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Implications of Sea Level Rise to Coastal Issues in BC Waters

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Update on status of SLR

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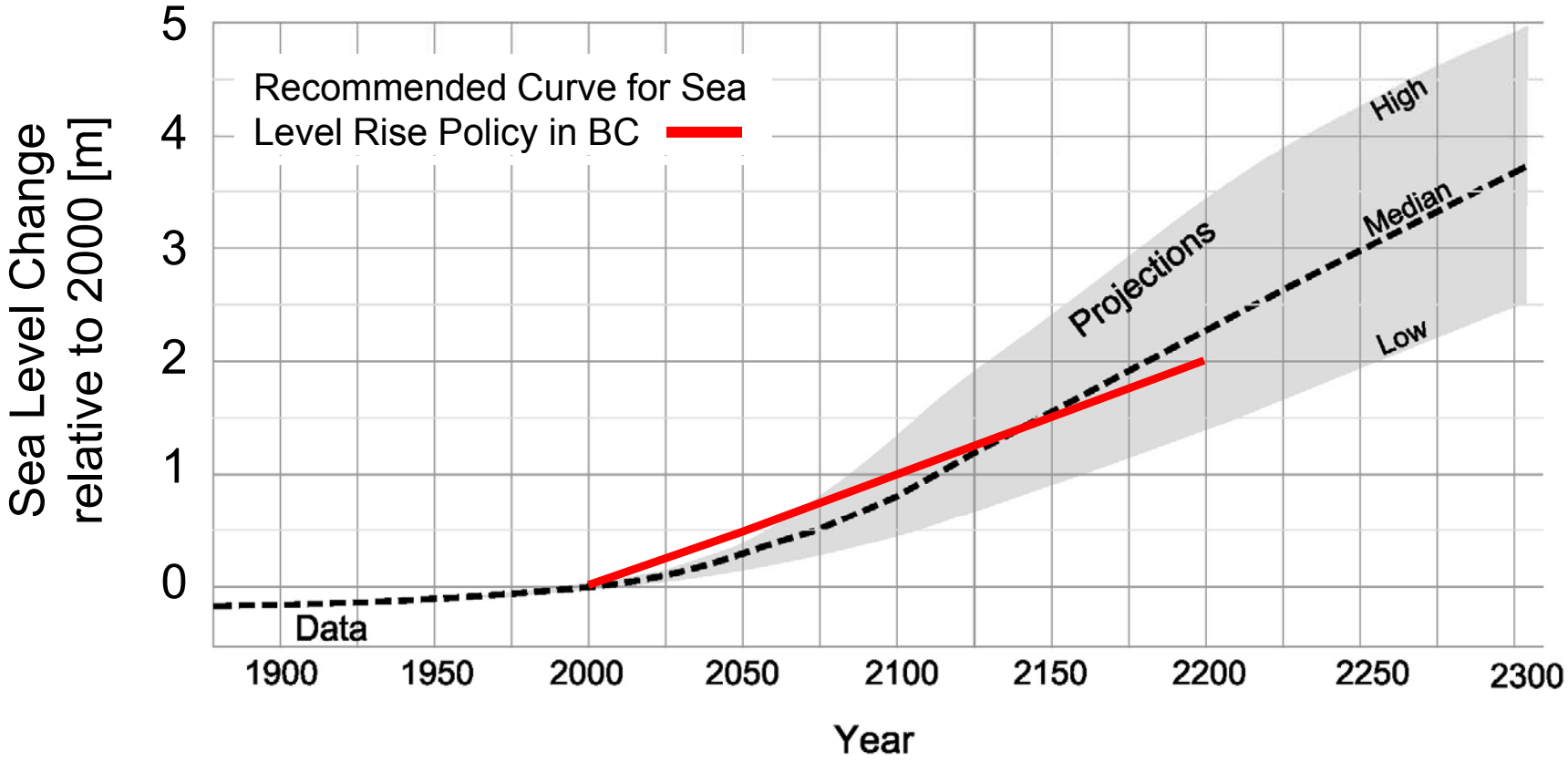
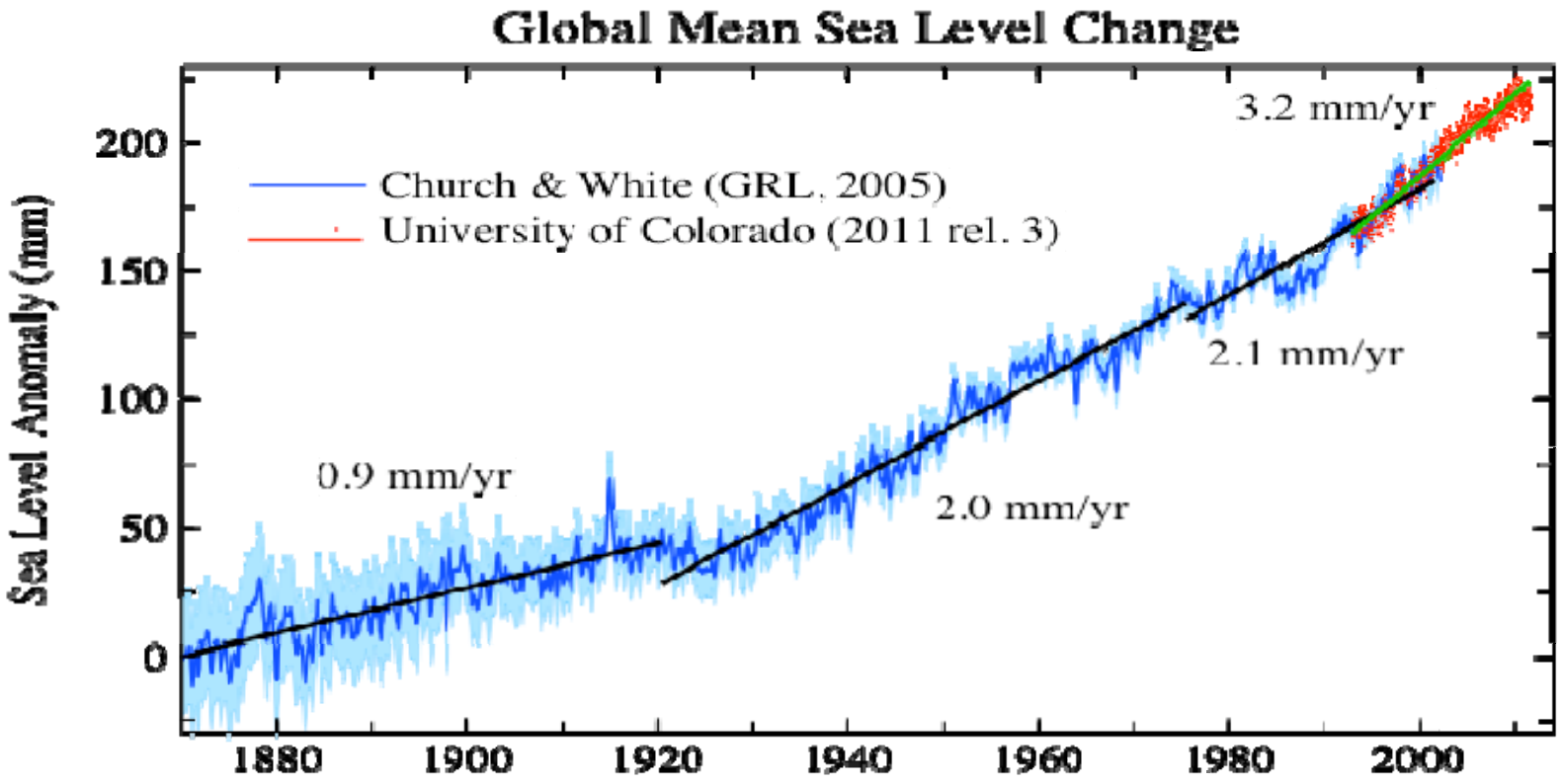
BC Guideline (2011)
Recommendations for SLR Planning

