



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-458

Proposal Title: Predicting Foam Formation and Motion in Minnesota Waters

Project Manager Information

Name: Lian Shen

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: This project will build prediction tools, validated using existing observational and environmental data, to identify where contaminant-rich foam is likely to form on Minnesota lake surfaces and accumulate along shorelines.

ENRTF Funds Requested: \$500,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Water (B)

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.

This proposal addresses a concerning phenomenon on Minnesota lake shorelines: floating foams, which can concentrate contaminants at the water surface to levels 10 to 1,000 times higher than in the water beneath. Some foams originate from harmless natural organic substances, but others form from synthetic contaminants such as detergents and chemicals. Harmful algal blooms create a similar hazard because cyanotoxins in surface foams may far exceed recreational health thresholds. Foams consist of air pockets whose film boundaries accumulate surface-active chemicals.

Wind-generated waves and currents transport foams toward beaches, boat launches, and lakeshore parks, increasing public exposure. MDH advises avoiding contact with contaminated foams, and MPCA relies on bloom reporting and volunteer monitoring to track lake conditions. However, these efforts focus on monitoring and advisories, without forecasting where contaminant-rich foams will form or which shorelines face the greatest risk. In recent years, LCCMR has supported substantial work on emerging contaminants and harmful algal blooms, yet no funded project addresses the physical process that concentrates contaminants through foaming and delivers them to shorelines. Because existing efforts emphasize reporting, advisories, and local monitoring, which are valuable but lack a forecasting component, there is no advance notice of contaminant-rich foam events.

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.

We propose to build a physics-based prediction tool that forecasts where foam forms on Minnesota lakes, how wind carries it, and which shorelines are most likely to receive elevated contaminant concentrations. Our approach combines advanced computational capabilities developed over the past decade, including: (1) wind-wave interaction models that predict where air is entrained as bubbles, (2) surfactant transport models that track how surface-active chemicals are scavenged by those bubbles, (3) foam formation models that simulate contaminated bubble clustering into persistent foams, and (4) large-scale transport models that predict how wind drives foams toward downwind shorelines.

This project will produce two deliverables for MPCA and MDH. First, we will develop a tool to generate a statewide Foam Risk Map that ranks lake shoreline segments by predicted foam arrival frequency, accounting for wind patterns, lake fetch, organic matter inputs, and proximity to known contaminant sources. Second, we will develop a Foam Forecast tool that uses National Weather Service wind forecasts to predict which shorelines will receive foam over the next 48 hours. We will validate the model against field observations from selected lakes in representative regions of the state.

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 give state agencies practical tools to identify where contaminant-rich foams are likely to form, where wind will transport them, and which shorelines face the greatest exposure risk. Specific outcomes include: (i) a tool to generate a statewide Foam Risk Map ranking shoreline segments by predicted foam-arrival frequency and vulnerability; and (ii) a Foam Forecast tool identifying shorelines likely to receive foam over the next 48 hours. The project will also produce a Minnesota-specific dataset on contaminant enrichment in foams and a publicly accessible archive of model results.

Activities and Milestones

Activity 1: Compile Wind, Wave, Shoreline, and Contaminant Source Data for Minnesota Lakes

Activity Budget: \$125,000

Activity Description:

The objective of this activity is to assemble the data needed to study and predict foam formation and transport on Minnesota lakes. We will compile wind climatology data, including wind speed, direction, and seasonal patterns, from National Weather Service observations and Minnesota State Climatology Office records for representative lake regions. Lake bathymetry, fetch, and shoreline geometry will be derived from Minnesota DNR lake depth maps and survey products, together with federal hydrography datasets. Contaminant-source information will be assembled from MPCA water-quality monitoring records, MPCA harmful algal bloom reports and bloomWatch observations, MDH harmful algal bloom illness and public-health datasets, and existing or emerging microplastics datasets from LCCMR-funded projects. We will also compile chlorophyll-a and related lake-water-quality measurements from MPCA records, and dissolved organic carbon, where available, from statewide lake-monitoring programs, because dissolved organic matter is a key natural foam stabilizer and algal biomass is an important indicator of organic-matter production. Based on exposure potential, proximity to contaminant sources, and recreational use, we will select test sites for model development and validation in the following activities.

