Haida Gwaii Coastal Flood and Erosion Study

Planning for Sea-level Rise and Tsunami Hazards

Project Review

Presented to:
The Village of Port Clements

Presented by:

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nhc

nhc
northwest hydraulic consultants

50 YEARS

Agenda

- Background
  - Project Scope
  - Sea Level Rise
- Coastal Storm Flood Hazards
  - Metocean
  - Joint Probability
  - Wave Runup
- Erosion Susceptibility
- Tsunami
- Summary and Next Steps

Project Team

Project Partner:

NHC: Project lead
Coastal Wave Modelling
Erosion Susceptibility Assessments
Preparation of Maps
Reporting

ONC: Digital Elevation Model Preparation
Tsunami Modelling

Background

- Project Scope

  Quantify the flooding hazards of two independent natural phenomena occurring when sea levels are higher:

  - Large windstorm generated waves
  - Tsunami
  - Erosion Susceptibility (Note: detailed erosion assessments for individual properties were not done)

- Project jointly funded by multiple Haida Gwaii communities to leverage efficiencies in offshore analysis

Background

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  - Tsunami
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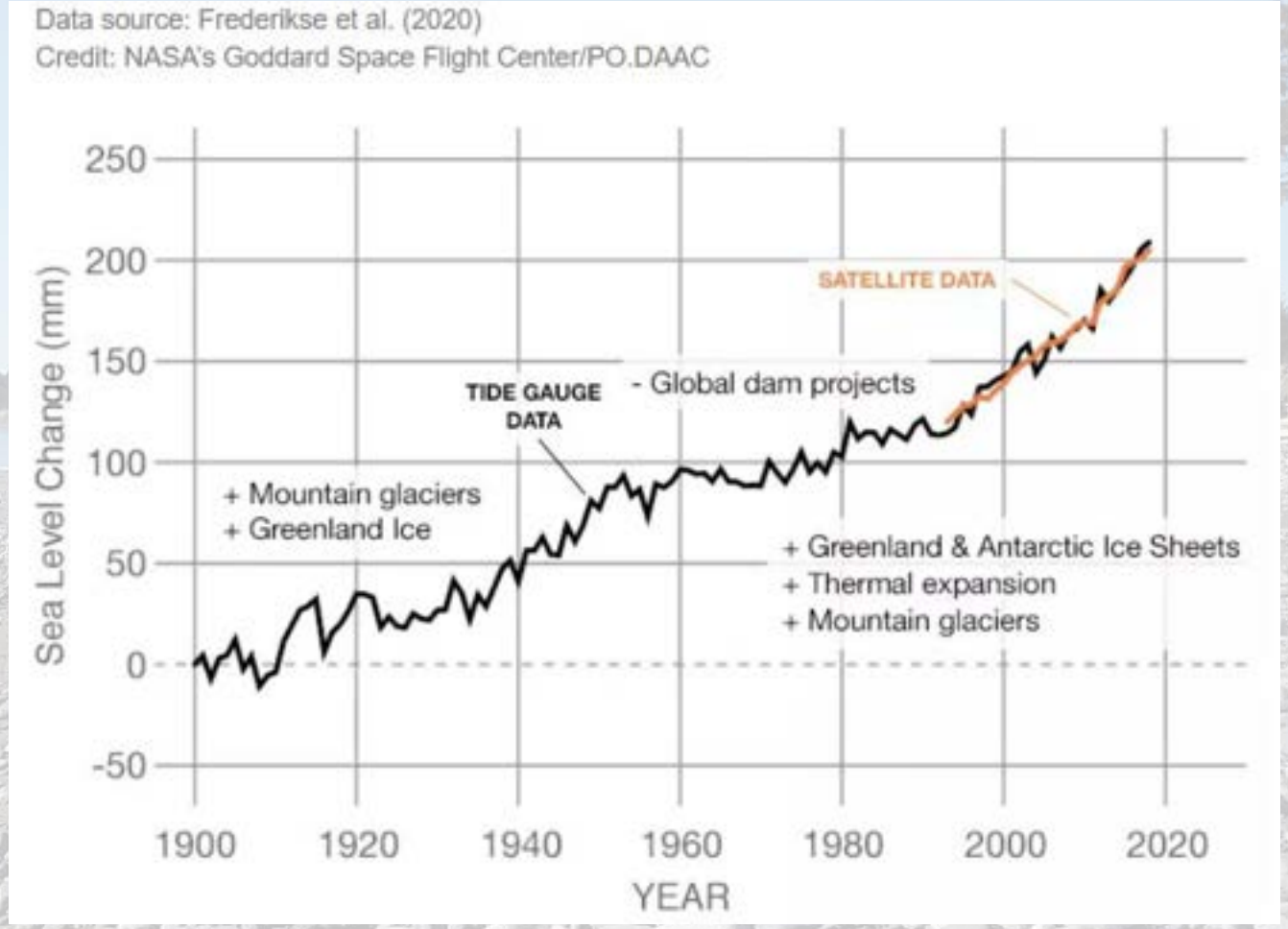
Sea Level Rise

Climate Change Impacts

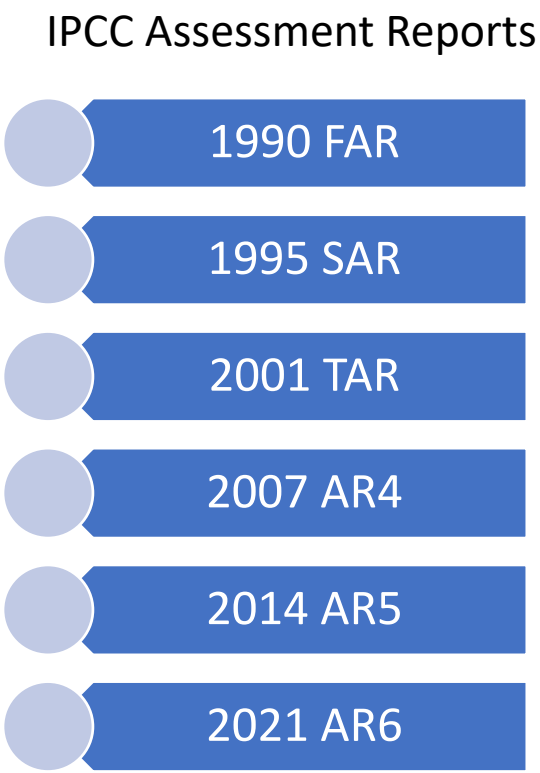
- Global Average Sea Levels are rising
- Rate of change is increasing
- Very little uncertainty that 1 m of SLR will occur
- Higher uncertainty on future rates of SLR and timing
- Regional variability in SLR



Sea Level Rise (SLR) Guidance

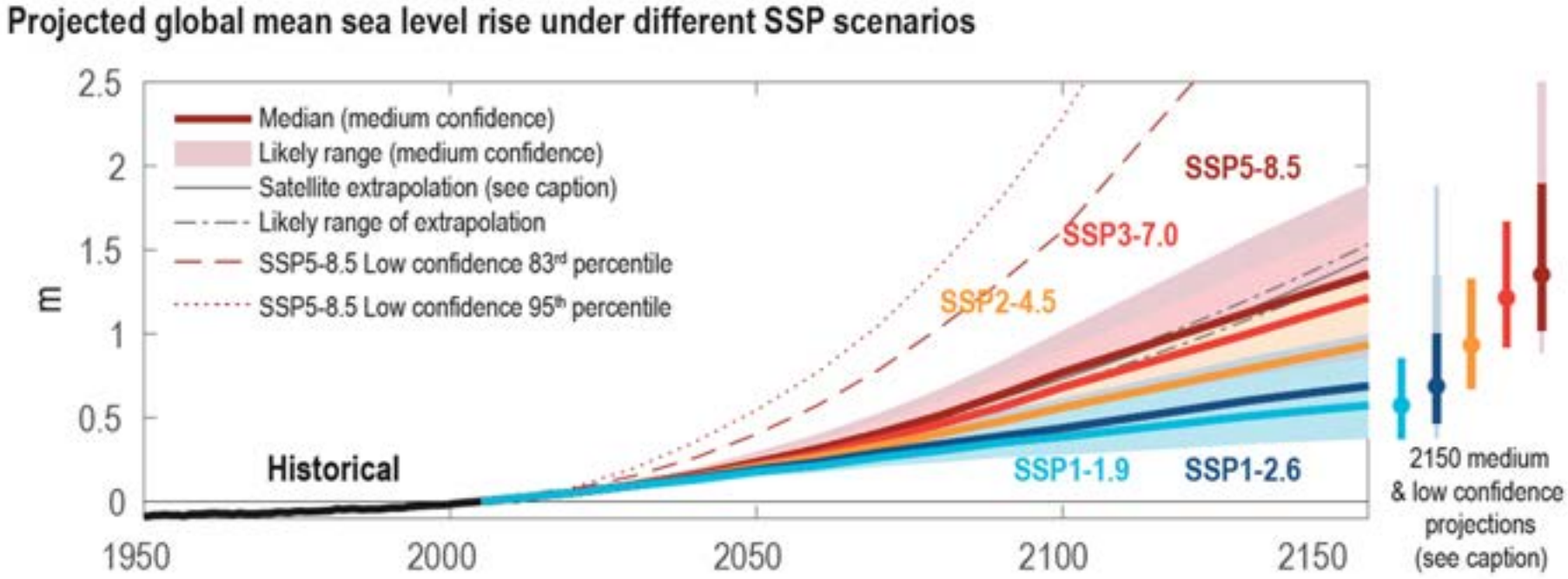
Guidance available from scientific journals and also International Panel on Climate Change (IPCC) reports.

- The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.
- The sixth Assessment Report (AR6) Physical Science Basis was released in 2021.



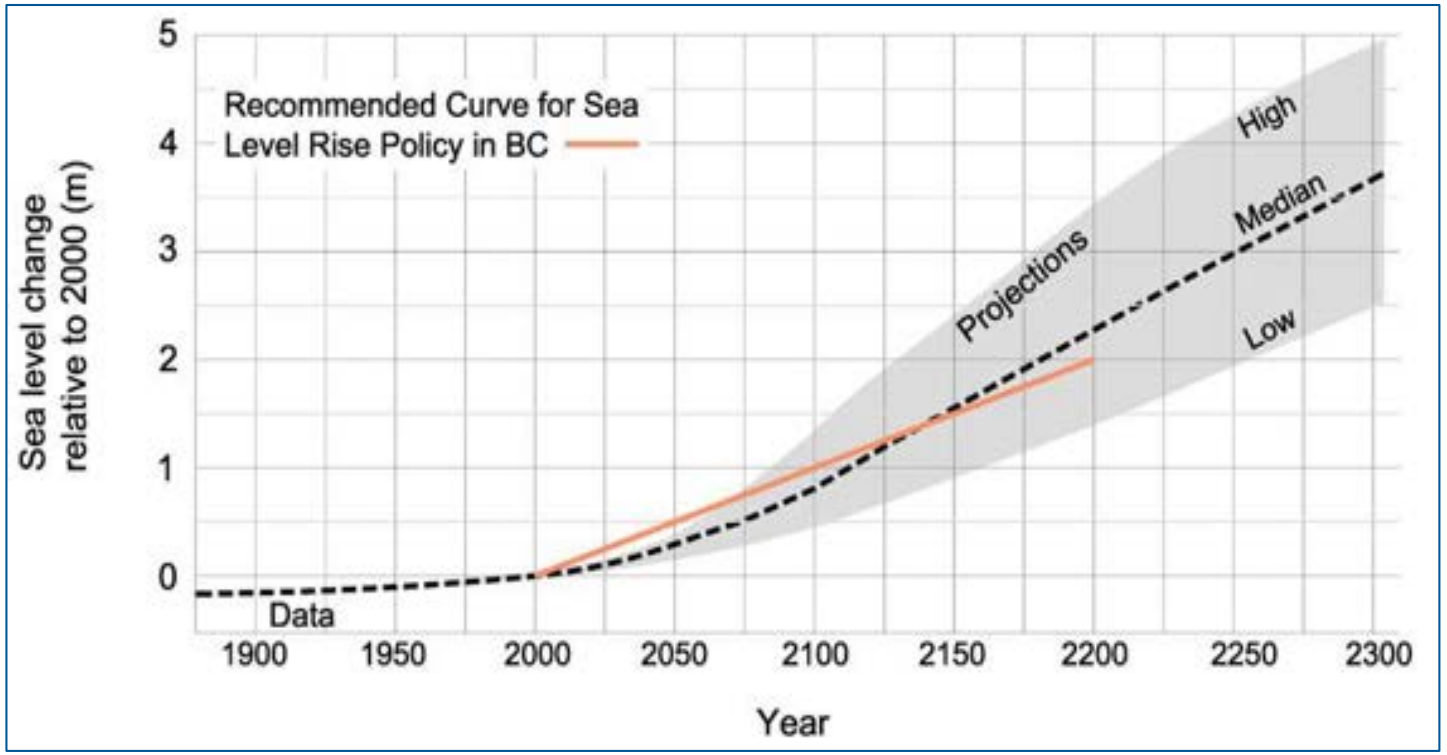
Sea Level Rise – IPCC AR6 (2021)

