Shoreline Erosion

January 19, 2023

Joseph Keller, Executive Director, Fox Waterway Agency

Rob Bowman, Superintendent, Fox Waterway Agency

Jeff Boeckler, Northwater Consultants

Brian Valleskey, Geosyntec Consultants

Introduction

Joseph Keller

Executive Director

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Goals

Educational series to bring awareness on topics on water quality that tie in to the development of a Watershed Plan.

The goal of the watershed plan is to bring funding to the area to implement projects that will improve water quality.

Successful project implementations will ….

- ✓ Make our water clear enough to see the bottom in shallow water
- ✓ Make our water clean enough to limit or eliminate algae blooms
- ✓ Make our water clean enough that there are no restrictions for boating, swimming, fishing, or any other type of recreational use.

Rob Bowman

Superintendent
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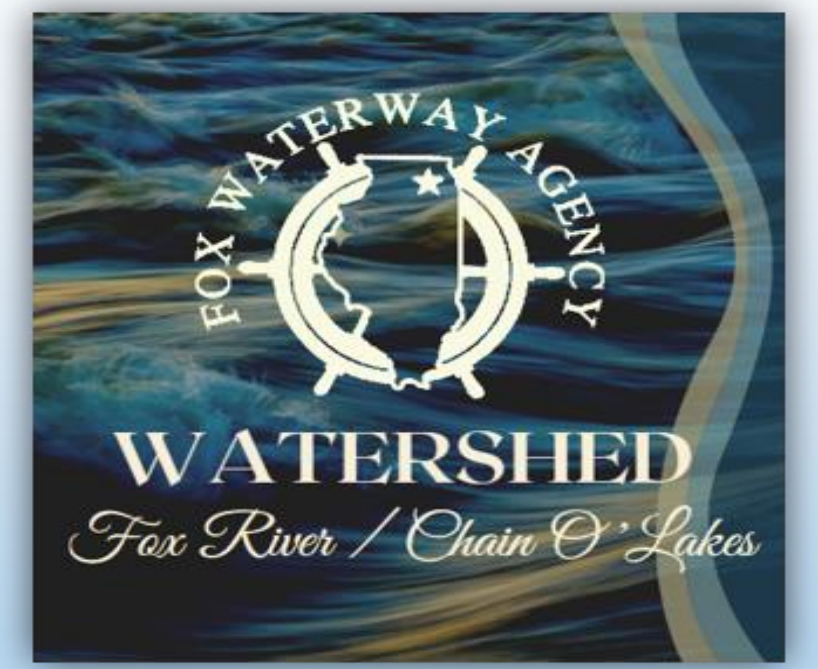


Overview of the topics today…

Part 1 - Rob Bowman- Fox Waterway Agency, Field Superintendent

- General discussion of what shoreline erosion is.
- How does shoreline erosion negatively affect the surrounding ecosystem.
- What causes a shoreline to fail.
- The importance of addressing at risk or failing areas.

Part 2- Jeff Boecker, Northwater Consulting

- Current Conditions of the Fox / Chain ‘O Lakes Shorelines

Part 3- Brian Valleskey – Geosyntec Consultants

- Corrective measures, Restorative Best Management Practices

What is shoreline erosion?

Shoreline erosion is the wearing away along the edge of a body of water caused by the natural processes such as waves, storms, flooding, or human activities like construction, development, or recreational activities.

Negative impacts of shoreline erosion…

Shoreline erosion can lead to….

1. Loss of land and property that may not be able to be recaptured
2. Damage to infrastructure, buildings, vegetation
3. Increase of nutrient loading which can release pollutants that have accumulated on the streambank such as pesticides and heavy metals into the lake
4. Excessive sedimentation will lead to reduced recreational use
5. Reduction in property values
6. Increase the risks from flooding
7. Negative impact ecosystems and habitats for animals
8. Increase sedimentation can change the lakes hydrology and circulation which can affect the survival and distribution of fish and other aquatic species

Example of erosion causing sedimentation…

What causes a shoreline to fail and become unstable?

- Natural erosion- wind, waves, storms- acts of God
- Human- induced erosion - land use changes, construction, dredging, filling in wetlands, recreational activities
- Loss of vegetation can cause destabilization
- Uncontrolled changes in water levels – flooding
- Shoreline becomes weak due to a failing seawall or change in activity

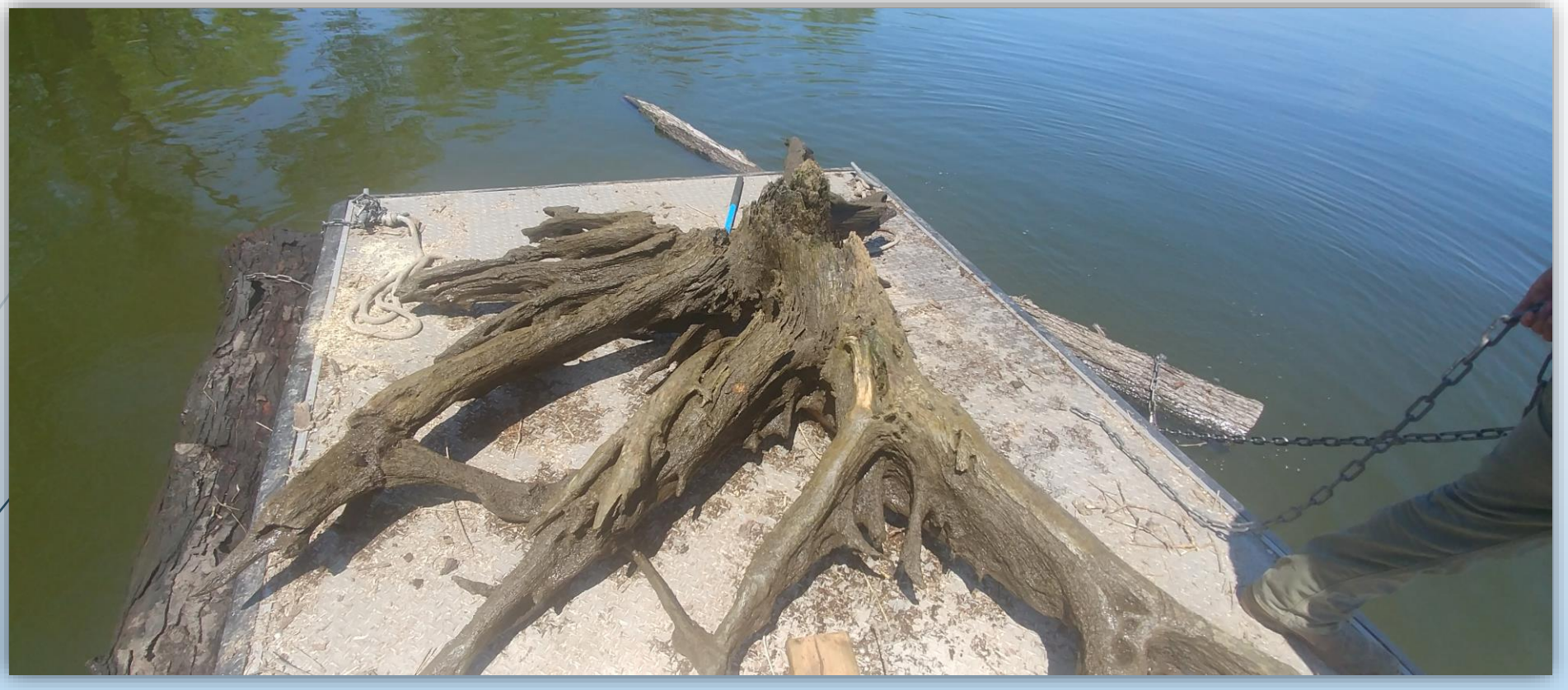
Why it's important to address areas impacted by shoreline erosion?

