Capital Region Coastal Flood Inundation Mapping Project Summary

Version 2.0, November 2021

CRD

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Note: Version 2.0 of this Capital Regional Coastal Flood Inundation Mapping Project Summary replaces the previous 1.0 report, published in June 2020.

Capital Region Coastal Flood Inundation Mapping Project Summary

Capital Regional District | **November 2021**

The Capital Regional District (CRD) retained Associated Engineering, DHI and Westmar Advisors to undertake the Capital Region Coastal Flood Inundation Mapping Project (the project) in 2019 - 2021.

On behalf of local government and other regional stakeholders, staff worked closely with an inter-municipal and multi-disciplinary project team to complete the Regional Coastal Flood Inundation Project in order to better understand regional impacts from coastal storm flooding due to sea level rise and tsunamis.

This work was completed to:

- Provide the CRD, local governments, First Nations and other stakeholders a comprehensive picture of coastal flooding due to rising sea levels and tsunamis.
- Help planners and emergency managers prepare the region for tsunami events that may strike southern Vancouver Island and the Southern Gulf Islands.
- Offer guidance to regional stakeholders to inform coastal flood hazard policy, planning and future regulatory efforts, including Flood construction levels.
- Better understand the infrastructure, ecosystems and cultural sites that may be at risk due to future sea level rise through an intertidal risk assessment.
- To identify risks to residents and infrastructure (e.g., harbours/marinas/docks) within the capital region, as a result of tsunami waves and currents through a targeted tsunami risk assessment.

The project was completed by three main tasks with results provided in the following reports:

- Task 1: Digital Elevation Model Development Report (Task 1 Report)
- Task 2: Sea Level Rise Modelling and Mapping Report (Task 2 Report)
- Task 3: Tsunami Modelling and Mapping Report (Task 3 Report)

This executive summary is intended to provide a brief overview of the project only. It is important for users to fully understand methodologies and limitations. Refer to the project reports in their entirety, available at www.crd.bc.ca/coastalflood, for further information.

Legislative Context

Under the British Columbia Local Government Act, local governments are responsible for managing natural hazards through land use planning and regulations. The 2004 provincial Flood Hazard Area Land Use Management Guidelines (the Guidelines) provide direction for local governments to implement land use management plans and make subdivision approval decisions for flood hazard areas.

Local governments must consider the Guidelines in making bylaws under the Local Government Act. It is the responsibility of each municipality and electoral area to review, interpret and consider how to implement the Guidelines, and incorporate them into related local land use regulatory, policy and planning tools, including flood construction levels. The Province also recommends considering tsunami risk when establishing flood hazard regulations, such as flood construction levels.

Under the Emergency Program Act, Local Authorities for public services and facilities are responsible for assessing risk and planning for potential emergencies and disasters, and should consider coastal flooding when developing local emergency plans. Local emergency plans set out procedures, and other preparedness, response and recovery measures to reduce possible impacts on people and property during emergencies and disasters. Through their emergency operations centres, Local Authorities also coordinate and lead the response and recovery of emergency events.

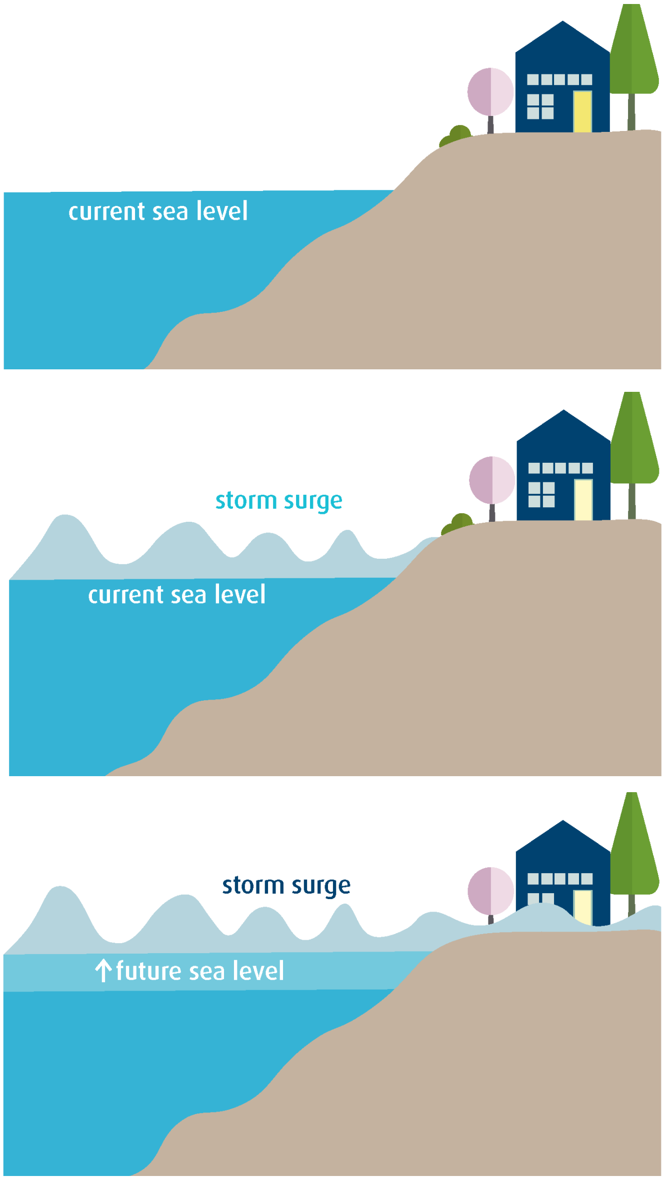
Context – Sea Level Rise

The capital region has a long and complex coastline (approx. 1,300 km), with several low-lying areas exposed to coastal flood hazard now, and into the future with sea level rise. Most coastal flooding that occurs today is due to a combination of storm surge, wind and waves occurring at high tide. Sea Level Rise (SLR) means that the still-water elevation of the oceans surrounding the region will rise.

