Natural & Nature-Based Features (NNBF) and Flood Risk Reduction – Canadian Perspectives

Natural & Nature-Based Features Symposium – University of California, Santa Cruz

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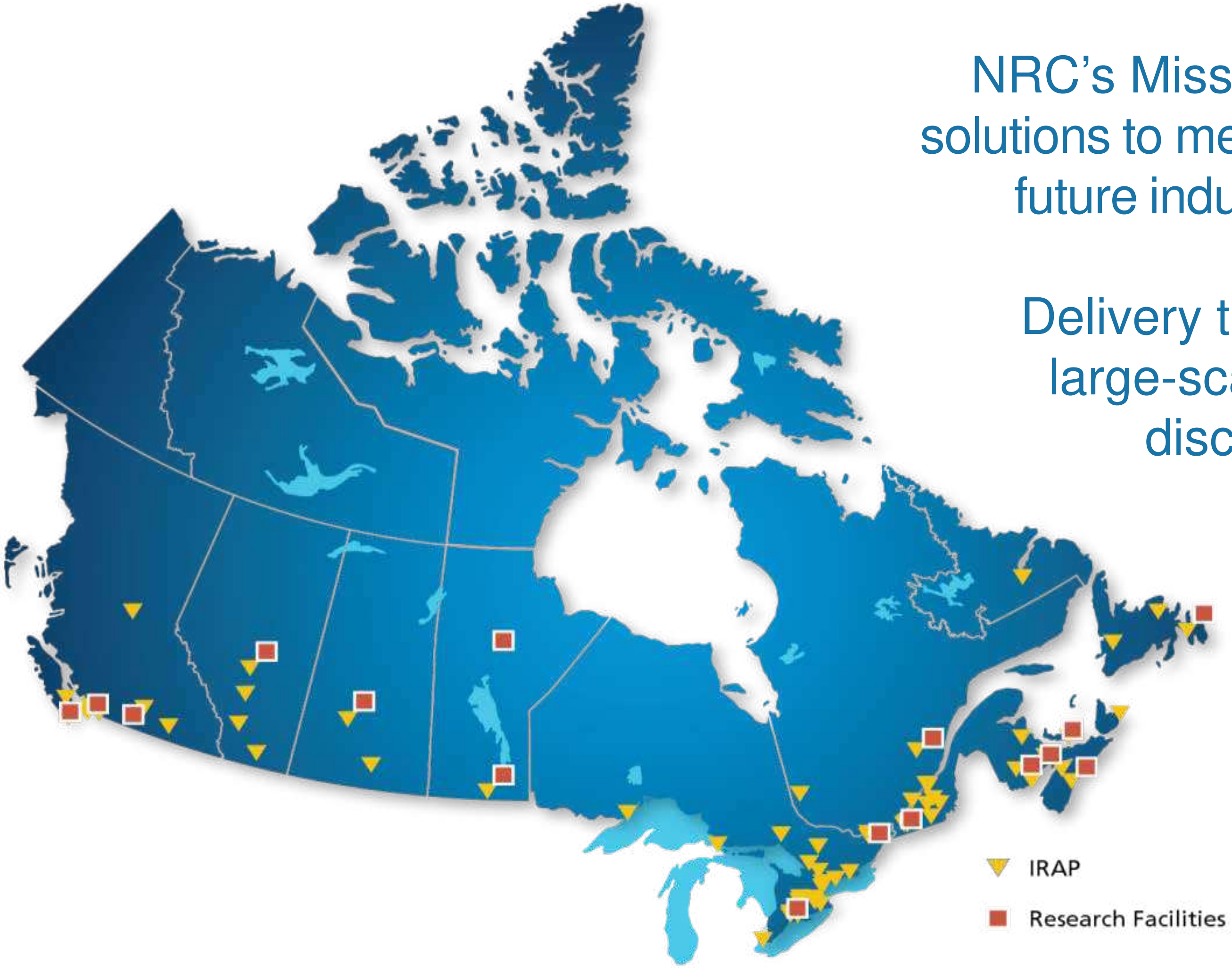
National Research Council Canada



NRC's Mission: Develop and deploy solutions to meet Canada's current and future industrial and societal needs

Delivery through a set of focused large-scale, collaborative, multi-disciplinary R&D programs.

100-year history
of science and innovation for Canada

$1B
Total expenditures in 2016/17

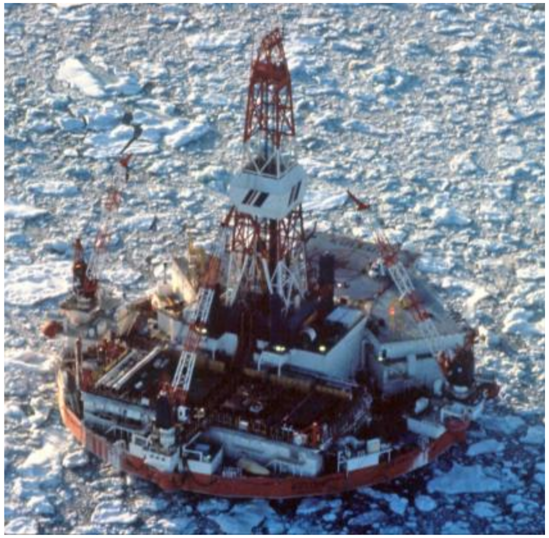
3,700
employees

Ocean, Coastal & River Engineering Research Centre

- 100 people in 2 locations – Ottawa and St. John's
- 3 Research Programs
- Coastal engineers, water resources scientists, ice mechanics specialists, software engineers

Marine Vehicles

Arctic



Marine Infrastructure, Energy & Water Resources (MIEWR)

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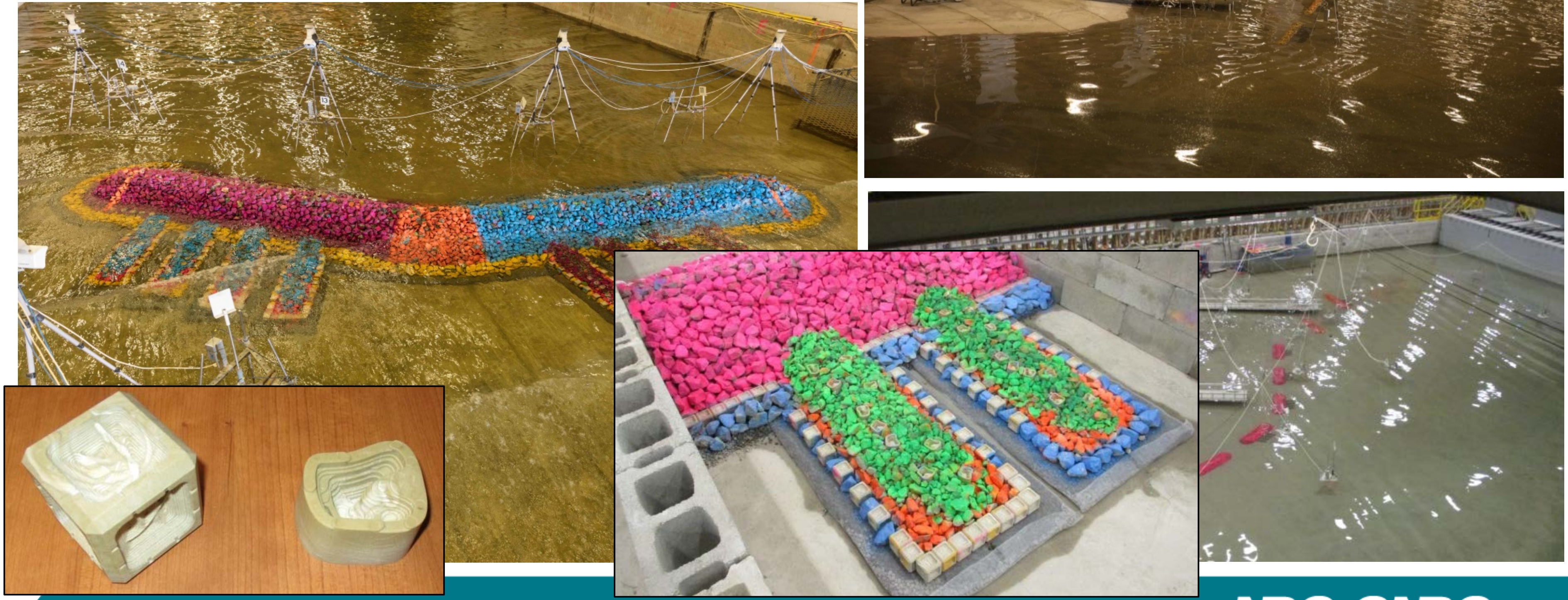
NRC-OCRE Research Facilities – Ottawa