Activity Milestones:

Description	Approximate Completion Date
Compilation of wind climatology and lake bathymetry data for representative lake regions	March 31, 2028
Assembly of contaminant source data from MPCA, MDH, and LCCMR projects	June 30, 2028
Compilation of lake-water-quality datasets and selection of representative test sites for subsequent model development	September 30, 2028

Activity 2: Build Foam Formation and Shoreline Transport Model

Activity Budget: \$150,000

Activity Description:

The goal of this activity is to develop a prediction model that simulates how foams form on lake surfaces and travel to shorelines. The model has three components. The first is a wind-wave interaction module that predicts where waves break on the lake surface based on wind speed, fetch distance, and lake depth. Wave breaking generates bubbles, the building blocks of foam. The second component is the foam formation module that tracks how dissolved organic matter and algal byproducts collect at the air-water interface and stabilize bubble films into persistent foam. This module builds on our group's latest research on advanced simulation techniques for bubble dynamics, surface-active agent transport, and foam formation. The third component is a large-scale wind-driven transport module that predicts how surface foam moves across the lake and deposits on downwind shorelines, accounting for shoreline geometry, wind variability, and foam persistence.

Activity Milestones:

Description	Approximate Completion Date
Wind-wave and bubble generation module developed using available lake observational datasets	December 31, 2028
Foam-formation module calibrated using dissolved organic matter, algal, and enrichment-ratio datasets	March 31, 2029
Shoreline transport and deposition module integrated with the wind-wave and foam-formation components	June 30, 2029

Activity 3: Validate Predictions Against Field Observations

Activity Budget: \$150,000

Activity Description:

Model development and validation will rely primarily on publicly available observational and environmental datasets identified in Activity 1, including buoy records, meteorological products, wave datasets, shoreline imagery where available, and related water-quality observations. These resources will provide the basis for developing and testing the wind-wave, foam formation, and shoreline transport components across a range of Minnesota lake settings. Validation of the integrated model will use available records of foam occurrence, shoreline location, spatial extent, and persistence, together with existing image archives and water-quality measurements where available. This approach emphasizes broad applicability, efficient use of existing data resources, and flexibility in selecting study sites. Model predictions of foam arrival location, timing, and persistence will be compared with the collected observations, and discrepancies between predicted and observed events will be used to improve model performance. A rigorous accuracy assessment will be completed and incorporated into the final tool.

Activity Milestones:

Description	Approximate Completion Date
Model evaluated against documented foam events across selected Minnesota lakes using available observations and images	September 30, 2029
Model refined based on discrepancies between predicted and observed foam events	December 31, 2029
Formal accuracy assessment completed and incorporated into the final predictive tool and project documentation	December 31, 2029

Activity 4: Build and Disseminate Tools for Generating Statewide Foam Risk Map and Foam Forecast

Activity Budget: \$75,000

Activity Description:

In the final activity, we will package the validated model into practical products for lake managers and public health agencies. The first product will be a tool for generating a Foam Risk Map that ranks shoreline segments on Minnesota lakes using a green-yellow-red risk scale based on predicted foam-arrival frequency, wind exposure, shoreline geometry, and proximity to known contaminant sources or recurring harmful algal blooms. The second product will be a Foam Forecast tool that uses National Weather Service forecast data to identify shorelines likely to receive foam over the next 48 hours via a web-based interface. The tools will be developed in consultation with MDH beach-monitoring staff, MPCA water-quality staff, and local lake associates to ensure the outputs support beach advisories and lake-management decisions. All model inputs, simulation outputs, field observations, and computational codes will be archived in a publicly accessible repository, such as the Data Repository for the University of Minnesota (DRUM), in a manner consistent with ENRTF/LCCMR dissemination expectations. Dissemination will include training sessions for agency and local-government users, presentations to lake associations and stakeholders, and a public-facing summary of findings.

Activity Milestones:

Description	Approximate Completion Date
Release of the tool for generating Foam Risk Map to state agencies	January 31, 2030
Release of the tool for Foam Forecast to state agencies	January 31, 2030
Training sessions for agency and local-government users; public-facing project summary	April 30, 2030
Completion of the public data archive with all model inputs, outputs, field data, and software	June 30, 2030

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.

We will ensure that data and results generated by the project are communicated broadly and effectively to stakeholders.

Scientific and technical dissemination includes: (1) Peer-reviewed publications: Results from modeling foam formation, persistence, and shoreline transport will be submitted to scientific journals for publication. (2) Conference presentations: Findings will be presented at professional conferences to ensure visibility and encourage collaboration. (3) Technical reports and policy briefs: We will summarize outcomes and environmental tradeoffs.

Stakeholder engagement and communication efforts will include: (1) Agency briefings to share findings and recommendations with state and local partners involved in lake monitoring, water quality management, and public communication. (2) Partnerships with lake associations, watershed organizations, and nonprofit groups to share project outcomes and gather feedback on monitoring needs and management priorities. (3) Two-way knowledge exchange through meetings and webinars so that stakeholder input can help guide interpretation, application, and future use of project results.

Public communication and education efforts will include: (1) Plain-language summaries, fact sheets, and infographics that explain how foam forms, why it accumulates along shorelines, and how project results can support Minnesota communities. (2) Presentations through public events, community outreach activities, and interactive visualizations to help make the science accessible to broader audiences.