- Protection of property and infrastructure
- Reduction of sedimentation and nutrients into the waterway
- Preservation of ecosystems for habitat
- Flooding risk reduction for property loss
- Economic benefits – tourism
- Aesthetics

Examples of concerns from shoreline issues:

Trees removed as hazards from reduction of shoreline…

Flood impacts 2018



Tree root removed from lake, destabilized shoreline…

Impacts of Flooding

2005

Prior to flooding.

2022

Note red areas of land loss.

Bog removed 2019 due to flooding and improper stabilization…

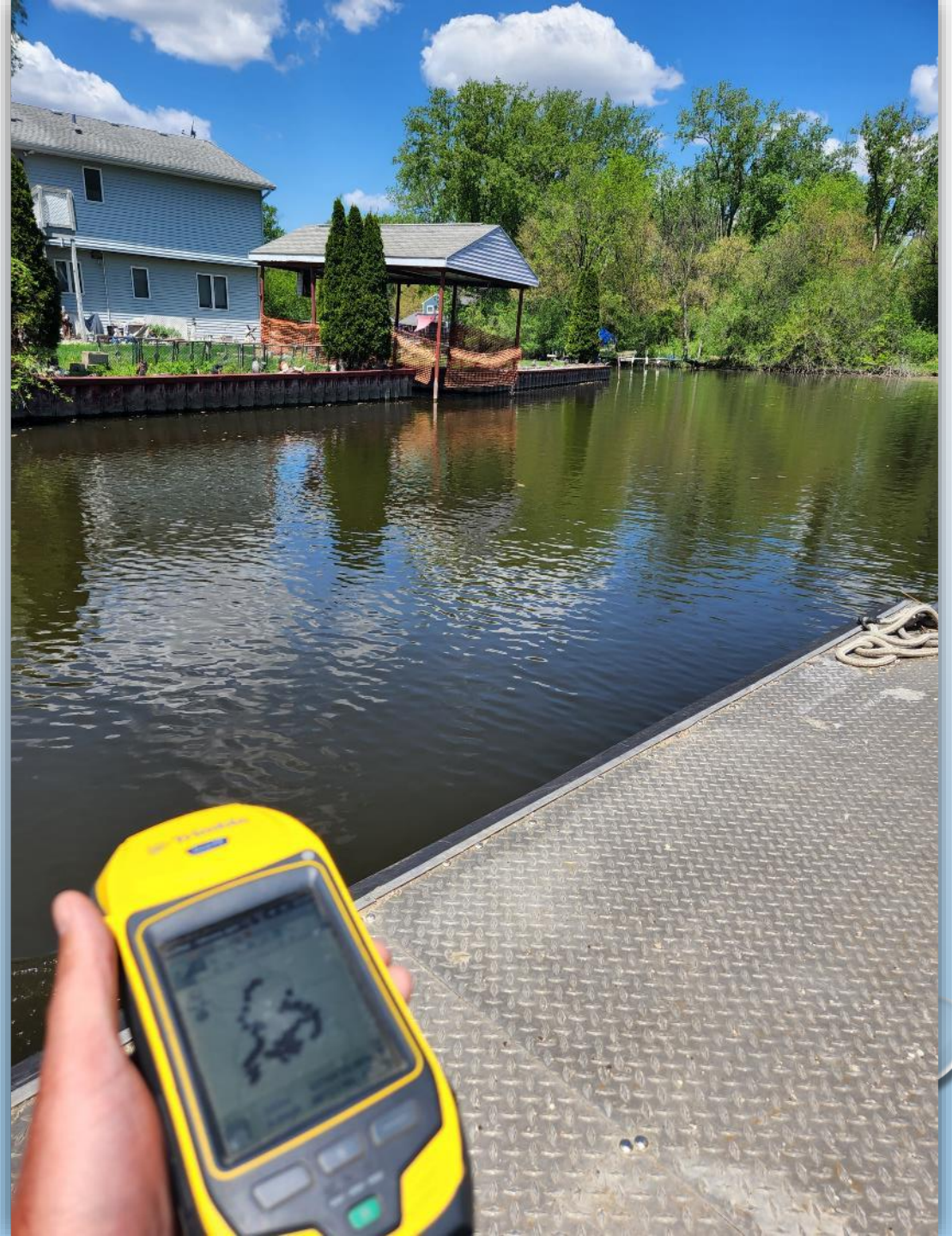
Fox Chain O' Lakes Shoreline Erosion Current Conditions

