MEMORANDUM
Comfort Lake-Forest Lake Watershed District

To: Board of Managers **Date:** February 22, 2019

From: Mike Kinney

Subject: LimnoTech Proposal

Background/Discussion

Through our partnership with the University of St. Thomas, I was introduced to Arduino technology as it is currently applied to fields of science such as water monitoring. In 2017, students began laying the ground work for building and deploying water level monitoring equipment in Bixby Park. The cost of such equipment is a small percentage of traditional probes and other devices.

In 2018, the students continued to use Arduino technology and in one case, they demonstrated a new, very low-cost monitoring device which can provide laboratory quality results for a fraction of the cost. It is my recommendation that the District deploy these devices with the support of District staff along with assistance from lake associations and other citizen scientists depending on the location and need for data.

It is very plausible that some of our current monitoring could be replaced with this equipment while greatly increasing the amount of high quality data for decision making.

Recommended Action

Proposed Motion: Manager _____ moves to authorize the administrator, on advice of counsel, to enter into an agreement with LimnoTech in accordance with the February 21, 2019 proposal and in an amount not to exceed $_____. Seconded by Manager _____.

Attached: LimnoTech Monitoring Program Proposal

Scope of Work & Budget Justification
for LimnoTech to provide

Development of Open-Source, Do-It-Yourself Monitoring Program

A proposal to

Comfort Lake - Forest Lake Watershed District

44 Lake Street South, Suite A

Forest Lake, MN 55025

Submitted: February 21, 2019

LimnoTech

Water Environment | Scientists Engineers

LimnoTech
Water Environment | Scientists Engineers

7300 Hudson Blvd.
Suite 295
Oakdale, MN 55128
651.330.6038
www.limno.com

February 21, 2019

Mike Kinney | District Administrator
Comfort Lake - Forest Lake Watershed District
44 Lake Street South, Suite A
Forest Lake, MN 55025
Office: 651-395-5858 | Direct: 651-395-5855
michael.kinney@clflwd.org

RE: Development of Open-Source, Do-It-Yourself Monitoring Program

Dear Mike,

LimnoTech is pleased to submit this proposal to serve your greater goals to develop and establish an open-source, do-it-yourself (DIY) monitoring program for Comfort Lake - Forest Lake Watershed District.

We understand that you seek LimnoTech's assistance in getting your DIY monitoring off the ground, by requesting that we submit a proposal for these three separately scoped tasks that can each be funded and completed independently of the others:

1. Develop DIY Nutrient Protocol
2. Review Existing Continuous Monitoring Program
3. Design and Build Open Source Wireless Sensor Stations for Wetlands and Streams

We provide task and sub-tasks descriptions and budgets in this proposal for you to independently assess.

We would love to serve you on this innovative project and look forward to discussing our approach and capabilities further.

Sincerely,

Hans P. Holmberg, PE
Associate Vice President

Anthony Aufdenkampe, PhD
Senior Environmental Scientist

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SCOPE OF WORK

Comfort Lake - Forest Lake Watershed District (CLFLWD) has a long-term goal to develop and establish a scientifically-sound, open-source, do-it-yourself (DIY) monitoring program for their staff, volunteers and contractors.

This proposal describes three separately scoped tasks to assist CLFLWD in their goal. Each of these tasks can be funded and completed independently of the others:

1. Develop DIY Nutrient Protocol
2. Review Existing Continuous Monitoring Program
3. Design and Build Open Source Wireless Sensor Stations for Wetlands and Streams

Task and sub-tasks descriptions and budgets are provided below for you to independently assess.

Task 1. Develop DIY Nutrient Protocol

The most widely used EPA-approved laboratory analyses for nutrients use colorimetry. In all these colorimetric methods, specific regents are added a water sample and develop color in proportion to the target chemical. The deeper the color, the more of the target chemical. Swimming pool chorine tests are an example of a colorimetric method. In a laboratory, however, the depth of the color is measured very precisely by an instrument known as a colorimeter. Commercial colorimeters typically cost thousands to tens of thousands of dollars.

