



Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-026

Proposal Title: Wind Wave and Boating Impacts on Inland Lakes

Project Manager Information

Name: Jeffrey Marr

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: Field study to measure the impacts of boat propeller wash and boat wakes on lake water quality, and compare them to the impacts of wind-waves.

Funds Requested: \$440,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Water Resources (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 research project seeks to develop new understanding for how recreational boating is linked to lake water quality and riparian health. Recreational boating on Minnesota lakes and rivers is growing in the number of boats, as well as their overall size, weight, and power. With the emergence of the sport of wakesurfing, there has been an increase in the engine size and power of boats operating on our lakes - some with engines as large as 600 horsepower. Wakesurfing also introduces a new mode of operating boats - at moderate sub-planing speeds where maximum engine power is needed to plow water to generate large surfable wakes. Additionally, the propeller of all boats produces a strong turbulent jet of water, termed propeller wash, that penetrates into the water column of the lake. Recent research completed by this team has shown that different recreational boat types and usage scenarios represent a significant shift in wave energy and propeller wash-induced mixing in our lakes. SAFL-UMN has received hundreds of communications over the last two years from stakeholders with concerns over perceived threats to water clarity, shoreline erosion, personal property, and human and wildlife safety, and are seeking guidance on proper usage of boats.

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 are proposing a field-based research project to investigate the impacts of common recreational boats (non-wakesurf and wakesurf boats) for both shallow near-shore zones and deep-water zones. We will study both boat-generated waves and propeller wash produced by a number of boats operated under a range recreational activities at varying distances from shore and water depths. Additionally, the project will measure wind-generated waves to give a baseline for comparison.

Propeller wash research will investigate how deep the propeller wash jet penetrates into the water column, the jet velocity, and sediment suspension. Data will be collected on the vertical water column mixing, interaction with the lake bottom (e.g., resuspension of solids), and aquatic vegetation damage due to propeller wash.

Boat-generated and wind-generated waves will be studied by carefully documenting the wave activity at four study shorelines. These sites will be fully characterized at the beginning of the project and, over two field seasons, we will document the characteristics and frequencies of boat and wind waves, and how different wave exposures are linked with lake bottoms, shorelines and water quality.

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. Capability to predict the depth-of-penetration of propeller wash for various wakesurf and non-wakesurf boats and data-supported recommendations for the minimum operational depths to minimize impacts to lakes and rivers for various recreational activities.
2. Guidance on solids resuspension from wind- and boat-generated waves including alum treated lakes.
3. Data-driven report that will serve as a primer on wind- and boat-generated waves on inland lakes. The report will leverage our 2022 UMN research study and the 2023 LCCMR research results to answer questions on the different types of waves, similarities/differences, and linkages to water quality, lake bottoms and shorelines.

Activities and Milestones

Activity 1: Investigate propeller wash impacts within deep-water and near-shore zones of inland lakes

Activity Budget: \$166,833

Activity Description:

Activity 1 will involve field-based research examining the propeller wash interactions with the water column and lake bottom. Four study sites will be selected to provide a representative variety of Minnesota environments. Two sites will be within a metro area lake and two sites will be within a northern Minnesota lake. Baseline measurements will be collected to characterize bottom sediment, aquatic vegetation, and water quality. Half of the sites will be deep water (~30ft depth) and half shallow water (~10ft depth).

At each lake we will evaluate the propeller wash from up to three recreational boats. The boats will be operated at different speeds replicating various recreational activities (e.g., wakesurfing, wakeboarding, waterskiing, cruising, etc.). Sensors placed on the lake bottom will measure the water velocity and turbulence generated by the propeller wash as the test boats pass by. Underwater cameras will document movement of sediment and vegetation associated with the propeller wash. Intensive water sampling will be performed before, during, and after testing. Water samples will be analyzed for total suspended sediments and composition. Post-testing water samples will be collected to document the time necessary for water quality to return to baseline condition.