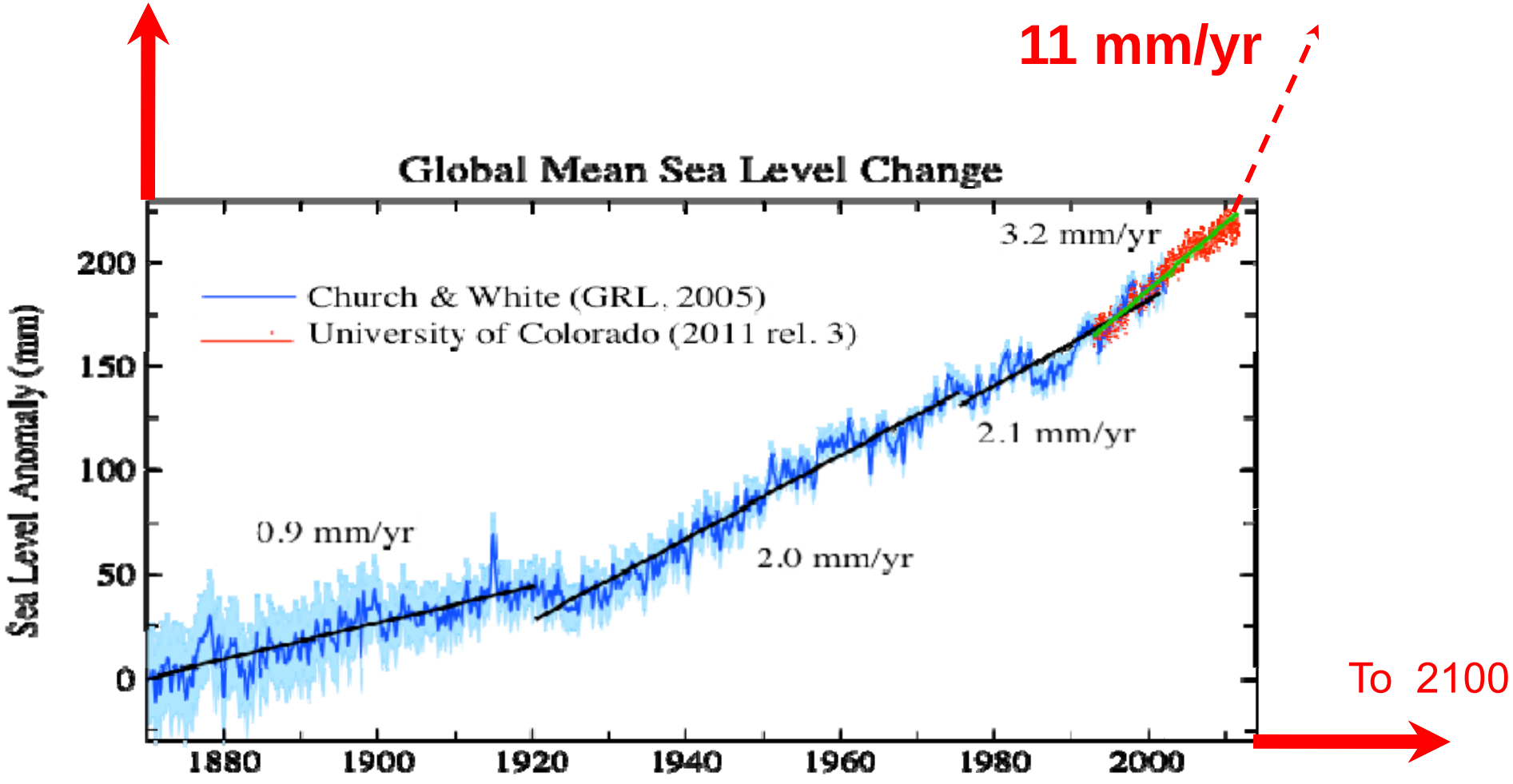


Recent Sea Level Rise Rate

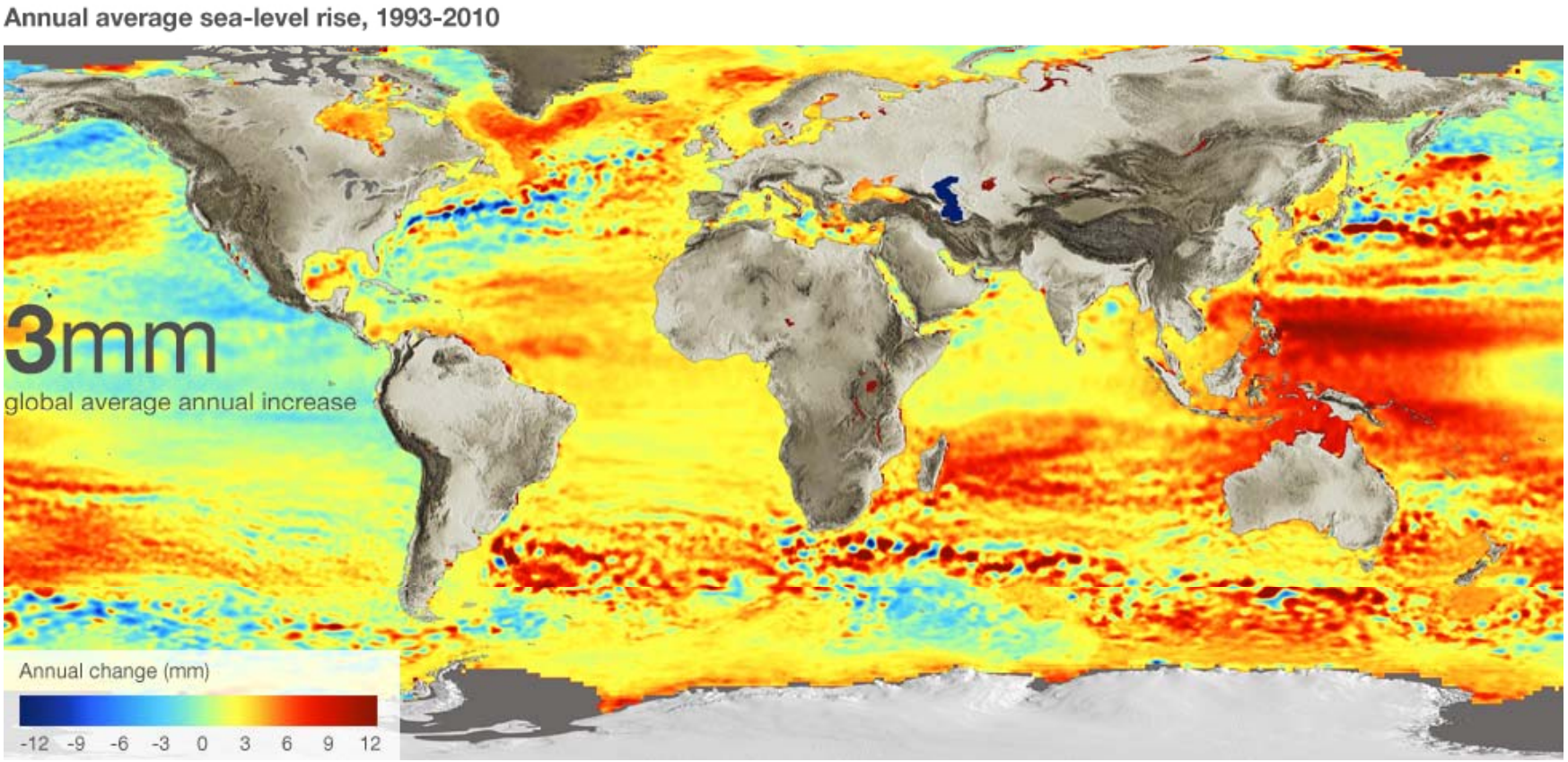


Sea Level Rise Rate to Meet Guideline

to 1000 mm by 2100

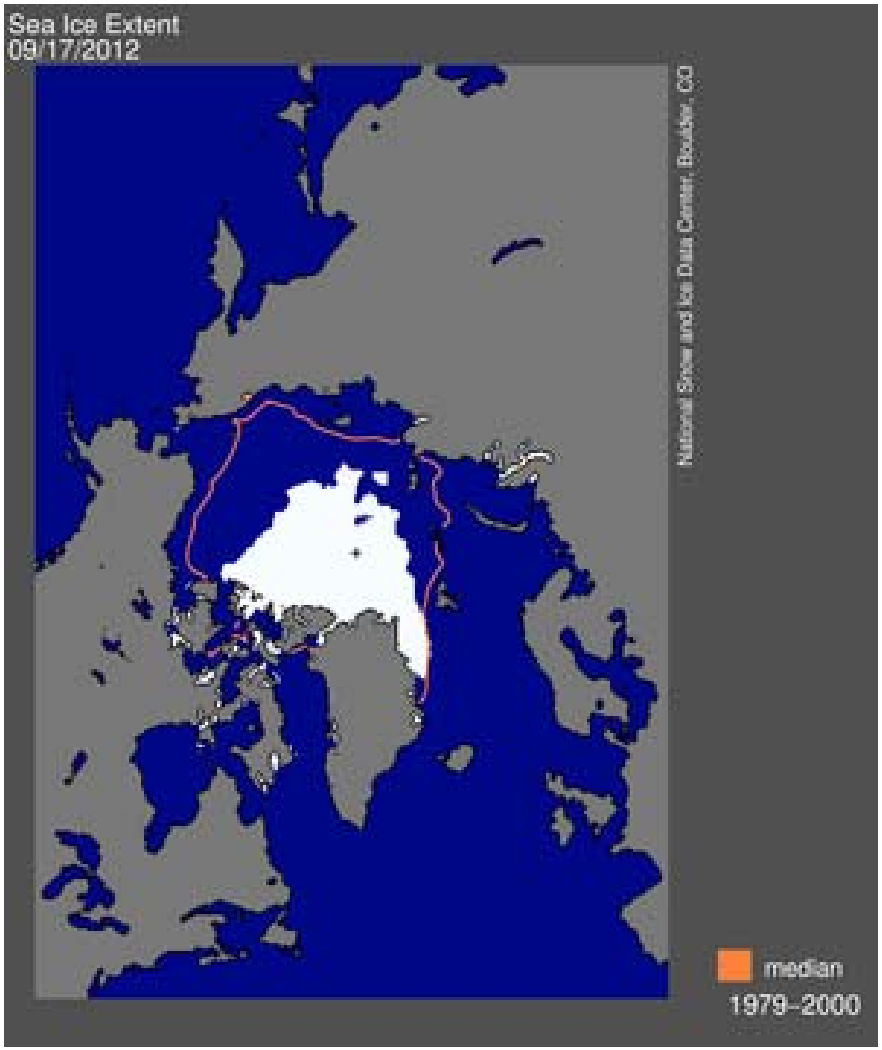


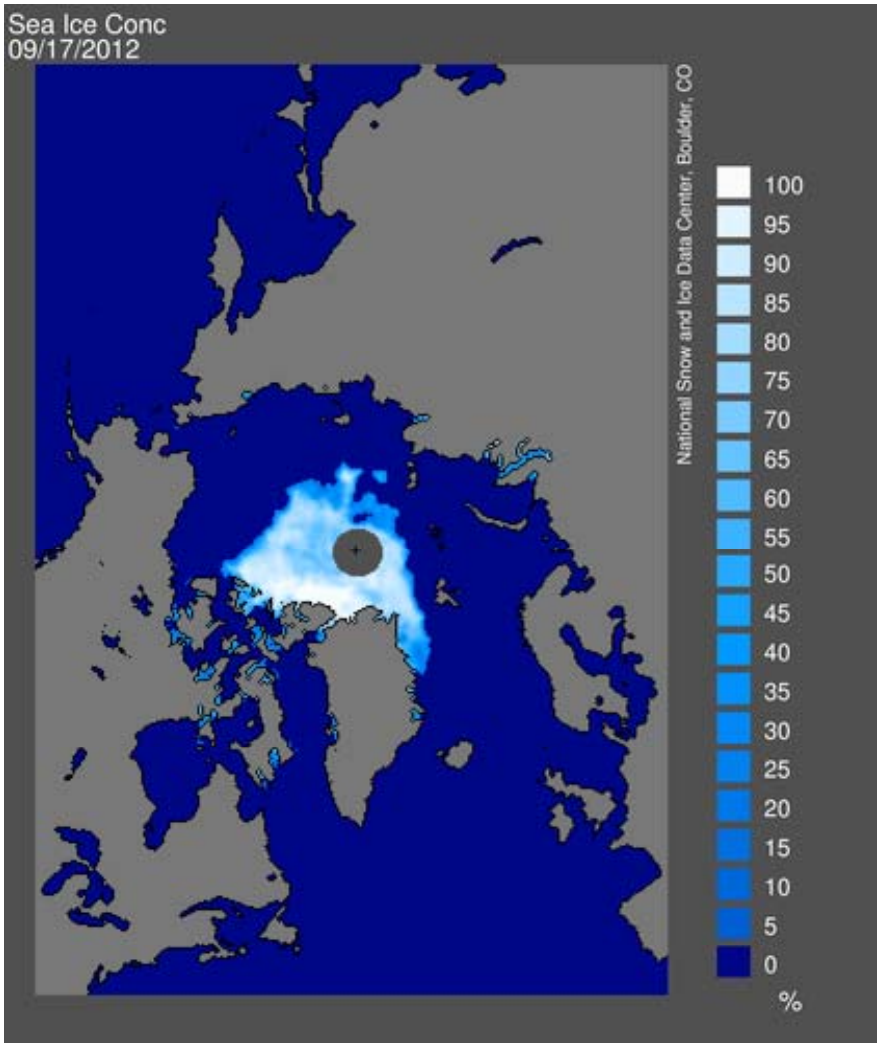
Measured Global Sea Level Pattern 1993 - 2010



University of Colorado – Sept 2012

Summer Melting of Arctic Sea Ice



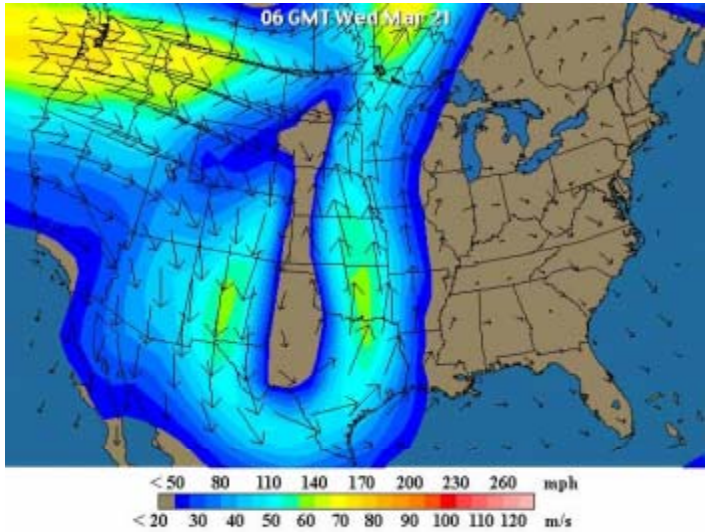


Data: 17 September 2012.
Source: Hansen 2012 and National Snow and Ice Data Center, Boulder, Colorado

Arctic Warming

- Arctic warming is altering and slowing the jet stream
- Upper atmosphere weather systems are progressing more slowly
- Increasing occurrence of persistent (stalled) weather
- In future, may increase the chance of a storm at high tide

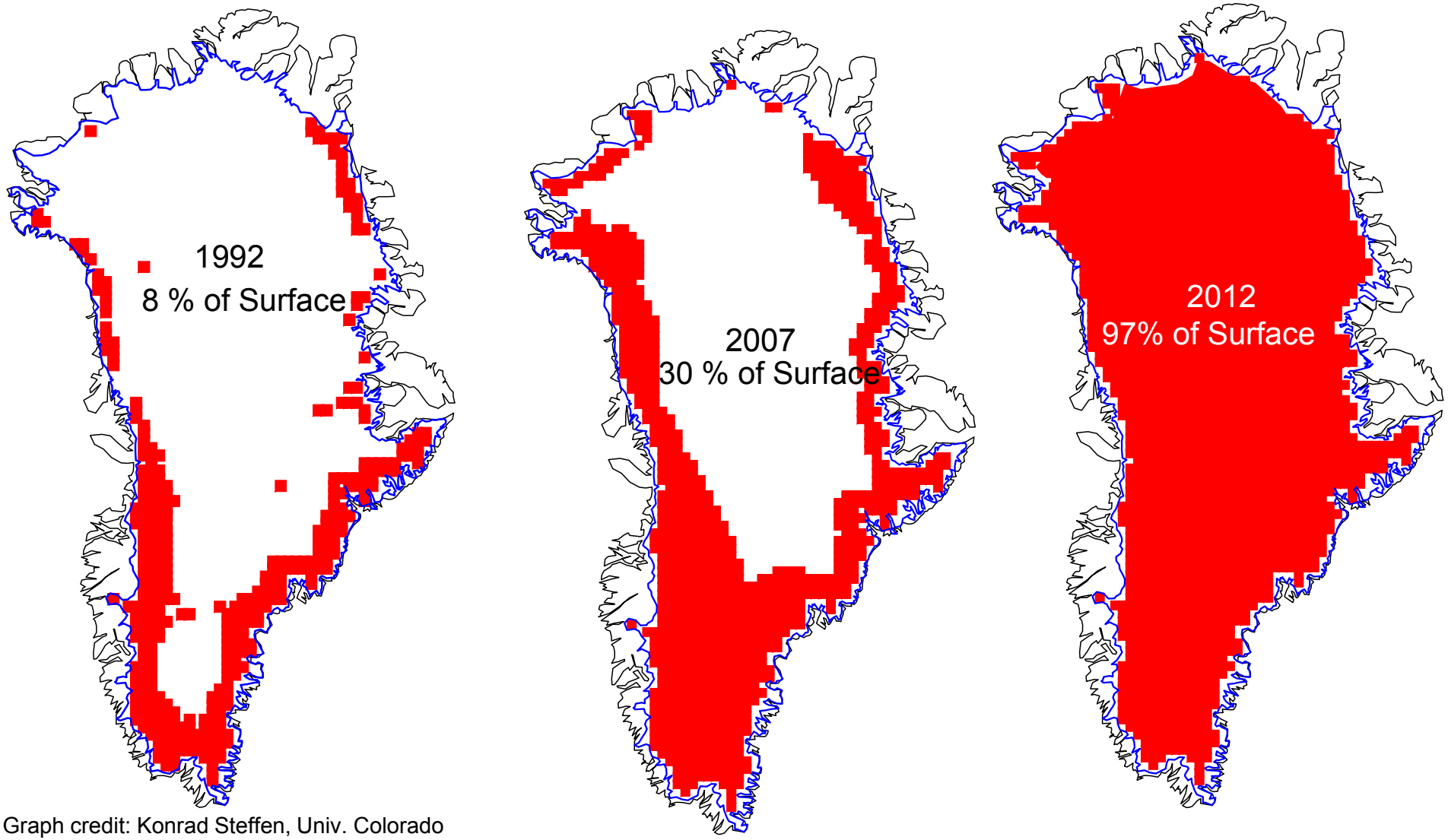
Path of the jet stream on March 21, '12.
Credit: weatherunderground.