The open-source hardware revolution has led to the development of professional quality but cost-effective laboratory equipment. One of these is the open-source colorimeter by IORodeo (https://iorodeo.com/collections/open-source-colorimeter), which sells for $105. Nitrate and phosphate can be measured with near-laboratory accuracy using this IORodeo Colorimeter, about $30 in Aquarium Nutrient Test reagent kits (such as https://www.amazon.com/API-FRESHWATER-800-Test-Freshwater-Aquarium/dp/B000255NCI) and about $0.60 per sample for disposable filters.

Here we propose tasks to support CLFLWD's interest in launching a scientifically-defensible monitoring program for citizen science volunteers to begin in spring 2019.

Task 1.1. Develop protocols for open-source colorimeter

LimnoTech will develop and test protocols for the collection, handling, measurement and data sharing of dissolved nutrients (nitrate+nitrite and phosphate) using the IORodeo open-source colorimeter. The protocol will be:

- Easy to follow by citizen-science volunteers;
- Safe for use and disposal in a home kitchen;
- For sample collection during both regular low-flow (baseflow, biweekly) and episodic high-flow (storm) stream conditions;
- For dissolved nitrate+nitrate and dissolved phosphate, requiring syringe filtration before analysis.
- Tested and documented as scientifically-defensible, based on clearly cited similarities with EPA-approved and/or published protocols.

The Task 1.1 deliverable will be a written protocol, with appendices and references.

Task 1.2. Train CLFLWD staff and volunteers

LimnoTech will develop and provide a training to CLFLWD staff and volunteers on the protocols developed for Task 1.1. The 2-3 hour hands-on training will be provided twice to accommodate the schedules of approximately 10 individuals, with about 5 people per training session.

The Task 1.2 deliverable will be two identical hands-on training workshops, of 2-3 hours each, plus five complete kits for the collection and analysis of water samples. The kits will be delivered to CLFLWD at the end of the second training.

Task 1.3. Develop a sampling strategy for the Forest Lake tributaries

LimnoTech will develop a sampling strategy for the Forest Lake inlet tributary network, to guide the CLFLWD to most effectively discover the reaches that have the greatest nutrient loads to Forest Lake. The sampling strategy will consider optimal locations and a logical sequence and timing of sample collection, including evaluating the benefits of long-term monitoring at key sites versus exploratory sampling up the stream network.

To complete this task, LimnoTech will require the CLFLWD engineering team (i.e. EOR) to deliver existing water quality data for the tributary network flowing to Forest Lake, along with GIS data for streams and previous monitoring sites.

The Task 1.3 deliverable will be a report and map outlining the recommended sampling locations and recommended timeline and frequency of sampling for each location.

Task 1.4. Evaluate MPCA adoption of DIY Nutrient protocols

LimnoTech will evaluate how these DIY Nutrient protocols might be adopted by MPCA's Citizen Lake and Stream Monitoring Programs.

The Task 1.4 deliverable will be a draft of a letter that CLFLWD would send to MPCA staff to introduce and propose the idea, and participation in two follow-up meetings with MPCA.

Task 2. Review Existing Continuous Monitoring Program

In 2019, CLFLWD will contract Washington Conservation District for $128,598 in Water Monitoring Services at long-term monitoring sites, including eight semi-automated stream water quality and discharge monitoring stations and manual monitoring of 12 lakes. The existing continuous monitoring station hardware is owned by CLFLWD and maintained by Washington Conservation District (WCD). EOR provides additional monitoring services on a project-need basis.

CLFLWD is interested in exploring whether newer technologies might provide greater value (i.e. more data) at the same cost or potentially reduce costs for the same data, and to implement such a plan in collaboration with WCD for the 2020 monitoring season.