Jeff Boeckler

Northwater Consulting

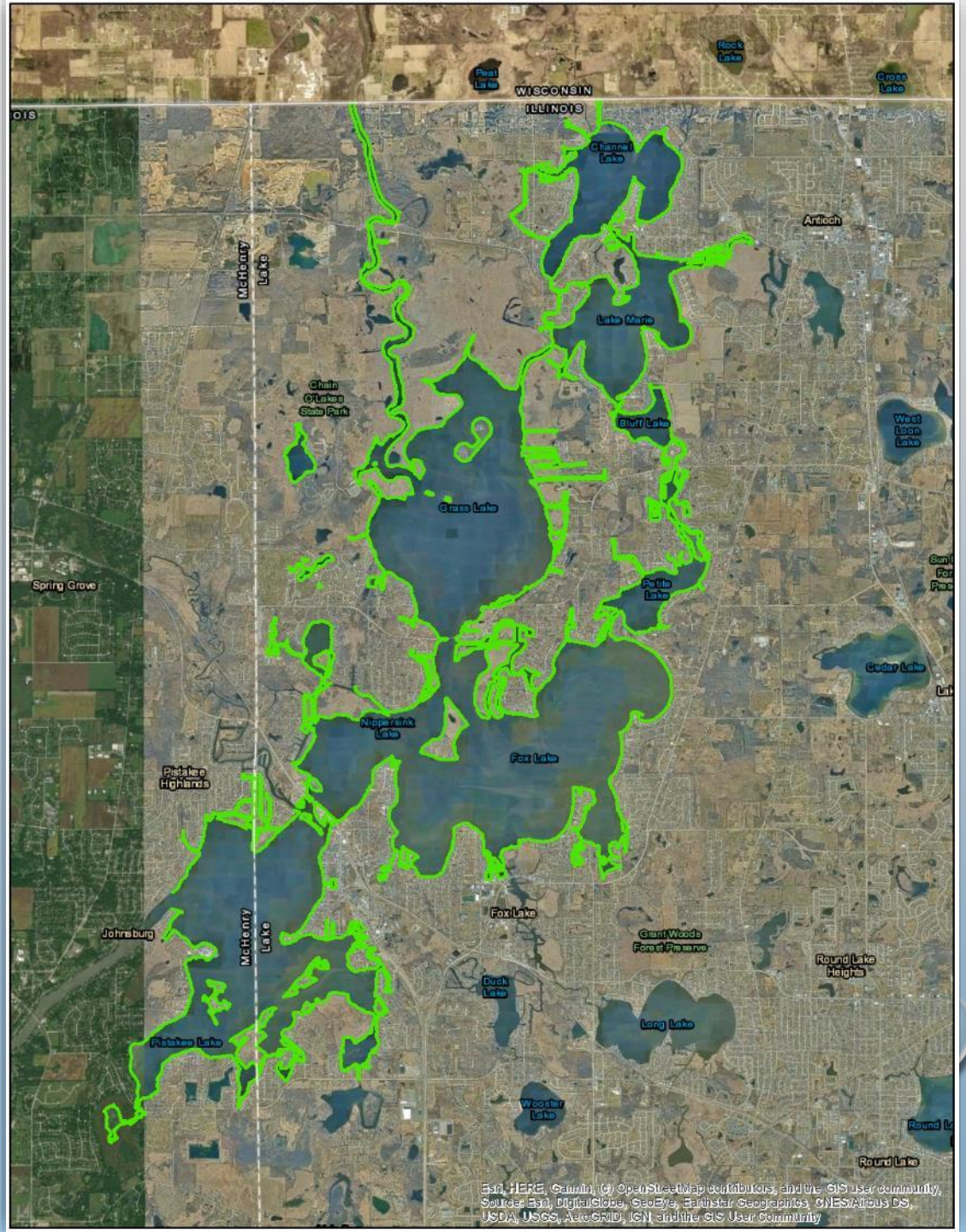
Methods

- **Direct measurement of shoreline**
  - ✓ Observations recorded with GPS
  - ✓ Over 150 miles assessed including Fox river up to state line
- **Data Processing**
  - ✓ Over 1,000 GPS points transferred to line files representing bank conditions, type and erosion rates
  - ✓ Historical image interpretation to confirm rates of bank loss for select areas
- **Soil cores taken by FWA (Rob) to estimate nutrient concentrations**



Primary Lakes Assessed

- Bluff Lake – 3 miles
- Channel Lake – 9.6 miles
- Dunns Lake – 4 miles
- Fox Lake – 23 miles
- Grass Lake – 30 miles
- Lake Catherine – 2 miles
- Lake Marie – 14 miles
- Nippersink Lake – 13.6 miles
- Petite Lake – 7.3 miles
- Pistakee Lake – 31 miles
- Redhead Lake – 2.1 miles
- Spring Lake – 4.6 miles



Results

- Annual Sediment Load
  - ✓ 6,000+ tons
- Annual Nitrogen Load
  - ✓ 150,000 + lbs
- Annual Phosphorus load
  - ✓ 4,700+ lbs
- Average of 40 tons of sediment per bank mile or 24 lbs/foot

Sediment in tons = eroding bank height X eroding bank length X lateral recession rate (ft/yr) X soil density (tons/cubic ft)

Nutrients in lbs = sediment in tons X soil nutrient concentration in lb/lb X 2000

Results

- 2,070 ft of bank eroding at over 1,000 lbs/ft or 1,227 tons
  - ✓ So, 0.26% of banks contributing 20% of the entire sediment load
- 4.95 miles of banks eroding at 100 lbs/ft or greater are responsible for 5,491 tons or 91% of the entire sediment load
  - ✓ 3.3% of banks responsible 91% of the entire sediment!!!

Results

- 6.2 miles of concrete bank
- 71 miles of natural bank – sand, vegetated, cobble
- 33 miles of Rip Rap
- 41 miles of Seawall (sheet pile/wood)
- 125 feet of tires
- 2 miles of failing seawalls, rock or concrete – 1.3% of all