SLR is the direct effect of climate change on the global oceans. Melting sea and glacier ice, and the thermal expansion of ocean waters, have resulted in increasing mean sea levels.

In 2004, the provincial government passed responsibility for flood management to local governments. The guidelines were amended in 2018 to incorporate climate projections and tsunami considerations into coastal building setbacks and flood construction levels.

Figure 1 - Effects of Storm Surges and Storm Surges Coupled with Sea Level Rise



The guidelines state a 0.5 m SLR increase by the year 2050, 1 m SLR increase by 2100, and 2 m by 2200. This appears to be overly conservative, based on observed water levels, to date. However, in 2019, the Intergovernmental Panel on Climate Change indicated sea levels are projected to increase at a rate faster than previously identified, as we move through the century.

While there is still great uncertainty in how exactly SLR rates will change in the coming years, it is prudent that local governments consider this uncertainty (and tsunami considerations) in their coastal flood hazard land use policies.

In 2015, CRD staff worked with members of the CRD Climate Action Inter-Municipal Working Group to complete an initial SLR study. This study only considered 24 sites, used a more basic analysis, and did not include all of the criteria required to inform flood construction levels.

This work identified the need for further study, including a more fulsome regional analysis. The current project (2021) provides further analysis and recommendation on appropriate flood construction levels for the entirety of the capital region.

Context – Tsunami

The west coast of Canada is vulnerable to tsunamis generated by earthquakes beneath the Pacific Ocean. The largest tsunamis in British Columbia result from earthquakes in the Cascadia Subduction Zone, where the oceanic Juan de Fuca plate moves underneath North America. The last significant Cascadia Subduction Zone event occurred on January 26, 1700. The British Columbia coast is also affected by tsunamis of more distant Pacific earthquakes, as experienced by an Alaskan earthquake in 1964. The region around the southern end of Vancouver Island, including the San Juan Islands and water bodies, such as the Juan de Fuca Strait, Salish Sea and Strait of Georgia are also possibly subject to the effects of local fault systems running through Vancouver Island and adjacent areas to the south and east (see Section 1.3, Task 3 Report).

The Province is responsible for the Emergency Program Act (1996), which provides the legislative framework for the management of disasters and emergencies in British Columbia. The provincial government provides guidance to local governments on emergency planning through Emergency Management BC. The Province, through Emergency Management BC, is the current notifying agency for local authorities and First Nation governments for tsunami alerts. Under the Emergency Program Act, Local Authorities are responsible for assessing risk and planning for potential emergencies and disasters.

Regionally, the Regional Emergency Management Partnership (REMP) is an inter-governmental group working to improve emergency management at all levels of government in the capital region. The REMP Steering Committee is responsible for overseeing the development and delivery of a coordinated seamless regional emergency management strategy supported by an integrated concept of emergency operations, strategic priorities and supporting plans. The Local Government Emergency Program Advisory Commission provides advisory recommendations on the direction of the REMP and initiatives that may be undertaken to provide consistency and coordination among local government emergency programs, and will advise the Regional Emergency Coordinators Advisory Commission on any local government program developments/ initiatives that may benefit or otherwise affect other emergency programs in the region.

In January 2018, a 7.9 magnitude earthquake in the Gulf of Alaska triggered a tsunami warning for Vancouver Island, including the communities in the capital region. Prior to this event, distant tsunamis were not known risks to the capital region. The region's emergency programs took the lessons learned from this event and identified the need for additional tsunami modelling to provide further insight on various tsunami scenarios and their impacts to their communities, under the guidance of researchers and field experts.

The purpose of this study also aimed to validate the previous regional modelling to ensure that updated results were used in current emergency notification alerts. As technology and science improves, risk modelling, including tsunamis, need to be continually conducted to update emergency preparedness, planning and response.