Documentation and data management efforts will include: (1) Data archiving: All computational models, raw data, and final analyses will be deposited in a public repository (e.g., University of Minnesota Digital Conservancy) for open access and long-term preservation. (2) Standard formats: Data will be documented following open-science best practices to ensure usability by future researchers, agencies, and the public.

In all the print and electronic media, publications, signage, and other communications of this project, we will acknowledge the Environment and Natural Resources Trust Fund through: (1) use of the trust fund logo, and/or (2) attribution language per the ENRTF Acknowledgment Guidelines.

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 Foam Risk Map and Foam Forecast tools will remain accessible after project completion. Where appropriate, MDH can integrate foam risk predictions into its existing beach-monitoring and swim-advisory framework. Foam risk rankings could also help inform responses to reported foam events. As MPCA and MDH collect additional monitoring data through ongoing programs, the model can be updated to improve predictions. The framework can also be extended to rivers and streams where foam events occur. Funding for continued maintenance could come from MDH operational budgets, future LCCMR projects, and federal agencies.

Project Manager and Organization Qualifications

Project Manager Name: Lian Shen

Job Title: Distinguished McKnight University Professor and Director

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Lian Shen is a Distinguished McKnight University Professor at the University of Minnesota. He also holds the Kenneth T. Whitby Professorship in the Department of Mechanical Engineering and serves as the Director of the St. Anthony Falls Laboratory. He earned his Doctor of Science degree from Massachusetts Institute of Technology in 2001. After three years of postdoctoral training at MIT, he joined the faculty at Johns Hopkins University in 2004. In 2012, he was recruited by the University of Minnesota to join its faculty. Dr. Shen is an internationally renowned expert in environmental fluid flows and renewable energy research, with over 160 journal publications. He also serves on the editorial boards of five academic journals. He has organized several national and international conferences and symposia, and he will host the 83rd American Physical Society Division of Fluid Dynamics Meeting, the world's leading fluid mechanics conference, in Minnesota in 2030. Dr. Shen has participated in many federally and state-funded research projects on environmental fluid flows.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

This project will be performed at the St. Anthony Falls Laboratory (SAFL, <http://www.safl.umn.edu>) at the University of Minnesota. SAFL is an interdisciplinary fluid mechanics research and educational center. It has 21 faculty members and 28 research and administrative staff members. Each year, more than 100 postdocs and students conduct research at SAFL. SAFL is a world-renowned research laboratory specializing in environmental, geophysical, and engineering fluid mechanics. SAFL researchers have conducted numerous innovative environmental studies for Minnesota. Some of the projects were/are funded by the Minnesota Environment and Natural Resources Trust Fund. The proposed research leverages SAFL's unique and advanced capabilities for simulating and measuring environmental and geophysical flows, with 16,000 square feet of dedicated research space.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Project Manager		Oversee the whole project, supervise the research team, lead the research, and take responsibility for project reporting			38.5%	0.09		\$37,440
Postdoctoral Associate		Design and establish the computational models for wind-waves, bubble and foam formation, and bubble transport on lake surfaces			28.1%	3		\$253,796
Graduate Student Research Assistant		Conduct computer simulations and perform data analyses to establish foam prediction model			28.9%	1.5		\$148,246
Undergraduate Student Assistant		Assist with data collection and analysis			0%	0.36		\$13,260
Computer Scientist		Data sharing and assist the computational setup			34.9%	0.39		\$45,258
							Sub Total	\$498,000
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Equipment								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-

Travel In Minnesota								
	Miles/ Meals/ Lodging	Estimated number of trips: 16. Each trip is estimated for two persons and 150 miles on average, \$0.725/mile * 150 =\$108.75. Each trip is estimated to cost \$16.25 for parking. Total cost of each trip: \$125.	The in-state trips are for the research team members to conduct field observations and meet with stakeholders.					\$2,000
							Sub Total	\$2,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$500,000

Classified Staff or Generally Ineligible Expenses

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

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
In-Kind	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	\$264,971
			Non State Sub Total	\$264,971
			Funds Total	\$264,971

Total Project Cost: \$764,971

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [f53ed386-f49.pdf](#)

Alternate Text for Visual Component

The top-left outlines the problem of foam on Minnesota lakes. The top-right shows a computer simulation of bubble and foam formation with a top view. The bottom-left shows shoreline foam on a Minnesota lake. The bottom-center and bottom-right summarize the proposed forecasting approach and expected project outcomes....

Supplemental Attachments

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

Title	File
University of Minnesota Authorization Letter	b0e43493-2b3.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

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:

Ben Vargas, Sponsored Projects Administration

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A