



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-106

Proposal Title: Impact of Recreational Boating on Alum Treated Lakes

Project Manager Information

Name: Jeffrey Marr

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: A laboratory and field study to investigate how alum treated lakes are impacted by large wake waves and propeller wash generated by motorized recreational boats.

ENRTF Funds Requested: \$475,000

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?

In the Future

Narrative

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

Alum treatment is a widely-applied lake treatment to prevent algal blooms and improve water quality. Once applied, alum flocs settle to the lake bed and form a chemical layer that prevents the release of bioavailable phosphorus from the lake sediments and significantly improves lake conditions, with effects lasting for years after treatment. Alum treatment costs vary but can approach \$1 million and are typically paid for with public funds.

With the recent trend of increasingly more powerful recreational boats and activities such as wakesurfing that produce powerful waves and propeller wash, there is an emerging concern that boating is undermining investments made in alum treatment. The concern is that the turbulence produced by powerful boats will destroy the alum layer incorporated into the lakebed surface, by either displacing the alum to another region of the lake or burying it deeper into the sediments, ultimately resulting in the release of phosphorus back into the water and subsequent algae blooms. Recent videos captured by UMN (ENRTF 2023-026) show intense erosion and resuspension in 14 ft of water by wakesurf boats, adding to the concerns and call for studying how boating may impact the expensive investment made in alum treatments.

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 a study to examine how currents, large waves, and propeller wash jets impact sediment-alum interactions. First, the study will leverage data and experience from a preliminary study of a metro area lake by Barr Engineering Co. and Riley Purgatory Bluff Creek Watershed District that recently underwent an alum treatment and is a popular recreational boating lake. Sediment cores will be collected and analyzed informing the design of indoor experiments. We will perform detailed sediment chemistry analyses each year at the end of the boating season to determine changes in the sediment and alum layer. Second, we will use existing research facilities (tanks, flumes and sensors) at SAFL to perform experiments on how turbulence, wave action, and propeller wash jets affect the stability and movement of newly-formed and aged alum flocs in sediments. Third, data from the field and laboratory will be combined with data collected during ENRTF project, "Wind wave and boating impacts on inland lakes (2023-026)" to develop guidance on boating and protection of alum-treated lakes. The team will develop journal article(s) as well as a publicly available guidance document on how to balance recreational boating with maximizing investments in alum treatment and water quality benefits.

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?

Alum treatments can be expensive, ranging from \$1,500-\$2,500/acre based on recent alum applications in Minnesota. Effective treatments can last for many years. The question being asked by lake managers is if they should invest in an alum treatment if boating will reduce the effectiveness and shorten longevity of the treatment.

Outcomes:

- Understanding how alum flocs interact with lakebed sediment to bind phosphorus at the lakebed preventing sediment phosphorus release.
- Understanding the conditions and turbulence levels capable of compromising alum-treated lakebed sediments.
- Developing guidelines/recommendations on how to optimize alum treatment performance in the presence of boating.

Activities and Milestones

Activity 1: Advisory group input, finalize study design, field sampling in alum-treated lakes

Activity Budget: \$199,075

Activity Description:

This activity will begin by convening an advisory group of lake and watershed managers having direct experience with alum treatment approaches and with managing lakes having high recreational usage. The advisory group will provide feedback needed to finalize project design and input on what types of deliverables are most needed and useful for implementation.

Second, we will supplement data collected by Barr Engineering Co. in the summer of 2025 on a popular boating and wakesurfing lake. The lake received two alum treatments in the last 10 years. Available data on phosphorus release rates and aluminum concentration before and after alum treatments will be supplemented with additional sediment cores collected in this project. We will evaluate if the alum effectiveness is decreasing in time faster than expected, and determine if the alum has been transported out of the treatment area or deeper into sediments.

Third, we will develop the methodologies to measure alum performance in a laboratory flume, including determining the types of lakebed sediment to evaluate, developing the mechanisms for wave and propeller wash generation, developing the procedures for dosing alum, and testing different methods for recording sediment and alum floc resuspension and movement (e.g. cameras with image processing).