Jennifer Francis,Rutgers and Stephen Vavrus University of Wisconsin Madison, GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L06801, 6 PP., 2012

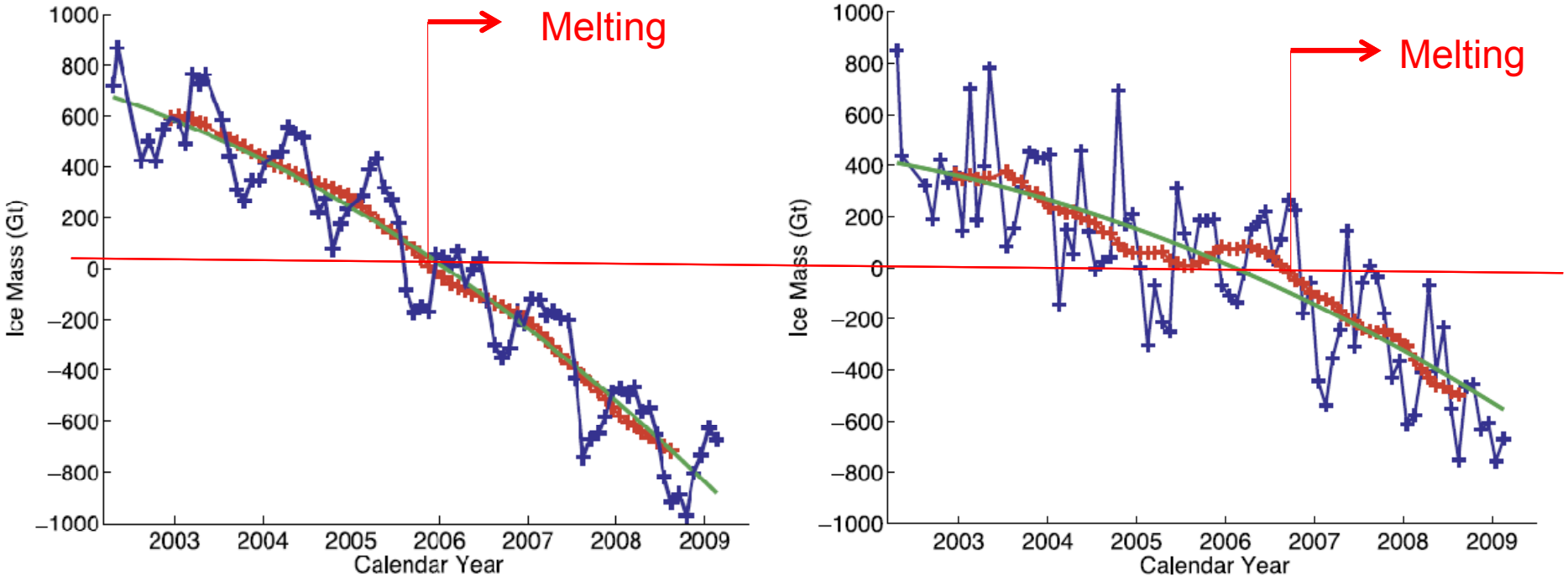
Also:Vladimir Petoukhov, lead author, Potsdam Institute for Climate Impact Research, Germany. Proceedings of the National Academy of Sciences, 2013.

Greenland Melt Area Trend



Graph credit: Konrad Steffen, Univ. Colorado

Melting of Large Ice Sheets

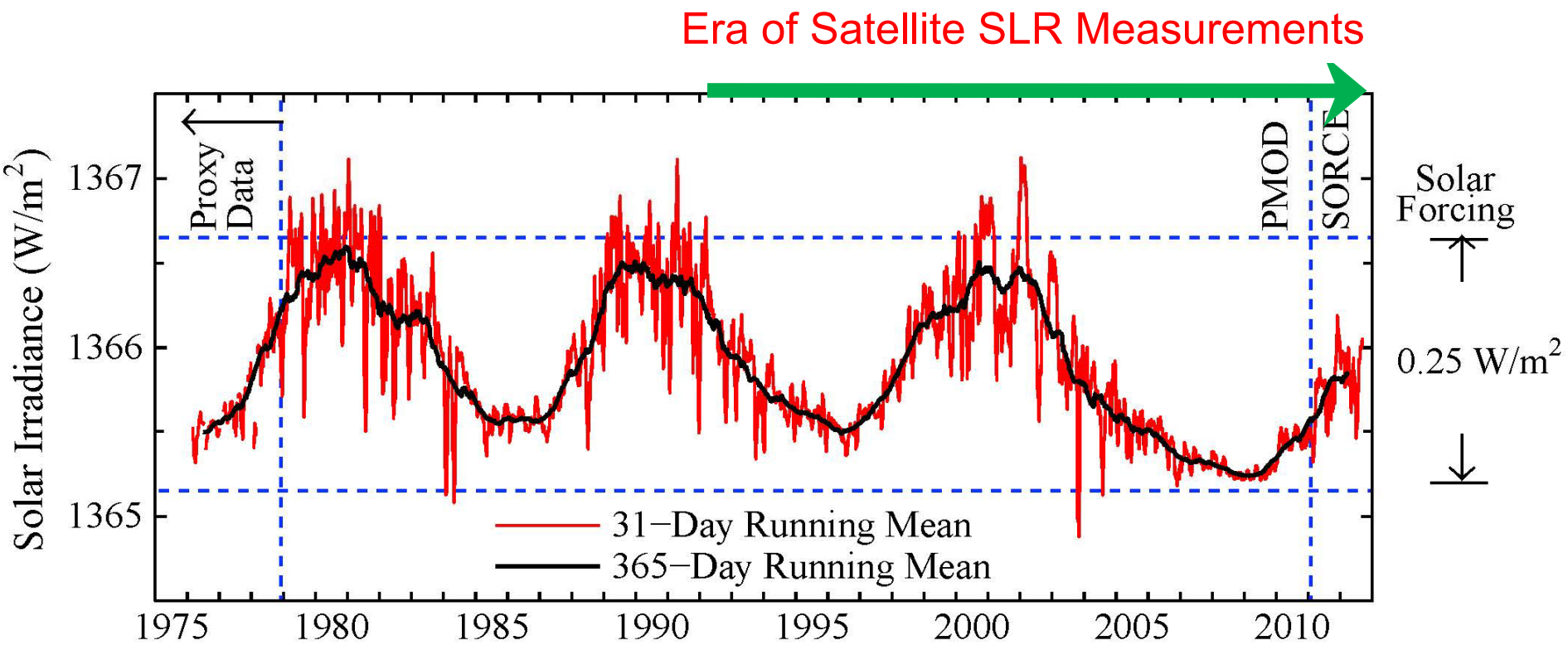


Greenland Ice Sheet

Antarctic Ice Sheet

Source: Velicogna, I. *Geophys. Res. Lett.*, **36**, L19503, doi:10.1029/2009GL040222, 2009.

Solar Radiation



Adapted from: “Update, through Aug. 2012, of Fig. 17 of Hansen et al., Atmos. Chem. Phys., 11, 13421-13449, 2011”

Implications to Coastal BC Waters

Intertidal Water Depths

- More wave energy moving closer to shore
- Stronger wave induced currents
- More and faster erosion of seabed and feeder bluffs, banks or cliffs

- could be offset by sediment transport, but only;
  if sources (cliffs, eroding banks) not armoured.

Implications to Coastal BC Waters

Shallow water near shoreline:

- Increased depth of water near high tide shoreline
- Larger breaking waves
- More wave runup on the shoreline
- Larger wave forces on beach and shoreline materials
- More overtopping (spray) on shorelines and coastal structures

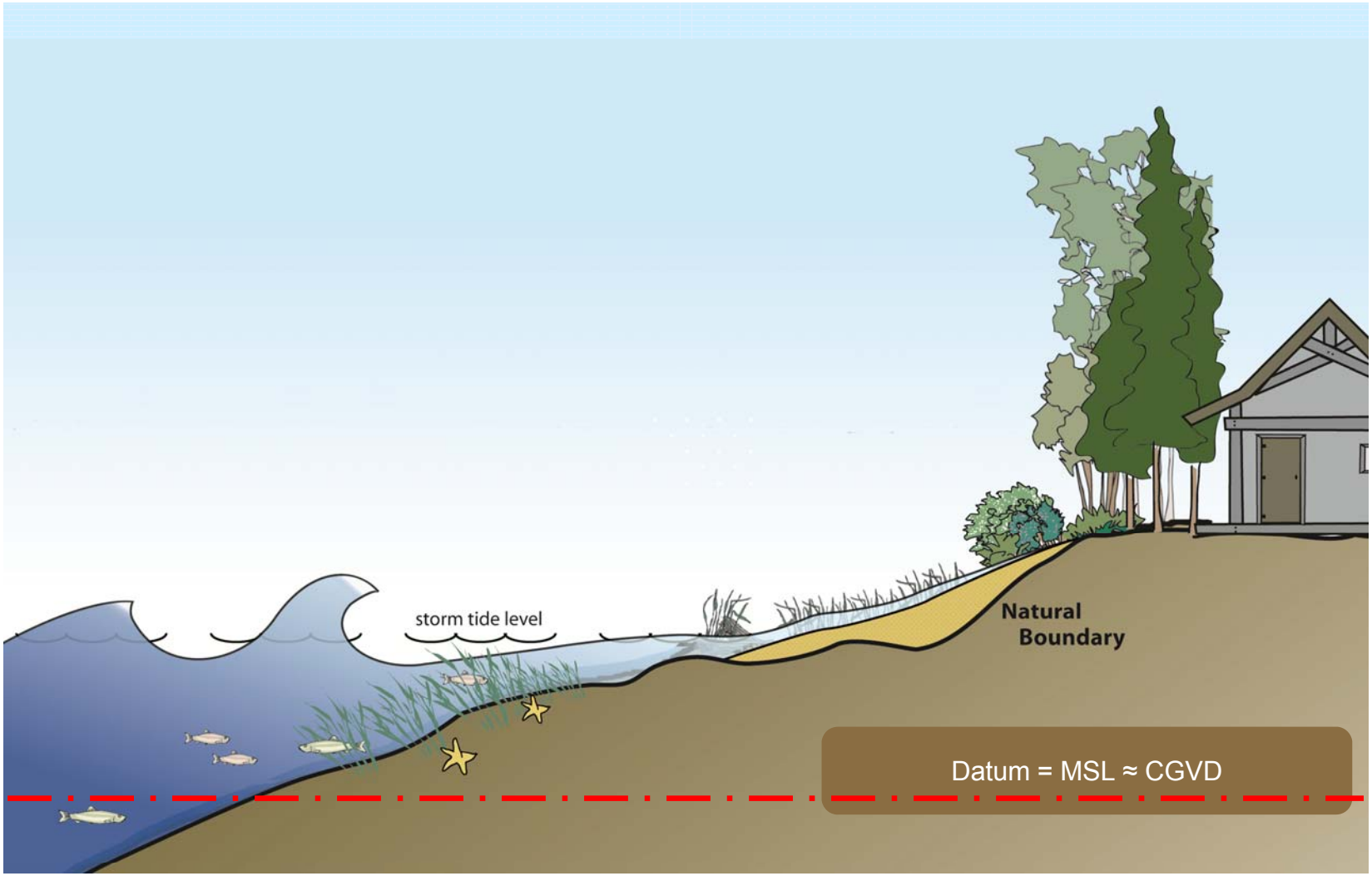
Breaking wave crests close to shoreline during SE storm of 12 March 2012

