Haida Gwaii Coastal Flood and Erosion Study

Planning for Sea-level Rise and Tsunami Hazards

Project Review

Presented to:

North Coast Regional District - communities of:

- Tlell
- Sandspit
- Tow Hill

Presented by:

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September 2023

northwest hydraulic consultants

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 <u>hazards</u> of two independent natural phenomena occurring when sea levels are higher:

  - Large windstorm generated waves
  - Tsunami

  Erosion Susceptibility evaluated to inform potential shoreline change over time with SLR

- Project jointly funded by multiple communities to leverage efficiencies in offshore wave & tsunami analysis

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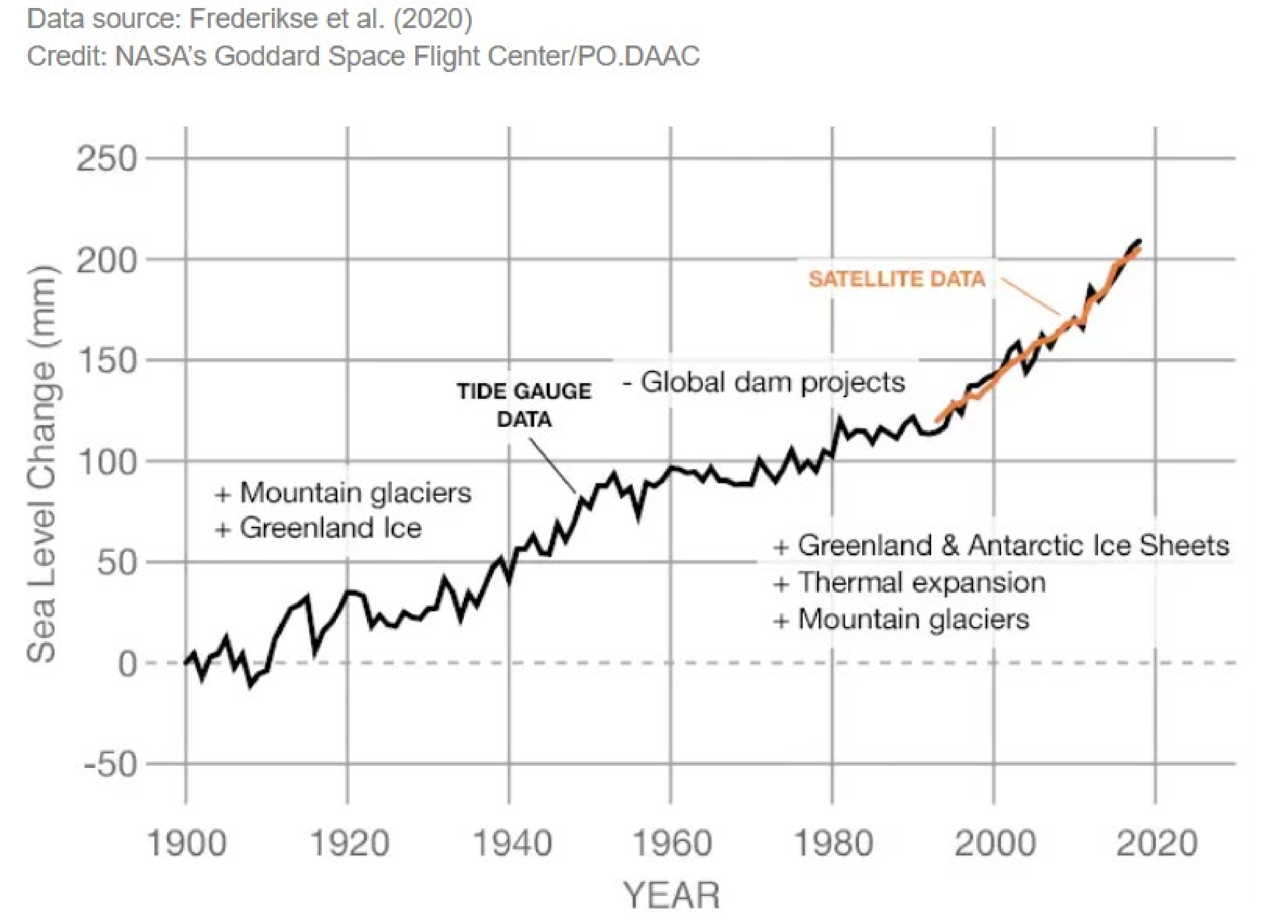
Sea Level Rise

- Climate Change Impacts

Global Average Sea Levels are rising

- Rate of change is increasing
- No uncertainty that 1 m of SLR will occur
- High uncertainty on future rates of SLR timing

Regional variable in SLR



Sea Level Rise (SLR) Guidance

Project team are <u>not</u> climate scientists.

Guidance on sea level rise from Intergovernmental Panel on Climate Change (IPCC) reports.

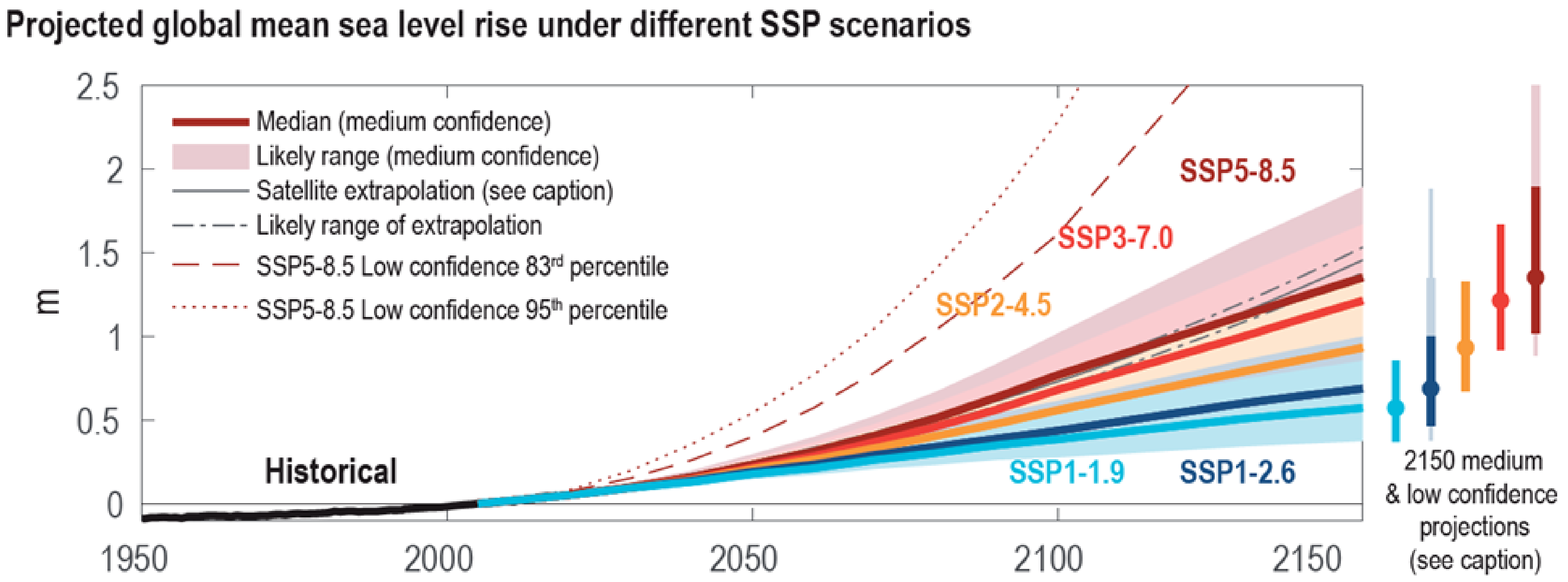
- The IPCC is the United Nations body for assessing the science related to climate change.
- The sixth Assessment Report (AR6) Physical Science Basis was released in 2021.

IPCC Assessment Reports

- 1990 FAR
- 1995 SAR
- 2001 TAR
- 2007 AR4
- 2014 AR5
- 2021 AR6

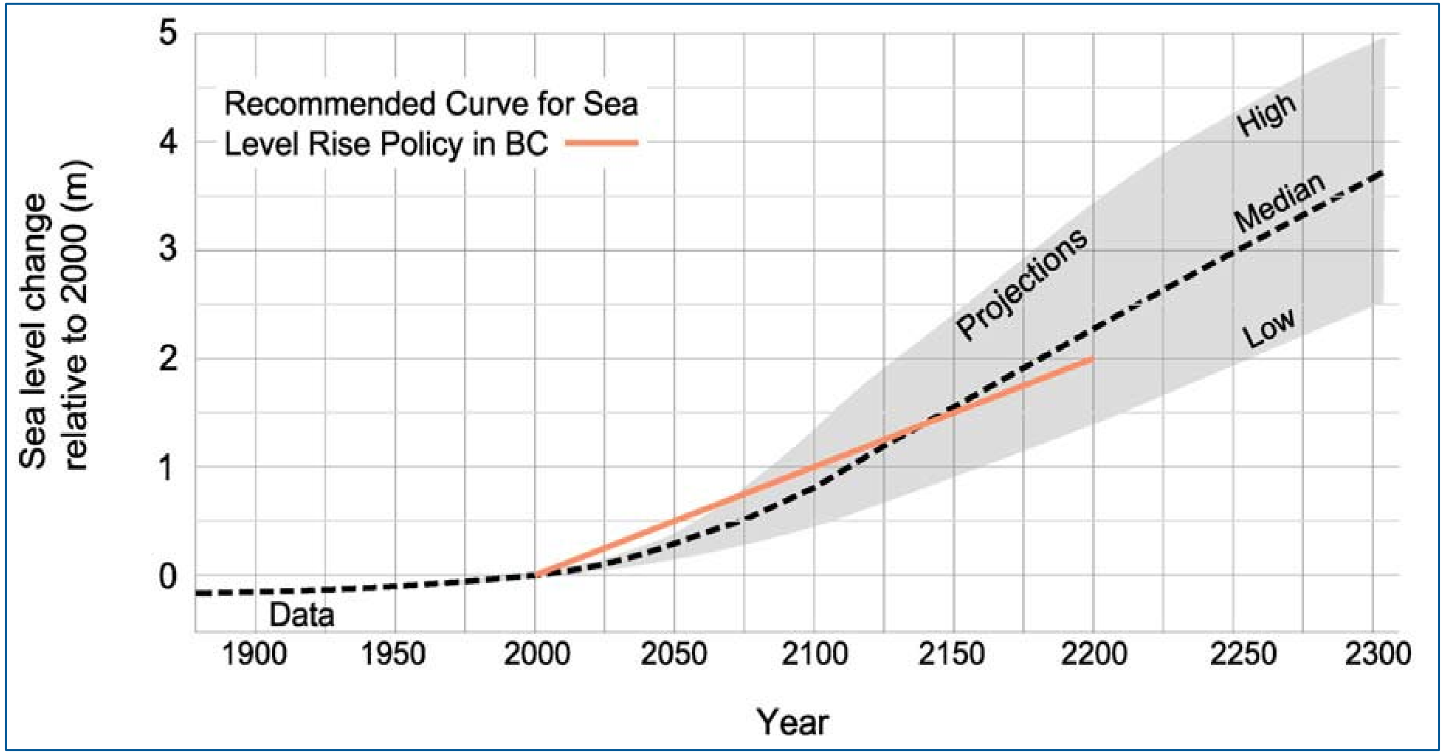
Sea Level Rise – IPCC AR6 (2021)

- SLR has high uncertainty based upon future human 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, 2011)
- Estimate developed using IPCC AR4 and other information available in 2009-2010 period. Was considered conservative when released. Remains appropriate planning level at this time.

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Governing Practice Guidelines – Coastal Storm Flooding

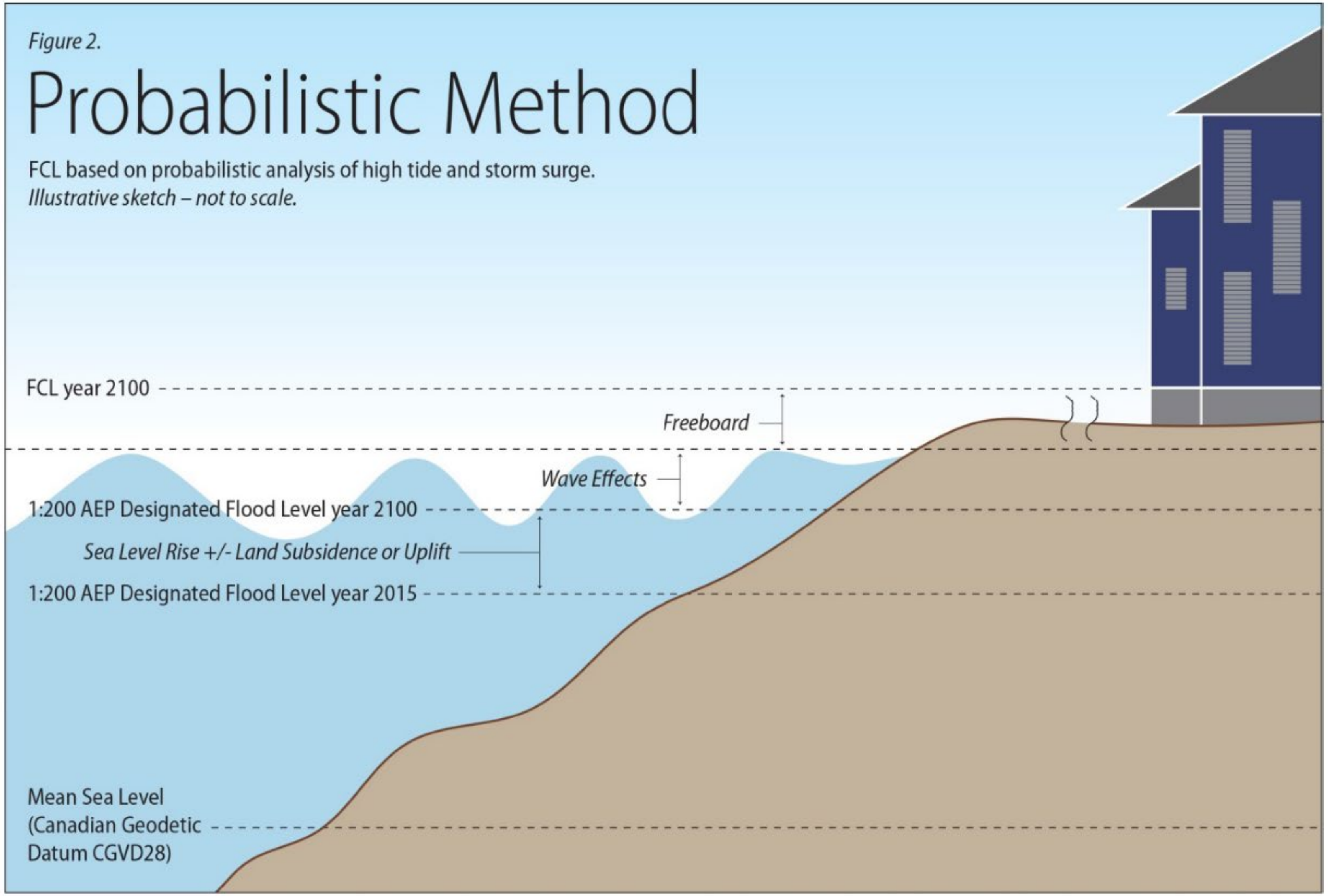
FCL = Flood Construction Level

To establish the elevation of the underside of:

- a wooden floor system, or
- the top of concrete slab

for habitable building space.

