Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-288

Proposal Title: Minnesota Lake Water Quality and Temperature Forecasting App

Project Manager Information

Name: Leif Olmanson

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: App to deliver up-to-date actionable comprehensive lake water quality and temperature information to Minnesota swimming, boating, fishing, and lake management communities to improve natural, recreational, and travel experiences

Funds Requested: $399,000

Proposed Project Completion: June 30, 2027

LCCMR Funding Category: Foundational Natural Resource Data and Information (A)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Summer in Minnesota means a day at the lake fishing, swimming, boating, and recreating. With warming temperatures, longer open water seasons, and more intense storms delivering more nutrients to our lakes, harmful algal blooms (HABs) are increasing, including in lakes where they have never occurred before. Knowing the current and forecast conditions of lakes is important for the successful planning of recreational activities to avoid health threats from HABs and improve the success rate for catching fish.

Water temperature is one of the most important physical characteristics of aquatic systems, regulating many chemical and biological processes. While water temperature measurements are relatively scarce, they are one of the most important things to know, if you want to catch fish and avoid areas where HABs are likely to occur.

This project is a compelling opportunity to take advantage of archived and current data streams from ground stations, operational satellites, and supercomputing resources at the University of Minnesota (UMN). This proposal is designed to fill a void for up-to-date information to inform citizens to improve outdoor recreational activities and travel experiences, while also producing important data for lake management, including watershed protection and conservation of fish habitats.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

The popular Minnesota LakeBrowser (https://lakes.rs.umn.edu/) will be restructured to automatically provide current and forecasted lake water quality and temperature information for Minnesota's lakes. To do this we will use over 4 million satellite-derived water quality measurements, linked with weather and lake temperature data to determine predictable patterns that will be modeled using machine learning methods. The models will use the most recent satellite lake temperature and water quality data (clarity, chlorophyll, color) as a starting point with weather data to predict current and forecast lake temperature and water quality information. The LakeBrowser will be updated daily with new water quality and temperature predictions and data.

This project will leverage:

- Lake water quality and temperature data from existing monitoring programs.
- An automated water quality monitoring system developed in a 2018 LCCMR project that provides historic and near real-time water quality data.
- Landsat lake temperature products developed by the US Geological Survey EROS Data Center.
- Lake temperature models developed by the US Geological Survey for 4000+ Minnesota recreational lakes which will be automatically updated with recent remotely sensed water quality, lake temperature, and weather data from the National Weather Service to improve accuracy.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This project will restructure the popular Minnesota LakeBrowser (https://lakes.rs.umn.edu/) to include lake temperature and implement forecasting capabilities. Online interactive maps for exploring Minnesota lake data will be automatically updated daily with current and forecasted water quality and temperature data. High-frequency up-to-date data will provide swimming, boating, fishing, and lake communities with the information needed to inform and plan recreational outdoor activities and successful travel experiences. Additionally, these data will cover the entire state at frequencies (>7 million measurements) unattainable by resource managers but essential for effective lake management, including watershed protection and conservation of fish habitat.

Activities and Milestones

Activity 1: Update the automated water quality monitoring system with temperature and machine-learning water quality models.

Activity Budget: $130,000

Activity Description:
Modify the current water quality monitoring system to work with Landsat temperature products. This includes machine-to-machine access to U.S. Geological Survey servers to acquire archived and current imagery to supply the demand for near real-time data. Newly acquired imagery will be sent through multiple scripted processing modules, which include (1) identifying and omitting contaminated pixels caused by clouds, cloud shadows, atmospheric haze, wildfire smoke, and specular reflection, and (2) classification of water pixels through a normalized difference water index to delineate an image-specific water mask. The combined masks result in qualified pixels which advance to the development of models using routinely collected field temperature data to calibrate available temperature satellite products for Minnesota lakes. The temperature models will then be applied to all available clear archived 2017 to 2026 and ongoing Landsat 8, 9 data to produce databases of lake temperature.

The current water quality monitoring system models will be updated using machine learning methods and trained using all available clear image occurrences with available in situ field measurement matchups (30,000+). These models will be applied to available imagery from 2017 through 2026 to create water quality products to repopulate and continuously update the LakeBrowser in Activity 3.

Activity Milestones:

Description	Approximate Completion Date
Develop methods for 2017 to 2026 and ongoing Landsat temperature satellite products	June 30, 2025
Add temperature to the automated water quality monitoring system	June 30, 2026
Develop near real-time capability in the automated water quality and temperature monitoring system	December 31, 2026
Update database with archived and ongoing clarity, chlorophyll, color, and temperature data	March 31, 2027

Activity 2: Develop and implement machine learning models to predict current and forecast lake water quality and temperature data.

Activity Budget: $139,000

Activity Description:
To fill in lake temperature and water quality data between the most recent clear satellite image occurrence and current time, first we will automate USGS lake temperature models for 4000+ Minnesota lakes using historic weather data and improve them using our remotely sensed water quality data and machine learning methods. We will run those models on UMN supercomputers and link them to near real-time water quality data and real-time and forecast weather data from the National Weather Service to predict and forecast lake temperature for 4000+ lakes. Second, we will develop models that use over 4 million satellite-derived water quality measurements (Activity 1), linked with weather and lake temperature data (Activity 1) to determine predictable patterns that will be modeled using machine learning methods. These models will combine the most recent satellite water quality data (clarity, chlorophyll, CDOM) and lake temperature data to predict current conditions and forecast near-term future water quality data.

