Streambank and Lake Restoration

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Lake Restoration

Lakes and ponds are valuable resources that provide ecological, aesthetic, and recreational services.
Lake Restoration

Lakes can be stressed by anthropogenic or natural influences

- Shoreline erosion
- Sediment buildup
- Eutrophication
- Algal blooms
- Invasive species
Lake Restoration

- Lake Ecology
- Eutrophication Issues
- Algae Control
- Biomanipulation
- Lake Dredging
- Stream bank and Shoreline Restoration
Lake Ecology
Lake Ecology

- Lake Morphology
- Water Quality Variables
- Aquatic Organisms
Lake System

- Bioassessment
- Physical Habitat
- Chemical Quality
Lake Morphology

Shape and Size

• Depth
• Surface area
• Volume
• Length of shoreline

Hydraulic residence time

• Determines flushing rate
• Usually a slow resupply of water
Lake Morphology

Inflow = $Q$

Volume = $V$

Residence Time = $T_R$

$$T_R = \frac{V}{Q}$$
Water Quality Process

INFLOW

H₄A ⇌ H⁺ + A⁻
Acid-Base Equilibria

Volatilization

H⁺ + O₂
Hydrolysis

Precipitation-Dissolution

Photolysis

Adsorption-Desorption

Sedimentation

Bioconcentration

Reduction-Oxidation

OUTFLOW
Water Quality

- Tends to vary with depth and season
  - Pollutant loading determined by land use
  - Sediments can be a factor
- Minimal reaeration from surface
- Riparian buffers very important
  - Protection of shoreline
  - Filtration
  - Nutrient uptake
Water Quality

Water Quality Variables

- Acidity
- Alkalinity
- Hardness
- Color
- Turbidity
- Transparency
- Nutrients
- Dissolved Oxygen
- Toxic substances
  - Metals
  - Pesticides
  - Petroleum products
- Microorganisms
  - Bacteria
  - Viruses
  - Protozoa
Aquatic Organisms

- Plankton
- Macrophytes
- Invertebrates
- Vertebrates
- Microorganisms
Lake Biota

• Less streamlined than in streams
  – Fish wider bodies
  – Plants wider leaves
• Entire water column
  – Invertebrates swim
  – Planktonic organisms
• Large predators
  – Often hunt
  – Food will swim by
Eutrophication
Eutrophication - definition

Excess nutrient and sediment load into lakes at a rate sufficient to increase the potential for high biological production and a decrease in basin volume.
Eutrophication

Causes

– Excess nutrients and silt entering lake system from runoff
– Nutrients can be sorbed on silt which can later become available to algae and plants
– Excess plants deplete oxygen and release more nutrients as they decay
– Nutrients can be released from sediments
Eutrophication

Common Symptoms

– Reduced clarity
– Large daily oscillations in dissolved oxygen
– pH shifts
– Algae blooms
– Excessive weed growth
– Fish kills
– Odor, aesthetic, and taste problems
Algae Control
Algae blooms are a tell tale sign of a nutrient enriched system.
Algae Control

1st defense: source control of nutrients

– Limit fertilizer use
– Landscaping to limit lawn area
– Native plant buffer to intercept nutrients in runoff - biofilters
– Manage leaf litter
– Maintenance of on-site septic systems
– Restrict boat traffic to prevent resuspension of phosphorous in sediments
Algae Control

Other algae control techniques

– Precipitate phosphorus with chemical addition (buffered alum)
– Dyes
– Aeration
– Barley straw
– Aquascaping
– Algaecides
– Physical removal – nets or booms
Buffered Alum

- Binds with inorganic phosphorus
- Phosphorus precipitates out of the water
- Best for deep lakes
- Use in lakes that flush infrequently
Buffered Alum

Application techniques

- Low dose whole lake application from a boat as a solid or a slurry
- Sediment blanket
- Flow metered dosing
- Integration with sediments
- Apply with an aerator
Buffered Alum

Potential problems

- Alum toxicity
- Stimulated growth
- Elevated bacteria counts (temporary)
- Temporary reduction in benthic assemblage

Cost

- $25 per bag or $0.50 per gallon
Dyes

- Block sunlight
- Reduce algae growth
- Best in shallow lakes with severe benthic or filamentous algae problems
- Can enhance blue color
Dyes

- Liquid or powder form
- Inert dye similar to blue food colorant #5
- Use the dye in lakes or ponds that have limited outlets and a long detention time
- Usually lasts 6 to 8 weeks
Aeration

Artificial circulation brings oxygen-poor water up to the surface

– Surface Spray
– Paddlewheel
– Air Diffusers
Aeration

Benefits

– Provides oxygen for aerobic decomposition of organic matter
– Controls blue-green algae
– Prevents fish kills
– Liberates dissolved gases into the air instead of allowing them to build to harmful levels in the pond (NH₃, CO₂, H₂S, and methane)
Aeration

