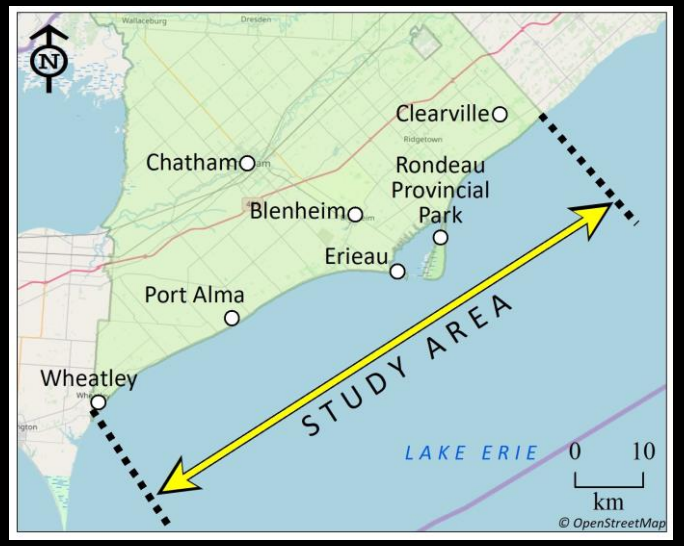

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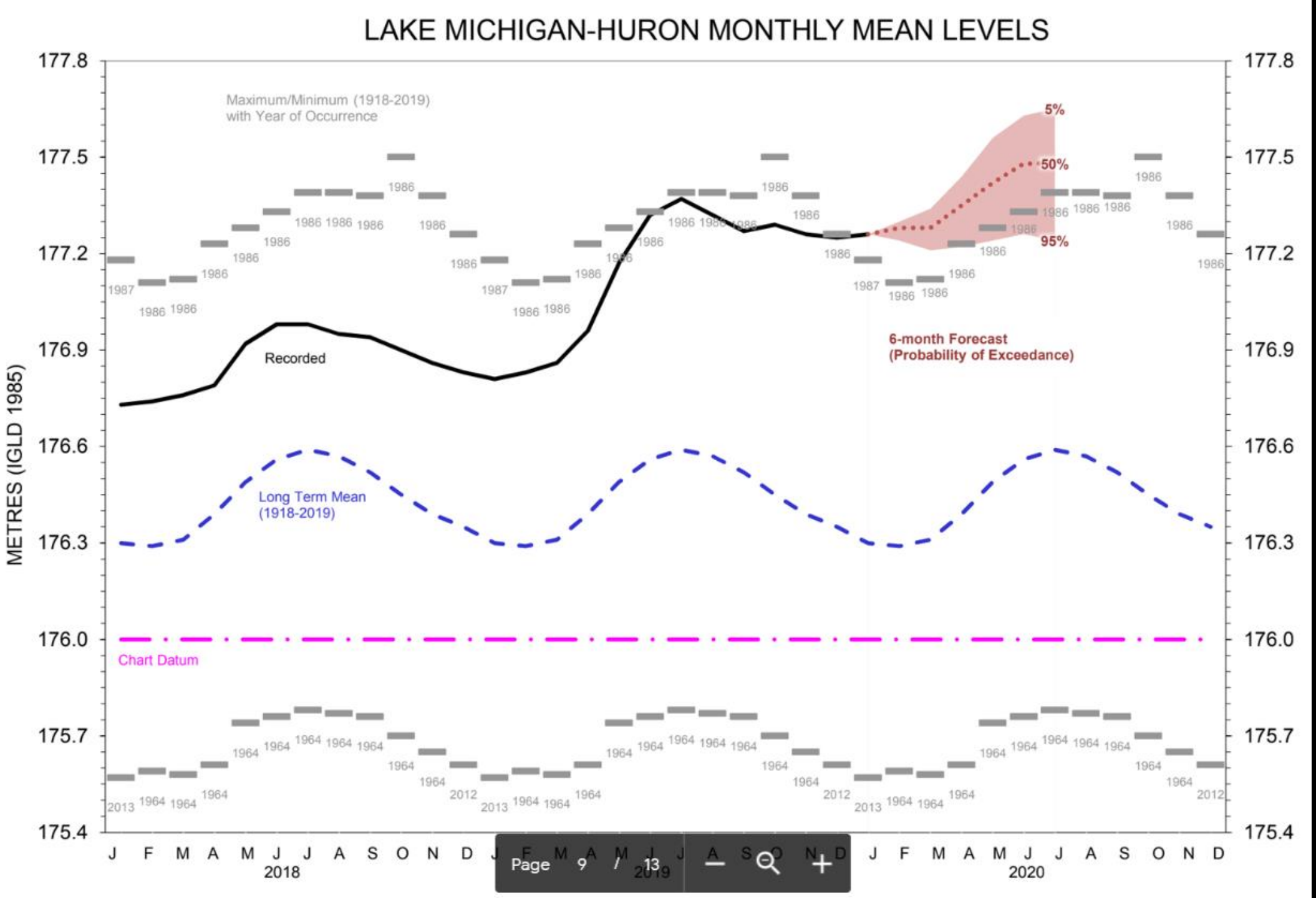
Shoreline Erosion and Community Scale Adaptation Strategies

Pete Zuzek, Zuzek Inc.
February 25, 2020

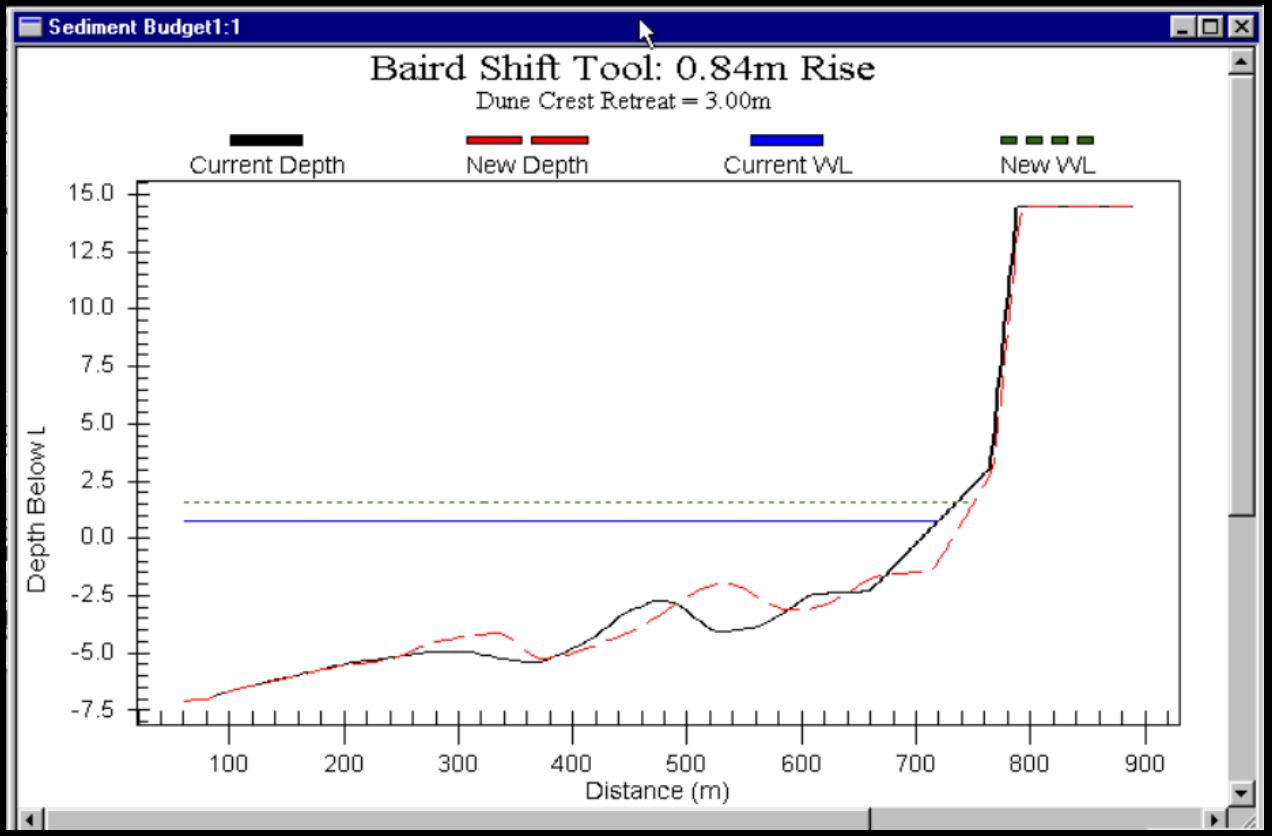
I – Beach Erosion

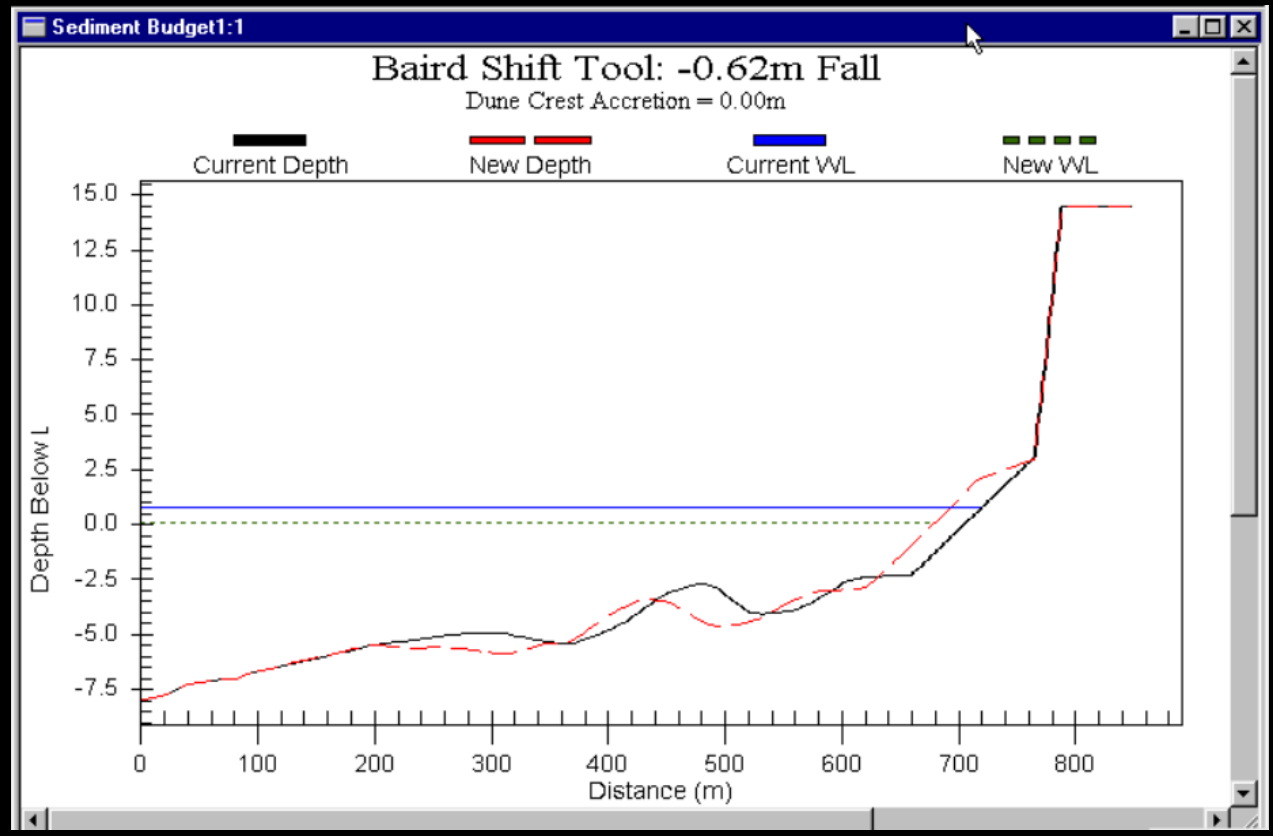
ECCC Water Level Projections



Impacts of Rising and Falling Water Levels on Beaches and Nearshore Bars

- Work completed for the Lake Michigan Potential Damages Study
- Evaluate impacts of lake level trends on beaches





Shoreline Hazards – Lake Ontario

- Dynamic Beach Hazard is defined as:
  - "Where a dynamic beach is associated with the waterfront lands, the appropriate allowance inland to accommodate dynamic beach movement"