Waves at edge of highway during storm in November 2011

Implications to N and S Pender Island

Credit: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdf_drawings/

Implications to Shorelines: Components



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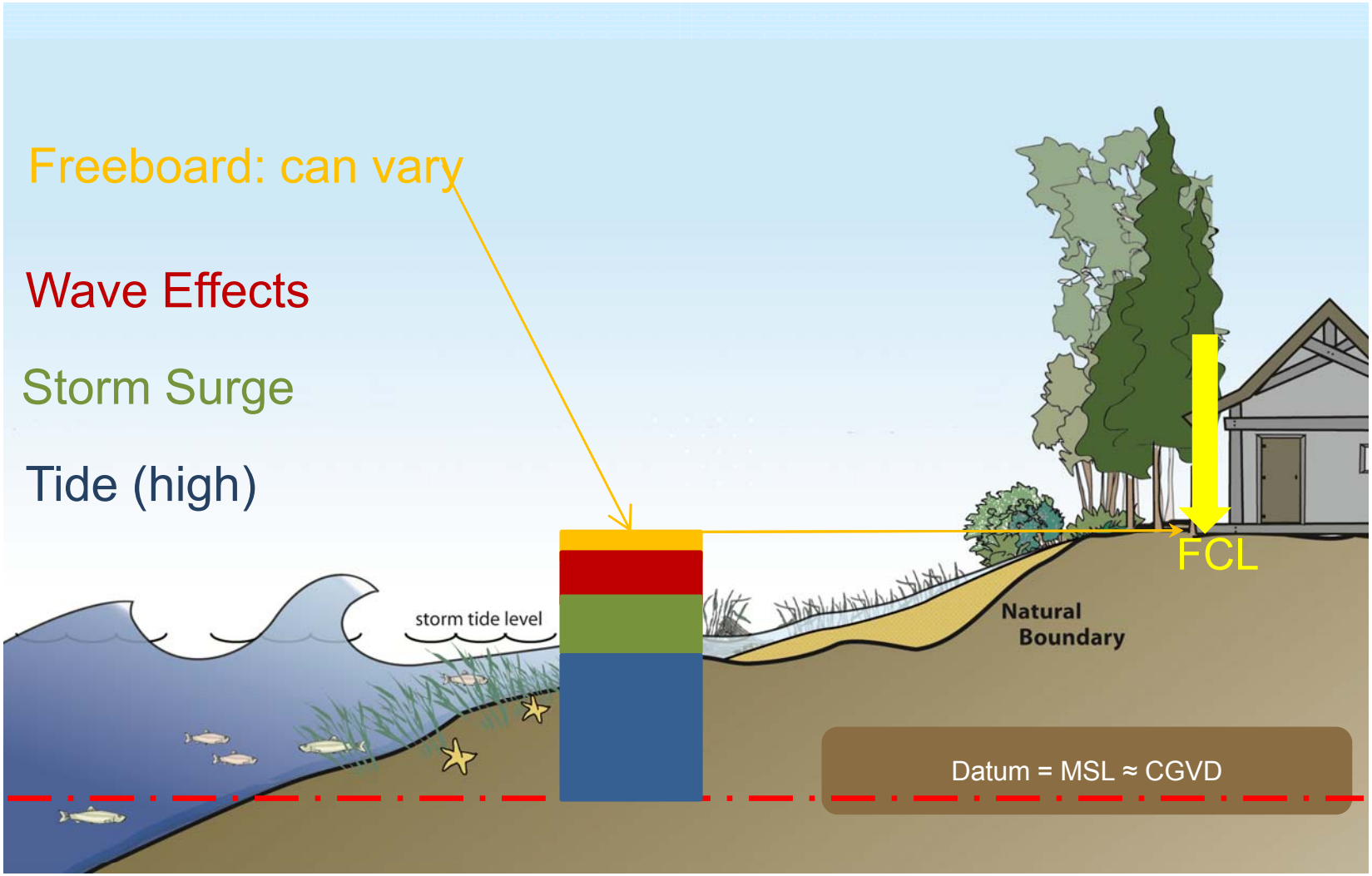
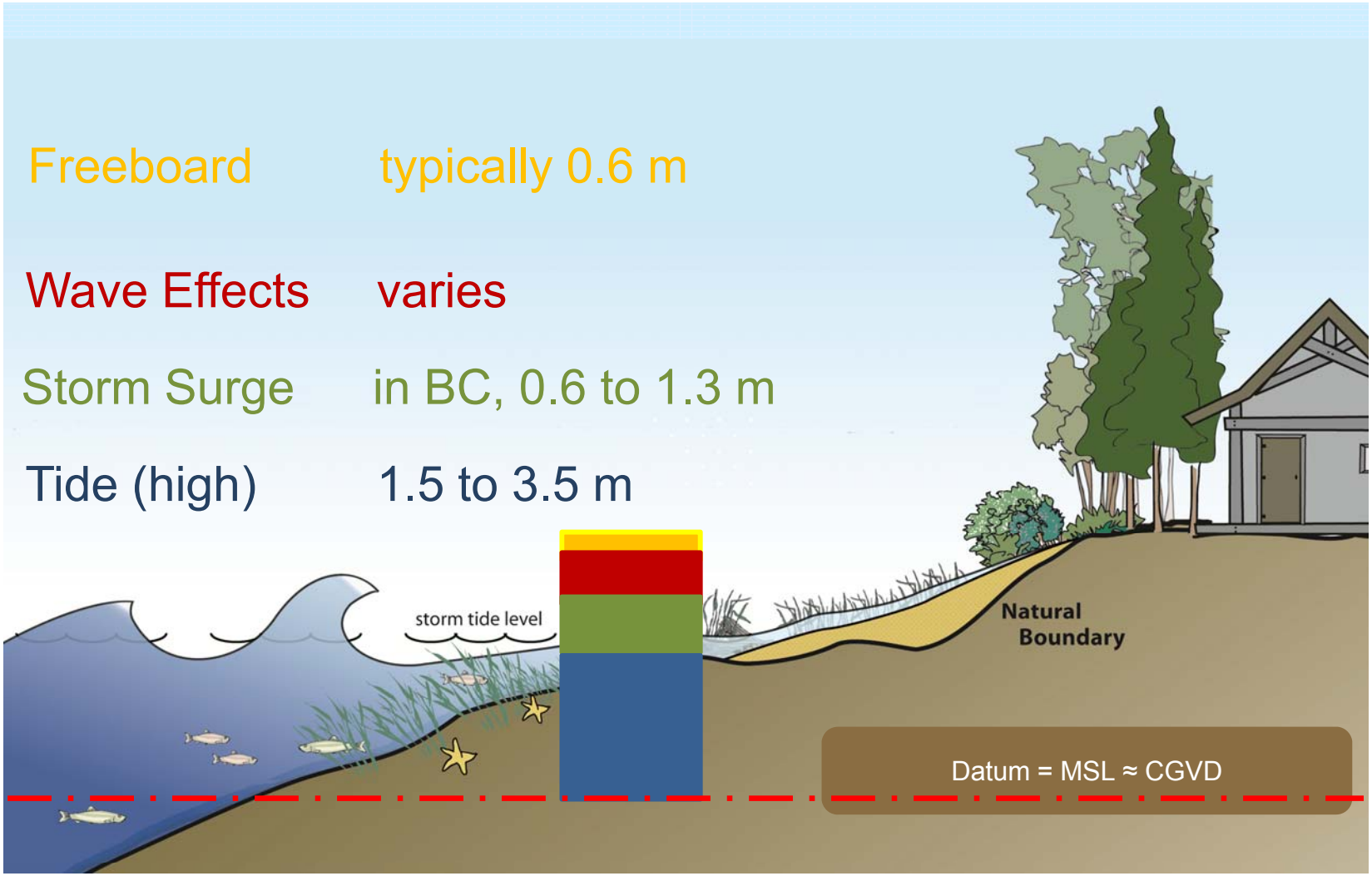


Implications to Shorelines



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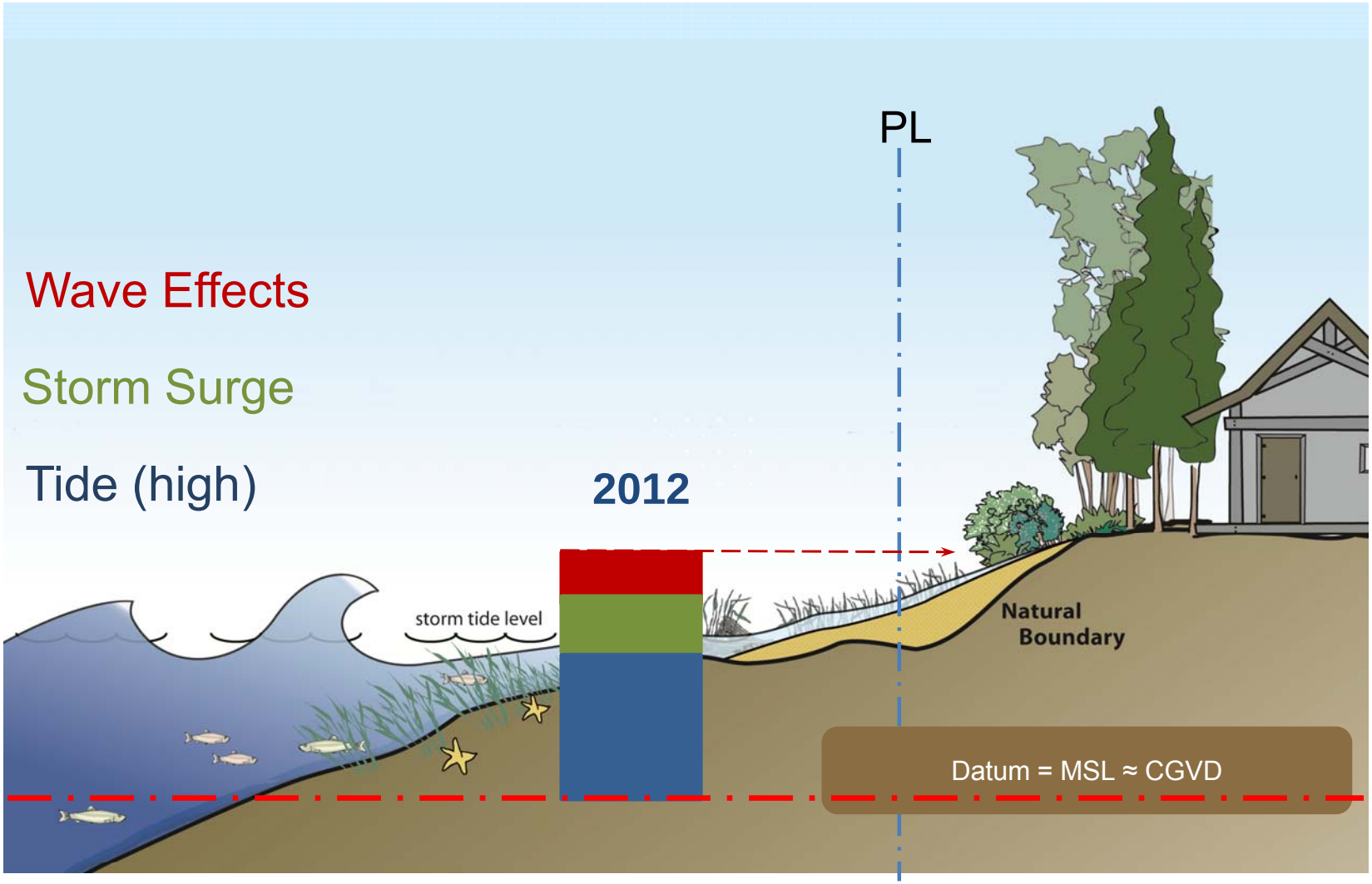

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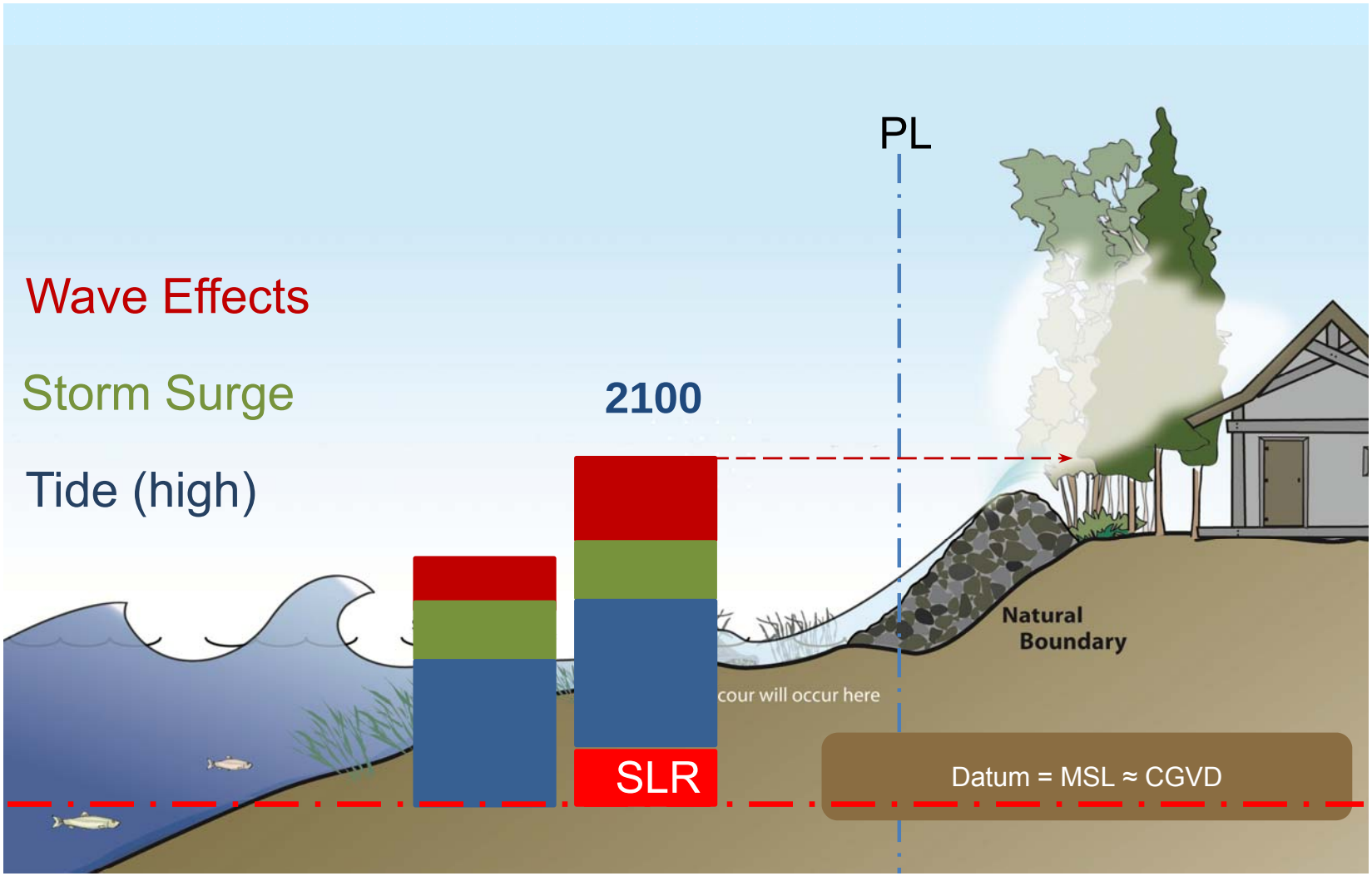