- 50m x 30m Large Area Basin
- 36m x 30m Multidirectional Wave Basin
- 64m x 14m Coastal Wave Basin
- 93m x 2m Large Wave Flume
- 21m x 7m Ice Tank
- 63m x 1.4m Steel Wave Flume



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Historical Context – Flood Risk Management in Canada

1976 – Flood Damage Reduction Program (FDRP)

1996 – FDRP terminated

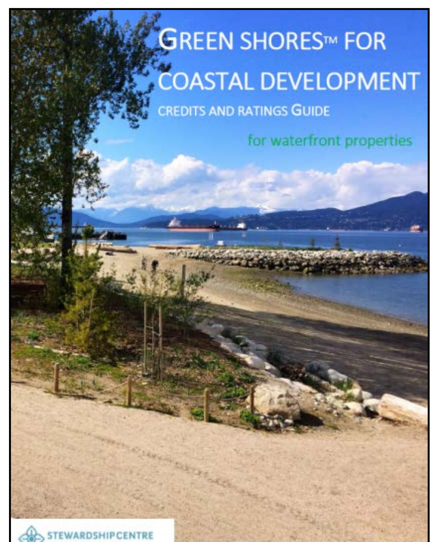
2015 – National Disaster Mitigation Program (NDMP)

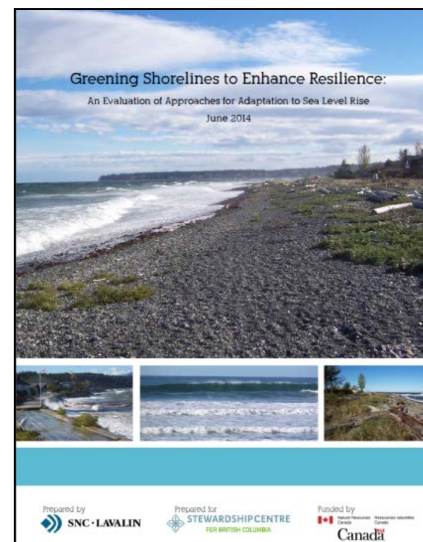
2016 – Climate-Resilient Buildings & Core Public Infrastructure Initiative

NNBF in Canada

There is history and experience with the use of NNBF in Canada:

- 1974 – cobble beach nourishment scheme implemented at UBC campus in Vancouver
- Many regional initiatives linked to NNBF, e.g.:
  - Making Room for Wetlands, St. Mary's University, Nova Scotia
  - Maritime Natural Infrastructure Collaborative, New Brunswick
  - Greening Shorelines to Enhance Resilience, British Columbia
- 2018 Coastal Zone Canada conference – Cold Regions Living Shorelines Community of Practice being established





NNBF in Canada

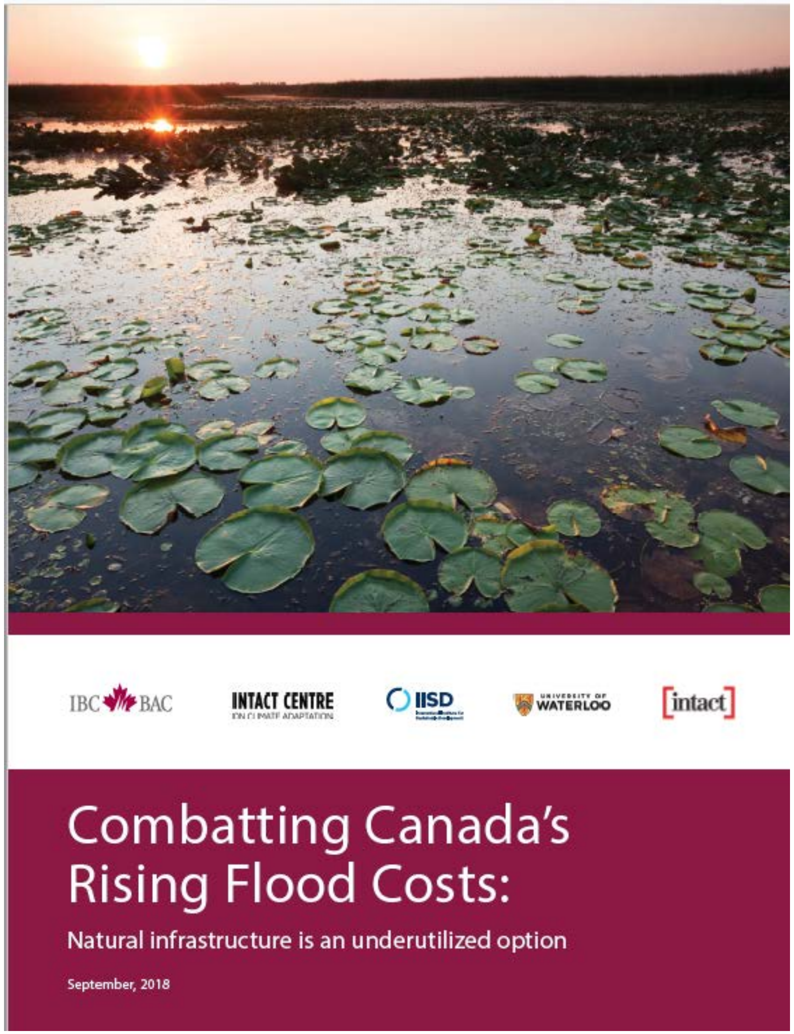


Figure 1:
Framework for Natural Infrastructure Project Implementation

- Total economic value (TEV) methodology to illuminate broader range of benefits offered by natural infrastructure solutions to flood risk management

