

# Shoreline Stabilization: Hard Armoring

Reservoir Habitat Restoration Workshop  
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# Hard Armor Techniques

- Bulkheads
- Offshore Breakwaters
- Revetments
- Toe Caps
- Groynes
- Stone Framed Deflectors
  
- Sills, stone gabions, others...

# Bulkheads

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# Bulkheads/Seawalls

## Advantages

- Stops erosion
- Long lifespan if installed correctly
- Provides good access



## Disadvantages

- Expensive
- Labor intensive
- Little fish habitat value
- Aesthetics??
- Weakens with age



# Offshore Breakwaters

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# Offshore Breakwaters

## Advantages

- Disperse wave energy
- Long lifespan
- Good fish/wildlife habitat value

## Disadvantages

- Expensive
- Potentially labor intensive
- Slope limited



# Offshore Breakwaters



# Revetments





# Revetments

## Advantages

- Highly adaptable
- Low tech
- Easily maintained
- Average fish habitat value

## Disadvantages

- Wide footprint
- Potentially expensive
- Access issues
- Aesthetics



# Revetments



# Revetments



# Toe Capping



# Toe Caps

## Advantages

- Fills a specific niche
- Minimally invasive
- Easily constructed
- Long lifespan
- Average fish habitat value
- Aesthetics

## Disadvantages

- \$ → \$\$\$\$ to construct
- Distinct limitations
- Specialized contractors



# Longitudinal Peak Stone Toe



# Longitudinal Peak Stone Toe



# Groynes (jetties)





# Groynes (jetties)

## Advantages

- Control lateral drift
- Low tech
- Easily maintained
- Good fish habitat value
- Good fishing access

## Disadvantages

- Moderate cost
- Potential access issues
- Fill material??
- Aesthetics??



# Groynes (jetties)



# Geotubes: temporary storage or permanent habitat...



 **TENCATE GEOTUBE**

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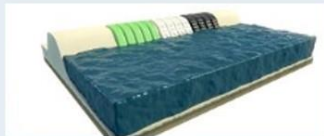
[SOLUTIONS](#)

[APPLICATIONS](#)

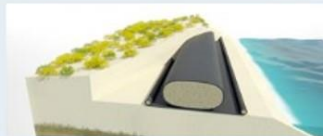
[CASE STUDIES](#)

[TECHNICAL INFO](#)

[PARTNERS](#)



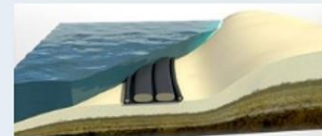
**REVTMENTS**



**DYKES AND LEVEES**



**JETTIES AND GROYNES**



**BREAKWATERS**



**OFFSHORE STRUCTURES**



**ENVIRONMENTAL DREDGING**



**INDUSTRIAL WASTEWATER  
PROCESSING**



**MINING AND MINERAL  
PROCESSING**



**MUNICIPAL APPLICATIONS**



**AGRICULTURE**



# Stone Deflectors



# Stone Deflectors

## Advantages

- Slows/stops erosion
- Highly adaptable
- Low tech
- Great fish habitat value
- Good fishing access

## Disadvantages

- Moderate/high cost
- Potential access issues
- Requires wider footprint



# Stone Deflectors



# Stone Deflectors



# Biotechnical Approach

- Combines structural materials and plants
- Provides improved erosion control in dynamic environments

## Advantages

- Highly adaptable
- Grows stronger with age
- Good fish/wildlife habitat value
- Aesthetics

## Disadvantages

- Moderate to high costs
- Extensive planning
- High monitoring and maintenance
- Poor shoreline access



# Biotechnical Approaches

- Vegetated geogrids
- Vegetated gabions
- Joint planting
- Geocells
- Cellular block systems
- Concrete block mats
- Others...



