# Sediment Budgets, SBAS, and the Great Lakes – Moving from Ontario to Superior


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# LRD and Buffalo District Committed to Regional Sediment Management Principles

- Recognize sediment as a valuable resource
- Manage sediment-related issues in an integrated fashion from upland sources to estuaries and the coast
- Project decisions involving sediment must consider the regional implications and effects over long time scales (decades).
- Take every opportunity to implement RSM principles in all projects

# Lake Erie/Ontario Sediment Budget: Project Overview

BLUF: Study of Lake Ontario and Lake Erie sediment transport processes has resulted in a treasure trove of data. Refinement of data and ease of access to interested parties is the next step in communicating with stakeholders and landowners


Historically – wide, sandy beaches
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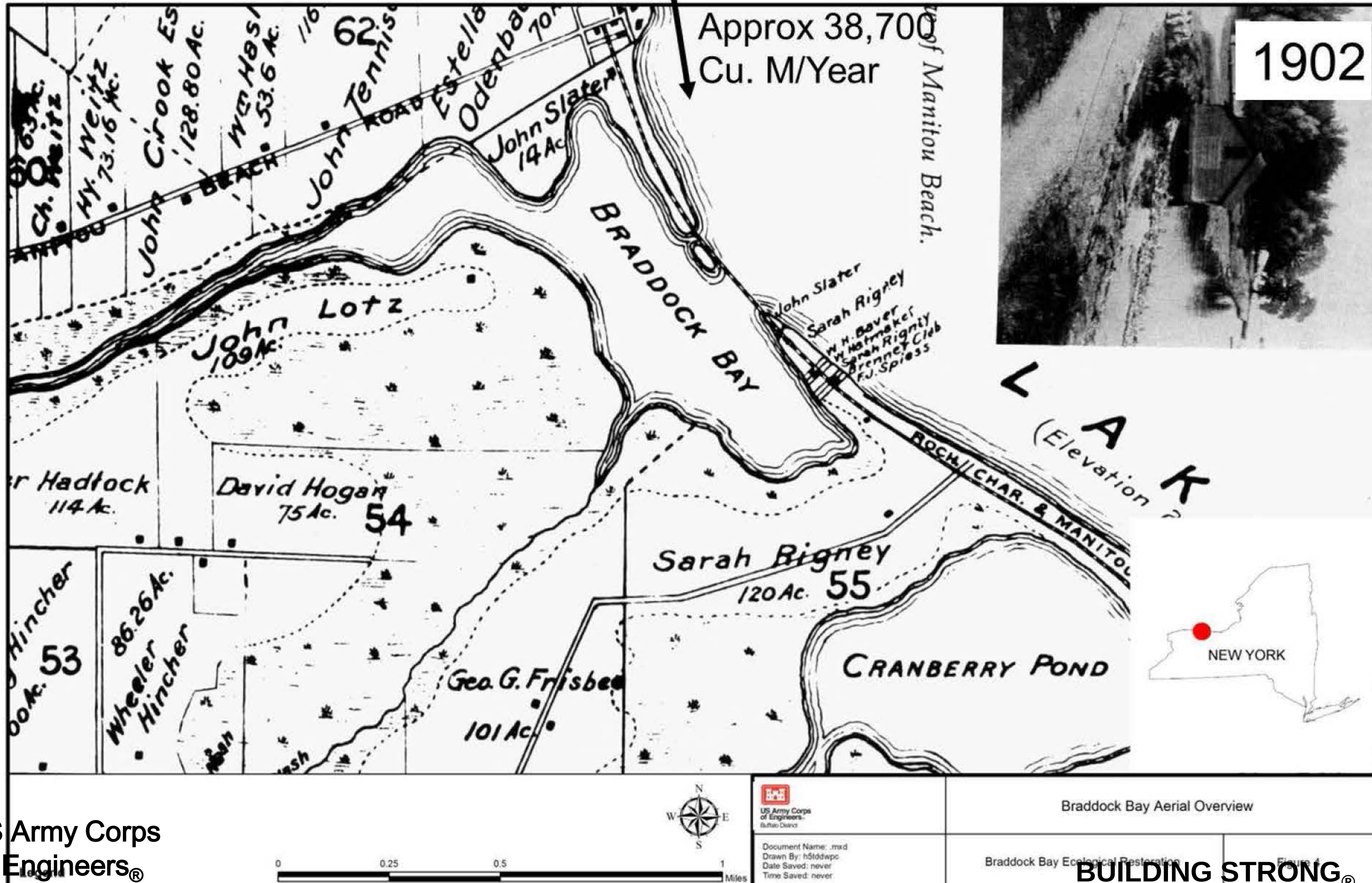
Today – Extensively hardened, sediment starved
Shore armoring / littoral barriers decrease supply

# Reduced Supply: Braddock Bay, NY

Approx 38,700 Cu. M/Year

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# Reduced Supply: Braddock Bay, NY

# Lake Erie/Ontario Waves

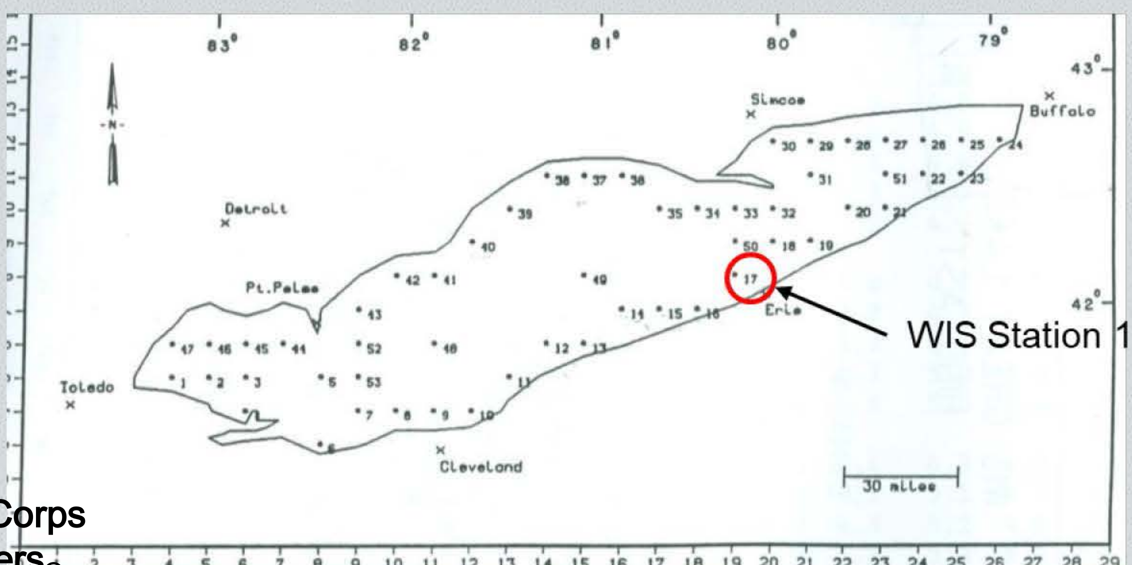
- <u>No</u> long period waves or tides
- Most wave energy comes from gravity waves (T=1-10 sec)
- Net result:
  - Little to no depositional wave energy
  - Net crossshore transport of sediment is almost always lakeward

STATION E17 42.15N 80.35W FOR ALL DIRECTIONS
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

| HEIGHT(METRES) | <3.0 | 3.0-3.9 | 4.0-4.9 | 5.0-5.9 | 6.0-6.9 | 7.0-7.9 | 8.0-8.9 | 9.0-9.9 | 10.0-10.9 | 11.0-LONGER | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00-0.24 | . | 242 | 11 | 3 | . | . | . | . | . | . | 256 |
| 0.25-0.49 | . | 1102 | 73 | 32 | 1 | . | . | . | . | . | 1208 |
| 0.50-0.74 | . | 1731 | 497 | 221 | 25 | . | . | . | . | . | 2474 |
| 0.75-0.99 | . | 566 | 496 | 274 | 56 | . | . | . | . | . | 1392 |
| 1.00-1.24 | . | 77 | 880 | 418 | 170 | 8 | . | . | . | . | 1553 |
| 1.25-1.49 | . | . | 210 | 358 | 127 | 14 | . | . | . | . | 709 |
| 1.50-1.74 | . | . | 36 | 516 | 239 | 42 | 1 | . | . | . | 834 |
| 1.75-1.99 | . | . | . | 143 | 242 | 44 | 2 | . | . | . | 431 |
| 2.00-2.24 | . | . | . | 47 | 350 | 68 | 6 | . | . | . | 471 |
| 2.25-2.49 | . | . | . | . | 122 | 86 | 7 | . | . | . | 215 |
| 2.50-2.74 | . | . | . | . | 36 | 145 | 14 | . | . | . | 195 |
| 2.75-2.99 | . | . | . | . | 6 | 63 | 14 | . | . | . | 83 |
| 3.00-3.24 | . | . | . | . | 2 | 37 | 37 | . | . | . | 76 |
| 3.25-3.49 | . | . | . | . | . | 5 | 22 | . | . | . | 27 |
| 3.50+ | . | . | . | . | . | 2 | 39 | 6 | . | . | 47 |
| TOTAL | 0 | 3718 | 2203 | 2012 | 1376 | 514 | 142 | 6 | 0 | 0 | |

