FINAL REPORT SUMMARY

Big Doctor Lake Study Results Summary (2021)

The Big Doctor Lake Management Plan (2020) identified further study needed to better understand Big Doctor Lake water quality. Bill James from the UW-Stout Sustainability Sciences Institute - Center for Limnological Research and Rehabilitation completed studies to identify the amount and cost of alum needed for internal phosphorus load treatment, identify algae species, and analyze phosphorus loading from wetlands adjacent to the lake. Results of these studies are summarized in this handout. Copies of the reports will be posted along with the lake management plan on the Wisconsin DNR website lake pages.

Alum Dosing and Cost

Big Doctor Lake experiences frequent summer algae blooms and is on the Wisconsin Department of Natural Resources list of impaired waters. Alum is a reliable method for controlling phosphorus (P) loading from lake sediments, and internal loading contributes at least 55 percent of the P budget in Big Doctor Lake.

Empirical modeling suggests that control of internal P loading from bottom sediment via an alum treatment would lead to improved summer water quality conditions that meet State of Wisconsin water quality standards. Average summer total P, chlorophyll, and Secchi transparency are predicted to improve to 0.031 mg/L, 13 µg/L and > 8 ft, respectively (Figure 1). Chlorophyll is a measure of algae growth. The percent of time in the summer that chlorophyll a exceeds20 µg/L is predicted to improve from 91% to only 17% if internal P loading is controlled.

Results:

1. The recommended Al dose is ~ 95 g/m^2. The application should be split into lower doses of 40 g/m^2 in year 1, 30 g/m^2 in year 3, and 25 g/m^2 in year 5.
2. The treatment area should encompass sediments within the 7-ft depth contour (89 acres) to account for sediments located in seasonally anoxic or hypoxic areas (Figure 2).
3. Application should occur in mid-June or earlier to avoid peaks in chlorophyll that might interfere with Al floc formation.
4. The Al doses are above the maximum allowable Al dose to maintain pH above 6.0. Thus, a buffered alum (aluminum sulfate-sodium aluminate) application would be needed.
5. Application costs for 95 g/m^2 are approximately $457,000 for buffered alum starting in 2023. The 40 g/m^2 application in 2023 would cost ~ $181,000, the 30 g/m^2 application in 2025 would cost ~ $ 146,000, and the 25 g/m^2 application in 2027 would cost ~ $ 130,000.
6. Because alum dose and application strategies are still evolving and becoming refined with new research world-wide, James recommends an adaptive management approach using post-treatment lake and sediment monitoring to assess lake response to alum treatment. Aquatic ecosystem management with alum is complicated particularly in a large, shallow lake because alum may move or become redistributed by water currents or resuspension, necessitating adjustments in future application.

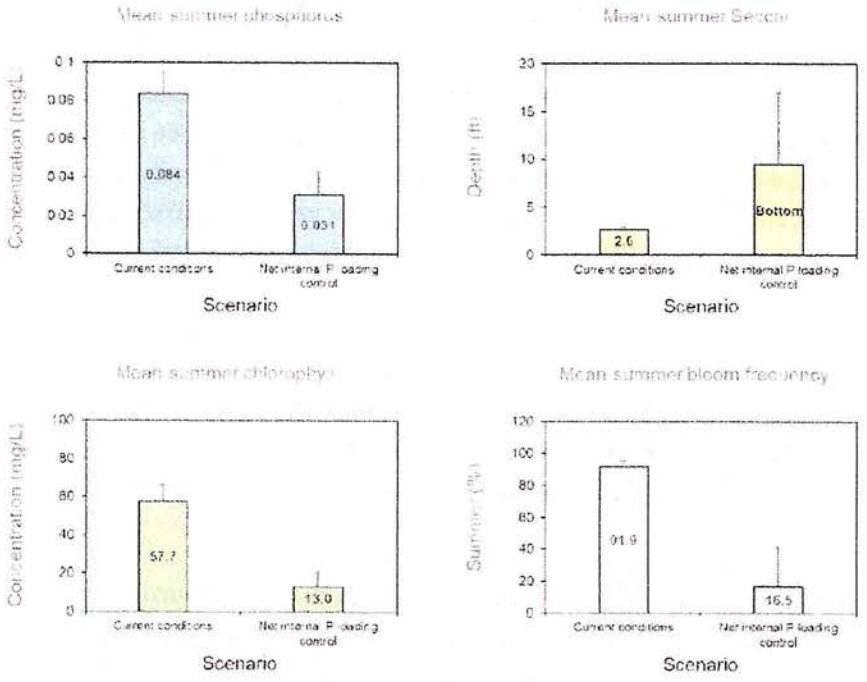

Figure 1. Current conditions and projected changes in mean summer total phosphorus, chlorophyll, Secchi transparency, and frequency of algae blooms as a result of internal phosphorus loading control

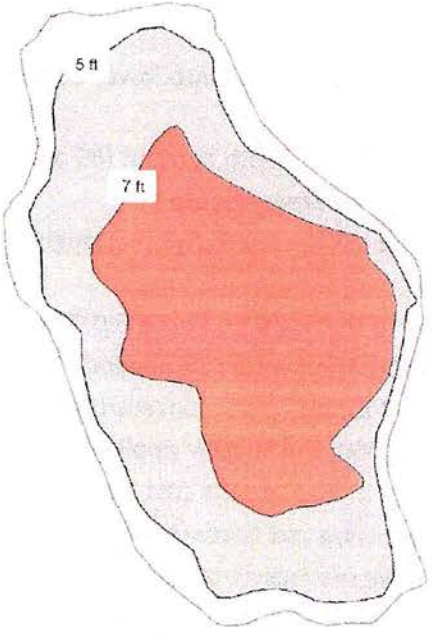

Figure 2. Recommended alum application area (in red)

Algae Identification

Another possible mechanism of internal phosphorus (P) loading is direct uptake by algae of sediment P. Some algae species form resting stages in the sediment and can migrate vertically. These species (primarily cyanobacteria) can potentially take up P directly from the sediment, grow with stored surplus P assimilated from sediment, and could thus inoculate the water column.

Results: The algae present in August 2021 were dominated by cyanobacteria. Most of these have the ability to form overwintering cells called akinetes that can become re-suspended in shallow lakes and inoculate the water column. Germinated cells can potentially bring up internal P loads from the bottom waters of Big Doctor Lake. These cyanobacteria species also can produce toxins that can impair human health.

Wetland Phosphorus Loading

The degree of P loading from wetlands that receive wastewater treatment plant effluent from the Village of Siren wastewater treatment plant is not well understood. The adjacent wetland, although not directly connected to the lake via a discrete channel, may exchange water with Big Doctor Lake. While current wastewater treatment methods have significantly decreased P in effluent, the sediments in the wetland may have become saturated with P over time and now become a source of P to the wetland. Exchanges of water and P between the wetland and Big Doctor Lake may provide a significant source of P for algal growth.

Results: Although wetland soil chemistry indicates some potential for P recycling, there is likely little water mixing between the wetlands and Big Doctor Lake, suggesting minimal impact on P loading. In addition, wetland soils near the lake had little potential for release of P under anaerobic conditions. These soils were very organic and peaty which makes them more likely to store instead of release P.

Sources:

James, William. UW-Stout Sustainability Sciences Institute - Center for Limnological Research and Rehabilitation *Further investigations on Big Doctor Lake, Wisconsin 2021: Wetland soil phosphorus characteristics.* 2022.

James, William. Aquatic Restoration and Research, LLC. *Aluminum sulfate dosage and application strategies for Big Doctor Lake, Wisconsin.* 2022.