Activity Milestones:

Description	Completion Date
Research and select lakes, tests sites and test boats	August 31, 2023
Complete testing at Lake 1 – Site A and Site B on three test boats	October 31, 2023
Complete testing at Lake 2 – Site C and Site D on three test boats	July 31, 2024
Complete data analysis, complete interim report and submit for external peer review	March 31, 2025

Activity 2: Impacts of wind and boat waves on water quality within near-shore and deep water zones of a metro area lake

Activity Budget: \$102,447

Activity Description:

Activity 2 will be a field-based research study examining interactions between waves (wind or boat-generated) and lake bottoms, suspended sediments, aquatic vegetation and shorelines. The study site in Activity 2 will be a lake within the Twin Cities, representative of typical metro-area inland lakes. The site will be fully characterized early in the project (e.g. bottom sediment, aquatic vegetation, bathymetry, prevailing winds, etc.).

Wave monitoring sensors will be deployed at the site to capture wave height, wavelength, period, energy and power. For wind waves, we will capture low, moderate, and high wind days when little recreational boating is occurring on the lake. For boat-generated waves, we will operate test boats during low wind days under various operational conditions. For both wind and boat waves, water velocities will be measured and intensive water sampling will be performed. Water samples will be analyzed for suspended sediments and composition. We will document the characteristics of boat and wind waves and how they are linked to lake bottom properties, shorelines and water quality. Water quality measurements by the project team will be supplemented with citizen water quality measurements, such as Secchi disk measurements.

Activity Milestones:

Description	Completion Date
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Research and select lakes, tests sites and test boats	October 31, 2023
Begin field study of Twin Cities Lake	June 30, 2024
Complete wind and boat wave evaluations on Twin Cities lake site	October 31, 2024

Activity 3: Impacts of wind and boat waves on water quality within near-shore and deep-water zones of a northern Minnesota lake

Activity Budget: \$170,720

Activity Description:

Activity 3 is a continuation of wave research but will take place on a northern Minnesota lake. We will select a study site within northern Minnesota, where recreational boating is very popular but the environmental attributes of the lake are different from the metro area lakes (e.g. bottom sediments, water clarity, aquatic vegetation, etc.). As in Activity 2, we will study interactions between waves (wind or boat-generated) and lake bottoms, suspended solids, aquatic vegetation and shorelines.

Again, like Activity 2, wave monitoring sensors will be deployed at the site to capture wave height, wavelength, period, energy and power. For wind waves, we will capture low, moderate, and high wind days when little recreational boating is occurring on the lake. For boat-generated waves, we will operate test boats during low wind days under various operational conditions. For both wind and boat waves, water velocities will be measured and intensive water sampling will be performed. Water samples will be analyzed for suspended sediment and composition. Water quality measurements by the project team will be supplemented with citizen water quality measurements.

Activity 3 also includes synthesis of data from Activity 2 and 3 and creation of a report from the entire research.

Activity Milestones:

Description	Completion Date
Research and select lakes, tests sites and test boats	October 31, 2024
Begin field study of northern Minnesota lake	June 30, 2025
Complete wind and boat wave evaluations on northern Minnesota lake	October 31, 2025
Complete data analysis, complete interim report and submit for external peer review	March 31, 2026
Publish Activity 2 and 3 report on wind and boat wave impacts and disseminate results to stakeholders	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
William Herb	University of Minnesota - St. Anthony Falls Laboratory	Dr. Bill Herb is Co-PI and will oversee field and laboratory research characterizing boat-generated waves and interaction with sediment and vegetation. Herb is a Research Associate at SAFL and led a LCCMR-funded project studying wind-wave energy and nearshore fish habitat in Minnesota lakes.	Yes
Jessica Kozarek	University of Minnesota - St. Anthony Falls Laboratory	Dr. Jessica Kozarek is Co-PI and will oversee field and laboratory research characterizing boat-generated waves and interactions with sediment and vegetation. Kozarek is a Research Associate at SAFL and is Manager of the SAFL Outdoor StreamLab.	Yes
Mathew Lueker	University of Minnesota - St. Anthony Falls Laboratory	Research Engineer: Review of wind driven wave effects Literature review for characterization of wakes from boat hulls and propellers to aid design of datalogging equipment. Experimental design for laboratory testing. Analysis and reporting. Lueker is lead hydraulic modeler at SAFL with over 15 years of project experience.	No
Andrew Riesgraf	University of Minnesota - St. Anthony Falls Laboratory	Project Coordinator, Research Scientist - Andy will serve as day-to-day project coordinator and will be a primary researcher on all activities.	No
Jeffrey Marr	University of Minnesota - St. Anthony Falls Laboratory	Project Manager/Principal Investigator. Jeff will provide oversight of the project along with budgetary, and schedule management. He will be involved in all activities of the project including development of final reports.	No
Kimberly Hill	University of Minnesota - SAFL & Department of Civil, Environmental and Geo-Engineering	Associate Professor Hill is Co-PI and will guide field and laboratory research in all areas with special focus on characterizing the propeller wash and impingement on lake sediments. Hill is an expert in particle physics and sediment transport with applications to lake, reservoir, river, and pond environments.	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 information generated in this research is sought by a large stakeholder community. We will produce a final project report from this research, which will be published as a Project Report that will be freely available through the UMN Digital Conservancy. Implementation of the research will be via stakeholders, boat owners, and resource managers who will use the findings to make management decisions about recreational boating and resource preservation. The scope of this project may be expanded with additional funding from other sources for work on shoreline erosion due to boat- and wind-generated waves.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
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MAISRC Subproject 21.2: Field Validation of Multibeam Sonar Zebra Mussel Detection	M.L. 2017, Chp. 96, Sec. 2, Subd. 06a	\$0
Enhancing Spawning Habitat Restoration in Minnesota Lakes	M.L. 2017, Chp. 96, Sec. 2, Subd. 08e	\$294,000

Project Manager and Organization Qualifications

Project Manager Name: Jeffrey Marr

Job Title: Associate Director of Engineering and Facilities

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

Marr is a licensed professional civil engineer (Minnesota) and the Associate Director of Engineering and Facilities at SAFL. He received his BS (1996) and MS (1999) from the University of Minnesota, Department of Civil Engineering and has been a member of SAFL professional research staff for over 20 years. Marr will serve as Project Manager and Principal Investigator for this project. His research expertise is in the areas of hydraulics, boat-generated waves, and sediment transport including river and delta systems, deep water gravity currents, and reservoir/lake sedimentation and erosion. Marr manages SAFL’s Applied Research and Engineering team, a 13 member team that supports ongoing faculty research and carries out applied research with public and private sponsors. Marr is an experienced project manager and principal investigator, having managed large infrastructure projects such as the \$16M renovation of SAFL and \$8.5M construction of the UMN Wind Research Facility at UMore Park in Rosemount, MN. Marr has also managed many multi-investigator applied research projects.

For this proposed project, two factors are especially important to the success of the effort. The first, is to recognize that this topic of recreational boating and environmental impact carries with it a variety of perspectives and viewpoints. It is critical to acknowledge both the economic importance and broad recreational enjoyment of boating as well as the delicate linkages within complex environmental systems such as lakes and rivers. The project team understands these contexts and has the experience to carry out robust, unbiased research for the benefit of multiple viewpoints. Second, the data and outcomes of the work are sought by many different stakeholder groups. The project team is experienced in publicly funded and applied research such as this proposed project and we are committed to broad and clear distribution of our findings to these stakeholder communities.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