Method for determining the 200-year FCL as per BC Guidance:



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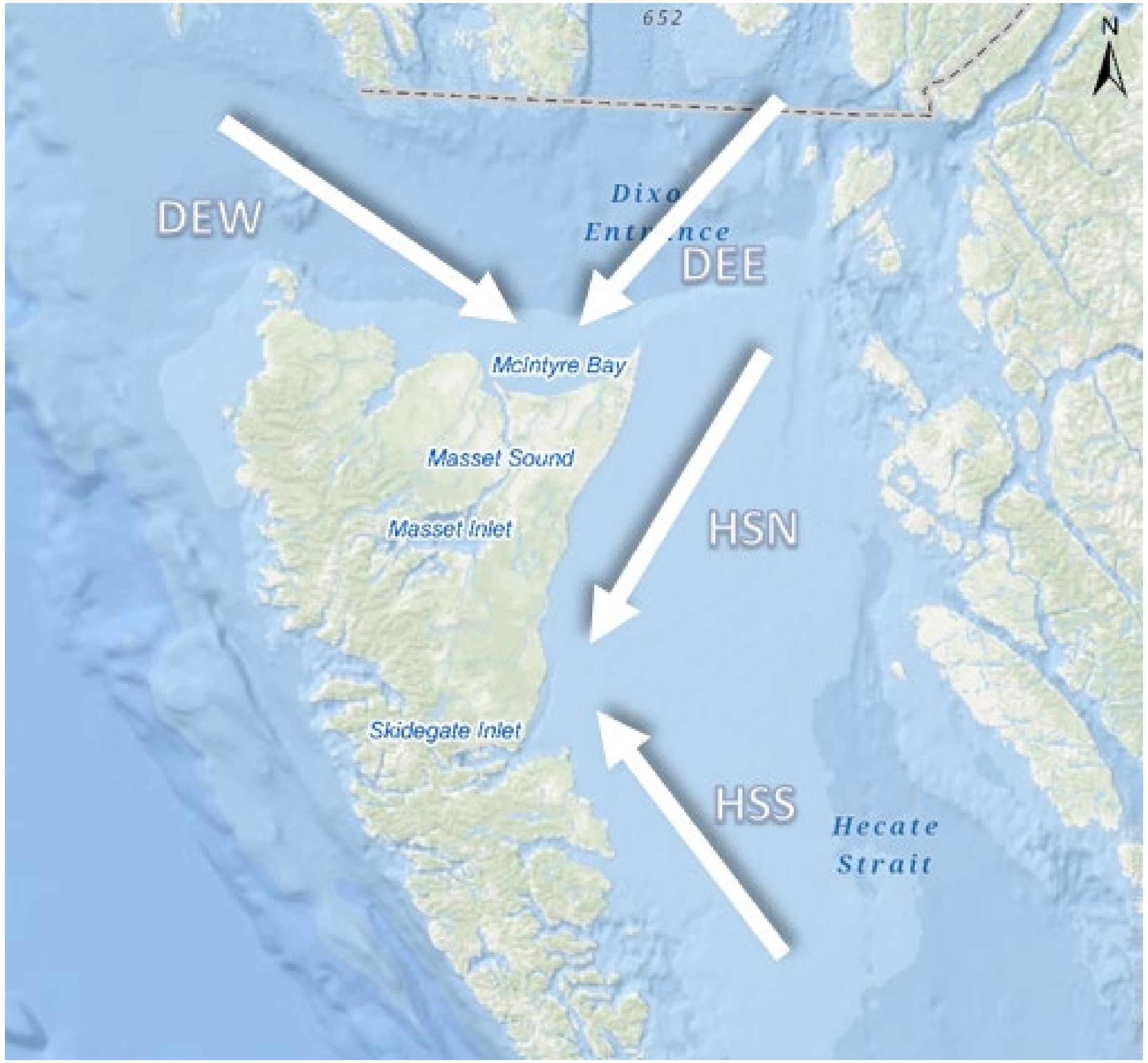
Metocean

Metocean = Meteorology and oceanography

Science basis to establish design flood and storm conditions.

- 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

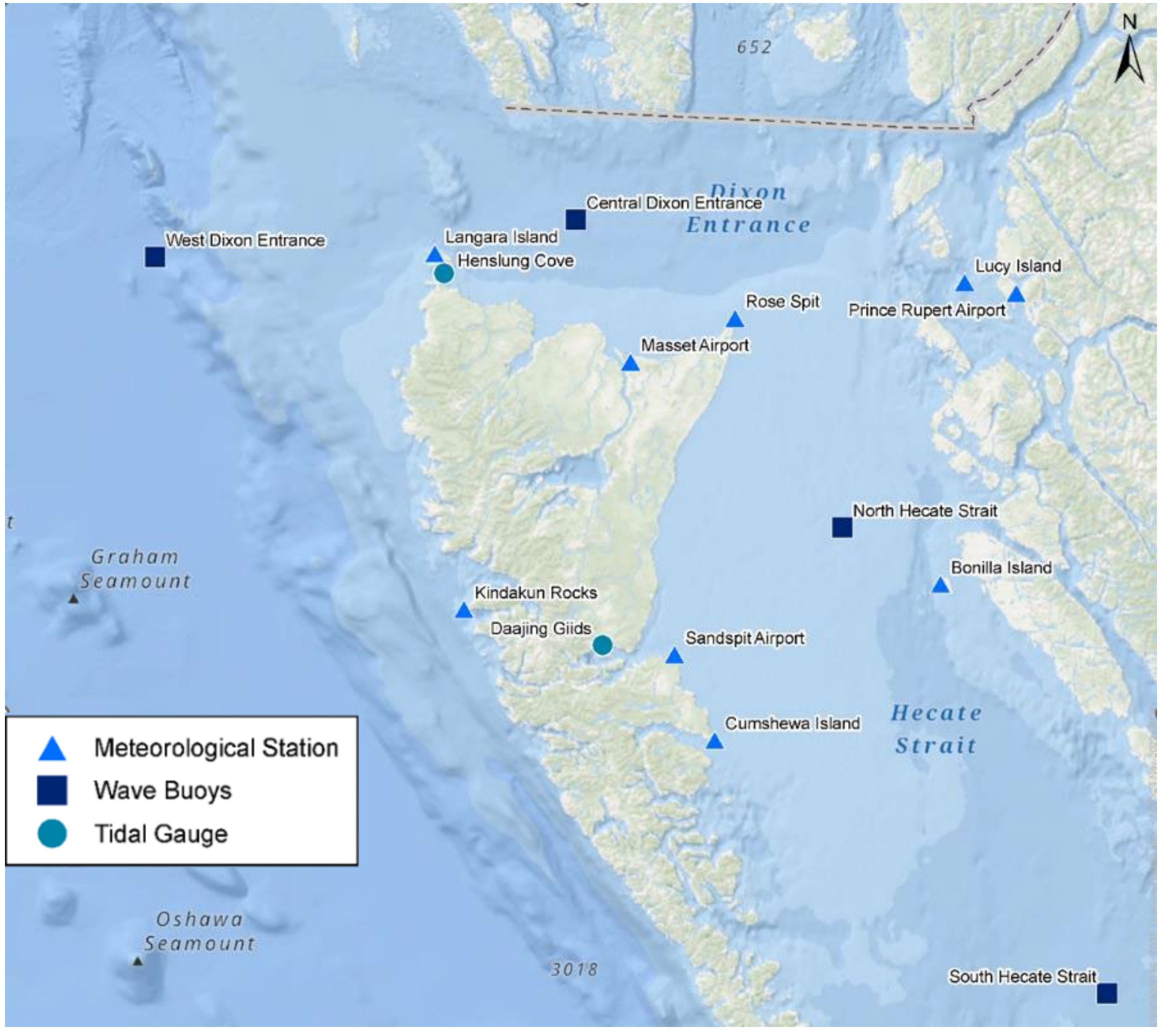


Primary Fetch Exposures for wind waves in study area

Metocean

- Wind data at Cumshewa, Sandspit, and Bonilla primary for Hecate Strait Modelling.
- Wave buoy data to calibrate models
- No nearshore records of wave heights

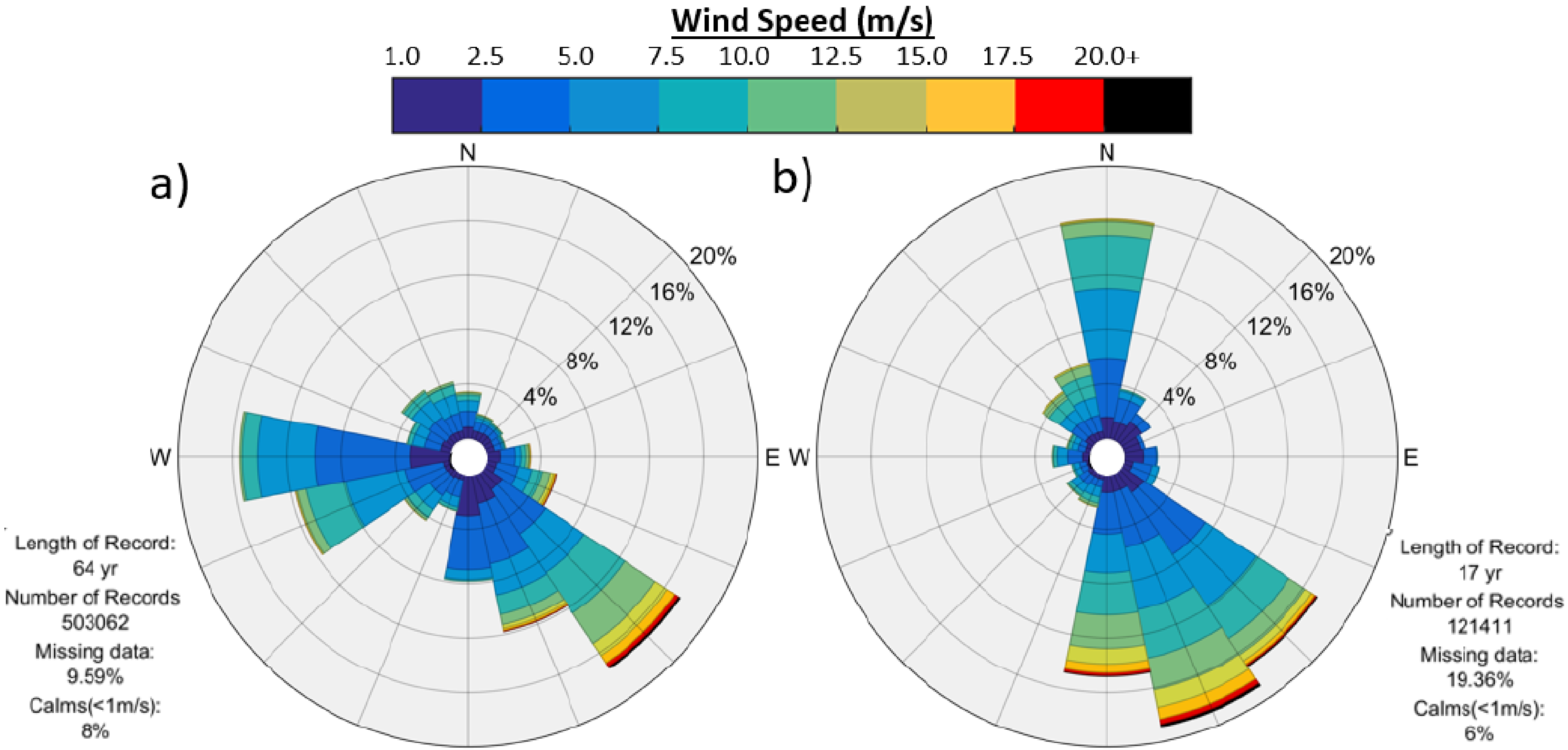
Used numerical wave models to transform offshore waves to shoreline.



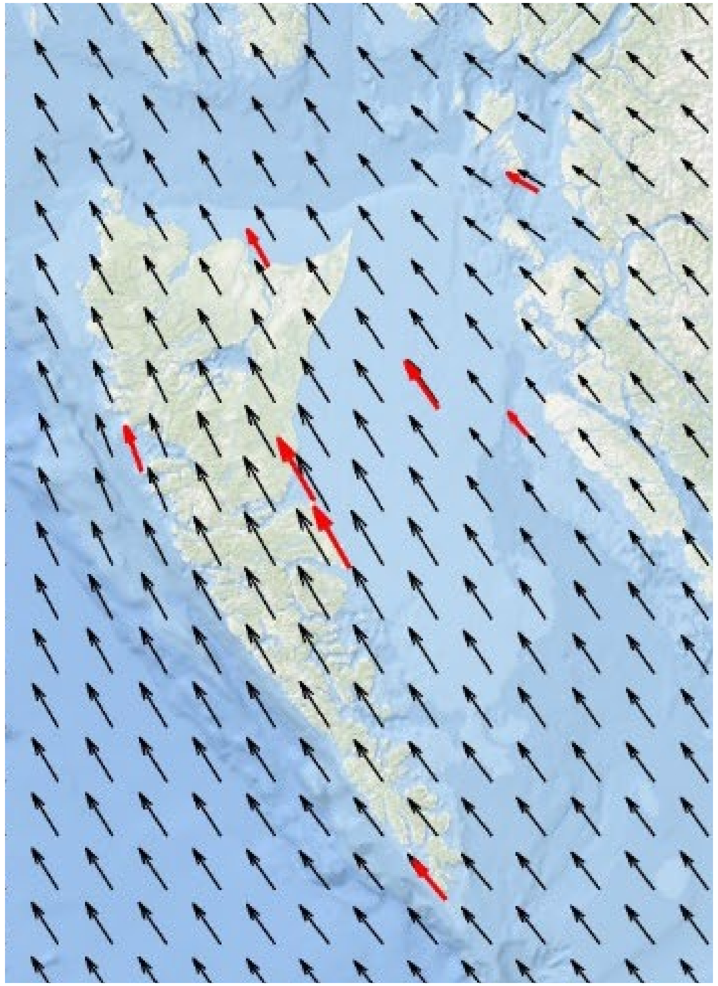
Wind and Wave measurement station locations