# Where to begin...

- Determine what is causing the erosion
  - Water level fluctuation, boating, wind, water current, ice heave, etc.
- Determine project goal(s)
- Use existing knowledge/resources to choose a technique(s)
  - Annual water regime, access, erosive force, goals, technical specialists, soils, budget, grant/partnership opportunities, etc.
- Ensure proper installation/follow-up





# Things to consider

- Root of problem
- Project goal(s)
- Access
- Cost
- Longevity
- Maintenance
- Aesthetics
- Habitat value



# Questions

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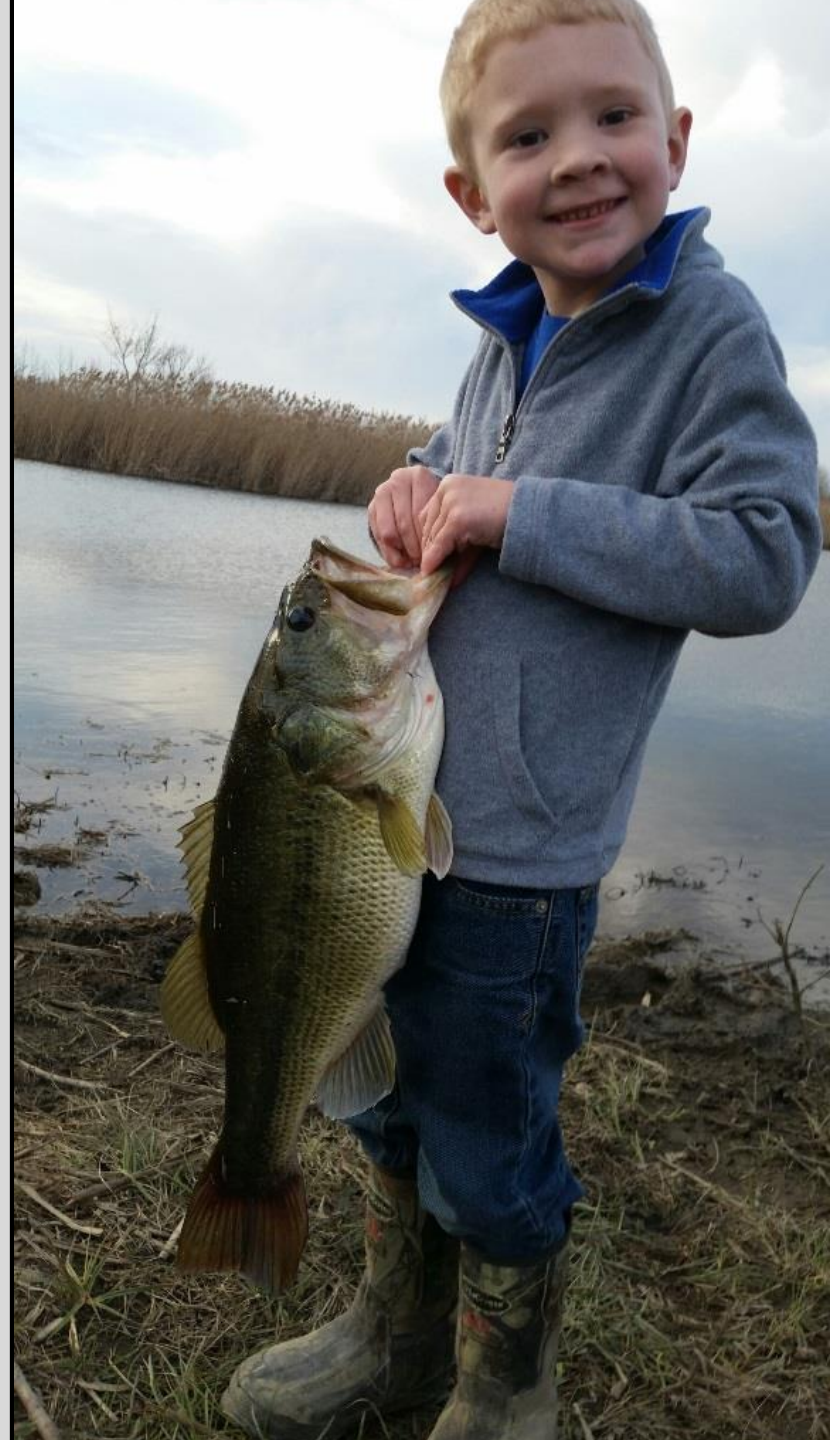
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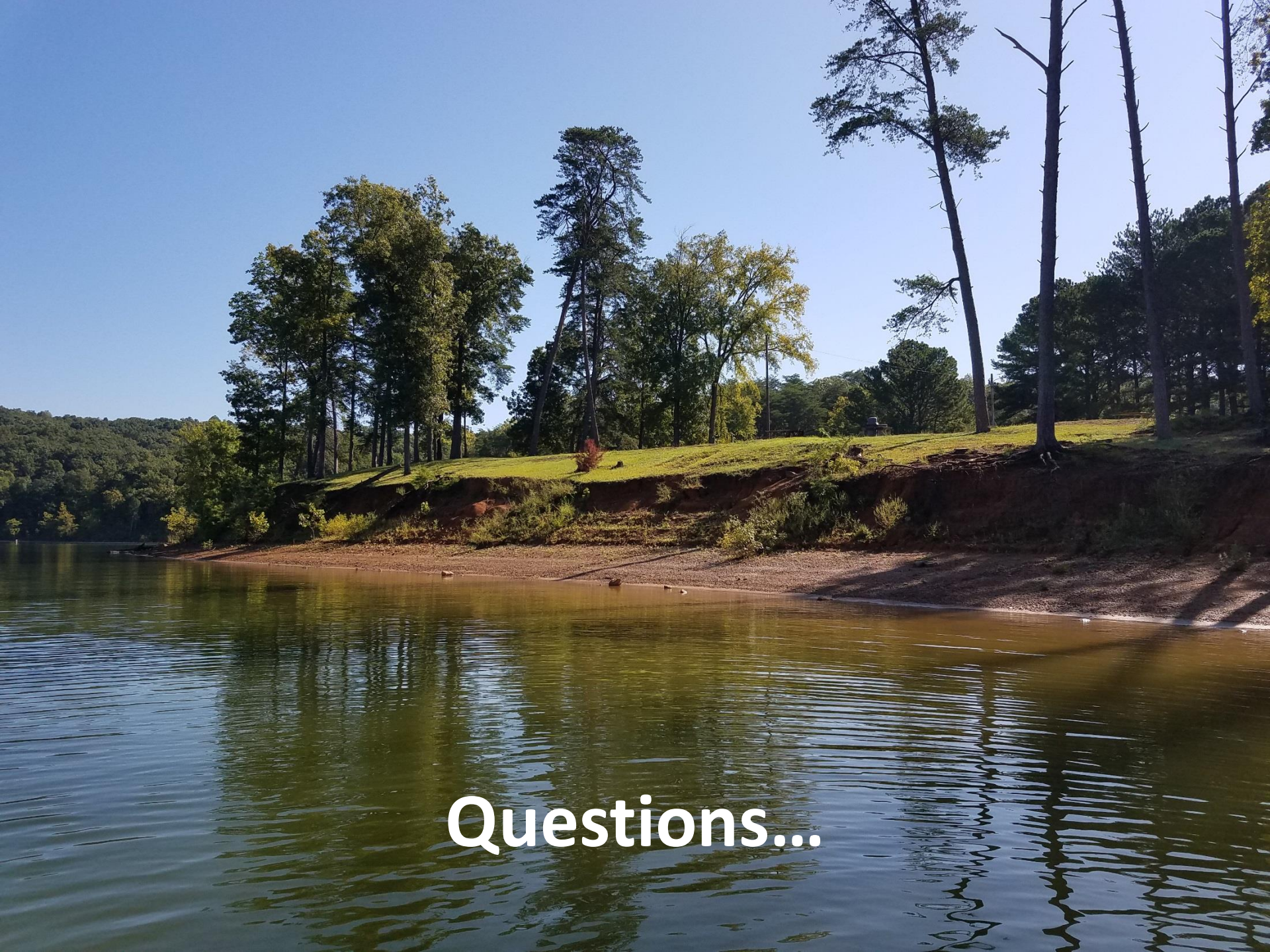
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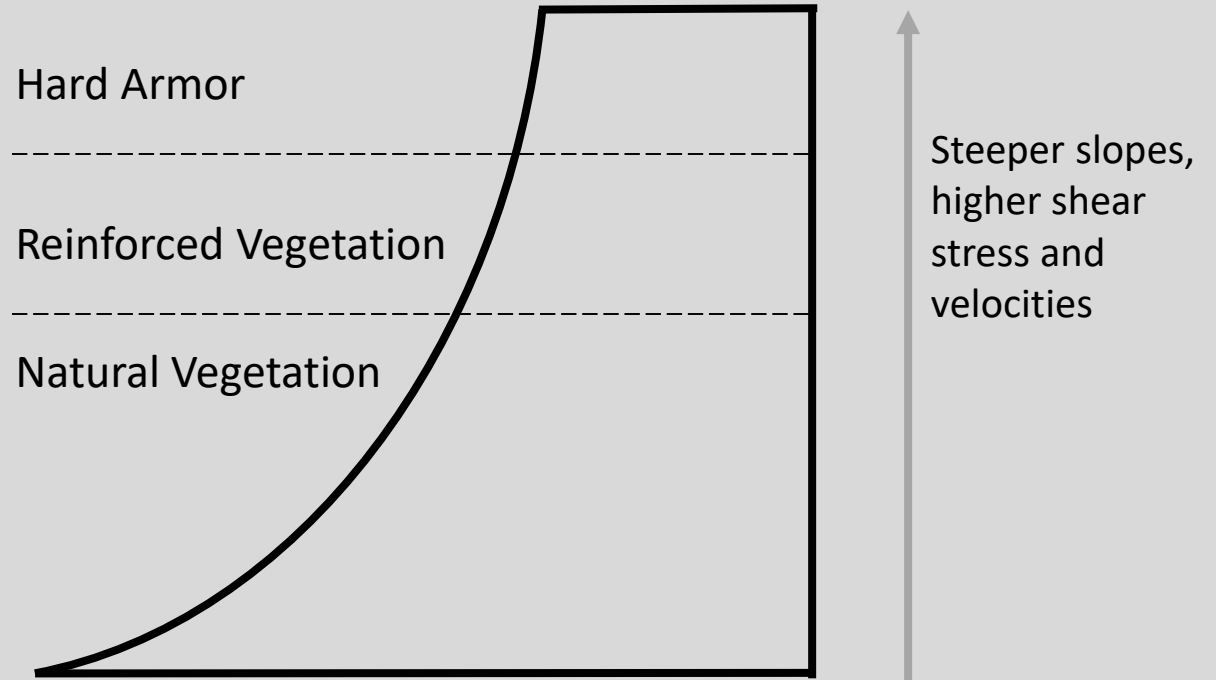
Questions...