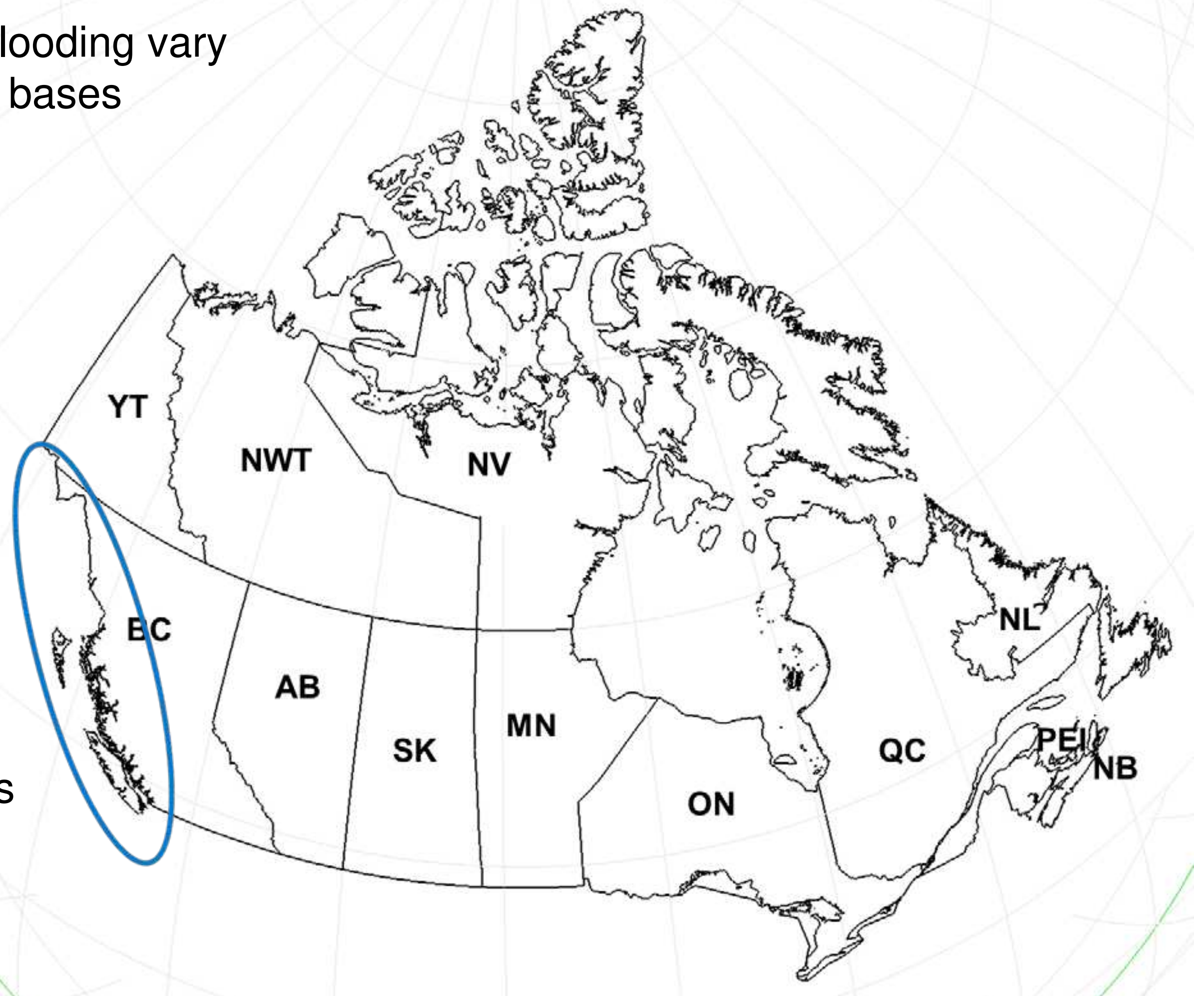
Challenges for NNBF in Canada

- Regional variability (e.g. metocean, climate, urbanization)
- Need for authoritative technical guidance – many municipalities and provinces lack resources and technical expertise
- Need more demonstration projects and experimentation (and funding to support)
- Regulatory challenges (e.g. habitat trade-offs for projects involving fill below waterline)
- Need for more cross-disciplinary engagement
- Need for strategic shoreline management planning framework

Pacific Coast Flood Hazards

- Dominant sources of coastal flooding vary regionally and on site-specific bases

- 2016 – Widespread coastal flooding in Delta, Richmond and White Rock (160,000 homes without power, 1 fatality)
- 2012 – Haida Gwaii tsunami
- 2009 – Flooding on Vancouver Island due to heavy rain and high tides
- 2006 – Storm surges, high tides and waves breach dykes at Delta