Activity Milestones:

Description	Approximate Completion Date
Compile preliminary input from the advisory group and finalize project design for all activities.	October 31, 2027
Complete collection of sediment cores from the local lake.	December 31, 2027
Finalize experimental design and setup and commissioning of the facility.	May 31, 2028
Complete analysis of field-collected sediment cores.	May 31, 2028

Activity 2: Laboratory flume experiments on stability, movement, and vertical penetration in the lakebed of newly formed alum floccules.

Activity Budget: \$116,641

Activity Description:

This activity will focus on flume-based research to study alum flocs soon after formation, which is a vulnerable stage in the alum treatment process. Immediately after dosing, alum floccules form and settle to the lake bed, forming an alum layer at the lakebed. In the initial period, flocs are loosely deposited on the lakebed surface and are more susceptible to being resuspended or transported to another location by currents, waves, or boat generated effects.

First, we will examine horizontal currents, recording when flocs start to move, how they move and where and when they stop moving. Second, we will use a wave generator to create wave motions, varying the height and period of the waves, and making similar observations on how and when floc particles move. Finally, we will simulate propeller wash - the powerful jet produced by a boat's propeller. For all three cases, phosphorus release rates from alum-treated sediment samples in the flume will be compared to data from lake cores to verify the experimental methods. Computer modeling will also be performed to characterize how wave and propeller wash induced velocities penetrate the sediment layer and affect the transport of phosphorus in and out of the sediment.

Activity Milestones:

Description	Approximate Completion Date
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Complete tests on newly formed alum flocs under currents and wave action.	September 30, 2028
Complete test on newly formed alum flocs under propeller wash.	March 31, 2029
Preliminary analysis of collected data.	June 30, 2029

Activity 3: Laboratory flume experiments on stability and performance of established alum sediment barrier in simulated lake bed.

Activity Budget: \$159,284

Activity Description:

This activity will focus on testing how aged flocs (i.e. fully-formed alum layers well after treatment) are impacted by currents, wave action, and propeller wash jets using the same experimental flume as Activity 2. For the aged alum layers, we will determine the water velocities required to either erode the barrier layer or to create flow through the barrier layer, and the impact of these processes on the effectiveness of the barrier layer in retaining phosphorus in the sediment. The effect of the simulated lake bottom velocities on alum effectiveness will be evaluated by measuring phosphorus concentrations over time in the flume and by taking small sediment core samples and testing phosphorus release rates and sediment phosphorus fractionation.

This activity also includes analyses and developing the final report. The report will be published in an accessible format through the UMN Digital Conservancy. The team will also participate in a final meeting with the advisory group and will present the results through webinars and invited presentations. Our objective is to deliver research results that support decision-making on the informed use of recreational boats, restoration of Minnesota lakes, and optimizing the impact of public funds.

Activity Milestones:

Description	Approximate Completion Date
Complete tests on alum layer under currents and wave action.	June 30, 2029
Complete tests on alum layer under propeller wash.	December 31, 2029
Complete final report, complete meeting with project advisory group and other knowledge transfer activities.	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jeffrey Marr	St. Anthony Falls Laboratory, UMN	PI, project manager, reporting, support experimental design, laboratory experiments setup, data collection and analysis, report drafting, knowledge transfer	Yes
Poornima Natarajan	St. Anthony Falls Laboratory, UMN	co-PI, lead of field data collection and analysis of lake cores, data analysis, report drafting, knowledge transfer	Yes
William Herb	St. Anthony Falls Laboratory, UMN	co-PI, design of laboratory experiments, numerical modeling, data analysis, report drafting, knowledge transfer	Yes
Andy Riesgraf	St. Anthony Falls Laboratory, UMN	Co-PI, support field collection of sediment cores, laboratory experiments setup, data collection and analysis, report drafting, knowledge transfer	Yes
Chris Milliren	St. Anthony Falls Laboratory, UMN	Engineer, supporting laboratory experiments setup and data collection	Yes
Ben Erickson	St. Anthony Falls Laboratory, UMN	Technician, supporting safety training, equipment supply and training, field deployment support, flume safety and operational training.	Yes
Addie Johnson	St. Anthony Falls Laboratory, UMN	Researcher, Lake sediment cores collection and analysis	Yes
Emma Squires	St. Anthony Falls Laboratory, UMN	Researcher, Lake sediment cores collection and analysis	Yes
Joseph Bischoff	Barr Engineering Company	Engineer/scientist, advise project with expertise in design and implementation of alum treatment, data analysis, reporting, knowledge transfer	Yes
Kate Lucas	Barr Engineering Company	Engineer/scientist, advise project with expertise in design and implementation of alum treatment, data analysis, reporting, knowledge transfer	Yes
Jessica Kozarek	Michigan Technological University, Department of Civil, Environmental, and Geospatial Engineering	Engineer, project advisor on experimental design for flume experiments, data analysis, reporting	Yes

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.

