Bluff Erosion along Lake Michigan in Ozaukee County, WI

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Causes

- wind erosion
- bluff slumping
- sliding
- toe erosion
- surface water runoff
- rain, rill and gully erosion
- groundwater seepage and septic outflow
- wave attack
- water level
Processes

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**Subaerial**

- **Surface Erosion**
  - Freeze/thaw
  - Runoff
  - Groundwater
- **Toe Erosion**

**Subaqueous**

- **Wave Impact Height**
  - Wave
  - Water level
  - Runup
  (Beach, Bathymetry)

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**Lakebed Downcutting**

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**Slope Stability**

- Stratigraphy
- Composition
Bluff Failure Cycle

1. **PHASE 1**: Unstable bluff with high likely-hood of failure

2. **PHASE 2**: Material move in a process called "mass wasting"

3. **PHASE 3**: Wave erosion of toe begins

4. **PHASE 4**: Wave erosion continues, lower bluff steepens

5. **PHASE 5**: Both toe and eventually the top of the bluff move ever-inland

6. **PHASE 6**: Unstable bluff with high likely-hood of failure

Bluff Crest Recession

Bluff Toe Recession
Shoreline Type and Erosion Rate

Water Level

0.08 ~ 1.52 m/year
(Epoch 1875 ~ 1995)

2-3 times higher
(Epoch 1966 ~ 1975)
Case (i): Port Washington, WI

Long-Shore Distance (m)
Recession Rate (m/yr)
Average Annual Recession Rate

Toe Recession
Crest Recession

North of Harbor
WE Energy
Waukesha Bank
Lions Den Gorge

Harbor

1995 - 2010

Accrete
Erode
Bluff Profiles

Beach Widths Vary

Horizontal Distance

Elevation (m)
Badger-Streamer

Long-shore Sediment Transport
Regional Sediment Budget

Unstable Steep Bluff

Bluff Crest Erosion

Bluff Toe Deposition

Beach Formation

Long-shore Transport

Cross-shore Transport

Graph showing changes in water levels over time.
Bluffs at the north and south respond differently.
• Drainage tile system performed well.
• Bluff enhancement increased *slope stability*. 

![Diagram showing groundwater table and depth measurements.](image-url)
Regional Sediment Budget

Unstable Steep Bluff

Bluff Crest Erosion

Bluff Toe Deposition

Beach Formation

Long-shore Transport

Cross-shore Transport
Case (iii): Plot Scale Revetment

225’

400’

440’
Summary

- **Causes**
- **Processes**
- **Cycle**

**Recession Rate**

**Regional Sediment Budgets**

*Port Washington  Concordia Univ.  Plot Scale*
Regional Integrated Bluff Management (IBM)