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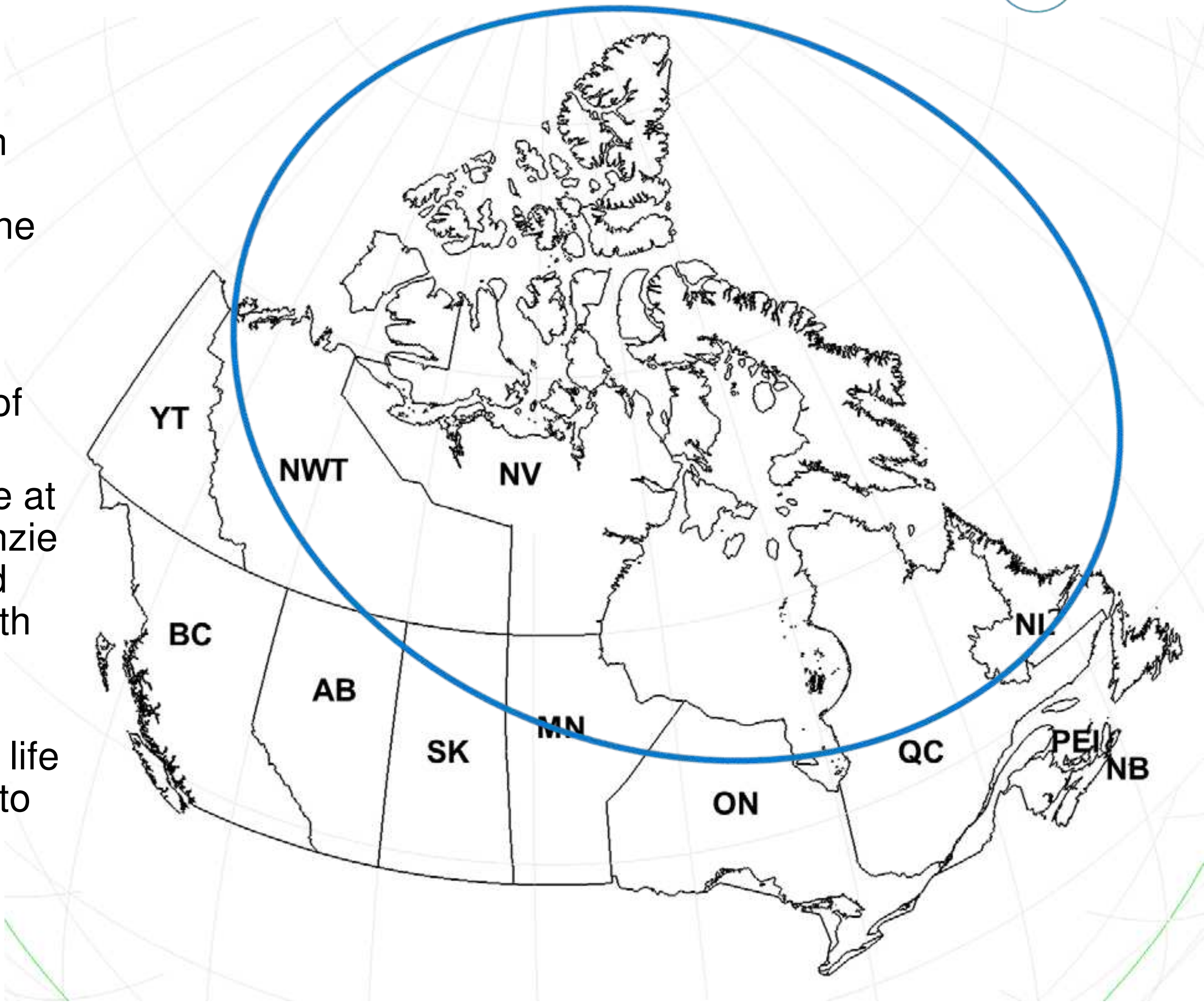
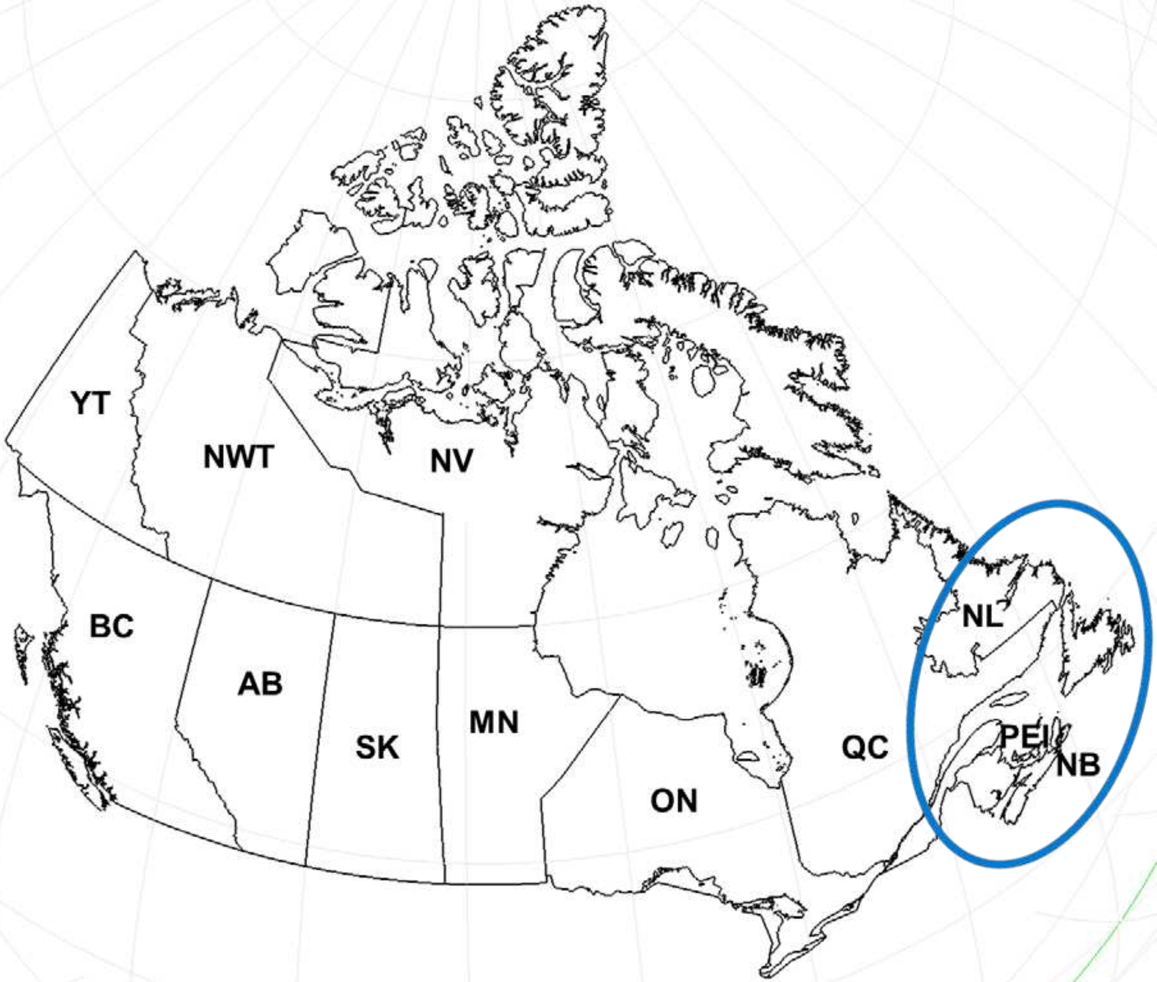
North Coast Flood Hazards

- 2016 – Storm surge and high tides cause flooding and erosion in northern parts of the Northwest Territories
- 1999 – Storm surge in MacKenzie Delta resulting in damage to 30,000 hectares of sensitive ecosystem
- 1993 – Flooding and damage at Tuktoyaktuk and the MacKenzie Delta due to storm surge and extreme waves coinciding with extensive open water
- 1970 – Extensive flooding, property damage and loss of life at Tuktoyaktuk reported due to storm surge event



East Coast Flood Hazards

- 2016 – Hurricane Matthew ($30 million costs)
- 2011 – Tropical Storm Irene ($165 million, 2 fatalities)
- 2010 – Hurricane Igor ($94 million, 1 fatality)
- 2003 – Hurricane Juan ($32 million, 8 fatalities)
- 2000 – Storm surge event ($300,000, 460 properties flooded including power plant)
- 1991 – Hurricane Bob ($11 million, 2 fatalities)
- 1983 – Flooding along the Gaspésie and Gulf of St. Lawrence shores ($119 million)
- 1976 – Groundhog Day storm in the Bay of Fundy ($33 million)

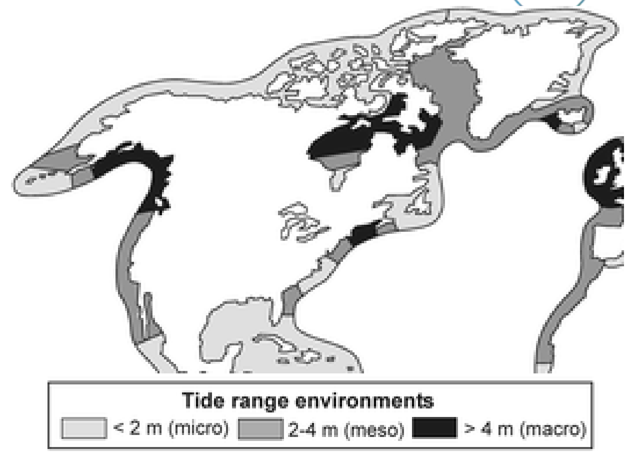


Great Lakes Flood Hazards

- 2017 – Coastal flooding as a result of elevated water levels in Lake Ontario
- 1985 – Multiple storms on Lake Erie and Lake Huron (properties destroyed, access roads washed out, beaches eroded and dikes breached)
- 1973 – Heavy damage due to storms on the southern coast of Lake Huron

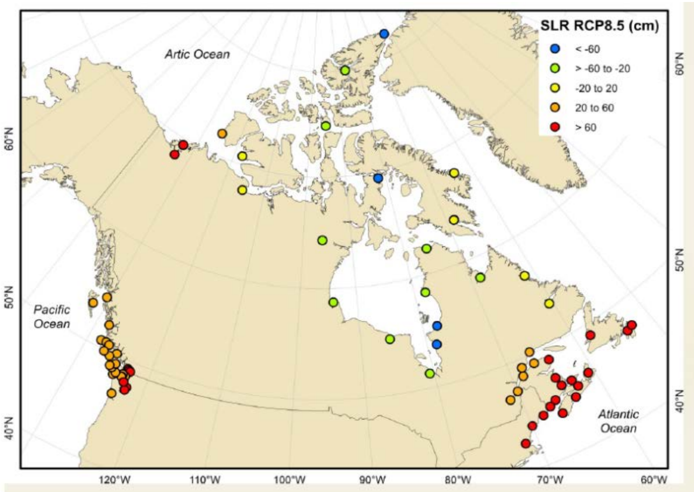
Regional Variability

- Tidal range
- Exposure to storm surges and waves
- Urban areas / remote communities
- Climate change and climate variability
- Lake / sea ice cover
- Debris (wrack, logs, ice)
- Permafrost
- Geology and coastal geomorphology
- Relative sea level rise (or fall!)
- Adaptive management of water levels in Great Lakes
- Historical approaches to coastal engineering and FRM
- Provincial / territorial and municipal standards and regulations