Surface agitators create turbulence

- Oxygen circulation
- Nutrient consumption
- Temperature control
Aeration

Selecting an aerator

– Oxygen Transfer Rates (OTR) in excess of 1lb/5kg per horse power per hour
– Pumps in excess of 300 GPM or 1200 LP per horsepower
– Recommend 1 to 3HP aerating units per surface acre
Surface Spray

- Best vertical circulation in lakes less than 15 ft deep
- Create convection currents
- Break up algae mats
Aeration

Paddlewheel

- Shallow lakes
- Low above surface spraying
- Creates a strong current
Aeration

Air Diffusion

- Best mixing for deep lakes
- Diffuser on lake bottom
- Supplied by an air compressor
Aeration

Considerations

– Keep units off the sediments
– Place aerator to create a positive current
– Align to prevent shore erosion
– Cost $500 to $7000 plus power
Barley Straw

Decomposition produces compounds that inhibit or reduce algal growth
Barley Straw

Application

– Contained in wire mesh and staked to the bottom
– Deployed in spring
– Approximately 225 pounds of straw per acre
– EPA considers barley straw an algicide
Aquascaping

“Water Gardening”

– The use of aquatic plants to create a desirable plant community
– Plants compete with algae for nutrients
– Serve as habitat for zooplankton to compete with algae for nutrients
– Deter geese
– Stabilize shoreline
– Improve aesthetics and habitat
Aquascaping

Planting

- Match species to depth
- Use diverse native species
- Be aware of invasive intrusion
- Includes vegetative buffers
Algaecides

Is it an algae or a plant?

- ID the algae
- Establish a nutrient control plan
- Select an appropriate algaecide
Algaecides

Problematic algae

– Filamentous
– Planktonic
– Stalked
Algaecides

Filamentous

- stringy
- grows on bottom
- breaks off and accumulates on surface
Algaecides

Planktonic

– exist throughout water column
– can form surface scums
– includes blue-green algae
Algaecides

Stalked

- *Chara* and *Nitella*
- can look like plants
- no roots
- usually beneficial for habitat
- can be a nuisance in shallow ponds
Algaecides

Active ingredients

- copper
- coppersulfate
- endothol
- percarbonate

AlgaePro from SePro – copper
AquaCure from Gordons – copper
Algaecides

Application

– Like herbicides, must be applied by licensed applicator in New Jersey
– EPA registered algaecides
– Apply according to label
– Water temperature requirements
– Usually apply once start growing, but not so late in the summer that decaying biomass is a problem
Algae Removal

- Removal with nets and booms
- Works best with filamentous algae
- A lot of biomass to dispose of
- Does not control source of problem
Biomanipulation
Biomanipulation

• Ecosystem control
• Manage aquatic plants
  – Introduce grass carp
• Manage algal blooms
  – Add predatory fish to eat the small minnows that feed on the zooplankton that feed on the algae
Biomanipulation

Grass Carp (White Amur)

- Biological tool for weed control
- Not native to US
- Triploid strain (sterile)
Grass carp considerations

– Can the problem plant be controlled by grass carp?
– Use only triploid certified fish
– Obtain appropriate permits
– Stock at least 8” fish in spring
– Stocking density 5-15/acre
– Monitoring
Biomanipulation

Palatable plant species

– Milfoil
– Naiad
– Elodea
– Coontail
– Curley leaf pond weed
– Duckweed
– Bladderwort
– Musk Grass
– Water star grass
– Cabomba
Biomanipulation

Regulation of grass carp in New Jersey

– Restricted to ponds less than 10 acres
– Fish certified triploid strain
– Only use if have more than 40% coverage of weeds, palatable to grass carp
– Restrict fish from downstream outlet
Biomanipulation

Algae control

– Limit the population of fish that graze on zooplankton by introducing other predator fish
– Bottom line is to increase zooplankton population
Biomanipulation

Lake Hopatcong
- Considering biomanipulation with a nutrient management plan
- Need to conduct holistic fish survey
- Hybrid striped bass and brown trout considered
- Alewife the dominant zooplankton-eating fish

Oradell Reservoir
- Introduced hybrid striped bass to control perch and gizzard shad
Lake Dredging
Lake Dredging

Why dredge?