Task 2.1. Review existing water quality monitoring program

LimnoTech will review existing long-term water quality (WQ) monitoring program for lakes and streams within CLFLWD. LimnoTech will specifically focus on evaluating opportunities for upgrading, extending, or replacing existing continuous monitoring hardware with newer technologies such as open-source

environmental Internet of Things (IoT) devices. LimnoTech will review information publicly available on CLFLWD's website, such as annual reports and water quality data reports, which include methods sections.

The Task 2.1 deliverable will be an informal meeting with CLFLWD staff to discuss preliminary findings and potential recommendations.

Task 2.2. Recommend cost-effective automation of monitoring program

LimnoTech will recommend cost-effective approaches to further automate the collection of WQ data, including the potential to integrate new monitoring technologies with existing monitoring hardware and the opportunity to add automated monitoring stations for lake level, for lake water quality (i.e. buoys), and for stream/wetland water level and water quality. LimnoTech's recommendations will include confidence levels for proposed new technologies and also alternative approaches. LimnoTech will also consider the potential benefits of selling existing equipment to other watershed districts.

The Task 2.2 deliverable will be a monitoring recommendations report.

Task 3. Design and Build Open Source Wireless Sensor Stations for Wetlands and Streams

We are seeing a revolution in low-cost wireless sensing devices that share real-time data via the internet. This Internet of Things (IoT) revolution has great potential to transform water quality monitoring. Many IoT devices are built on open-source hardware and software that was designed for use by hobbyists. Do-it-yourself (DIY) environmental monitoring geeks have combined these open-source electronic capabilities to develop sophisticated, solar-powered wireless water quality monitoring stations at a fraction of the cost of commercial, black-box systems. These new environmental IoT technologies are surprisingly easy to build, program and maintain due to their open-source roots. In fact, in spring 2018 undergraduate Environmental Science students at University of St. Thomas installed DIY stations at CLFLWD's Bixby Park restored wetland (https://www.envirodiy.org/construction-of-water-level-monitoring-sensor-station/).

LimnoTech staff are nationally-recognized leaders in development and deployment of professional-grade environmental IoT monitoring stations for the emerging Internet of Water.

Here we propose to serve CLFLWD's interest in open-source environmental IoT by piloting the use of six wetland water level stations and six stream water quality stations in collaboration with EOR at their 2019 project sites.

Task 3.1. Build six wetland water level monitoring stations

LimnoTech will design, procure components, assemble and program six ultra-sonic water level monitoring stations to sit atop piezometers/wells in wetlands. The ultra-sonic water level sensor will look down from the well cap and measure distance to water with 1-2 mm of precision. The brain of our solar-powered, wireless stations is the EnviroDIY Mayfly data logger board, developed by the EnviroDIY community for sharing do-it-yourself (DIY) ideas for environmental science and monitoring (https://www.envirodiy.org). These monitoring stations will wirelessly send their data every 15 minutes to the EnviroDIY Data Sharing Portal, http://data.envirodiy.org, which is built on Internet of Water standards and web services for open data access and machine-to-machine data exchange. Data can then

be manually downloaded or automatically harvested at any time from this website in a variety of formats, including comma separated values (CSV).

The Task 3.1 deliverable will be the delivery of the six monitoring station devices. Installation services are not included, but can be separately estimated once monitoring sites have been identified.

Task 3.2. Build six stream water quality monitoring stations

Will design, procure components, assemble and program six water quality monitoring stations for streams. These solar-powered, wireless stations will include all capabilities of the wetland stations, plus they will also measure water temperature and water conductivity. Temperature and conductivity can be used to estimate changes in water sources and pathways (e.g. baseflow separation), reveal dynamic changes in total dissolved solids (e.g., salts), and estimate concentrations of chloride. Additional water quality sensors -- such dissolved oxygen (DO) or turbidity (with automated cleaning brush) -- can be added to these stations at an additional hardware cost of about $800-$1000 per additional sensor.

The Task 3.2 deliverable will be the delivery of the six monitoring station devices. Installation services are not included, but can be separately estimated once monitoring sites have been identified.