Appelquist & Halsnaes (2015)

https://www.giss.nasa.gov/research/news/20011105/



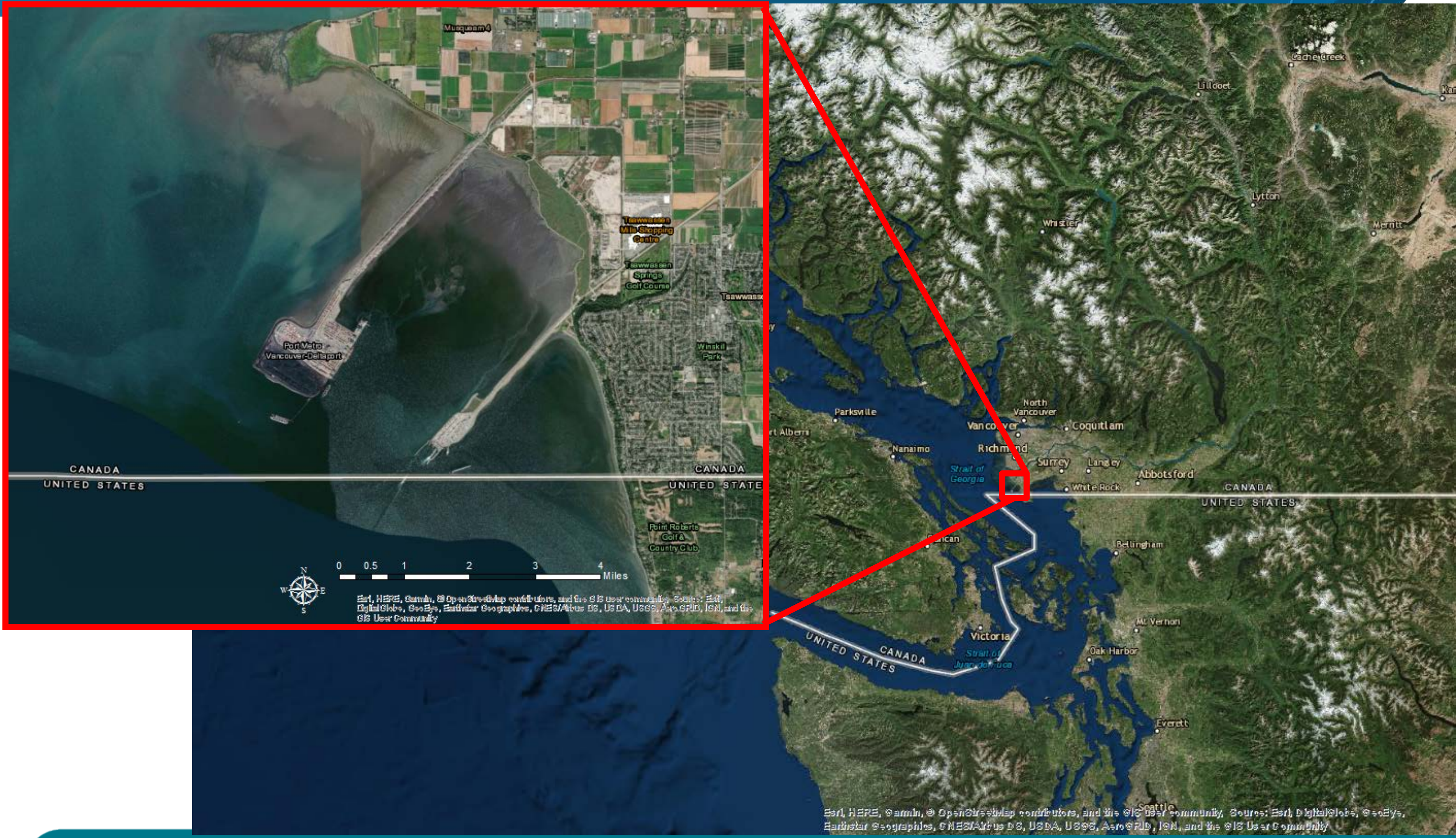
James et al. (2014)

Case Studies

Three case studies illustrating some challenges, variability and need for local/regional context:

- Deltaport Barrier Beaches and Salt Marshes, British Columbia (Pacific Region)
- Lakeview Waterfront Connection, Ontario (Great Lakes / St. Lawrence Region)
- Souris Intertidal Reefs, Prince Edward Island (Atlantic Region)

Deltaport Causeway, B.C.



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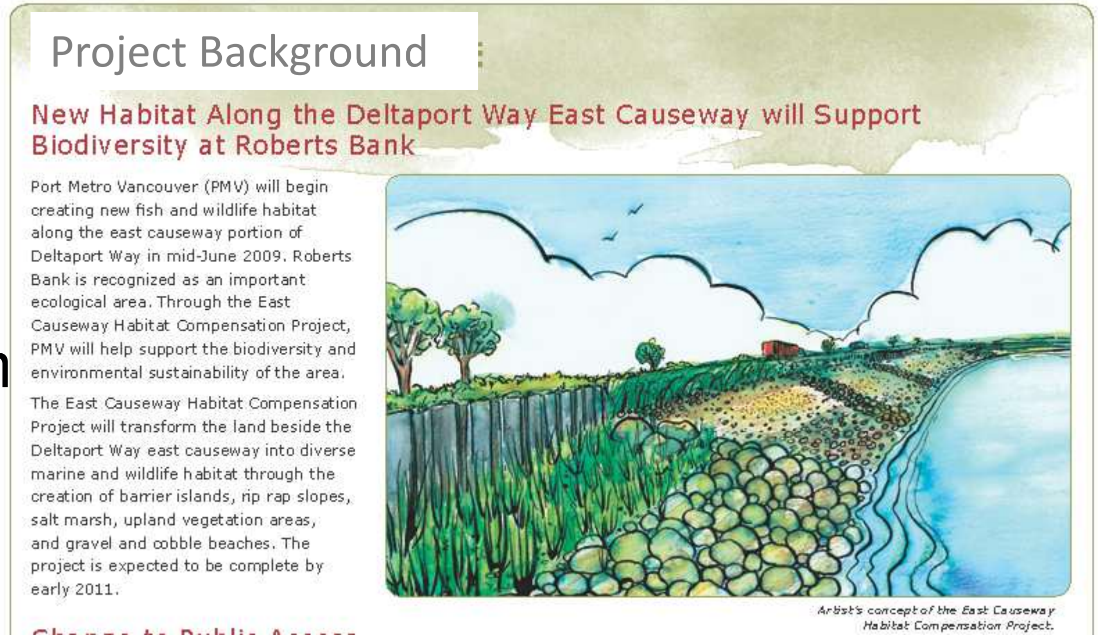
Deltaport – Project Background



Project Background

New Habitat Along the Deltaport Way East Causeway will Support Biodiversity at Roberts Bank

Port Metro Vancouver (PMV) will begin creating new fish and wildlife habitat along the east causeway portion of Deltaport Way in mid-June 2009. Roberts Bank is recognized as an important ecological area. Through the East Causeway Habitat Compensation Project, PMV will help support the biodiversity and environmental sustainability of the area.

The East Causeway Habitat Compensation Project will transform the land beside the Deltaport Way east causeway into diverse marine and wildlife habitat through the creation of barrier islands, rip rap slopes, salt marsh, upland vegetation areas, and gravel and cobble beaches. The project is expected to be complete by early 2011.