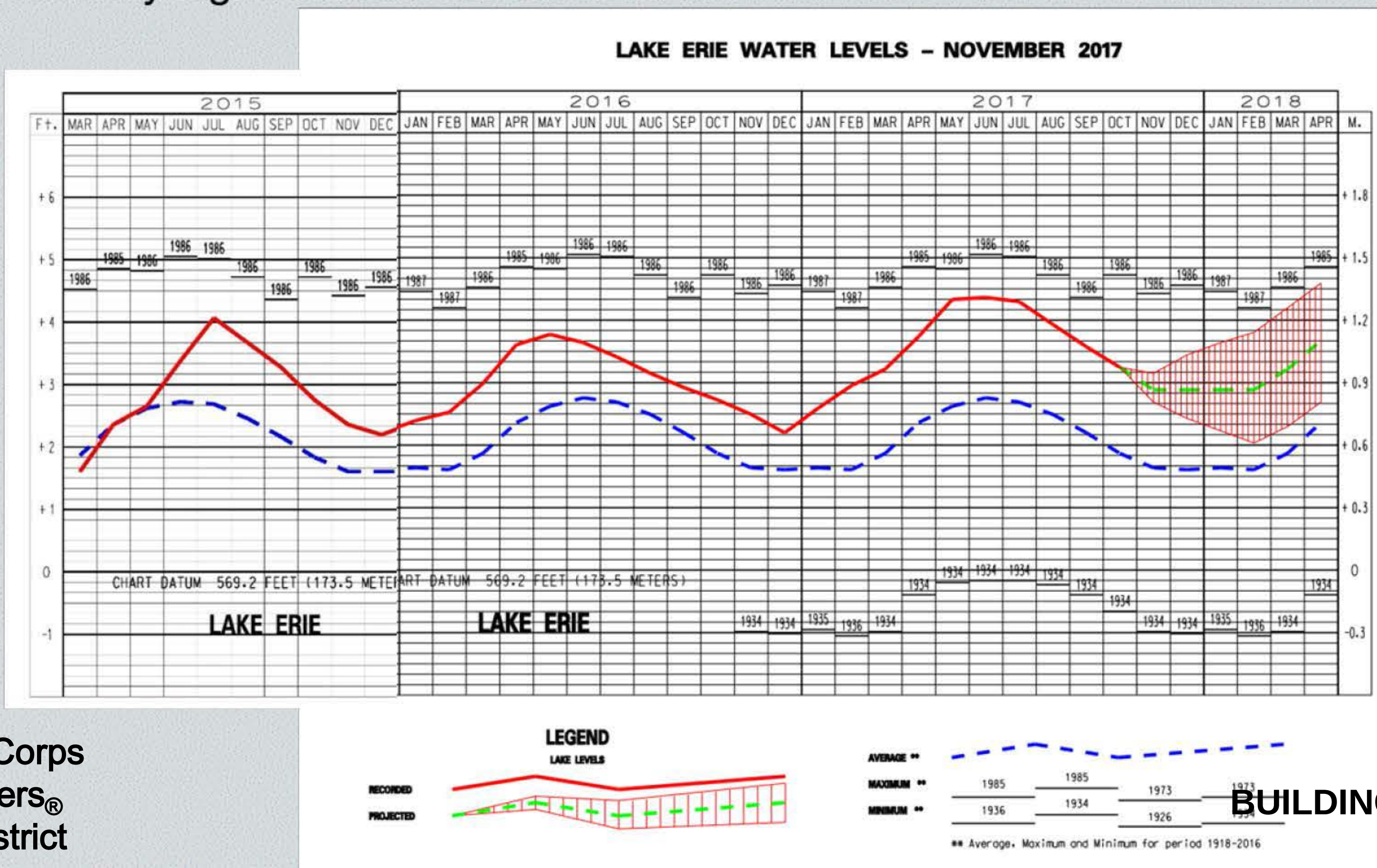
MEAN HS(M)= 1.1 LARGEST HS(M)= 5.6 MEAN TP(SEC)= 4.3 TOTAL CASES= 93504.

Max T: 9.9 sec
Mean T: 4.3 sec



# Lake Erie Water Levels

- <u>No control of water level</u>
- Ice
  - Lake freezes most years, providing some protection during winter storms
- Persistently high water levels since 2015

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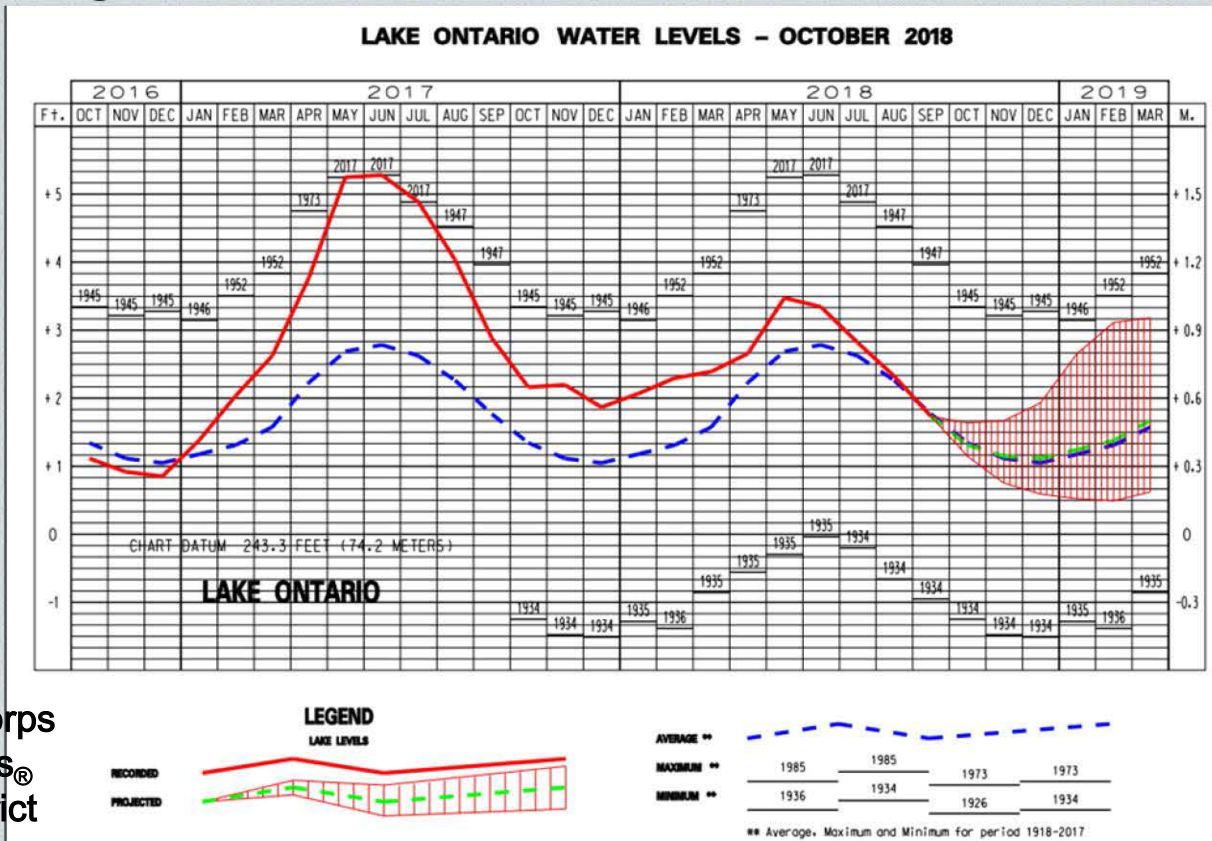
# Lake Ontario Water Levels

- <u>Some control of water levels</u> via the Moses-Saunders Dam, but still at the will of nature
- Ice
  - Shorefast ice most winters, rare for lake to freeze over
- Record high water levels, 2017