Methodology – General

Following provincial and international guidelines, and peer-reviewed best practices, the consultant team completed the project based on the overarching steps summarized below:

- **Background Data Collection:** Gathered the available historic reports, analyses and geospatial data.
- **Digital Elevation Model (DEM) Development:** Using newly available topographic and bathymetric data, created a Digital Elevation Model that can be used in hydraulic models to simulate coastal flooding.
- **Sea Level Rise Flooding Analysis:** Analysed coastal storm inundation for various storm surge and sea level rise scenarios and developed coastal flood construction levels for the capital region using a transect analyses (222 total representing the region's coastline); as well as detailed flood modelling in select locations (Victoria Harbour/Gorge Waterway, McNeill Bay/Oak Bay, Cadboro Bay, Sidney/Tulista Park, Sidney/Roberts Bay). These sites were chosen, due to their low-lying topography, potential susceptibility to coastal flooding and their relatively high population density.
- **Tsunami Model and Mapping Report:** Assessed flooding, due to tsunami activity in the entire region, undertook a detailed analysis within Victoria/Esquimalt, Saanich/Oak Bay, Sidney, Sooke and Port Renfrew, and qualitatively assessed the risk to harbours/marinas/docks within the capital region, as a result of tsunami waves and currents hitting these vulnerable facilities.
- **Final Report:** Summarized the significant volume of technical work completed in reporting (via three distinct reports), accompanied by inundation and Flood Construction Level mapping and associated geographic information system deliverables, for the entire project area. The three main reports can be found at www.crd.bc.ca/coastalflood.

Methodology – Sea Level Rise

This project used a refined form of the probabilistic method from the Provincial Guidelines to estimate the total water levels for the four sea level rise scenarios (0 m, 0.5 m, 1.0 m and 2.0 m), for five annual exceedance probabilities (AEP).

This accounts for the joint probability of occurrence of all the different processes contributing to coastal flooding: SLR, high tide, local and regional surge and wave effects (set-up and run-up). In addressing this task, the project team relied on a number of overarching local and international guidelines and best practices.

For each transect, flood construction levels (FCL) were derived for all four relative sea level rise (RSLR) scenarios following the provincial recommendations of using a 1:200 (0.5%) AEP total water height and adding 600 mm of freeboard. Freeboard is a commonly used factor of safety usually expressed in distance above a flood level for purposes of floodplain management and planning, and was used in this analysis.

At each transect, two distinct FCL values were calculated for each RSLR scenario; an FCL derived using mean wave runup (R_{mean}) and an FCL derived using 2% wave runup ($R_{2\%}$) which is estimated using a larger wave effect contribution only exceeded by 2% of waves. The recommended $R_{2\%}$ FCLs are identified for the "Primary Wave Effect Zone" in this report, while backshore FCLs are use the the R_{mean} FCL value.

An AEP gives a sense of how often a flood of a certain magnitude could be expected (i.e., 1:200-year flood can be expected to happen once every 200 years or has a 0.5% chance of happening in any given year).

In addition, as a separate sub-task, the consultant team utilized existing regional-scale data sets to complete a high-level intertidal risk assessment to understand SLR impacts on coastal ecosystems and known archaeological sites.

Several different mapping efforts were completed:

- mapping the flood construction levels for 1.0 m and 2.0 m SLR scenarios
- mapping still water level for a 0.5% (1:200) AEP for 1.0 m and 2.0 m SLR scenarios
- detailed modelling and subsequent mapping of flood extent and depth for the five study sites

Other deliverables include:

- recommended flood construction levels by transect across the region
- total water levels for all relative sea level rise scenarios and the five different AEPs

Methodology – Tsunami

The project involved a review of available scientific literature and analyses to select appropriate tsunami-generating sources for modelling. Previous tsunami modelling for the capital region focused on potential events in the Cascadia Subduction Zone, and although this is an important focus, there existed a need to explore hazards from other tsunami sources.

The selected scenarios, 11 in total, in this project included distant (e.g., Alaska and Haida Gwaii), subductions zone (e.g., various Cascadia scenarios, including a worst-case and more likely scenario), and local source (e.g., Devils Mountain and Southern Whidbey Island Fault) tsunami sources.

Each of these 11 events have resulted in different maximum water levels in each community within the capital region, but also have different expected dates of occurrence (i.e., return periods), which is important to consider this when reviewing the results. The selection of the sources and the magnitudes were guided by researchers and experts in this field.

The project developed hydraulic models to simulate tsunami wave propagation from source to inundation of the coast. Following international standards, a tsunami model was used to analyze the whole region by 30 m grids. Five sites were further analyzed in 4 m grids to give detailed results on flood levels, currents, and whirling motion of the water utilizing a tsunami model.

The five locations, which received the higher detailed analysis, include sites within Victoria/Esquimalt, Saanich/Oak Bay, Sidney, Sooke and Port Renfrew. These areas were also chosen because they have a high level of exposure to the tsunami events from the Cascadia Subduction Zone.