Artist's concept of the East Causeway Habitat Compensation Project.

- Tidal range = 3.0 to 4.5 m
- Storm surge ~ 1 m
- Design Hs ~ 1.2 m

Deltaport – Project Background

Deltaport – Design Concept

- Local, natural analogs
- Crenulate barrier beaches
- Backbeach salt marsh
- Work with natural processes and within site constraints

Deltaport – Results and Lessons Learned

- Wrack and large woody debris management
- Vegetation – waves generated along short fetches just as critical during initial period of establishment
- Needs for adaptive management and field experimentation

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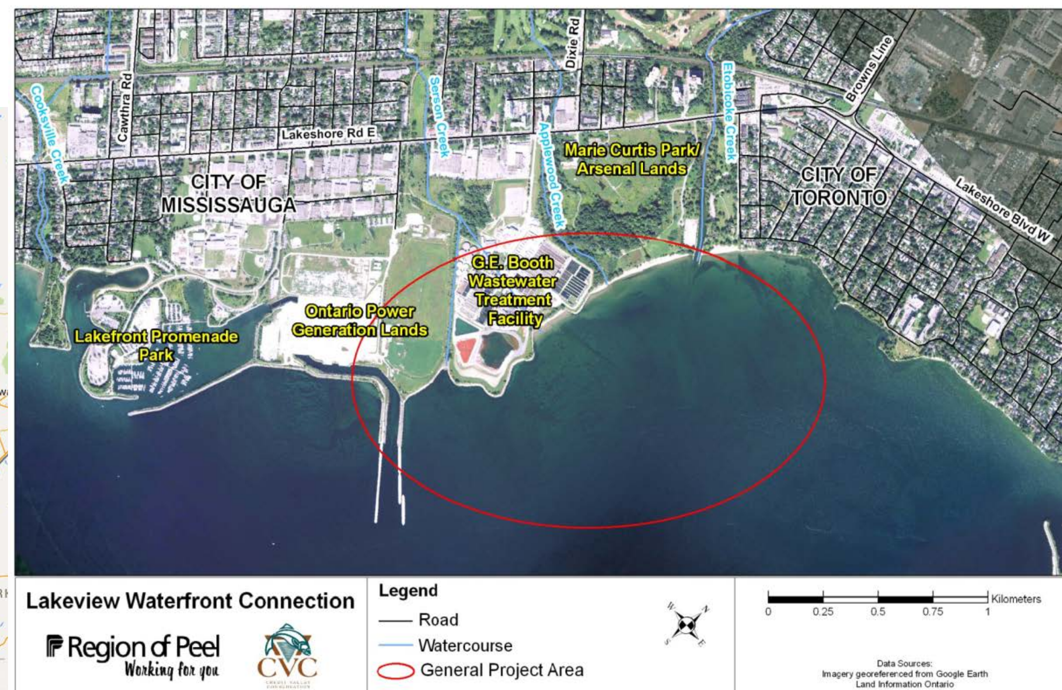
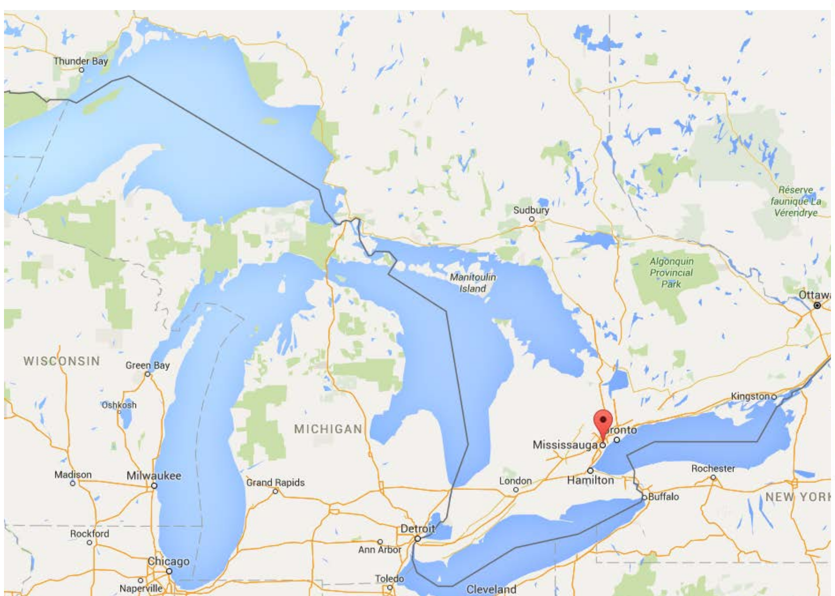
Lake Ontario – Lakeview Waterfront

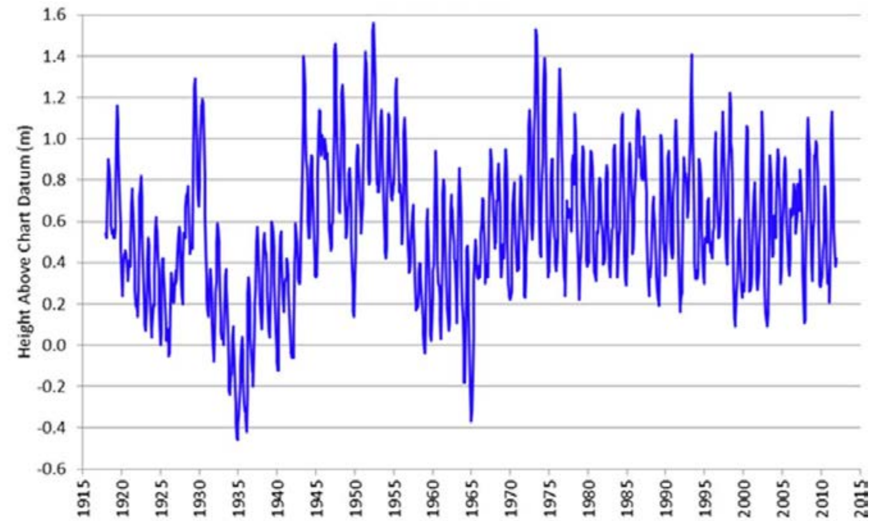
- Shoreline rehabilitation and flood protection
- Restore habitat and improve public linkages
- Use of clean fill from regional infrastructure projects

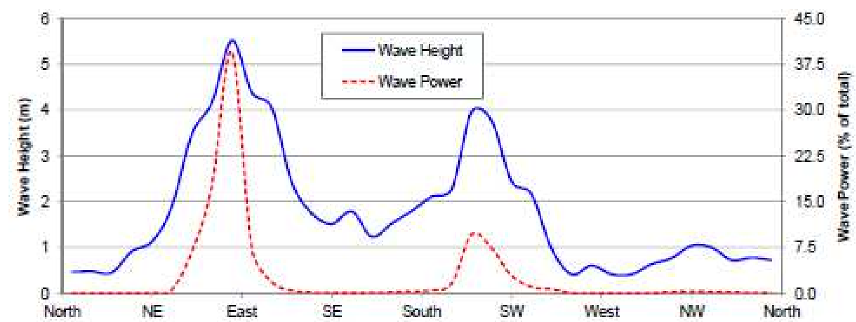




Lakeview Waterfront - Concept

- Cobble beaches and habitat features with stabilizing control structures, coastal wetlands