- SLR has high uncertainty based upon future anthropogenic behaviour
- SSP = shared socio-economic pathway:
  - SSP1-2.6 is rapid reduction in emissions, net zero 2050, below 2°C warming
  - SSP2-4.5 is roughly in-line with Paris Agreement Pledges
  - SSP5-8.5 is high reference “business as usual” emissions scenario



IPCC AR6, Working Group 1, Science Basis Report, Chapter 9

Sea Level Rise (SLR) – BC planning

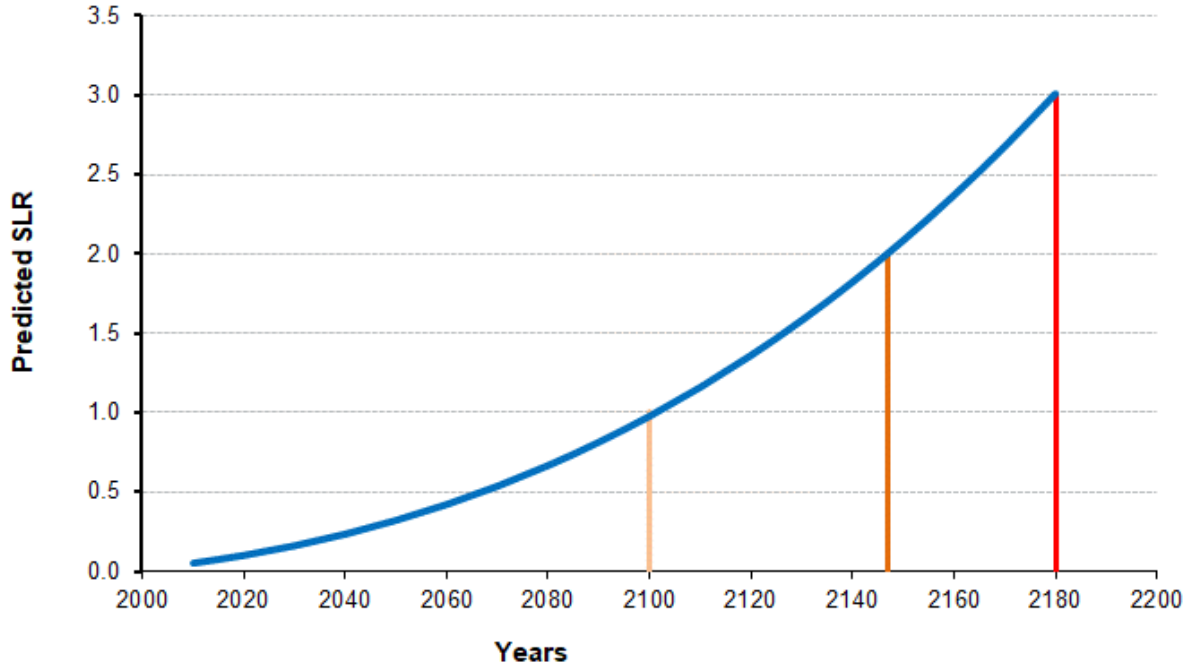


- BC Guidance is for 1 m for year 2100, and 2 m for year 2200 (Credit: BCMOE, Ausenco-Sandwell 2011)

- Single value for planning purposes. Estimate developed using IPCC AR4 and other information available in 2009-2010 period. Was considered conservative when released.

Sea Level Rise – Planning Windows

- SLR is expected to accelerate in the future
- Implication for planning cycles (High Emissions):
  - First metre of SLR likely to occur over the next 75 to 130 years *
  - Second metre of SLR could occur in the following 40 to 65 years *
  - Third metre of SLR possible in the subsequent 25 to 45 years * (40 mm/yr)



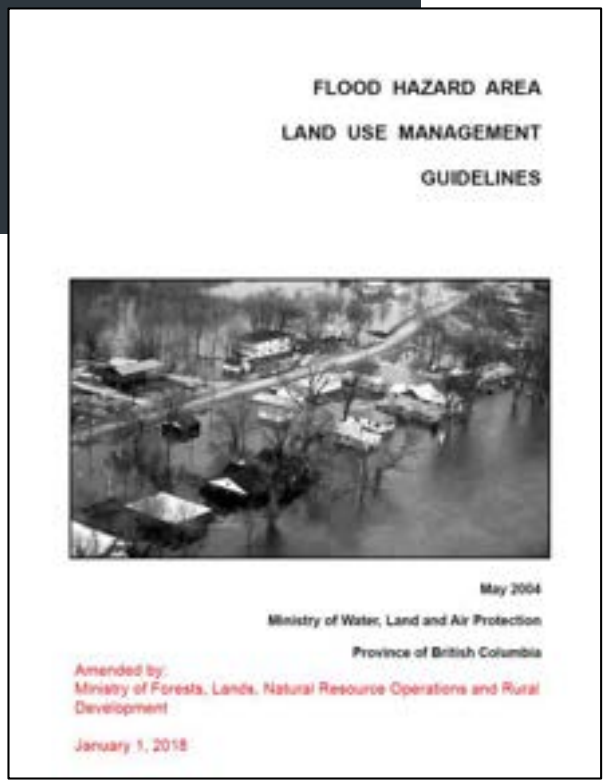
Polynomial fit of RCP8.5 curve from AR5 past year 2100. (G Lamont & J. Readshaw)

* Depending on emissions scenario

Flood Hazard Assessments
Governing Practice Guidelines - BC

The following guidelines and regulations exist in BC:

- Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC (EGBC, 2018)
- Flood Hazard Area Land Use Management Guidelines (BCMFLNRD, 2018)
  - Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Policy Discussion Paper (BC Ministry of Environment, 2011a)
  - Coastal Floodplain Mapping – Guidelines and Specifications (BC Ministry of Environment, 2011b)
  - Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use (BC Ministry of Environment, 2011c)

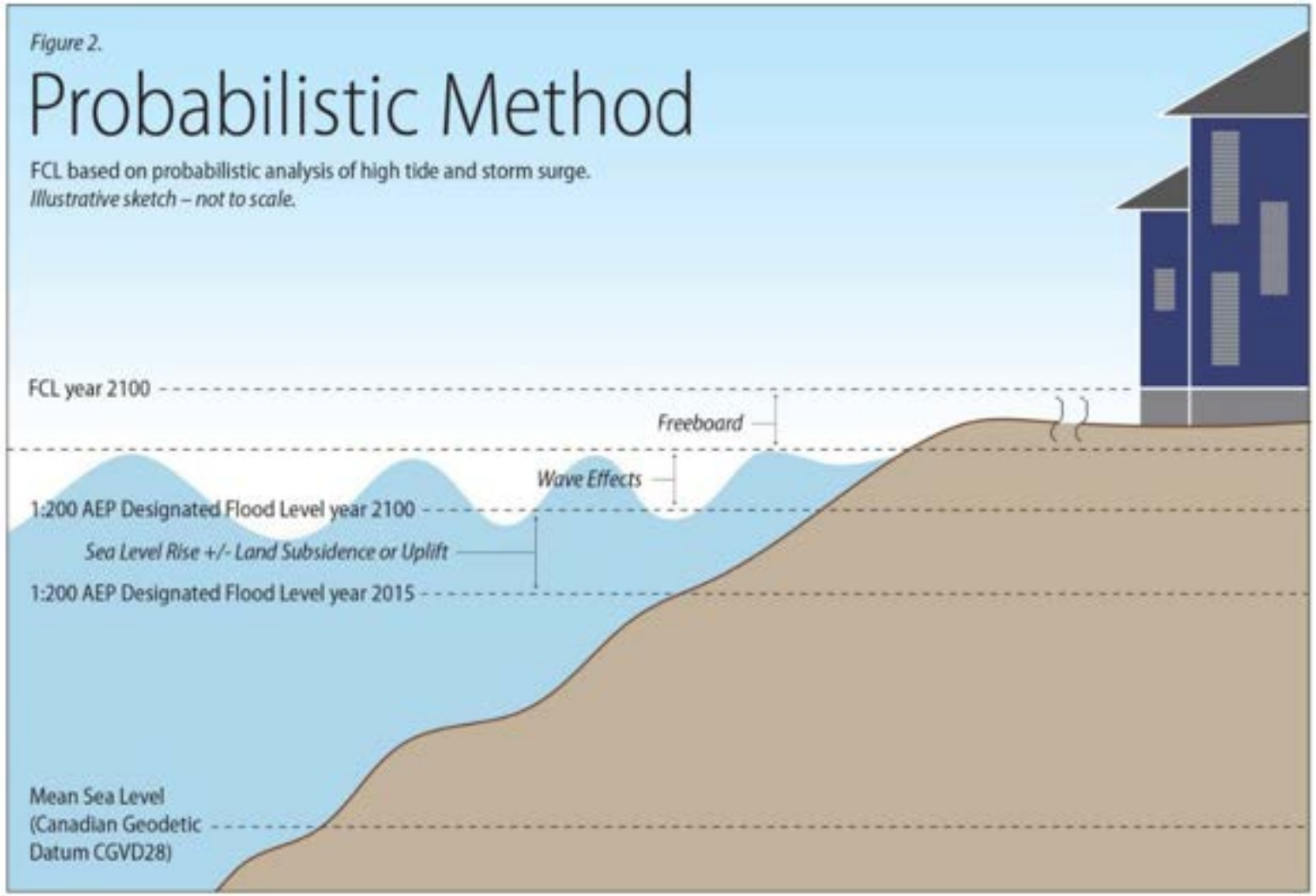


Flood Construction Level (FCL)

- The elevation of the underside of a wooden floor system or top of concrete slab for habitable building space.
- In the case of a manufactured home, the ground level or top of concrete or asphalt pad, on which it is located, shall be equal to or higher than the above described elevation. It also establishes the minimum crest level of a Standard Dike.

Governing Practice Guidelines – Coastal Storm Flooding

There are two approaches for determining the 200-year FCL as per BC Guidance:



Joint Probability Method

- Considers the probability of severe events occurring simultaneously
- More extensive analysis required to complete

Joint Probability Analysis

Joint probability analysis not possible for Masset Inlet due to lack of historical data.

- Modelled storm winds from multiple compass directions to determine worst case combinations of wind and fetch for shoreline wave conditions.
- Tide range in Masset Inlet is attenuated compared to open coasts. Combination of tide and storm surge was used to establish the designated flood level (DFL).
- Once the DFL was established, the wave runup (wave effect) on shorelines was evaluated to establish the FCL.