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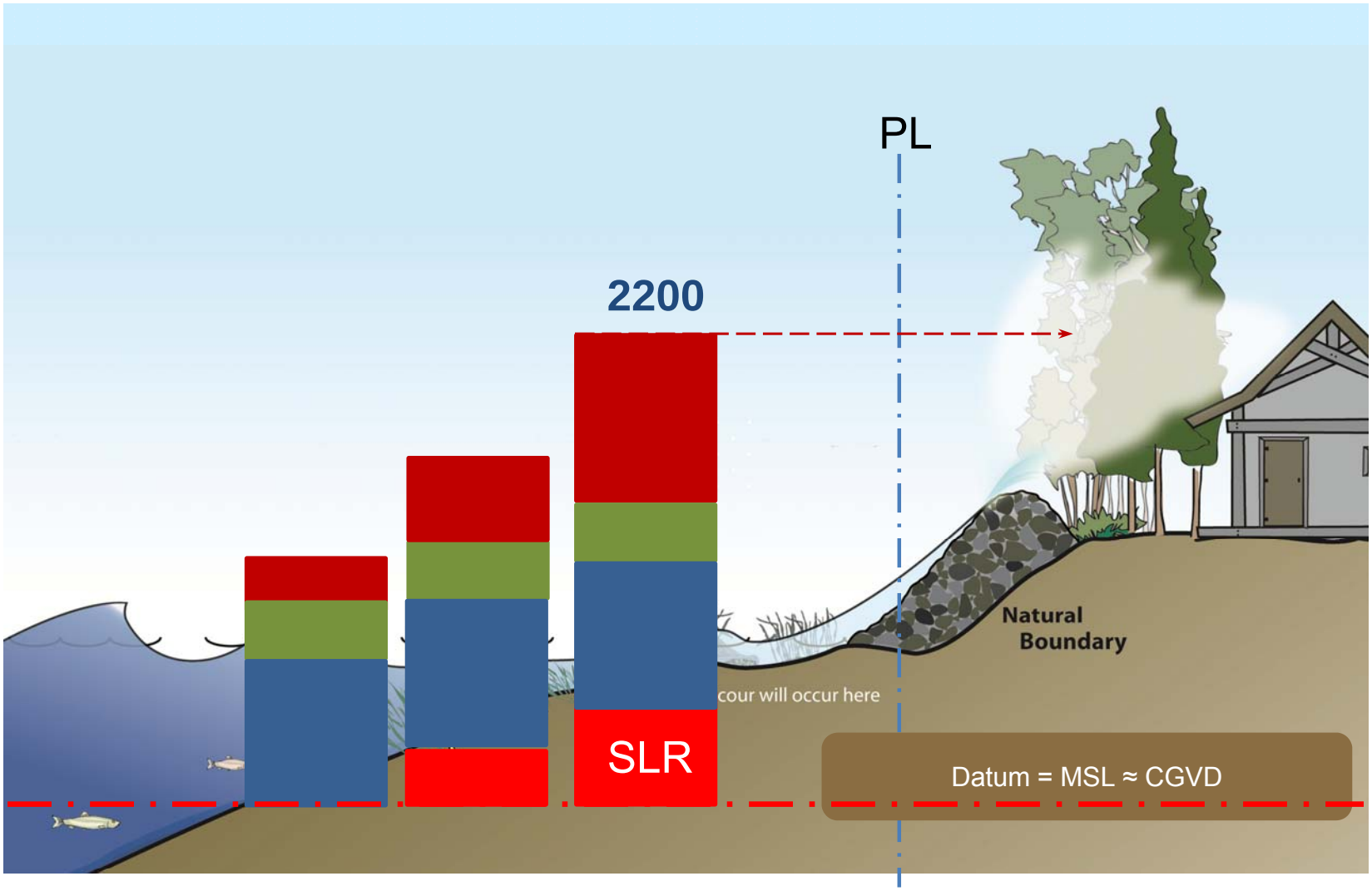

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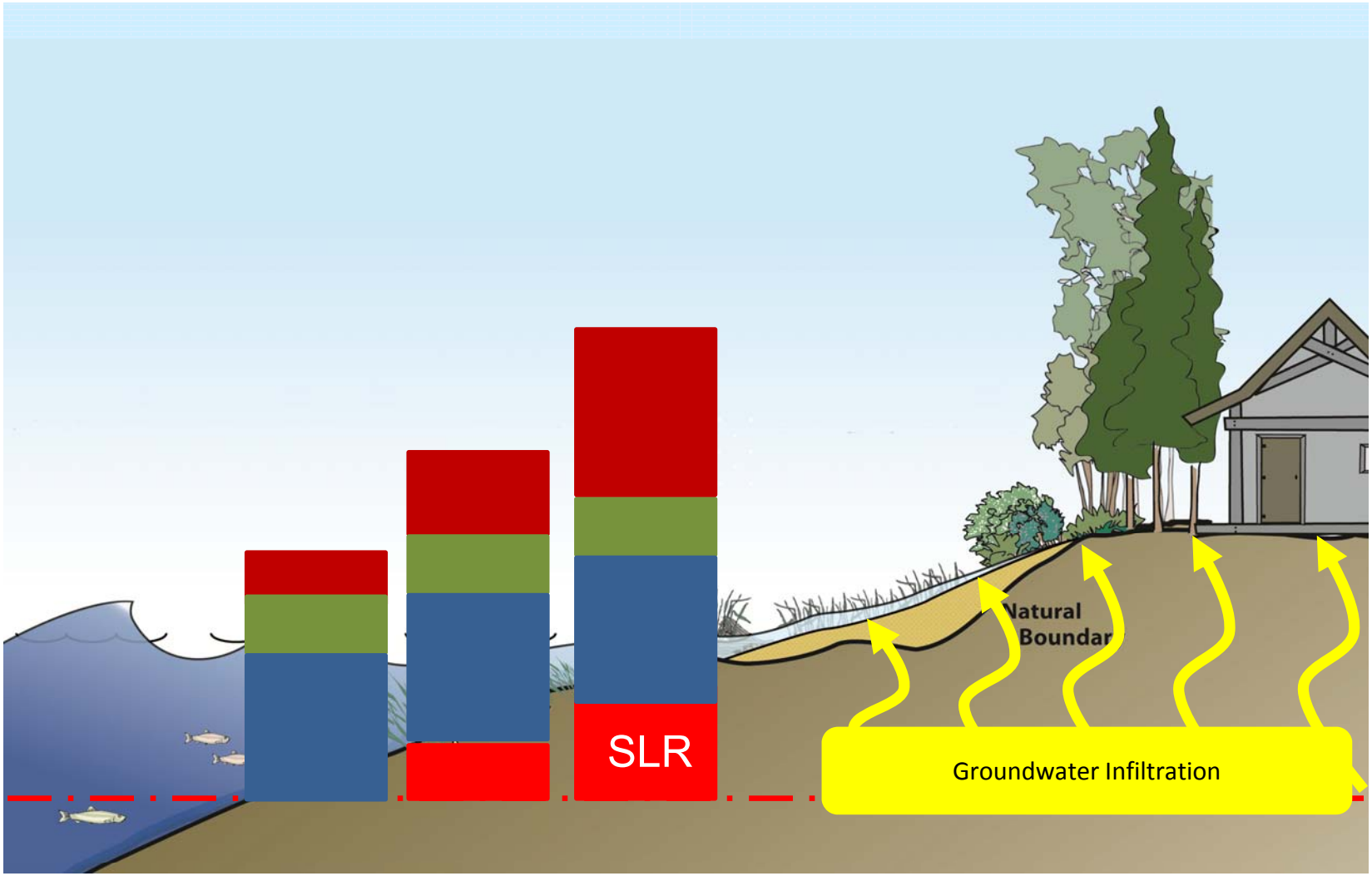

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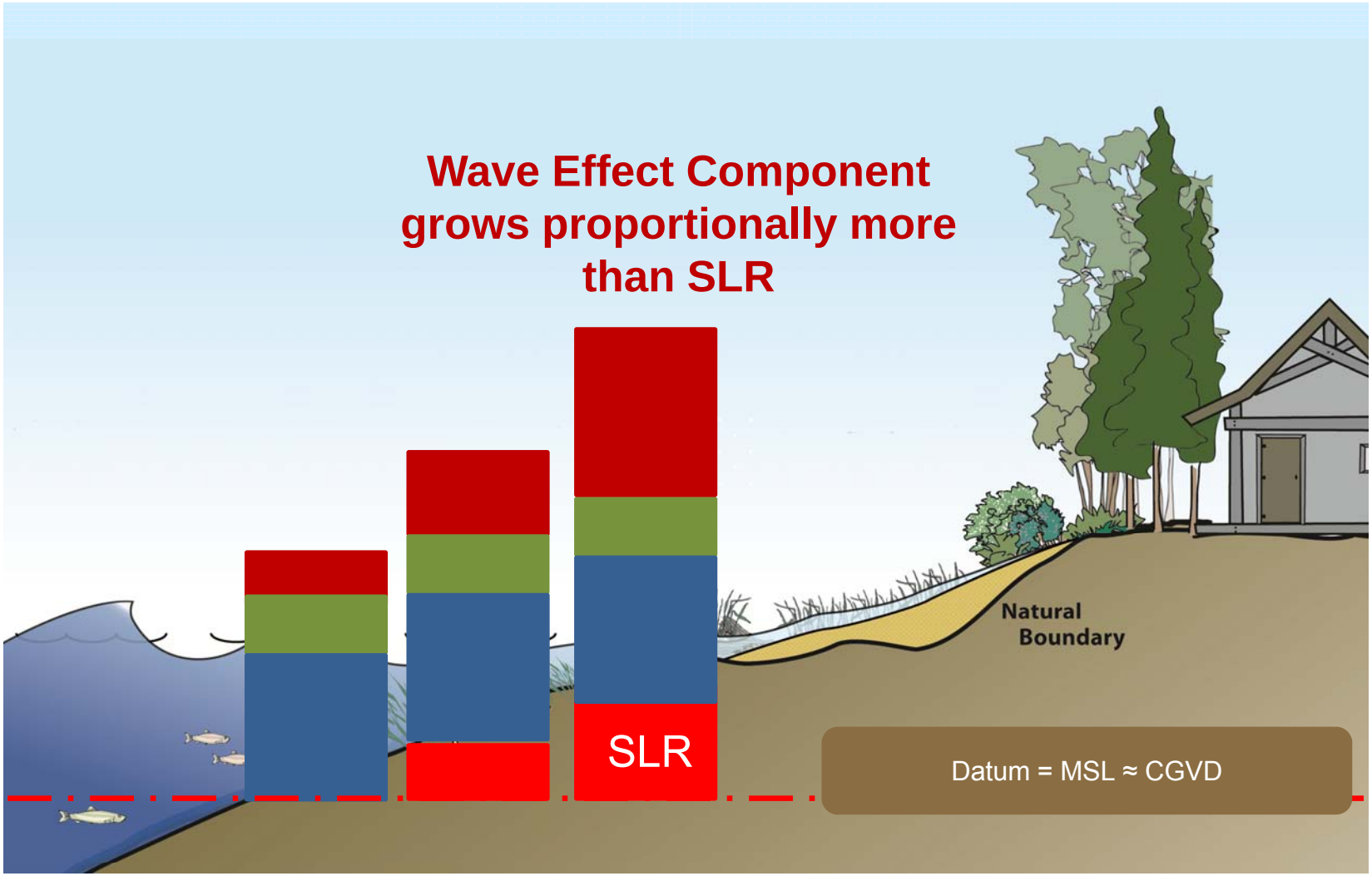
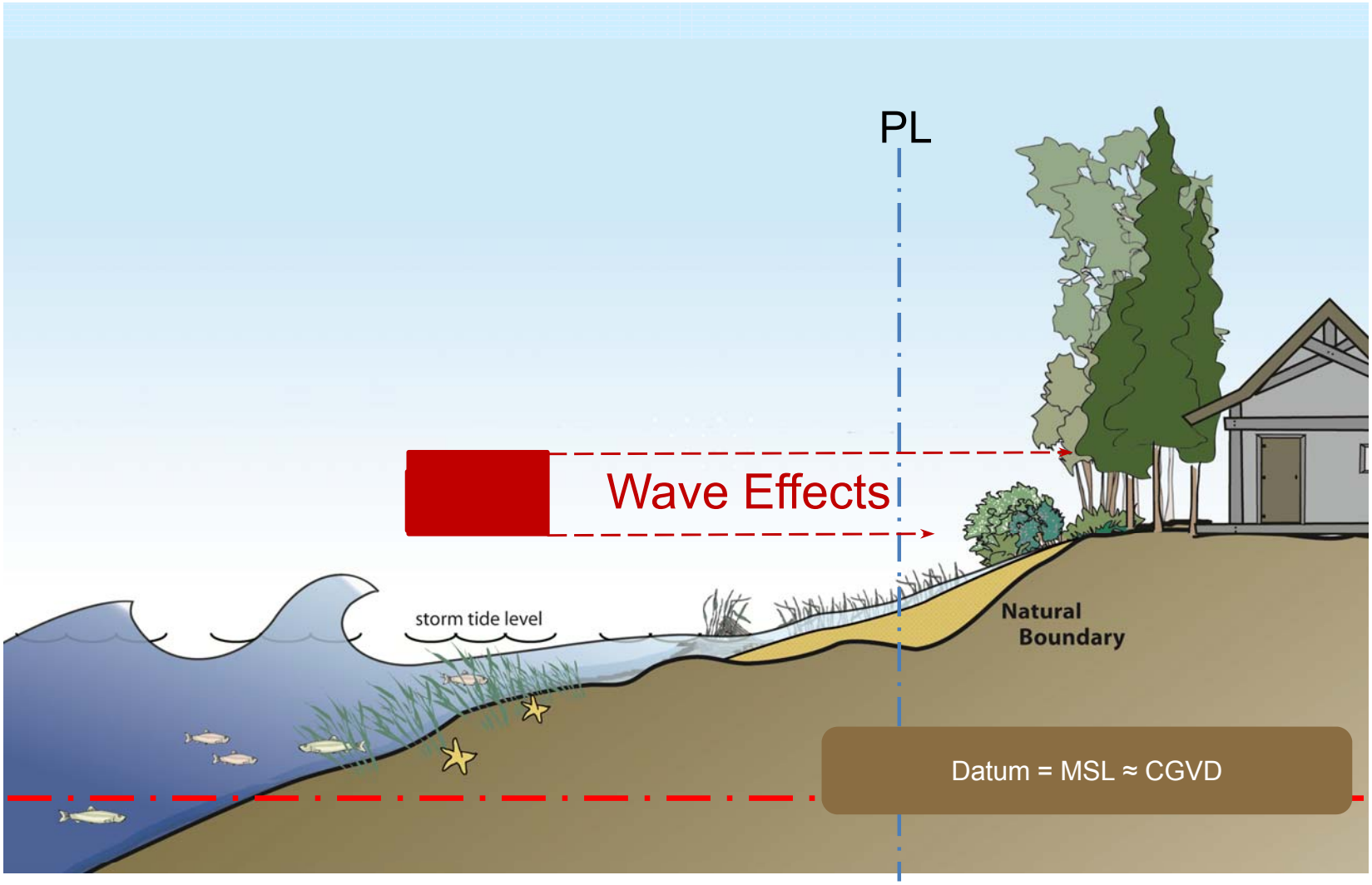


