beaches represented approximately 82% of the total mapped shoreline with 58% ranked as moderate and 23% as high vulnerability, respectively (Table 5.3). The observations of the filtered CVI statistics for shoreline protection generally remain the same as the unfiltered statistics for shoreline protection. However, for the unprotected shorelines it is clear that the bedrock composition beaches influenced the high percentage of low vulnerability unprotected shorelines.

Table 5.3 CVI rank by shoreline protection.

CVI rank	Shoreline protection as percent of shoreline (%)		
	Continuous	Discontinuous	Natural/Unprotected
Low	1.0%	0.0%	62.5%
Moderate	2.3%	2.9%	22.4%
High	0.2%	0.4%	8.3%
Total percent of shoreline (%)	4.0%	3%	93%

Table 5.4 CVI rank by shoreline protection excluding bedrock composition segments.

CVI rank	Shoreline protection as percent of coarse or fine composition shoreline (%)		
	Continuous	Discontinuous	Natural/Unprotected
Low	2.8%	0.0%	0.0%
Moderate	6.2%	7.9%	58.8%
High	0.6%	1.2%	22.5%
Total Percent of coarse or fine composition shoreline (%)	10%	9%	81%

5.1.3 Shoreline morphology

Approximately 67% of the shoreline morphologies in the study area were classified as bedrock or anthropogenic, of which 64% were ranked as low vulnerability. Morphologies including pocket beach, lagoon, bluff, mixed bedrock and steep backshore made up 24% of the mapped shoreline, with 20% ranked as moderate vulnerability. Delta, tidal flat and low backshore morphologies represent approximately 9% of the total mapped shoreline with 4% ranked as moderate and with 5% as high vulnerability, respectively (Table 5.5).

Table 5.5 CVI rank by shoreline morphology.

CVI rank	Shoreline morphology as percent of shoreline (%)		
	Bedrock/Anthropogenic	Bluff/Pocket beach/Lagoon/Mixed Bedrock/Steep backshore	Low backshore area/Delta/Tidal Flat
Low	63.5%	0.0%	0.0%
Moderate	3.4%	20.2%	3.9%
High	0.0%	4.2%	4.6%
Total percent of shoreline (%)	67%	24%	9%

5.1.4 Foreshore slope

Approximately 88% of all foreshore slopes in the mapped areas are greater than 50%, of which 59% were ranked as low vulnerability and 23% as moderate vulnerability. Foreshore slopes between 20% and 50% made up 9% of the mapped shoreline, with 4% ranked as low vulnerability and 3% as moderate vulnerability. Less than 20% foreshore slopes represent approximately 3% of the total mapped shoreline with 1% ranked as low, moderate and high vulnerability, respectively (Table 5.6).

Table 5.6 CVI rank by foreshore slope.

CVI rank	Foreshore slope as percent of shoreline (%)		
	> 50% slope	20% to 50% slope	<20% slope
Low	58.6%	4.0%	0.9%
Moderate	22.9%	3.3%	1.4%
High	6.1%	1.4%	1.3%
Total percent of shoreline (%)	88%	9%	3%

5.2 Hydro-physical processes

The following sections present descriptive statistics of the CVI rank for each hydro-physical process considered in CVI calculation. The division of coastal vulnerability by each hydro-physical process can be used to understand the overall erosion hazard along the SCRD shoreline and provide insights into the influence on shoreline type and vulnerability.

5.2.1 Incident wave height

Incident wave heights greater than 1.5 m represented 79% of the total mapped shoreline, of which 57% were ranked as low vulnerability and 14% as moderate vulnerability. Incident wave heights between 1 m and 1.5 m make up 11% of the mapped shoreline, with 5% ranked as low vulnerability and moderate vulnerability, respectively. Less than 1 m incident wave heights represent approximately 10% of the total mapped shoreline with 8% ranked as moderate, moderate and 2% as low vulnerability, respectively (Table 5.7).

Table 5.7 CVI rank by incident wave height.

CVI rank	Incident wave height as percent of shoreline (%)		
	0 m to 1 m	1 m to 1.5 m	> 1.5 m
Low	2.1%	4.6%	56.9%
Moderate	7.7%	5.5%	14.4%
High	0.1%	1.3%	7.5%
Total percent of shoreline (%)	10%	11%	79%

5.2.2 Surf parameter

Approximately 85% of the mapped shoreline surf parameters are greater than 2.5 m representing collapsing/surging, of which 57% were ranked as low vulnerability and 22% as moderate vulnerability. Surf parameters between 1 m and 1.5 m (plunging) make up 13% of the mapped shoreline, with 6% ranked as low vulnerability and 5% as moderate vulnerability, respectively. Spilling surf parameters, less than 0.5 m, represent approximately 2% of the total mapped shoreline with 0.9% ranked as low and 0.5% as moderate vulnerability, respectively (Table 5.8).

Table 5.8 CVI rank by surf parameter.