Metocean

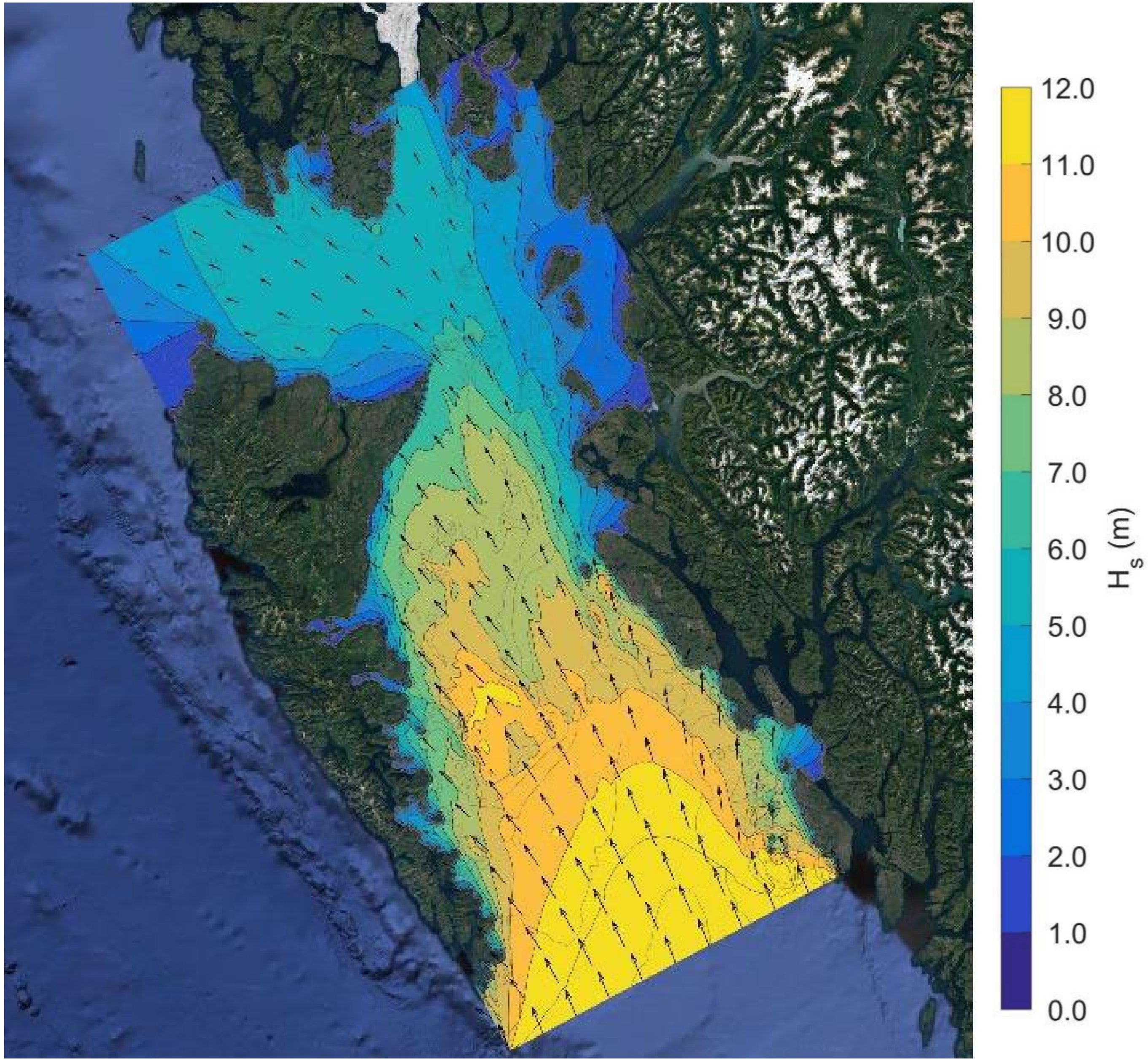
Historical wind data at Sandspit (left) and Bonilla (right).



Metocean



Interpolated wind field – SE storm

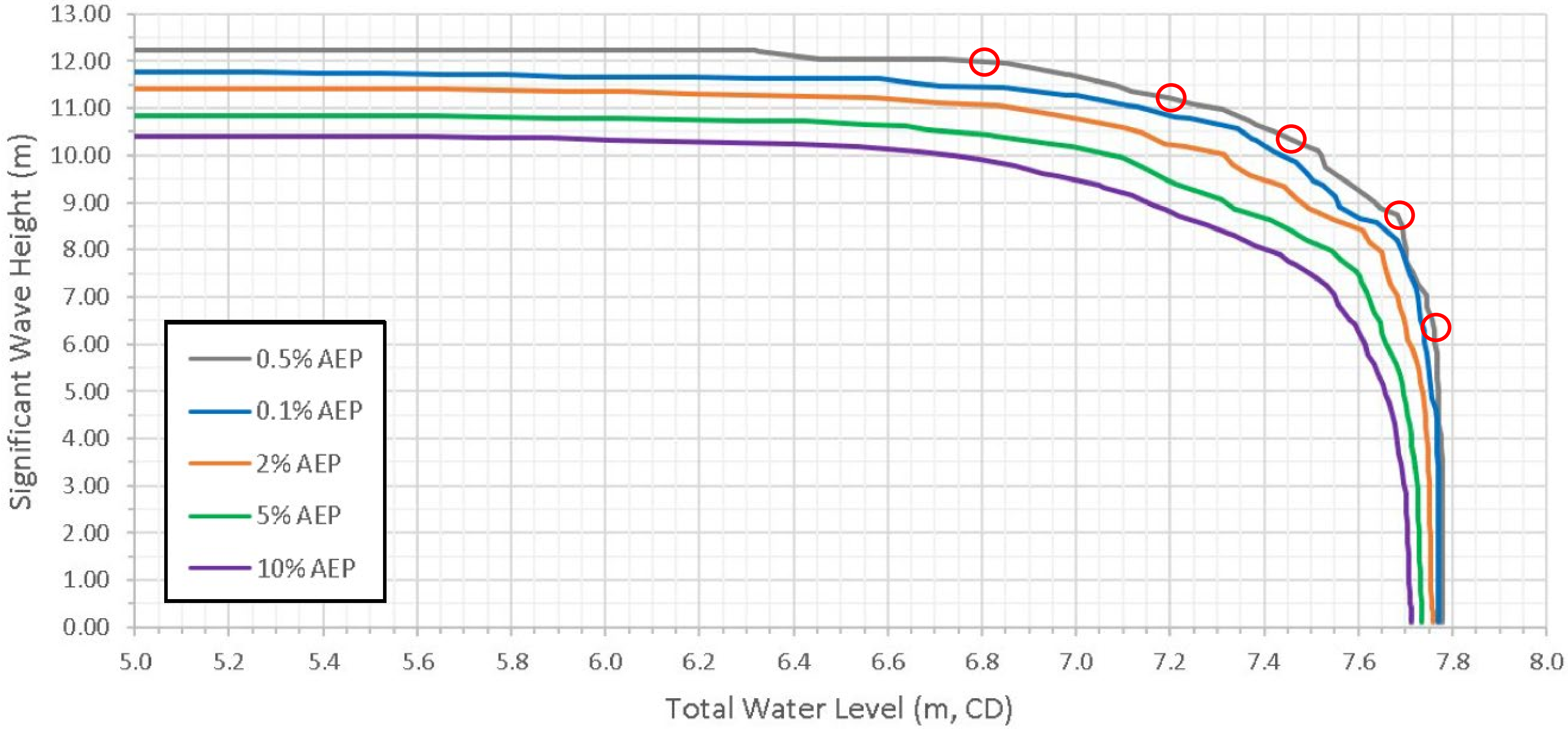


NHC SWAN model output

Joint Probability

Joint probability of water levels and waves that results in 1-200 coastal flood hazard (grey line)

Curves of constant joint probability (Hecate Strait – SE Storms)



Wave Effects – Incident Wave Heights at Tlell

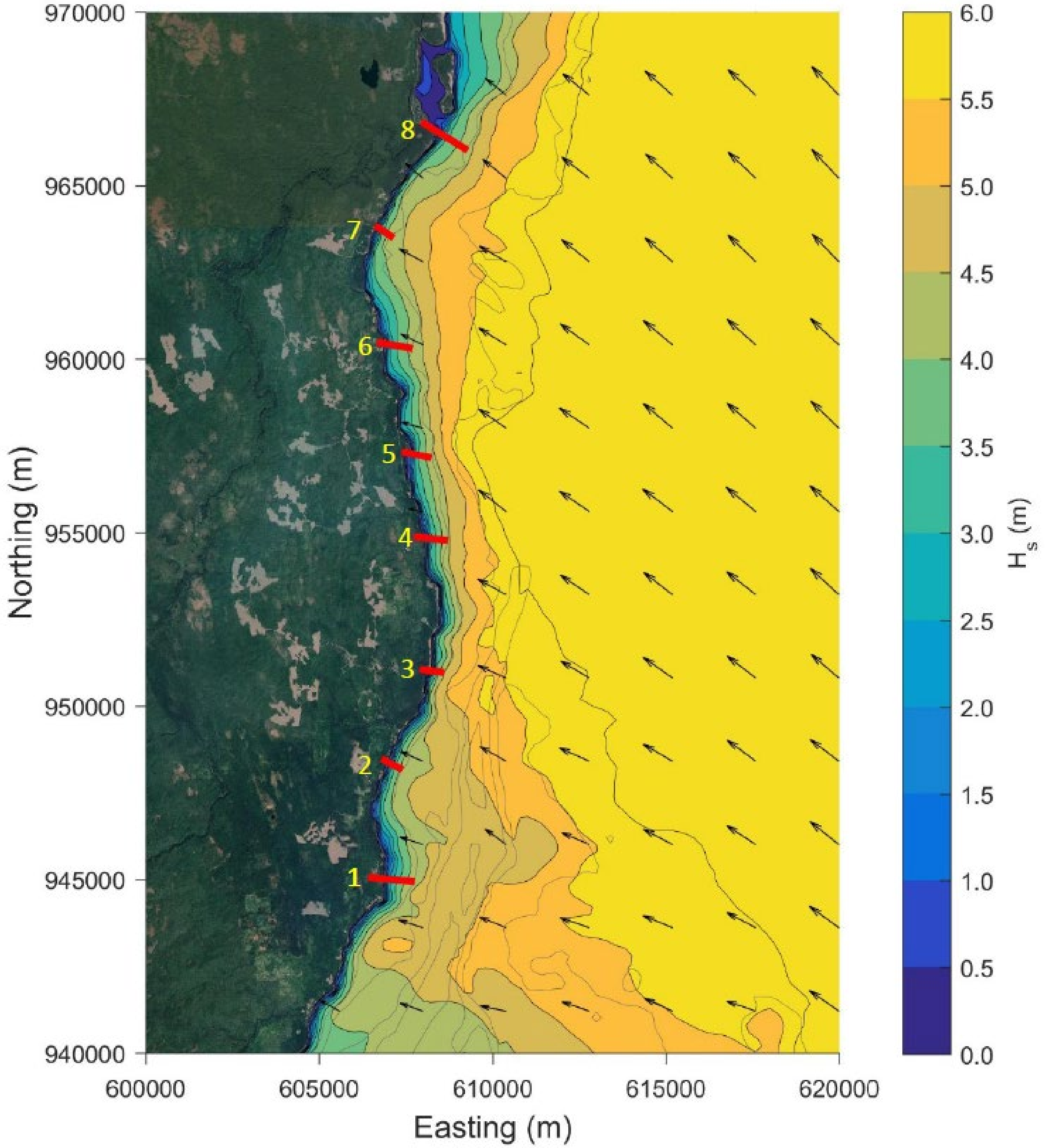


Table 3-4. Incident Design Seastate Conditions from wave model ensemble for Tlell

Transect	Easting	Northing	Depth	Hs (m)	Tp (s)	Direction
1	607800	945000	9.7	4.2	15.7	110
2	607400	948200	9.3	4.0	15.7	114
3	608600	951000	9.2	4.4	15.7	116
4	608800	954800	10.2	4.5	15.7	110
5	608200	957200	8.6	4.0	17.2	106
6	607600	960200	8.7	3.8	17.2	111
7	607200	963400	10.6	4.3	11.8	115
8	609200	966000	10.2	4.3	11.8	125

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

Wave Effects – Incident Wave Heights at Sandspit

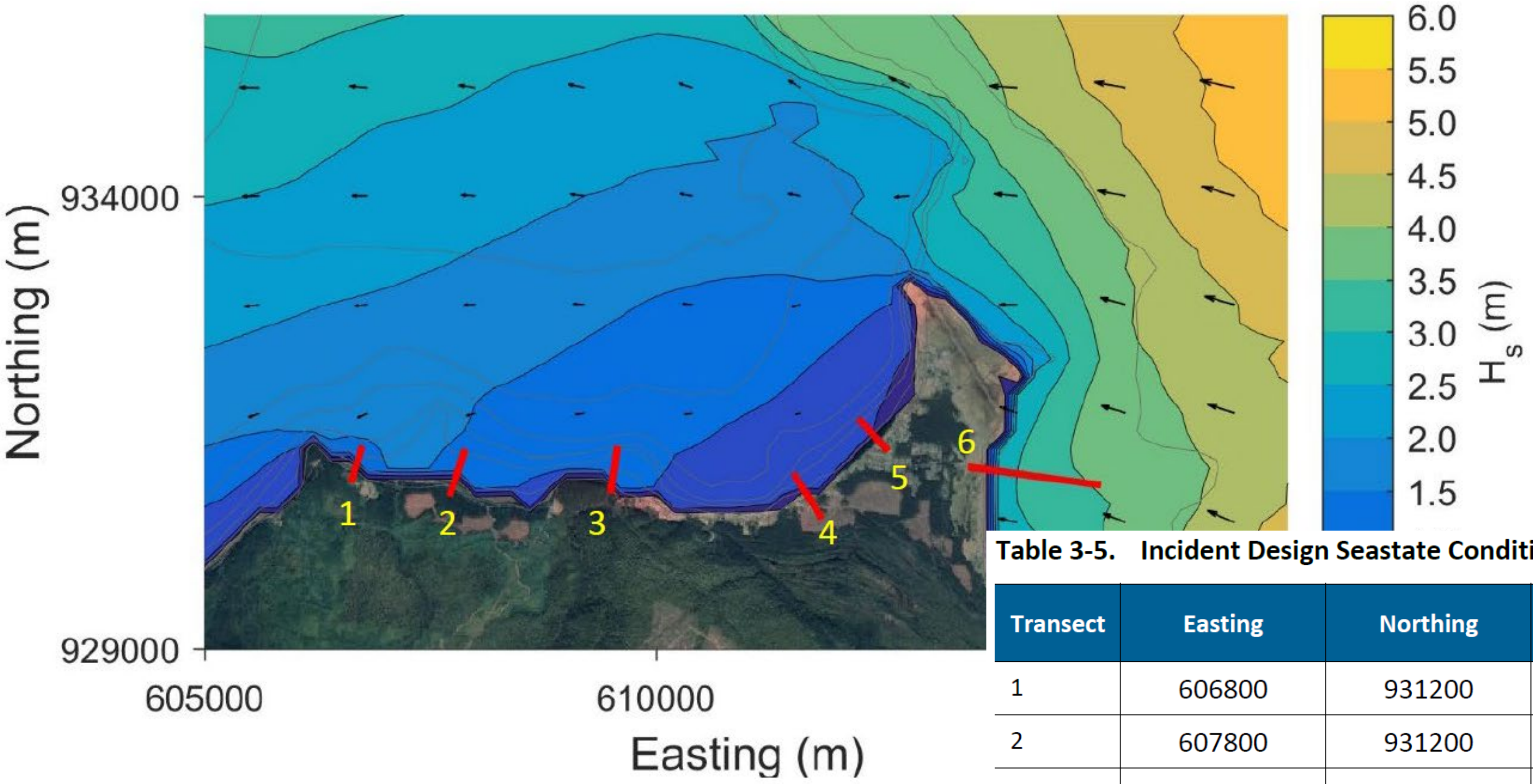


Table 3-5. Incident Design Seastate Conditions from wave model ensemble for Sandspit

Transect	Easting	Northing	Depth	Hs (m)	Tp (s)	Direction
1	606800	931200	12.4	2.8	8.1	21
2	607800	931200	10.6	1.4	15.7	62
3	609550	931250	14.3	2.7	8.1	9
4	611500	930950	13.0	2.2	7.4	351
5	612200	931600	16.6	2.0	8.1	350
6	615000	930800	8.9	3.6	15.7	110

Notes: 1. Water depth at offshore end of transect during simulation
2. Transect 6 is outside of the study limits.