Wave Effects – What are they?



Wave Effects

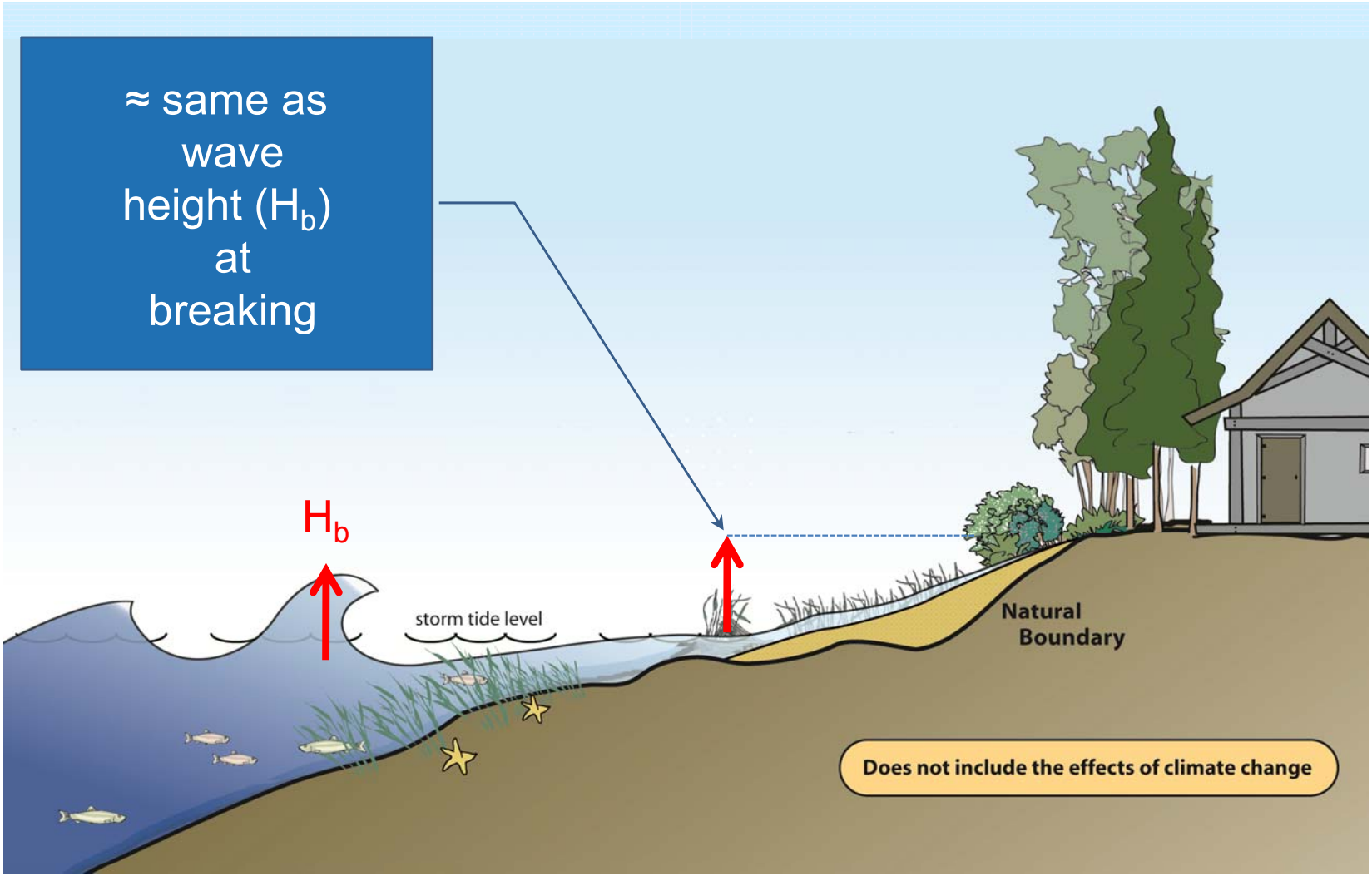
Wave Effects

Photo credit: S. Johnson

Wave Effects

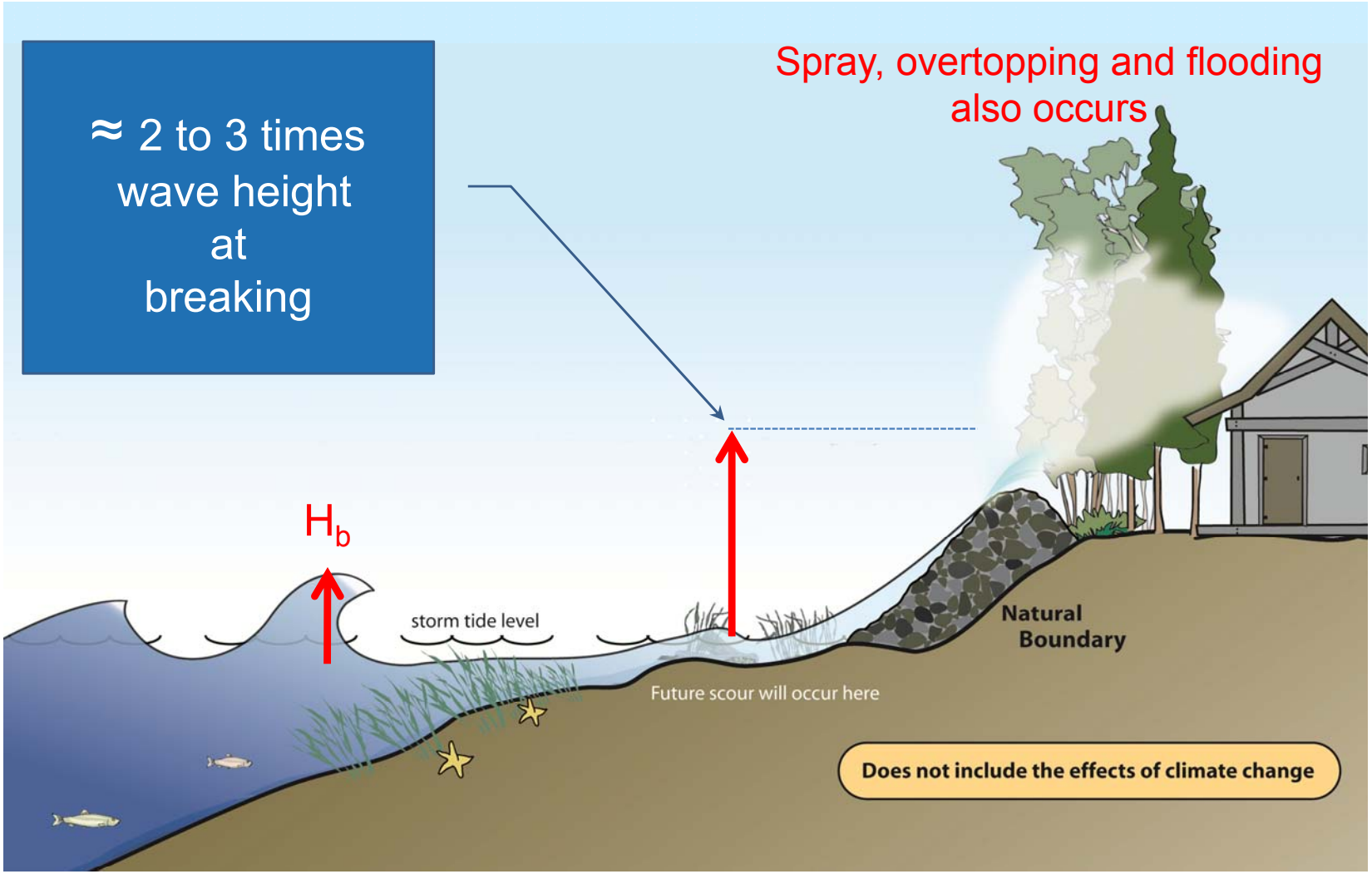
Wave Effect and Structures

Gentle Slopes - Beaches



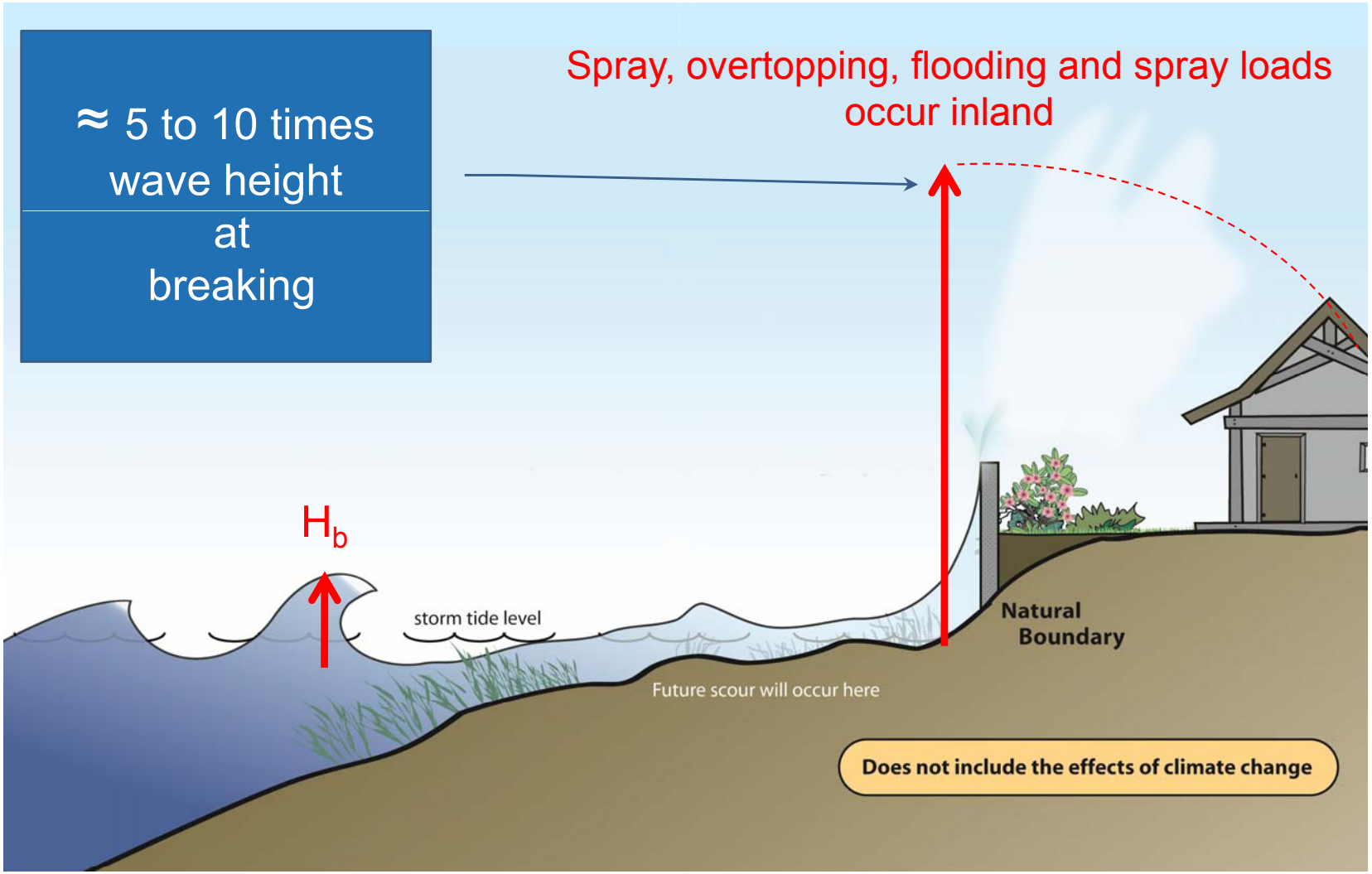
Wave Effect and Structures

Steep Slopes - Revetments



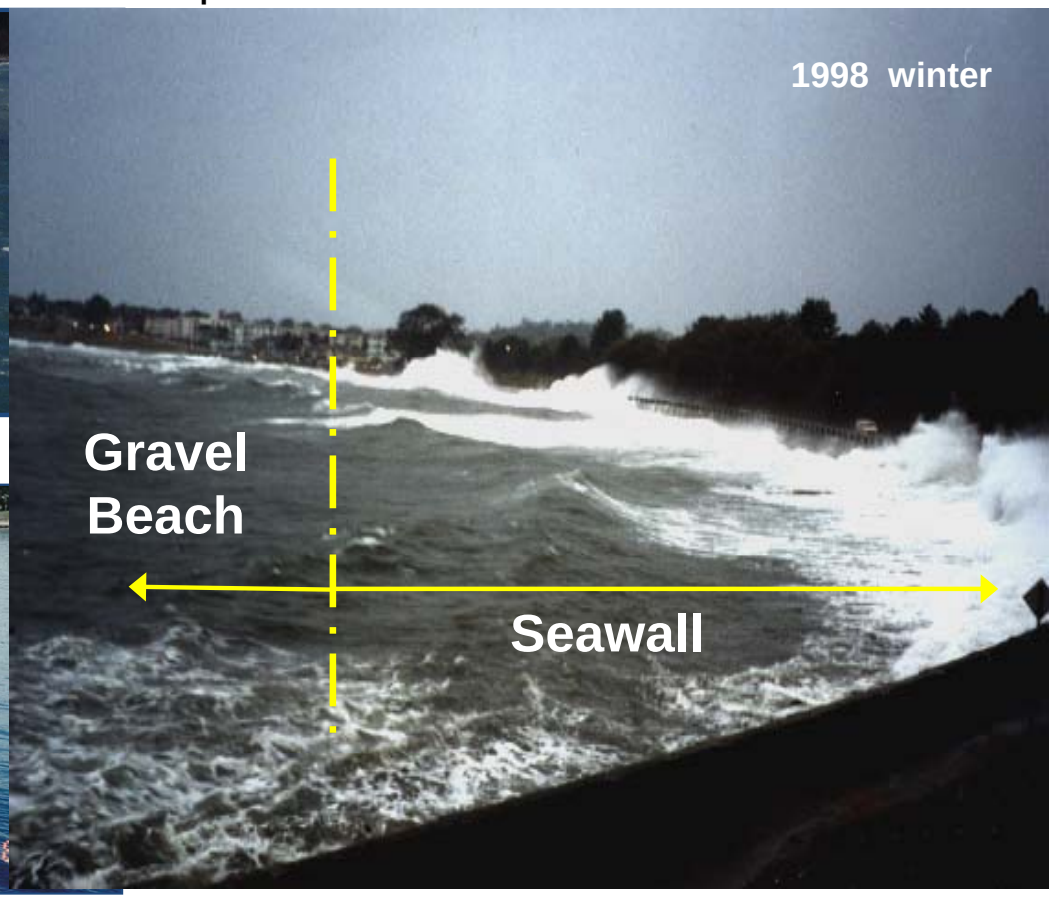
Wave Effect and Structures

Vertical Walls



Beaches Compared to Seawalls

Ross Bay
1994 – stepped seawall overlay installed
1998 – gravel beach in 2 phases



Seawalls and Wave Effects

"Seawall" in approximately 4 m water depth

Flooding at Vertical Walls

Horizontal Wave Momentum Continues

Flooding at Vertical Walls

"Seawall" in approximately 4 m water depth

Overtopping Criteria

Criteria exist for acceptable amounts of wave overtopping.

Hazard and Reason	Mean Discharge liters/m/sec	source
No damage if sea dike crest or rear slope is well protected	50-200	EA, ENW, KFKI, 2007
No damage if sea dike crest or rear slope is a grass covered clay embankment	1-10	EA, ENW, KFKI, 2007
