



Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-216

Proposal Title: Rapid Pathogen Detection and Mitigation in Minnesota Lakes

Project Manager Information

Name: Miki Hondzo

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Protection and enhancement of Minnesota waters by rapidly detecting, forecasting, and selectively mitigating viral and bacterial pathogens. Public and policymaker education on how to detect and mitigate emerging pathogens.

Funds Requested: \$646,000

Proposed Project Completion: June 30, 2027

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.

Pollutants from excessive stormwater runoff and the warming of lakes are increasing algae blooms and bacteria infestation, degrading water quality and plaguing lakes across the State. Increasingly swimming beaches are closed, restricting people's access to natural resources. The City of Minneapolis completed Minneapolis Stormwater Pathogen Toolbox (2022) and summarized pathogen detection, sources, monitoring, and mitigation in stormwaters. The State's water quality regulators, including the Minnesota Pollution Control Agency, have embraced the toolbox. Implementing the Pathogen Toolbox statewide in Minnesota lakes requires extensive monitoring, sample analysis by specialized laboratories, information on unavailable pathogen spatial and temporal concentrations, and comprehensive mitigation efforts. We propose to overcome these implementation issues by establishing a) rapid protocols for pathogen detection, b) models for forecasting, and c) site-specific mitigation of pathogens in Minnesota waters. We will develop and verify a) fast and accurate pathogen identification by specific gene quantification, b) site-specific pathogen transport modeling based on nutrient input, water flow, and local meteorological conditions, c) online graphical visualization of spatially and temporally variable pathogen occurrence patterns, and d) the location of pathogen mitigation hot spots. The project will enhance and protect Minnesota waters from increasing invasion of pathogens due to land use and climate change.

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.

Most aquatic systems in Minnesota (and nationally) do not have any virus data. While historical sets of fecal indicator bacteria data are available, only a fraction of potentially pathogenic bacteria are routinely monitored. Consequently, the problem is that reported pathogen concentrations are biased because only a fraction of the diversity and temporal or spatial variability is currently quantified. We propose rapidly collecting water samples by drone technology and in situ scanning of virus samples via molecular biology technologies. The proposed technologies will enable the detection and quantification of the pathogen in the water with new speed, sensitivity, spatial resolution, and simplicity of use. The contamination of pathogens (viruses, bacteria, protozoa) is associated with or derived from birds, domestic animals, pets, cyanobacteria blooms, resuspended sediments, and humans themselves. Therefore, the sources of pathogens are diverse, with high spatial and temporal resolutions, potentially making public alert questionable with inefficient mitigation efforts. We propose to use generic three-dimensional and unsteady open-source modeling with a novel pathogen detection system to predict the potential of pathogen presence, transport, and mitigation in Minnesota lakes and wetlands. Outreach efforts will focus on educating the public and providing hands-on procedures to policymakers on using the proposed technologies independently.

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 addresses significant issues in managing Minnesota waters' protection, enhancement, and safety. Outcomes from this project will provide local authorities with timely and quantitative information to identify the hot spots of pathogen mitigation, minimize public health risk of pathogen exposure, and alert the public of exploring Minnesota lakes. The proposed outreach efforts will develop public awareness of emerging pathogens' sources and concentrations that can be collectively minimized to protect and preserve Minnesota waters. The findings of this project will be used to train water resource managers on how to implement local and site-specific pathogen mitigation and monitoring programs.

Activities and Milestones

Activity 1: Evaluation of new fast response pathogen identification and quantification technologies in the field

Activity Budget: \$350,000

Activity Description:

Minnesota needs rapid and accurate detection and quantification technologies for bacterial and viral pathogens to increase the protection and conservation of the State's precious water resources and safeguard their recreational use. The low cost and improved accuracy of pathogen identification by third-generation DNA sequencing platforms provide a significant opportunity for improved water quality assessment. Current technologies have a long (>36-48h) response time and require sample processing in dedicated laboratories. Recent advances in semiconductor membrane technology led to the development of small handheld DNA sequencers with computer and touchscreen for fast and easy data collection and analysis in the field. We propose to evaluate this new technology for pathogen detection in Minnesota lakes by benchmarking the technology against existing molecular and cultivation-based methods currently used in the State. We will collect one-liter replicates water samples using a drone from different locations (lake inlets, outlets, stormwater outlets, piers, and beaches) within three Minnesota lakes. A starting test-bed lake will be Bde Maka Ska, with historical pathogen outbreaks. Samples will be analyzed in the field with the new technology and in the laboratory for comparative analysis with current standard methods. The data will be utilized for forecasting and online public alert (Activities 2-3).