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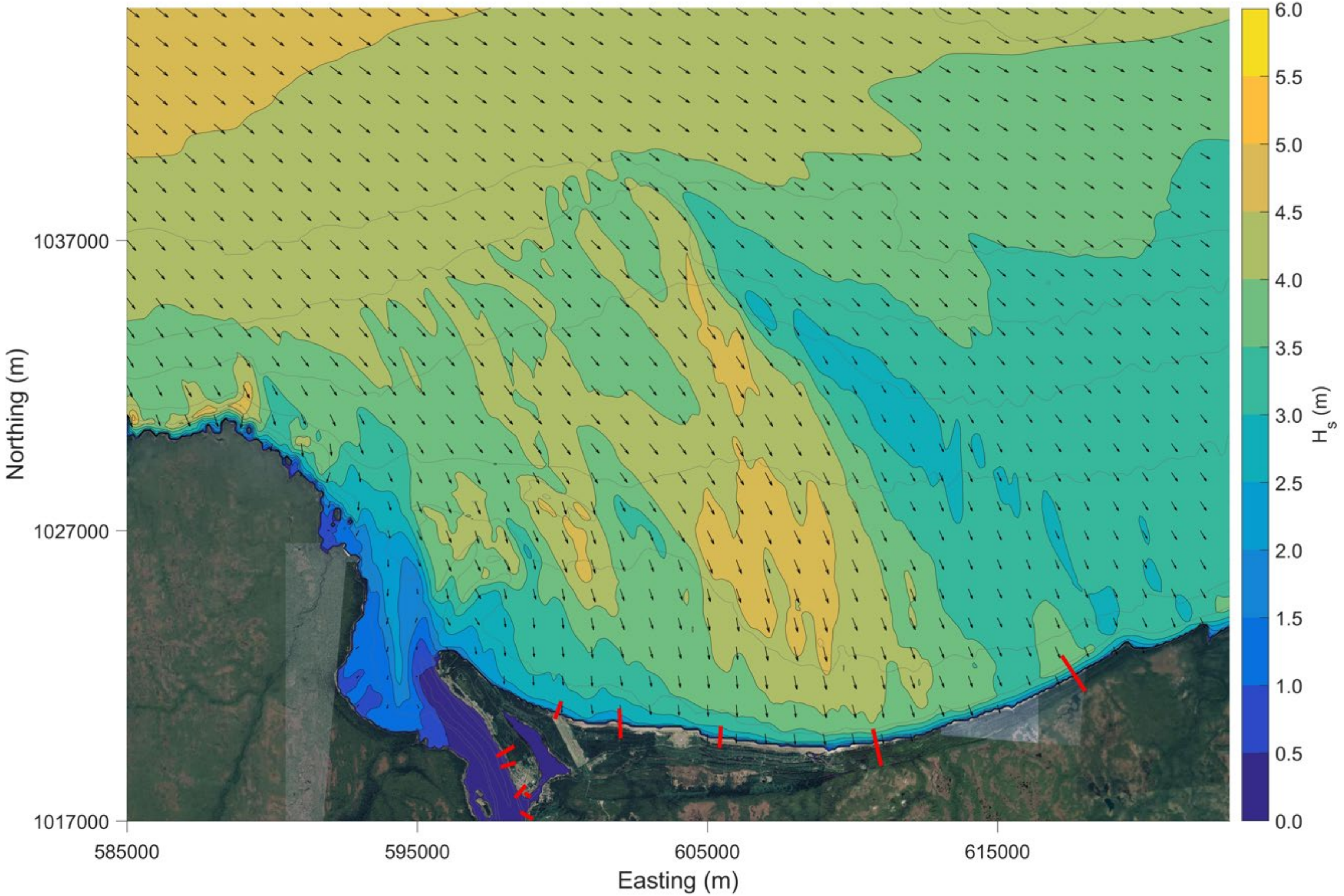
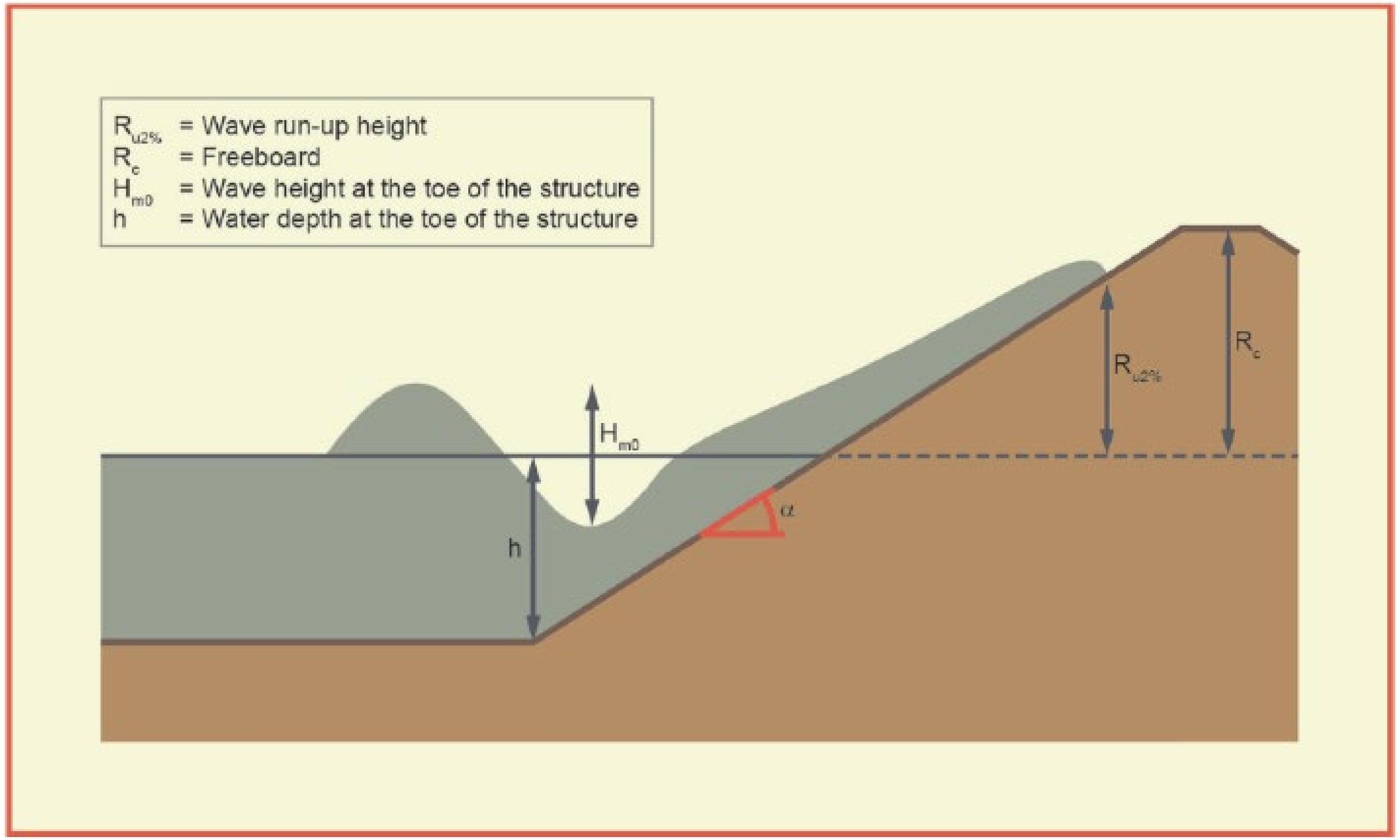
Wave Effects – Incident Wave Heights at Tow Hill



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

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Governing Practice Guidelines – Coastal Storm Flooding

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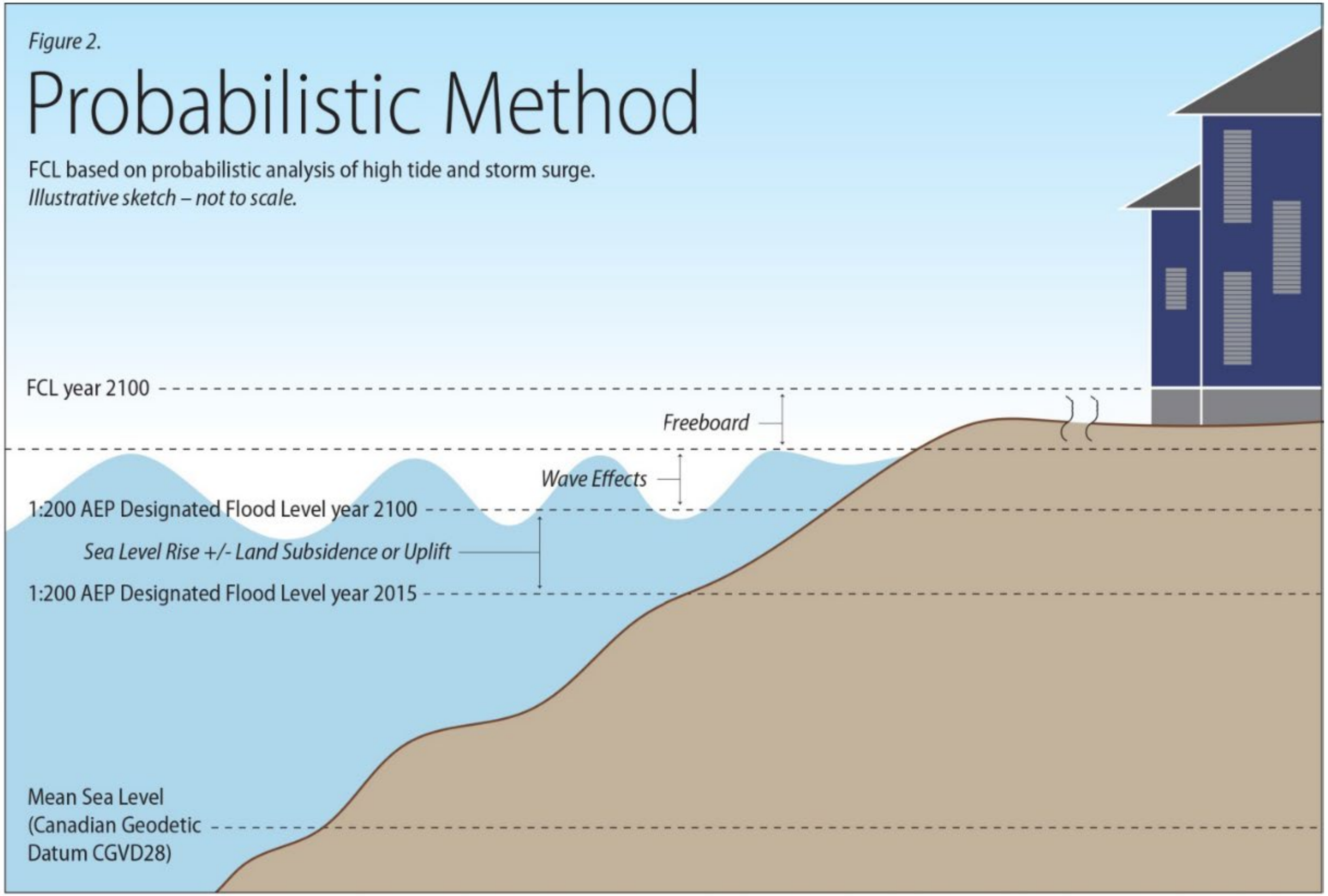
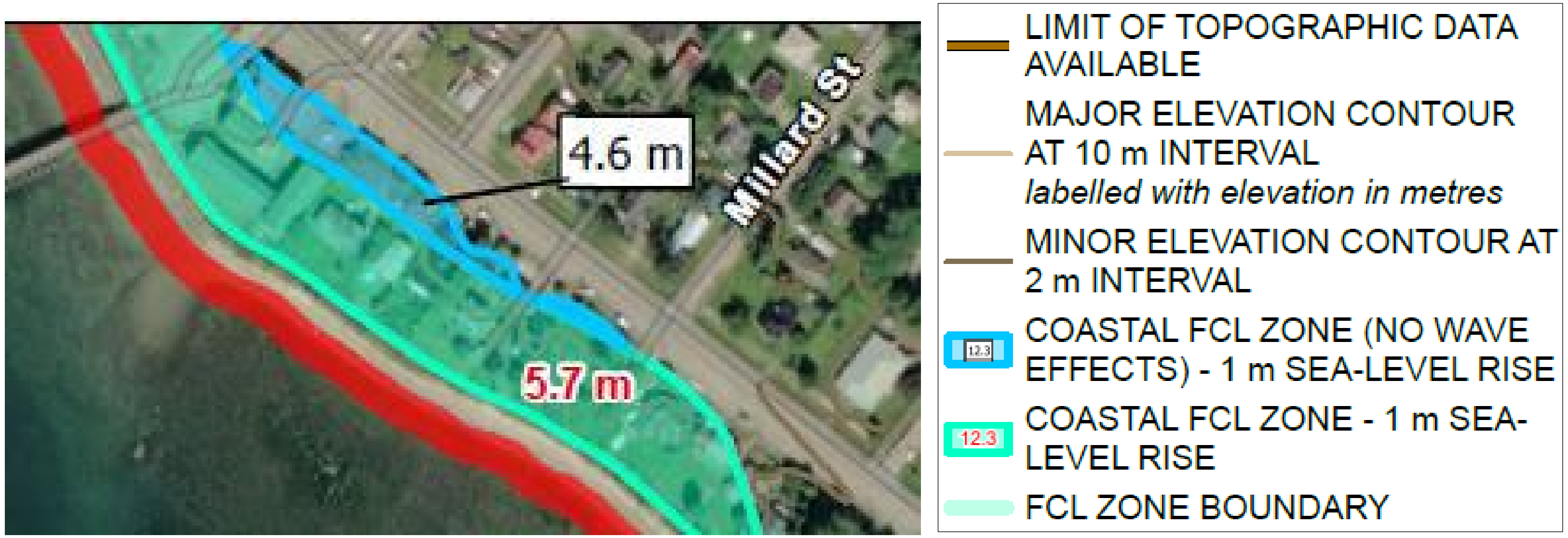
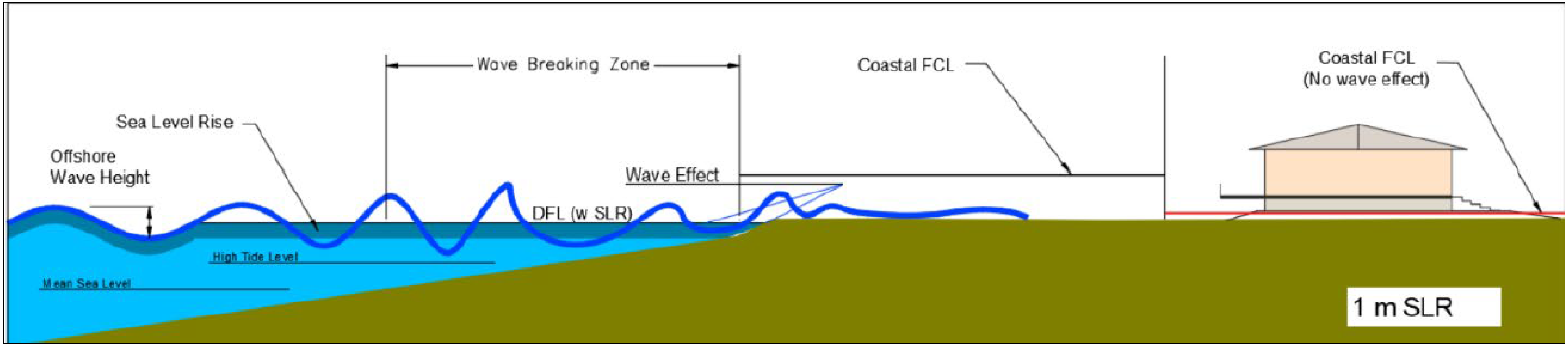
Method for determining the 200-year FCL as per BC Guidance:



Wave Effects (display on maps)