# Resources

- Miranda, L.E. 2017. Reservoir fish habitat management. Lightning Press, Totowa, New Jersey. 306 pp.
- Guidelines for Streambank Stabilization. Revised 2000. Georgia Soil and Water Conservation Commission.
- Tuttle, R.W. and R.D. Wenberg. 1996. Streambank and Shoreline Protection *in* USDA NRCS Engineering Field Handbook, Ch. 16. U.S. Department of Agriculture.



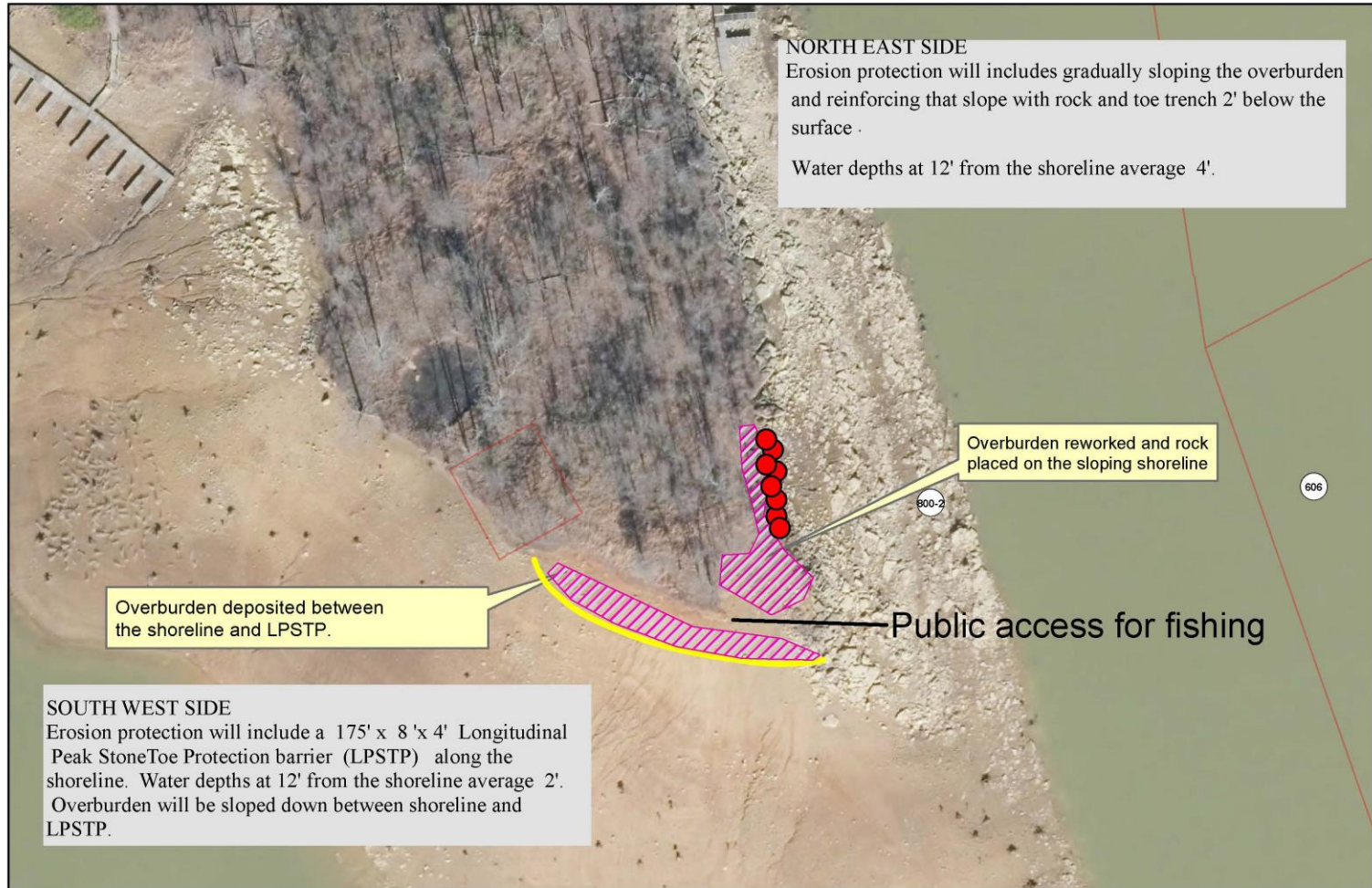




# Questions



# Longitudinal Stone Toe



OPTION 2: Site #2 Diplomat Shores Bank Stabilization Project