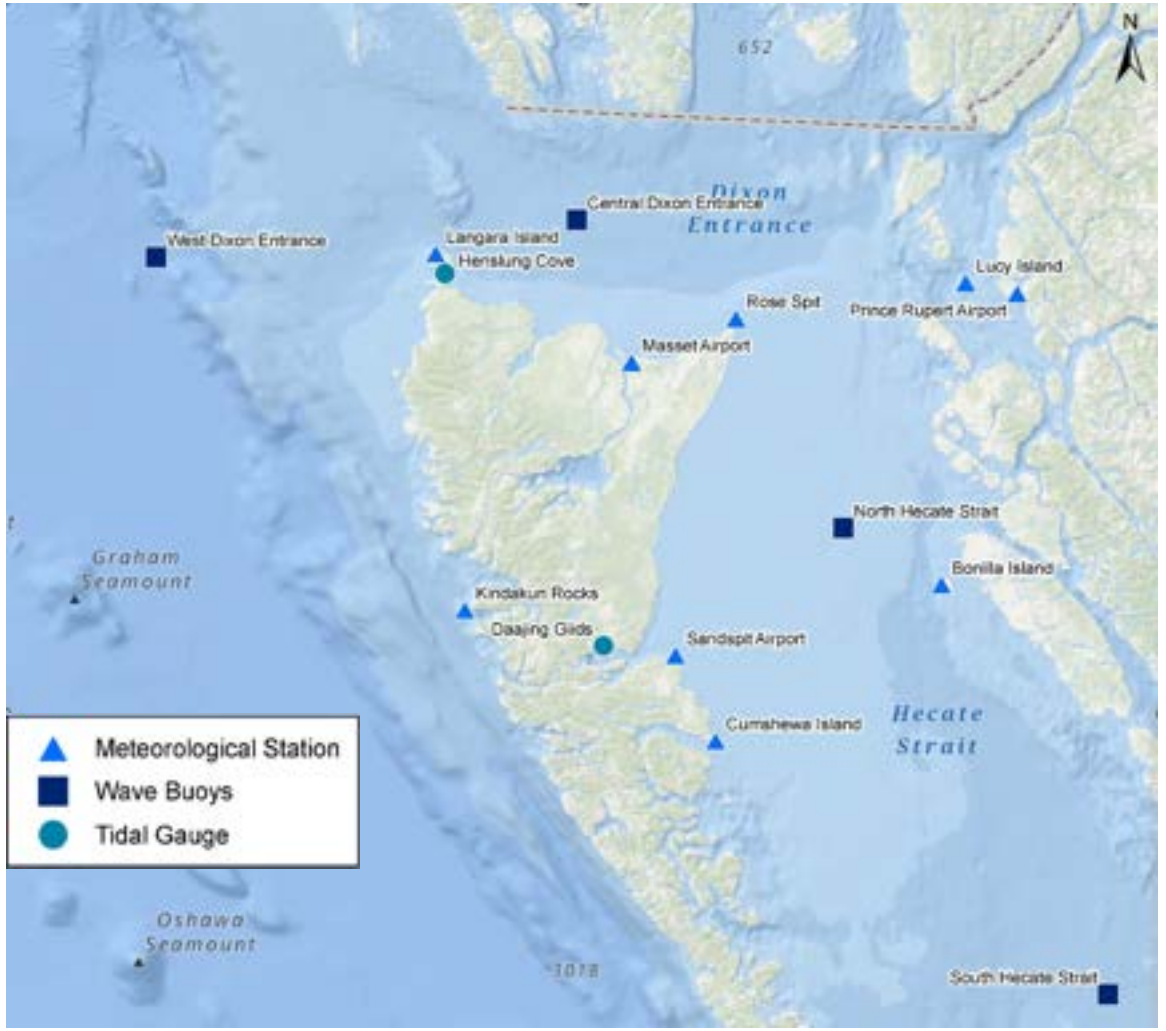
Metocean

- Primary Fetches for local wind waves for offshore study areas:
  - HSN = Hecate Strait North
  - HSS = Hecate Strait South
  - DEW = Dixon Entrance West
  - DEE = Dixon Entrance East

Primary Fetch Exposures for wind waves in study area

Metocean

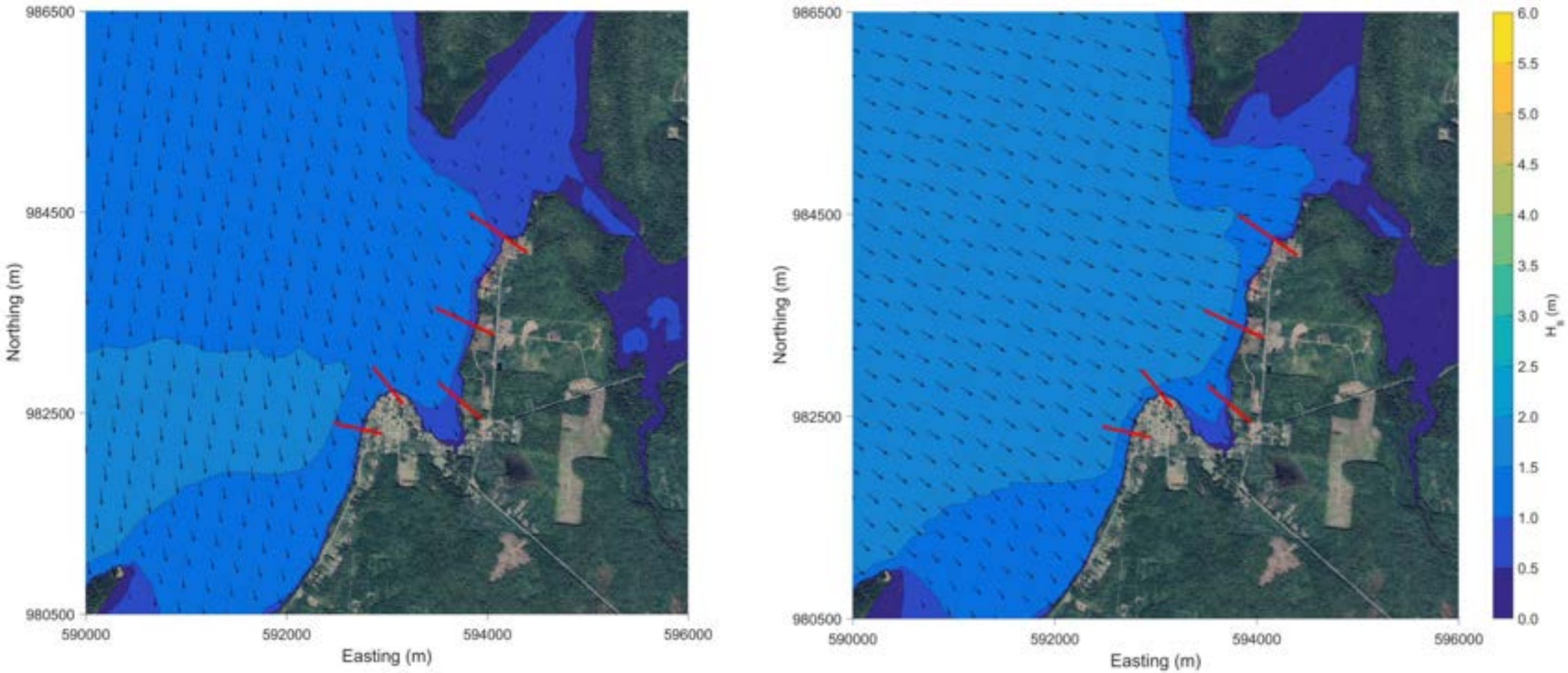
- Challenge for Port Clement and Juskatla is lack of data available in Masset Inlet.
- No long-term recorded wind or wave height data available.
- Adopted approach of using scaled winds between Masset Airport and Sandspit Airports with over-land corrections.



Wind and Wave measurement station locations

Metocean

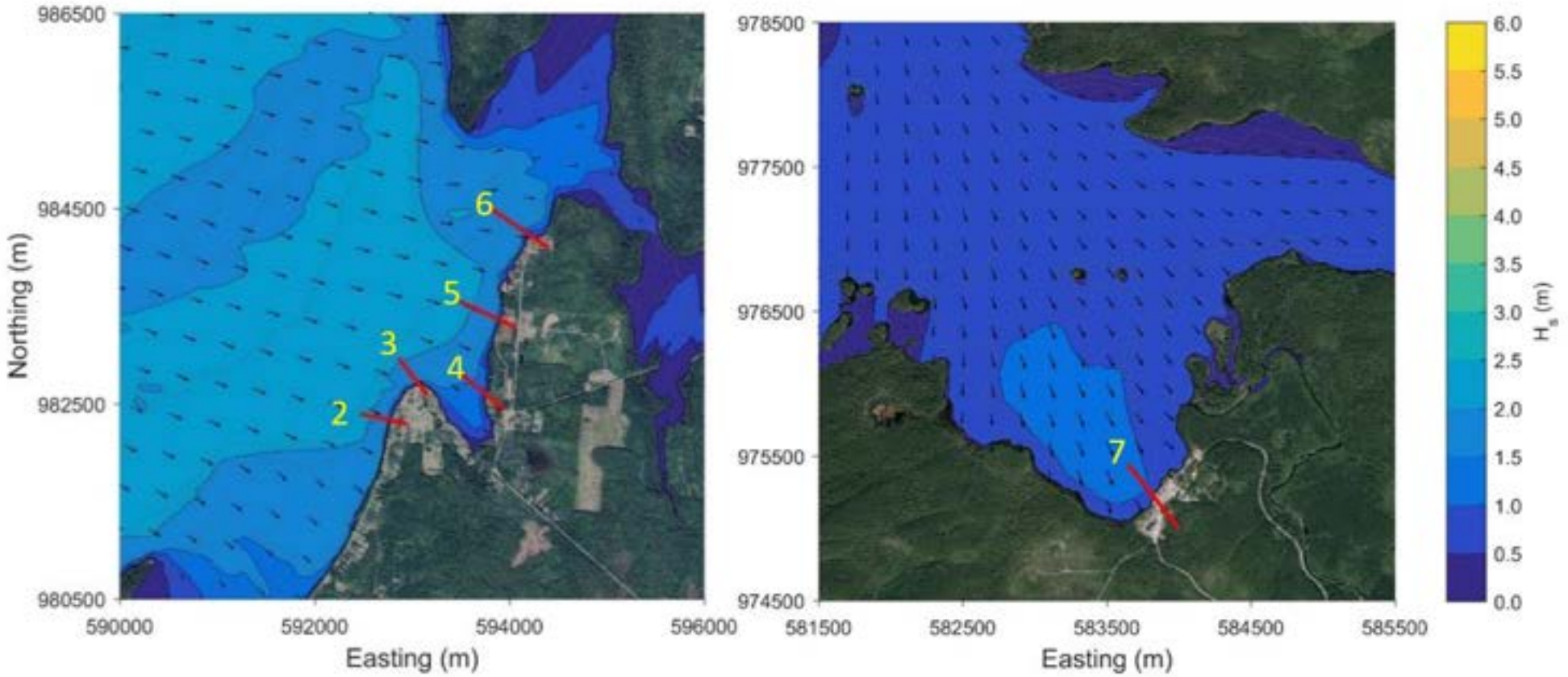
- Masset Inlet wind wave modelling



NHC SWAN model output; N winds (left) and WNW winds (right)

Wave Effects

- Wave effects on shoreline determined based upon offshore wave heights.
- Numerical modelling used to transform offshore waves to nearshore



