MEMORANDUM
Comfort Lake-Forest Lake Watershed District

To: Board of Managers **Date:** November 24, 2021

From: Mike Kinney

Subject: Forest Lake Water Quality Improvement Projects and Internal Load Analysis

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Background/Discussion

The purpose of this agenda item is to consider a scope of work from the District Engineer, Emmons & Olivier Resources (EOR), to perform an internal load analysis for Forest Lake. Staff and EOR will provide a presentation on this topic at the board meeting.

Addressing internal phosphorus loading in a lake is one of the final steps to ensuring that lake meets long-term water quality goals and is a major achievement. First, the District addresses external phosphorus loading by performing a diagnostic study to target projects, then implementing projects to address external phosphorus loading hot spots such as degraded wetlands, agricultural practices, or urban development. The District completed the Forest Lake Diagnostic Study in 2018, identifying a total phosphorus load reduction goal of 923 lbs/yr.

The District has implemented several water quality improvement projects that have resulted in a cumulative phosphorus load reduction of 760 pounds per year to Forest Lake. Based on water monitoring data, we estimate these projects have achieved 83% of the phosphorus reductions necessary to bring Forest Lake to its long-term water quality goals, including water clarity of ≥7 ft. The District has several projects planned and in progress to achieve the remaining portion of this goal.

Achieving in-lake water quality goals is the District's top priority, and the District has an excellent track record of obtaining grant funds for these projects. Over the past decade the District has obtained a cumulative $2.1 million in grant funds for water quality projects resulting in nutrient reductions to Forest Lake. The District is the statewide top cumulative winner of Clean Water Fund Projects & Practices grant dollars for fiscal years 2014-2021. It has obtained an additional $300,000 in grant funds since 2014 for aquatic invasive species prevention and management on Forest Lake (not counting contributions from partners).

At this point, the District must assess how internal loading is occurring in Forest Lake's complex 3-basin system and identify if/how to address excess internal phosphorus loading. The attached scope of work from EOR outlines how this will be done.

Recommended Action

Proposed Motion: Manager _____ moves to authorize the administrator, on advice of counsel, to enter into an agreement with Emmons and Olivier Resources, Inc in accordance with the November 24, 2021 scope of work and in an amount a not to exceed $36,330. Seconded by Manager _____.

Attached: Forest Lake Internal Analysis Scope of Work

Links to More Information

- Forest Lake Diagnostic Study Presentation (October 26, 2017 Regular Board Meeting)
- Information on Forest Lake Water Quality Improvement Projects

- County Road 50 Iron Enhanced Sand Filter
- Shields Lake Stormwater Reuse & Alum Treatment
- Hilo Lane Stormwater Retrofit
- Shields Lake Fish Barrier Retrofit
- Enhanced Street Sweeping Study
- Enhanced Street Sweeping 2019 Results
- 3rd Lake Pond Wetland Treatment Basin

technical memo - forest lmd

Project Name |	Forest Lake In-lake Phosphorus Management Options Analysis	**Date** |	11/24/2021
To / Contact info |	CLFLWD Board of Managers		
Cc / Contact info |	Mike Kinney, District Administrator		
From / Contact info |	Cecilio Olivier, PE & Joe Pallardy		
Regarding |	Scope of Work for In-Lake Phosphorus Management Recommendations		

Purpose

The purpose of this memorandum is to present next steps for addressing in-lake phosphorus (P) loading in Forest Lake, beginning with the development of an in-lake feasibility study. The in-lake feasibility study is required to secure BWSR Clean Water Funds for all in-lake management activities. The goal would be to have this study completed in time to submit a Clean Water Fund Application in 2022 for implementation (applications are typically due around August).

Background

A 2018 Diagnostic Study and Implementation Plan Update identified that a Total Phosphorus reduction of 923 lbs/year was needed to achieve a long-term, five-year average summer phosphorus concentration at or below 30 ppb as identified in the CLFLWD 2012-2021 Watershed Management Plan. The following key implementation activities were identified as being needed to achieve the phosphorus reduction goals:

Major Completed Activities (District has achieved over 80% of the external load reduction goal for Forest Lake):

- Design and construction of the treatment wetland in the 3rd Lake Pond drainage area
- Design and construction of the Iron-enhanced sand filter in the Heath Avenue drainage area
- Leasing of agricultural land in Castlewood Drainage area and conversion from row crops to perennial vegetation
- Design and construction of the Stormwater Harvest and Irrigation Reuse System in the Shields Lake drainage area and subsequent Shields Lake in-lake alum treatment
- Feasibility and assessment studies in the WJD-6, Hayward Avenue, and Castlewood drainage areas to identify potential projects.
- Completion of the Forest Lake Enhanced Street Sweeping Plan, plus technical and financial support for the City of Forest Lake purchasing of a regenerative air vacuum sweeper and the implementation of an enhanced street sweeping program
- Design and construction of the Shields Lake Fish Barrier and winter aerator to support gamefish populations and subsequently control carp reproductive success.
- Other numerous smaller cost share projects and implementation of District permitting, aquatic invasive species management, and education & outreach programs