Portion of a FCL map





Schematic showing FCL zones in profile

Coastal Storm Hazard Areas (1 m SLR)

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

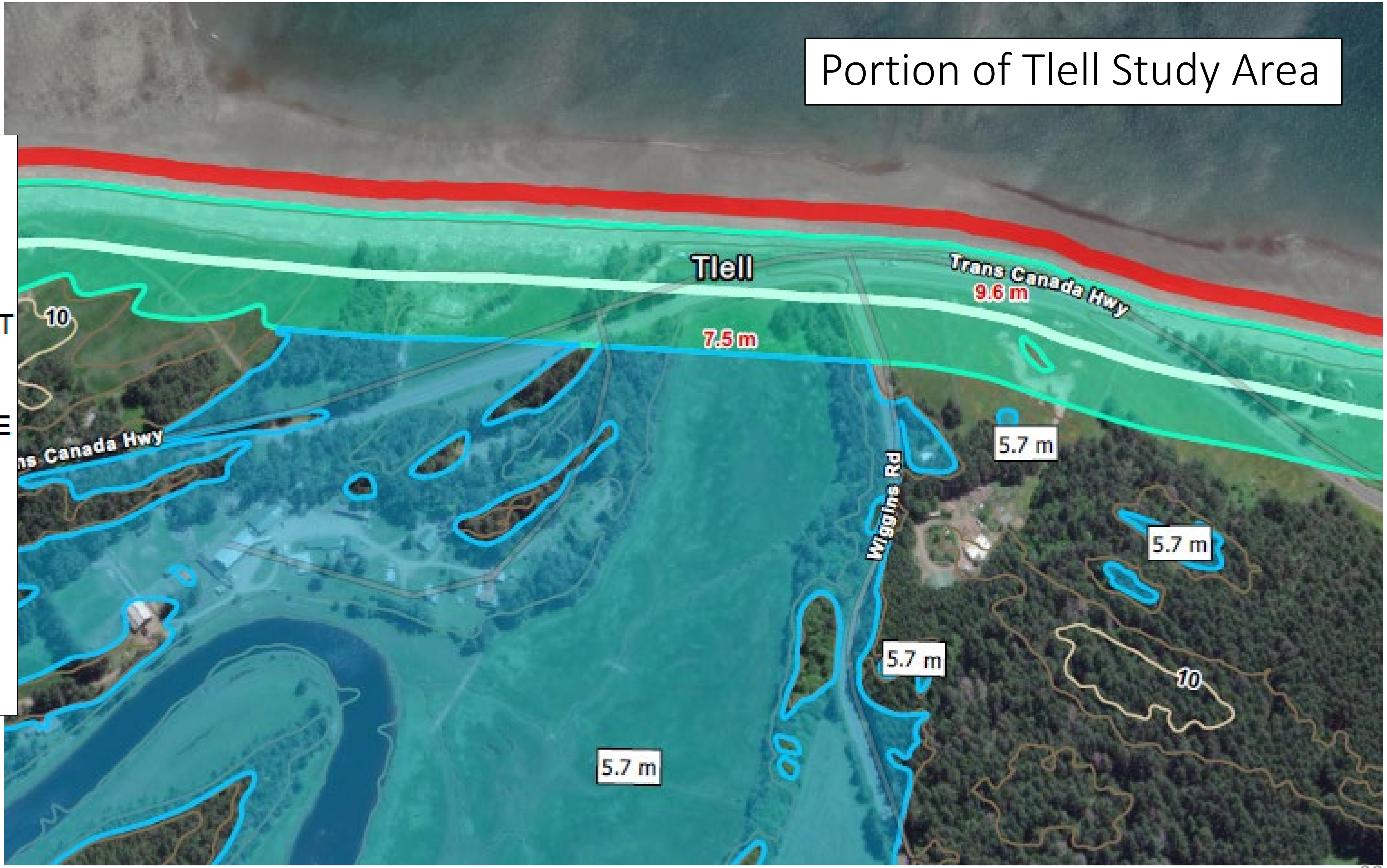
FCL ZONE BOUNDARY

EROSION SUSCEPTIBILITY

HIGH

MEDIUM

LOW



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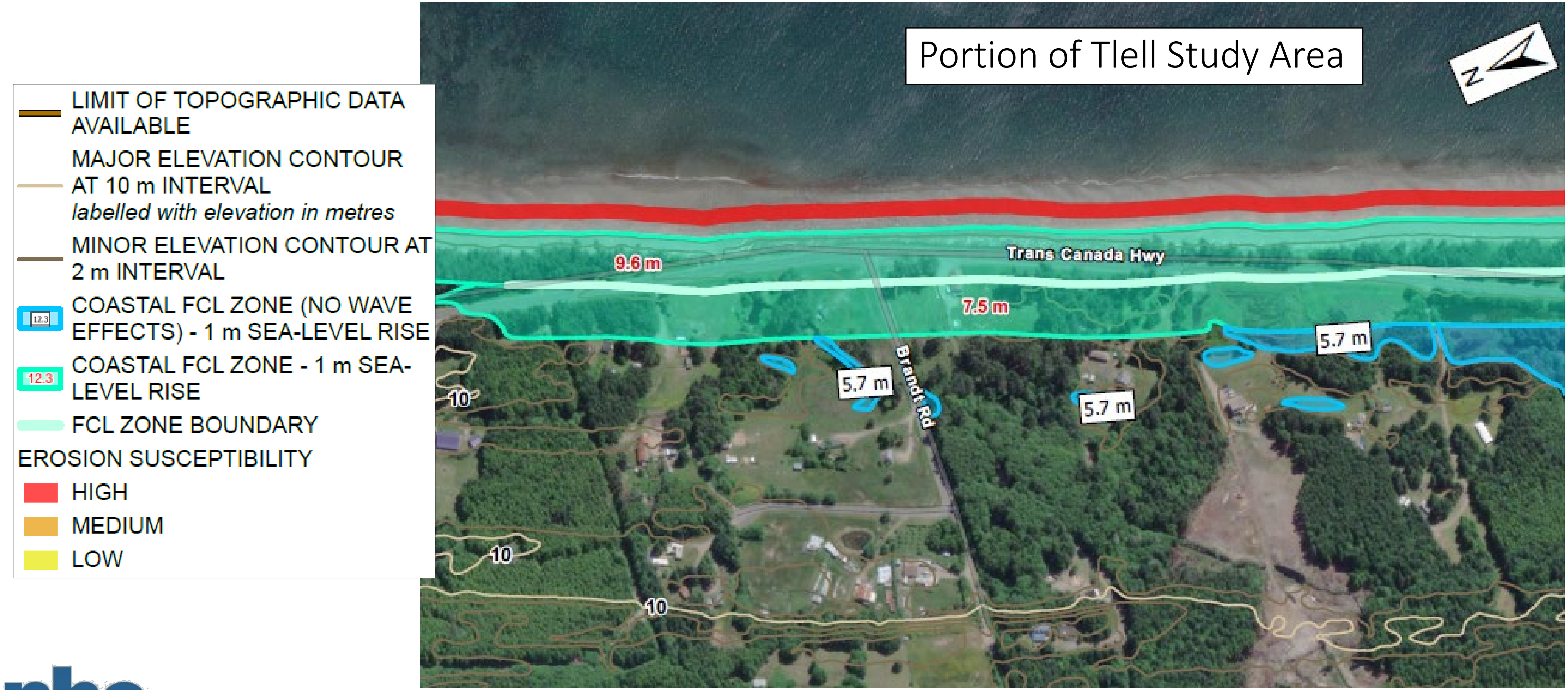
Coastal Storm Hazard Areas (1 m SLR)



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Coastal Storm Hazard Areas (1m SLR)

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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
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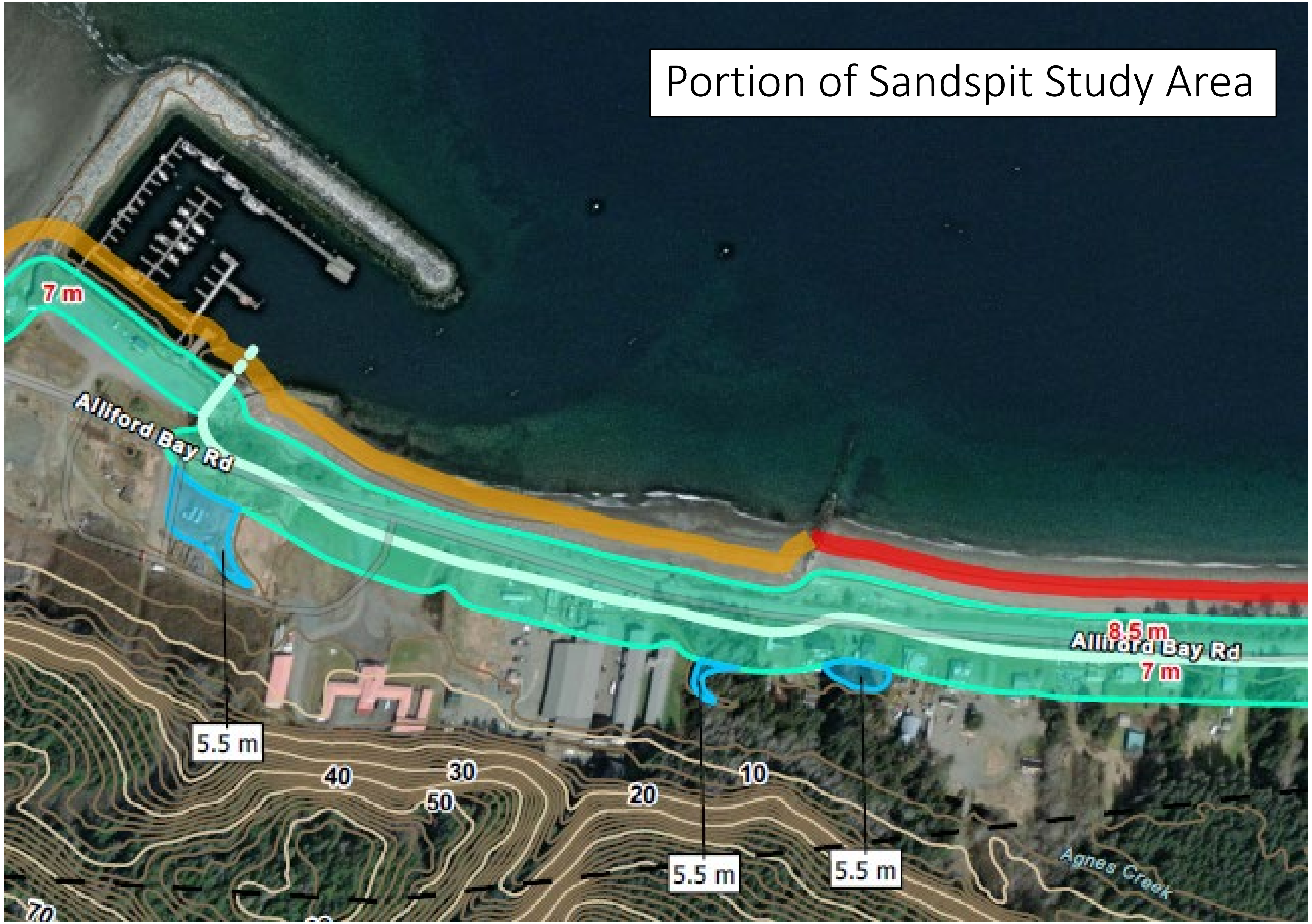
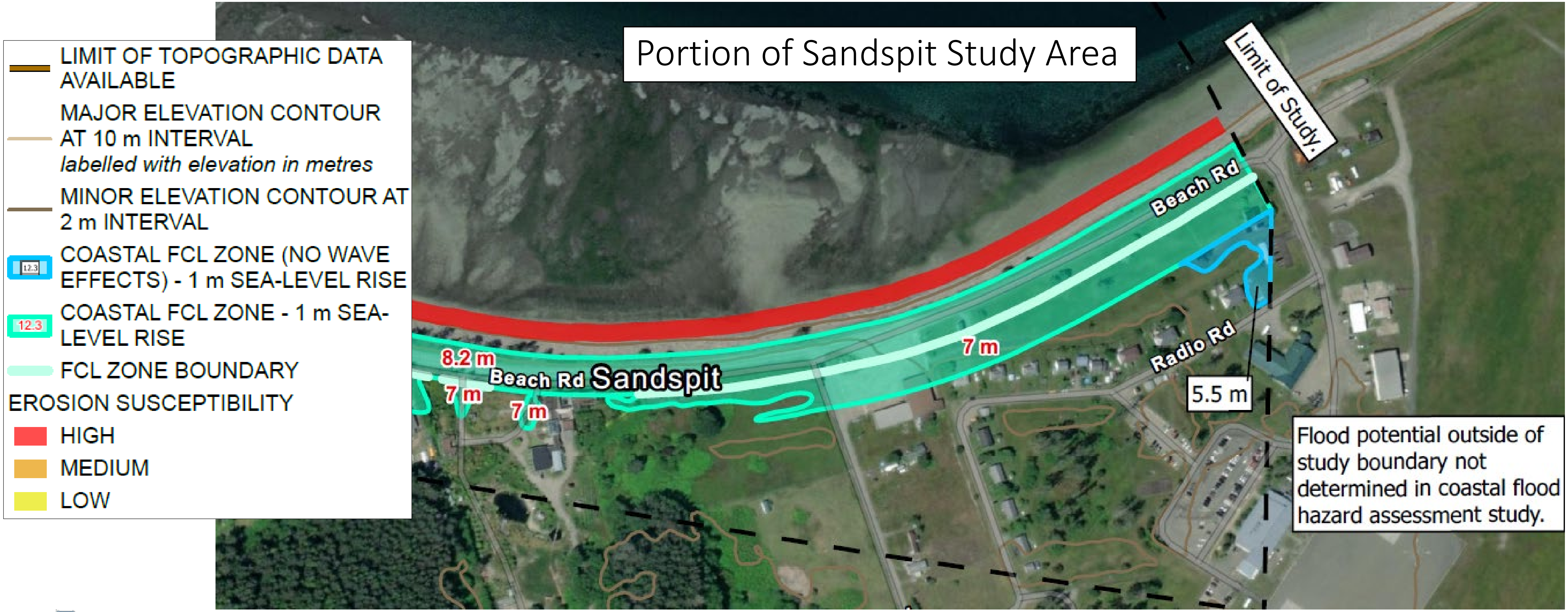


Coastal Storm Hazard Areas



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Coastal Storm Hazard Areas – Tow Hill Study Area

With 1 m SLR

With 2 m SLR

Note much wider flood zone for 2 m SLR to reflect potential for erosion, and future change in high water level on shoreline.