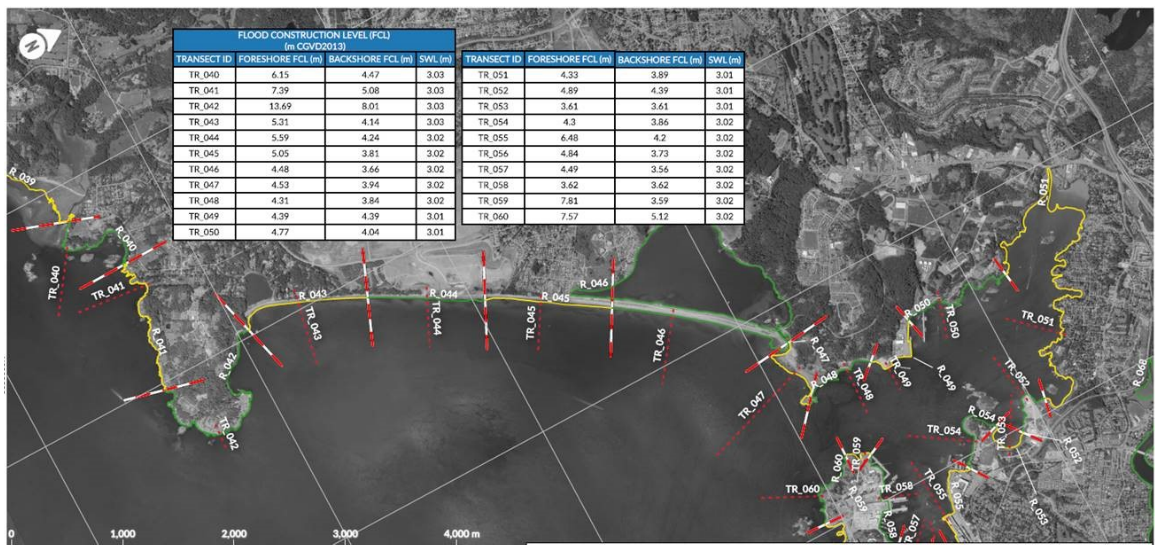
As a sub-task to the tsunami analysis, the consultant team undertook an assessment to identify the potential risk of damage to ports and harbours at selected sites across the region, as a result of flooding and strong currents generated by tsunami waves.

Summary Results – Sea Level Rise

The majority of the capital region's coastline is quite elevated, such that the general risk of extensive flooding is low. However, low-lying areas in the region are susceptible to coastal storm flooding–the extents of which are set to increase significantly over time, due to SLR.

SLR flood construction level results for all 222 transects were developed for different scenarios of SLR, and associated maps were produced (see Section 3.3, Appendix C, Task 2 Report). Figure 2 provides an example of the SLR flood construction level mapping output for one area.

Figure 2 - Example of 1.0m Relative Sea Level Rise Map representing 21 Transects



TRANSECT ID	FORESHORE FCL (m)	BACKSHORE FCL (m)	SWL (m)
TR_040	6.15	4.47	3.03
TR_041	7.39	5.08	3.03
TR_042	13.69	8.01	3.03
TR_043	5.31	4.14	3.03
TR_044	5.59	4.24	3.02
TR_045	5.05	3.81	3.02
TR_046	4.48	3.66	3.02
TR_047	4.53	3.94	3.02
TR_048	4.31	3.84	3.02
TR_049	4.39	4.39	3.01
TR_050	4.77	4.04	3.01

TRANSECT ID	FORESHORE FCL (m)	BACKSHORE FCL (m)	SWL (m)
TR_051	4.33	3.89	3.01
TR_052	4.89	4.39	3.01
TR_053	3.61	3.61	3.01
TR_054	4.3	3.86	3.02
TR_055	6.48	4.2	3.02
TR_056	4.84	3.73	3.02
TR_057	4.49	3.56	3.02
TR_058	3.62	3.62	3.02
TR_059	7.81	3.59	3.02
TR_060	7.57	5.12	3.02

Source: Map sheet 11, Appendix C, Task 2: Sea Level Rise Modelling and Mapping Report, Associated Engineering (October 2021)

The following table provides a summary of average SLR flood construction level using the $R_{2\%}$ value within each local government, using the 200-year (0.5% AEP) total water level plus 600 mm freeboard, as per provincial guidelines.

The 95th percentile means that 95% of the time data points are below that value and 5% of the time they are above that value. The report provides detailed information on recommended flood construction levels for local government consideration.

Table 1 - Summary of Average and 95 Percentile Relative Sea Level Rise Flood Construction Levels ($R_{2\%}$ FCL)

Local Government/ Electoral Area	0.0 m RSLR FCL (m CGVD2013)		0.5 m RSLR FCL (m CGVD2013)		1.0 m RSLR FCL (m CGVD2013)		2.0 m RSLR FCL (m CGVD2013)	
	Ave.	95%ile	Ave.	95%ile	Ave.	95%ile	Ave.	95%ile
Central Saanich	4.13	6.49	4.64	7.00	5.14	7.50	6.14	8.51
Colwood	3.75	4.47	4.25	4.97	4.75	5.48	5.75	6.49
Esquimalt	5.17	7.81	5.69	8.32	6.19	8.83	7.21	9.85
Highlands	5.09	6.28	5.59	6.78	6.09	7.28	7.11	8.29
Juan de Fuca Electoral Area	5.03	8.03	5.53	8.53	6.03	9.03	7.04	10.04
Langford	2.76	2.76	3.27	3.27	3.77	3.77	4.83	4.83
Metchosin	5.30	9.70	5.81	10.22	6.32	10.74	7.33	11.76
North Saanich	4.56	7.09	5.08	7.62	5.59	8.13	6.59	9.14
Oak Bay	5.70	8.19	6.33	8.70	6.98	9.22	8.41	11.25
Saanich	4.61	6.90	5.15	7.41	5.68	8.33	6.69	9.38
Salt Spring Electoral Area	4.53	6.94	5.03	7.45	5.53	7.95	6.53	8.95
Sidney	4.74	6.62	5.38	7.65	6.05	8.85	7.37	11.34
Sooke	4.20	8.12	4.81	9.20	5.51	10.78	6.89	13.86
Southern Gulf Islands Electoral Area	5.30	9.10	5.80	9.59	6.32	10.08	7.32	11.06
Victoria	5.28	8.41	5.84	9.23	6.34	9.77	7.34	10.79
View Royal	3.12	3.66	3.64	4.22	4.15	4.78	5.19	5.91