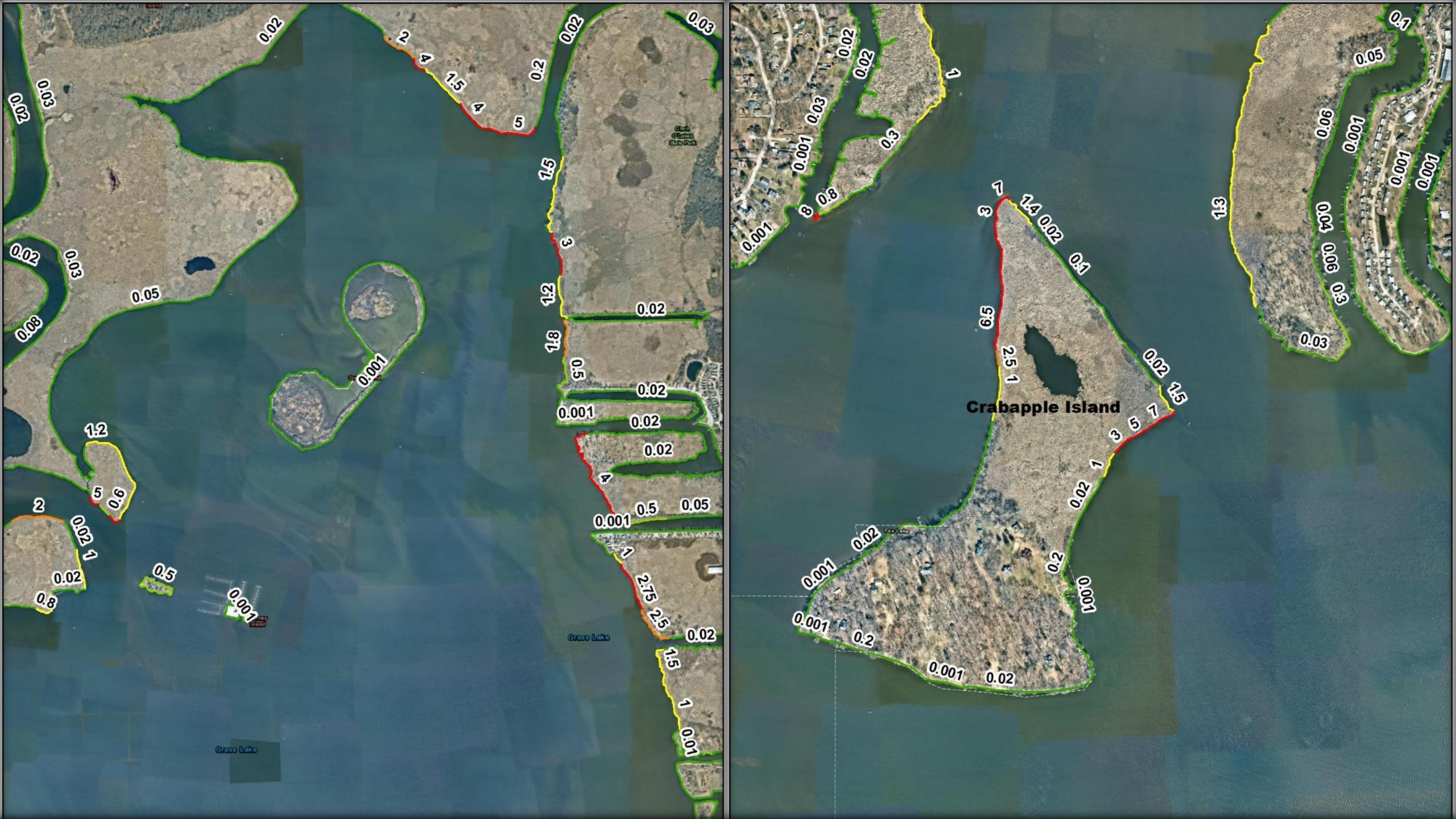
Results by lake

- Grass
  - ✓ 2,643 tons/yr sediment – 44% of total
  - ✓ 67,783 lbs/yr nitrogen – 45% of total
  - ✓ 2,097 lbs/yr phosphorus – 44% of total
- Nippersink
  - ✓ 1,666 tons/yr sediment – 28% of total
  - ✓ 43,032 lbs/yr nitrogen – 29% of total
  - ✓ 1,328 lbs/yr phosphorus – 28% of total

Results by lake

- Fox Lake
  - ✓ 744 tons/yr sediment – 12% of total
  - ✓ 18,539 lbs/yr nitrogen – 12% of total
  - ✓ 581 lbs/yr phosphorus – 12% of total
- Pistakee
  - ✓ 518 tons/yr sediment – 9% of total
  - ✓ 12,529 lbs/yr nitrogen – 8% of total
  - ✓ 398 lbs/yr phosphorus – 8% of total
- Followed by the Fox River, Dunns, Lake Marie, Petite, Spring Lake, Channel Lake
  - ✓ Lake Catherine is the lowest contributor of the major assessed lakes


WISCONSIN
ILLINOIS
Peat Lake
Rock Lake
Cross Lake
Channel Lake
Antioch
McHenry Lake
Lake Marie
Chain O'Lakes State Park
Bluff Lake
West Loon Lake
Grass Lake
Spring Grove
Petite Lake
Cedar Lake
Nippersink Lake
Fox Lake
Pistakee Highlands
Johnsburg
Grant Woods Forest Preserve
Round Lake Heights
Duck Lake
Long Lake
Pistakee Lake
Turner Lake
Fox Lake Country Club
Vern Thelen Park
Dunn Lake


Crabapple Island
Grass Lake
Grass Lake
Fox Lake


Pape Island
Dunns Island
Nippersink Creek
Dunn Lake
Lotus Woods
Nippersink Lake Open Space
Nippersink Lake
Riverside Island
Pistakee Lake
Fox Lake
0.001
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.16
0.2
0.3
0.4
0.6
0.9
1.2
1.5
1.8
2
6

Key Takeaways

- **A small number of banks are contributing the vast majority of sediment AND NUTRIENTS**
  - ✓ STRATEGIC STABILIZATION WILL BE EFFECTIVE
  - ✓ Almost half of all banks are already stabilized – seawalls are common
- **Lake bank soils are very rich in nitrogen**
- **Grass lake is the largest contributor**
- **Crabapple island has experienced and continues to experience excessive erosion**
- **Rob Bowman is one heck of a boat driver**

Geosyntec consultants

Shoreline Erosion

January 19, 2023

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Shoreline Erosion Control

Before we get into the presentation: Background Info:

Image courtesy of Brazos River Authority

1. Shoreline erosion and what causes it

2. Understanding principles of stabilization – types

3. Restoration approaches
   a) 100% natural
   b) 100% artificial
   c) Hybrid (bioengineering)

Shoreline Erosion Control

General Lakeside Property Ownership Thinking (not necessarily Chain O'Lakes)

1. It's my property I can do what I want
2. Lake water elevation is immaterial
3. A little pollution is of little consequence
4. *Consequences*
   - *Damages riparian habitat*
   - *Reduces flood storage capacity*
   - *Exposes new and "soft" shoreline to wave/wake action*
   - *Inundates local infrastructure*
   - *Unanticipated expenses*
5. Not a considerable impact? Time of exposure

Image courtesy of Cape Cod Times

Image courtesy of Clemson University

Shoreline Erosion Control

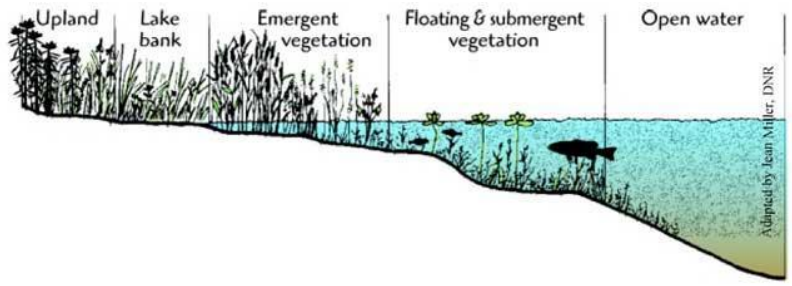
Why should we protect a shoreline?

1. Water quality and clarity; often associated with property value/protection
    1. Minnesota study of perception and screening of desirable shorelines – Chicago Botanic Garden, Bob Kirschner
    2. Value of clarity in Madison, WI – WDNR Study

2. Self-defeating paradigm: by trying to deepen the lake, the sediment is dislodged and deposited in the very same shallow areas.