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Erosion Susceptibility

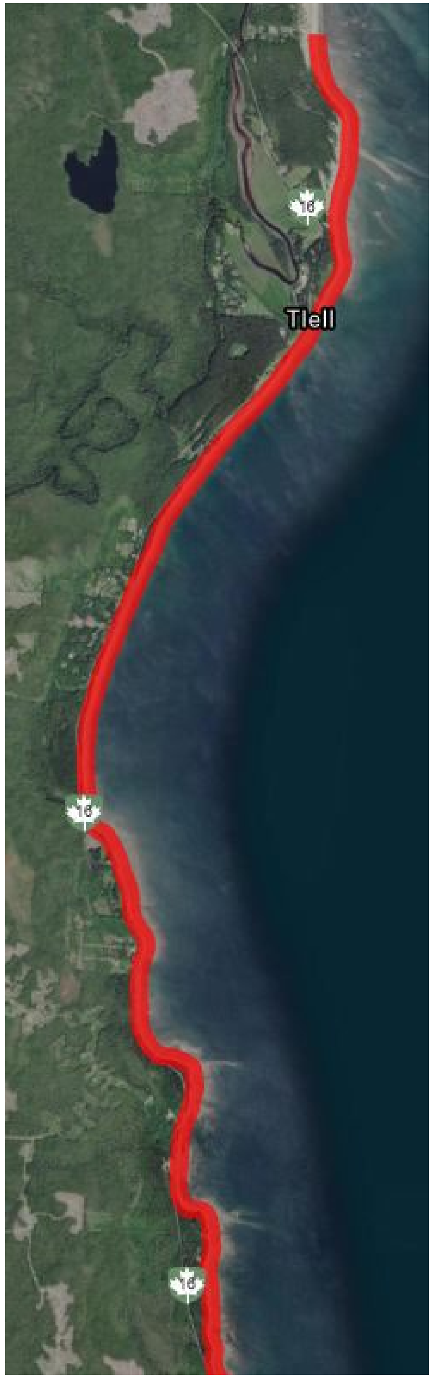
- Intended to provide additional information to understand coastal flooding
- Not intended to predict rates of future erosion
  - Actual erosion will depend upon human intervention (upgrade, maintenance of shoreline protections)
- Rating is relative;
  - “low” does not mean non-erodible,
  - “high” does not necessarily mean rapid retreat
- No reliance on the presence of coastal protection structures (riprap, etc.)
  - Riprap is often indicative of a eroding shoreline. Mapping indicates underlying condition of shoreline.

Erosion Susceptibility

Tlell Shorelines

EROSION SUSCEPTIBILITY

- HIGH
- MEDIUM
- LOW



Erosion Susceptibility – Tlell Shorelines

Gravel-cobble beach fronting treed shoreline in Tlell

Erosion Susceptibility – Tlell Shorelines

Rock protection near Wiggins Road

Erosion Susceptibility – Tlell Shorelines

Rock protection near Brandt Road

Erosion Susceptibility

Sandspit

Erosion Susceptibility – Sandspit Shorelines

Broad beach terminating at low shoreline east of Onward Point.

Erosion Susceptibility – Sandspit Shorelines

Gravel-rich beach with low backshore.

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Erosion Susceptibility – Sandspit Shorelines

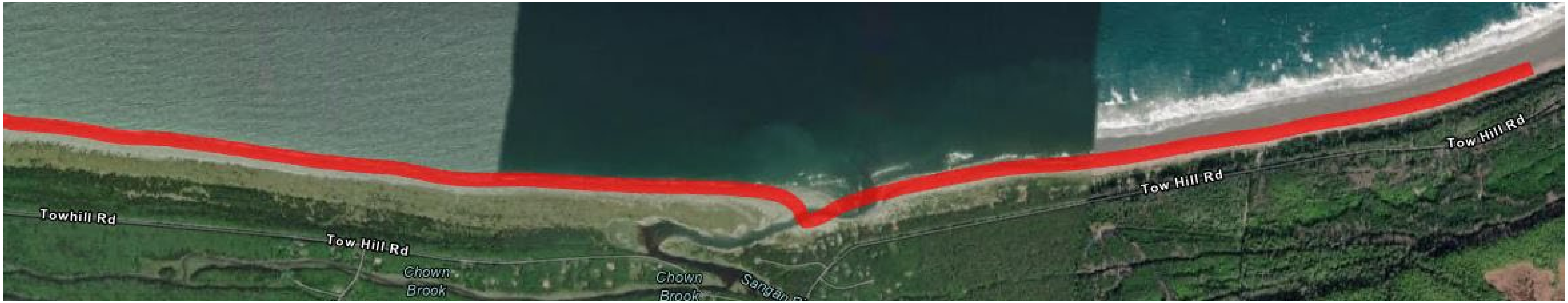
Damaged shoreline rock protection structure.

Erosion Susceptibility

Tow Hill– North Beach Shorelines

EROSION SUSCEPTIBILITY

- HIGH
- MEDIUM
- LOW



Erosion Susceptibility – Tow Hill

Broad sand and gravel beaches fronting backshore dune system along much of the Tow Hill study area shoreline.

Erosion Susceptibility – Tow Hill

Typical backshore dune and swale system along much of the Tow Hill study area shoreline.

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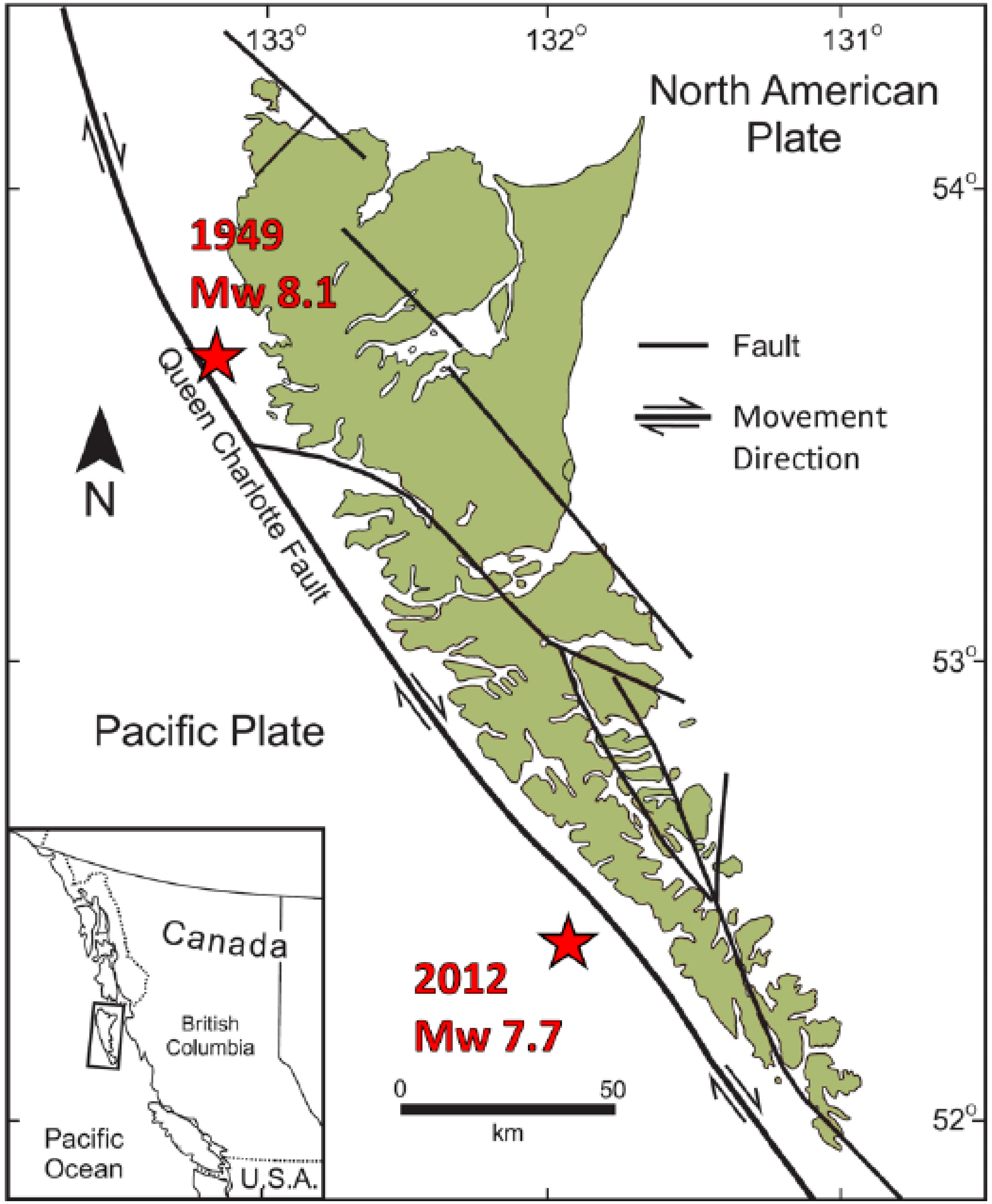
Tsunami

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

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

Tsunami

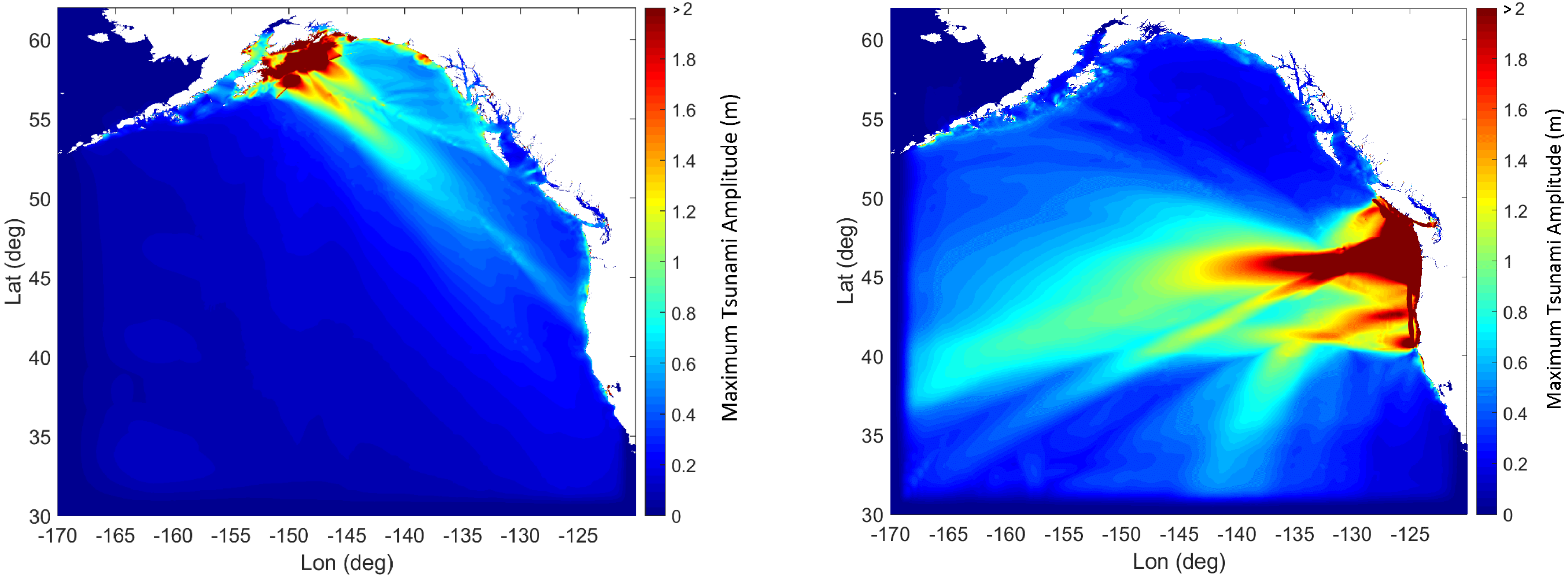
- Haida Gwaii near local faults. Mainly strike-slip and not 'dip-slip' faults.
- Little vertical motion expected from strike-slip faults, so minimal tsunami risk from local faults.
- Project team evaluated numerous sources and historic events. Only the most severe sources were mapped.



Haida Gwaii fault and location of significant earthquakes (adapted from Shellnutt and Dostal, 2019)

Tsunami

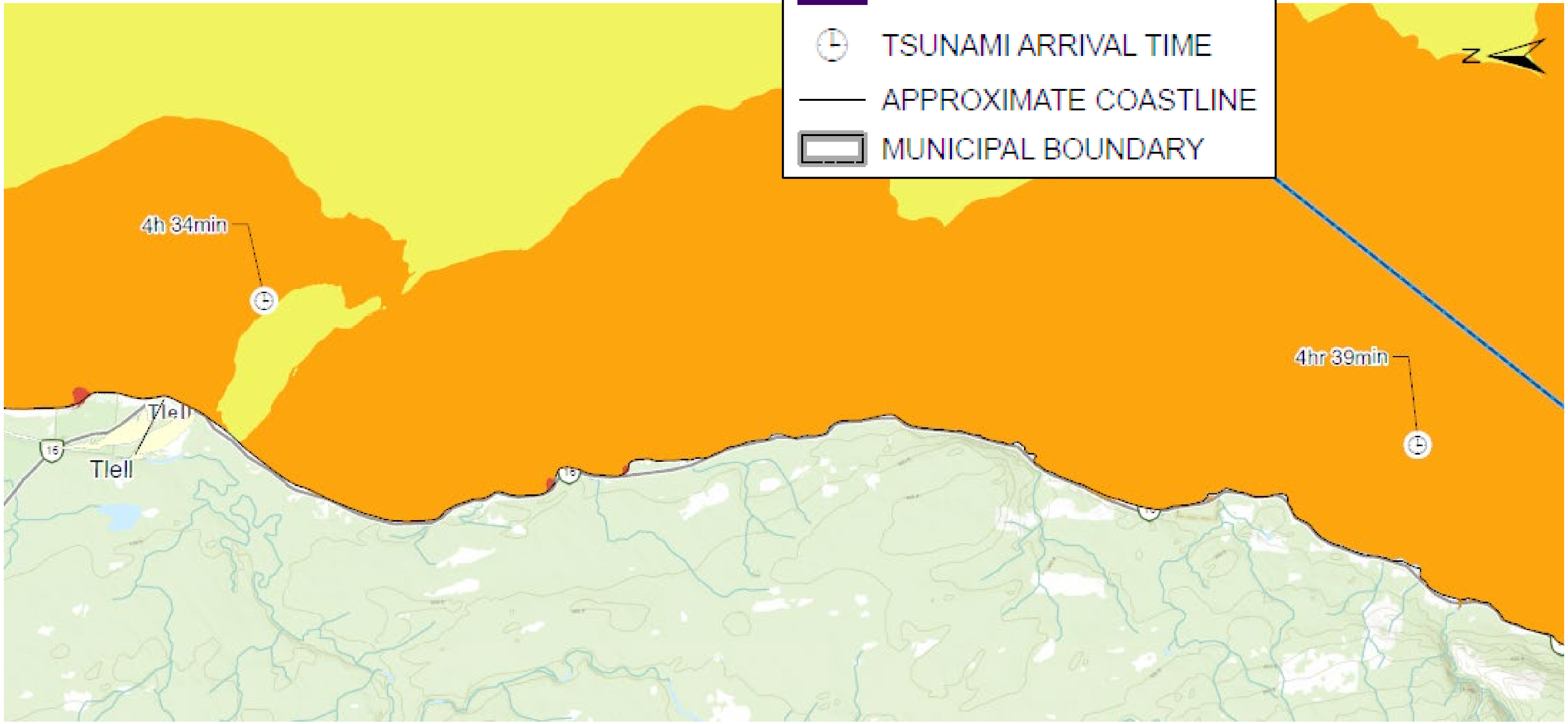
- Two major tsunami sources (Alaska / Cascadia Subduction Zone) modelled.