No damage if sea dike crest or rear slope is not protected	0.1	EA, ENW, KFKI, 2007
Note: The mean discharge (q) is defined at the crest of the sea dike.		

If personnel or vehicles will be on seawall (for inspection) allowable discharges reduce by 1 to 2 orders of magnitude.

Flooding at a Rock Seawall

125 L/m/s

Sustained winds in Strait of Georgia:
40 – 45 knots
(approx “annual” expected storm peak windspeed)

Sea state (Hs) at Halibut Bank:
3.1 m
(approx “1/5 year” storm)

High tide + 0.6 to 0.8 m surge
approx “annual expected surge water level”

CONSEQUENCES:

- **Revetment was damaged in many places**
- **Flooding occurred in properties on other side of the road**
- **Roadway unsafe for pedestrians**

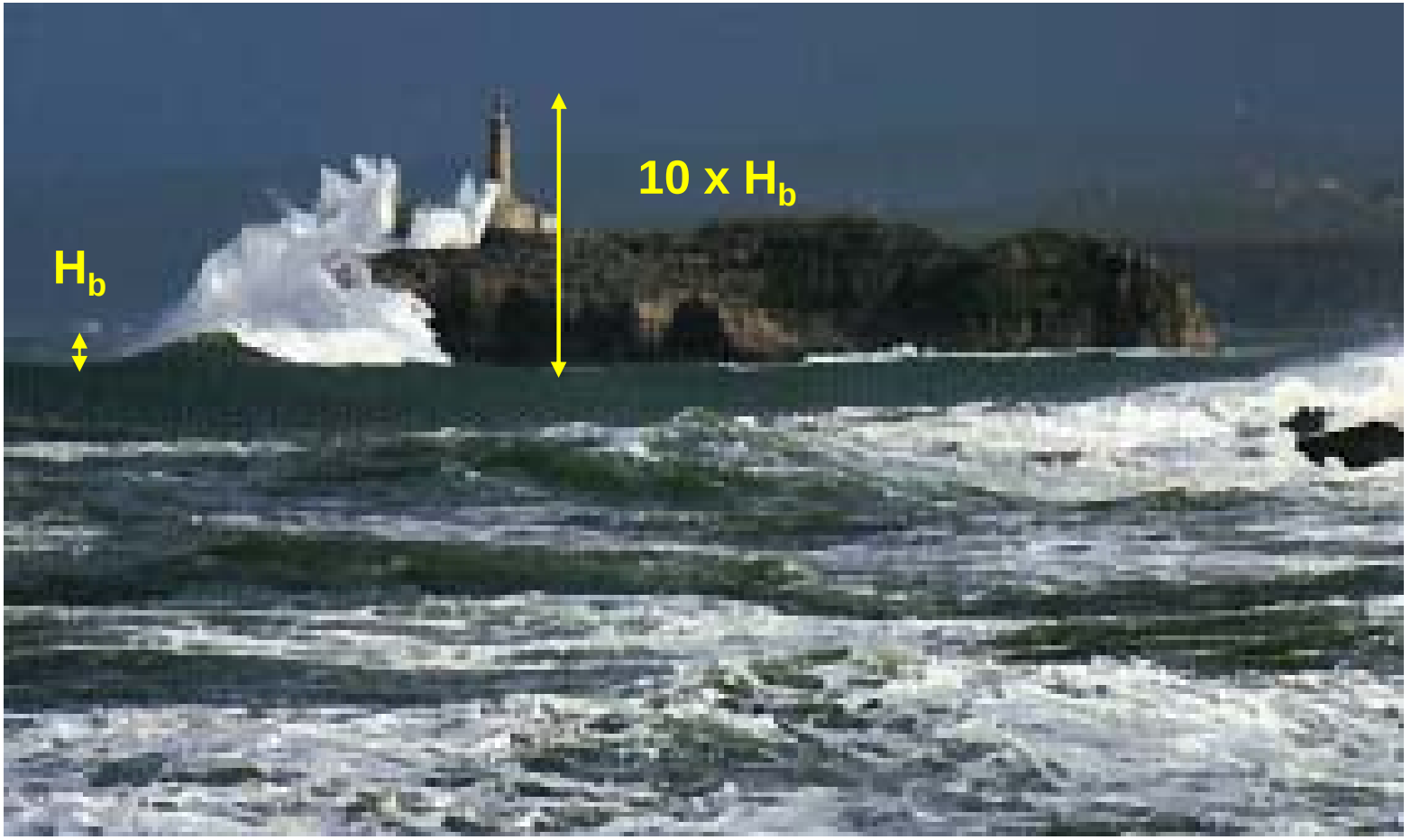
Runup on a Beach

Ross Bay Beach

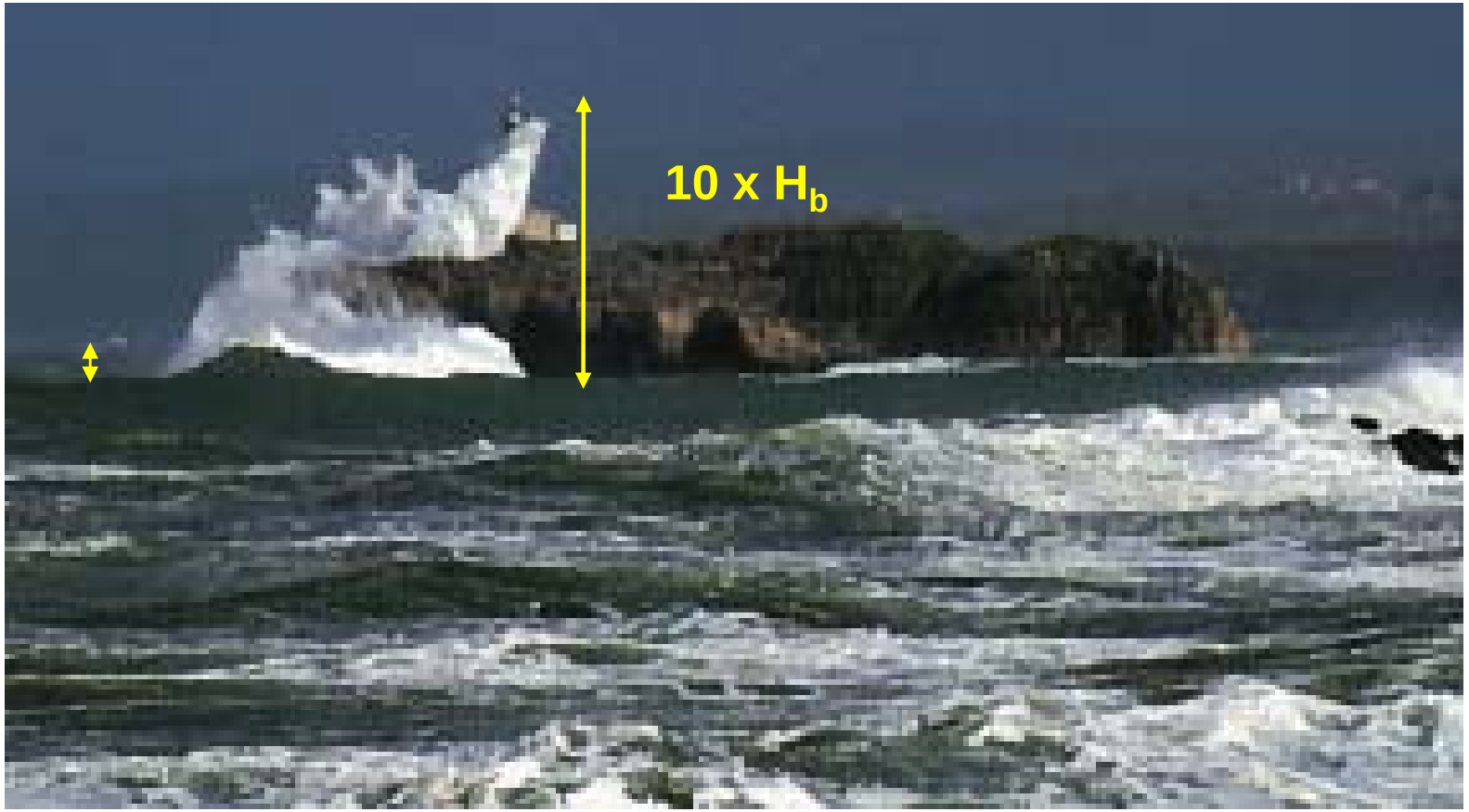
- 12 March 2012 storm 09:00 AM
- Views show maximum wave run up on beach near high tide
- Sidewalk = +3.5 m CGVD
- Approximately 1.1 m above Tide plus Surge