Offshore Wave Heights

Transect 1 is in Fergusun Bay

Transect 7 is at Juskatla

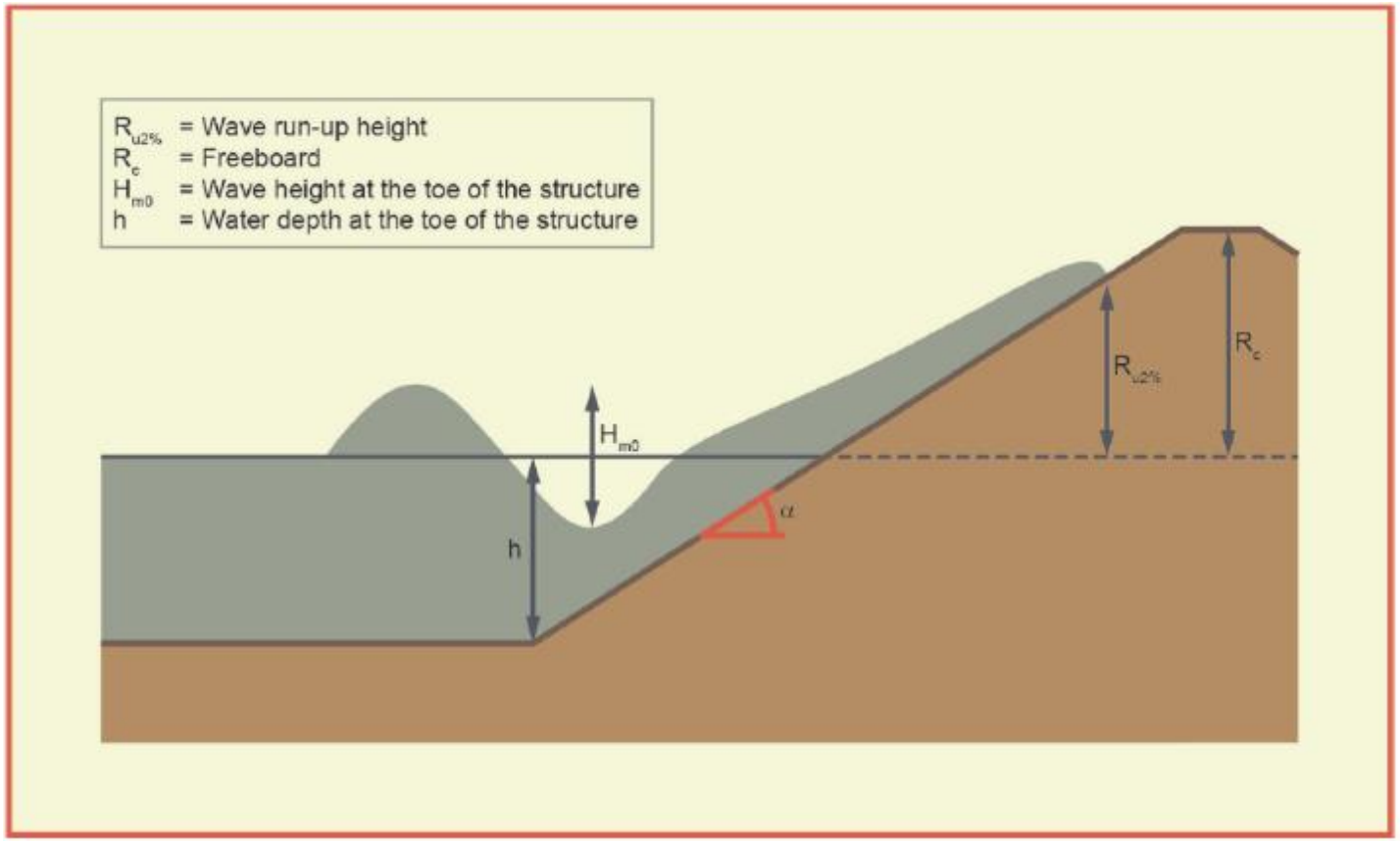
Transect	Easting	Northing	Depth	Hs (m)	Tp (s)	Direction
1	586387	981609	16.7	1.7	4.6	25
2	592478	982403	13.1	2.1	5.6	288
3	592861	982965	11.4	2.0	5.6	293
4	593524	982808	4.6	1.7	5.6	304
5	593491	983545	11.6	2.0	5.6	289
6	593819	984482	11.2	2.0	6.1	265
7	583640	975440	14.5	1.0	3.5	324.3

Notes: 1. Water depth at offshore end of transect during simulation

2. Transect No. 1 at Port Clement not shown on figure. Location at log sort area.

Wave Effects (Wave Runup)

Note: Empirical wave runup assumes a continuous slope upwards.

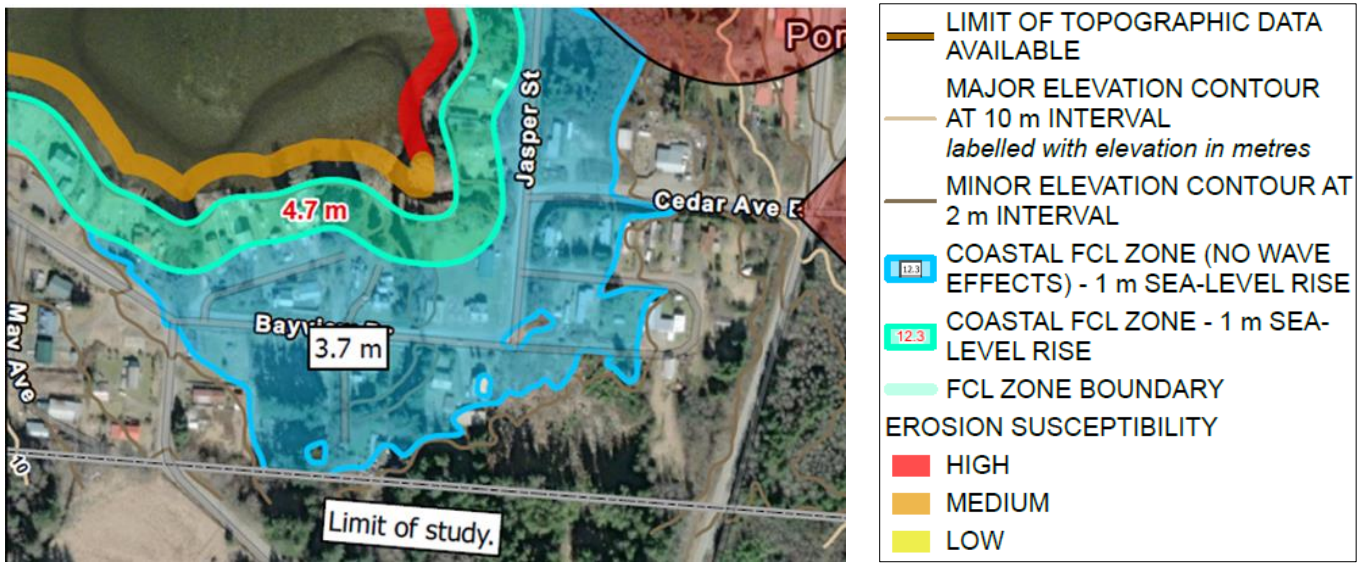


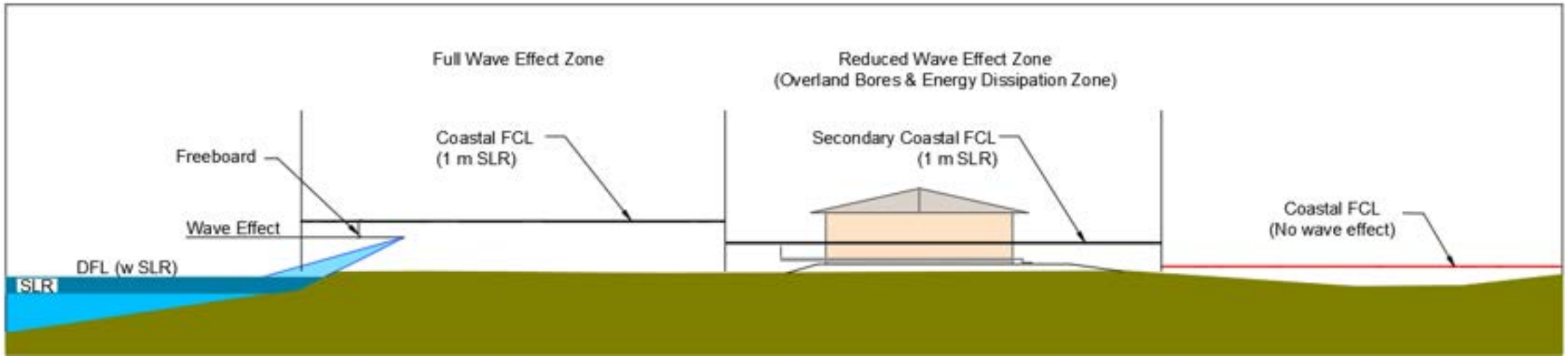
Ref: EurOtop Manual (2018): Manual on wave overtopping of sea defences and related structures. (Second Edition)

Photo: NHC – West Vancouver, December 20, 2018

Wave Effects (display on maps)

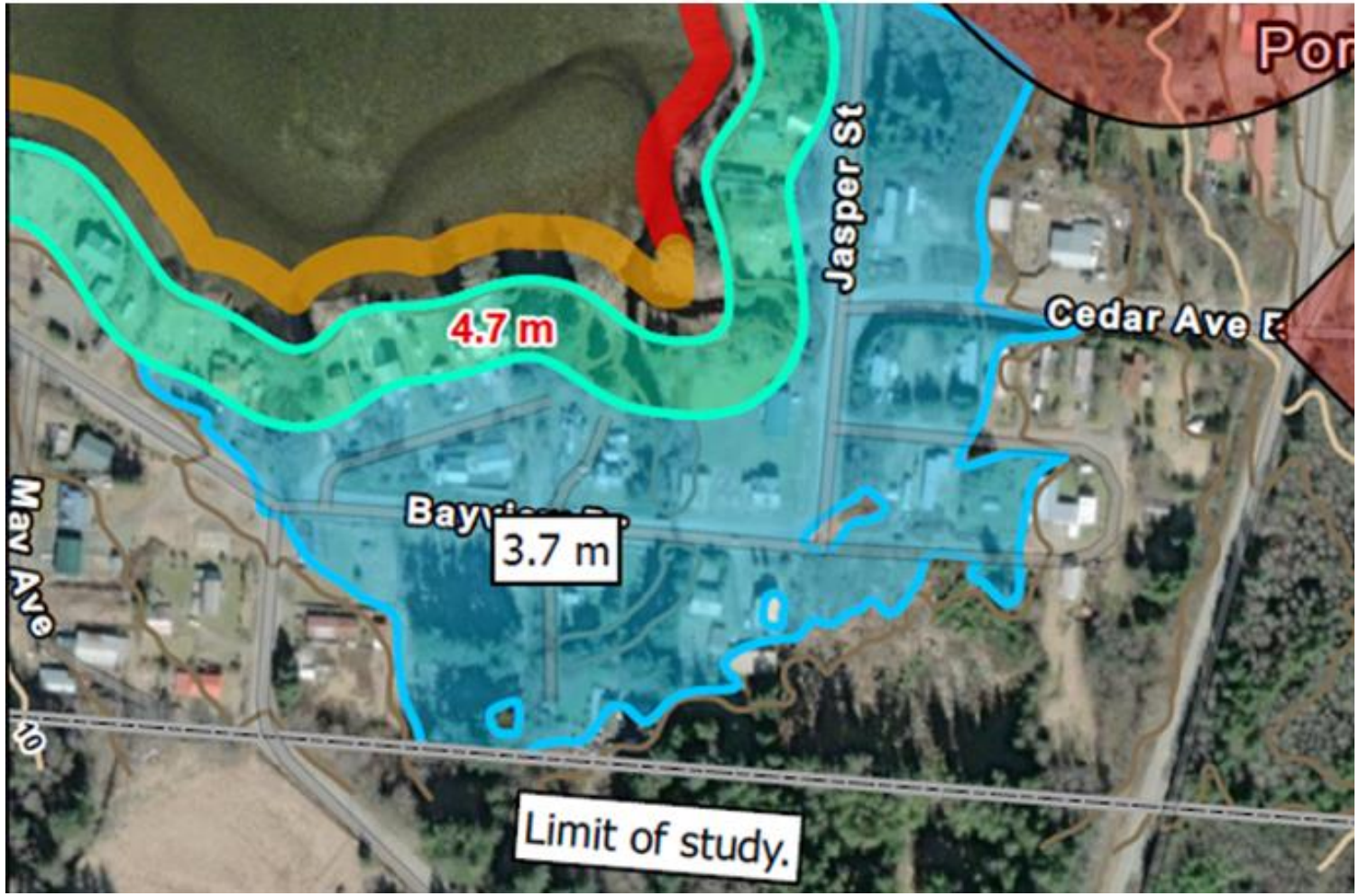
Portion of a FCL map for Village of Port Clement.