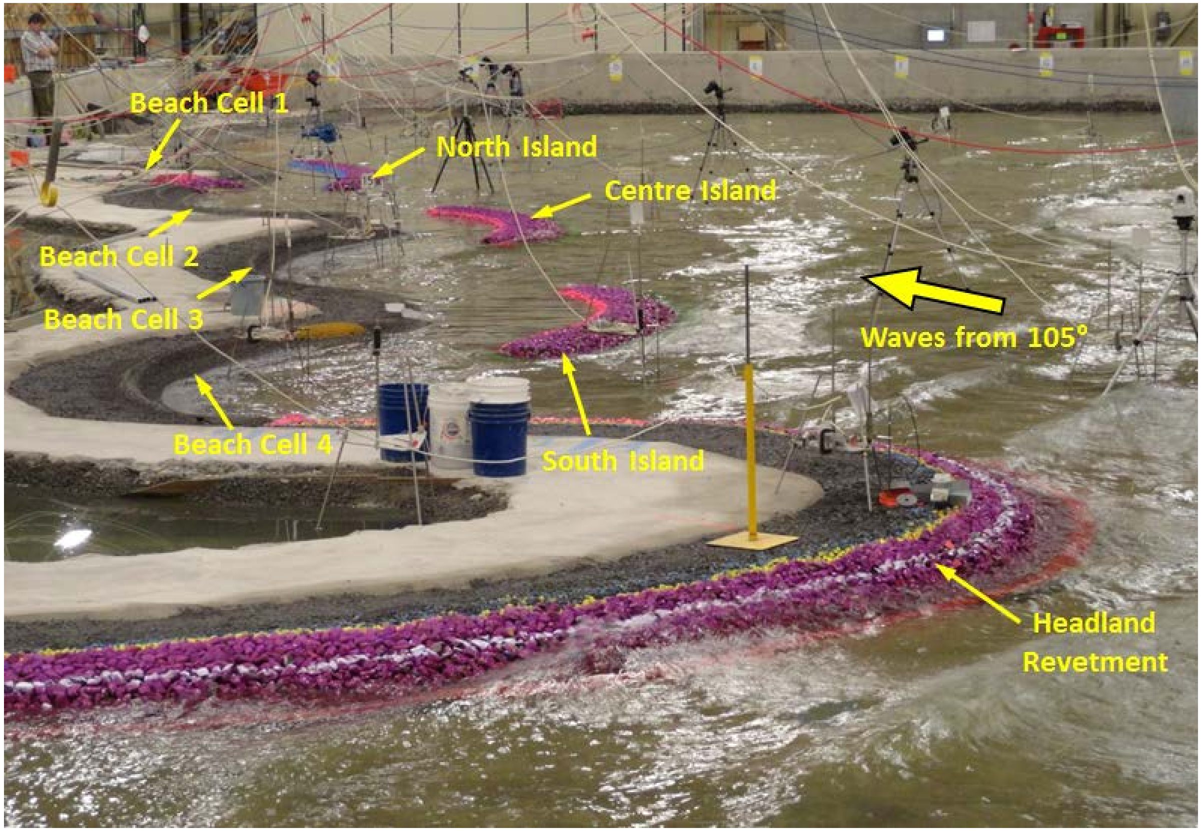




SENES Consultants (2014)

Lakeview Waterfront – Physical Modelling

- 1:35 physical scale model
- NRC's 50m x 30m Large Area Basin in Ottawa



Lakeview Waterfront – Physical Modelling

- Tested range of storm wave conditions (moderate to extreme)
- Observed stability of beaches and control structures
- Reduce design uncertainty and risk

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Lakeview Waterfront - Observations

- Verification of beach material size distribution
- Steep berm formation in exposed areas

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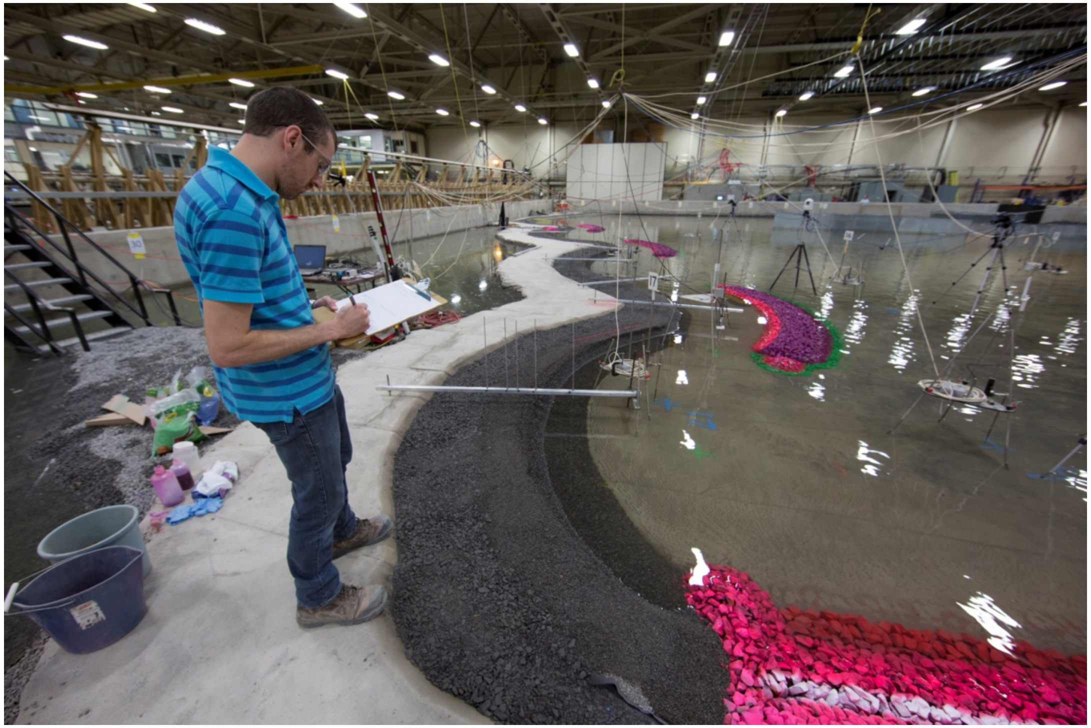
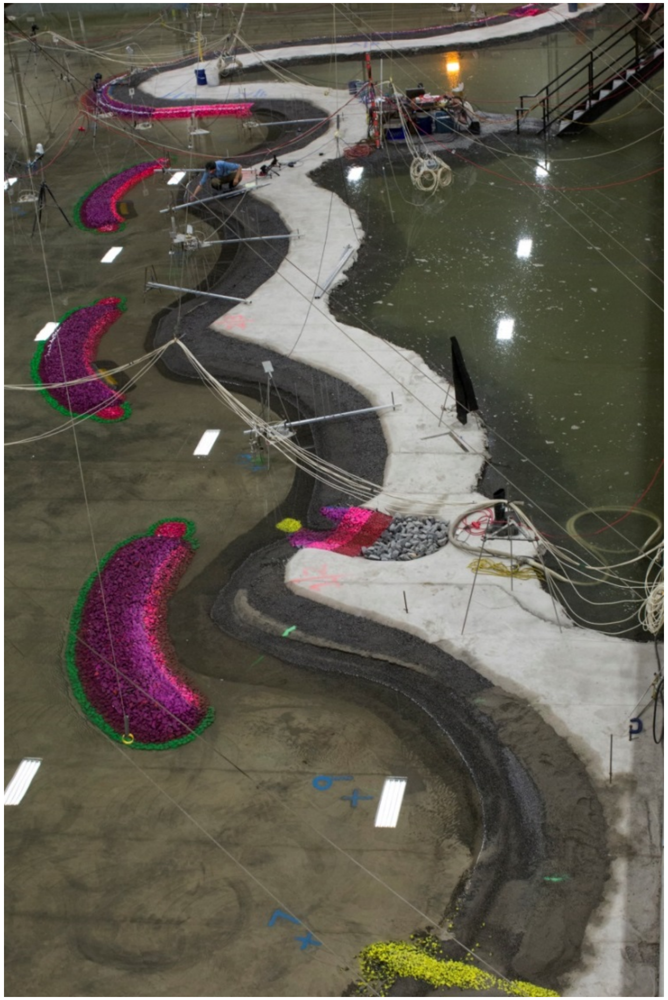
Lakeview Waterfront - Observations