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# Lake Ontario Water Levels

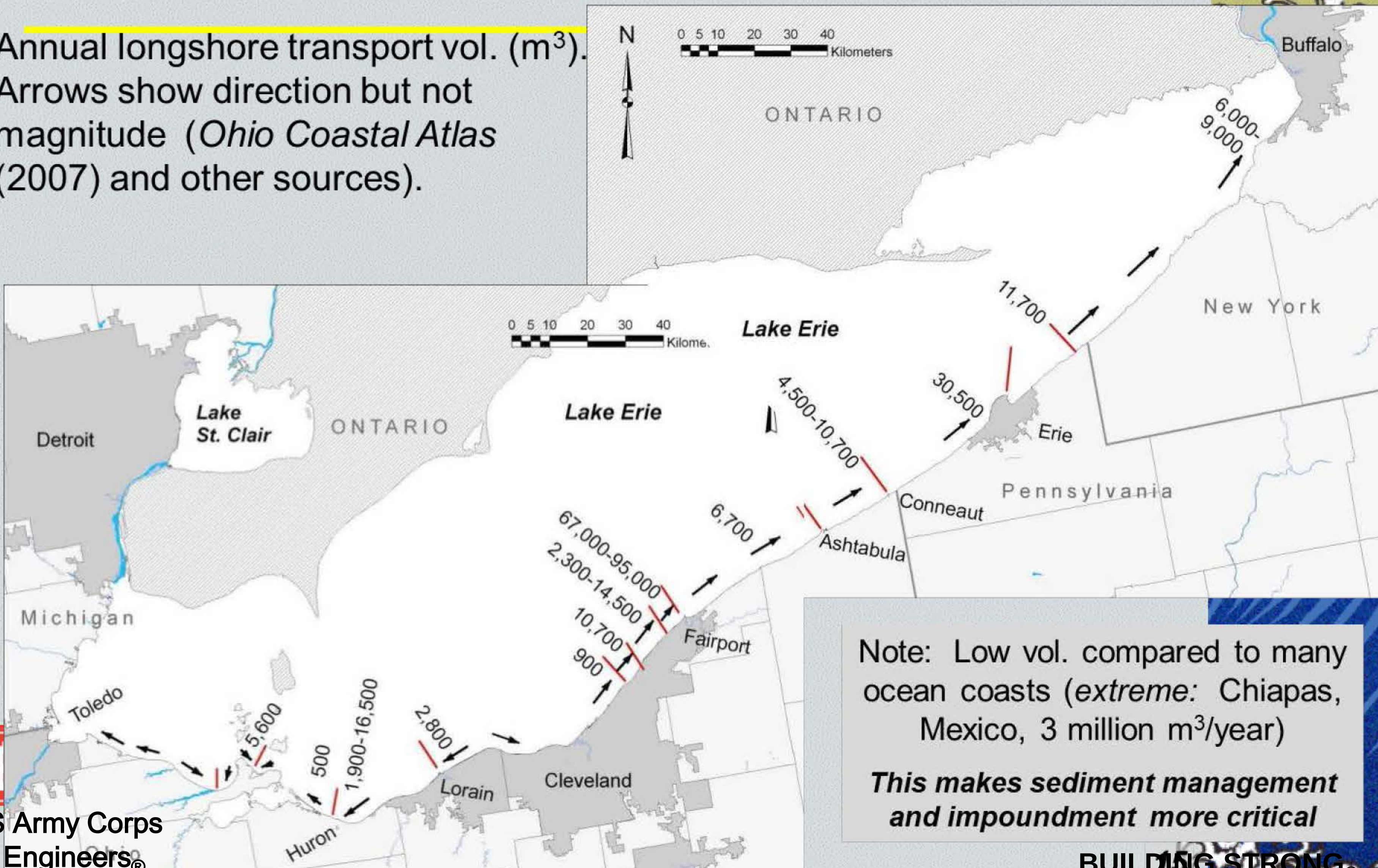
High water leading to increased demands for Armoring


19
Rd

Need for proper understanding of littoral volumes!

# Longshore Sediment Transport

Annual longshore transport vol. ($m^3$). Arrows show direction but not magnitude (*Ohio Coastal Atlas* (2007) and other sources).




Note: Low vol. compared to many ocean coasts (*extreme:* Chiapas, Mexico, 3 million $m^3$/year)

***This makes sediment management and impoundment more critical***

# Sediment Sources and Losses

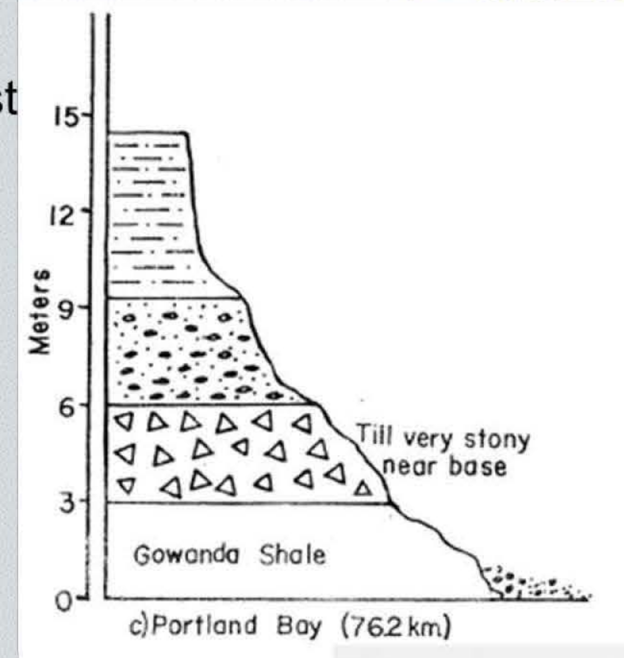
- **Sediment sources:**
  - Material brought down rivers (mostly fine-grained)
  - Industrial dumping and runoff from sewers
  - **Gravel, sand, clay eroded from glacial till bluffs and banks**
  - **Sediment created in situ from bedrock bluff weathering**
  - Limited supply from lake bed lowering and offshore outcrops
- **Sediment losses:**
  - **Wave- and ice-induced transport into deep water**
  - **Material trapped in fillets at harbor jetties**
  - Material dredging from harbor entrance channel and placed in confined disposal facilities or placed in deep water
  - Bluff armoring
  - Beach mining (no longer a factor)

# Geology and Shore Types

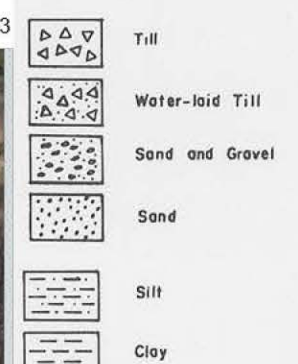
Three dominant geological processes and timeframes:

- Post Glacial Deposits
- Glacial Deposits
- Bedrock

Youngest ↑ Oldest



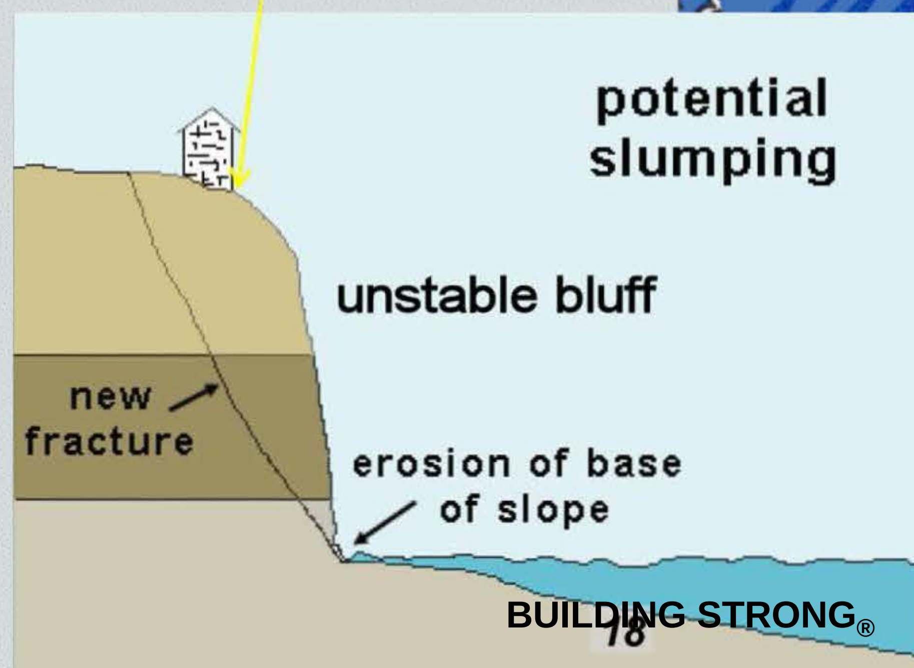

From: Geier and Caulkin, 1983



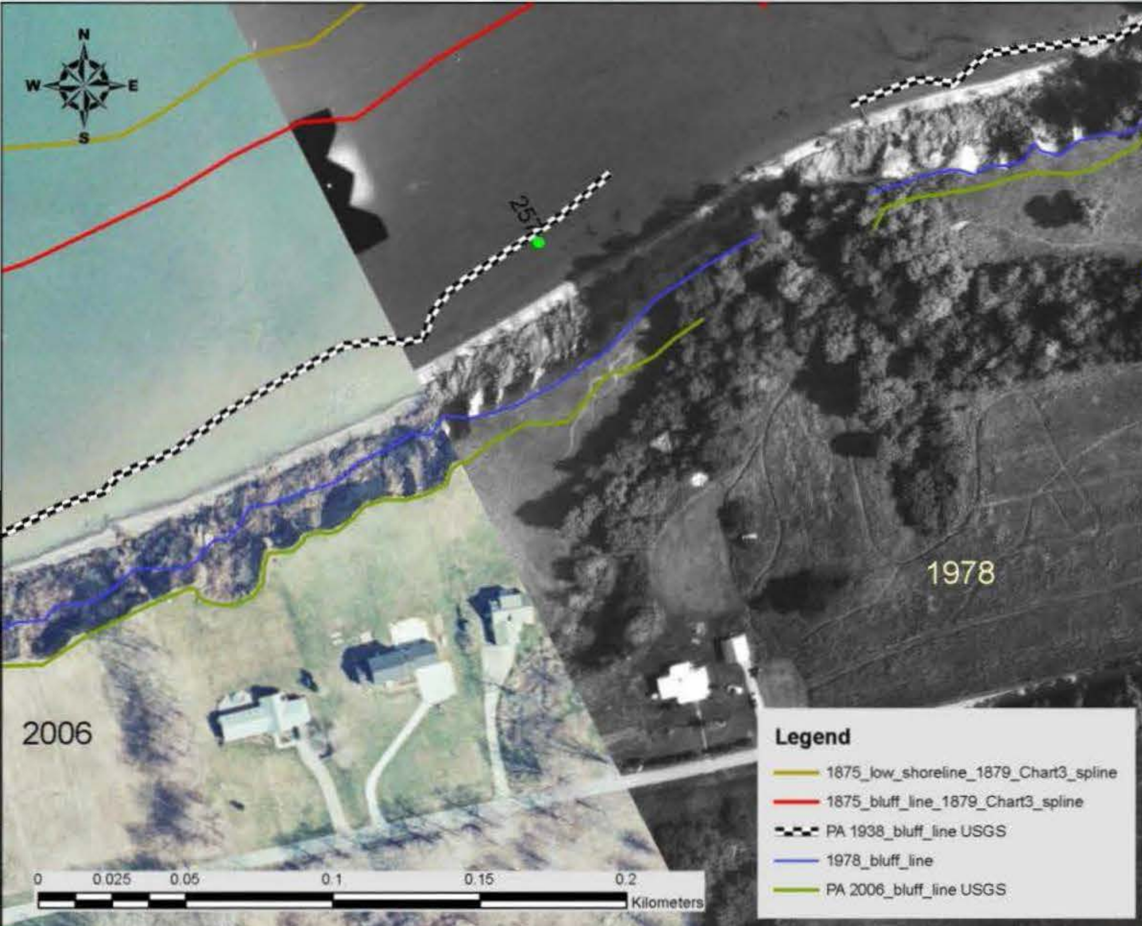

# Bluff Recession

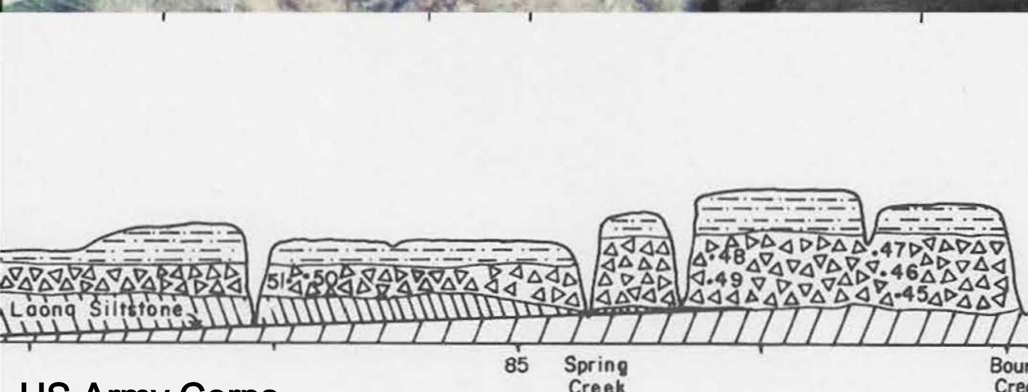
Showse Park, east of Vermilion, OH, August 1999. Low-grade, friable shale weathers from wave impact, groundwater percolation, and freeze-thaw cycles.

Bluff edge



# Bluff Recession




**Approach**

- Bluff line change measured over time
    - NOAA 1870's Coast Charts
    - Aerial imagery – 1930s, 1970s
- Stratigraphy acquired to determine bluff height and composition
- Coarse fraction estimated from parent material

# Determination of Bluff Volume

**Approach**

- Each 1-km reach used:
  - Bluff Height
  - Bluff Composition
  - Recession Rate

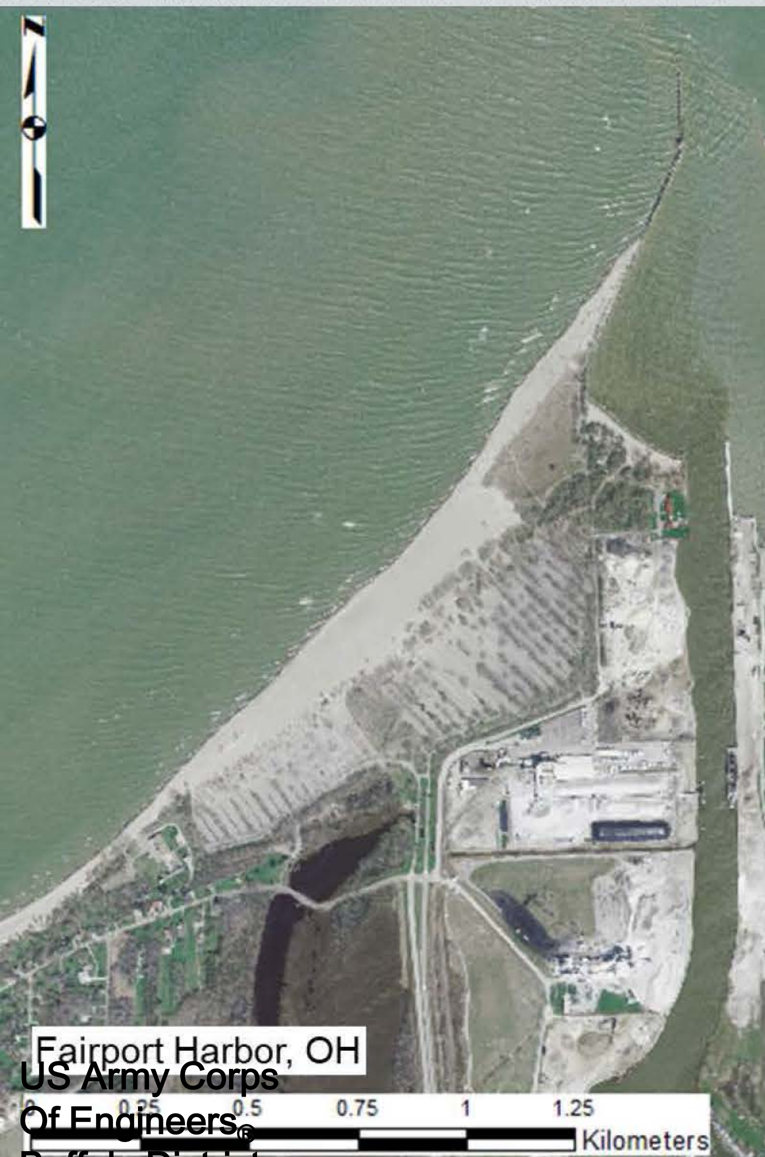
Coarse fraction factor:

| | |
|---|---|
| Shale: | 0.3 – 0.5 |
| Till: | 0.2 - 0.27 |
| Lacustrine: | 0.1 |
| Sand and gravel: | 0.95 |

$$Sed\_vol = Strata\_ht \times Factor \times Recession\_rate \times Effective\_reach\_length$$