Schematic showing FCL zones in profile

Coastal Storm Hazard Areas

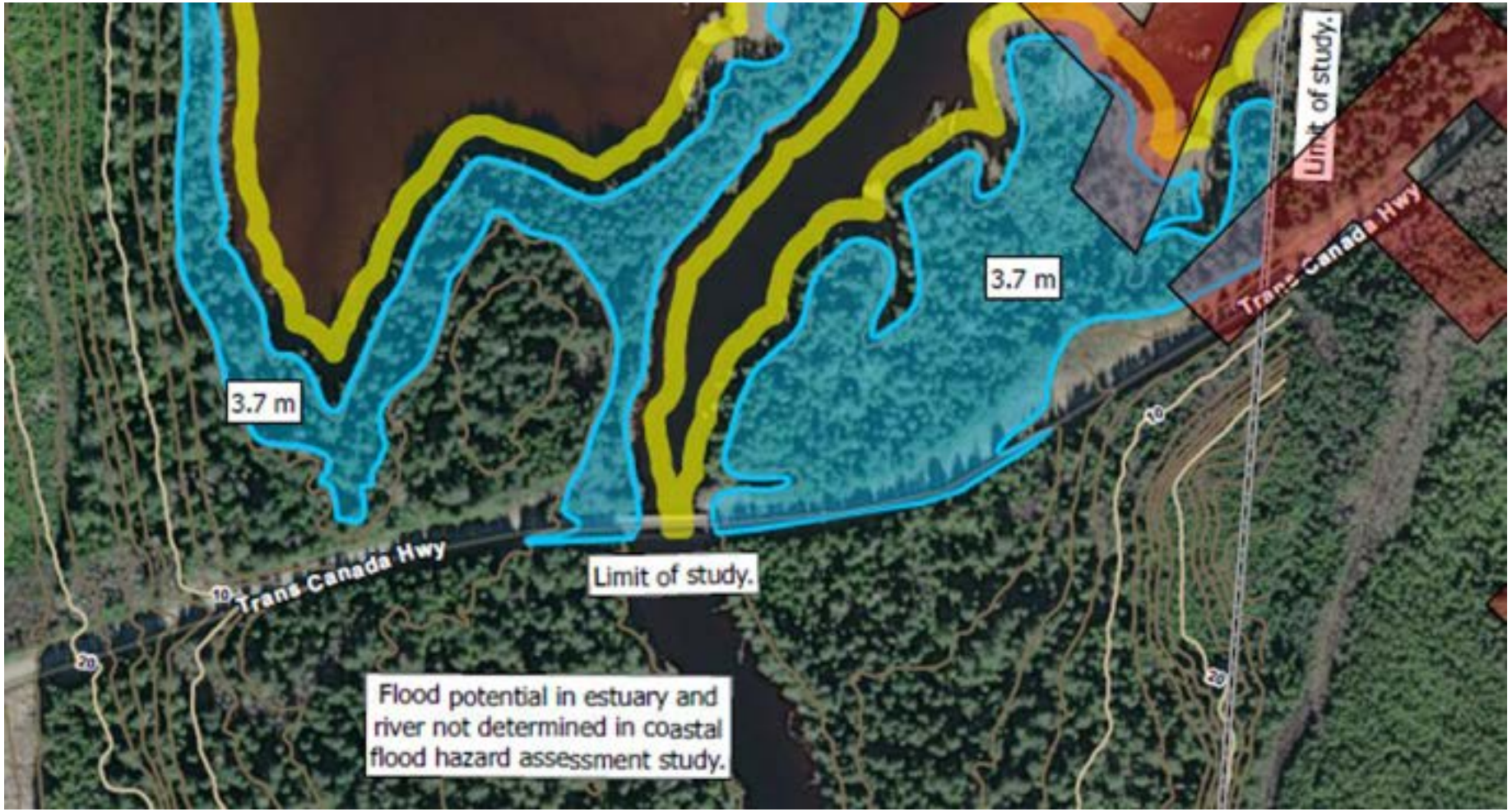


- LIMIT OF TOPOGRAPHIC DATA AVAILABLE
- MAJOR ELEVATION CONTOUR AT 10 m INTERVAL
  labelled with elevation in metres
- MINOR ELEVATION CONTOUR AT 2 m INTERVAL
- COASTAL FCL ZONE (NO WAVE EFFECTS) - 1 m SEA-LEVEL RISE
- COASTAL FCL ZONE - 1 m SEA-LEVEL RISE
- FCL ZONE BOUNDARY

EROSION SUSCEPTIBILITY

- HIGH
- MEDIUM
- LOW

Coastal Storm Hazard Areas



Coastal Storm Hazard Areas

Erosion Susceptibility

- Not intended to predict future erosion, rather a description of susceptibility to erosion in future
- Based on existing conditions as well as expected conditions in the future
- No reliance on the presence of coastal protection structures (riprap, etc.) – these structures point to past erosion activity requiring intervention
- Rating is relative – “low” does not mean non-erodible, “high” does not necessarily mean rapid retreat

Erosion Susceptibility

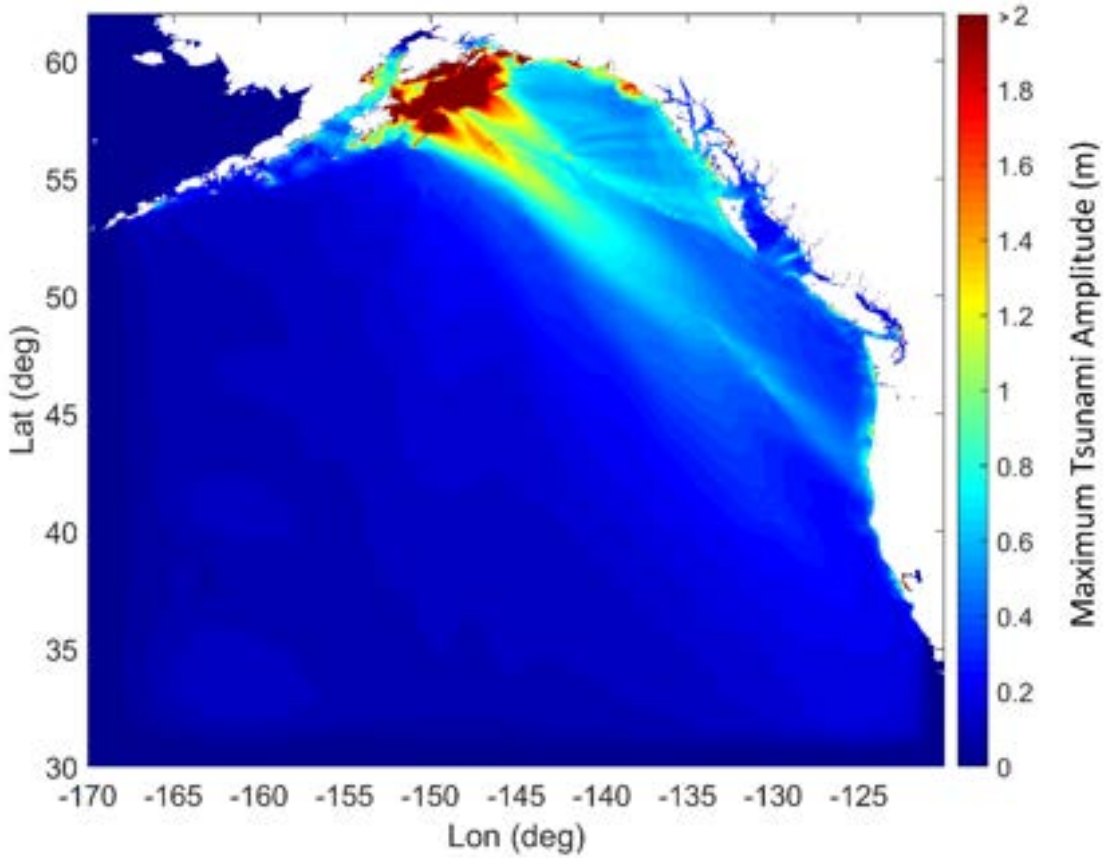
Tsunami

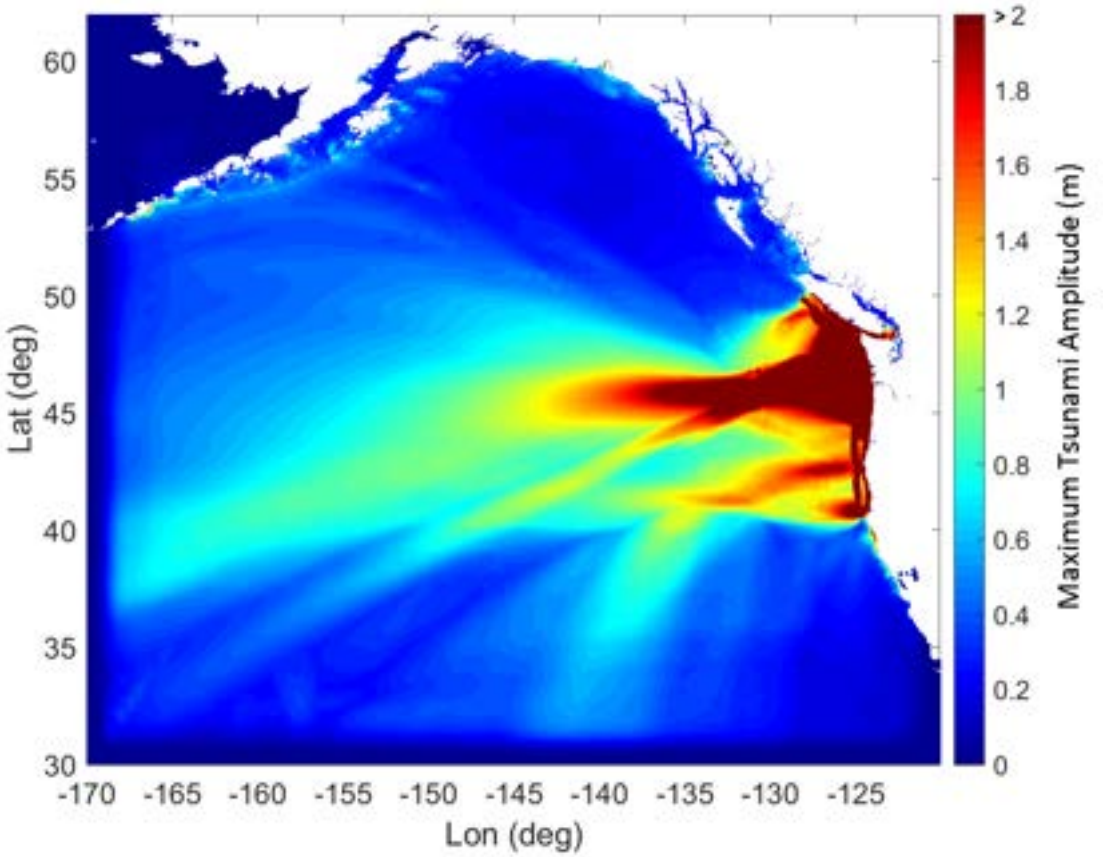
- Haida Gwaii exposed to tsunami originating along Pacific Ocean ‘ring of fire’.

Subduction zones around Pacific (adapted from Atwater et al., 2005)

Tsunami

- Two major tsunami sources (Alaska / Cascadia Subduction Zone) modelled.