- Identification of areas prone to scour and erosion

Lakeview Waterfront – Benefits

- Estimated project cost savings of $3 million compared to EA costing (more than 10x modelling costs)
- Identification of potentially problematic aspects to be addressed through final design
- Cost savings + design optimization = reduced project risk





Prince Edward Island

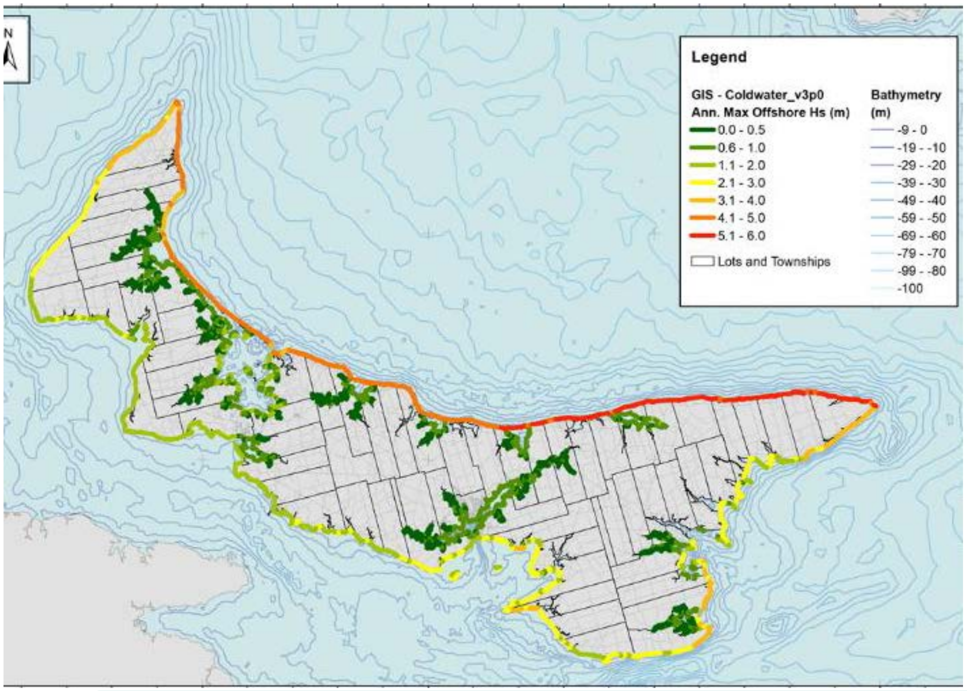
Prince Edward Island

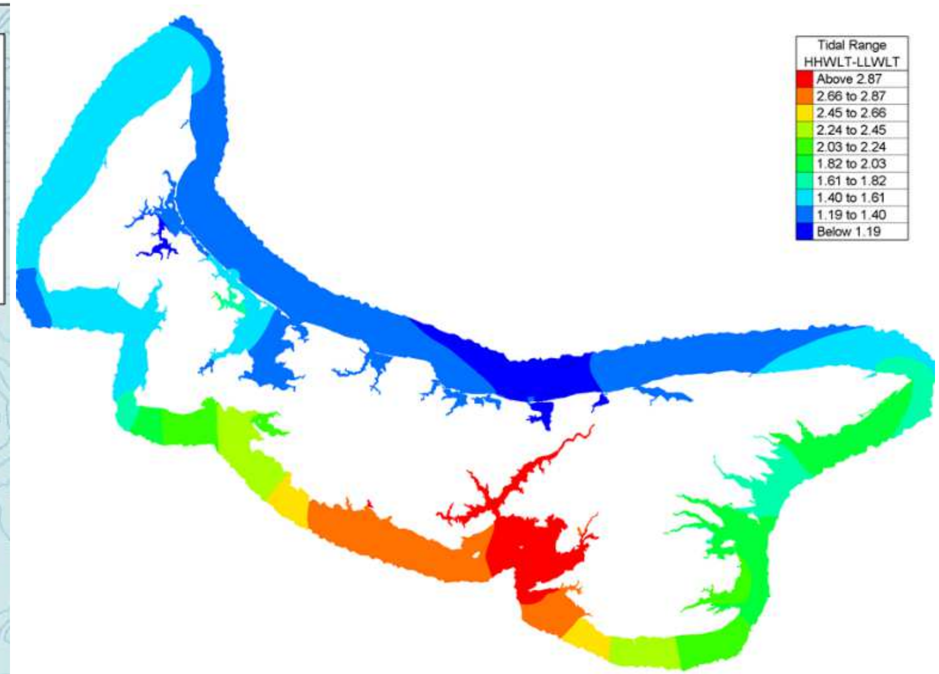
North Shore

- Hs up to 5 m
- Tidal range < 1 m
- Waves and surge aligned

South Shore

- Hs ~ 1 m
- Tidal range > 2 m
- Tide-surge interaction
- Offshore waves during surge events





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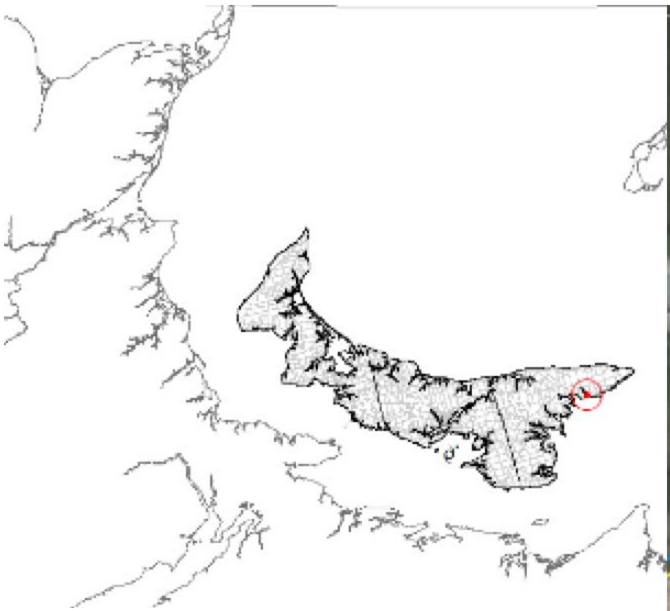
Trans-Canada Highway at Souris

- Increasing risks of coastal flooding due to sea level rise and dynamic shoreline



Souris Demonstration Project

- Inter-tidal reefs (island sandstone)
- Stabilize the beach and dune area to provide flood protection to highway
- Wave attenuation
- Small tidal pools
- Oversized rock to account for ice loads and effects

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Souris – Monitoring

- Mid-tide

- Low tide

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Summary & Conclusion

- NNBF increasingly recognized as part of the FRM toolbox in Canada
- Still some challenges to be overcome

Reduce / mitigate project risks by:

- Implementing projects as part of strategic shoreline management plan
- Considering site specific constraints and processes – seek out natural analogs
- Appropriate level of analysis (guidelines?) - better use of available tools and technologies (e.g. numerical and physical models)
- Demonstration projects, field experimentation
- Monitoring and adaptive management

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Thank you

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