Source: Page 4-3, Task 2: Sea Level Rise Modelling and Mapping Report, Associated Engineering (October 2021)

The SLR flood construction levels presented in this report differ in comparison to previously established levels and studies completed in the region. See Task 2 Sea Level Rise Modelling and Mapping Report, Section 6.4. Different outcomes that can occur in the same study region due to the varying interpretations of the Provincial Guidelines and the range of engineering methodologies, numerical modelling techniques, data sets, and calculation procedures that are applied that influence study outcomes.

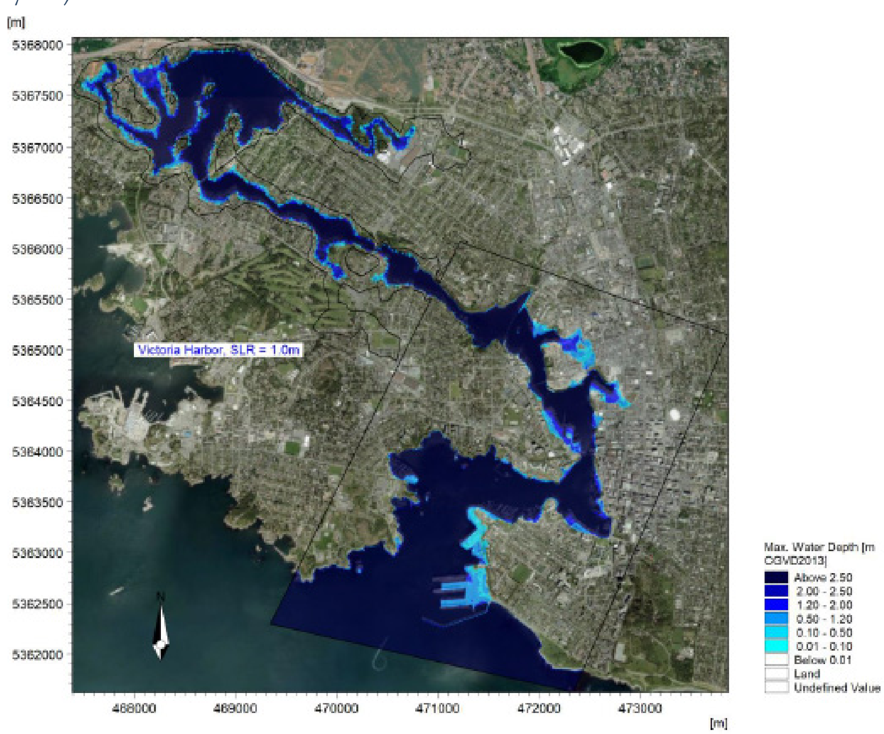
While the setting of flood construction levels is a matter for each local government, the consultant team has given recommendations on selecting an appropriate flood construction level in a tsunami-prone area of the region, depending on if SLR or tsunami hazard governs at that particular transect location. See section 6.5 of the Task 2: Sea Level Rise Modelling and Mapping Report.

While the analysis has been comprehensive, the consultant team has recommended further detailed inundation modelling in some low-lying locations to help strengthen understanding of potential flood risk and supplement the data at their transects.

Sea Level Rise – Detailed Modelling

As suspected, during initial investigation, the low-lying areas chosen for detailed inundation modelling show increasing vulnerability to coastal flooding as mean sea levels increase. These sites include: Victoria Harbour/Gorge Waterway, McNeill Bay/Oak Bay, Cadboro Bay, Sidney/Tulista Park, Sidney/Roberts Bay. Individual figures showing flood extent, maximum depth of flood and water surface elevation for each area and all four RSLR scenarios are included in the Task 2 Report, Appendix E.
Below is an example from one of the sites with a 1 m SLR scenario:

Figure 3 - Example - Victoria Harbour/Gorge Waterway 1 m SLR Annual Exceedance Probability 0.5% (200 year)



Source: Appendix E, Task 2: Sea Level Rise Modelling and Mapping Report, Associated Engineering (October 2021)

Sea Level Rise: Intertidal Ecosystem and Cultural Sites Risk Assessment

Utilizing existing regional scale data, terrestrial ecosystems that are important for biodiversity were identified, categorized and mapped and overlaid with SLR criteria and mapped across the region.

Similarly, documented archaeological and historic sites, collated from the provincial Remote Access to Archaeological Data were also mapped using a generalized format. Results found that a number of coastal ecosystems and known historical sites will be impacted by SLR.

See Section 5 of the Task 2 Report for further information.

Summary Results – Tsunami

The report included modelling of various tsunami sources, including distant, subduction, and local sites. Tsunami sources were shortlisted to 11 for purposes of this study. The selected tsunami sources impact the communities within the capital region in different ways.