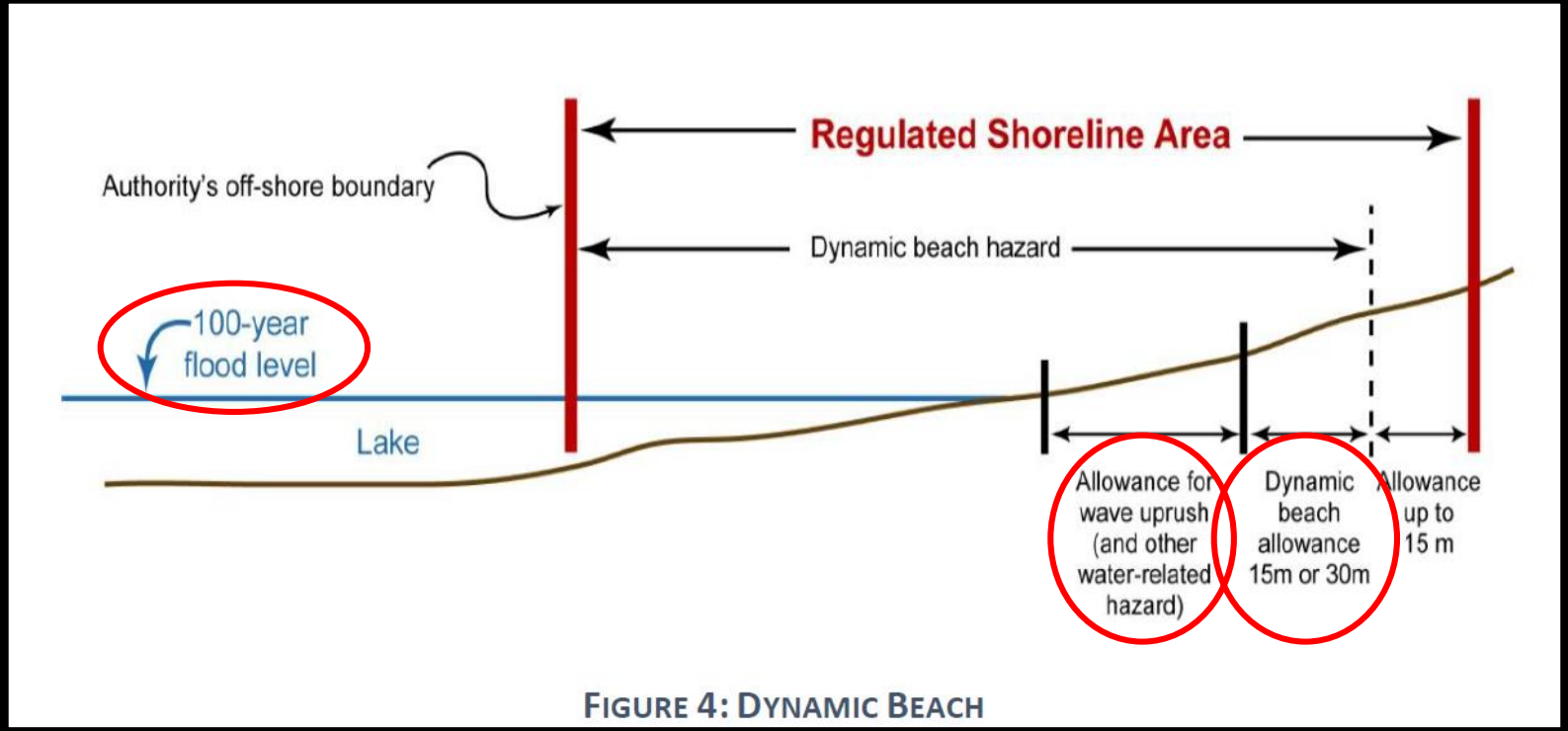


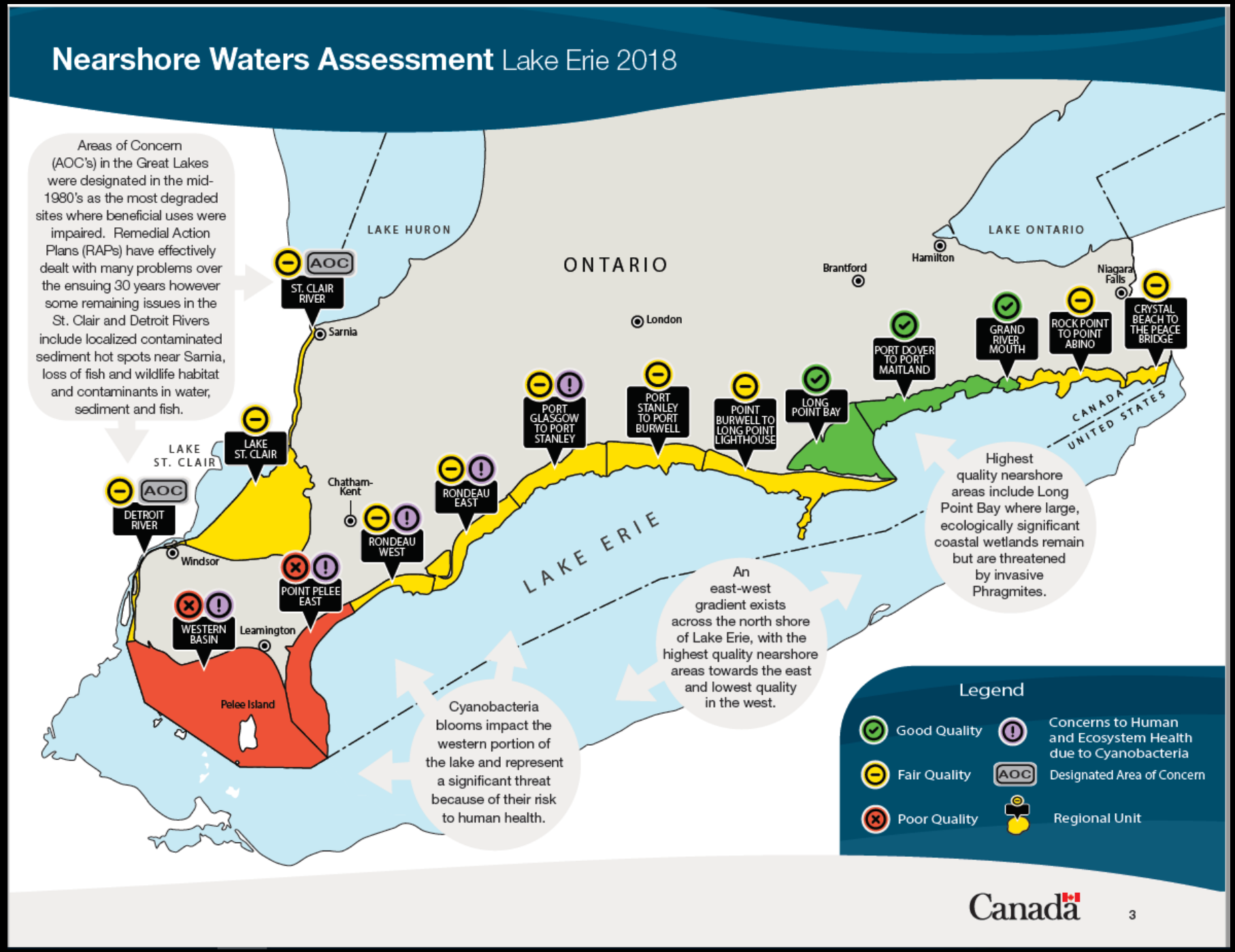
FIGURE 4: DYNAMIC BEACH

Figure taken from LTCA Policy Manual – Ontario Reg. 163/06

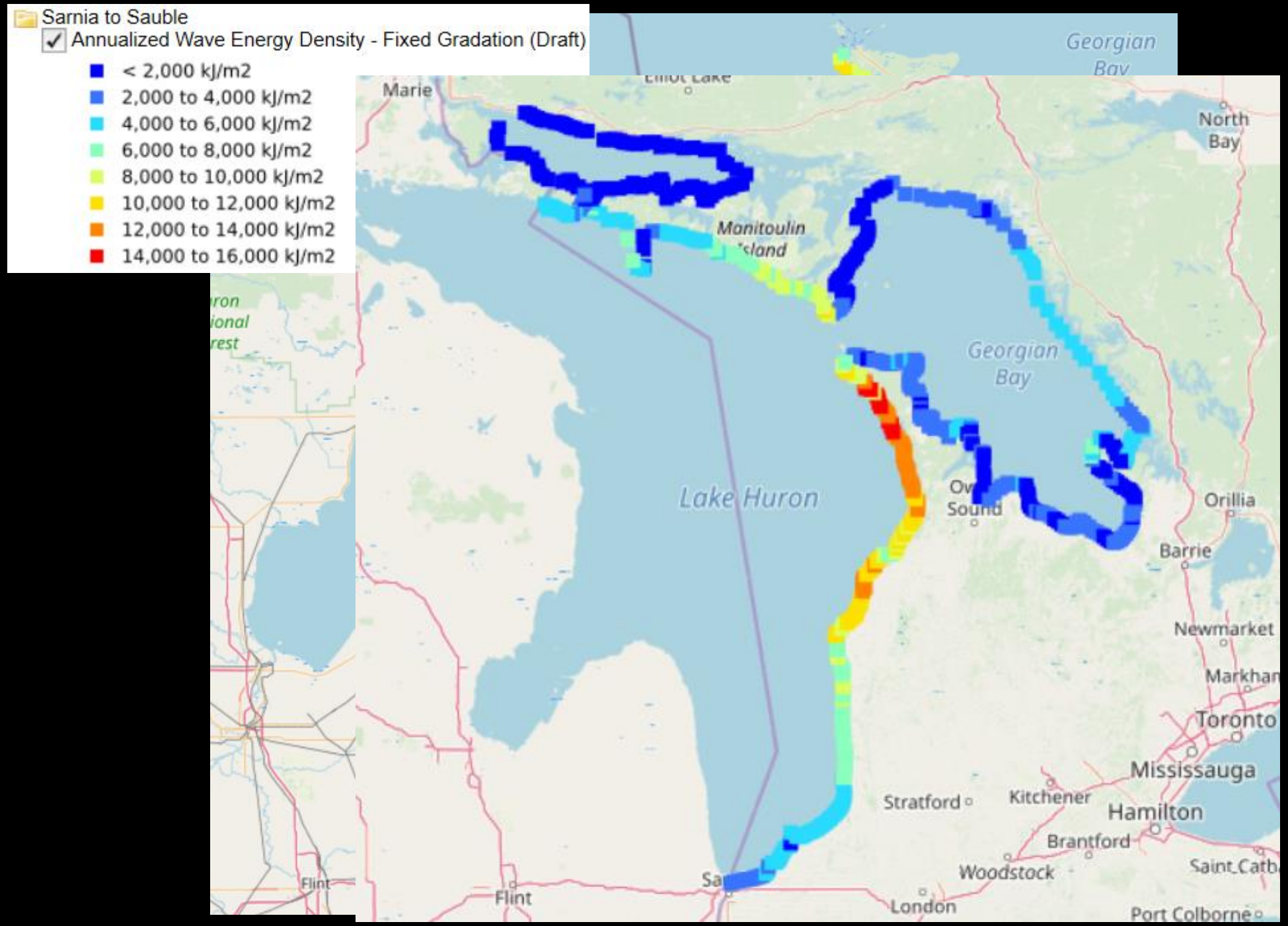
II – Shoreline Management and Erosion Mitigation

ECCC Nearshore Framework

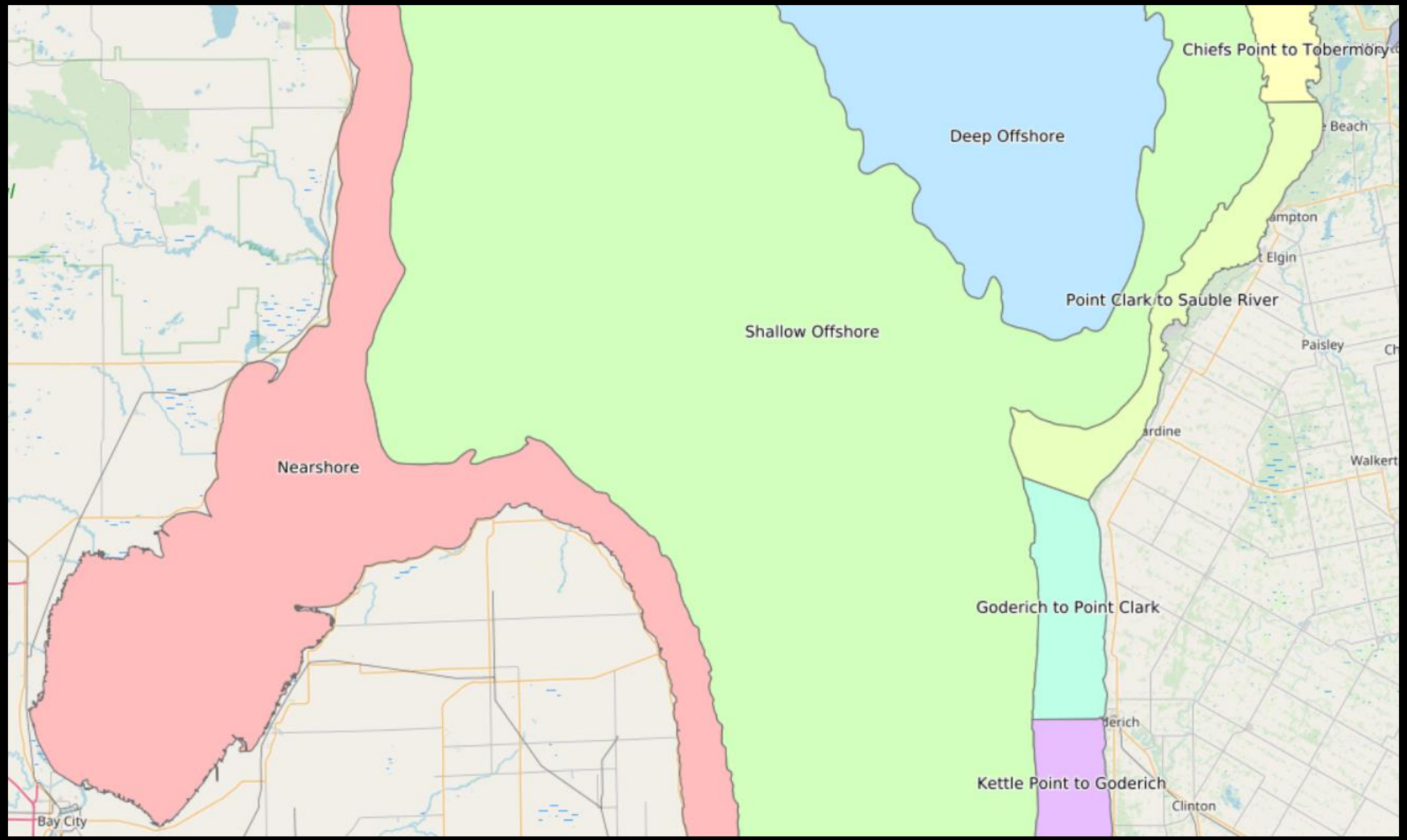
Lake Erie Regional Unit



ECCC Lake Huron Nearshore Wave Energy Gradients



ECCC Lake Huron Nearshore Framework Regional Units



Hardened vs. Natural Shorelines

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Shoreline Classification
Hardened vs. Natural

Near Port Stanley, Ontario

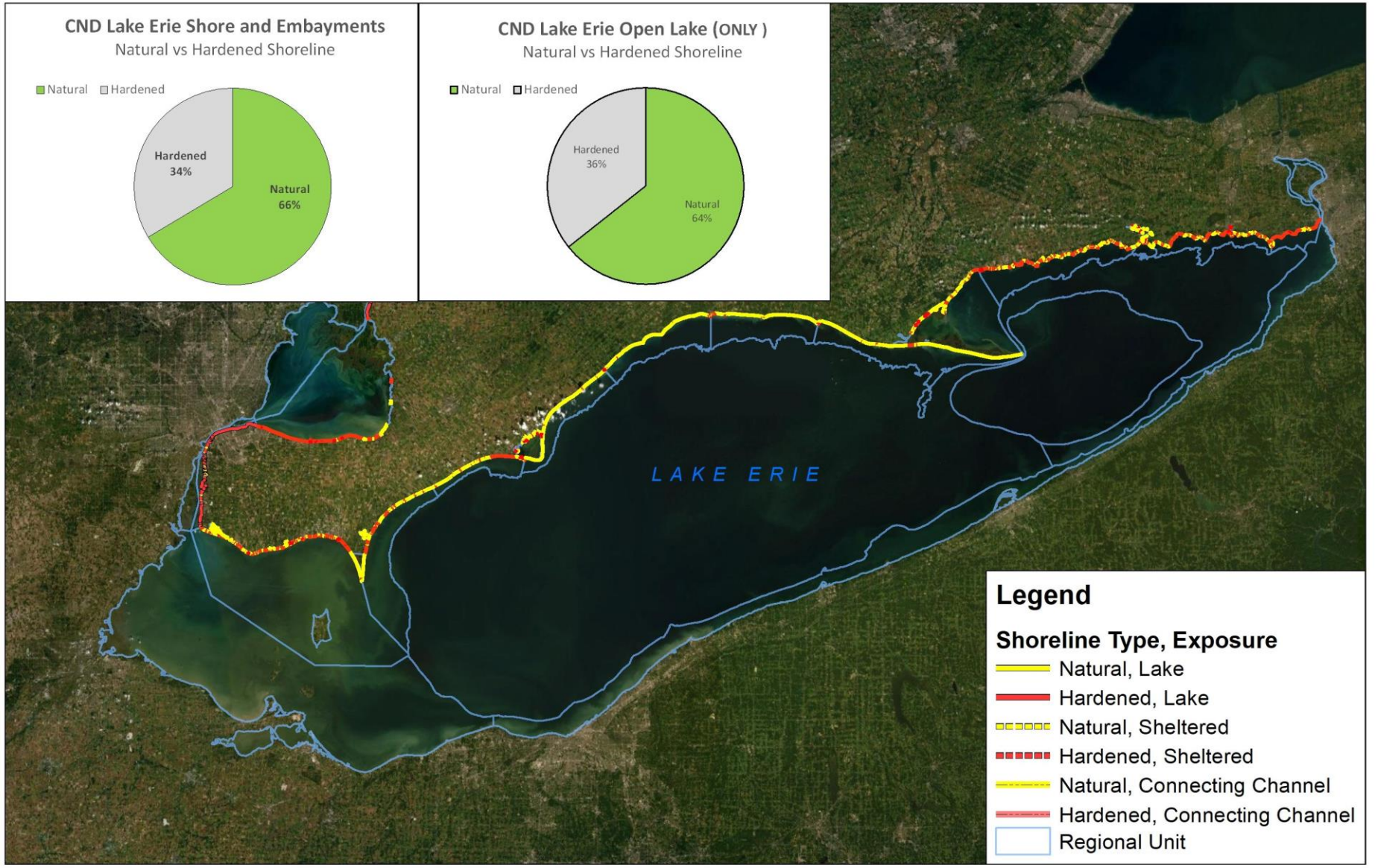
Background:
2015 SWOOP, provided by ECCC

DRAFT

N
W E
S

0 100
m

Shoreline Hardening



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Shoreline Classification
Hardened vs. Natural

Background:
Esri World Imagery Basemap

DRAFT

N
W E
S

0 10 20 30 40 50
km

PROTECT:

Nature Based Solution

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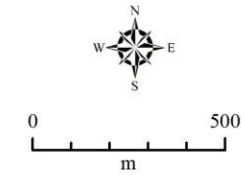
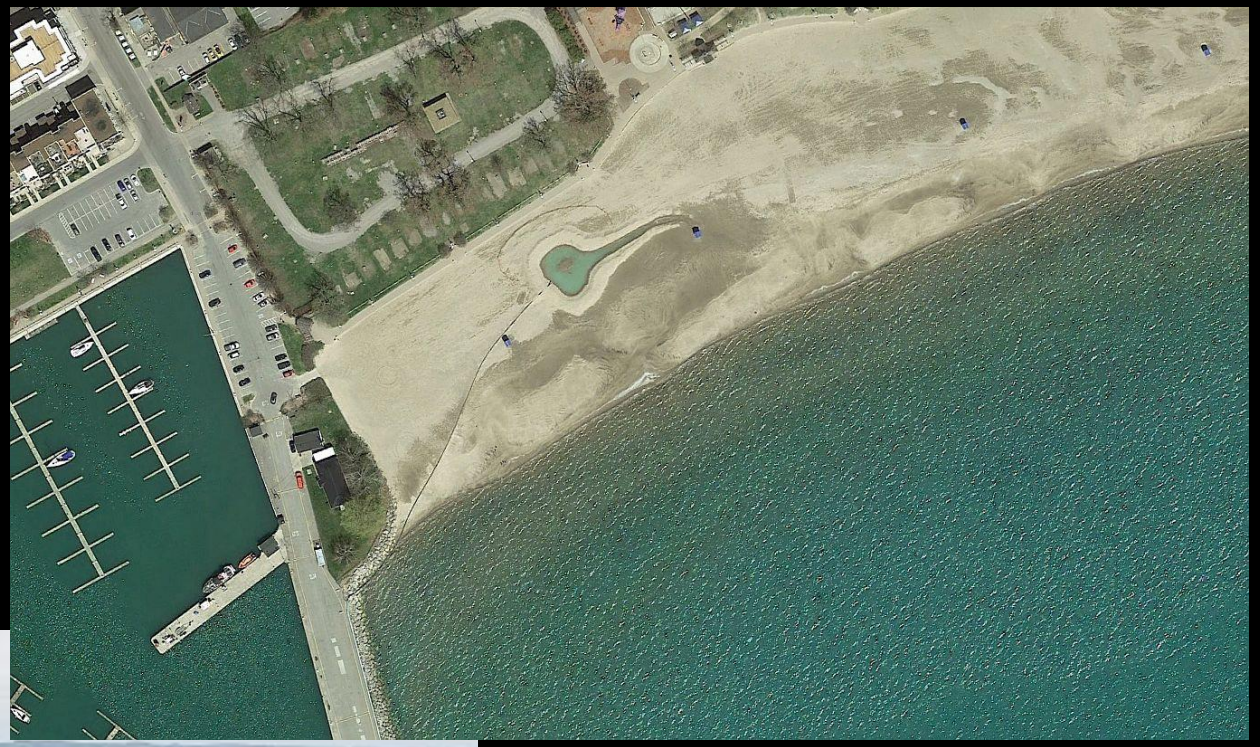
Sediment Movement at Cobourg