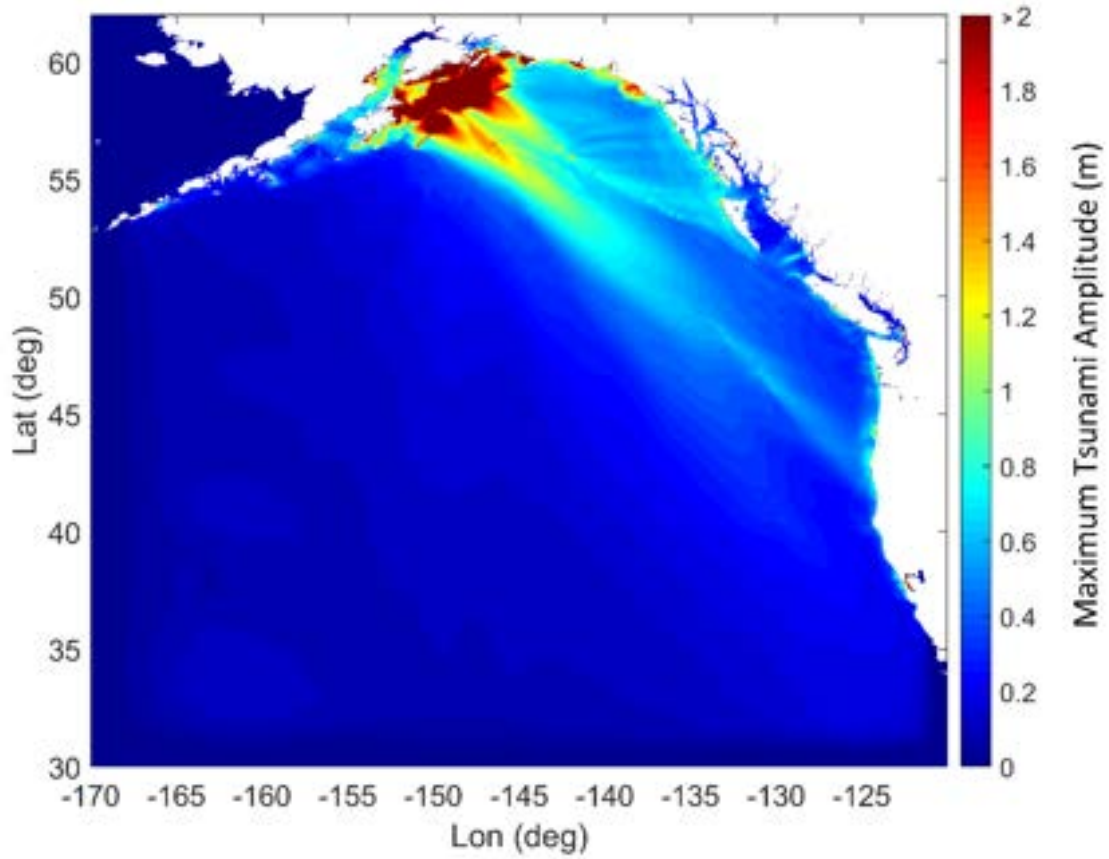


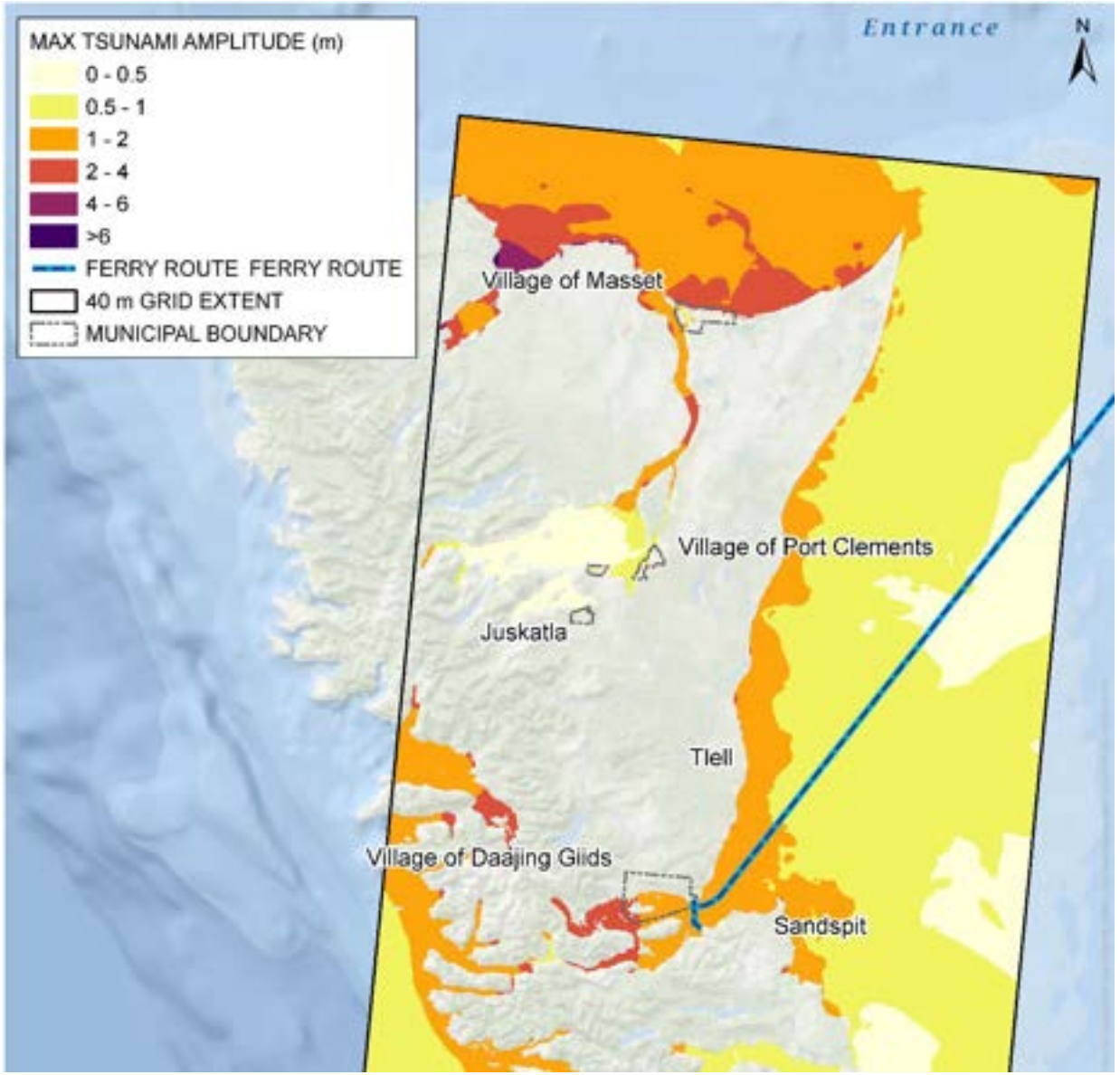


Alaska (left) and Cascadia Subduction Zone (right) tsunami maximum amplitude plots

Tsunami

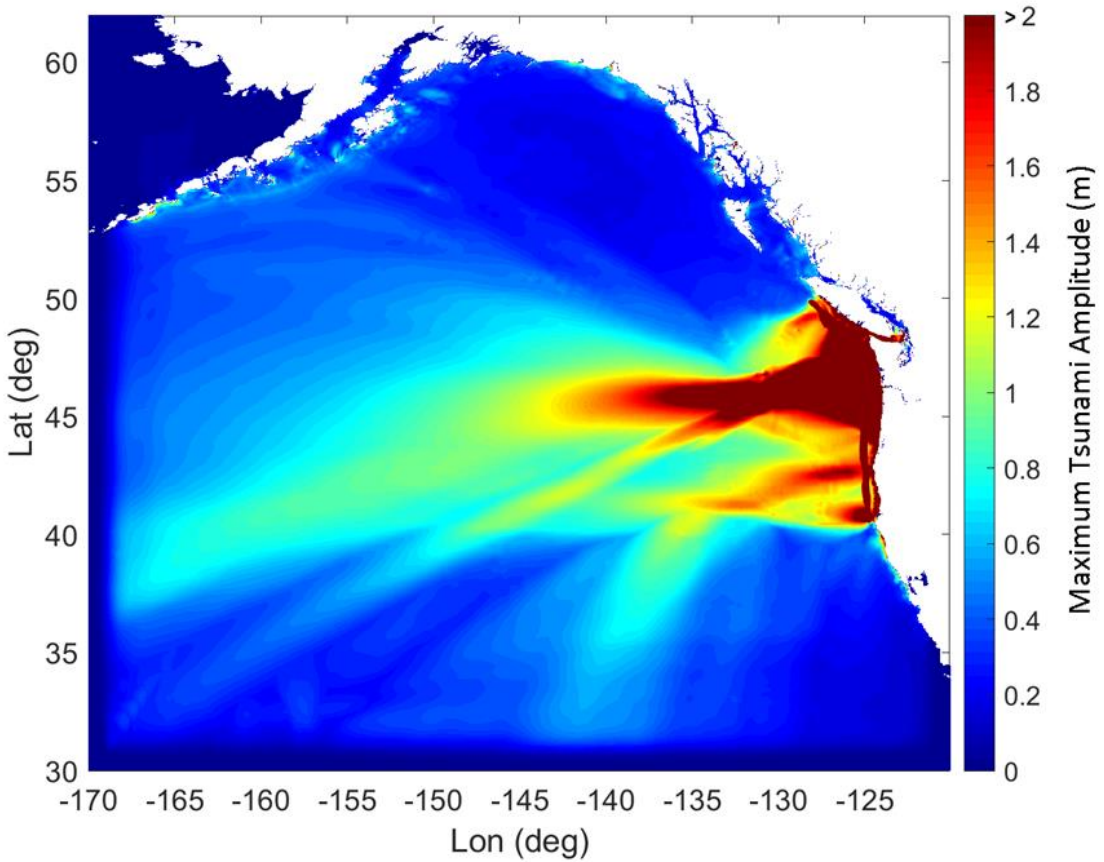
- Maximum Amplitude (Alaska-Aleutian subduction zone event)