SAFL is an interdisciplinary fluid mechanics research facility of the College of Science and Engineering at the University of Minnesota. SAFL research focuses on environmental, energy, and health challenges. SAFL is well instrumented for the study of waves and erosion and for the study of interactions between fluid mechanics and biota with expertise and equipment for measuring flow and turbulence at a range of scales including acoustic Doppler velocimeters (ADV) and Acoustic Doppler Current Profilers (ADCPs). This project team completed a substantial effort on boat-generated waves in February 2022 and is initiating a follow on project focusing specifically on characterizing the hydrodynamics of propeller wash. Through these efforts, which were fully funded through public crowdfunding, we have established a leading role in research on recreational boating and impacts to inland lakes.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Jeff Marr		Project Manager/Research engineer			33.5%	0.09		\$35,480
William Herb		Researcher - William will serve as a research lead on the project focusing on Activity 2 and Activity 3			33.5%	0.15		\$43,967
Jessica Kozarek		Researcher - Jessica will serve as a lead researcher focusing on water quality and hydraulics for all three Activities.			33.5%	0.24		\$72,889
Kimberly Hill		Advisor - Kimberly will serve as technical advisor on this project			33.5%	0.03		\$15,625
Andrew Riesgraf		Project coordinator/researcher - Andy will serve as day-to-day project coordinator and primary researcher on all activities.			28.7%	0.3		\$72,054
Matthew Lueker		Research engineer - Matt will serve as a researcher on this project, responsible for design and data collection of watercraft performance			28.7%	0.27		\$63,155
Ben Erickson		Research support technician - Ben will provide technician support to field campaign and open water safety.			28.7%	0.21		\$53,705
Chris Milliren		Research Engineer - Chris will support development and deployment of data acquisition systems.			33.5%	0.06		\$15,758
Undergraduate Researchers		UMN undergrad will provide field support.			0%	0.12		\$11,912
							Sub Total	\$384,545
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Mobile cell phone service to upload data from field	data collected remotely in the field will need to be uploaded through cellular network continually during data collection.					\$2,000

	Tools and Supplies	Water sampling and analysis	Sample bottles and supplies to perform water quality analysis on collected samples						\$7,641
	Tools and Supplies	Wave Monitoring Sensor	structural mast, sensors and data logger for measuring waves at test shorelines						\$5,000
	Tools and Supplies	Water velocity measurement	Sensors and structural mounts to deploy water velocity measurements in all Activities of the project						\$12,000
	Tools and Supplies	Undewater video capture	Supplies needed to support underwater cameras needed to capture sediment movement at lake bottom.						\$1,000
	Tools and Supplies	Boat Gas	Fuel to operate test boats during data collection						\$3,000
								Sub Total	\$30,641
Capital Expenditures									
								Sub Total	-
Acquisitions and Stewardship									
								Sub Total	-
Travel In Minnesota									
	Miles/ Meals/ Lodging	Travel to northern mn field site	mileage reimbursement to travel to field site in northern minnesota						\$1,843
	Miles/ Meals/ Lodging	mileage reimbursement for instate travel to metro area field site	travel is in support of field work. (Activity 1)						\$1,872
	Miles/ Meals/ Lodging	Lodging	lodging for norther mn field work (Activity 1)						\$2,880
	Other	Truck rental	work truck rented for Activity 1 to support research activities						\$3,000
	Miles/ Meals/ Lodging	meals out of town work	meal per diem for work occurring in northern Minnesota (Activity1)						\$1,650
	Miles/ Meals/ Lodging	Travel to field twin cities field site	mileage reimbursement for travel to local field sites (Activity 2)						\$1,872

	Miles/ Meals/ Lodging	Travel to northern MN field site	Mileage reimbursement for travel to northern Minnesota field site (Activity 3)					\$2,637
	Miles/ Meals/ Lodging	housing for work at field sites	housing reimbursement for northern Minnesota field work (Activity 3)					\$5,760
	Miles/ Meals/ Lodging	per diem for out of town work	meal reimbursement for northern Minnesota field work (Activity 3)					\$3,300
							Sub Total	\$24,814
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$440,000

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	\$242,000
			Non State Sub Total	\$242,000
			Funds Total	\$242,000

Attachments

Required Attachments

Visual Component

File: [5a7d07d5-e63.pdf](#)

Alternate Text for Visual Component

The visual component summarizes the motivation and objectives of the project. The MOTIVATION is Larger boats and newer recreational activities like wakesurfing are increasing wave energy and vertical mixing in Minnesota lakes. PROJECT OUTCOMES will include two reports that will be publicly available....

Optional Attachments

Support Letter or Other

Title	File
Letter of Support - University of Minnesota	5bdb510a-698.pdf
Letter of Support - Minnesota Coalition of Lake Associations	ac9a3df9-8c1.pdf
Letter of Support - Gull Chain of Lakes Association	15352054-dd3.pdf
Letter of Support - Hubbard County Coalition of Lake Associations	d6904faa-b59.pdf
Letter of Support - MN Association of Watershed Districts	328b0dbd-5d7.pdf
Letter of Support - Minnesota Lakes and Rivers Advocates	f50ac0f4-bee.pdf
Letter of Support - Lake Minnetonka Conservation District	973face9-2d9.pdf
Letter of Support - Whitefish Area Property Owner's Association	d229fad1-05b.pdf
Letter of Support - Watson - Whitefish Area Property Owners Association	1b8f7b68-557.pdf
Letter of Support - Michigan Lakes and Streams Association	b2829fd9-224.pdf
Letter of Support - Clear Lake Property Owners Association	daeb8e32-305.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?