3. Ecological value vs recreational value

4. Govt entity caught in a no-win situation between appeasing property owners and mortgaging a valuable resource.



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What causes shorelines to erode?

- Erosion is a natural process, however shorelines have adapted to their environmental stressors over time.
- Natural adaptation may take centuries if not longer
- What are unnatural stressors?
  - Higher water levels (changing water levels)
  - Manmade waves
  - Landscape alteration
    - Runoff
    - Slope
    - Surface cover (species changes or denuding)

Shoreline Erosion Control

Common incorrectly used terminology in lake shoreline design and protection

- Shoreline stabilization
- Shoreline restoration
- Shoreline enhancement

Shoreline Erosion Control

Shoreline Stabilization

1. Most common project type. Often incorrectly diagnosed as "restoration"
2. Stabilization simply put is meant to stabilize an area with means as to stop current passive or exacerbated shoreline deterioration
3. Often combined with minimal elements of shoreline restoration
4. Typically cheaper to install and results are easier to identify with.

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Shoreline Restoration

1. Essentially means as the term suggests. Return to the original state.
2. Typical true restorations are few and far between. Typically are done in a hybrid staged project with stabilization.
3. True restoration is often misplaced in our urbanized environments.
4. Adds to the cost of maintenance.

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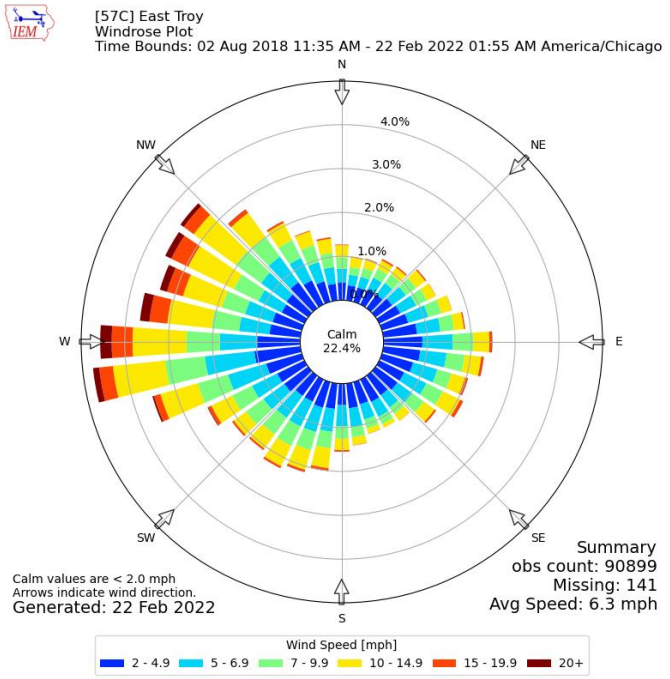
Shoreline Enhancement

1. Process of improving a stabilization or restoration above base level.
   a) Species diversity
   b) Invasives removal
   c) Habitat improvements
2. Difficult (and expensive) to document or verify that the results are effective
3. Results are difficult to quantify visually and are therefore only sought after by a defined crowd (fishermen, activists, purists)
4. Requires an area that is reasonably decent shape already, with limited alterations. Tough to come by in urbanized environment.

Wind Generated Waves

- Wind Speeds and Direction
- Exposure
- Water Depths

Coastal Engineering Design & Analysis System Version 4.0



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Vessel Wakes

- Direction/Maneuvers of Vessels
- Types of Vessels
- Vessel Speed
- Distance from Shoreline
- Water Depths

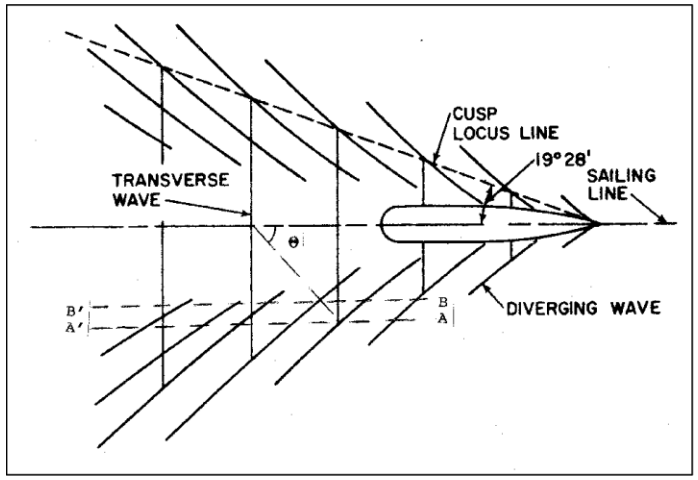
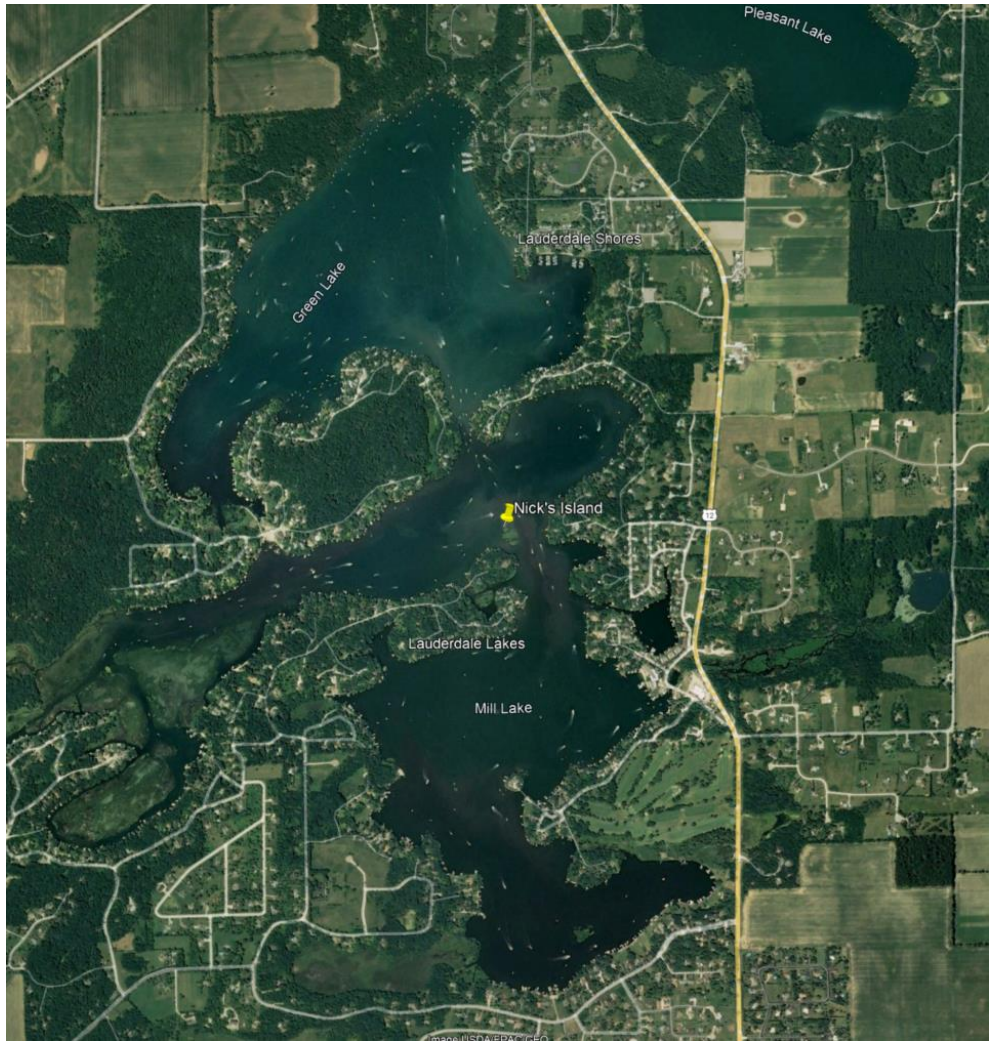