These sources also have different probabilities of when they may occur and should be considered as results are reviewed. For example, it is important to understand that the Cascadia Subduction Zone – L1 (CSZ-L1) event has the highest magnitude and highest impact for the capital region communities, but has the lowest probability to occur, due to its 2,500-year return period.

In comparison, the Cascadian Subduction Zone – Northern Segment (CSZ-NS) event, has a lower magnitude, lower impact to the capital region's communities, but has a higher probability of occurrence with an approximate 500-year return period.

Table 2 provides a summary for the probabilities of each modelled event.

Table 2 - Summary of Tsunami Sources Modelled

Source	Abbrv.	Magnitude	Probability	Comment
Cascadia Subduction Zone - L1 Source	CSZ-L1	9.1-9.2	2500-yr return period	Worst-case earthquake scenario (L1)
Cascadia Subduction Zone - Northern Segment	CSZ-NS	8.5-9.0	500-600 yr return period	Rupture of northern segment
Cascadia Subduction Zone - Central Segment	CSZ-CS	8.5	500-600 yr return period	Rupture of central segment (southern Washington, northern Oregon), identified by Wang et al., 2013
Alaskan 1964	AL	9.2	500-1000 yr return period	Same as 1964 earthquake
Aleutian Trench	UN	8.6	unknown	1946 Aleutian Trench earthquake, off Unimak Island
Haida Gwaii	HG1	7.7	unknown	2012 earthquake
South of Haida Gwaii	HG2	7.5	unknown	Hypothetical event spanning between Haida Gwaii failure and Nootka fault
Devil's Mountain Fault Mw 7.5	DM1	7.5	2000-yr return period	Worst-case earthquake – Long transpressive rupture (>50 km)
Devil's Mountain Fault Mw 6.5	DM2	6.5	<2000-yr return period	Middle length transpressive rupture (<50 km)
Southern Whidbey Island Fault Mw 7.5	SW1	7.5	2000-yr return period	Worst-case earthquake – Long transpressive rupture (>50 km)
Southern Whidbey Island Fault Mw 6.5	SW2	6.5	<2000-yr return period	Shorter transpressive rupture (<50 km)

Source: Page 2-3, Task 3: Tsunami Modelling and Mapping Report, Associated Engineering (October 2021)

Modelling results found that the capital region is at risk of tsunami activity, which would cause high waves to strike the coastline, and cause flooding in low-lying areas.

Depending on the tsunami scenario and the geographic location across the region, modelled results indicate a range of average water surface elevations. The following table provides a summary of results for all the earthquake scenarios assessed by local government.

Table 3 - Summary of Modelled Average Water Surface Elevations for Various Tsunami Events

Tsunami Source / Local Government or Electoral Area	CSZ-L1 (CSZ - L1 Source)	CSZ-NS (CSZ - Northern Segment)	CSZ-CS (CSZ - Central Segment)	AL (Alaskan 1964)	UN (Aleutian Trench)	HG1 (Haida Gwaii)	HG2 (South of Haida Gwaii)	DM1 (Devil's Mountain Mw 7.5)	DM2 (Devil's Mountain Mw 6.5)	SW1 (Southern Whidbey Mw 7.5)	SW2 (Southern Whidbey Mw 6.5)
Central Saanich	4.27	3.26	1.43	1.44	1.25	Event used for calibration purposes only. Effects in capital region minimal.	Effects in capital region minimal.	3.37	1.31	2.38	1.27
Colwood	6.76	4.44	1.09	1.02	0.83			3.53	0.88	2.41	0.88
Esquimalt	6.85	4.47	1.08	1.03	0.84			3.58	0.87	2.40	0.88
Highlands	3.54	2.94	1.41	1.37	1.28			1.97	1.25	1.72	1.24
Juan de Fuca Electoral Area	7.42	4.94	1.48	1.37	1.15			1.83	1.17	1.98	1.17
Langford	3.60	3.06	1.42	1.39	1.25			2.58	1.31	2.05	1.28
Metchosin	5.22	3.51	1.03	0.94	0.79			2.07	0.86	1.71	0.86
North Saanich	3.86	2.74	1.40	1.34	1.23			2.47	1.29	1.96	1.26
Oak Bay	3.81	2.68	0.94	0.92	0.78			3.55	0.90	2.04	0.91
Saanich	3.57	2.62	0.96	0.90	0.78			3.52	0.93	1.92	0.84
Salt Spring Electoral Area	3.26	2.52	1.35	1.30	1.23			2.06	1.26	1.78	1.25
Sidney	4.69	3.02	1.42	1.38	1.24			3.40	1.31	2.29	1.27
Sooke	7.13	4.36	1.30	1.23	1.06			1.47	1.06	1.44	1.07
Southern Gulf Islands Electoral Area	3.11	2.41	1.36	1.33	1.23			2.03	1.26	1.74	1.25
Victoria	5.55	3.88	1.02	0.97	0.79			3.18	0.85	2.23	0.87
View Royal	8.45	6.29	1.18	1.14	0.90			4.57	0.96	3.64	0.97

Source: Page 4-4, Task 3: Tsunami Modelling and Mapping Report, Associated Engineering (October 2021)