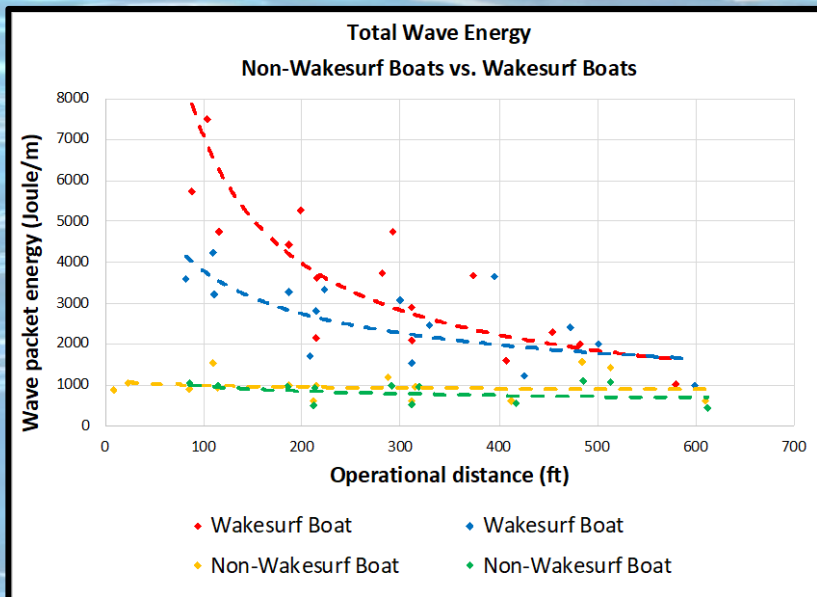
Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Wind wave and boating impacts on inland lakes

MOTIVATION: Larger boats and newer recreational activities like wakesurfing are increasing wave energy and vertical mixing in Minnesota lakes.



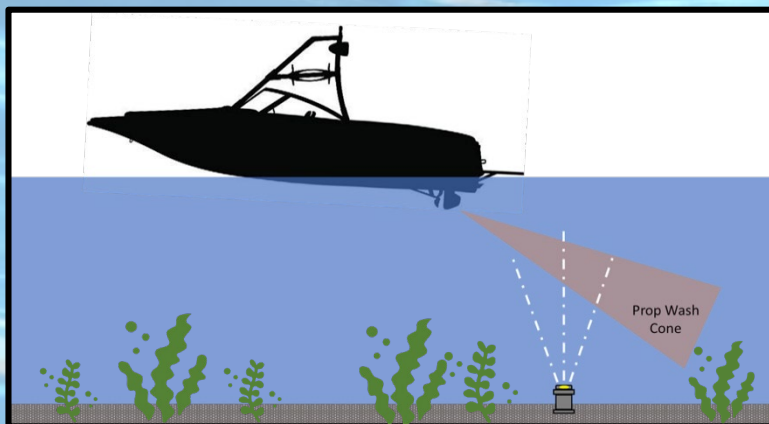
RESEARCH ACTIVITIES:

1. Investigate propeller wash impacts on water quality in deep-water and near-shore zones of lakes
2. Study impacts of wind and boat-generated waves on water quality in lakes

PROJECT OUTCOMES:

REPORT: Propeller wash characteristics associated with recreational boats and various tow sports. Information on minimum water depth for low-impact operation.

REPORT: Comparison of wind and boat-generated waves and impact on near-shore zones.



LEVERAGING CITIZEN-FUNDED RESEARCH:

Project leverages experience, equipment, and data made possible via two citizen supported crowdfunding campaigns – 2020 Campaign (\$140,000) & 2022 Campaign (\$175,000 goal)