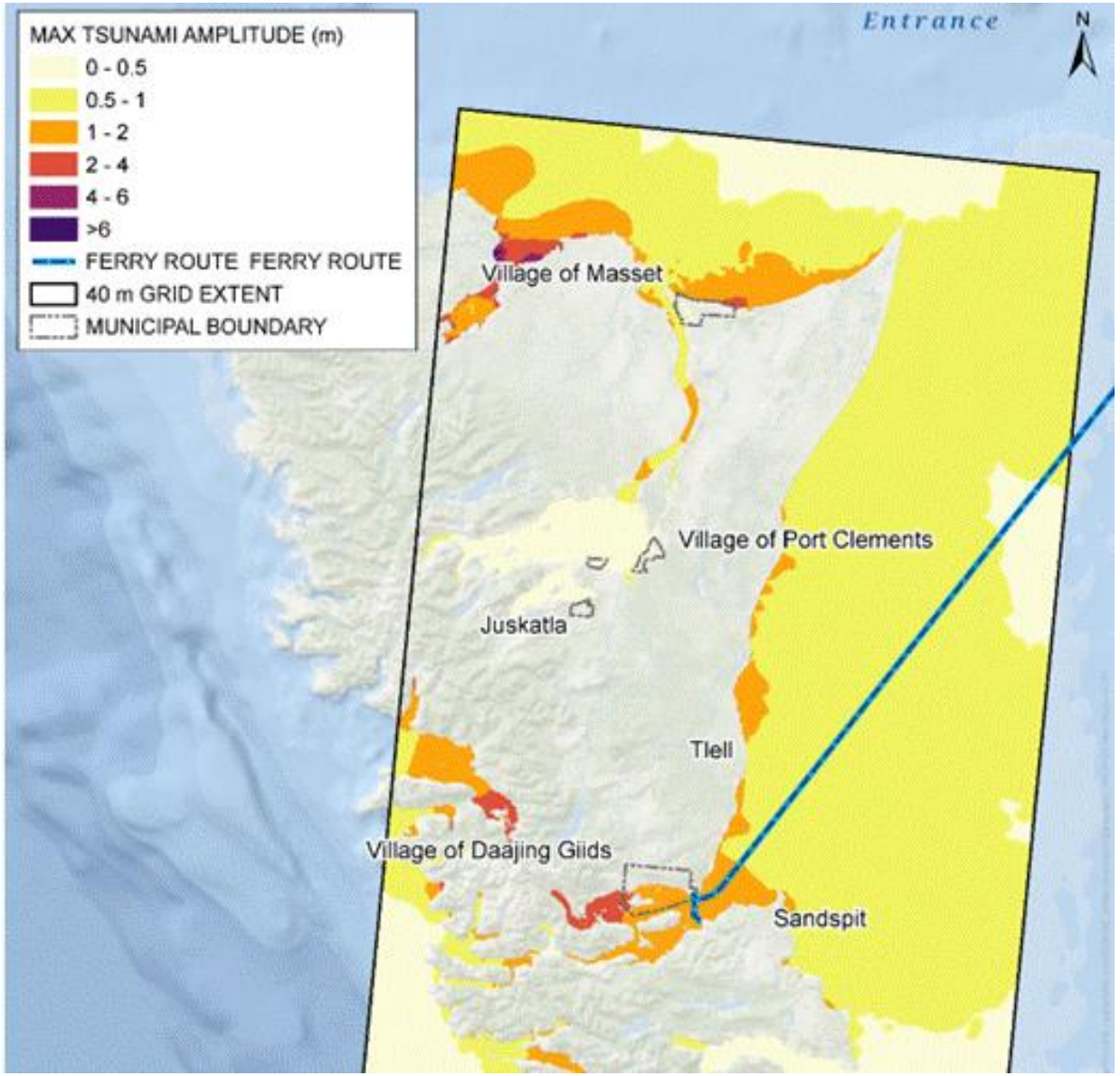




Tsunami

- Maximum Amplitude (Cascadia subduction zone event)





Tsunami

- Maximum Amplitude and arrival times

Area	Arrival Time[1]	Inundation Level for Emergency Planning[2] (CGVD2013)		
		Current-day (m)	1 m SLR (m)	2 m SLR (m)
Masset Airport	2h 32min	6.9	7.6	8.6
Tow Hill	2h 37min	7.2	8.5	9.4
Masset (Village Core)	2h 38min	4.3	6.0	7.1
Port Clements	3h 31min	2.8	3.7	4.9
Ferguson Bay	3h 36min	1.8	2.9	3.8
Juskatla	4h 29min	0.4	1.4	2.4
Tlell	3h 49min	5.7	6.7	7.6
Daajing Giids	3h 52min	6.1	7.3	8.7
Sandspit	3h 43min	6.9	8.0	7.8

Tsunami

- Tsunami maps; SLR of 1m (light blue) and 2m (dark blue)

INUNDATION EXTENTS FOR 1 m OF RELATIVE SEA LEVEL RISE

INUNDATION EXTENTS FOR 2 m OF RELATIVE SEA LEVEL RISE

LIMIT OF INUNDATION MAPPING

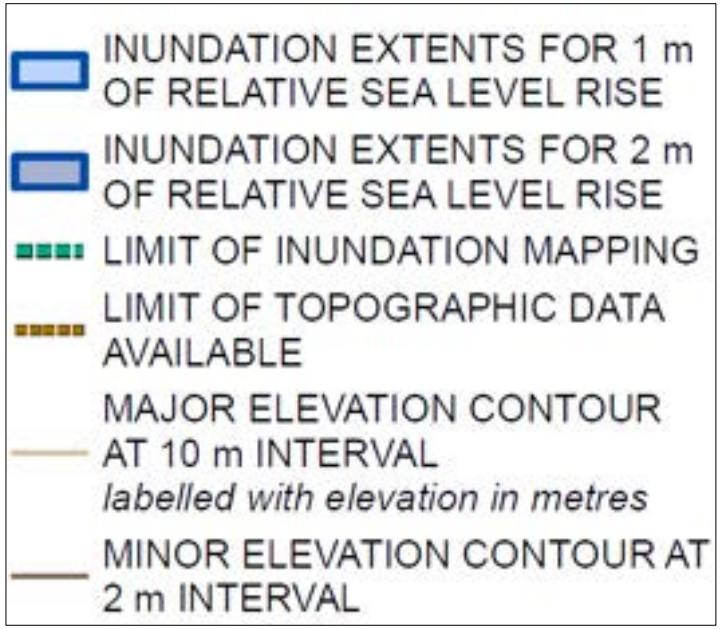
LIMIT OF TOPOGRAPHIC DATA AVAILABLE

MAJOR ELEVATION CONTOUR AT 10 m INTERVAL
labelled with elevation in metres

MINOR ELEVATION CONTOUR AT 2 m INTERVAL

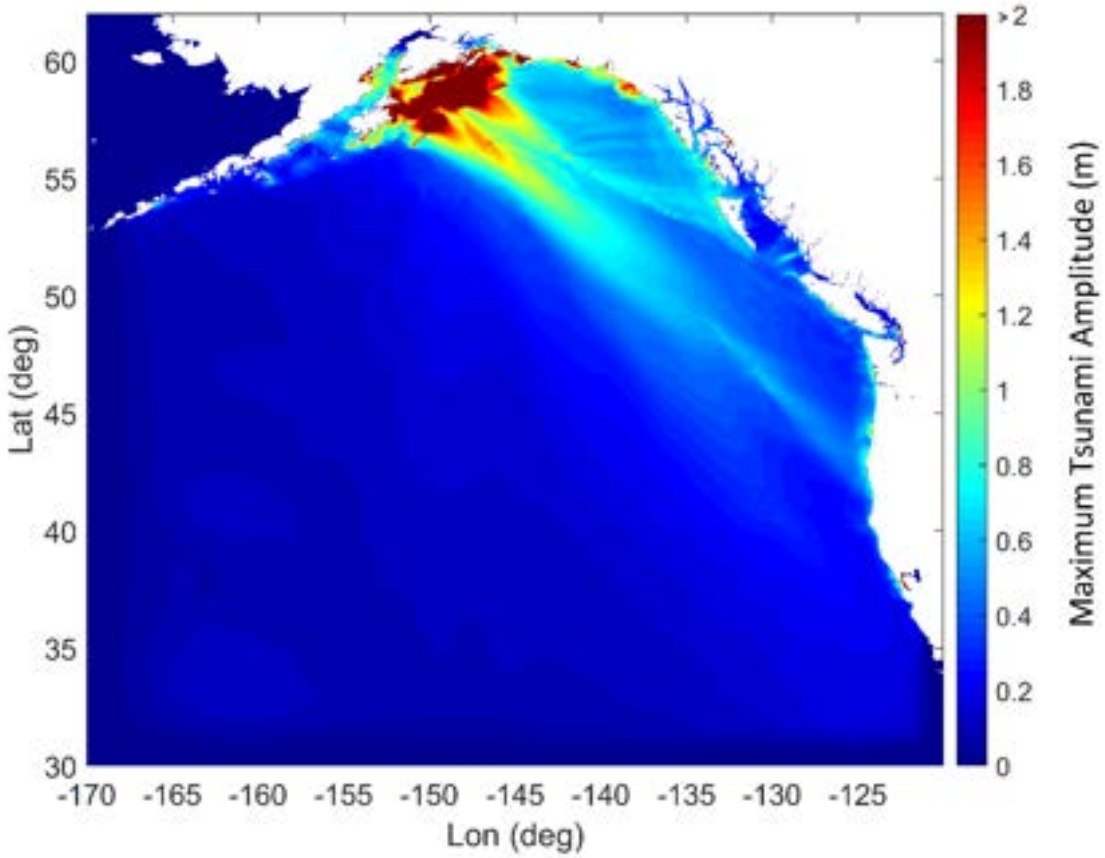
Tsunami

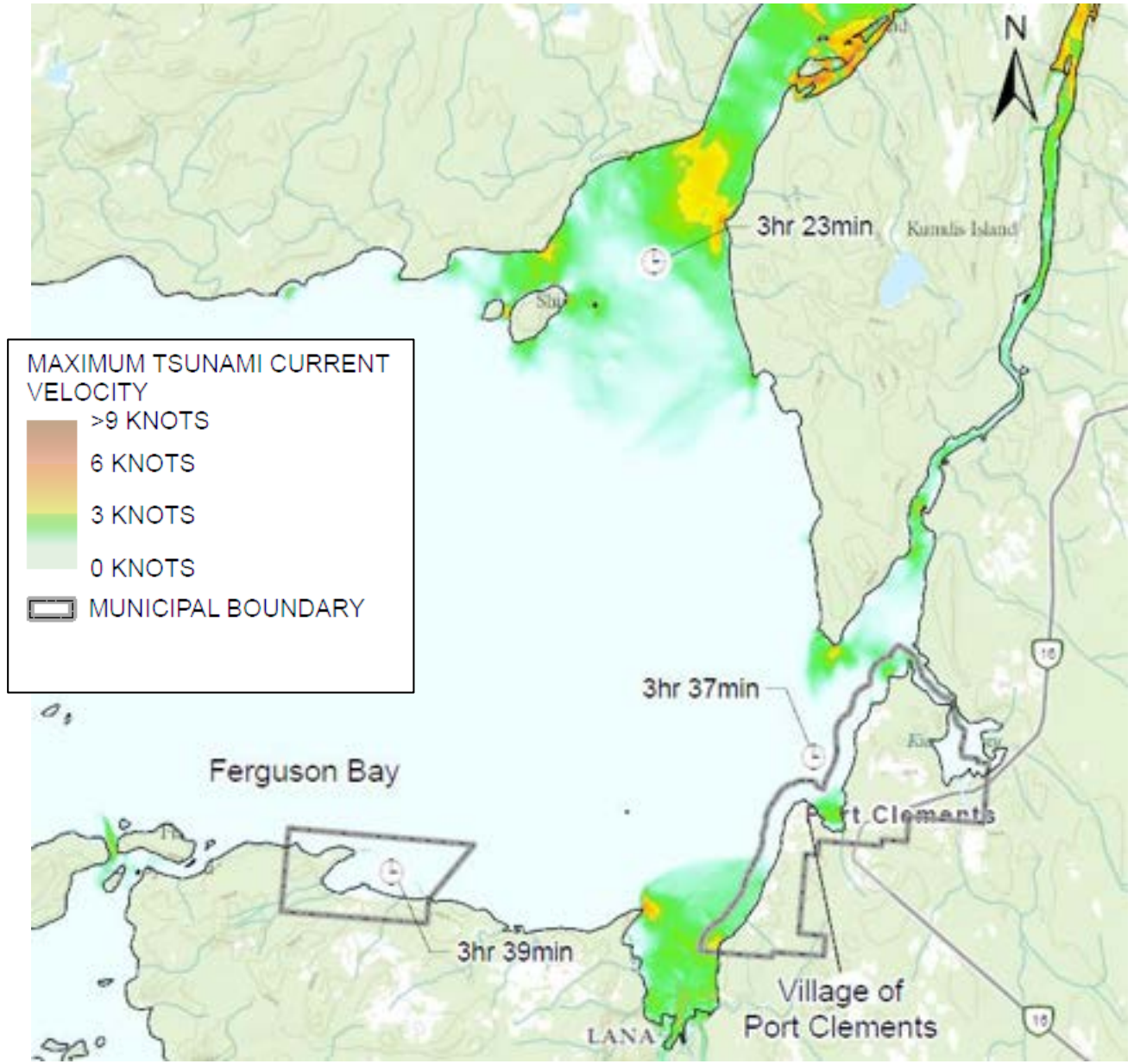
- Tsunami maps; SLR of 1m (light blue) and 2m (dark blue)