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

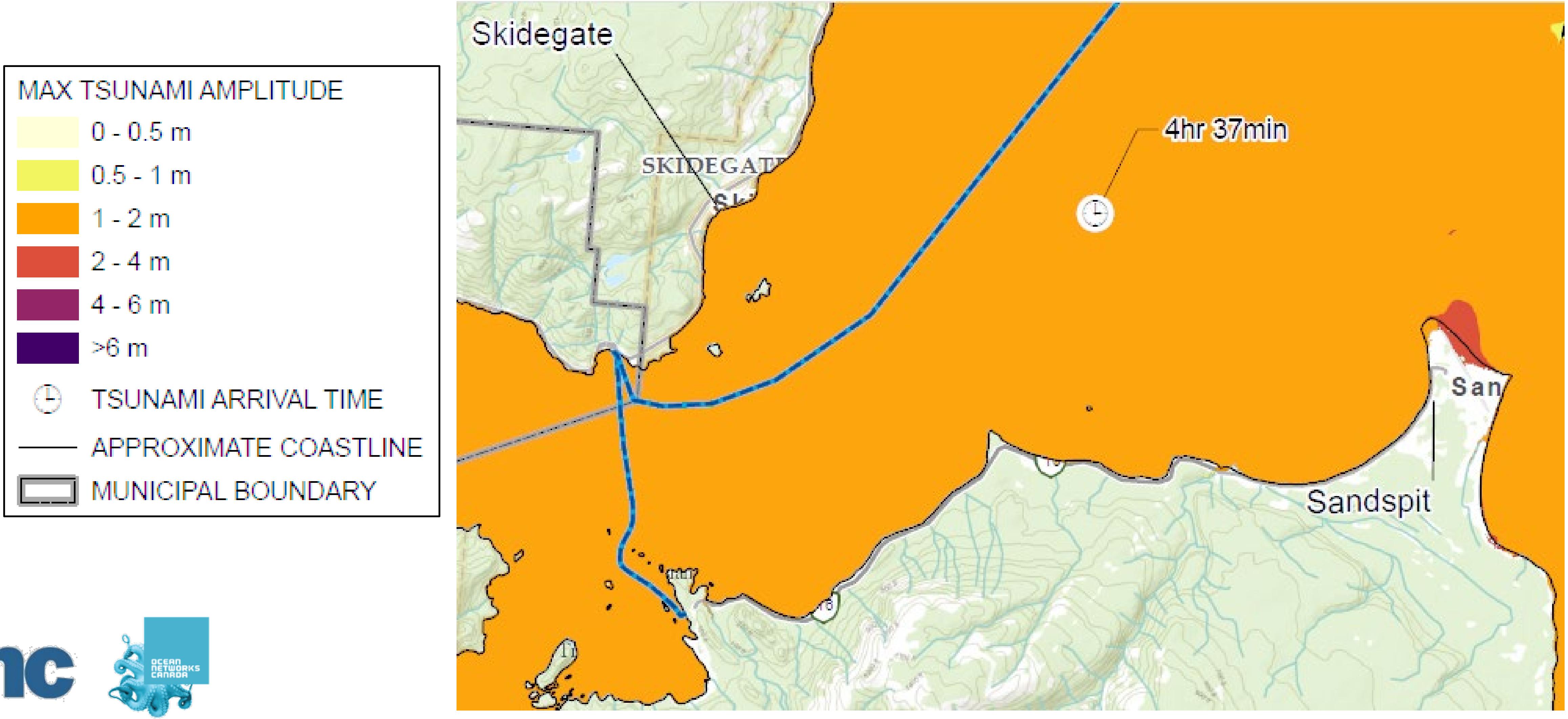
Tsunami (Tlell)

- Maximum Amplitude (Alaska-Aleutian subduction zone event)



Tsunami (Sandspit)

- Maximum Amplitude (Alaska-Aleutian subduction zone event)



Tsunami (Tow Hill)

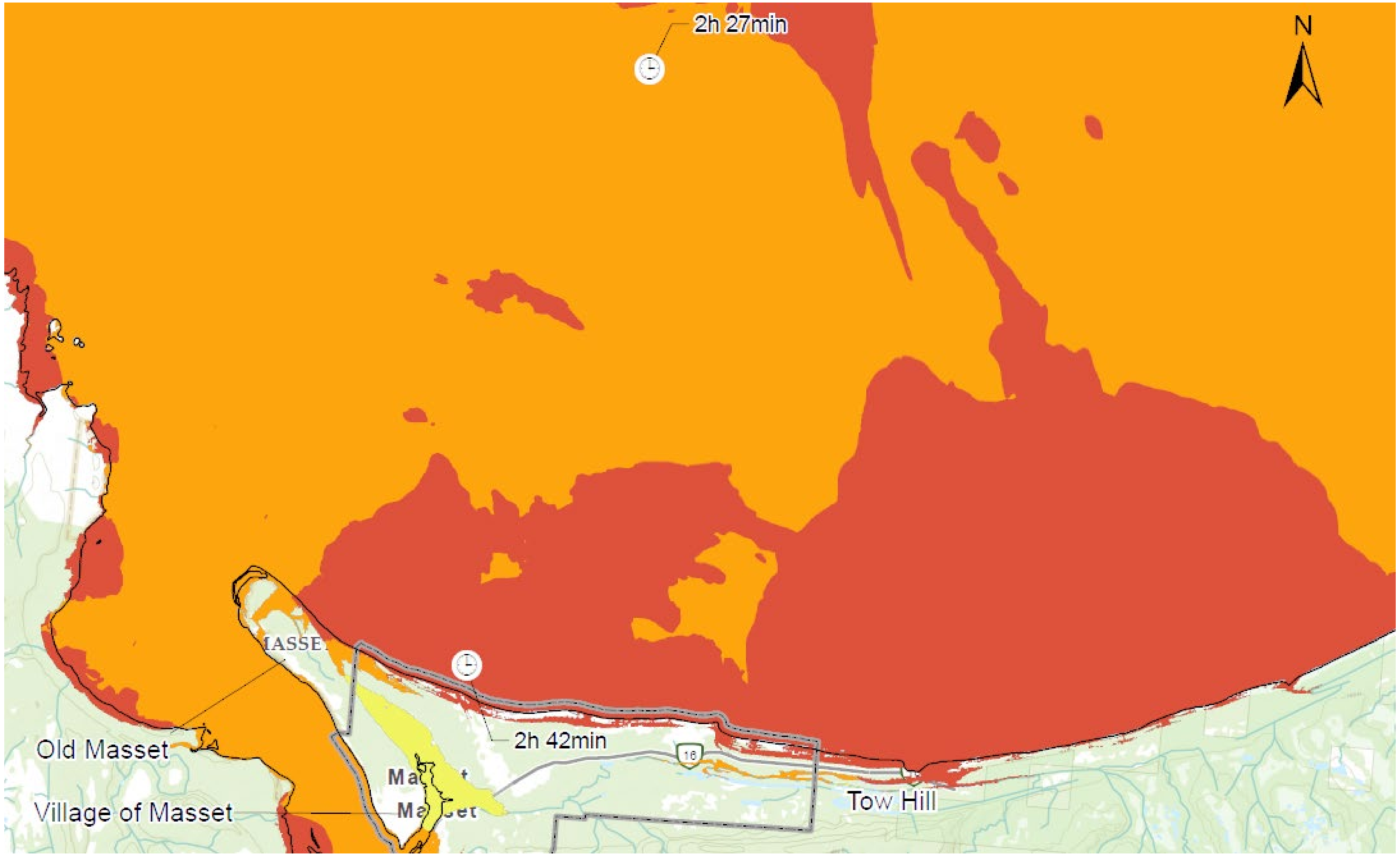
- Maximum Amplitude (Alaska-Aleutian subduction zone event)

MAX TSUNAMI AMPLITUDE
- 0 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- 2 - 4 m
- 4 - 6 m
- >6 m

TSUNAMI ARRIVAL TIME

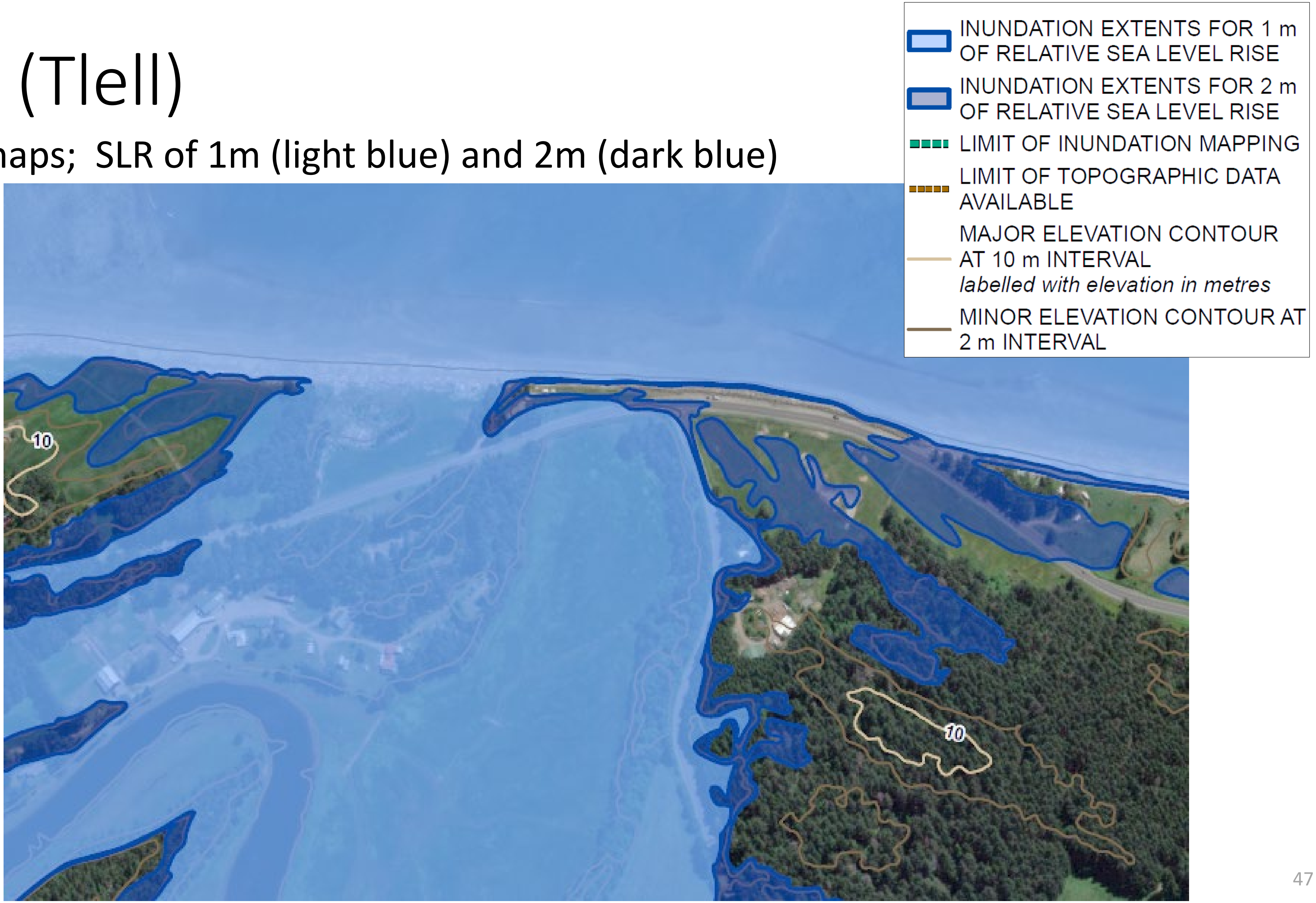
APPROXIMATE COASTLINE

MUNICIPAL BOUNDARY



Tsunami (Tlell)

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



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Tsunami (Tlell)

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

Tsunami (Sandspit)

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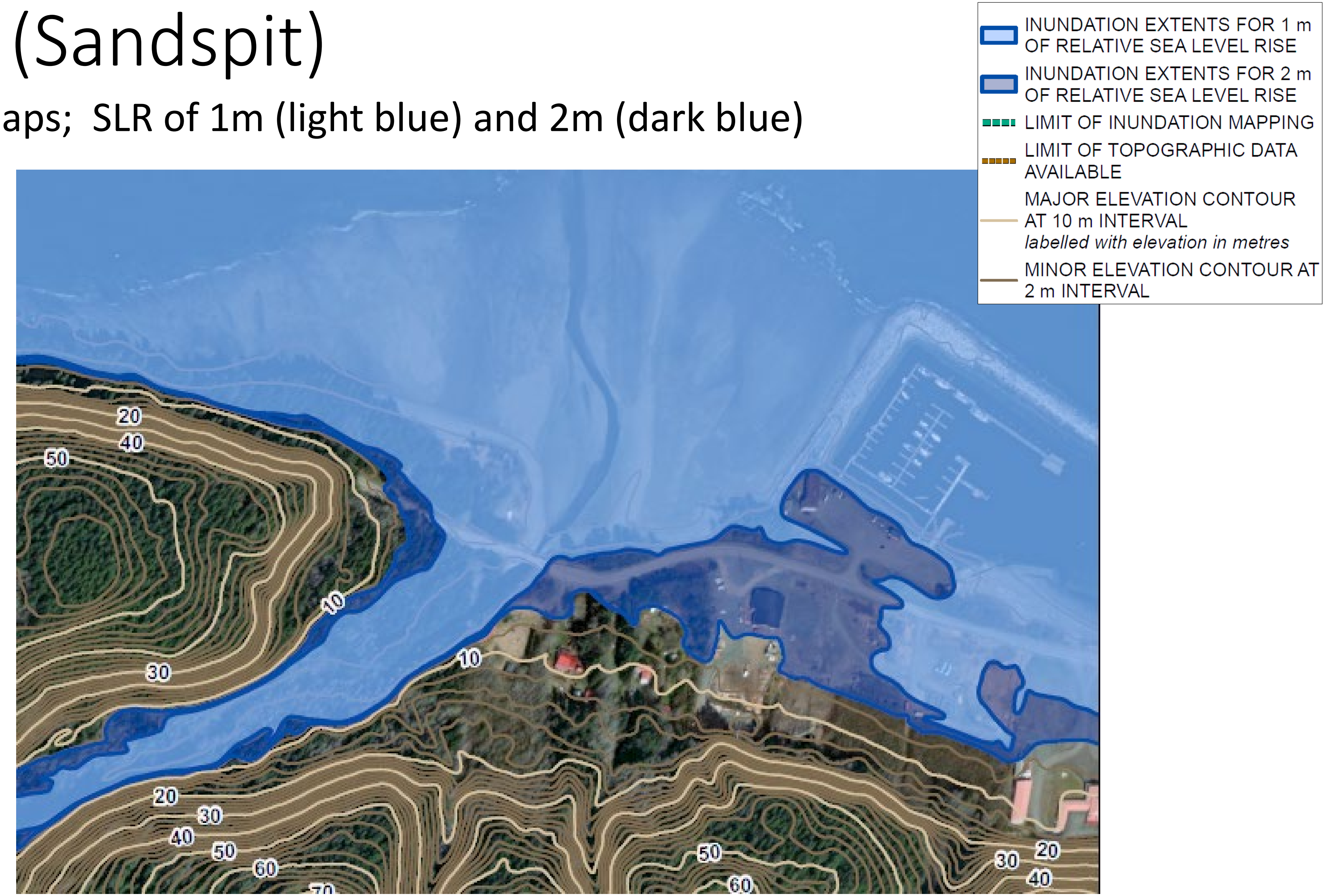

Tsunami (Sandspit)