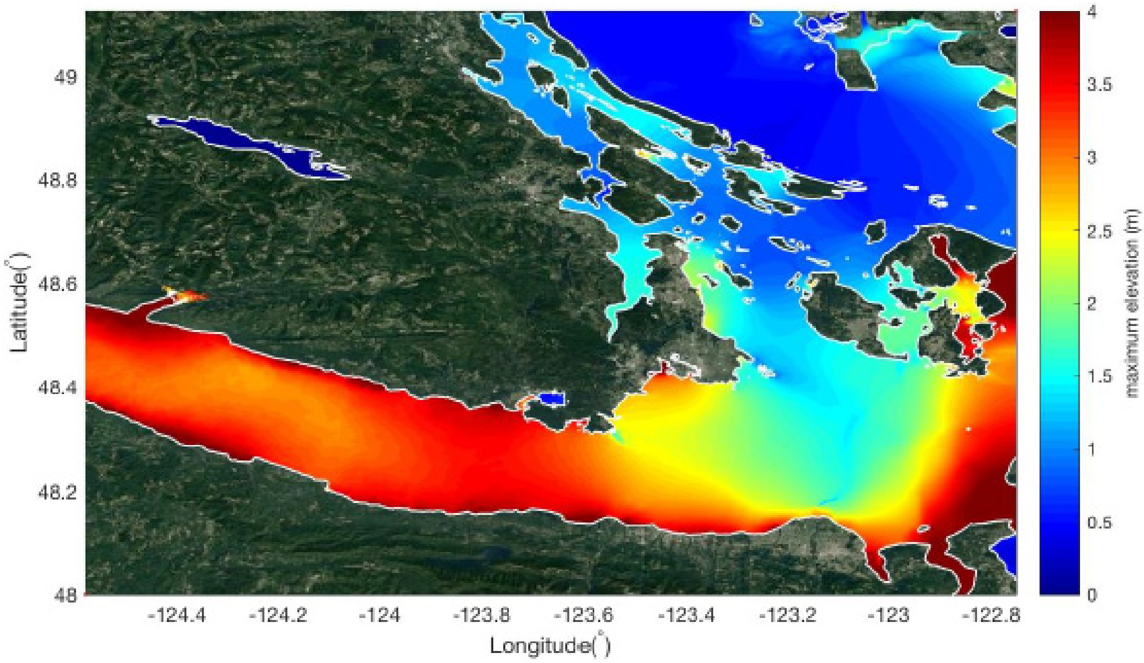
The results show that a Cascadia Subduction Zone – L1 event, (i.e., the worst-case scenario, low probability 2,500-year event) would significantly affect the entire study region and would cause the largest water level values.

An event similar to the 1700 Cascadia Subduction Zone earthquake, known as the CSZ-NS event for purposes of this study, found similar results to previous regional analysis completed in 2013. A few anomalies (including Esquimalt Harbour) have been described in the Task 3 Report, Section 4.3.

The more distant Alaskan earthquake, would have a lower impact within the capital region. The low probability, local crustal events (Devils Mountain Fault line sources) would impact parts of Sidney, Saanich and Oak Bay.

Figure 4 provides an example of a mapping result for the CSZ-NS scenario at a 30 m resolution. Similar maps for all modelled tsunami scenarios, are found in Section 4.3 and Appendix A of Task 3 Report.

Figure 4 - Example: CSZ-NS (500-year return period) Maximum Water Surface Elevation Model Results



Source: Appendix A, Task 3: Tsunami Modelling and Mapping Report, Associated Engineering (October 2021)

The approximate travel times for each tsunami scenario, for each local government/ electoral area are given in Table 4. Travel times denote the amount of time in minutes required for the first tsunami wave to travel to a particular location, after generation at the source. These numbers will give decision makers a sense of how much time is available to emergency services and the greater community to facilitate evacuation (if required).

Table 4 - Summary of Approximate Arrival Time for Each Modelled Tsunami Event (mins)

Tsunami Source	CSZ-L1	CSZ-NS	CSZ-CS	AL	UN	HG1	HG2	DM1	DM2	SW1	SW2
Central Saanich	100	100	125	280	325	170	170	5	5	5	5
Colwood	75	75	100	255	300	145	145	5	5	5	5
Esquimalt	75	75	100	255	300	145	145	5	5	5	5
Highlands	120	120	145	300	345	190	190	30	30	30	30
Juan de Fuca Electoral Area	40	40	65	220	265	110	110	15	15	15	15
Langford	75	75	100	255	300	145	145	5	5	5	5
Metchosin	70	70	95	250	295	140	140	5	5	5	5
North Saanich	105	105	130	285	330	175	175	10	10	10	10
Oak Bay	85	85	105	265	310	155	155	5	5	5	5
Saanich	90	90	115	270	315	160	160	5	5	5	5
Salt Spring Electoral Area	115	115	135	290	340	180	180	15	15	15	15
Sidney	110	110	135	290	335	180	180	15	15	15	15
Sooke	60	60	85	240	285	130	130	15	15	15	15
Southern Gulf Islands Electoral Area	100	100	125	280	325	170	170	5	5	5	5
Victoria	80	80	105	260	305	150	150	5	5	5	5
View Royal	80	80	105	260	305	150	150	5	5	5	5

Source: Page 4-5, Task 3: Tsunami Modelling and Mapping Report, Associated Engineering (October 2021)

Detailed flood modelling illustrating maximum water levels was carried out at a grid resolution of 4 m for areas, including Victoria/Esquimalt, Sidney, Saanich, Oak Bay, Sooke, and Port Renfrew for the following scenarios (Table 5).