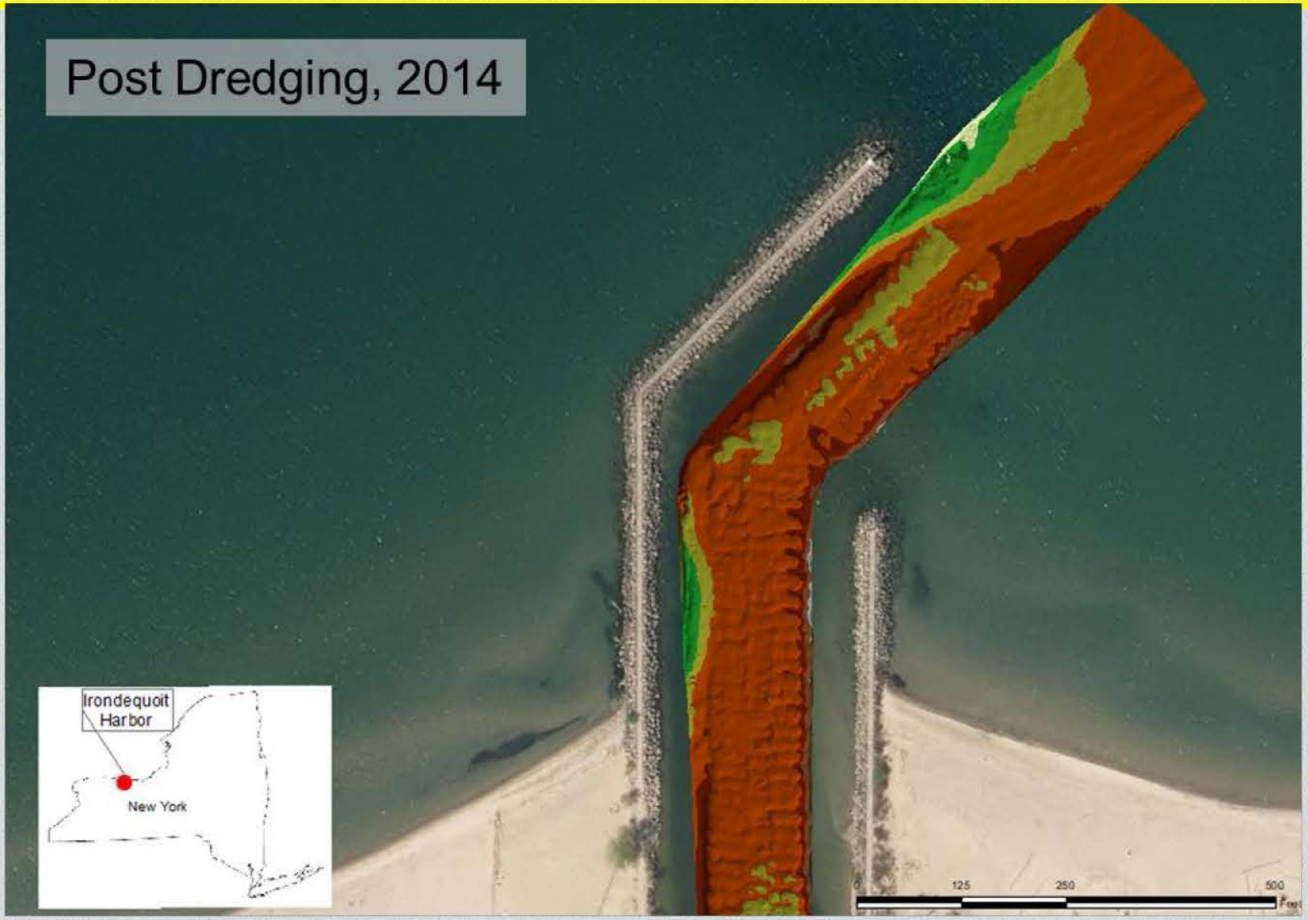
- Coarse and fine fractions determined from stratigraphy
  - Fines are lost offshore to deep water
  - 20% of coarse component lost offshore to deep water due to storm waves (Based on USACE Buffalo District 1984)

# Sediment Sink: Trapping at Harbor Mouths





# Sediment Sink: Trapping in Federal Channel

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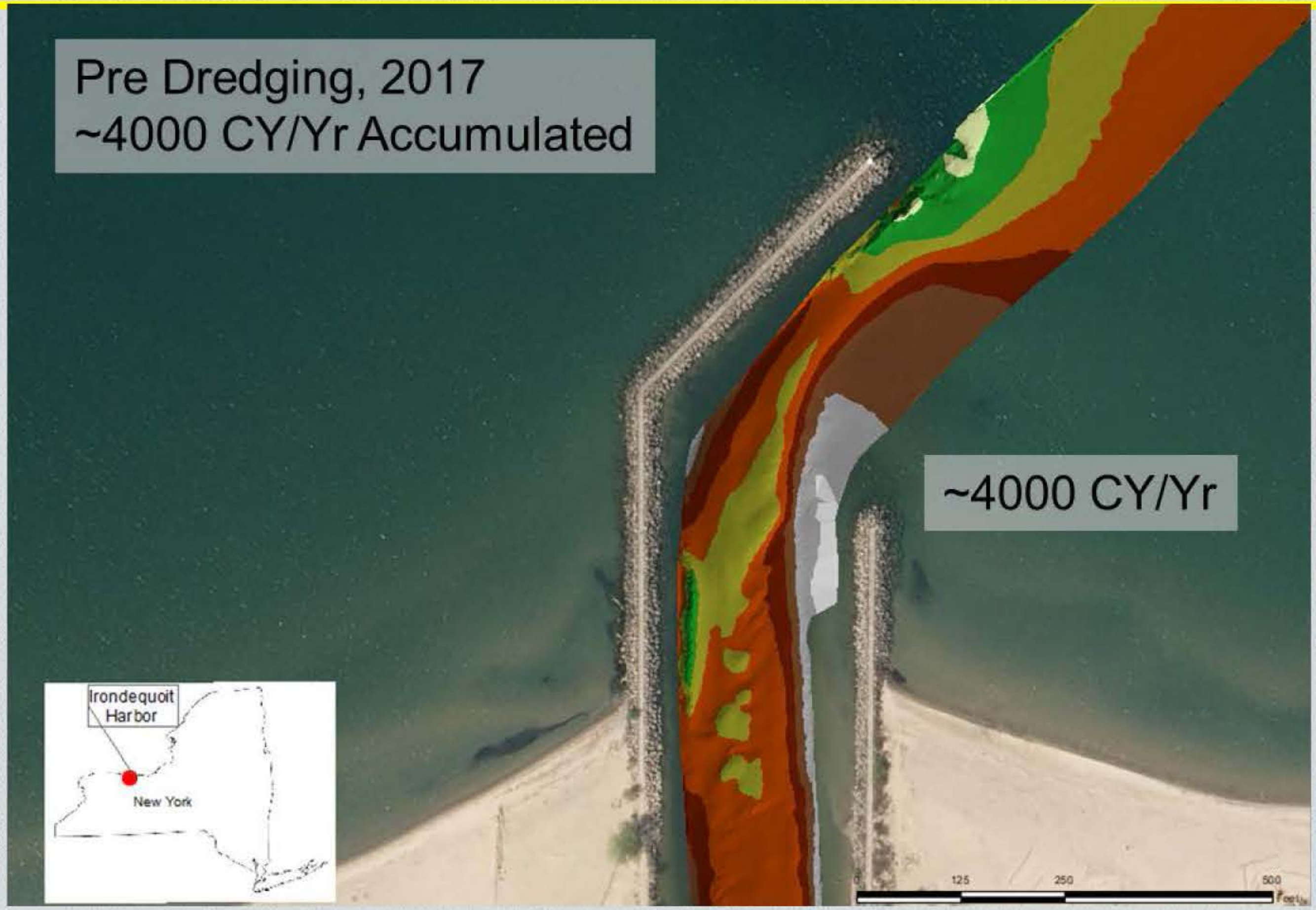
# Sediment Sink:
# Trapping in Federal Channel