Figure 1. Deep water wave crest pattern by the bow of a moving vessel



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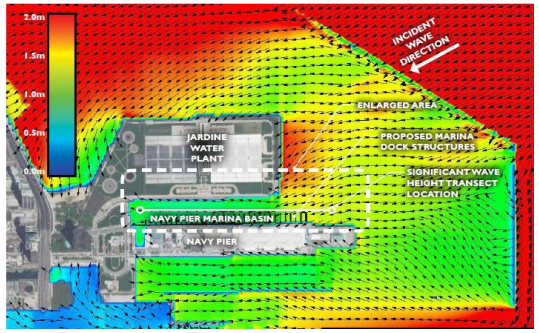
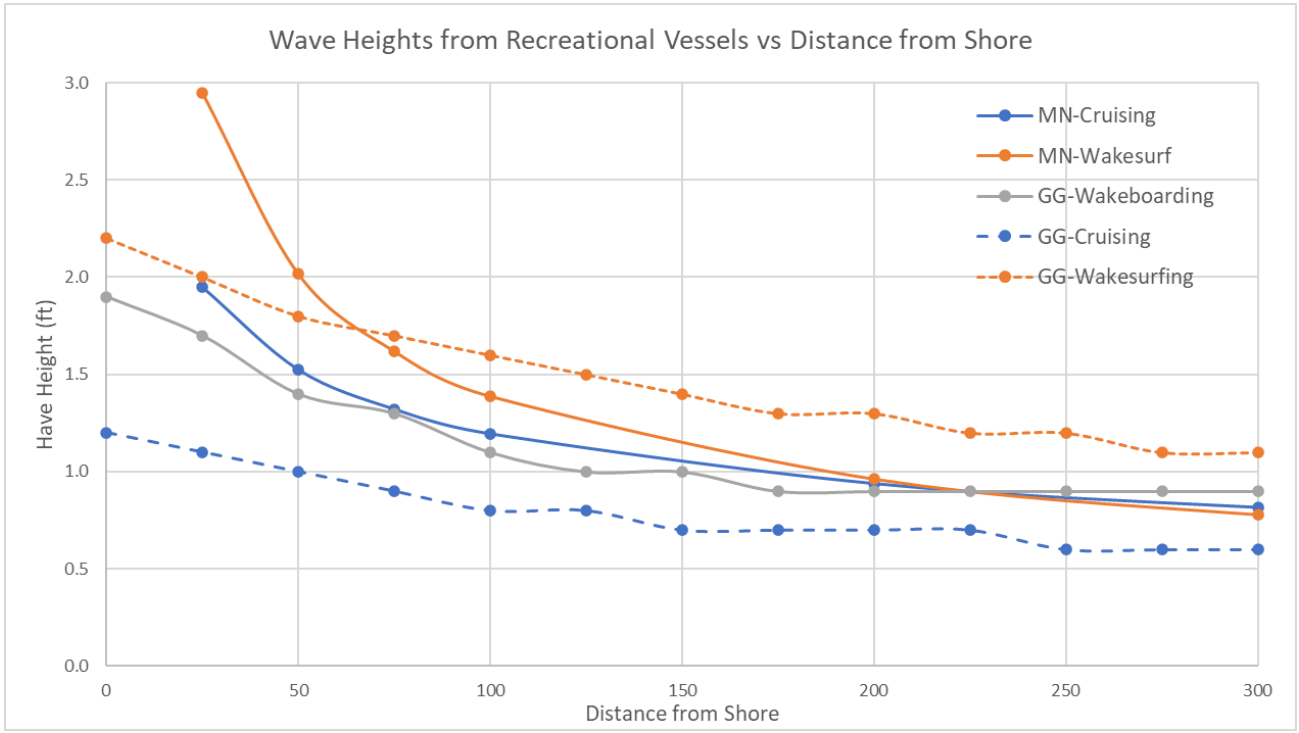
Recreational Vessel Wake Studies

- Install Wave Sensors/Wave Buoy
- Review existing studies
- Perform desktop calculations
- Visual Observations
- Numerical Modeling





Design Vessel Wake
Maximum Wave Height (Hm) = 1.9 ft
Peak Period (Tp) = 2.5 sec

50-Year Wind-generated Wave
Significant Wave Height (Hs) = 1.5 Feet
Peak Period (Tp) = 2 Sec

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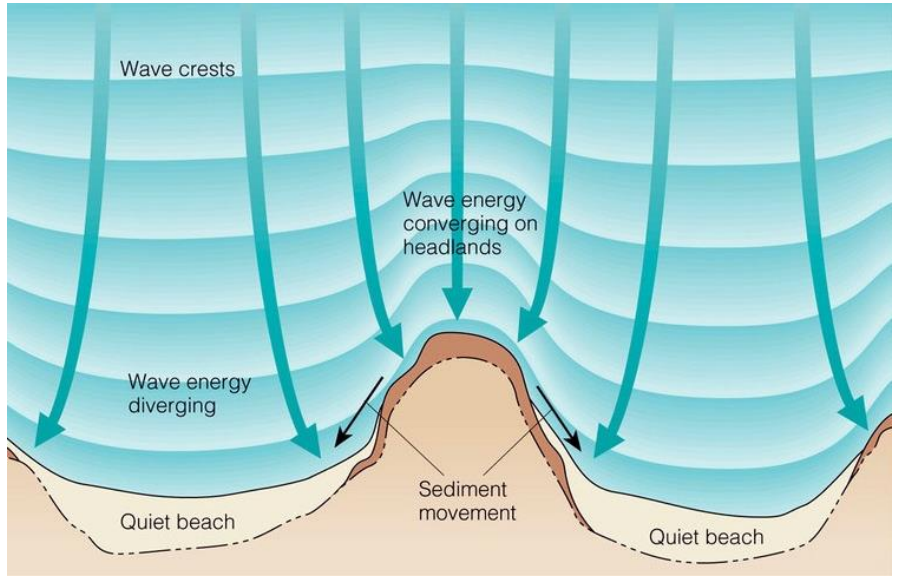
Effects of Coastal Structures