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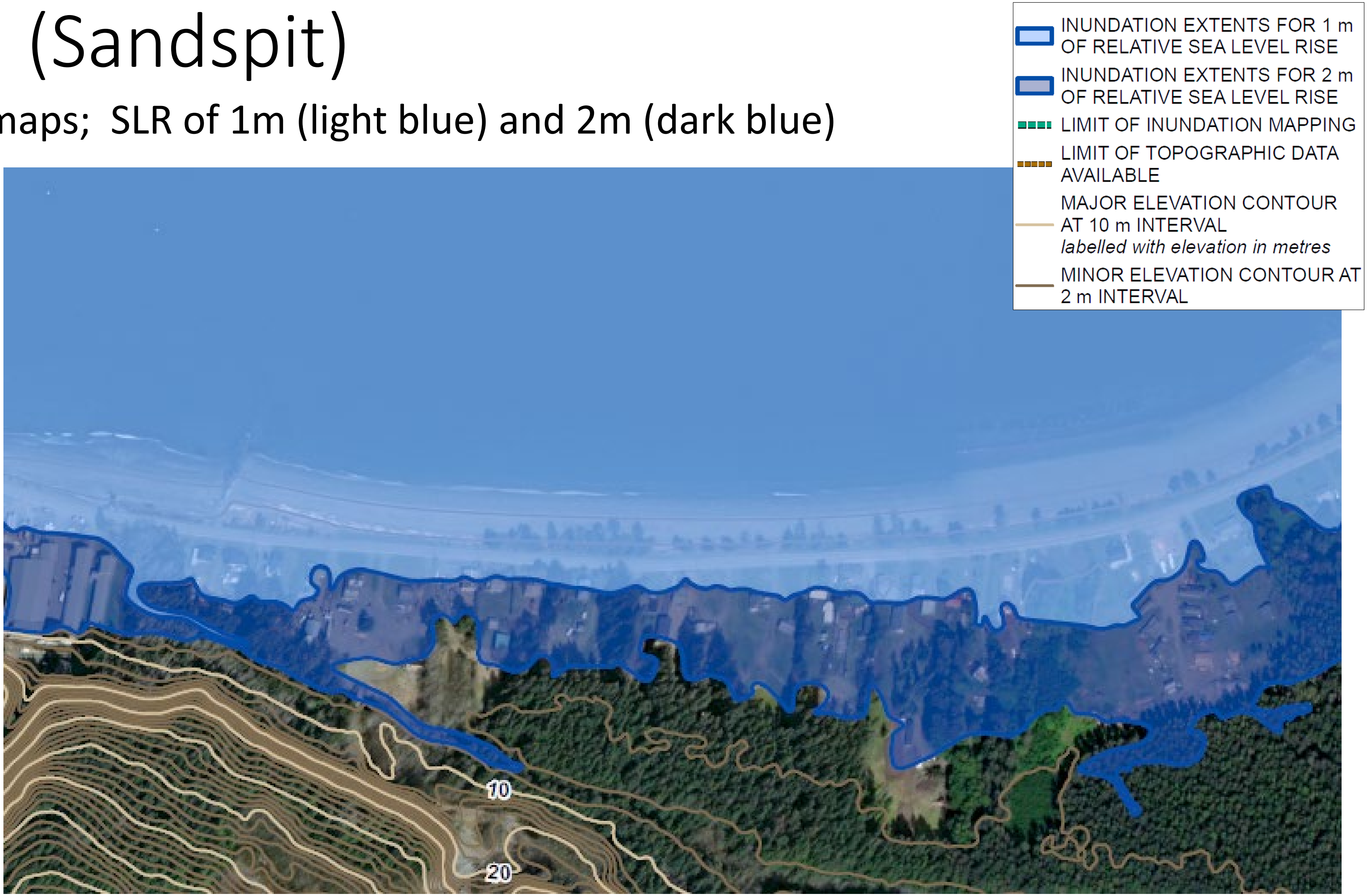


Tsunami (Tow-Hill)

- 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

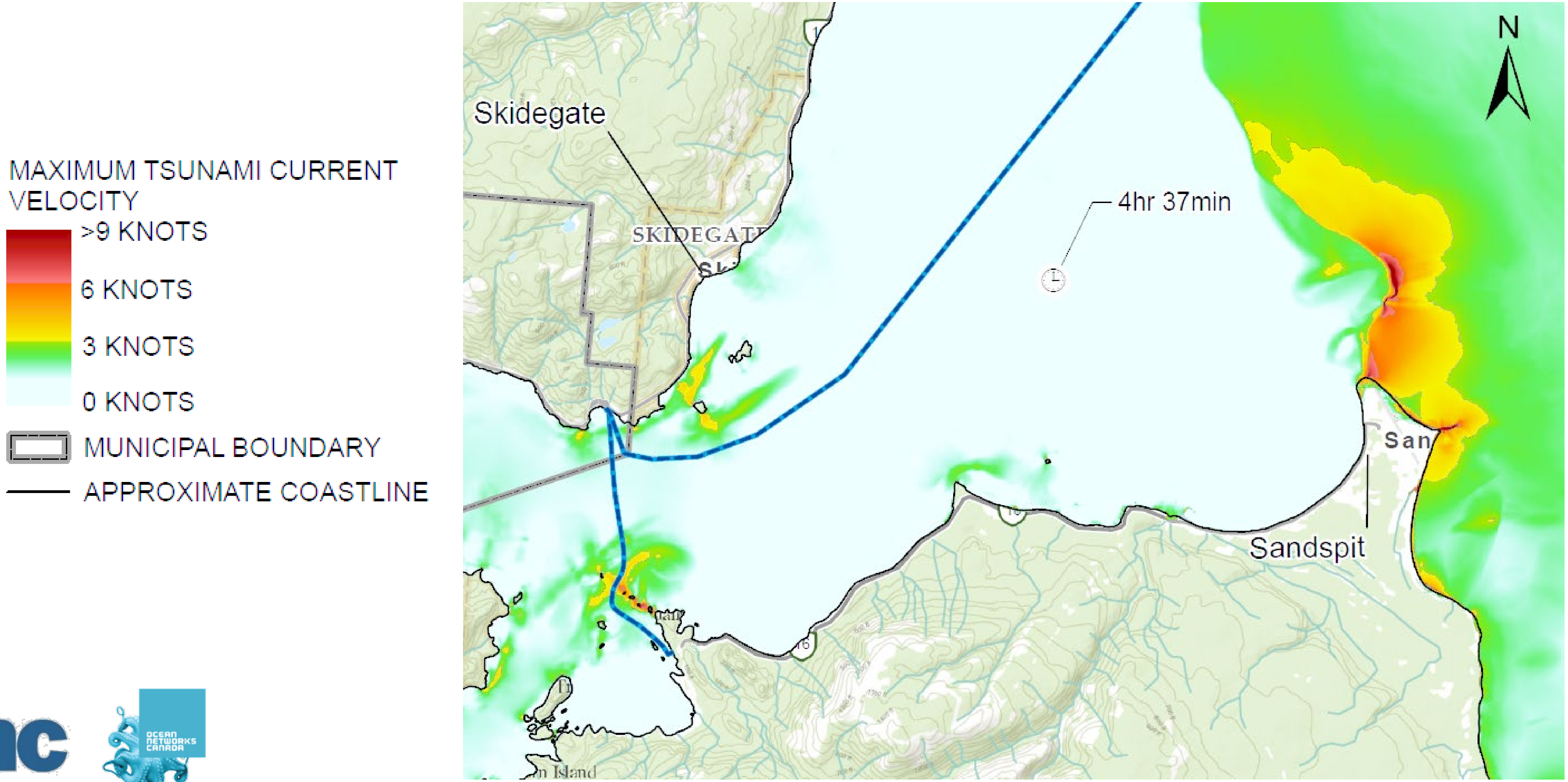
LIMIT OF TOPOGRAPHIC DATA AVAILABLE

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

MINOR ELEVATION CONTOUR AT 2 m INTERVAL

Tsunami

Risk to Mariners / Marine Infrastructure



Tsunami

Risk to Mariners / Marine Infrastructure

MAXIMUM TSUNAMI CURRENT VELOCITY

>9 KNOTS

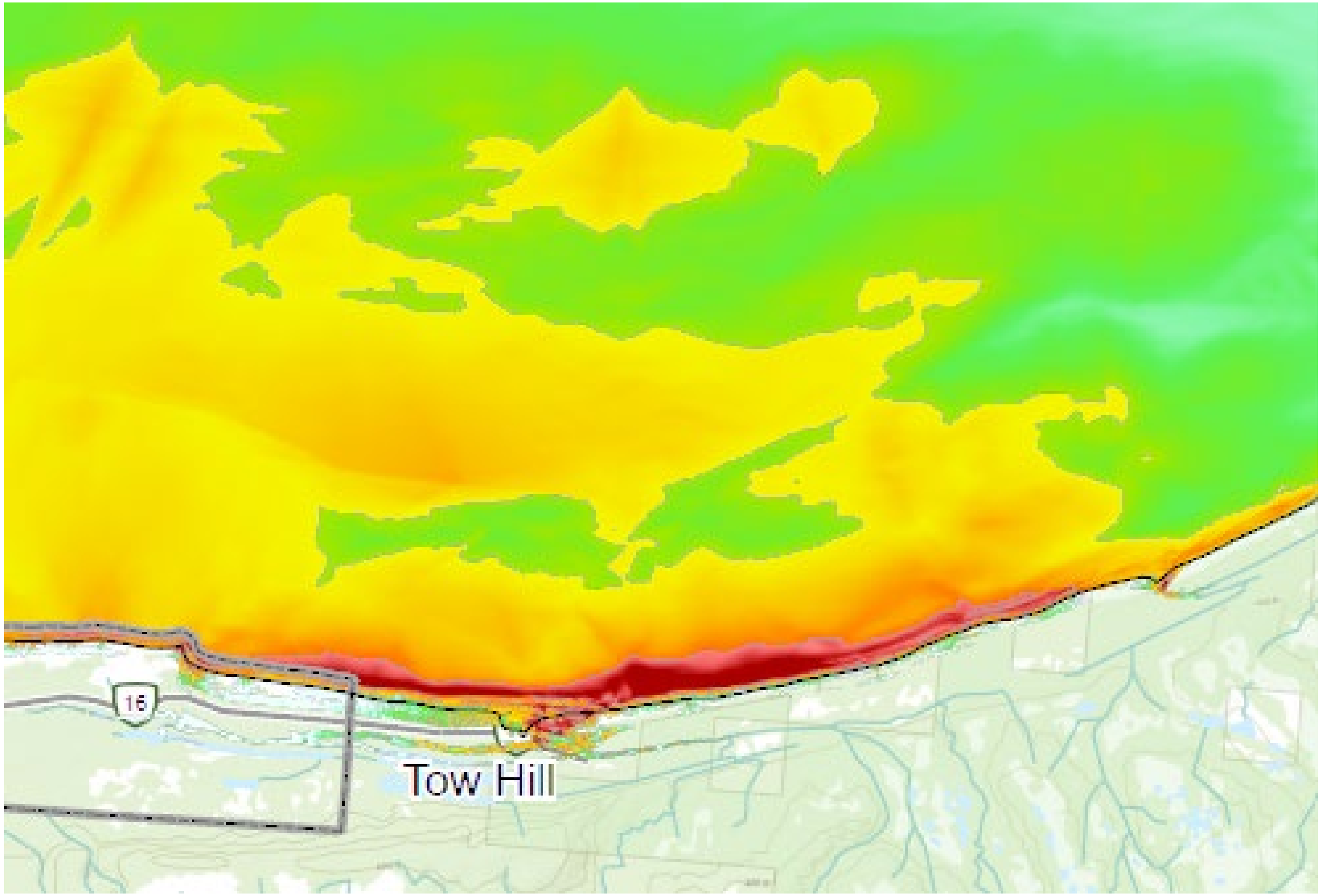
6 KNOTS

3 KNOTS

0 KNOTS

MUNICIPAL BOUNDARY

APPROXIMATE COASTLINE



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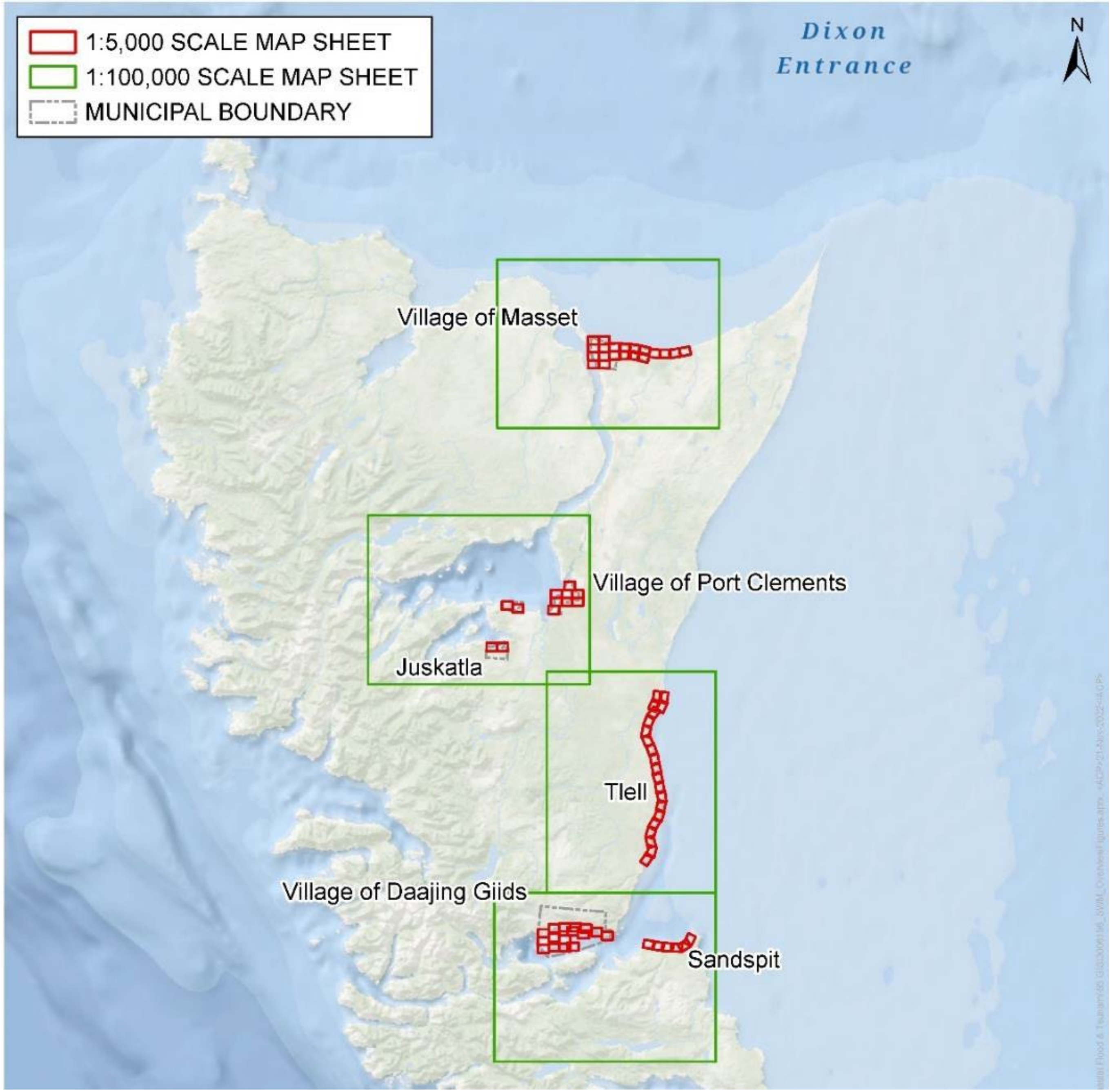
Project Output

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

Coastal FCL maps include erosion susceptibility mapping.

Community Reports



Planning & Next Steps

- Study results (maps, reports) to inform community planning

- Develop Tools to reduce future coastal flood risk
  - Limit new development in hazard zones
  - New construction in hazard areas to adopt Flood Construction Levels
  - Update Tsunami evacuation planning

- 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

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Questions?