Activity Milestones:

Description	Approximate Completion Date

Create a system to automatically model lake temperature using water quality and weather data	June 30, 2025
Develop machine learning models to predict current and forecast water quality and temperature data	March 31, 2026

Activity 3: Adapt LakeBrowser to continuously update with near real-time satellite and modeled current and forecast water quality and temperature data

Activity Budget: $130,000

Activity Description:

This project will restructure the Minnesota LakeBrowser to be more like a "Weather App" for lakes where Minnesotans and visitors can access current and forecast water quality and temperature data either on their computer or mobile device. This allows users access to the most up-to-date information for planning their outdoor activities for that day or for an upcoming vacation to their favorite lake area. While also having an advantage over a "Weather App" with users and lake managers also having access to regional summaries and all the data that has been collected by our system for each of 10,000+ Minnesota lakes going back to 1975. So users can see historical and seasonal trends and how each lake reacts to different climatic conditions.

To accomplish this, the Minnesota LakeBrowser will be updated with water quality and temperature data created in (Activity 1) and we will develop processes to update the LakeBrowser daily with near real-time satellite and current and forecast modeled temperature and water quality data (Activity 2) as it becomes available.

Activity Milestones:

Description	Approximate Completion Date
Add water quality and temperature data developed in Activity 1 to the LakeBrowser	June 30, 2026
Develop code to continually update the LakeBrowser with new data as it becomes available	December 31, 2026
Release fully operational and regularly updated Minnesota LakeBrowser	June 30, 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
David Porter	Minnesota Supercomputing Institute, University of Minnesota	Porter will work with Olmanson to develop new models for deriving current and forecast lake water temperature and quality and integrate these models into the existing water quality monitoring system. He will also automate the updated system for ongoing near-real-time monitoring and forecasting.	Yes
Peter Wiringa	U Spatial, University of Minnesota	Wiringa (GIS and web development) developed the current LakeBrowser and will add the new water quality and temperature data to the LakeBrowser. He will make near real-time updates and forecasts available.	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?
Semi-automated computer code will routinely acquire the latest satellite imagery and provide lake water quality and temperature data. Information will be freely available to all through the Minnesota LakeBrowser. Maintenance of the Minnesota LakeBrowser and any updates to data processing would be funded by pursuing funds from data users.

To get the word out about the forecasting capabilities of the next-generation LakeBrowser we will conduct outreach activities such as making presentations at conferences and reaching out to conservation/nature reporters. We will also encourage the use of the data by lake water quality professionals to advance lake management.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Providing Critical Water-Quality Information for Lake Management	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03b	$250,000

Project Manager and Organization Qualifications

Project Manager Name: Leif Olmanson

Job Title: Researcher 6

Provide description of the project manager's qualifications to manage the proposed project.
Leif Olmanson will oversee the overall management of the project and has had experience co-managing previous LCCMR projects. He has over 25 years of experience developing remote sensing applications to create temporally and spatially rigorous datasets of water and land resources for large-area ecosystem characterization. He is particularly interested in developing field-validated image processing methods implemented in automated geospatial analysis systems such as Google's Earth Engine and Minnesota Supercomputing Institute supercomputers to gain a better understanding of the natural environment. He led a team of researchers and computer scientists to build a near real-time water quality monitoring system for Minnesota's >10,000 lakes using satellite imagery to provide critical water quality information for citizens and lake management. He also oversaw the modifications of the Minnesota LakeBrowser with the new capability to take advantage of the high volume of data provided by the automated system.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:
All personnel are based at the University of Minnesota, one of the largest, most comprehensive, and most prestigious public universities in the US (https://twin-cities.umn.edu/). The labs and offices of the investigators are equipped with the necessary space and facilities needed for the proposed work.

The Minnesota Supercomputing Institute (MSI) is the University of Minnesota's principal center for computational research. Its main data center is located in the basement of Walter Library (room B40) on the U of M Twin Cities campus. It has an IT raised floor surface of approximately 3700 sq.ft. and over 1 MW of available power. The Institute HPC systems are composed of over 90,000 x86 64-bit compute cores, NVIDIA GPUs, and 500 TB of RAM, which can support over 6 double-precision PFLOPS of peak performance. HPC nodes are connected via Infiniband and are equipped with between 64 GB and 2 TB of RAM to support applications that require small and large amounts of memory, all nodes have local scratch drives, and 83 nodes include various configurations of the NVIDIA general purpose GPU accelerators (V100, A100), from 2- to 8-way.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Leif Olmanson		Researcher			26.7%	1.2		$134,584
David Porter		Scientific Computing Consultant			26.7%	0.81		$144,769
Peter Wiringa		Geospatial Analyst			26.7%	0.66		$94,475
							Sub Total	**$373,828**
Contracts and Services								
University of Minnesota Remote Sensing Laboratory/ MSI/GEMs APIs	Internal services or fees (uncommon)	Access to remote sensing/GIS software and computers for model development and to resources at Minnesota Supercomputing Institute and GEMs APIs at the University of Minnesota.				-		$21,572
							Sub Total	**$21,572**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration	1 to 2 trips, 1 to 2 people per year	Present results of LCCMR-funded work, outreach, and demonstration of the					$3,600

	Miles/ Meals/ Lodging		new capabilities of the new Minnesota LakeBrowser App.					
							Sub Total	**$3,600**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$399,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$219,135
			Non State Sub Total	**$219,135**
			Funds Total	**$219,135**

Attachments

Required Attachments

Visual Component

File: 4786fcde-5f9.pdf

Alternate Text for Visual Component

Shows the workflow of the automated lake water quality and temperature system that this project will develop and the outcome to provide current and forecasted water quality and temperature information to swimmers, boaters, fishers, recreators, and lake managers to improve natural, recreational, and travel experiences....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
SPA Endorsement Letter	48a659db-68c.pdf
LOS MSI UMN	45e32c6f-ba1.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services, as defined in Minnesota Statutes section 299C.61 Subd.7?

No