Lake Ontario SMP



PROTECT:

Sand Pumped onto Beach



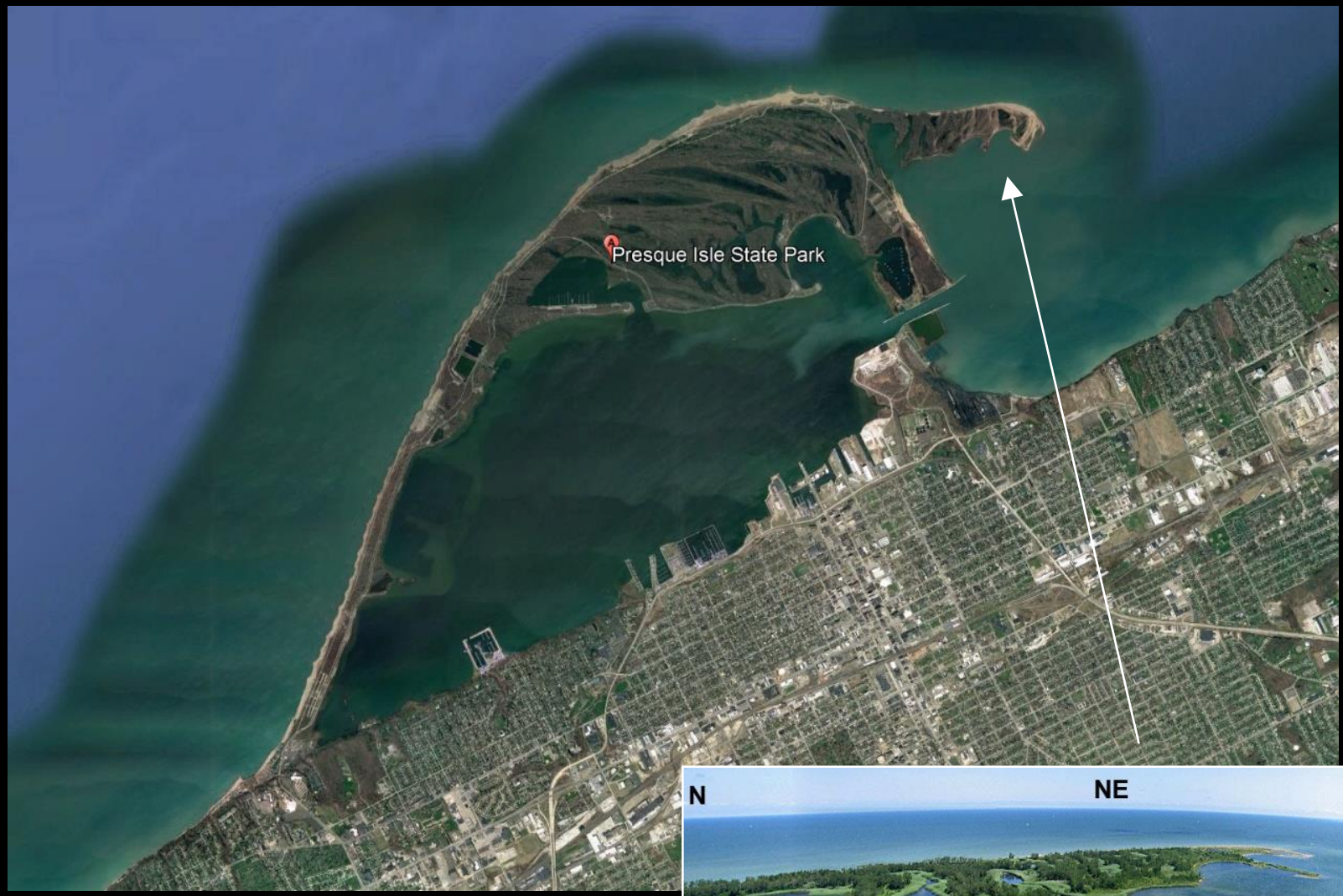
Lack of Sand Dunes for Urban Beaches

Cobourg Beach 2019 vs. Darlington Provincial Park

PROTECT

Presque Isle State Park, PA

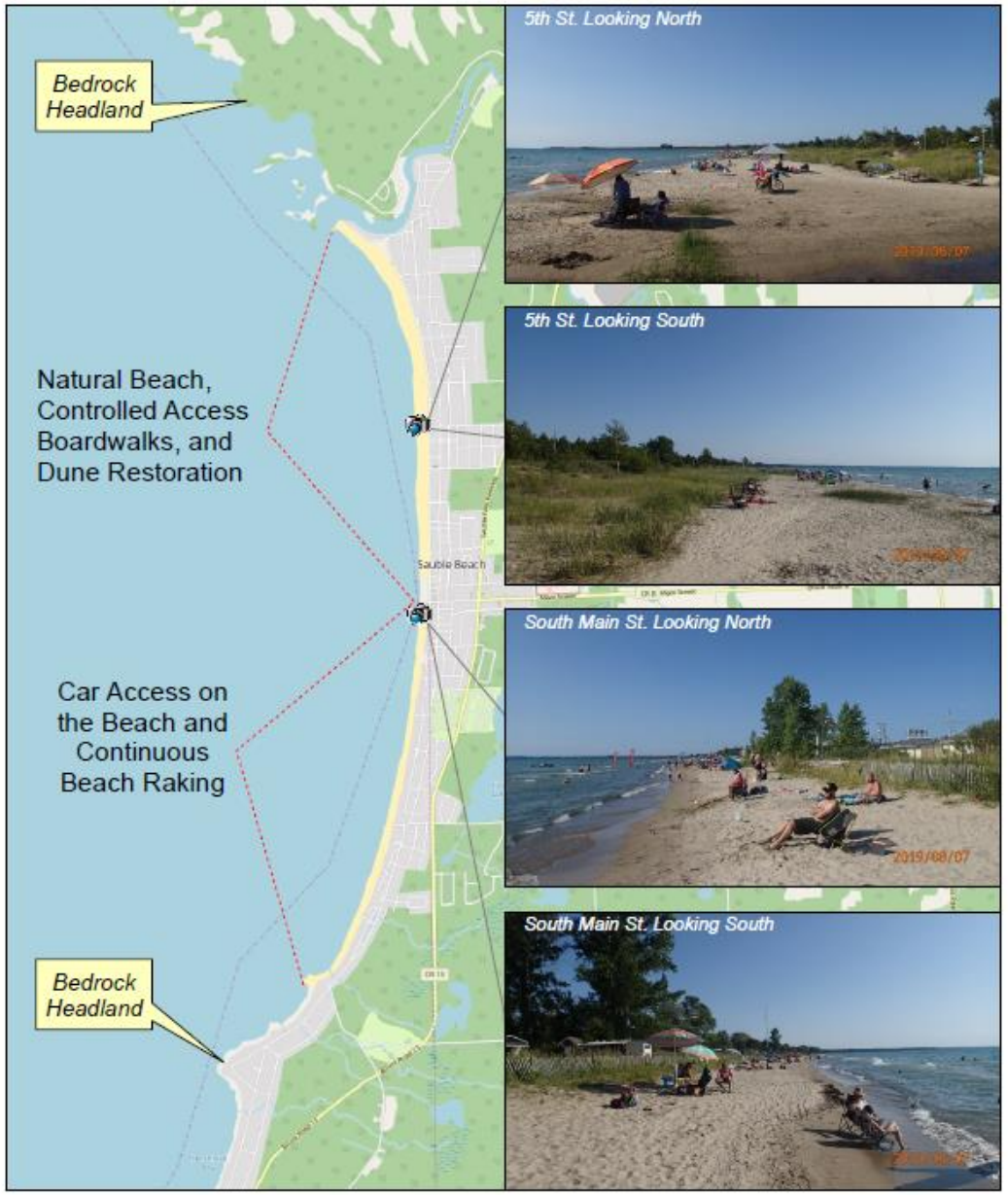
Long-term Nourish-ment Program



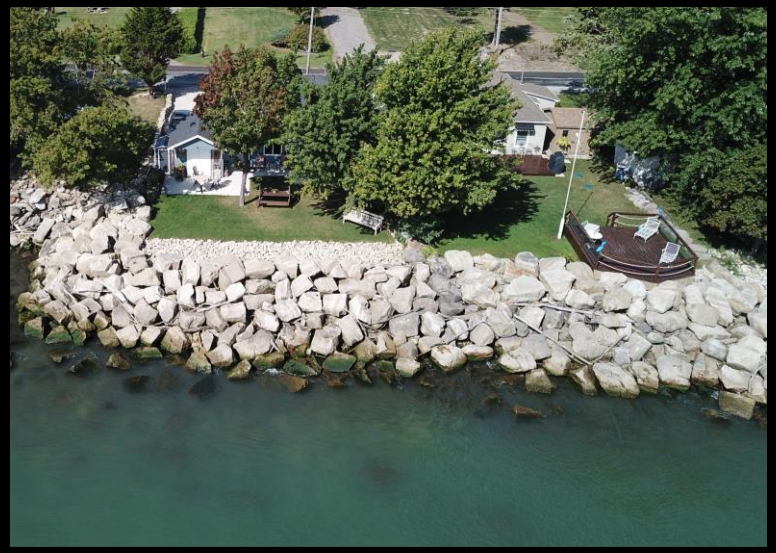
Presque Isle State Park – USACE Involvement

- 1975 to 1990, 176,000 CY/year of sand placed by truck
- Then, 55 Offshore Breakwaters completed in 1992, $30M
- USACE started a 50 year commitment to nourishment
- Post-breakwater construction, 38,000 CY/year sand placed

Role of Healthy Coastal Dunes



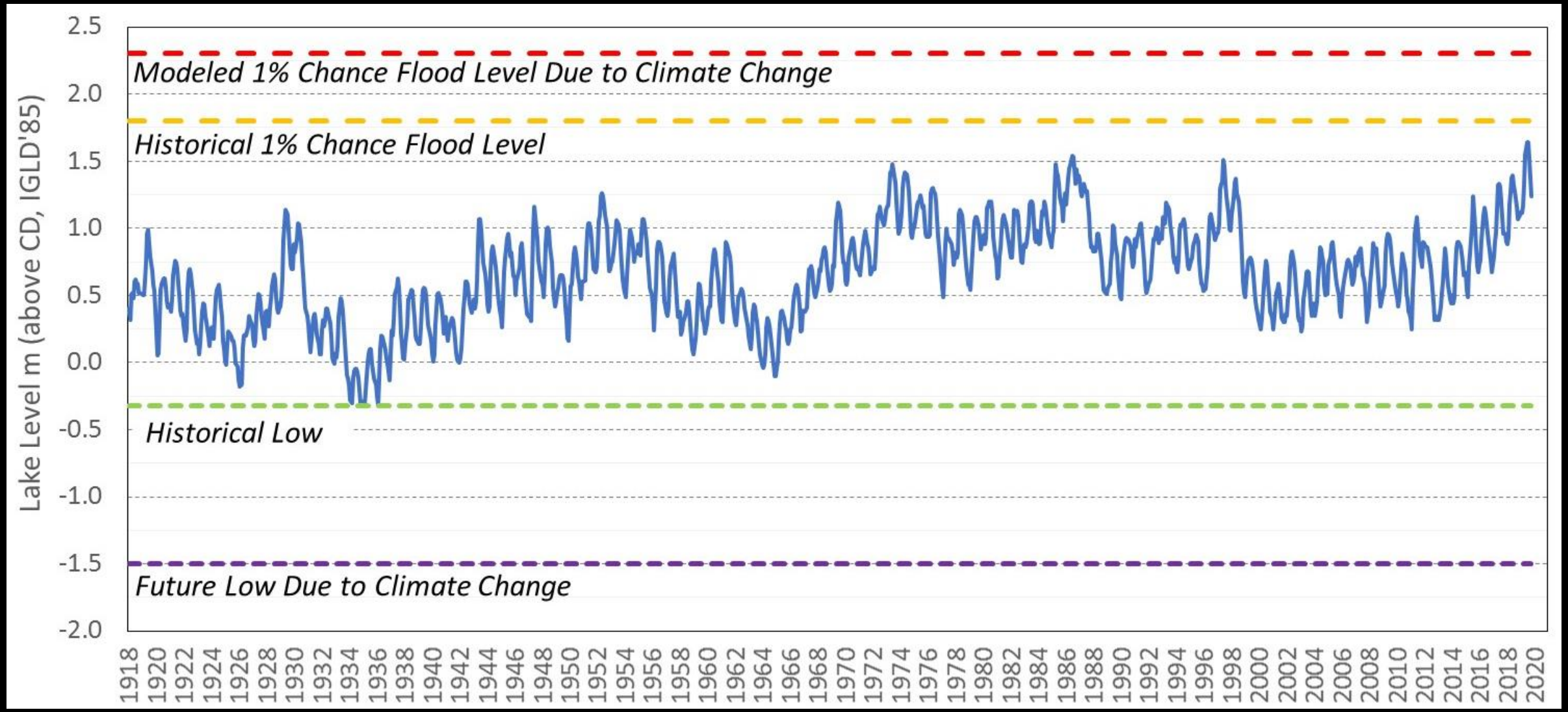
PROTECT: Traditional Private Property Approach



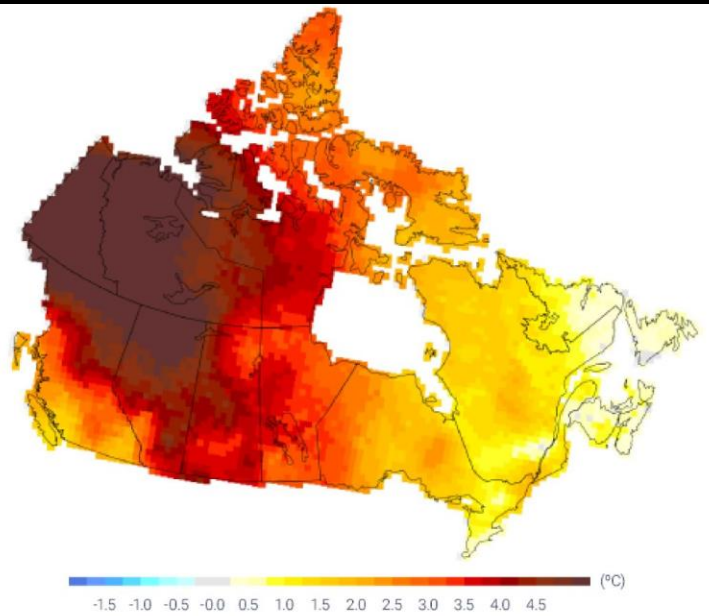
- Lot by lot protection is a near-term solution
- Structures should dissipate wave energy and have gradual failure mechanisms
- Monitoring/maintenance required
- Should be “well-engineered”

III – CLIMATE CHANGE IMPACTS ON LAKE LEVELS AND STORMS

Lake Erie Historical Water Level Range and Future Projections due to Climate Change (2041 to 2070)

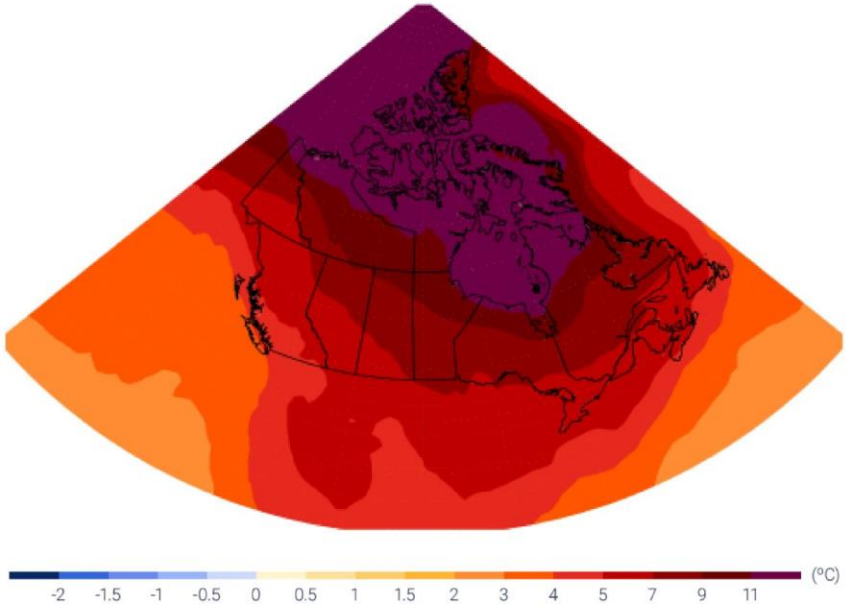


1948 to 2016 Winter Air Temperature Increase



Source: Vincent et al, 2015. In 'Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019): Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, pp 112-193'.

2081-2100 Winter Warming Projection for RCP8.5



Source: Climate Research Division, Environment and Climate Change Canada. In 'Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019): Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, pp 112-193'.