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 freely available through the UMN Digital Conservancy (UDC). Data and associated metadata collected as part of this project will be published and made freely available through the University of Minnesota Data Repository (DRUM). Both the UDC and DRUM are long-term repositories managed by UMN for research finding and data.

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 alum treatment design/implementation. The report described above will be written to a practitioner audience. Our intention will be to present findings of the study via an online/virtual seminar series accessible to stakeholders such as through Minnesota Lakes and Rivers Advocates or Minnesota Coalition of Lake Associations. We will also present findings at the annual Minnesota Water Resources Conference and Minnesota Lake Management Society symposium. It is likely the team will be invited to present at other conferences and board meetings and we will take advantage of these opportunities. The research will also be submitted for publication in an academic journal.

Environment and Natural Resources Trust Fund will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement 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?

We will produce a final project report from this study, which will be made freely available through UMN Digital Conservancy. Our team has strong connections with stakeholders (e.g. watershed managers, MPCA scientists, consultants, and lake associations) involved in water quality decision-making and will use these connections to communicate our results and provide implementation support. Stakeholders will be able to use the findings from this study to make decisions on managing boating and implementation of alum treatment for lake restoration. If additional research is needed, we will use this project to leverage funding from other federal, state, and local sources.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Wind Wave and Boating Impacts on Inland Lakes	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 04c	\$415,000
Modeling the Future Mississippi River Gorge	M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 04n	\$427,000

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 25 years. Marr will serve as Project Manager and Principal Investigator for this project. His research expertise is in the areas of river 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 10 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 including two ongoing LCCMR/ENRTF projects.

The project will leverage the support of well established grant management groups at UMN including the sponsored research administration (SPA) and Sponsored Financial Reporting (SFR). SAFL also has its own administrative, purchasing and accounting support that help PIs manage projects.

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 and will serve as the lead organization for this project. 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 alum treated lakebed 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). We will leverage existing water tanks/flume at SAFL to conduct field experiments. Our team includes two individuals from Barr Engineering who lead much of the design and implementation of alum treatments on lakes in Minnesota and neighboring states. The SAFL team also has experience working in the field, collecting lakebed sediment cores and analyzing for nutrients and phosphorus flux rates. SAFL receives capable administrative support from our local administration team as well as purchasing, accounting, communications, and grants management support from the College of Science and Engineering, Sponsored Projects Administration, UM Purchasing, and the UM Public Relations team.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Jeffrey Marr		Principal Investigator. Responsible for project management, reporting. Technical contribution to design of all aspects of project, coordination with the Advisory Group, report development and knowledge transfer activities			38.5%	0.27		\$52,265
Poornima Natarajan		co-PI, lead of field data collection and analysis of lake cores, data analysis, report drafting, knowledge transfer.			38.5%	0.45		\$55,368
William Herb		co-PI, design of laboratory experiments, numerical modeling, data analysis, report drafting, knowledge transfer.			38.5%	0.54		\$70,905
Andrew Riesgraf		Co-PI, support field collection of sediment cores, laboratory experiments setup, data collection and analysis, report drafting, knowledge transfer, technology and environmental monitoring systems, GPS and app-based boat tracking analysis.			38.5%	0.9		\$105,569
Chris Milliren		Engineer, supporting laboratory experiments setup and data collection .			38.5%	0.09		\$8,668
Ben Erickson		Technician, supporting safety training, equipment supply and training, field deployment support, flume safety and operational training.			34.9%	0.09		\$7,937
Emma Squires		Researcher, Lake sediment cores collection and analysis.			34.9%	0.36		\$22,709
Addie Johnson		Researcher, Lake sediment cores collection and analysis.			34.9%	0.36		\$22,709
Undergraduate Support		General field and laboratory support			0%	0.24		\$9,248
							Sub Total	\$355,378
Contracts and Services								
Barr Engineering Company	Service Contract	Barr Engineering engineers (Bischoff and Lucas) are experts in alum treatment of lakes and will collaborate with our team in design of field and lab research. They will support data collection, analysis				-		\$40,000