- Deepening
- Limit nutrient cycling
- Reduction of macrophyte nuisances
- Removal of toxic sediments
Lake Dredging

Dredging Concerns

- Release of nutrients
- Resuspension of contaminants
- Destruction of benthic fish-food organisms
- Adequate disposal facility
- Cost
Lake Dredging

Sediment source control
(root cause analyses)
– ID source of sediments
– Control the source to reduce the need to dredge again in the near future
Lake Dredging

Sediment Sources
- Stormwater outfalls, ditches
- Bank erosion
- Impervious surfaces
- Agriculture
- Construction sites
Lake Dredging

Sediment Testing

• **Sampling**
  – Sediment cores to project depth
  – Core composition

• **Physical Analyses**
  – Water content
  – Organic content
  – Particle size distribution
Lake Dredging

Chemical Analyses for upland disposal

total phenols
oil and grease
reactivity
nitrogen
phosphorus
minerals (Ca, Mg, K)
base neutral priority pollutant organics

heavy metals
TCLP
PCB’s, DDT, and metabolites
pH
sulfur
chlorides
chlordane
Lake Dredging

Standards to compare the results

- If testing of dredge sediments is required, it is compared to the soil cleanup criteria for site remediation (e.g., residential or nonresidential)
Lake Dredging

Permits to dredge

County –

Soil Conservation District S&E Permit, may also need approvals to transport over county roads

State –

NJDEP Freshwater Wetlands
  GP 1 Maintenance of existing structure
  GP 13 Lake and pond dredging
State permits (cont’d)

NJDEP Stream Encroachment
NJDEP Bureau of Solid Waste (if landfilling)
Water Quality Certificate
NJDEP Lake Lowering, NJDEP Fish & Wildlife
NJPDES may be required as part of a hydraulic dredging project
Lake Dredging

Public Notice

Adjacent property owners
County planning board
Local planning board
Environmental Commission
General Permit 13

- May request permit no more than once every 5 years
- DEP may require testing of the sediment if it is suspected to be contaminated
General Permit 13

Required Documentation

– Aerial photography
– Original construction plans
– Core borings
– Show that dredging will go no deeper than the original configuration and bottom contours of the lake
– Show will not enlarge the lake beyond the original configuration
Lakes larger than five acres

- A USGS quad map showing all of the upstream land and water surface areas draining to the lake
- Land use in the upstream drainage area
- List and locations of sediment sources that discharge directly into the lake or into a tributary within 1,000 feet of the lake
- An estimate of the percent impervious surface cover of upstream drainage area
Lake Dredging

Dredging Process

Mechanical – best for small projects & shorelines

- Grab buckets
- Clam shell
- Excavation
- Dragline
Lake Dredging

Hydraulic

- Pumps as a slurry
- Best for large scale projects
- Softer sediments
- Produces a high water content to be disposed
Lake Dredging

Disposal of dredge material
Beneficial reuse vs. disposal at landfill

- Engineered uses
- Agricultural and product uses
- Environmental Enhancement
- Roadway embankments
- Beach nourishment
- Use options depend on material type
Lake Dredging

Cost of dredging

Mechanical

– $8 – $25/ yd$^3$
– Plus containment

Hydraulic

– $6-$12/ yd$^3$
– Plus travel
Disposal

Site Preparation

- Engineering
  (for hydraulic must size sedimentation basin)
- Clearing
- Dikes and berms
- Drainage
- Access
- Security
Disposal

Environmental Protection
- Liners
- Monitoring Wells
- Chemical Testing

Site Closure
- Time for dewatering
- Grading and seeding
- Landscaping
Shoreline Restoration
Shoreline Restoration

Predominant shoreline issue is erosion

Causes of erosion

• Runoff
• Wave action
• Ice
• Access points
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Bioengineering and hard structure

Vegetative buffer enhancements

- Native plants
- Water tolerant, sturdy vegetation

Revetments – riprap, rootrap, gabions

Outfall retrofitting with BMPs

- Stormwater treatment wetlands
- Bioretention systems
- Premanufactured treatment systems.
Shoreline Restoration

Bioengineering solutions

Plants and other natural materials used to stabilize and restore existing or potential erosion problems
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Benefits of Bioengineering

– Improve aesthetics
– Long term, low maintenance
– Cost
– Environmental quality
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Basic components of bioengineering

- Grading
- Live cuttings
- Erosion blanket
- Biologs
- Seeding
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Vegetative systems
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Structural Design

- Live Stakes
- River Stone

River Stone & Live Stakes
Shoreline Restoration

Stabilization with biologs

Diagram showing:
- Native plantings
- Erosion control mat
- Biolog

Biolog stabilization
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Biologs
Shoreline Restoration

Logs for bank stabilization
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Provide human access points to the lake
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Restoration project

Original Condition
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Restoration in progress
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Restored shoreline
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Outfall retrofitting with BMPs

- Stormwater treatment wetlands
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- Pre-manufactured treatment systems
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Stormwater treatment wetlands
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Bioretention Systems
Shoreline Restoration

Pre-manufactured treatment systems