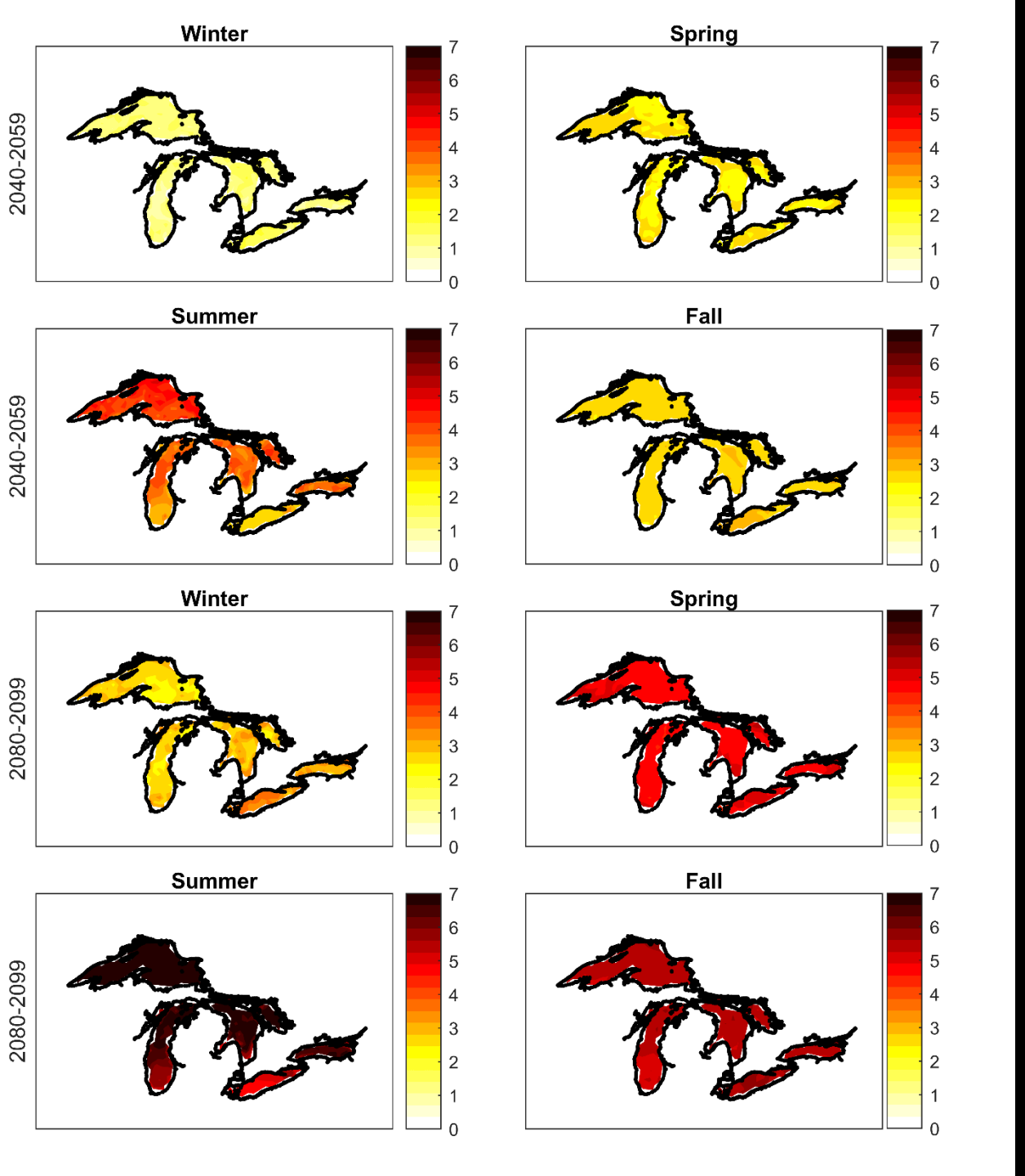
Warming has already decreased the extent and duration of Lake Erie ice cover. In the future, the lake could be ice-free in the winter.

Lake Ice Cover Near 100%

Partial Ice Cover on the Lake

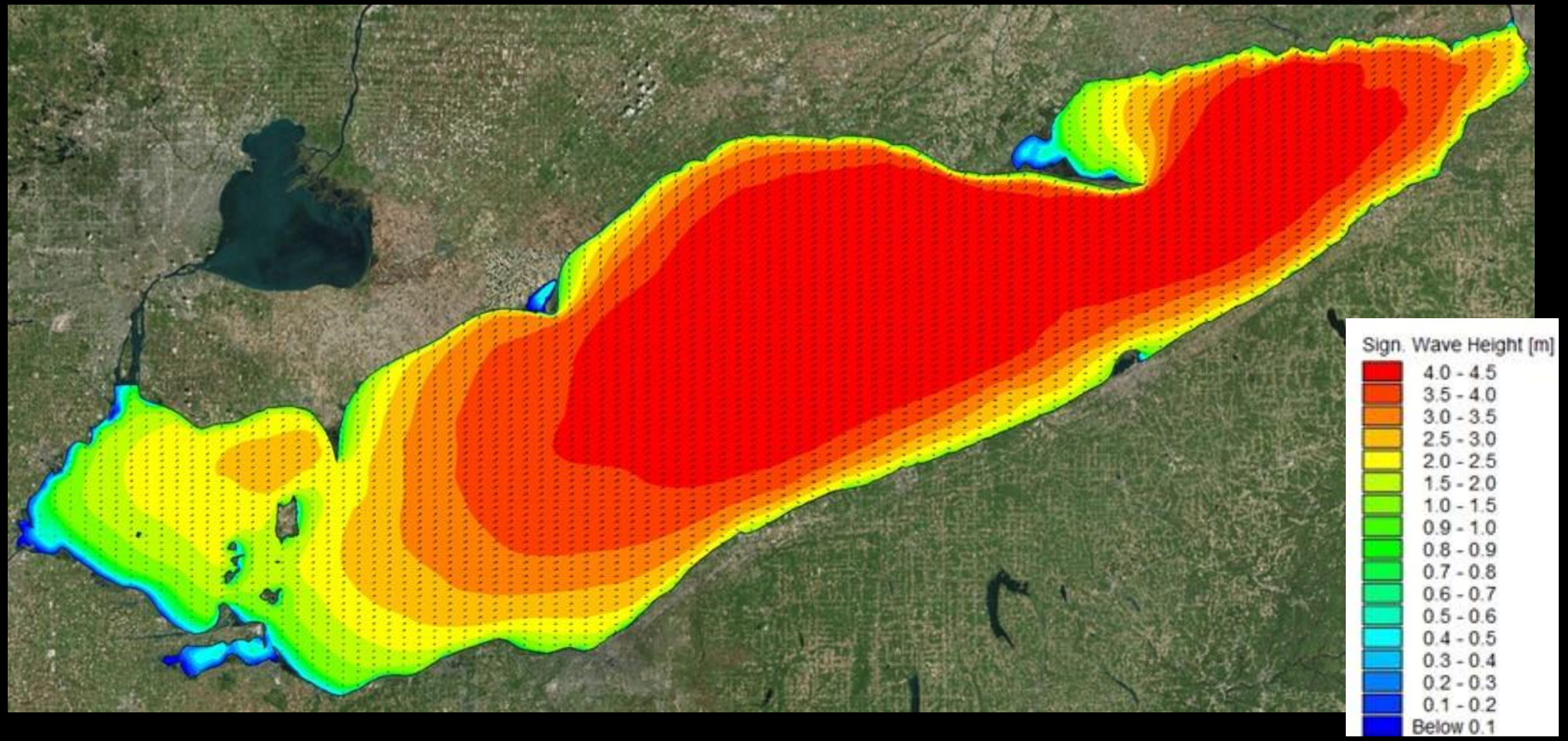
Ice Cover Limited to the Eastern Basin

Changes in Lake Surface Temp. for RCP8.5



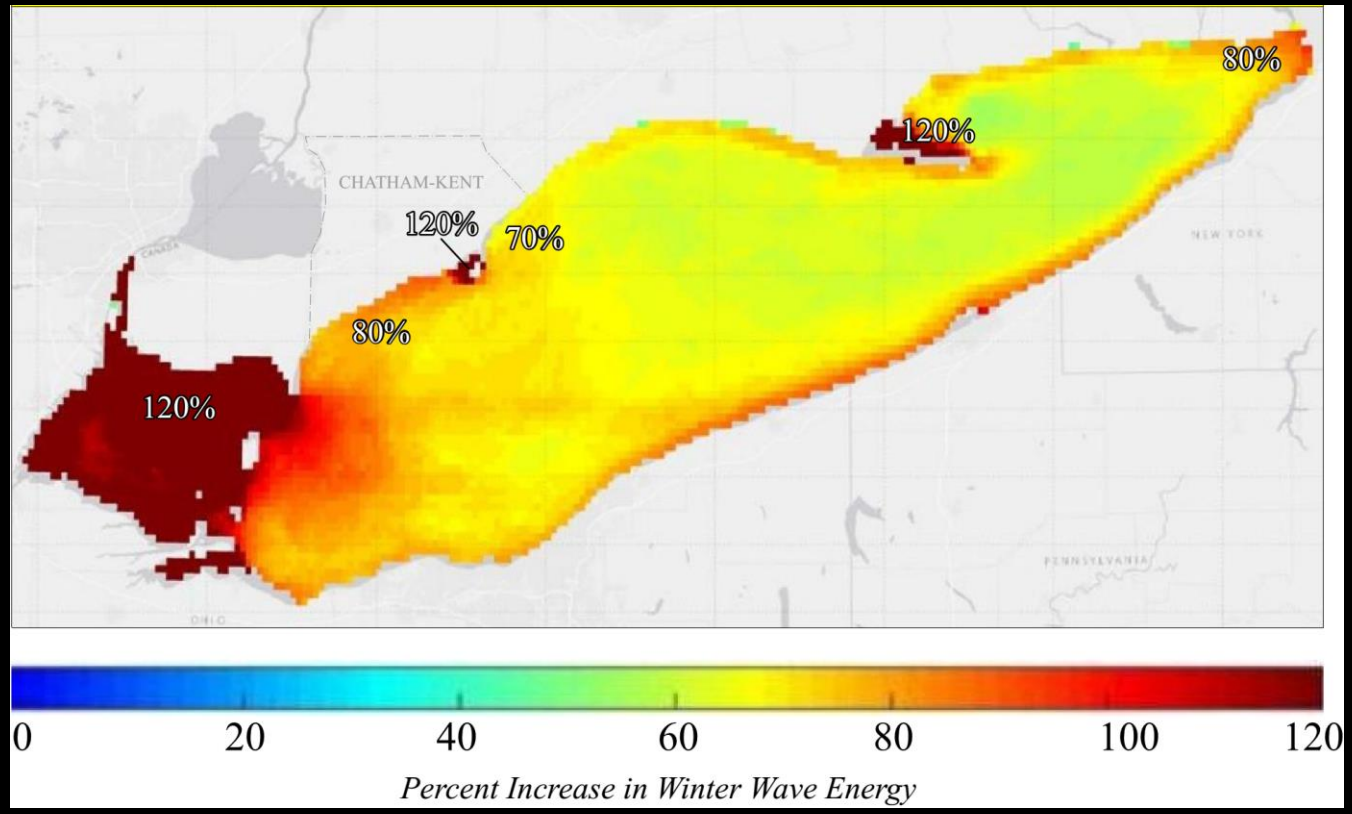
Numerical Models Simulate Wave Conditions

- Spatially varying wave heights for the December 10, 2009 storm

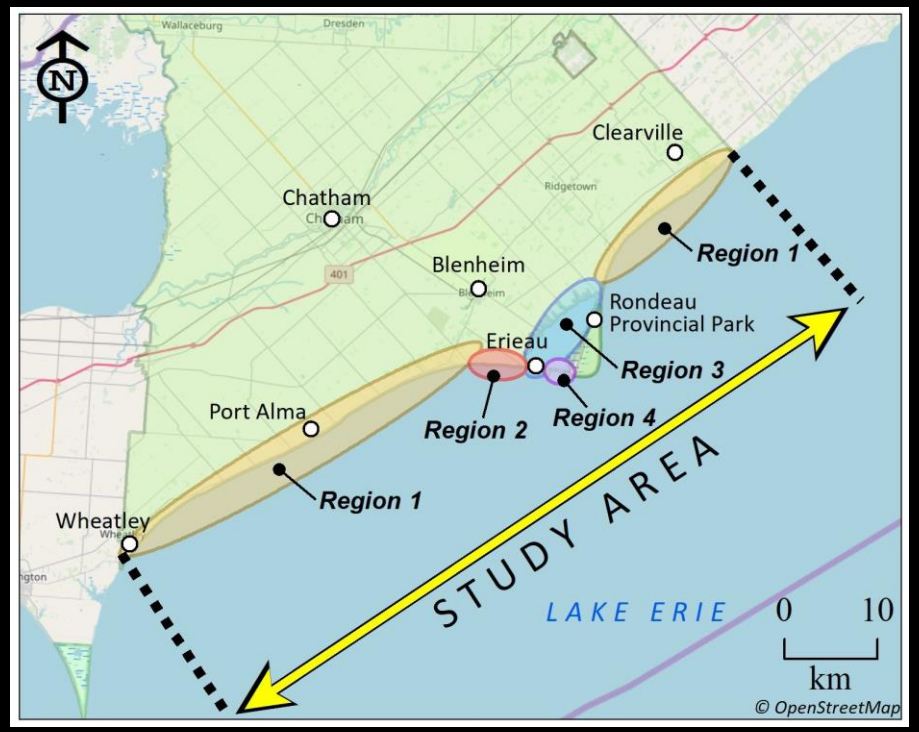


Projected Increase in Wave Energy due to Reduced Ice Cover

- Due to projections of future reductions in ice cover, winter wave energy may increase 70% to 120% for the study area shoreline (by late century/2080)
- Shoreline erosion rates may also increase 70% to 120%



IV – C-K VULNERABILITY AND RISK



Study Partners for Climate Change Study

- Supported by Natural Resources Canada's Climate Change Adaptation Program
- This project has received funding support from the Government of Ontario. Such support does not indicate endorsement by the Government of Ontario of the contents of this material
- Municipality of Chatham-Kent (C-K)
- Lower Thames Valley Conservation Authority (LTVCA)
- A Steering Committee with representation from all levels of government
- The Community of Chatham-Kent