- End Effects – wave refraction & diffraction
- Starvation of Natural Sediment Supplies
- Scour and wave amplification
- Biological Impacts

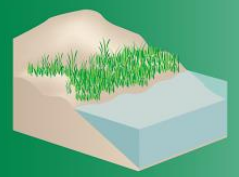


Shoreline Erosion Control

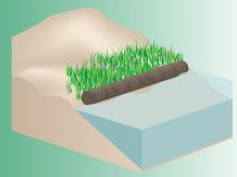
HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GREEN - SOFTER TECHNIQUES → **GRAY - HARDER TECHNIQUES**

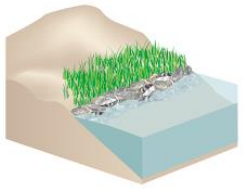
Living Shorelines



VEGETATION ONLY - Provides a buffer to upland areas and breaks small waves. Suitable for low wave energy environments.

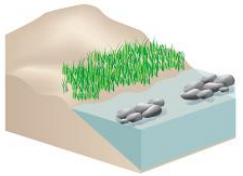


EDGING - Added structure holds the toe of existing or vegetated slope in place. Suitable for most areas except high wave energy environments.

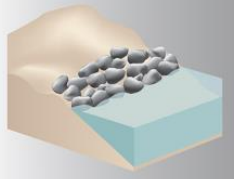


SILLS - Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.

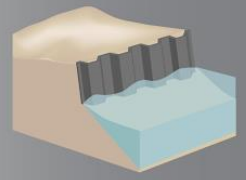
Coastal Structures



BREAKWATER - (vegetation optional) - Offshore structures intended to break waves, reducing the force of wave action, and encourage sediment accretion. Suitable for most areas.



REVETMENT - Lays over the slope of the shoreline and protects it from erosion and waves. Suitable for sites with existing hardened shoreline structures.



BULKHEAD - Vertical wall parallel to the shoreline intended to hold soil in place. Suitable for high energy settings and sites with existing hard shoreline structures.

Shoreline Erosion Control

Vertical Bulkhead

- Seawall (vinyl, steel, wood)
- Bulkhead, typically concrete
- Are not bulletproof
  - ❑ Scouring at toe can compromise wall if not driven deep enough (still needs toe protection)
  - ❑ Wave action above wall leaches out fines creating separation from shore
  - ❑ New science indicates forces can move laterally impacting nearby shorelines (adjoining property)
  - ❑ Can create a biologically sterile environment

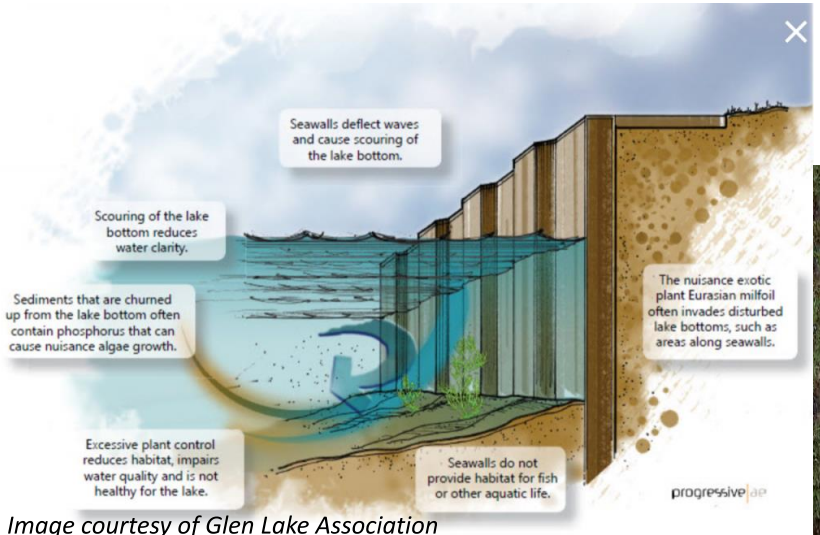


Image courtesy of Glen Lake Association

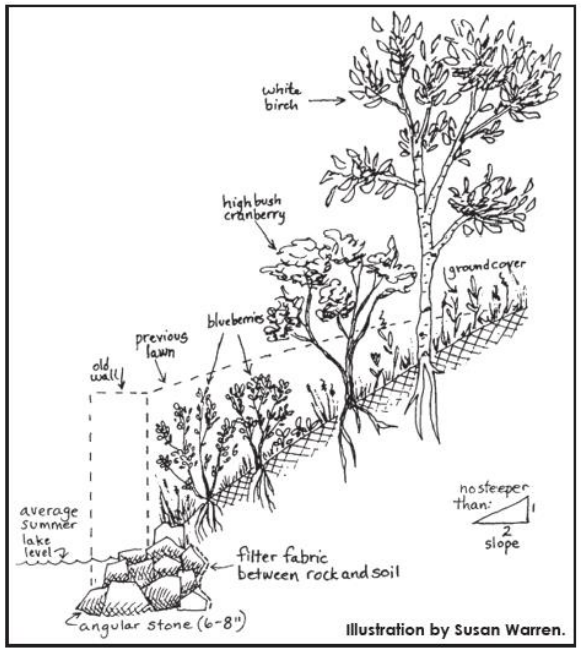
Image courtesy of CNN

Shoreline Erosion Control

Armor and Stone Revetments

- Can cause some localized scouring effects
- To a lesser extent than that of walls which reflect energy
- Very cost effective
- Not as simple as dumping rock
- Should be keyed below bed/toe elevation

Image courtesy of State of Vermont



A resloped bank stabilized with native vegetation and a shallow rock toe that is only partially visible above water giving it a natural look.