Tsunami

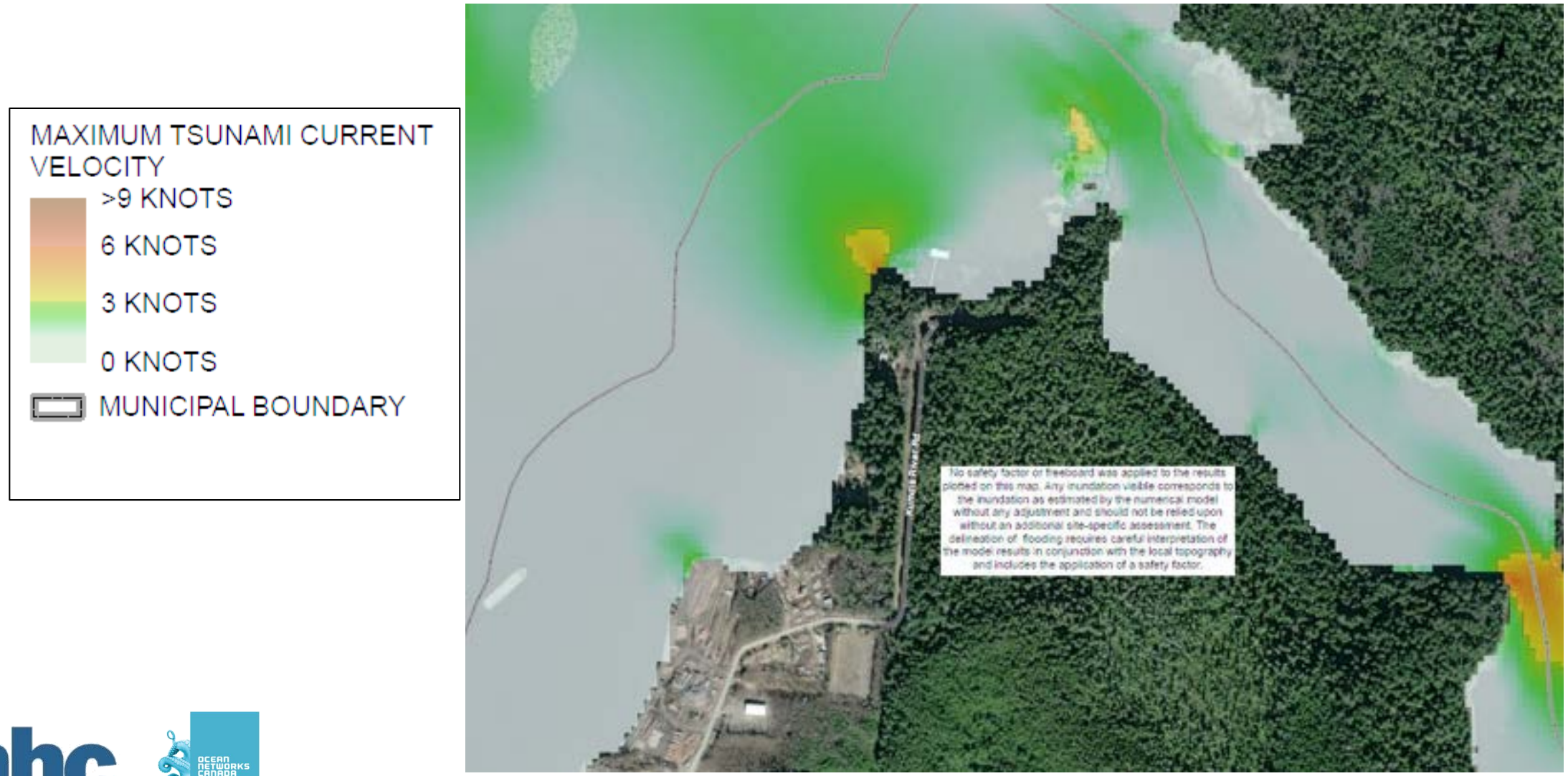
- Maximum Velocity (Alaska-Aleutian subduction zone event)





Tsunami

- Tsunami maps; max velocity



Tsunami

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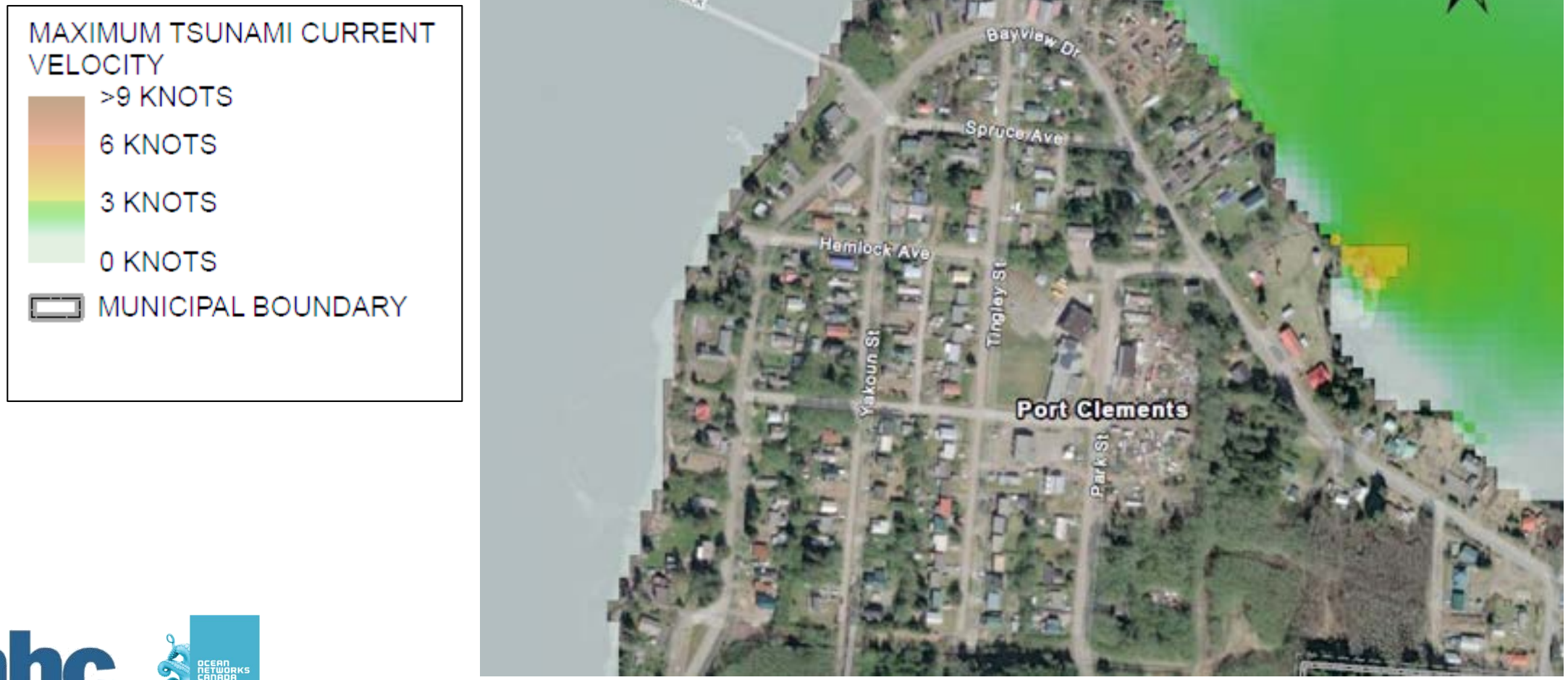
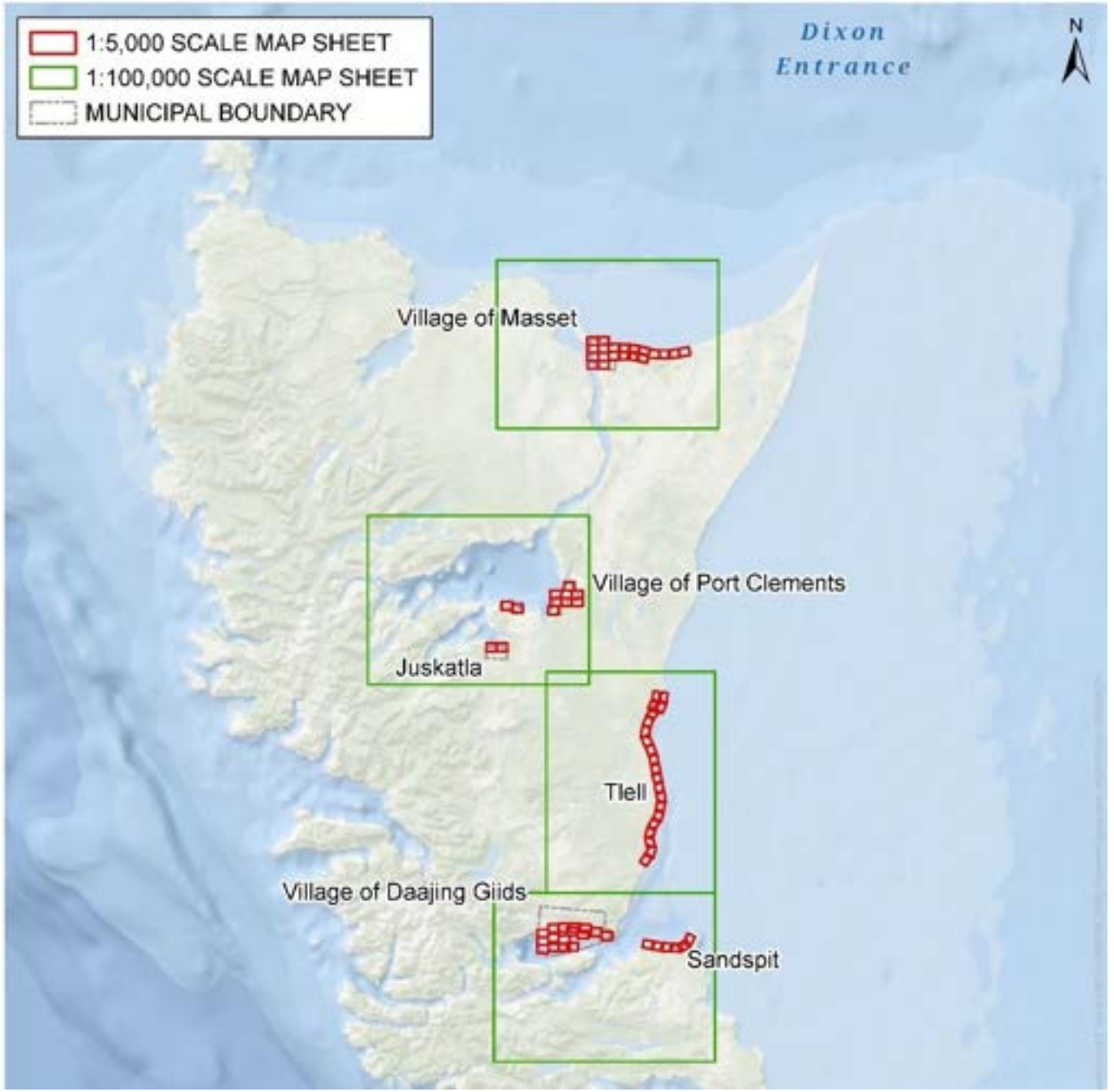


Planning & Next Steps

Local Maps

- Coastal FCL maps 1m SLR
- Coastal FCL maps 2m SLR
- Tsunami Inundation
- Tsunami Velocity (maximum currents)

Coastal FCL maps include erosion susceptibility mapping.



Planning & Next Steps

- Study results (maps, reports) to inform community planning
- Tools to reduce future coastal flood hazards
  - Bylaw approaches to limit new development in hazard zones
  - New construction in hazard areas to adopt Flood Construction Levels
- Incorporate sea level rise impacts into long-term community masterplans, stakeholder meetings, etc.
- Begin conversations with other levels of government with infrastructure in hazard areas
- Review evacuation planning for Tsunami