CVI rank	Surf parameter as percent of shoreline (%)		
	Spilling (<0.5m)	Plunging (0.5-2.5m)	Collapsing/Surging(>2.5 m)
Low	0.9%	5.6%	57.0%
Moderate	0.5%	5.4%	21.7%
High	0.3%	2.3%	6.3%
Total percent of shoreline (%)	2%	13%	85%

5.3 CVI Examples

Table 5.9 presents examples of each CVI ranking

Table 5.9 Examples of manually mapped CVI variables. Imagery source: BC Shore Zone

CVI Summary	Example	Location
Beach Comp: Fine; 2 – High Shore Morphology: Low Backshore; 2 – High Shoreline Protection: Continuous; 0 – Low Slope: 0.5; 0 – Low Wave Height: 2.1; 2 – High Surf Parameter: 2 – High Total Score: 8 - Moderate		Pebble Beach, Sechelt
Beach Comp: Bedrock; 0 - Low Shore Morphology: Bedrock; 0 - Low Shoreline Protection: Unprotected-Bedrock; 0 – Low Slope: 3.4; 0 – Low Wave Height: 2.4; 2 – High Surf Parameter: 14.9; 2 – High Total Score: 4 - Low		Agamemnon Channel, bedrock shoreline

CVI Summary	Example	Location
Beach Comp: Coarse; 1 - Moderate Shore Morphology: Delta; 2 - High Shoreline Protection: Continuous; 0 - Low Slope: 1.2; 0 - Low Wave Height: 1.9; 2 - High Surf Parameter: 7.9; 2 - High Total Score: 7 - Moderate		Wakefield Creek Delta
Beach Comp: Engineered; 0 - Low Shore Morphology: Anthropogenic; 0 - Low Shoreline Protection: Continuous; 0 - Low Slope: 0.4; 1 - Moderate Wave Height: 1.5; 2 - High Surf Parameter: 2.2; 1 - Moderate Total Score: 4 - Low		Port Stalashen Marina

CVI Summary	Example	Location
Beach Comp: Coarse; 1 - Moderate Shore Morphology: Mixed Bedrock; 1 - Moderate Shoreline Protection: Discontinuous; 1 - Moderate Slope: 0.4; 0 - Low Wave Height: 1.9; 2 - High Surf Parameter: 2.7; 2 - High Total Score: 7 – Moderate		Shoreline near Robert's Creek
Beach Comp: Fine; 2 - High Shore Morphology: Bluff; 1 - Moderate Shoreline Protection: Unprotected; 2 - High Slope: 0.6; 0 - Low Wave Height: 1.3; 1 - Moderate Surf Parameter: 3.0; 2 - High Total Score: 8 - Moderate		North Thromby Island

CVI Summary	Example	Location
Beach Comp: Fine; 2 - High Shore Morphology: Delta; 2 - High Shoreline Protection: Unprotected; 2 - High Slope: 0.14; 2 - High Wave Height: 2.0; 2 - High Surf Parameter: 0.6; 1 - Moderate Total Score: 11 - High		Chaster – Bonnie Brook Beach
Beach Comp: Fine; 2 - High Shore Morphology: Delta; 2 - High Shoreline Protection: Unprotected; 2 - High Slope: 0.6; 0 - Low Wave Height: 1.3; 1 - Moderate Surf Parameter: 3.1; 2 - High Total Score: 9 - High		Sechelt Inlet Shoreline

6 ASSUMPTIONS AND LIMITATIONS

This section summarizes the assumptions and limitations associated with the SCRD erosion hazard assessment.

6.1 Assumptions

The assumptions of the erosion hazard assessment are as follows:

- The maximum incident wave height, foreshore slope and surf parameter from the model results was assigned to each shoreline segment. This conservative approach neglects local variations that likely occur across shoreline segments throughout the study area.
- It is assumed that engineered beach composition, continuous shoreline protection and anthropogenic shoreline morphologies are maintained.
- Bedrock shorelines are considered to be stable and do not pose a substantial erosion hazard

6.2 Limitations

The limitations of the erosion hazard assessment are as follows:

- This assessment covers erosion hazard factors; it does not include risk assessment. The information presented in this report may be used to inform a risk assessment.
- The erosion hazard assessment was mapped over an extensive area as a regional assessment. The results should be considered generalized vulnerabilities for neighbourhood-scale areas. Results cannot be used at the property scale.
- There are no well-defined empirical or simple physical relationships between variables and their assigned hazards. Variable CVI scores are based upon associative understanding of geomorphic processes, supported by desk-based aerial photo interpretation and limited site verification.
- CVI variables are all assigned equal weighting despite the variables not having equal influence on erosion vulnerability. Weighting CVI variables would have introduced significant subjectivity due to the lack of empirical relationships between variables.
- Manually mapped and interpreted variables (i.e. not calculated) include a certain amount of subjectivity. An example of this is the distinction between coarse and fine beach composition.

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APPENDIX C

INUNDATION MAPS

APPENDIX D

FCL MAPS

APPENDIX E

WAVE EFFECT MAPS