		and report writing. They will also help our team make connection with key stakeholders.						
Jessica Kozarek	Service Contract	Jessica is an engineer with expertise in research design in field and laboratory studies and will advise the project critical elements of the design and will support analysis and report drafting.				-		\$40,182
Research Analytical Laboratory	Service Contract	RAL is a sediment and water chemistry lab. We will use to analyze lake core sediment samples.				-		\$15,000
							Sub Total	\$95,182
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies for sediment coring	Supplies (polycarbonate tubes, caps, sampling equipment rental from LRC)					\$2,500
	Tools and Supplies	Laboratory supplies for chemical analysis	Supplies (centrifuge tubes, syringe filters, syringes, chemicals for P analysis)					\$6,400
	Tools and Supplies	sealants and cleaners for setup of the 20" flume	Flume will need specific modifications for these experiments and these are the necessary supplies. false floor, sealants, glass cleaner, paint, mechanicals to repair gate.					\$3,000
	Tools and Supplies	controller and sensors for wave 20" wave generator	motor, mechanical components, rate controller for wave generator upgrade					\$3,000
	Tools and Supplies	Supplies for lakebed sediment collection and transport to flume	supersack, buckets and equipment. Could be for contractor to provide or bagged sediment for surrogate supplies					\$1,500
	Tools and Supplies	Mini-core device	copper pipe, pistons, cable, and structural rig, storage bags					\$1,000
	Tools and Supplies	videography and lighting	Digital video cameras + Tripods used for documenting experiments and floc movement through the glass sidewall of the tank.					\$1,600
	Tools and Supplies	LED lighting	LED based lighting for illuminating the flume for video cameras and photography. Images will be a primary data collection method in these experiments					\$500

	Tools and Supplies	Supplies for propeller wash design and setup	mechanicals: DC motor and motor controller, shaft, propeller, controller to fabricate a propeller wash simulator.					\$500
	Tools and Supplies	Supplies to create an air/bubble Injection system	Air injection system: tubing, air regulator, pvalves to simulate the exhaust injected into propeller wash. This is an important part of the physics of propeller wash for modern recreational boats.					\$250
	Tools and Supplies	Supplies for propeller wash structural design	Structural: Support framing allowing positioning and variable pitch					\$300
	Tools and Supplies	Supplies for mixing alum and dosing into the flume	mixing tank, plumbing, mixer, pump, valves, flow meter needed to fabricate this element of the experimental setup.					\$2,390
	Tools and Supplies	General supplies to support experiments in Activity 2 and Activity 3	consumables needed for experiments: sediment, buckest, hoses, disposal of material, scoups, work gloves, safety PPE.					\$1,000
							Sub Total	\$23,940
Capital Equipment								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Mileage reimbursement for local travel, field work	Field work will take place in Twin Cities in Year 1. These funds will reimburse for mileage incurred using personal vehicles.					\$500
							Sub Total	\$500
Travel Outside Minnesota								

							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$475,000

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 and contract administration costs.	Pending	\$256,500
			Non State Sub Total	\$256,500
			Funds Total	\$256,500

Total Project Cost: \$731,500

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [64361f92-348.pdf](#)

Alternate Text for Visual Component

Images showing alum treatment of a lake, a boat hydroplaning on the water surface, and a graphic of the propeller wash and waves created by a boat and interactions with the lakebed. The page also summarizes project information including title, funding request, motivation and deliverables....

Supplemental Attachments

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

Title	File
UMN SPA Letter	21f44052-e64.pdf
Letter of Support_ MN Lakes and Rivers Advocates	47123c24-519.pdf
Letter of Support_ MNCOLA	ccd160cf-801.pdf
Letter of Support_ Three Rivers Park District	8d28e9e6-2b4.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:

SAFL: Angela Boutch, Bill Herb, Poornima Natarajan, Jess Kozarek; Barr Engineering: Joe Bischoff

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

Yes, I understand