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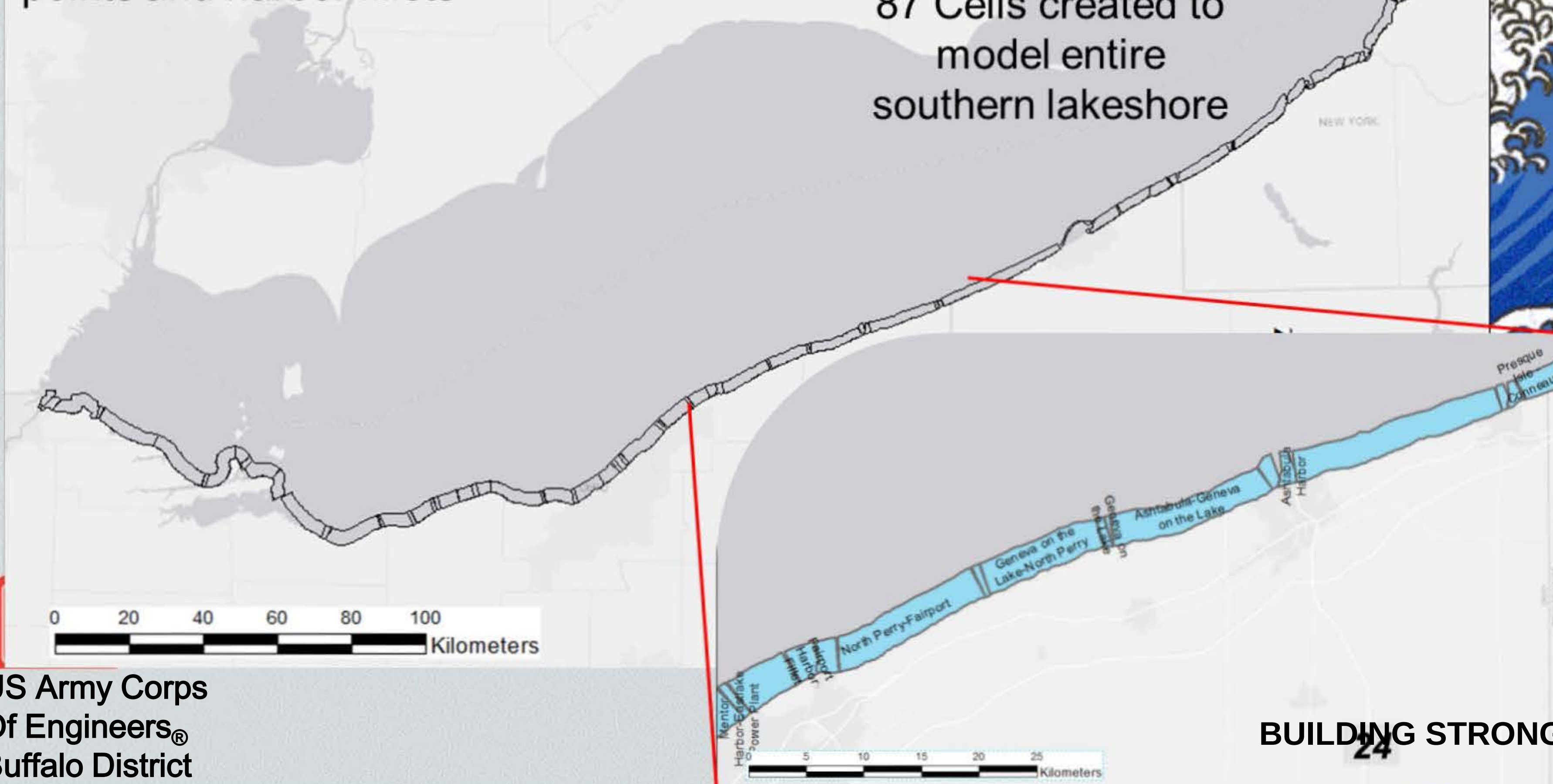
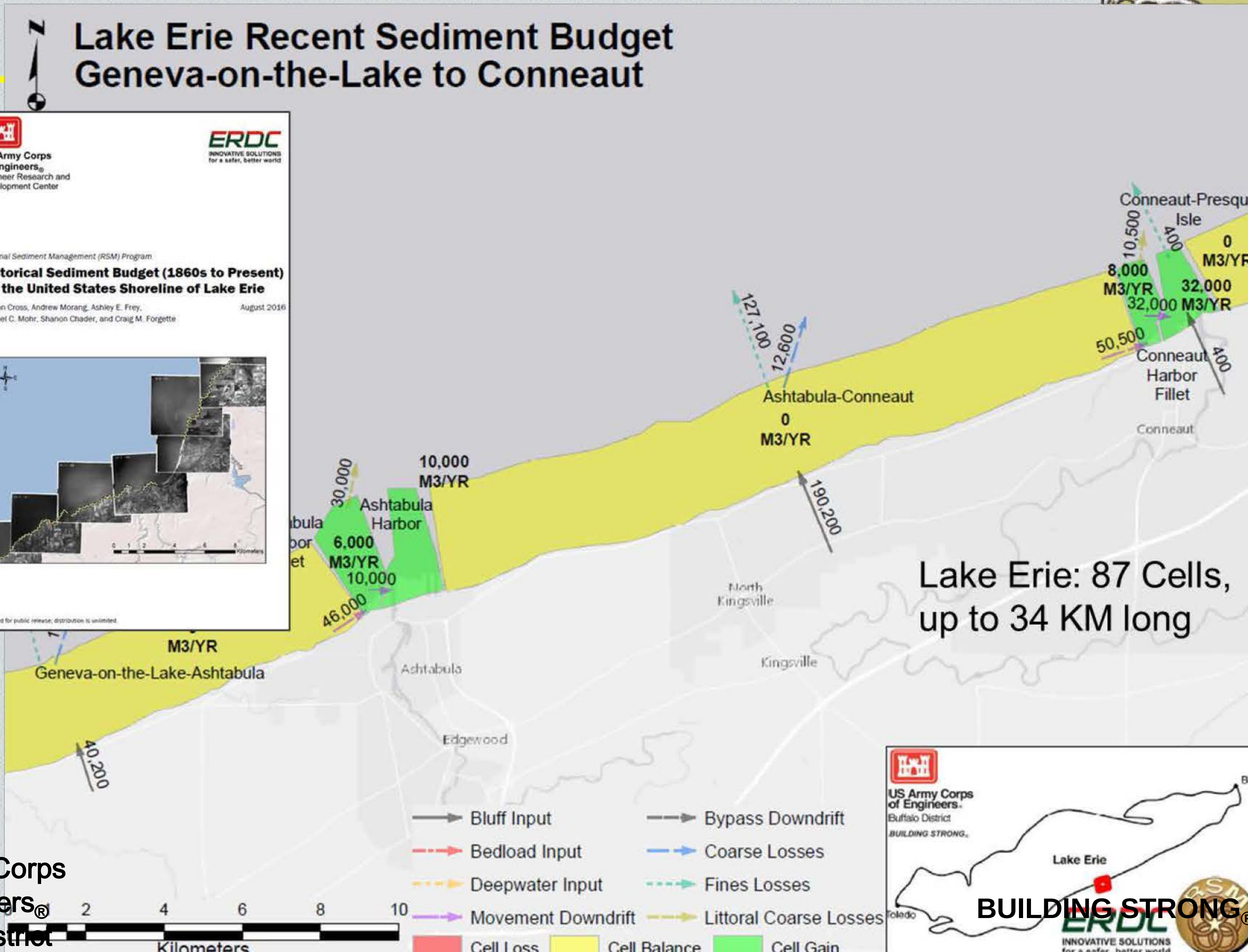
# 2011-2016 Work: Sediment Budget Cells/Fluxes

- For most of the shoreline, Cells bounded by harbor structures
- Additional cells delineated by nodal points and harbor fillets



# 2016: Completed Sediment Budget




ERDC/CHL TR-16-15

Coastal and Hydraulics Laboratory

US Army Corps of Engineers® Engineer Research and Development Center

ERDC INNOVATIVE SOLUTIONS for a safer, better world

*Regional Sediment Management (RSM) Program*

**Historical Sediment Budget (1860s to Present) for the United States Shoreline of Lake Erie**

Weston Cross, Andrew Morang, Ashley E. Frey, Michael C. Mohr, Shanon Chader, and Craig M. Forgette

August 2016

Approved for public release; distribution is unlimited.

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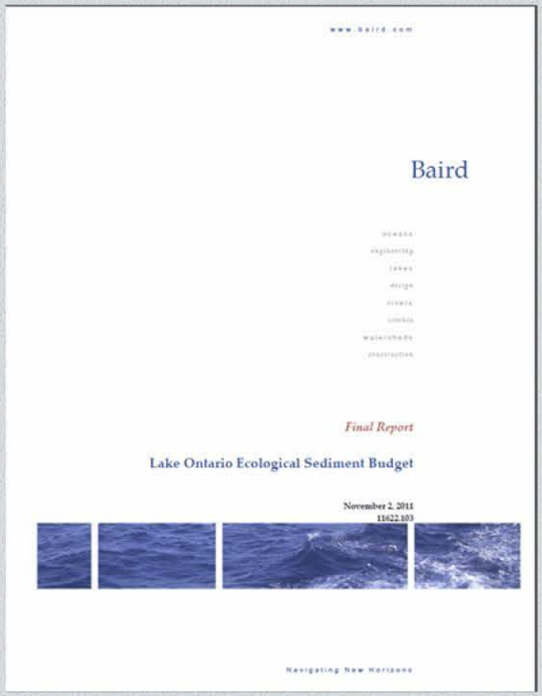
# 2011: Completed Sediment Budget