The LimnoTech Team:

LimnoTech has brought together a team with expertise in water quality monitoring, including open-source do-it-yourself approaches to solar-powered, wireless environmental monitoring stations.

Our project team will be led by Anthony Aufdenkampe, who is the founder of the EnviroDIY open-source hardware and software project. He will be supported by additional staff at LimnoTech's Central Region Office in Oakdale, MN.

Anthony Aufdenkampe, PhD

TITLE: *Senior Project Scientist*

EDUCATION: *PhD and MS, Chemical Oceanography, University of Washington; BA, Chemistry, Dartmouth College*

YEARS OF EXPERIENCE: *21*

Anthony Aufdenkampe is a Senior Scientist with more than 20 years of experience synthesizing biogeochemical, hydrological, geomorphic and contaminant data, models and knowledge of watersheds and estuaries. He has applied these skills to assess water quality, develop water quality criteria, biogeoscience research, and decision support for conservation implementation. Anthony's work often involves complex partnerships with government agencies, conservation organizations, funding institutions and other stakeholders. Anthony has authored over 65 peer-reviewed publications. He has led large project teams that integrate expertise across many areas of water and environmental science for several large open-source software development projects. Some examples include the Model My Watershed Web application for high-performance modeling and conservation decision support; the EnviroDIY system for low-cost, do-it-yourself environmental monitoring; and the Observations Data Model version 2 software system for cross-disciplinary data management and open-data

interoperability. Anthony has extensive international experience in South America, Africa, Asia and Europe. He was formerly an Associate Research Scientist at the Stroud Water Research Center, where he oversaw the Organic and Isotope Geochemistry laboratory group and maintained certifications with the National Environmental Laboratory Accreditation Program (NELAP) for dozens of organic and inorganic water quality analyses.

Hans Holmberg, PE

***TITLE**: Associate Vice President*

***EDUCATION:** MS, Civil and Environmental Engineering, University of Wisconsin-Madison; BS, Mechanical Engineering, University of Wisconsin-Madison*

***YEARS OF EXPERIENCE:** 26*

Hans is an Associate Vice President and Senior Environmental Engineer at LimnoTech. Hans provides leadership for LimnoTech's service area addressing Clean Water Act compliance, and he manages our Central Regional Office located in Oakdale, Minnesota. Hans has served clients facing complex technical and regulatory challenges related to a broad range of environmental issues since 1994. These clients include industries in the mining, chemical, pulp and paper, manufacturing, and agricultural sectors; municipalities; attorneys; state and federal agencies; and nonprofit organizations. He provides assessment, compliance, and planning services for clients needing to address wastewater, stormwater, contaminated sediment, soil, and groundwater issues. Hans has expertise in NPDES permit negotiations, TMDL development and review, water quality standards review and revision, and watershed and wet weather program planning. Hans' experience involves all phases of projects, including monitoring and modeling, remedial and restoration design, and implementation and construction oversight.

Dendy Lofton, PhD

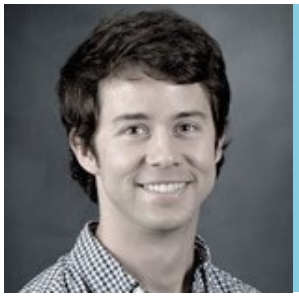
***TITLE:** Project Scientist*

***EDUCATION:** PhD, Environmental Science, University of North Carolina; MS, Biology, University of North Carolina; BS, Environmental Biology, University of Southern Mississippi*

***YEARS OF EXPERIENCE:** 12*

Dendy is a Limnologist and Aquatic Ecologist at LimnoTech. She has extensive experience in water resource monitoring, assessment, and management planning. Dendy applies her expertise in limnology, aquatic ecology and biogeochemistry to several focus areas, including lake restoration and management, urban waterfront revitalization and restoration, watershed planning and management, TMDL development and implementation, and biological community assessments. Dendy leads and supports water resource restoration- and management-related projects throughout the U.S., including Minnesota, Wisconsin, Illinois, Massachusetts, North Carolina, Florida, Texas, and California. Dendy works at LimnoTech's Central Regional Office in Oakdale, Minnesota.