Natural Resources Canada | Ressources naturelles Canada

Canada

Erosion of the Rondeau Provincial Park Barrier Beach

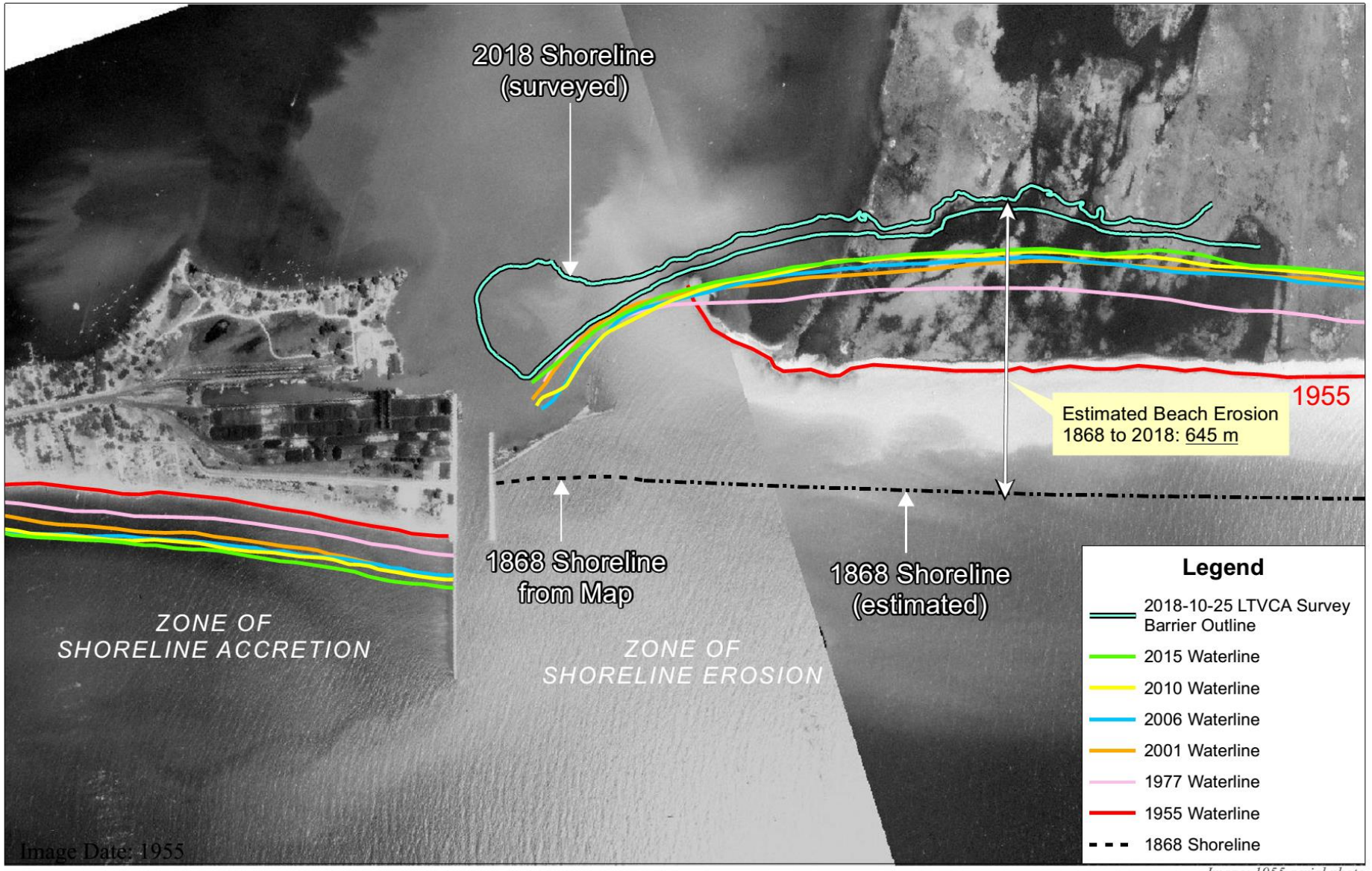


Image: 1955 aerial photo

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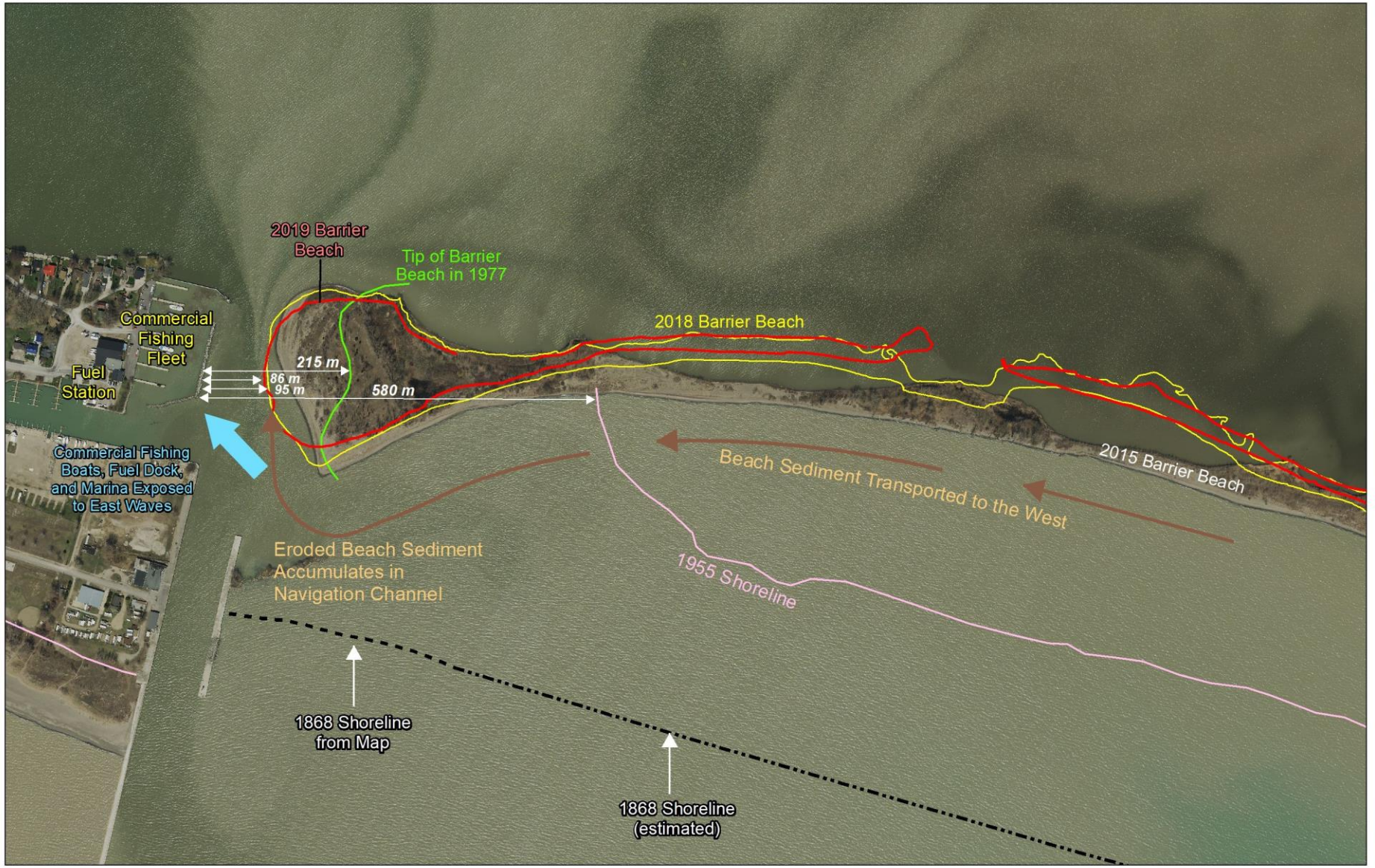
Change in Beach Position in the Town of Erieau and Rondeau Provincial Park from 1868 to 2018

Data Sources:
- 2018 survey of the barrier beach by LTVCA
- 1955 aerials provided by LTVCA

N E S W
0 100 200 300
m

Erosion of the Rondeau Provincial Park Barrier Beach



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Rondeau Bay Navigation Channel and Barrier Beach: 1868 to 2018 Evolution and Risk Exposure

2019-08-20 LTVCA Survey
2018-10-25 LTVCA Survey
1977 Shoreline
1955 Shoreline
1868 Shoreline

Data Sources:
- 2018 survey of the barrier beach by LTVCA
- 2015 orthophoto provided by ECCC

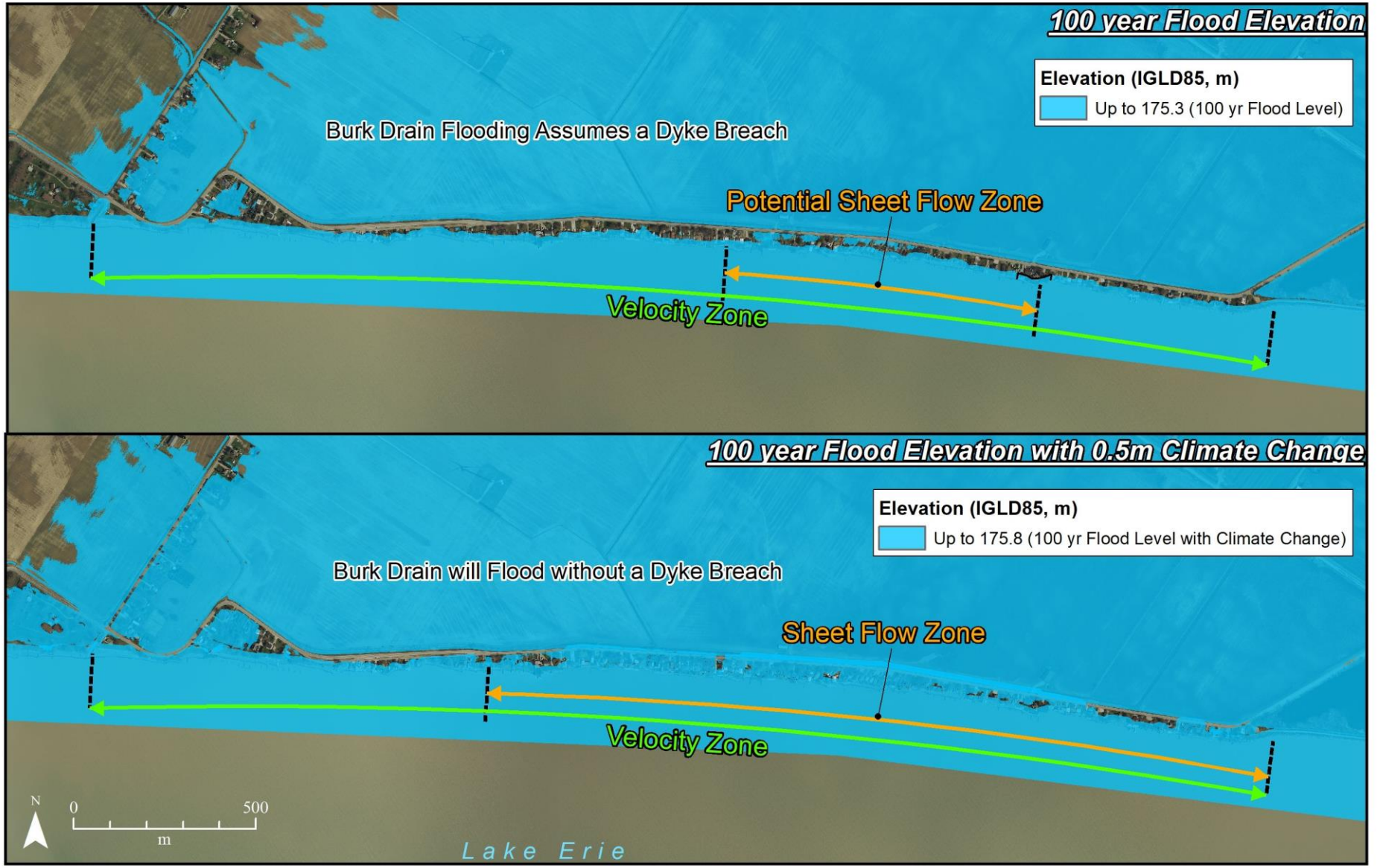
N W E S

0 100 200
m

High Water Impacts on Boating and Fishing Fleet (May 2019)

Flooded Fuel Dock and Boat Launch

Increased Wave Exposure for Fishing Fleet



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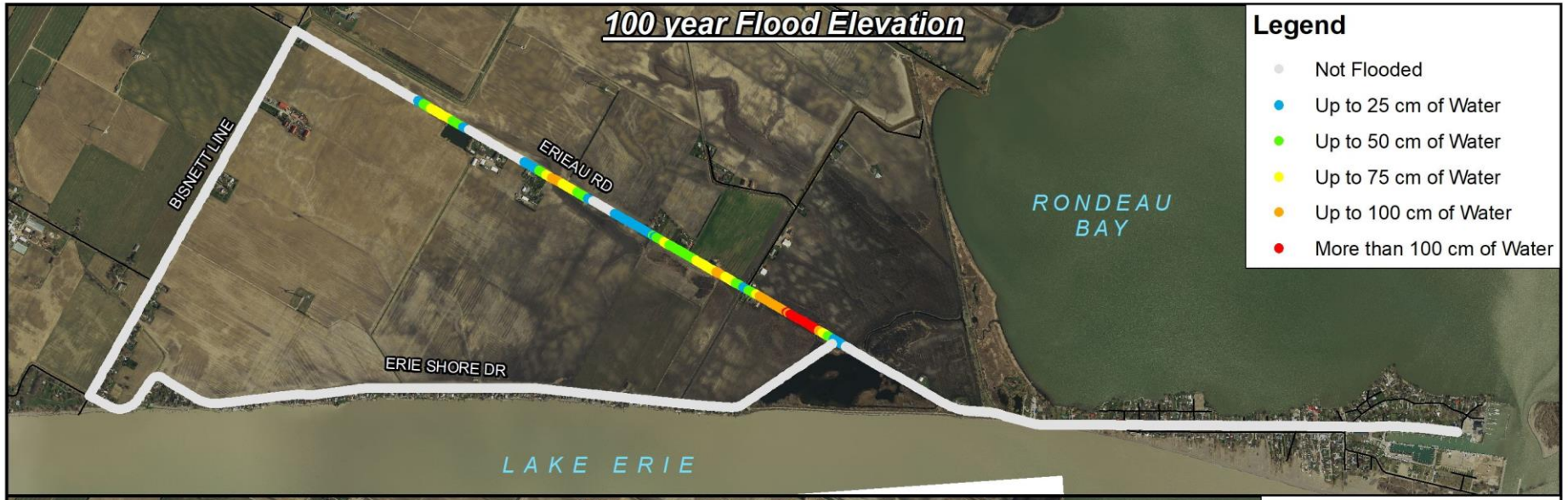
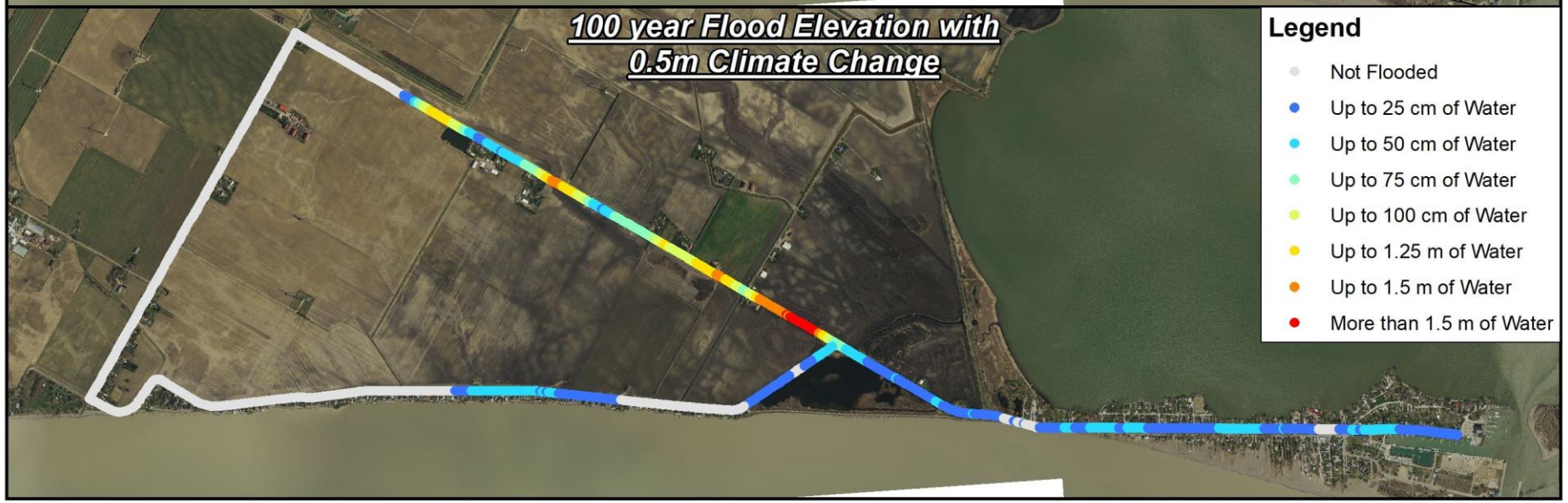
Erie Shore Drive Flood Vulnerability for the Historical 1% Chance Flood Level and the Future 1% Chance Flood Level with Climate Change Projection

Data Sources:
Flood surface derived from Spring 2017 LiDAR (OMAFRA).
Imagery from 2015 SWOOP.





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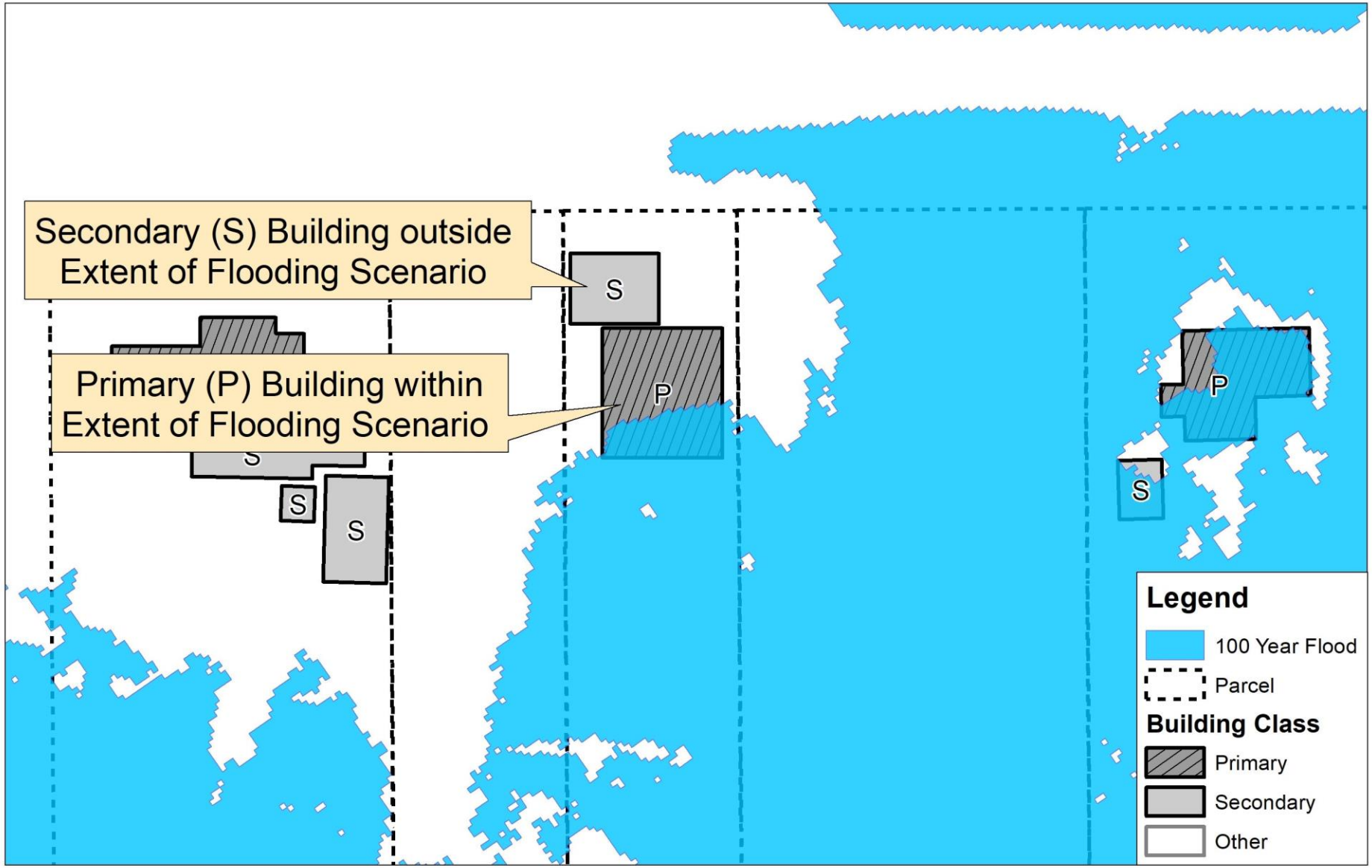
Potential Road Inundation During Flood Events

