Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-280

Proposal Title: Understanding to Improve Minnesota's Future Lake Water Quality

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: Use decade-long comprehensive real-world data to understand lake-specific drivers of water quality and high-resolution climate models to project the effects of future warming on HABs across Minnesota

ENRTF Funds Requested: $595,000

Proposed Project Completion: June 30, 2028

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.

There is a well-documented connection between agricultural management practices and the occurrence of harmful algal blooms (HABs) in Midwestern lakes. However, the occurrence of HABs is not only an agricultural problem. There are several drivers of these blooms, many of which have yet to be quantified. Water temperature is one of the most important physical characteristics of aquatic systems, regulating many chemical and biological processes. With warming temperatures, longer open water seasons, and more intense storms delivering more nutrients to our lakes, the occurrence of harmful algal blooms (HABs) and threats to fish habitats are increasing throughout Minnesota. As temperatures continue to increase a more precise understanding of temperature induced HAB risk will help mitigate assumptions about the key contributors to these blooms and enable improved identification of best management practices across sectors to help limit their economic, ecological, and human health impacts.

The project is a compelling opportunity to take advantage of cutting-edge climate modeling, archived and current data streams from operational satellites and the high-performance computing resources at the University of Minnesota. This forward-thinking approach allows for a comprehensive understanding to focus resources where needed to get ahead of the problem and conserve water quality for future generations.

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 overarching goal of this project is to fill a significant knowledge gap about the climatic drivers and occurrence of HABs in Minnesota's 10,000+ lakes while developing actionable insights, tools, and Extension training to ensure this research is integrated into decision-making and management practices across the state.

We will use real-world datasets to identify changes to HAB timing and intensity under different weather and land use scenarios. To do this we will develop comprehensive water quality and lake temperature data from satellite data for over 10,000 Minnesota lakes and utilize weather and watershed data available in GEMS Exchange APIs. Having a comprehensive dataset for an eleven-year period (10 million+ matchups) will provide a strong basis to determine weather patterns (e.g. warm/dry, wet/cool) that affect HAB timing and intensity for different lake and watershed characteristics. This will provide a strong real-world understanding of current and recent HAB timing and intensity for Minnesota lakes. This understanding will be used with state-of-the-art machine learning methods to develop strong models that we will use with high-resolution climate projections for different climate scenarios to analyze the effects of future warming on HABs in lakes across Minnesota and categorize at-risk lakes.

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?

1) Decade-long real-world Comprehensive database of lake water quality and lake water temperature to understand lake-specific drivers of water quality.
2) Use high-resolution climate model output to analyze the effects of future warming on HABs in lakes across Minnesota and categorize at-risk lakes.
3) Incorporate model results into an interactive recent lake water quality and temperature visualization tool and future climate data visualization tool.
4) Develop and deliver information to support agricultural and natural resource managers and Tribes to both understand and effectively manage HAB risks to better support the health of Minnesota's lakes and waterways.

Activities and Milestones

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

Activity Budget: $160,000

Activity Description:
Modify 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 imagery. 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 2017 to 2027 Landsat 8, 9 data to produce databases of lake temperature.

Update current water quality monitoring system models using machine learning methods and trained using all available clear image occurrences with field measurement matchups (60,000+). These models will be applied to available imagery from 2017 through 2027 to create water quality products that will be used along with temperature for climate projection modeling in Activity 2 and made available in the interactive visualization tool in Activity 3.

Activity Milestones:

Description	Approximate Completion Date
Develop methods for 2017 to 2027 Landsat temperature satellite products	December 31, 2025
Add temperature to the automated water quality monitoring system	June 30, 2026
Develop and apply Machine Learning water quality models	June 30, 2026
Compile database with water quality (clarity, chlorophyll, color), and temperature data for 2017 to 2026	December 31, 2026
Process and compile water quality and temperature data for 2027	December 31, 2027

Activity 2: Develop and apply weather informed HAB models to climate projections to predict effects of future warming on HABs in lakes.

Activity Budget: $195,000

Activity Description:
Link data developed in Activity 1 (water quality and temperature) with weather data (e.g. temperature, wind, precipitation), lake morphometric (e.g. size, depth, fetch) and watershed characteristics (e.g. landcover, soils, slope) to create matchup datasets. We will use Machine Learning methods to determine relationships with the dataset to develop weather informed growth rate for HABs species of concern (e.g. Microcystis) for different lake and land use types. The models will be used with high-resolution temperature projections to estimate HAB growth and timing for low, medium and high emission scenarios at twenty-year increments from 2040 to 2099. These are the scenarios and time periods that dynamically downscaled climate simulations are currently simulating. We will calculate two indicators, bloom timing and bloom intensity. Bloom timing is the time of year when water temperatures are warm enough to cause rapid algal growth and is defined by the week when growth reaches 75% of the maximum. Bloom intensity refers to the algal cell's potential growth at a particular point in time - higher potential growth suggests a more intense bloom. We will calculate these indicators in future scenarios and compare them to historical real-world measurements to analyze how blooms might change.

Activity Milestones:

Description	Approximate Completion Date
Develop weather informed HABs model for different lake types and watershed characteristics	March 31, 2027
Apply HAB models to low, medium and high emission climate scenarios	June 30, 2027
Test models, calibrate and validate with 2027 water quality and temperature data	March 31, 2028

Activity 3: Incorporate results into a lakes-focused climate data visualization tool.