Spray Loads

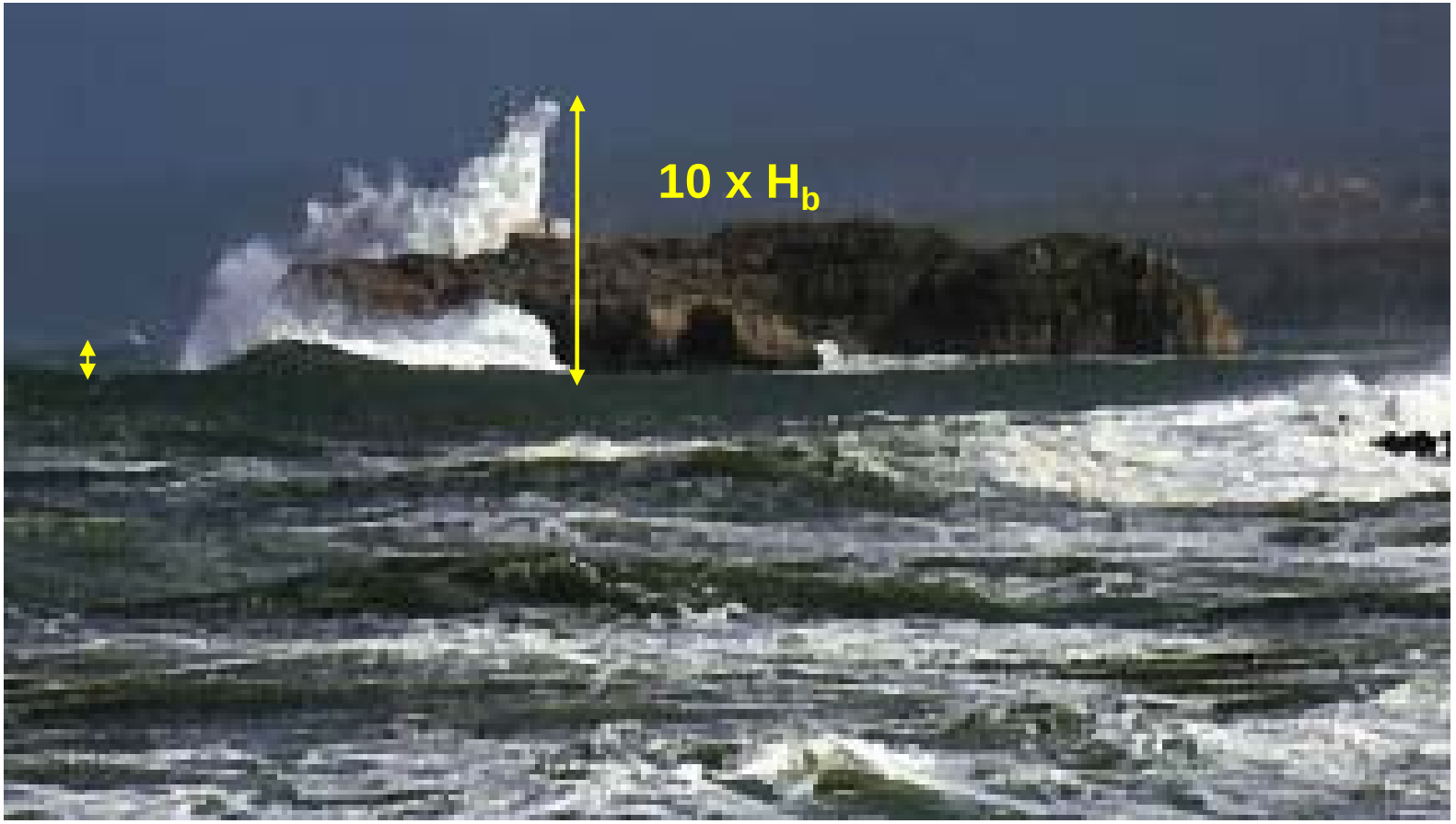
Spray Loads



Spray Loads



Spray Loads



Criteria for Structural Damage

Guideline Criteria exist to keep loadings within acceptable limits

Hazard and Reason	Mean Discharge liters/m/sec	source
No damage expected to Building structural elements on a building located behind the seawall. (q is defined at the building)	1	EA, ENW, KFKI, 2007
No damage to Equipment set back 5 – 10 m from edge of seawall crest. (q is defined at the sea dike)	0.4	EA, ENW, KFKI, 2007

Criteria for Structural Damage

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- Spray loads can be greater than usual design pressures (NBC Wind Loading Pressures)
- Very aggressive seawall returns are required to reduce loads.

Loads That Can Be Expected

NBC Wind Load on typical residential building:

0.8 KPa

Spray loads measured up to 50 m or more from seawall:

5 to 50 KPa

Loads used for design of weather deck structures on a ship:

20 to 35 KPa

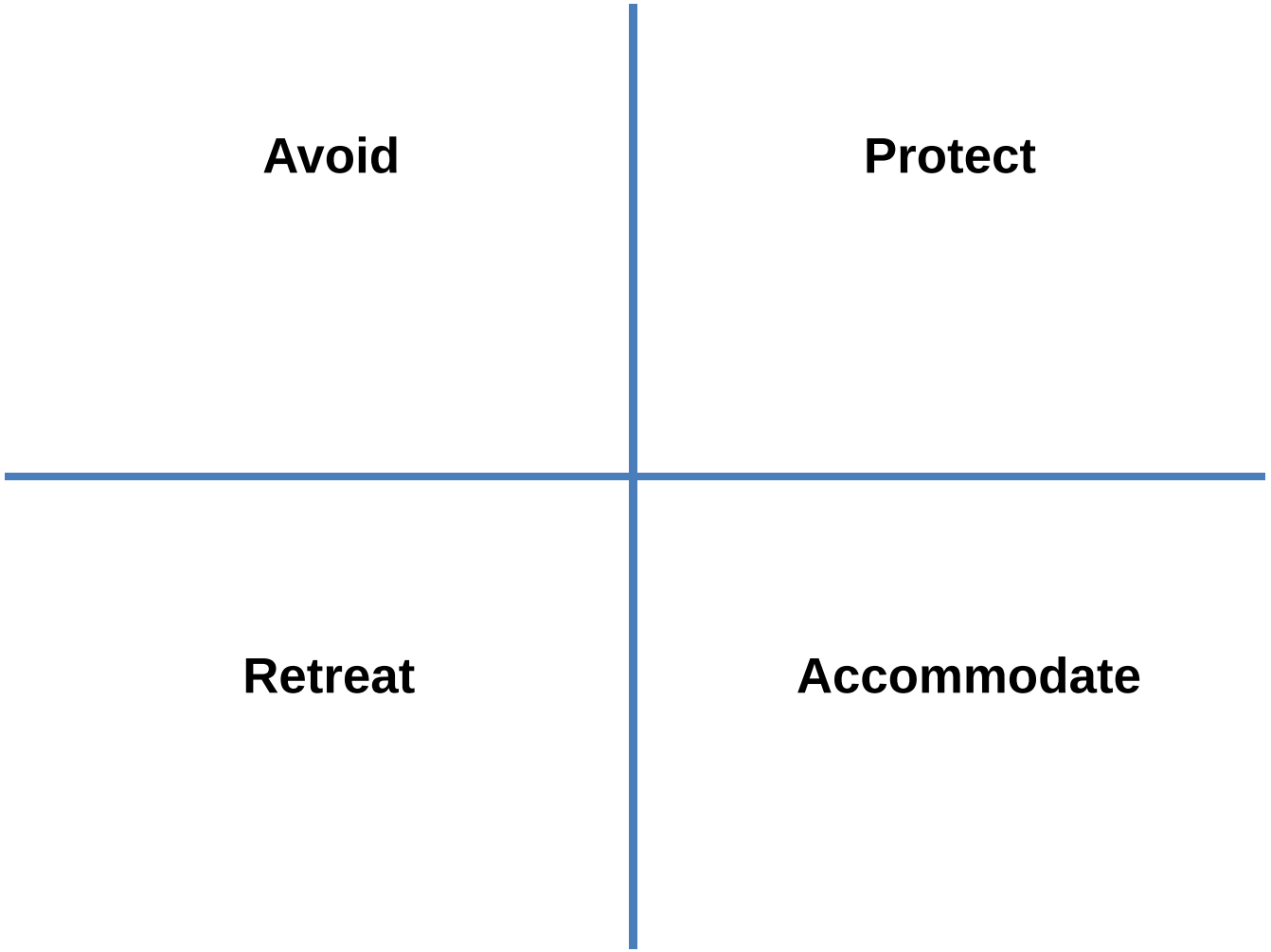
depending on Code

Loads on upper decks of ships:

5 to 10 KPa

depending on deck and Code

Options to Deal with SLR



Options to Deal with SLR

Avoid

Where?
How high?

Protect

Seawalls?
Revetments – Dikes?
Beaches?

Retreat

How far?
How high?

Accommodate

Interim protection?
Raise grades?
Flood Proof?

Issues to Consider

- How long should they last?
- How will access be provided to shoreline?
- What is the effect on the shoreline?
  - Scour
  - Loss of sediment supply to coastal processes
  - Effect on neighbouring properties
  - Effect on marine and riparian habitat
- What is an acceptable elevation?
- How can the Wave Effect Component be minimized?

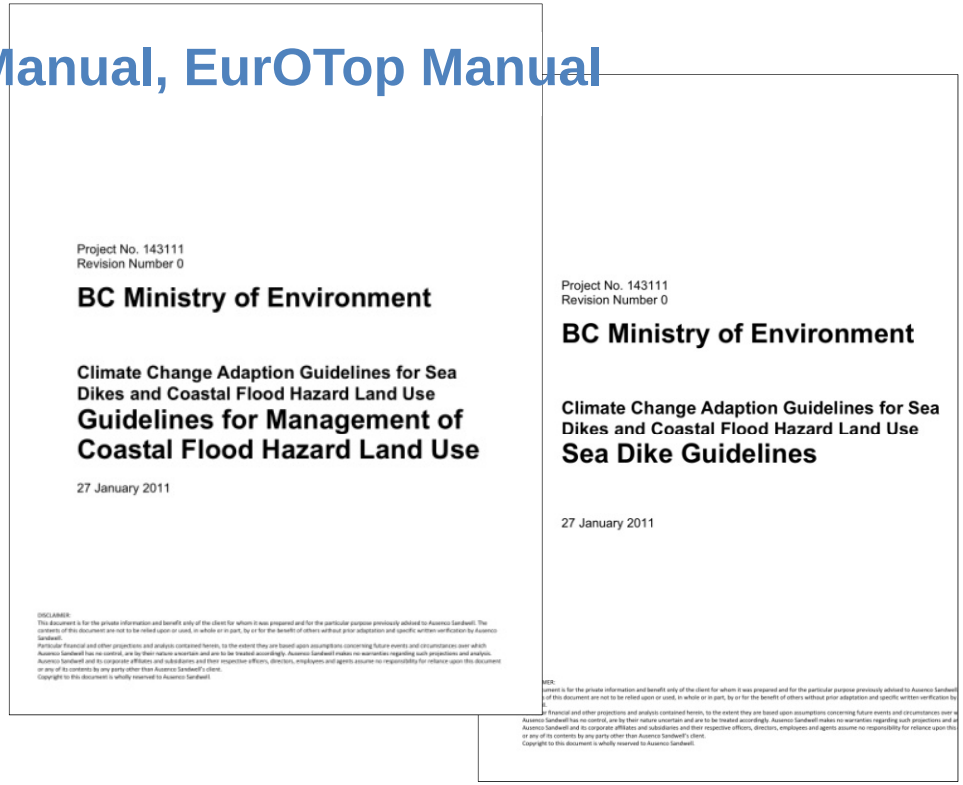
Guidelines and Standards

Engineering Standards

- ISO 21650: Actions from Waves and Currents on Coastal Structures
- British Standard (BSA 6349)
- CEM (USACE)
- EU (Codes and Guidelines), Rock Manual, EurOTop Manual

Stewardship Guidelines

- BCSC Coastal Stewardship Manual
- Green Shores ™
- Sea Grant Program USA: Wisconsin and Alaska
- WA State Department of Ecology
- Green Shores for Homes



What Can the Property Owner Do?

Observations, Observations, Documentation

- **Establish a known elevation reference on your property – make it visible**
- **Take repetitive photographs and video of wave interaction and beach changes**
  - Seasonal
  - High tides
  - Storm conditions – try to capture the angle of approach of waves in particular under many conditions
- **Document changes to the character (type of sediment, extent of coverage, changes in both) of beaches and toe of cliffs**
- **Review and consider upland alternatives:**
  - Divert or control surface water runoff
  - Maintain vegetative cover over shoreline area
  - Can access to shoreline for small equipment be improved?
  - Are there options to move back or up?
  - Talk with neighbours

Is This Safe?

Are There Better Solutions?

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Thank you.

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WE CARE
NOUS VEILLONS

WE CARE embodies SNC-Lavalin's key corporate values and beliefs. It is the cornerstone of everything we do as a company. **Health and safety, employees,** the **environment, communities and quality:** these values all influence the decisions we make every day. And importantly, they guide us in how we serve our clients and therefore affect how we are perceived by our external partners. **WE CARE** is integral to the way we perform on a daily basis. It is both a responsibility and a source of satisfaction and pride by providing such important standards to all we do.

WE CARE about the health and safety of our employees, of those who work under our care, and of the people our projects serve.

WE CARE about our employees, their personal growth, career development and general well-being.

WE CARE about the communities where we live and work and their sustainable development, and we commit to fulfilling our responsibilities as a global citizen.

WE CARE about the environment and about conducting our business in an environmentally responsible manner.

WE CARE about the quality of our work.