Table 5 - Matrix of Detailed Tsunami Inundation Scenarios Modelled at Each Domain

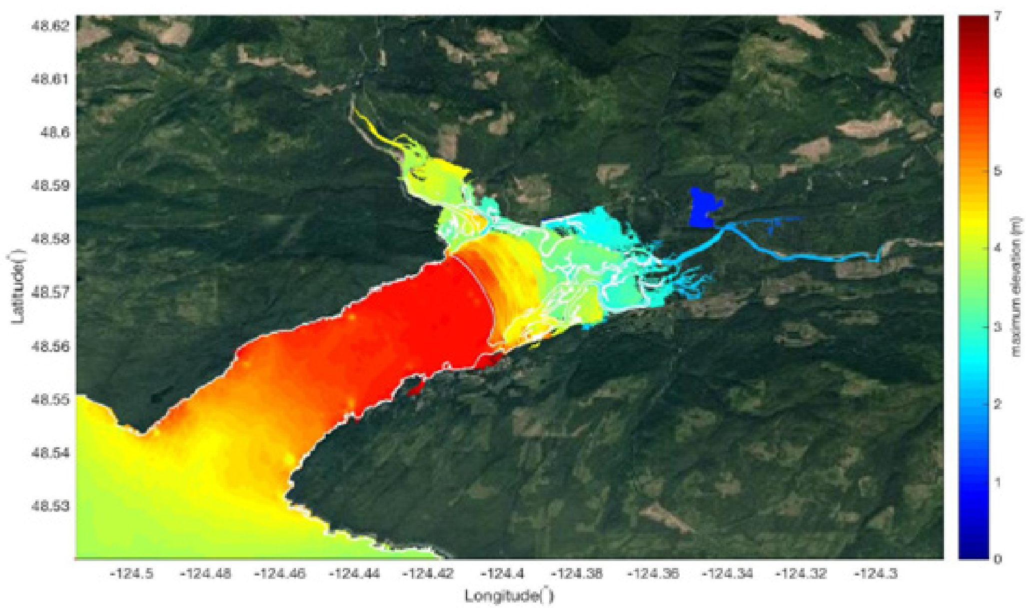
Detailed Modelling Scenarios	Abbrv.	Victoria/ Esquimalt	Saanich/ Oak Bay	Sidney	Sooke	Port Renfrew
Cascadia Subduction Zone - L1 Source	CSZ-L1	✓	✓	✓	✓	✓
Cascadia Subduction Zone - Northern Segment	CSZ-NS	✓	✓	✓	✓	✓
Cascadia Subduction Zone - Central Segment	CSZ-CS	✓	✓	✓	✓	✓
Alaskan 1964	AL	✗	✗	✗	✓	✓
Aleutian Trench	UN	✗	✗	✗	✓	✓
Haida Gwaii	HG1	✗	✗	✗	✗	✗
South of Haida Gwaii	HG2	✗	✗	✗	✗	✗
Devil's Mountain Fault Mw 7.5	DM1	✓	✓	✓	✗	✗
Devil's Mountain Fault Mw 6.5	DM2	✓	✓	✓	✗	✗
Southern Whidbey Island Fault Mw 7.5	SW1	✓	✓	✓	✗	✗
Southern Whidbey Island Fault Mw 6.5	SW2	✓	✓	✓	✗	✗

✓ - Source modelled for that detailed tsunami inundation domain
✗ - Source not modelled for that detailed tsunami inundation domain

Source: Page 2-29, Task 3: Tsunami Modelling and Mapping Report, Associated Engineering (October 2021)

Results of the detailed modelling and mapping are further described in Section 4.4 and appendices E through M in the Task 3 Report. Figure 5 is an example of the modelling outputs.

Figure 5 - Example: Maximum Occurring Water Surface Elevation in Port Renfrew CSZ-NS Event



Source: Appendix F, Task 3: Tsunami Modelling and Mapping Report, Associated Engineering (October 2021)

Tsunami – Risk Assessment

As a sub-task to the tsunami analysis, the consultant team did an assessment to identify the potential risk of damage to ports and harbours, as a result of flooding and strong currents generated by tsunami waves on selected locations across the region (see Section 5.2, Task 3 report). Utilizing public data sets, public and privately managed marine infrastructure (i.e., harbours, ports, marinas, etc.) from across the region were identified.

The water surface elevation and current velocity results from three tsunami scenarios (CSZ-L1, DM1, AL) from the study were then used to assess potential impact. Impacts to marine infrastructure were most expected from the CSZ-L1 scenario and DM1 scenario. More information can be found in Section 5, Task 3 report.

Dominant Hazards to inform Local Government Flood Construction Level Policy

The Task 3 Tsunami Report recommends using CSZ-NS as the standard, where tsunami risk exceeds the corresponding 1.0 m RSLR flood construction level at the specific location (see decision tree in Task 2 Report, Section 6.4). The report recommends results should always be checked against the results for the specific transect of interest (as summarized in Appendix B of the Task 2 Report, and Appendix D of the Task 3 Report).