Data Sources:
1) Elevations taken from 2017 LiDAR (OMAFRA).
2) 2015 SWOOP Imagery

N
W E
S

0 250 500 1,000
m

Method Flooding Impacts to Primary and Secondary Buildings



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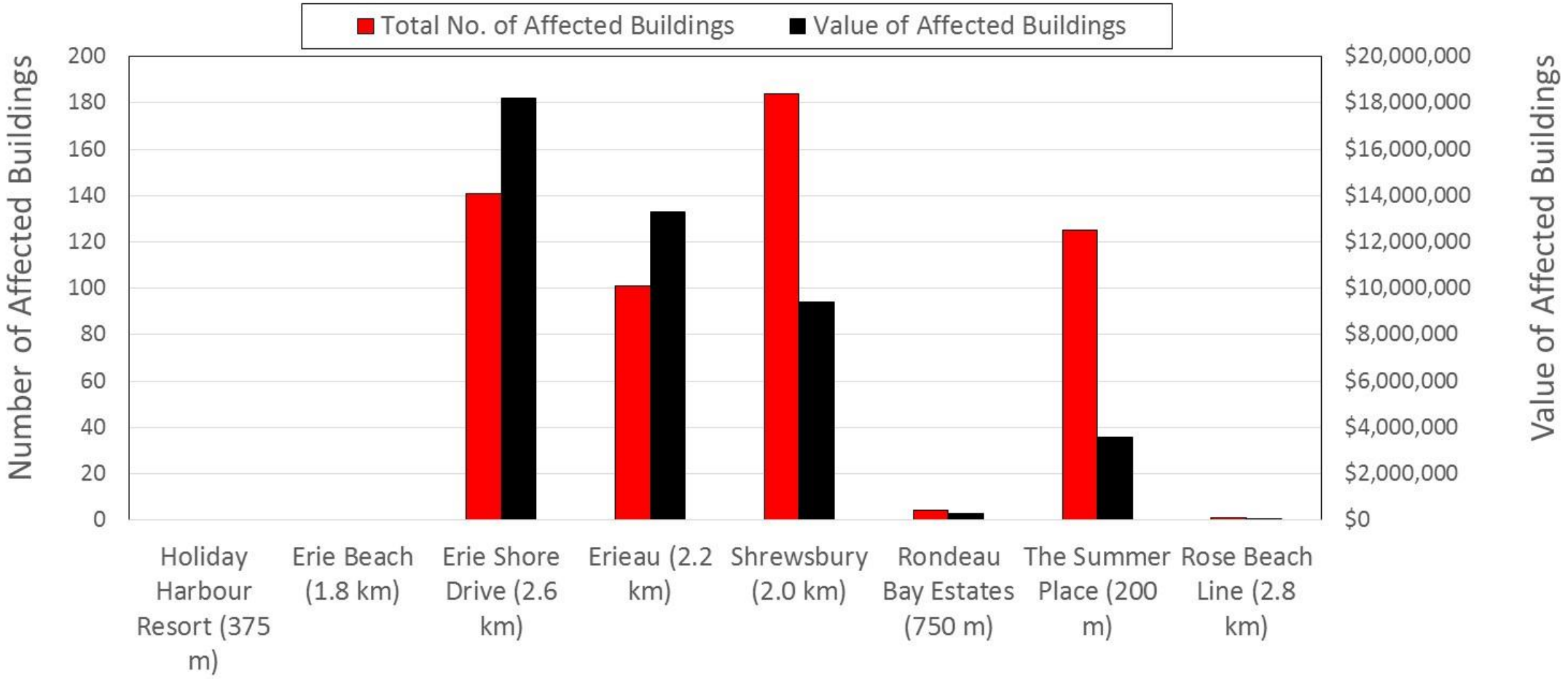
100 Year Flood Scenario

Data Sources:
2015 imagery provided by ECCC.
Parcel and building data provided by Municipality of Chatham-Kent.

0 10
m

Flood Vulnerability Assessment for the 1% Chance Lake Erie Water Level and Existing Conditions



MUNICIPALITY OF CHATHAM-KENT

Roads Vulnerable to Erosion in the Next 50 Years

Data Sources:
2015 SWOOP Imagery provided by ECCC.

Legend

- Talbot Trail - Affected Sections
- Roads
- 50-yr Hazard

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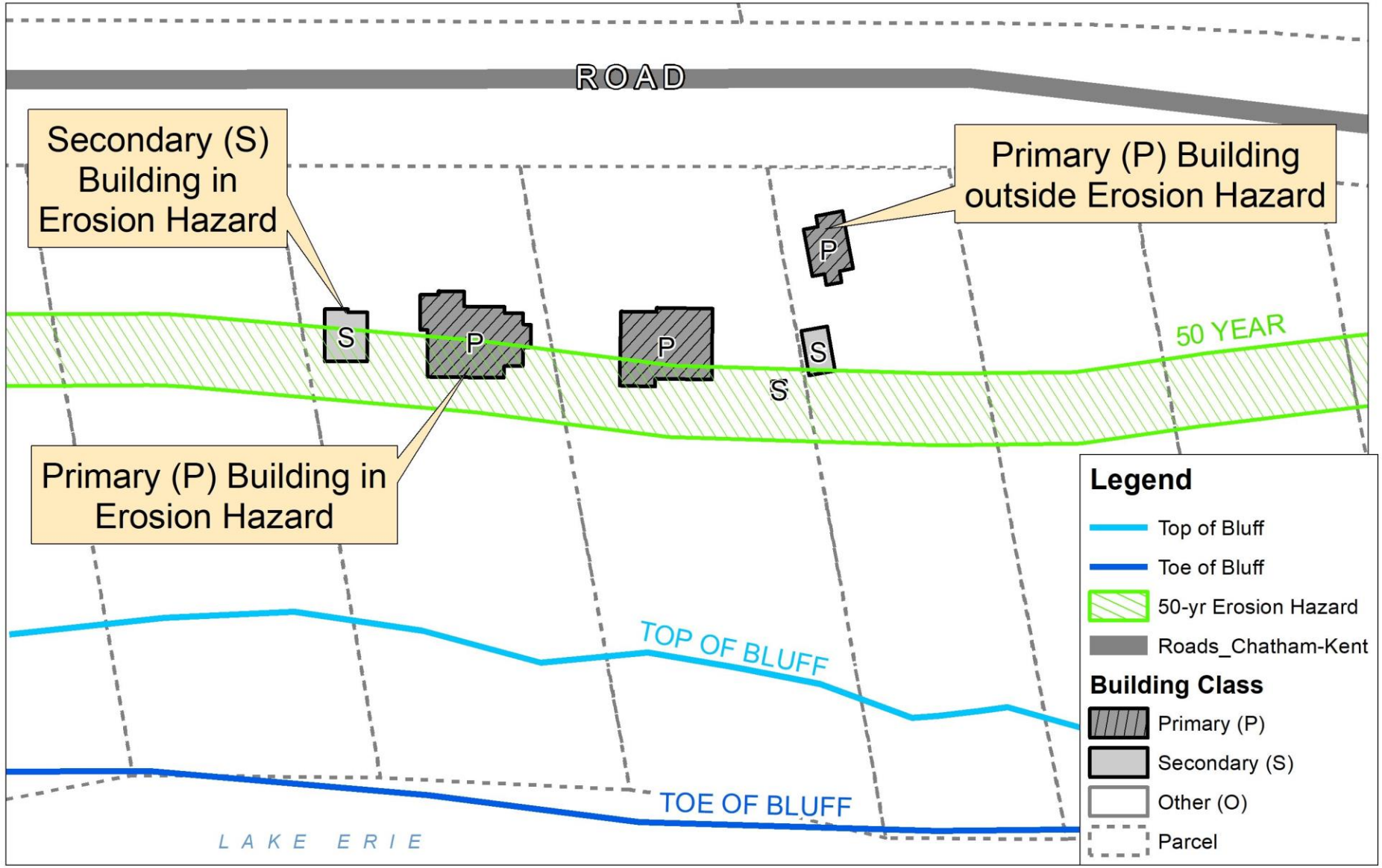
Erosion Impacts on Primary and Secondary Buildings



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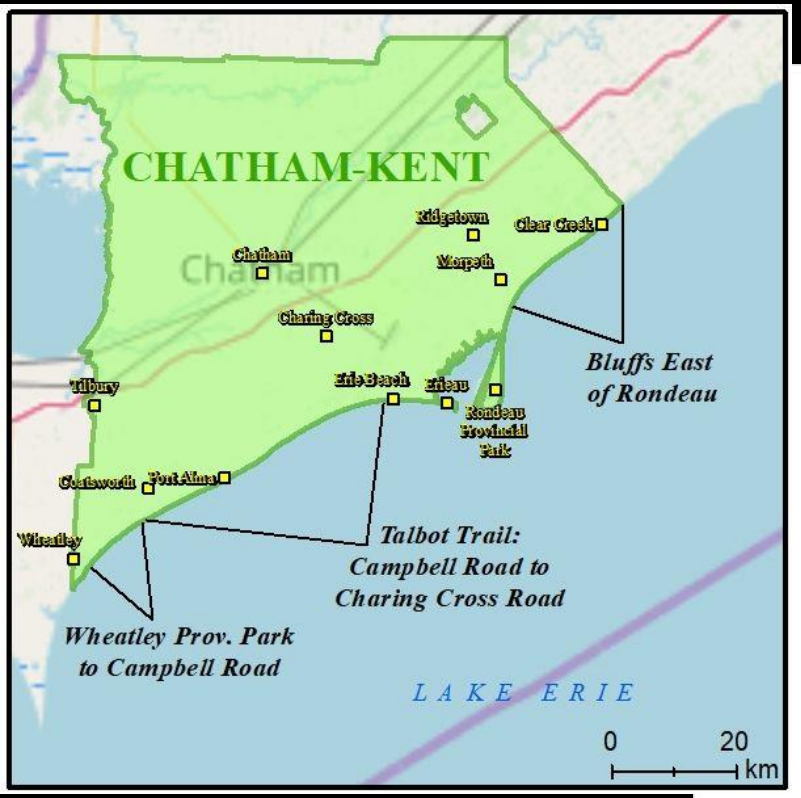
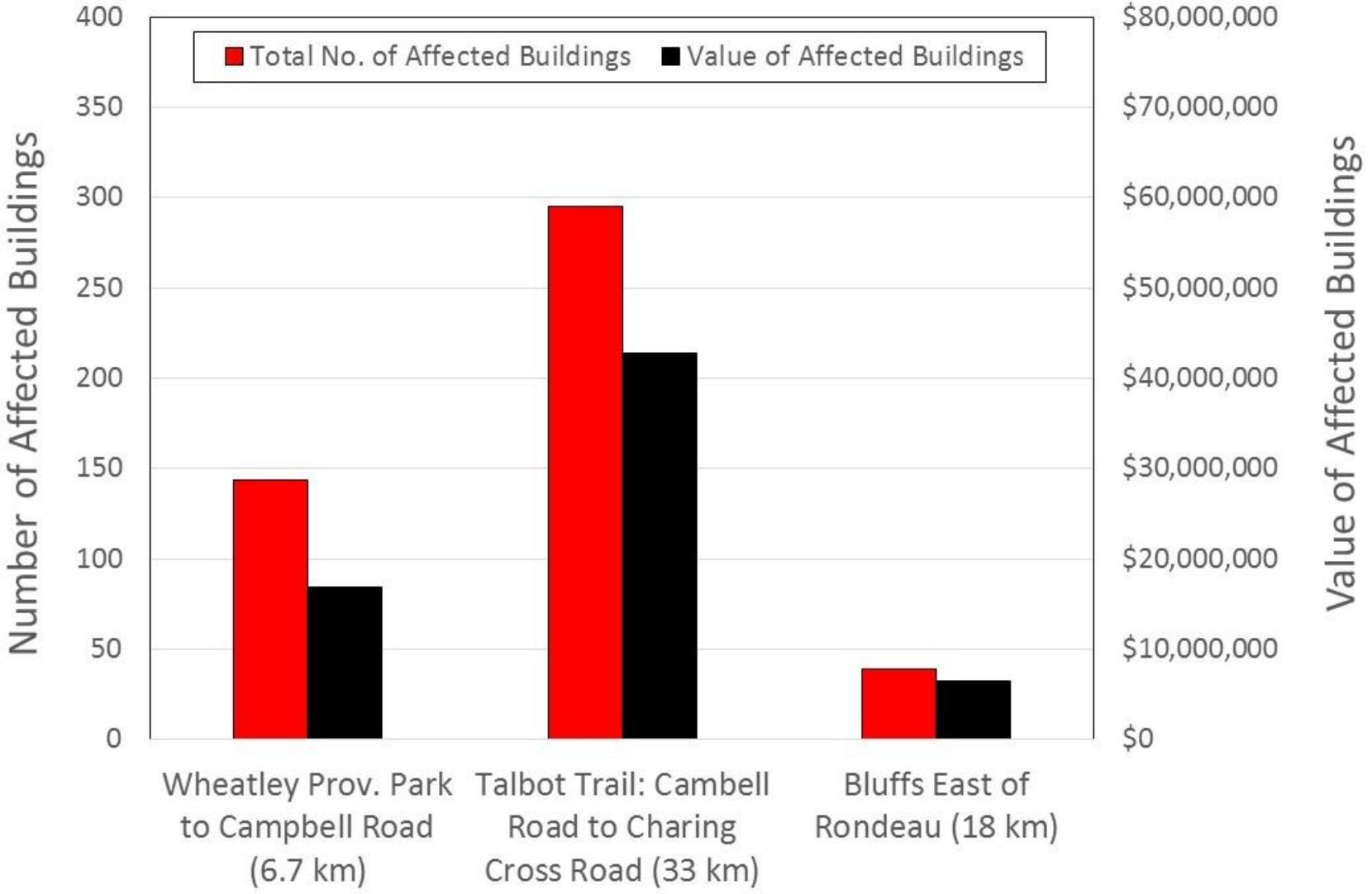
50 Year Erosion Scenario

Data Sources:
Parcel and building data provided by Municipality of Chatham-Kent.

0 10 20 30
m

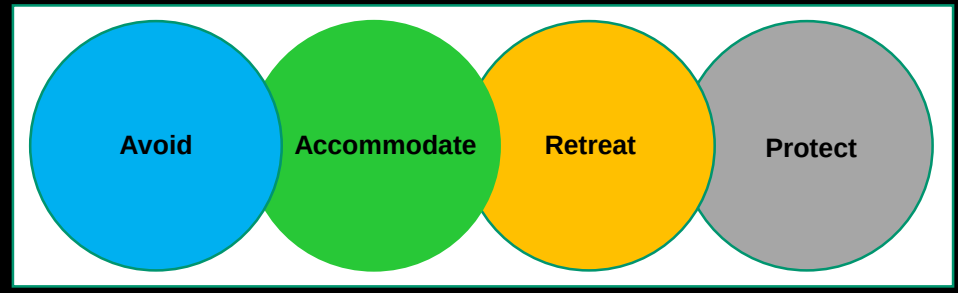


Erosion Vulnerability for the 50-Year Top of Bank Projection (assuming no structural Intervention)

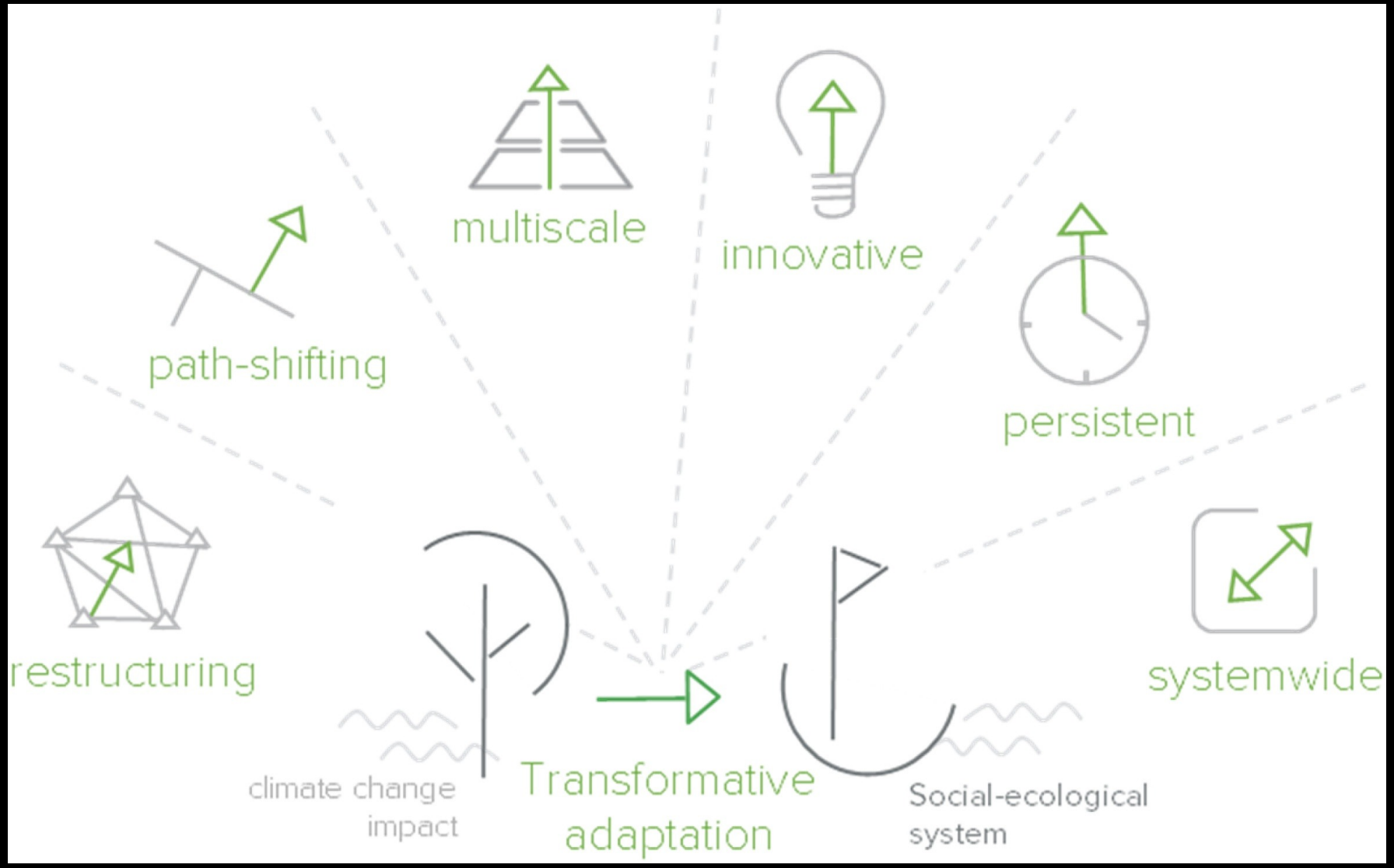


Types of Climate Change Adaptation Strategies

- **Avoid**: reduce exposure by ensuring new development doesn't occur on hazardous land (doesn't help with legacy development)
- **Accommodate**: an adaptive strategy that allows for continued occupation while changes to human activities or infrastructure are made to deal with hazards
- **Retreat**: a strategic decision to withdraw or relocate public and private assets exposed to coastal hazards
- **Protect**: a reactive strategy to protect people, property, and infrastructure. Traditional approach and often the first considered



Characteristics of Transformative Adaptation (Fedele et al, 2019)



AVOID

Mapping Hazardous Lands to Regulate New Building (e.g. Port Hope, ON)

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Port Hope West Beach
Draft Dynamic Beach Assessment

Data Sources:
2013 SWOOP aerial mosaic provided by GRCA.

