2022-20TS
Published July 2022

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Questions?
Contact research.dot@state.mn.us.

Technical Liaison:
Patrick Sejkora, City of Eden Prairie
PSejkora@edenprairie.org

Investigator:
John Gulliver, University of Minnesota

TOTAL PROJECT COST:
$222,467

LRRB PROJECT COST:
$107,560

Algae from excess phosphorus is harmful to human and ecological health.

DEPARTMENT OF TRANSPORTATION
OFFICE OF RESEARCH & INNOVATION

Pond Maintenance Strategies to Retain Phosphorus

Cities and counties depend on stormwater retention ponds to protect water quality in lakes and streams. New research has identified cost-effective methods for ensuring pollutants remain in pond sediment and are not released into other bodies of water.

What Was the Need?

Rainwater runs over Minnesota's roads and other impenetrable surfaces into more than 30,000 retention ponds that overflow into lakes and streams. Cities, counties and transportation agencies often each manage hundreds of these ponds. Stormwater contains dirt, vegetation and other material from municipal lawns and streets, agriculture and industrial sources. Much of this material, which generally settles to the bottom of the ponds, contains phosphorus. The ponds act as sinks, keeping the phosphorus from overflowing into lakes and streams.

Some older or failing ponds, however, are not retaining pollutants in the sediment. Instead, high concentrations are building up and overflowing into other bodies of water within the watershed. Too much phosphorous results in eutrophication—excess nutrients that promote certain plant growth such as algae and starve water of oxygen.

Good water quality needed to support aquatic life includes dissolved oxygen, and when oxygen levels are too low, phosphorus can be released from the sediment. While pond dynamics are complex, low oxygen levels can result from many factors, including a lack of sunlight and wind, which causes water temperatures to vary by depth, or thermal stratification. An excess of sodium chloride from road salt can cause a chemical stratification that can also lead to a phosphorus release.

A traditional pond management method has been to remove sediment by dredging, but logistical challenges and costs of disposing of the often-contaminated material have made this remedy problematic. Since some retention ponds were no longer providing the water quality benefits of their original design, the Local Road Research Board (LRRB) wanted to explore new management practices to ensure excess phosphorus is not released into other bodies of water.

What Was Our Goal?

This project's goal was to identify retention pond design strategies and maintenance measures to mitigate excess phosphorus overflow into lakes and streams.

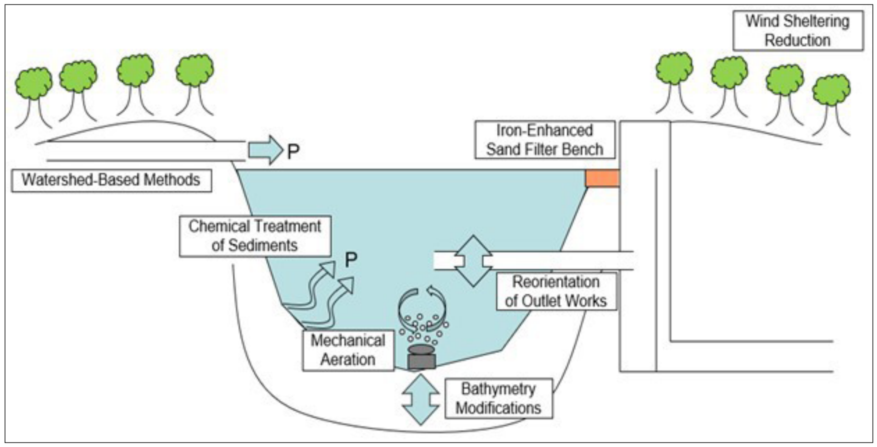
What Did We Do?

Researchers used modeling, field measurements and data analysis to identify best management practices for improving stormwater pond performance and protecting water quality.

After a literature review of various mitigation techniques, investigators entered phosphorus loading levels, chloride levels and other data into a numerical model that incorporates interacting factors affecting pond oxygen levels. The model simulates pond dynamics, including stratification and mixing from wind, outflow rates and vertical temperature profiles. The model further predicts oxygen and chloride levels and the amount of phosphorus released from the sediment. Investigators calibrated and verified the performance of the model through field measurements from the Alameda Pond in Roseville, which has been the subject of prior studies.

Researchers then chose four ponds that varied in size, age and land use context to model seven techniques for increasing oxygen and retaining phosphorus:

continued



The success of remediation techniques in removing phosphorus will depend, in part, on characteristics of the pond and the watershed.

- Chemically treating sediment with alum or iron filings.
- Changing the outflow to a lower depth.
- Mechanically aerating the pond with air diffusers.
- Reducing wind buffers around ponds by removing or thinning trees.
- Implementing watershed-based methods such as infiltration, which reduces the inflow of material into the pond, or street-sweeping.
- Modifying pond depths and surface areas to promote wind mixing.
- Creating an iron-enhanced sand filter bench at the outflow to treat pond effluent.

In addition to examining each technique's efficacy in decreasing phosphorus release, they also determined cost-effectiveness by estimating implementation costs over 10 years based on the reduction of released phosphorus.

What Did We Learn?

This modeling exercise showed that using certain redesign or maintenance measures can return failing stormwater ponds to their intended water quality performance.

Successful cost-effective strategies that reduce phosphorus outflow include:

- Chemically treating sediment with alum or iron filings.
- Mechanically aerating the pond.

Strategies that were not cost-effective for these four ponds include changing the outflow to a lower depth, removing trees to reduce wind sheltering and treating effluent with an iron-enhanced sand filter bench.

The success of watershed-based methods to reduce the inflow of material into the pond depended on the characteristics of the specific watershed and the resulting implementation costs. While infiltration reduced the volume of water coming in and, thus, the volume and concentrations of phosphorus going out, reducing phosphorus inputs through street-sweeping may be more cost-effective.

What's Next?

This research provides local governments with cost-effective alternatives to dredging to maintain the ability of retention ponds to preserve and improve water quality. While these methods will be used immediately, LRRB will also be watching for results in other studies that may broaden the scope of potential solutions to addressing excess phosphorus concentrations and overflow into Minnesota's lakes and streams.

This Technical Summary pertains to Report 2022-22, "Wet Pond Maintenance for Phosphorus Retention," published June 2022. The full report can be accessed at mndot.gov/research/reports/2022/202220.pdf.

"This work resulted in a powerful tool with quantified benefits for cities and counties to manage retention ponds more cost-effectively and to better answer questions from the public about ponds in their communities."

—Patrick Sejkora,
Water Resources Engineer,
City of Eden Prairie

"Local agencies now have a better understanding of retention pond dynamics, the role of dissolved oxygen in phosphorus release and approaches for individual ponds to reduce the phosphorus discharging into our lakes."

—John Gulliver,
Professor Emeritus,
University of Minnesota
Department of Civil,
Environmental and
Geo-Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Office of Research & Innovation
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research