www.baird.com

Baird

*Final Report*

Lake Ontario Ecological Sediment Budget

November 2, 2011

11622.103

Navigating New Horizons

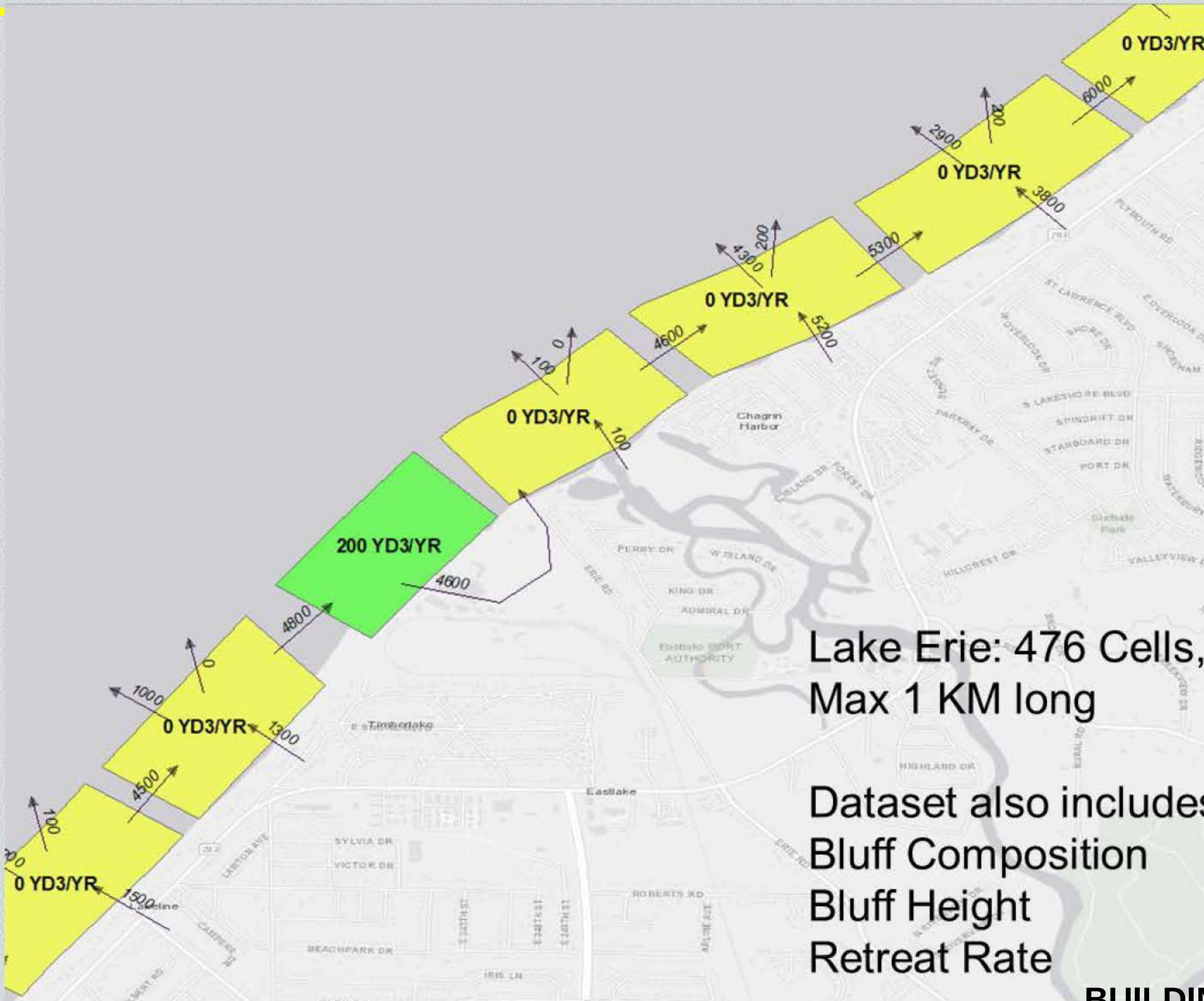
**Table B3 Lake Ontario Annual Sediment Budget (Existing)**

| Existing | | SOURCES | | SINKS | | *All values in 1,000 m³/year* | |
|---|---|---|---|---|---|---|---|
| Sub Cell | Input from Updrift Sub-Cell** | Bluff Recession | Lakebed Downcutting | Fillet Beaches | Harbor Sedimentation | Output to Downdrift Sub-Cell** | Δ |
| Niagara - Wilson*** | 0.0 | 0.3 | 0.1 | 0.1 | 0.1 | 0.3 | 0.3 |
| Wilson - Olcott | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | -0.1 |
| Olcott - Pt Breeze | 0.2 | 1.4 | 0.2 | 0.3 | 0.2 | 1.4 | 1.1 |
| Pt Breeze - Genesee | 1.4 | 2.8 | 0.1 | 1.8 | 1.8 | 0.6 | -0.7 |
| Genesee - Irondequoit | 0.6 | 0.0 | 0.0 | 0.6 | 0.5 | 0* | -0.6 |
| Irondequoit - Sodus Bay | 0.0 | 4.2 | 0.1 | 0.7 | 0.0 | 3.7 | 3.7 |
| Sodus Bay - Little Sodus | 3.7 | 18.8 | 0.1 | 0.6 | 0.1 | 21.9 | 18.3 |
| Little Sodus - Oswego | 21.9 | 7.9 | 0.1 | 0.0 | 1.6 | 28.3 | 6.4 |
| Oswego - ELO | 28.3 | 10.5 | 0.0 | 0.0 | 0.0 | 38.9 | 10.5 |

* Unknown input required to balance budget
** Assumes sediment bypassing at harbors (no numerical modeling completed to confirm this assumption)
*** Potential inputs from shoreline west of the Niagara River not quantified in this study