2016 topographic LiDAR provided by OMAFRA.

N
W E
S

0 50 100
m

ACCOMMO-DATE

Raise Building Foundation

(Long Point lower right)

RETREAT

C-K Building Relocation Example

- Bluff failure in early 1990s threatens home
- Building successfully relocated with Provincial funding
- Currently ~30 m from the bluff edge (adjacent image)

Imagery courtesy of LTVCA

Generic Options ‘D to F’ for all Regions

- **OPTION D: Construct New Shore Protection**

  Complete engineering design study and build new shoreline protection. Sloping armour stone revetments are the recommended alternative

- **OPTION E: Raise Grades and/or Foundation**

  Increase elevations around existing buildings and recreational areas to decrease flood risk

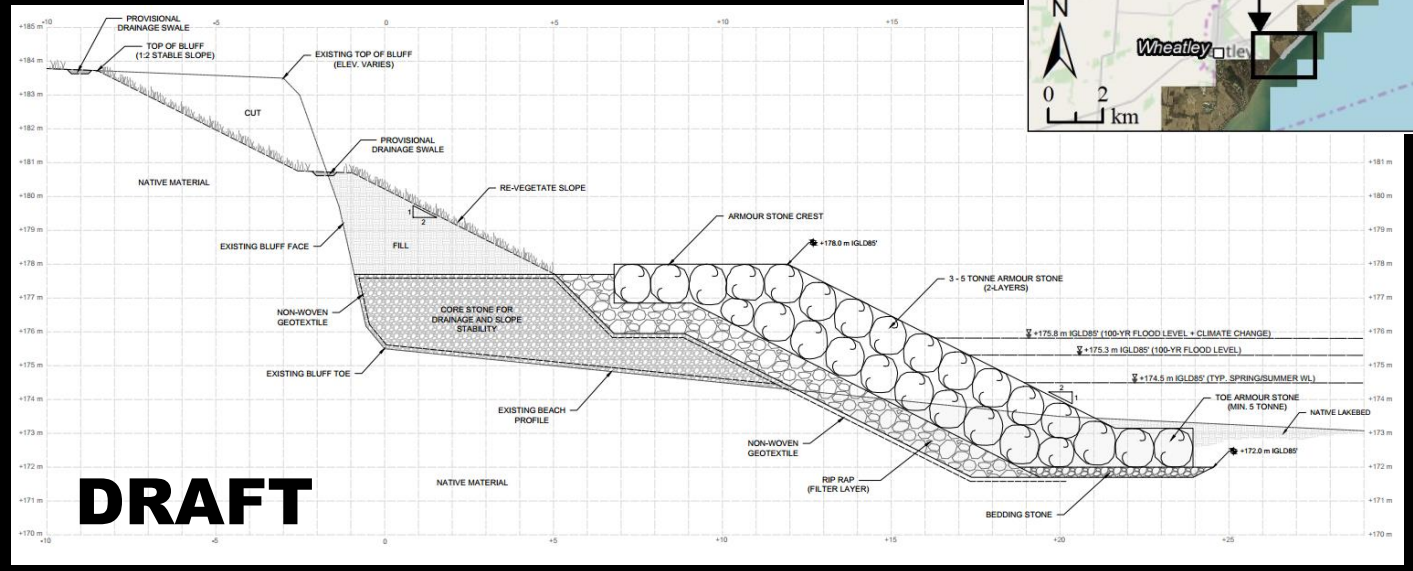
- **OPTION F: Relocate Buildings Inland**

  Locate existing buildings to the furthest inland location on a lot or to a new lot

OPTION 1-2: Protect Talbot Trail and Buildings with an Armour Stone Revetment

Protect

- Continuous 40 km revetment
- $600 to $900 million plus annual maintenance (1%)
- Pros: Long-term Protection
- Cons: Cost, securing approvals, and maintenance



Cons: Will eliminate the sediment supply to Erieau

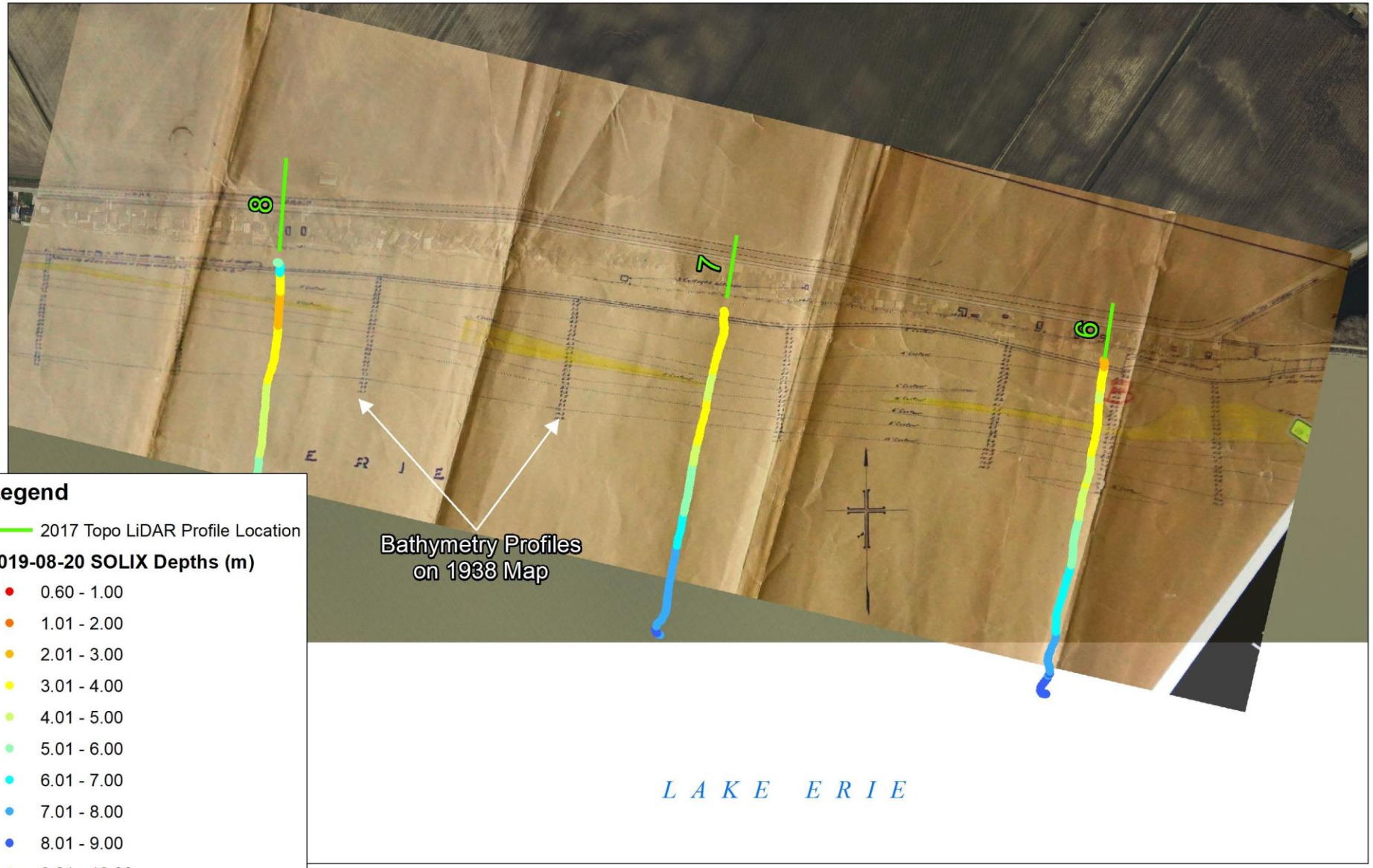
OPTION 1-3: Re-locate Talbot Trail and Buildings Inland (Option F)

Retreat

- Re-align Talbot Trail inland with a combination of existing and new roads at a cost of $31 to $40 million
- Option F: Relocate buildings (~500) over next 50 years, $37 to $68 million
- Pros: Cheaper than Protection Option 1-2
- Cons: Disruption to the local community

Example: Dexter Line/Highway 24 in Port Bruce recently moved inland ~800 m (see map below)

Erie Shore Drive 1938 Depth Survey



Legend

2017 Topo LiDAR Profile Location

2019-08-20 SOLIX Depths (m)

- 0.60 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 10.00

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1938 Map Location

1938 map provided by J.Vidler, Erieau Harbour Master

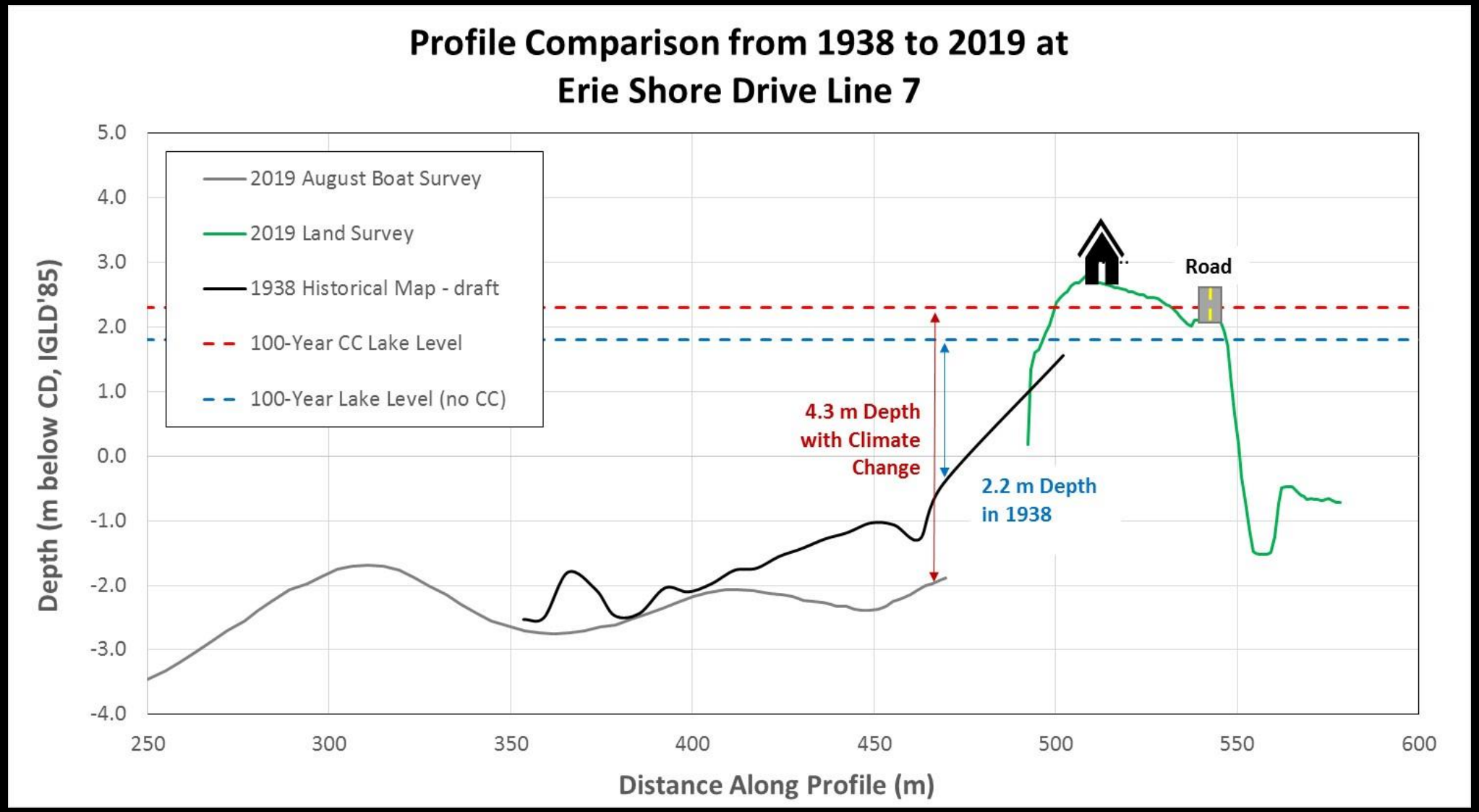
Background Image:
2015 SWOOP, provided by ECCC

DRAFT

N W E S

0 100 200
m

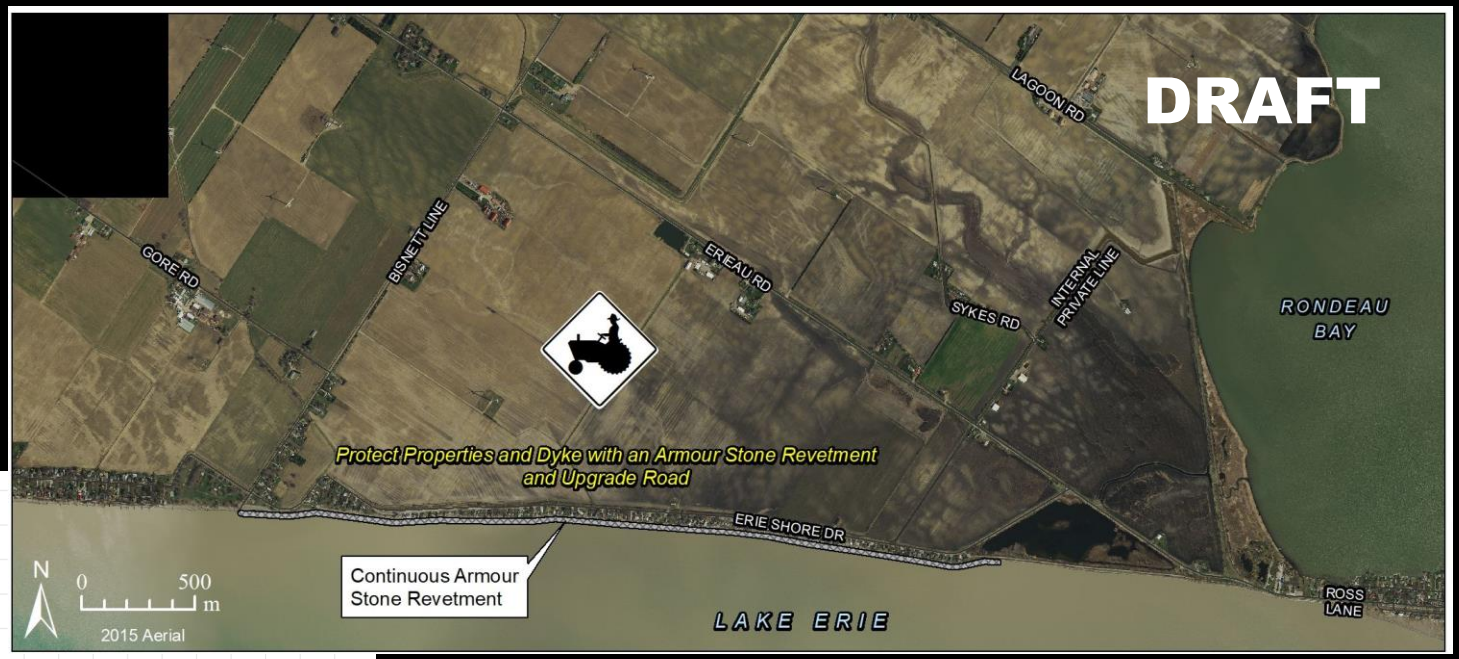
Erie Shore Drive – Line 7
1938 versus 2019 Lake Bottom