Activity Budget: $240,000

Activity Description:

Incorporate the results of Activity 1 and 2 into a lakes-focused climate visualization tool. We will engage stakeholders at every step of the process, from initial tool design to iterations on tool development and feedback on its usability. This process will determine if we can add the climate projections into an enhanced Minnesota LakeBrowser or if a new visualization tool is preferable. Users will have access to historic and recent water quality and temperature data along with HAB timing and intensity and be able to select future periods to see emissions scenarios, and HAB species they are interested in, and will have the option of viewing two map layers: one showing changes in bloom timing and another showing changes in bloom intensity. Users will be able to zoom into specific lakes or regions and download data in map image, geographic information systems (GIS), and text formats.

Activity Milestones:

Description	Approximate Completion Date
Final determination on Integration of new visualizations into Minnesota LakeBrowser or a new, separate application	March 31, 2027
Add water quality and temperature data developed in Activity 1 into the data visualization tool	June 30, 2027
Add climate projections of future warming and anticipated future HAB risks in 10,000+ lakes	January 31, 2028
Complete usability testing of updated Minnesota LakeBrowser and/or new application	February 28, 2028
Refine application based on usability testing	May 31, 2028
Release fully operational updated Minnesota LakeBrowser and/or data visualization tool	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Joel Larson	University of Minnesota Extension - Water Resources Center	Outreach and engagement: Integrate results into existing Extension programming; help to establish relationships with community partners.	No
David Rosen	Usability Services, Office of Information Technology, University of Minnesota	Provide expertise and services for user testing of the LakeBrowser and lake-focused climate visualization tool.	No
Suzanna Clark	University of Minnesota Climate Adaptation Partnership	Outreach and engagement: Integrate results into existing Extension programming; help to establish relationships with community partners.	No

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?

The data visualization tool developed in Activity 3 will be maintained at U-Spatial, either as a separate application or integrated with the Minnesota LakeBrowser. The water quality and temperature data created from this project will be added to the current LakeBrowser (https://lakes.rs.umn.edu/). Maintenance of the Minnesota LakeBrowser and any updates to data processing would be funded by pursuing funds from data users.

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 be responsible for overall project coordination and supervision of the study, including working with Porter on the development of machine learning models used for the creation of the water quality and temperature databases and developing an application of the weather-informed HAB models to climate projections to predict effects of future warming on HABs in lakes. He will also work with Wiringa and his staff to update the LakeBrowser and lake-focused climate visualization tool. He is currently and has managed many remote sensing of water quality projects in Minnesota, Michigan, and Massachusetts and was a Co-PI on LCCMR project M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03b. 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

(https://lakes.rs.umn.edu/) with the new capability to take advantage of the high volume of data the automated system provides.

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 in the basement of Walter Library (room B40) on the U of M Twin Cities campus.

GEMS, a joint CFANS and MSI agri-food informatics initiative of the University of Minnesota is a highly diverse international and interdisciplinary team of professionals. GEMS is re-imagining the relationships between data, institutions, and disciplines to inform and accelerate innovation within the food and agricultural sectors. The GEMS Informatics Initiative makes genomics, environmental, management, and socioeconomic data interoperable at varying spatial and temporal scales to generate actionable information and promote innovation partnerships that accelerate and sustain growth in local and global food and agricultural systems. The GEMS Exchange Application Programming Interfaces (APIs) include Satellite Imagery, Weather, Soils, Water, Crop Calendar, Elevation, Landcover, and high-resolution Climate data that will be used to develop and apply models.
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Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Leif Olmanson		Principal Investigator			37.1%	1.2		$140,466
Peter Wiringa		Co-Investigator			37.1%	0.06		$17,936
David Porter		Co-Investigator			37.1%	1.2		$226,632
To Be Determined		Researcher 5			37.1%	2		$200,166
							Sub Total	**$585,200**
Contracts and Services								
Unversity of Minnesota Remote Sensing Laboratory/MSI/GEMs APIs	Internal services or fees (uncommon)	Access to remote sensing/geographic information systems (GIS) software and computers for model development and to resources at Minnesota Supercomputing Institute and GEMs APIs at the University of Minnesota.				0.03		$3,000
							Sub Total	**$3,000**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	1 to 2 trips, 1 to 2 people per year	Present results of LCCMR-funded work, outreach, and demonstration of the new capabilities of the new Minnesota LakeBrowser App					$6,000
							Sub Total	**$6,000**

Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Honorariums for up to eight usability testers at $50/person for 2 years	Provide honorariums for usability testers to help ensure testing appointments are kept					$800
							Sub Total	**$800**
							Grand Total	**$595,000**

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	Unrecovered Facilities and Administration Costs UMN (55% overhead)	Operating costs of the UMN	Pending	$327,250
			Non State Sub Total	**$327,250**
			Funds Total	**$327,250**

Total Project Cost: $922,250

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 09fe4731-464.pdf

Alternate Text for Visual Component

Shows the workflow of the automated lake water quality and temperature system and how that data will be used with data from the GEMS Exchange APIs including high-resolution climate data to project HAB conditions into the future and the lake-focused climate data visualization tool with different climate scenarios....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
MCAP Letter of Support	eaeb64f6-4f8.pdf
UMN IT Letter of Support	ccd4b960-ce4.pdf
UMN SPA Letter	a8036627-9c3.pdf
WRC Letter of support	fe37fd2e-f0b.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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 pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

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 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

NA