Fish Lake Alum Treatment
Annual Progress Report 2018

Fish Lake is located in the City of Maple Grove. The lake area is 238 acres in surface area and has a maximum depth of 61 feet and a percent littoral area (water depth of < 15 feet) representing 38% of the lake area. The lake is included on the MPCA's 303(d) list as impaired for aquatic recreation due to excessive nutrients in 2008. Fish Lake was included in the watershed restoration and protection strategies (WRAPS) and the total daily maximum load (TMDL) studies that were completed by the Elm Creek Watershed Management Commission in partnership with MPCA in 2017.

As part of preparation of the TMDL for Fish Lake, sediment cores were collected and analyzed in 2012 by William James at the University of Wisconsin-Stout. The sediment cores were used to measure aerobic and anaerobic sediment phosphorus release rates for the estimation of internal phosphorus loading to support the development of the Fish Lake TMDL. The WRAPS/TMDL studies identified internal loading as comprising about 70% of the total phosphorus load affecting surface water quality and included a recommendation to treat the lake with alum to achieve the MPCA water quality standards. The sediment cores were used to develop the alum dosing options to address the internal phosphorus load. Based on the sediment core analysis, it was recommended to treat the lake with alum to achieve a sediment delivery rate of 80 grams of Al/m2 in areas of the lake 20 feet or deeper, which translated to a liquid alum application rate of 1,583 gallons/acre of commercial grade alum over 120 acres of the lake surface.

An adaptive management approach was used for implementation of the alum treatment. The current scientific literature indicates that multiple smaller doses spread out over a period of years improve the effectiveness of an alum treatment compared to administering the alum in one large dose at a single point in time. It has also been documented that phosphorus binding efficiency and capacity on the alum floc depends to a large extent on the rapidity of exposure to phosphorus after the alum application. Thus, the application of alum during late summer peak in hypolimnetic phosphorus accumulation can promote immediate exposure of the settling alum floc to soluble phosphorus for rapid binding and maintenance of a much higher phosphorus adsorption capacity after deposition onto the sediment surface.

It was recommended by William James to conduct two separate alum treatments during periods of peak anoxia with high hypolimnetic phosphorus concentrations at a delivery rate of 40 grams Al/m2 over a three-year time period. This would allow the opportunity to monitor changes in water quality and conduct a comprehensive study to measure alum effectiveness at controlling internal loading. Based on the outcome of the study, the second alum treatment could then be adjusted accordingly in order to maximize potential treatment effectiveness.

HAB Aquatic Solutions was awarded the contract and completed the first alum application in mid-September 2017. The treatment barge computer was pre-programed with bathymetry data that adjusted the target alum dosage rate of 40 grams/m2 based on water depth and travel speed. 95,349 gallons of alum were applied to 120 acres of Fish Lake at depths greater than 20 feet.

Three Rivers Park District (TRPD) and UW -Stout conducted a two-phased study to determine the effectiveness of the alum application in controlling internal phosphorus load. Phase 1 of the study involved the deployment of sediment traps above the sediment surface in two different locations of Fish Lake prior to the alum application to determine the Al:P binding capacity ratio immediately after the first alum treatment.

Phase 2 of the study involved collection of sediment cores in the same locations as the sediment traps to measure phosphorus sediment flux and the Al:P binding capacity ratio the following summer in 2018. TRPD also monitored the change in water quality in response to the fall alum treatment performed in 2017. Water samples were collected bi-weekly at the surface from May - September in 2018. Surface water samples were analyzed for total phosphorus, soluble reactive phosphorus, total nitrogen, and chlorophyll-a. The water clarity/transparency was also measured with a secchi disk. The surface water quality constituents were compared to the MPCA state water quality standards. Water samples were also collected at the top of the hypolimnion and 1-m from the bottom to estimate the change in hypolimnetic phosphorus due to sediment release during anoxic conditions in 2018.

The sediment traps were collected one week after the alum application to allow for the complete settling of the alum floc in 2017. The samples were analyzed for dry mass, total aluminum, aluminum-bound phosphorus, and the Al:P binding ratio. The sediment trap analysis was compared to the changes in the phosphorus vertical profile before and

after the alum application. The results indicate that the alum application was effective at removing phosphorus as the alum floc settled throughout the water column . A summary of the findings from Phase 1 are below.

- There were significant decreases in hypolimnetic phosphorus, and it was estimated that 33% to 41% of the total phosphorus (TP) and 29% to 44% of the soluble reactive phosphorus (SRP) was bound by the alum floc during deposition through the hypolimnion.
- Aluminum bound phosphorus in the sediment traps accounted for most of the hypolimnetic TP (60% to 80%) and SRP (79% to 88%).
- The Al:P binding ratios in the sediment traps was approximately 20:1 for both stations.

Sediment samples were collected from the two sediment trap locations the following summer of 2018. The phosphorus flux from the sediments was measured under anerobic conditions in the laboratory. The sediments were further analyzed for phosphorus fractionation and total aluminum to determine Al:P binding ratios. The results indicated that there was continual binding of phosphorus on the alum floc layer between the first alum treatment in September 2017 and August 2018. A summary of the findings from Phase 2 are below.

- The rates of diffusive phosphorus flux under anaerobic conditions were extremely low after the late summer 2017 alum treatment.
- The total aluminum was greatest at the surface of the sediments suggesting that the alum floc layer was located primarily on top of the original sediment surface. This alum concentration was similar to the concentration measured in the sediment traps during Phase 1 of the study.
- There was considerable phosphorus bound to the Aluminum on the alum floc over time.
- The Al:P ratio declined from 19:1 to 16:1 at station 1 and from 21:1 to 18:1 at station 2 in approximately 1 year. Declining Al:P ratios suggested that binding sites were continuing to be efficiently filled via phosphorus diffusing from underlying sediments.

The study results suggest the application of alum during the late summer stratified period and floc deposition through the phosphorus-rich hypolimnion lead to considerable binding of internal phosphorus loads, a relatively low Al:P ratio, and suppression of hypolimnetic phosphorus accumulation. The goal with the Fish Lake alum treatment was to maintain high phosphorus binding efficiency of the alum floc by exposing it to high concentrations of hypolimnetic phosphorus immediately after application. The decrease in the hypolimnetic phosphorus concentrations suggest that alum application has significantly reduce the internal loading within Fish Lake. Based on the results of the study, William James recommends completing the second alum treatment during a period of summer anoxia when the hypolimnetic phosphorus is at its highest to achieve optimal binding capacity. The second alum treatment for Fish Lake is planned for the summer of 2019.

The success of the alum treatment was further confirmed through the in-lake water quality monitoring efforts in 2018. The Fish Lake water quality report card shows the annual changes in water quality. The in-lake water quality conditions achieved the phosphorus state water quality standards throughout the entire season of 2018 . The hypolimnetic phosphorus concentrations were also the lowest recorded since monitoring has occurred. Despite the lake meeting phosphorus water quality standards in 2018, there was an algal bloom in August 2018 that resulted in chlorophyll-a concentrations exceeding the state water quality standard. This algal bloom occurrence has been observed the first year in other lakes that have recently had alum treatments. William James has observed rare algal blooms the first year after the alum treatments for two lakes in Wisconsin, and speculated that the algal species temporarily exploits a niche and dominates the first year after treatment. The rare algal specie appears to be a one-time occurrence that disappears the following year. TRPD will continue to monitor the water quality in-lake response to the second alum treatment that is planned for the summer of 2019.

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