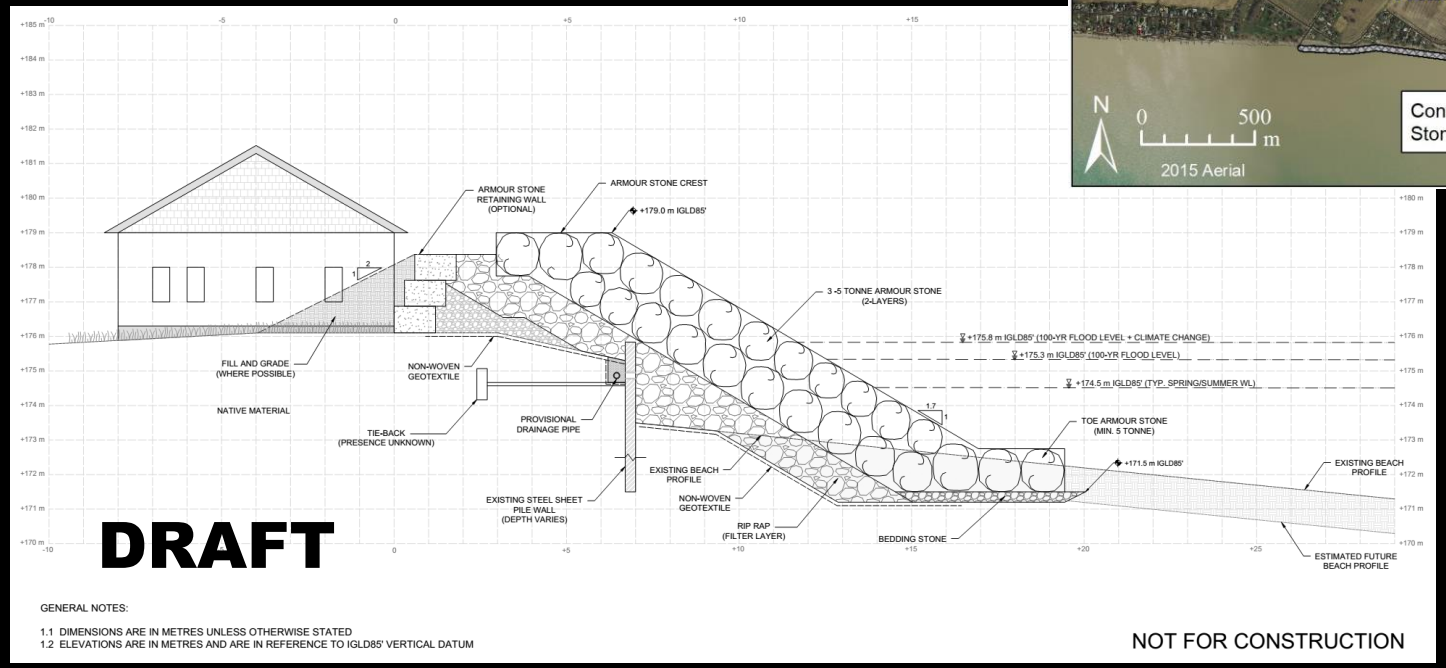


OPTION 2-1: Erie Shore Drive Armour Stone Revetment

Protect

- 3.35 km revetment
- $47 to $70 million plus annual maintenance
- Pros: Road/property protected
- Cons: Cost

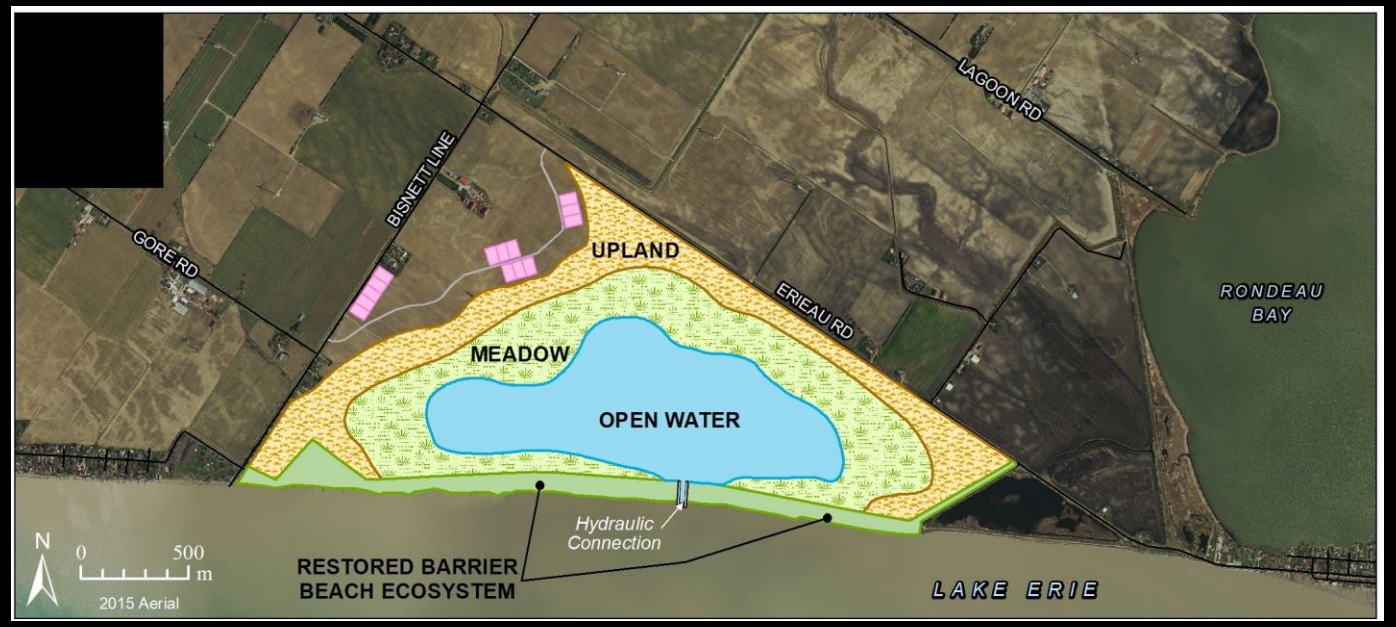




OPTION 2-3: Property Buy-outs, De-commission Road, and Re-naturalize Farmland

Transformative Adaptation

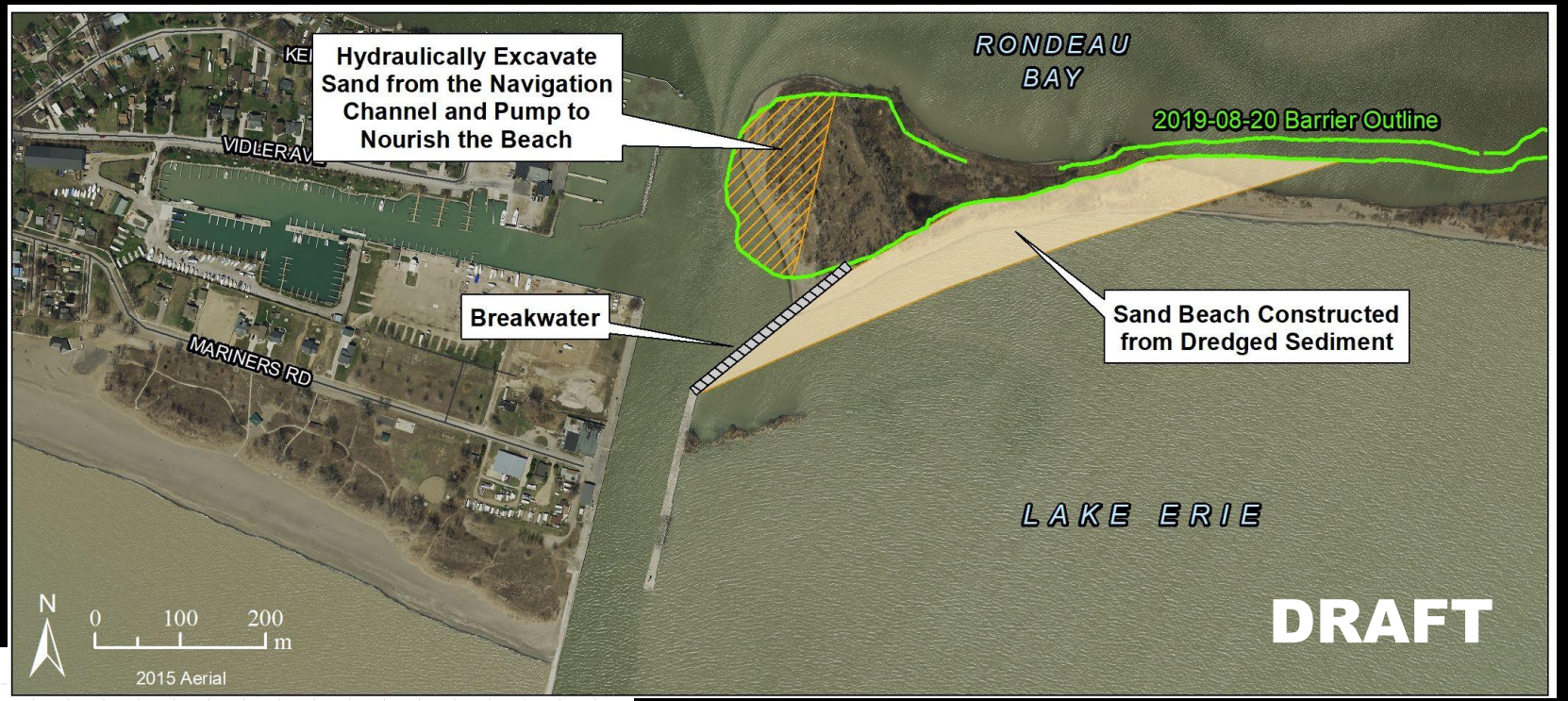
- Transformative Adaptation, 700 acre habitat restoration
- Relocate 120 residences to the NW corner
- Additional land to develop and reduce capital costs (not factored in yet)
- Pros: Eliminates threats to human safety with nature and preserves capital
- Cons: Requires significant land acquisition and relocation (change)
- $57 to $70 million
- Management of wetlands

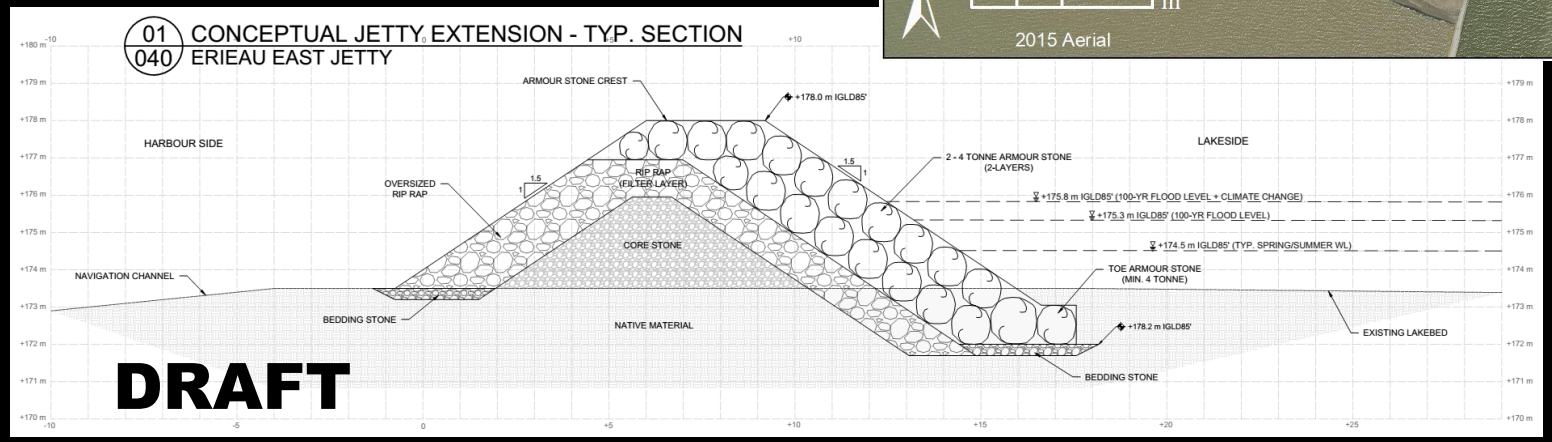


OPTION 4-3: Connect East Jetty to the Barrier Beach and Nourish with Hydraulic Dredging

Transformative Adaptation

- $2.8 to $3.5 million
- Pros: Protects fishing fleet, fuel dock, and marina. Creates a new recreational beach and habitat. Rondeau Bay communities protected
- Cons: None



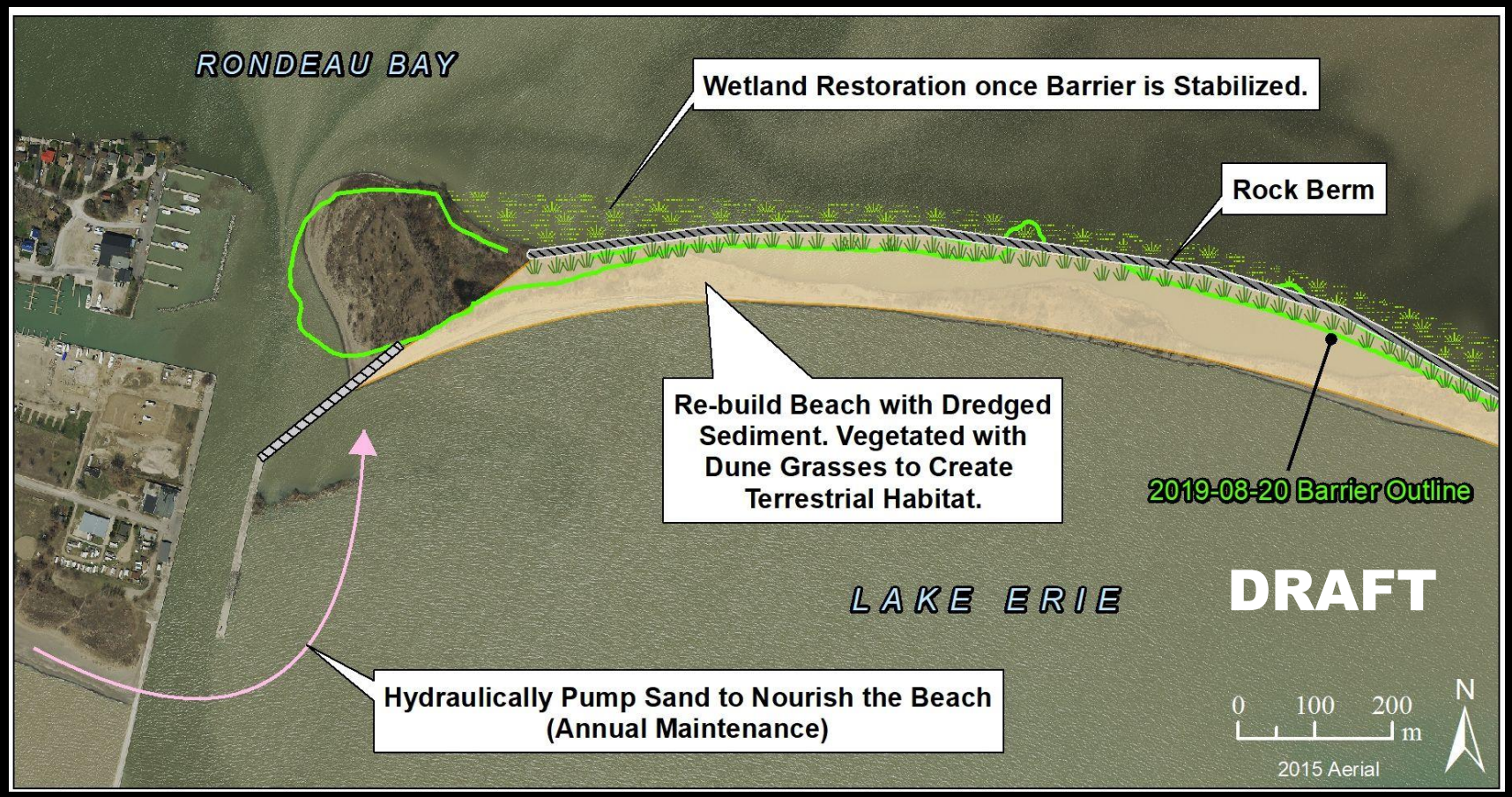


OPTION 4-3: Stabilize the Barrier Beach and Nourish with Hydraulic Dredging

Transformative Adaptation

- Pros: Restores eroded barrier beach, new recreational beach and boating destination, habitat for endangered species, and protects Rondeau Bay Communities
- $6.0 to $8.9 million

USACE e.g.: Braddocks Bay Barrier Beach, Lake Ontario



V – WHAT HAVE WE LEARNED?

Lessons Learned

- Our climate is changing in the Great Lakes
- In many locations, community resilience to coastal hazards is very low
- We assumed future erosion and flooding extremes could be predicted, and then developed our shorelines accordingly. We were wrong …
- Developing on eroding shorelines is a policy failure that must be fixed
- In our most vulnerable areas, the solutions are unaffordable
- We must learn from our mistakes and avoid making more in the future
- Municipalities and Conservation Authorities that embrace climate change and plan for uncertainty will enhance community resilience and reduce the economic burden on future generations

VI – QUESTIONS