Nick Grewe, PE



TITLE: *Project Engineer*

EDUCATION: *BE, Bioproducts and Biosystems Engineering, University of Minnesota; BA Environmental Studies, St. John's University*

YEARS OF EXPERIENCE: *6*

Nick is a Project Engineer at LimnoTech. His areas of expertise include watershed engineering, stream restoration, hydrologic/hydraulic modeling, and GIS application. Nick has extensive field experience in many areas of water resources including water quality monitoring, contaminated soils and sediments, Rosgen stream assessments, erosion control, and surface and groundwater monitoring, BMP inspections, bathymetry studies, and floodplain mapping. He has developed and applied models (HEC-RAS, HSPF, EFDC, BATHTUB) for watersheds and waterbodies throughout the country to aid in the preparation of permits, TMDL development, stream restoration and channel design, and decision-support tools. Nick is also proficient in ArcGIS, and he applies his skills to offer support on a diverse set of project-specific needs. Nick works at LimnoTech's Central Regional Office in Oakdale, Minnesota.

COST

Budgets by Tasks

Task / Activity	Labor Cost by Task	Non-Labor by Task	Total by Task
Task 1. Develop DIY Nutrient Protocol			
1.1 Develop protocols for open-source colorimeter	$ 3,695	$ 855	$ 4,550
1.2 Train CLFLWD staff and volunteers	$ 3,345	$ -	$ 3,345
1.3 Develop a sampling strategy for the Forest Lake tributaries	$ 3,995	$ -	$ 3,995
1.4. Evaluate MPCA adoption of DIY Nutrient protocols	$ 1,420	$ -	$ 1,420
Task 1 Totals:	$ 12,455	$ 855	**$ 13,310**
Task 2. Review Existing Continuous Monitoring Program			
2.1. Review existing water quality monitoring program	$ 4,145	$ -	$ 4,145
2.2. Recommend cost-effective automation of monitoring program	$ 3,120	$ -	$ 3,120
Task 2 Totals:	$ 7,265	$ -	**$ 7,265**
Task 3. Design and Build Open Source Wireless Sensor Stations for Wetlands and Streams			
3.1. Build six wetland water level monitoring stations	$ 3,495	$ 3,960	$ 7,455
3.2. Build six stream water quality monitoring stations	$ 3,495	$ 6,600	$ 10,095
Task 3 Totals:	$ 6,990	$ 10,560	**$ 17,550**

Each of these tasks can be contract independently from the others. The combined cost of all three task, if all selected, totals $39,285.

Task 1 includes the purchase of supplies for five complete colorimetry kits, including reagents, sampling bottles, and syringe filters. These kits will be used for testing developed protocols (Task 1.1) and for hands-on training (Tasks 1.2). The kits will be delivered to CLFLWD for their use after the completion of the second training.

Task 3 does not include installation services, but installation costs can be separately estimated once monitoring sites have been identified. Also, if additional stations are desired, costs can be scaled upwards proportionally. Last, additional water quality sensors -- such dissolved oxygen (DO) or turbidity (with automated cleaning brush) -- can be added to these stations at an additional hardware cost of about $800-$1000 per additional sensor.

Budget Justification

Personnel: Anthony Aufdenkampe will manage the project and do the majority of the work. Dendy Lofton will contribute to sampling strategies and the review of the existing continuous monitoring program. Hans Holmberg will provide internal reviews of deliverables and quality assurance on all aspects of the Project. Nick Grewe will assist in the building of monitoring stations.

Labor Rates: We offer our 2019 labor rates for the entire duration of this project. These rates include benefits and overhead costs, according to our 2015 Federal Acquisition Regulation (FAR) Overhead Audit report.

Non-labor: We offer monitoring station hardware at the direct costs of hardware components and shipping plus our typical 10% Fee on Other Direct Costs (non-labor).