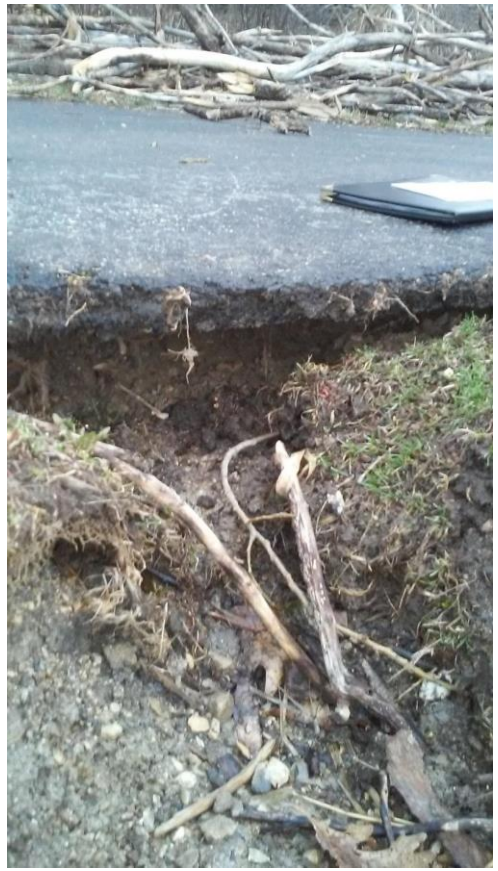
Shoreline Erosion Control

Example Stabilization Project (Paulus Park, Lake Zurich):

- Pressure on timelines for permitting and construction
- Unbudgeted project
- Pedestrian safety is an issue
- Simplified approach to restoration yielded quick return. Engineers and designers can outthink themselves.
- Project location allowed for a vanilla treatment approach
- Expedited permitting

Shoreline Erosion Control

Before:



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During Construction:

Shoreline Erosion Control

After Construction:

Rip Rap is great, easy, and cost effective, but in parks: stones and kids don't match

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Paulus Park Analysis:

- How much soil was lost?
- 300’ x 1.5’x 1.25’ = 562.5 CF
- 1CF soil weighs ~90 lbs
- 25.3 Tons

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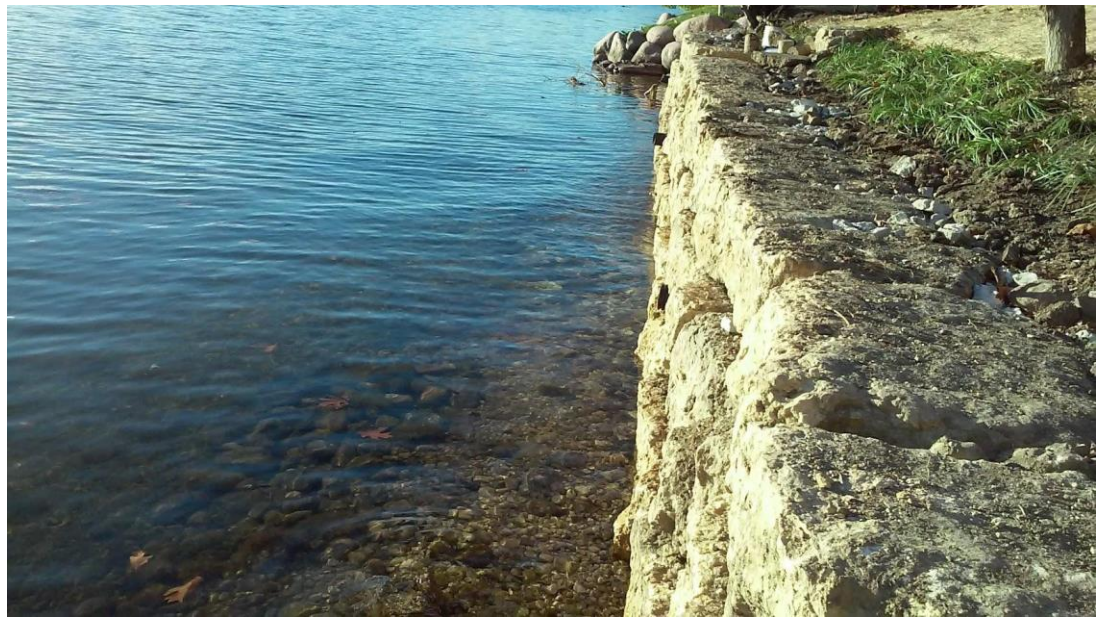
Another Lake Zurich Typical:



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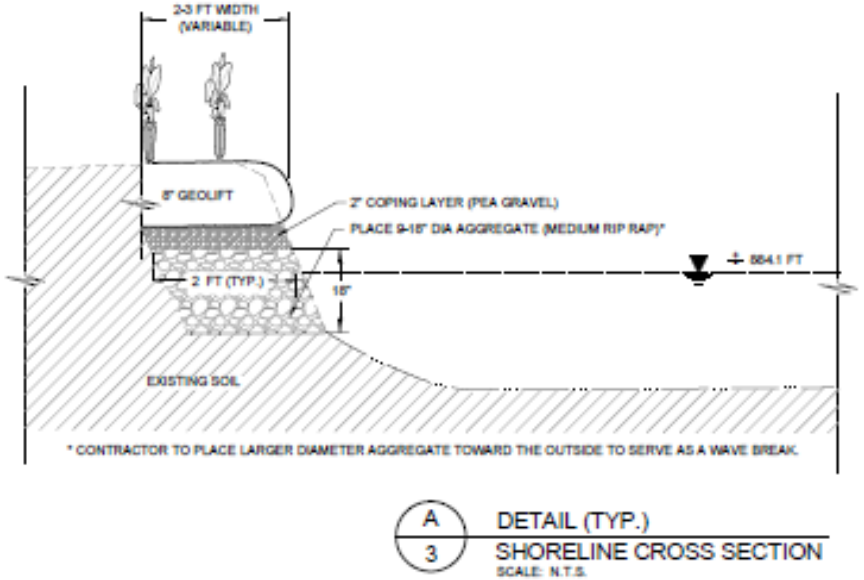
Bioengineering:

Providing a stabile toe beneath bioengineered media

Toe protects agains wave scour

Vegetation secures shoreline benefits

Don Jean Bay, Walworth County, WI



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Alternate take, same concept:

Things to consider:

- Water level control
- Soil erosion sediment control (SESC)
- Protection of others during construction
- Timing
- Constructability and sequencing
- Material and equipment storage
- Cost control
- Maintainability
- Shelf Life
- Other low hanging fruit
  - Habitat
  - Aesthetics
  - accesibility

Shoreline Erosion Control

Permitting (IL)

1. Village, County (if unincorporated).
2. U.S. Army Corps of Engineers: *wetland permit*
3. Lake County Stormwater Management (SMC): *floodplain and soil erosion and sediment control (SESC).*
4. IDNR/USFWS: *Threatened & Endangered Species consultation.*
5. EPA: *Water Quality*

Contact Information

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QUESTIONS?

THANK YOU!