Remaining Activities

- WJD-6 Implementation – CR50 Iron Enhanced Sand Filter planned for construction in 2022.
- WJD-6 Western Tributary Wetland Enhancement – Clean Water Fund Application submitted in 2021.
- Additional smaller best management practices (BMPs) around Forest Lake as opportunities arise (e.g., BMPs to be implemented with 2022 Forest Lake Street project on North Shore Circle)
- Potential future alum treatment in one or more of the basins of Forest Lake. Recommendation of which basin(s) would benefit from alum treatment will be determined by the outcome of this study.

2019-2020 Phosphorus Monitoring

Phosphorus load reduction in the Forest Lake watershed has been achieved by implementing the activities identified above. However, results from monitoring data collected in 2019 and 2020 still show elevated phosphorus concentrations, especially in the Middle Basin.

Middle Basin

The Middle Basin of Forest Lake has a maximum depth of 37 feet and a mean depth of 11.1 feet. In 2019, the average phosphorus concentration was 51 µg/L during the growing season (June-September). This is above the State Standard of 40 µg/L. In 2020, the average phosphorus concentration was 42 µg/L during the growing season.

Additionally, summer bottom water (hypolimnion) phosphorus concentrations in the deeper areas of Forest Lake, were consistently high in both 2019 and 2020. A preliminary review of in-lake data collected in 2021 showed a similar pattern with high hypolimnion phosphorus concentrations in August and September prior to an October mixing (turnover) event.

Furthermore, dissolved oxygen (D.O.) and temperature data collected by the St. Croix Watershed Research Station showed that the basin was stratified from June until early September in both 2019 and 2020. Therefore, phosphorus release was possible from early June until early September in both years, with increasingly high phosphorus levels occurring in the hypolimnion by August prior to a fall turnover (mixing event).

Eastern Basin

The Eastern Basin of Forest Lake has a maximum depth of 35 feet and a mean depth of 12.6 feet. Observed growing season phosphorus concentrations were below the 40 µg/L standard in both 2019 and 2020. Fifteen (15) of the 16 hypolimnion samples collected from 2019-2020 were also below 40 µg/L. One sample, collected in August of 2020 had a phosphorus concentration of 50 µg/L. D.O. monitoring conducted in 2019 and 2020 suggested the basin was stratified from mid-June until early September in both years. Therefore, phosphorus release was possible from mid-June through early September. However, bottom phosphorus concentrations remained low.

Western Basin

The Western Basin of Forest Lake has a maximum depth of 22 feet and a mean depth of 9.9 feet. Observed growing season phosphorus concentrations were below the 40 µg/L standard in both 2019 and 2020. Similarly, eighteen (18) of the 19 hypolimnion samples collected from 2019-2020 were below the 40 µg/L standard. D.O. monitoring conducted in the 2019 and 2020 suggested there was no extended period of low oxygen in the bottom waters. The Western Basin is likely intermittently stratified during periods of the year and may be subject to multiple mixing events throughout the growing season.

Next Steps

Given that Forest Lake has the characteristics of both a shallow lake (Western Basin) and a deep lake (Middle/Eastern Basin), a variety of management tools may be needed to control in-lake phosphorus release.

Water quality data collected in 2021, paleo cores collected in 2021, and sediment cores proposed to be collected in 2022 will be analyzed to validate the magnitude and duration of internal loading in each basin.

Following this analysis, a cost-benefit evaluation will be performed to estimate the amount of phosphorus reduction per dollar spent on internal load management practices within each basin.

EOR will generate a matrix that includes a range of potential in-lake treatment options that address internal loading in shallow lakes (Western Basin), deep lakes (Middle/Eastern Basin), and internal loading derived from the littoral zone. In-lake management options will be evaluated and presented to the Board.

Work Tasks & Cost

A combination of in-lake practices may be needed to address the internal loading in the three basins of Forest Lake. This scope of work is for analysis of in-lake data collected to date and analyses of additional sediment cores to be collected in 2022. The most feasible solution, balancing effectiveness with cost will be determined. The outcome of this work will be an in-lake management approach for Forest Lake with a preliminary estimate of probable cost and suggested implementation timeline.