Lake Ontario: 7 Cells, up to 55 KM long

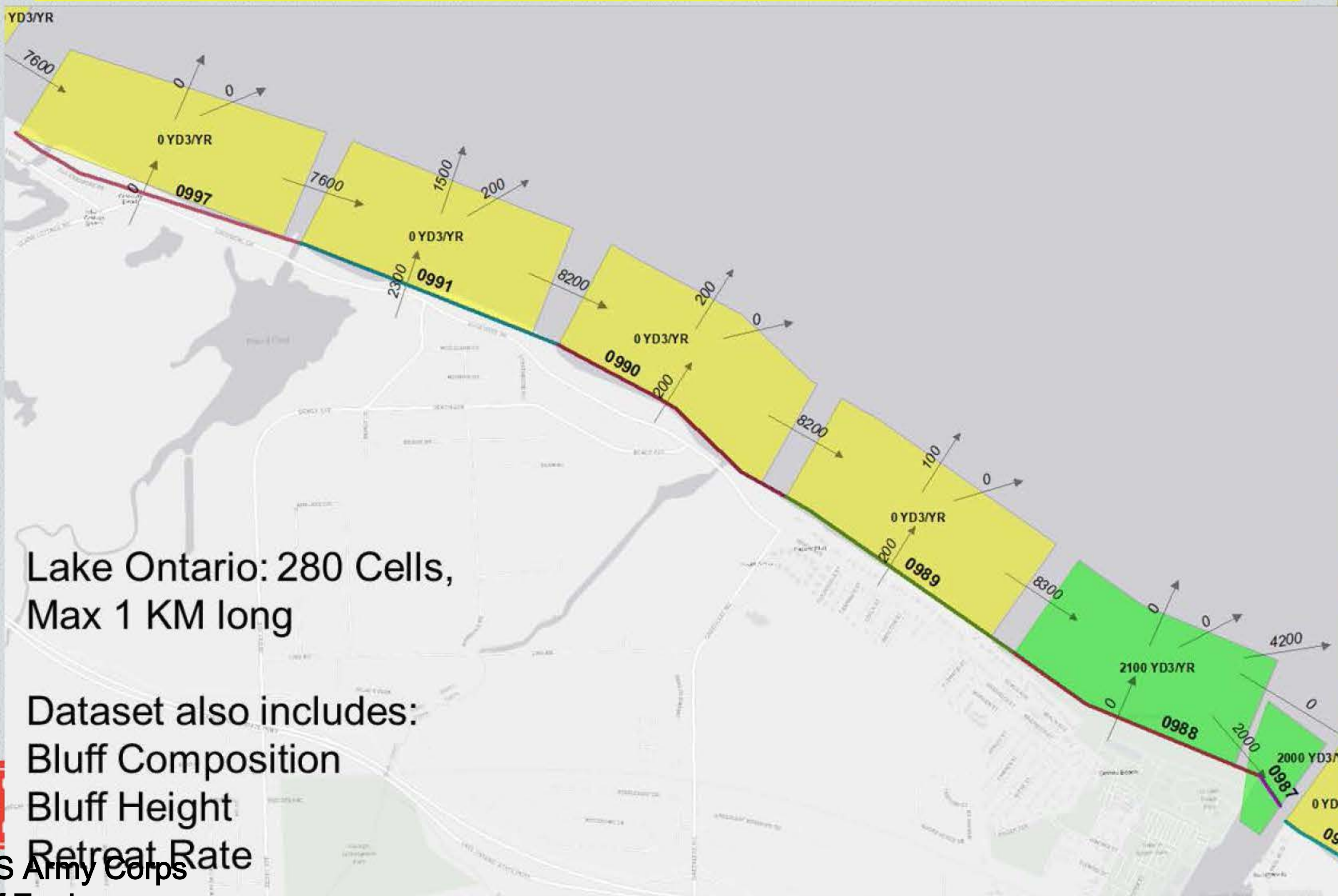
# 2018: Completed Sediment Budget




Lake Erie: 476 Cells,
Max 1 KM long

Dataset also includes:
Bluff Composition
Bluff Height
Retreat Rate

# 2018: Completed Sediment Budget




Lake Ontario: 280 Cells, Max 1 KM long

Dataset also includes:
Bluff Composition
Bluff Height
Retreat Rate

# Future Research Needs

Shale bluff erosion contribution to the littoral system


# Future Research Needs

Bypassing of sediment and loss at deep draft commercial harbors



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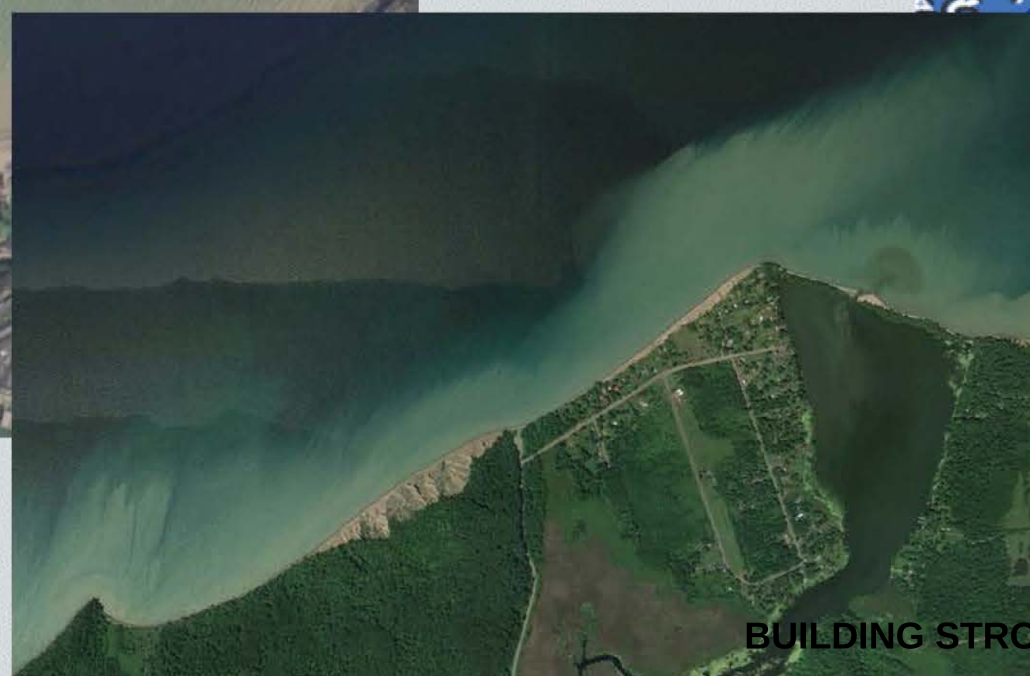
# Future Research Needs

Sediment plumes and losses at headlands

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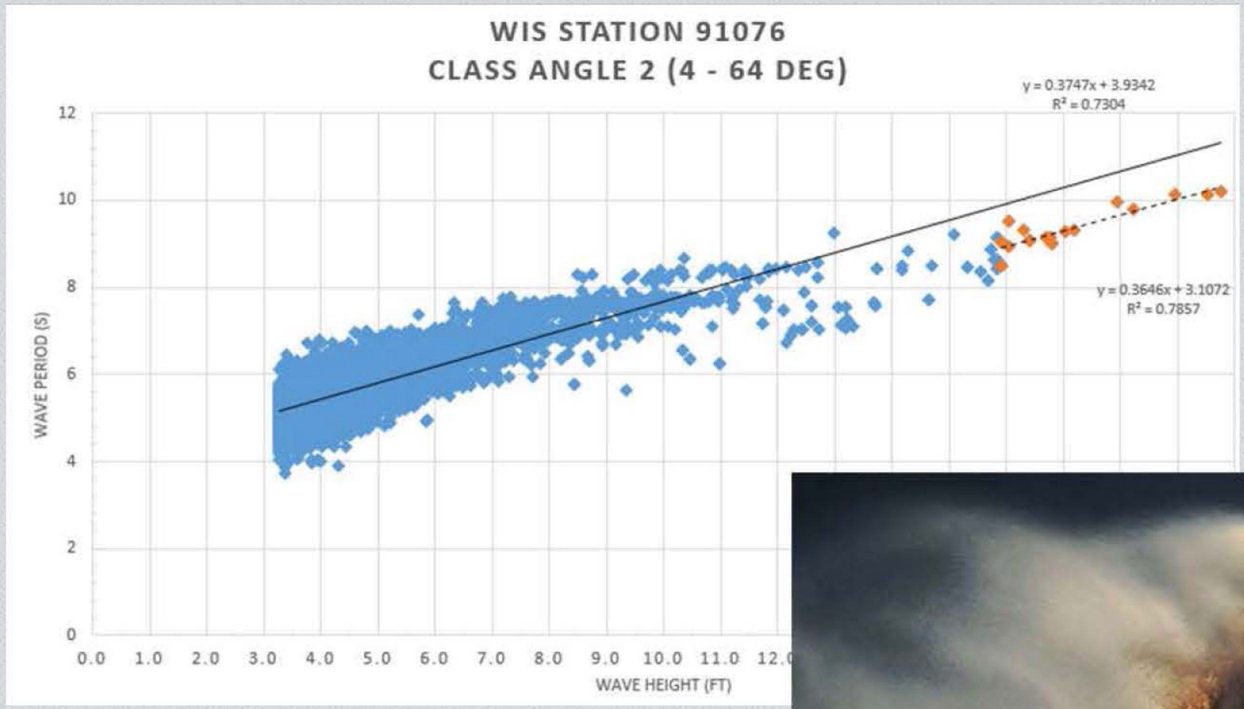
# Future Research Needs

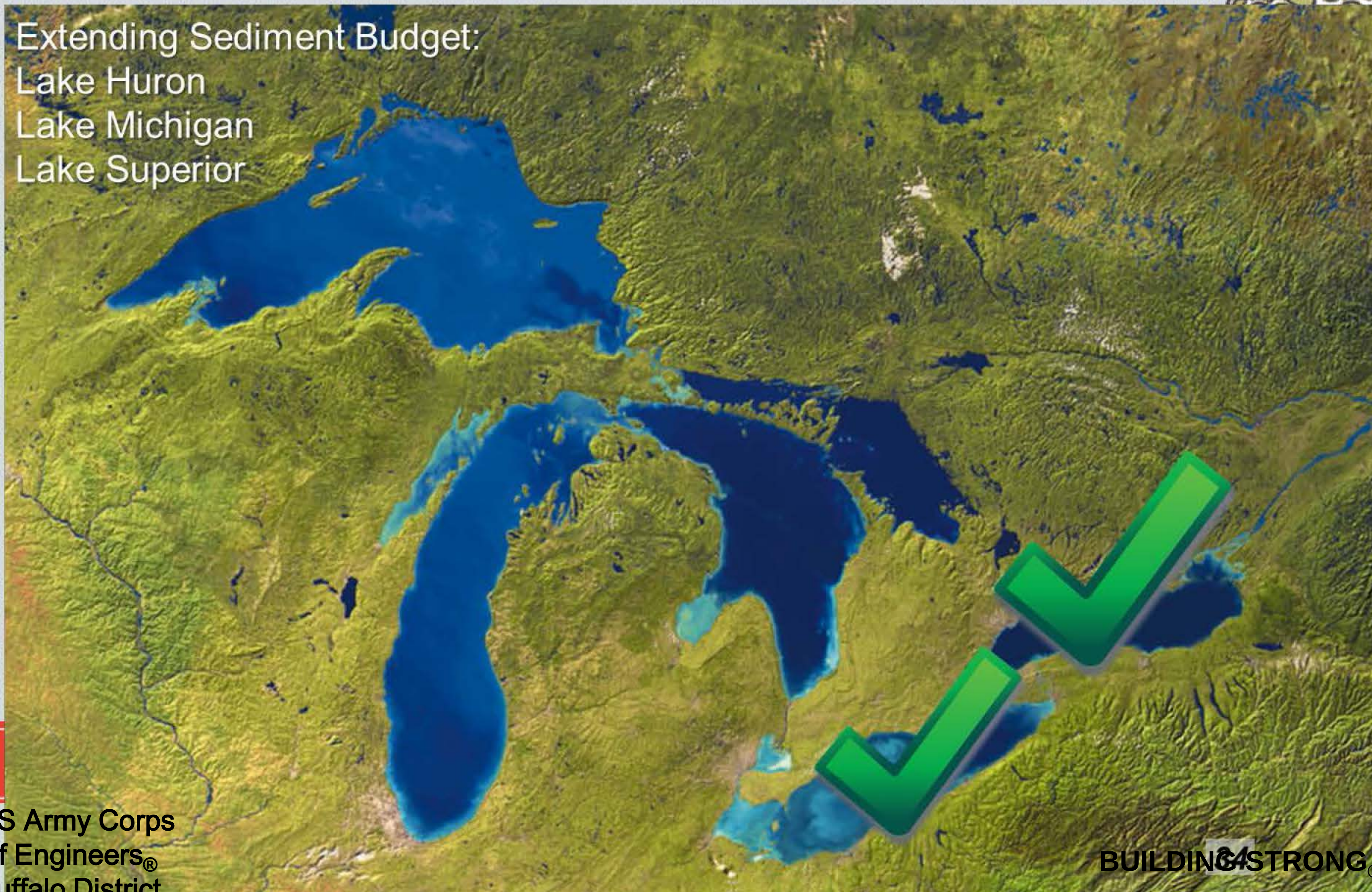
Better quantification of coarse material lost due to short period waves




# 2019: Completed Sediment Budget

- ~~Increased awareness among stakeholders/planners/land users~~ about coastal design parameters
- Greatly improved understanding of impacts of projects on greater system
- Identification of sources of sediment for bypassing/beneficial reuse
- Use in USACE coastal design

# Where to next……



# *Questions?*