Objective 1. Assembling Data and Develop Alum Dosing

Fieldwork that has been completed (or will be completed) will be assembled to determine the current carp population density, aquatic vegetation distribution and composition, and distribution of sediment phosphorus concentrations – all of which impact the feasibility and effectiveness of in-lake management techniques. Fisheries data will be provided by the DNR. Vegetation distribution, species, and density will be provided by work performed by Blue Water Science and other data sources.

In May of 2022, EOR will collect nine (9) additional sediment cores, including two (2) from the West Basin, two (2) from the Eastern Basin, and five (5) cores from the Middle Basin. The locations of the sediment cores will be representative of the basin conditions and will be designed to capture the spatial variation in sediment chemistry across the probable deep-water internal loading zones present in each basin of Forest Lake.

All cores will be left undisturbed and delivered to Professor Bill James at the University of Wisconsin-Stout. Bill is a Senior Researcher at the University's Center for Limnological Research

and Rehabilitation. Bill is the national leader in laboratory analysis of lake sediment samples and was recently recognized with the Advancements in Lake Management Technologies award at the 2018 North American Lake Management Society (NALMS) Conference in Cincinnati, Ohio. Bill was also part of a team that received national recognition from NALMS for their role in the Bald Eagle Lake alum application. Further, Bill has authored several studies on phosphorus binding dynamics, alum dosing rates, and aluminum to phosphorus binding ratios, many of which are published in peer-reviewed, scientific journals such as the Lake and Reservoir Management Journal.

Each of the nine (9) cores will be sectioned into five (5) two-centimeter increments. Each two-centimeter increment will be analyzed for phosphorus fractionation to identify the proportions of releasable-phosphorus present within the upper 10 cm of sediment. One core from each of the three lake basins will be used for the phosphorus release rate testing. The sediment phosphorus analysis will be completed by June 2022 and will provide information on the distribution of phosphorus fractionation in the lake sediments. In particular, the Limnological Research Center has unique expertise for determining important mobile phosphorus fractions in aquatic sediments. The lab results will be analyzed to suggest soluble phosphorus release rates, alum dosing levels, alum treatment zones, and associated costs needed to sequester phosphorus in the lakebed sediments.

Objective 2. Develop In-Lake Management Approach

Increases in water clarity following a reduction in internal loading may result in an increase in the abundance and distribution of submergent aquatic plants in Forest Lake. The in-lake management plan will identify complementary aquatic plant management practices that can further reduce internal loading in addition to the internal load reductions achieved via carp management, alum treatment or other in-lake practices.

Historical and current vegetation surveys will be reviewed to determine the feasibility of native vegetation re-establishment and the level of aquatic invasive species management likely needed with a focus on re-establishing native species, especially *Chara spp.* The *Chara* species, also known as Muskgrass, have the ability to bind and precipitate phosphorus from the water column and can deliver oxygen to the sediment – thereby preventing ironbound sediment phosphorus release.

Previous fish surveys and on-going carp management will also be reviewed, and appropriate management techniques researched and identified. While present in Forest Lake, fisheries surveys completed by the DNR in 2013 and 2017 suggest carp abundance in Forest Lake is low. Implementation of the Shields Lake Fish Barrier retrofit has further controlled the carp population in Forest Lake as Shields Lake has traditionally provided spawning habitat for common carp from Forest Lake. Research at the University of Minnesota has indicated that carp densities of 100 lb/acre or more can have a significant impact on the native vegetation community, and that a density of 30 lb/acre may be a more appropriate target for lake management (Bajer, Sullivan, &

Sorensen, 2009). EOR will review results from a July 2021 fishery survey performed by the DNR to determine if carp abundance has remained low.

Following this data analysis, EOR will recommend an integrated in-lake management approach and timeline, including a preliminary cost estimate for budgeting and planning purposes. In addition, the results from this study and the in-lake management recommendations will be presented to the Board for their input and consideration for future budgeting. As these management activities are undertaken iteratively, an adaptive management approach may allow the District to forego some proposed activities/costs.

Dr. Jim Almendinger, PhD, a senior scientist with more than 20 years of experience in hydrological research, will serve in an advisory role, verifying quality assurance and control on all aspects of the project.

Project Budget

Table 1. Project Budget

	Labor	Expenses	Total
Objective 1. Assembling Data and Develop Alum Dosing*	$10,110	$14,030	$24,140
Objective 2. Develop In-Lake Management Approach	$12,140	$50	$12,190
Project Total	**$22,250**	**$14,080**	**$36,330**

* Includes costs associated with U.W. Stout laboratory analysis of nine (9) sediment cores.

Project Timeline

This study and all necessary supporting information will be completed by July 30, 2022, such that EOR is positioned to help the CLFLWD apply for a Clean Water Fund grant application in August of 2022. If successful, grant would be awarded in spring of 2023, which would allow for a fall 2023 treatment.