Activity Milestones:

Description	Approximate Completion Date
Water sampling and processing in the field and in the laboratory	December 31, 2025
Nanopore technology testing and evaluation in the field	December 31, 2025
Pathogen detection and quantification with standard methods (Stormwater toolbox)	June 30, 2026
Comparative data analysis and benchmarking	December 31, 2026
Dissemination and publication of results/technology demonstration to water quality regulators	June 30, 2027

Activity 2: Pathogen transport prediction, visualization, and verification

Activity Budget: \$150,000

Activity Description:

Due to pathogens' high spatial and temporal variabilities, implementing a three-dimensional and unsteady prediction platform of pathogen transport is essential. At the University of Minnesota, we have successfully applied the prediction model of cyanobacteria and nutrient transport in MN lakes. We propose an online and open-source modeling platform designed to be publicly accessible. Any state's regulatory community, with UMN-approved access, will have the opportunity to explore and implement the platform at a desired location. The potential users of the platform will provide online lake longitude, latitude, and pathogen concentrations for the lake under investigation. In the background, the platform will generate a bathymetric map, computational grid, and download publicly available meteorological and watershed data to predict the distribution of pathogens at the desired location and time horizon. The proposed platform will predict and visualize hourly spatial distribution of pathogens in lakes. The predicted pathogen concentrations will be verified by measurements (Activity 1). In the project's third year, in collaboration with the Minnesota Pollution Control Agency, we will apply and demonstrate the pathogen platform in at least three lakes with historical pathogen occurrences across the State. The selected lakes will encompass different maximum depths, surface areas, and trophic levels.

Activity Milestones:

Description	Approximate Completion Date
Modeling platform online implementation (bathymetry, meteorological, and hydrological data generation)	December 31, 2025
Pathogen mass balance model verification in Bde Maka Ska	June 30, 2026
Pathogen transport model implementation and demonstration to water quality regulators across the State	June 30, 2027

Activity 3: Online lake pathogen tracker

Activity Budget: \$146,000

Activity Description:

We will develop an online pathogen tracker to perform a) risk assessment, b) future daily forecast, and c) identify the spatial locations of mitigation hot spots. Verified pathogen concentrations (Activities 1-2) will be statistically analyzed to quantify their statistical signatures (mean, standard deviation, probability distribution). The dose of each reference pathogen will be determined by multiplying the volume of swimmer-ingested water by the ambient concentration of pathogen. The dose will be used to determine the probabilities of infection and illness. The estimated risk will be evaluated with the health benchmark of 36/1000 (36 illnesses per 1000 swimmers, EPA standard). Monte Carlo simulations will provide a range of uncertainty in infectious illness risks to human health from lake water. A series of pathogen exposure risk maps will be generated to guide lake-specific mitigation strategies. In analogy to an online pollen alert tracking, the risk of pathogen alert (very low, moderate, very high) outlook will be generated for user-selected lakes. The application and hands-on procedure of implementing the proposed drone water sampling, handheld DNA pathogen sequencing (Activity 1), pathogen prediction (Activity 2), and tracking and mitigation (Activity 3) will be communicated to public and policy-regulated state agencies through three Zoom webinars.

Activity Milestones:

Description	Approximate Completion Date
Demonstration of drone water sampling and nanopore technology in the field (Zoom webinar 1)	December 31, 2025
Implementation and demonstration of pathogen risk assessment and identification of mitigation hot spots (webinar 2)	June 30, 2026
Implementation and demonstration of online pathogen tracker for three lakes across the State (webinar 3)	June 30, 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Prof. Sebastian Behrens	University of Minnesota	Co-Principal Investigator	Yes
Dr. Shahram Missaghi	Minneapolis Public Works - Surface Water & Sewers Division	Public outreach	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?

Outcomes from this project will provide local authorities (City of Minneapolis Public Works Department, MPWD, Minneapolis Park and Recreation Board, MPRB, Minnesota Pollution Control Agency, MPCA) with quantitative information to protect and mitigate Minnesota lakes and wetlands by developing quick pathogen detection system and formulating pathogen tracking system. The short-term success will be measured by our ability to rapidly detect new pathogens and quantify the health risk from exposure to contaminated water. The project's long-term success will be measured by the extent to which state stakeholders (MPWD, MPRB, MPCA, and lake associations) adopt our findings to manage recreational waters.

Project Manager and Organization Qualifications

Project Manager Name: Miki Hondzo

Job Title: Professor

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

Prof. Hondzo is a professor in the Department of Civil, Environmental, and Geo-Engineering, St. Anthony Falls Laboratory (SAFL), University of Minnesota. He will be responsible for developing and guiding the field monitoring and developing pathogen prediction and tracking platforms. In the field, Dr. Hondzo will be responsible for implementing drone sampling technology in the proposed three lakes (Activity 1). He will guide the development of modeling efforts in predicting pathogen concentrations in the proposed tree lakes across the State (Activities 2 and 3). Furthermore, he will communicate the research reports to the LCCMR and coordinate sampling schedules with the Minnesota Pollution Control Agency. Hondzo has 20 years of experience in physical limnology and water quality monitoring and modeling in lakes, rivers, and ponds. Dr. Hondzo is an Associate Editor of the Environmental Fluid Mechanics journal.

Organization: U of MN - College of Science and Engineering

Organization Description:

The proposed research is collaborative between the Department of Civil, Environmental and Geo-Engineering (CEGE) and the St. Anthony Falls Laboratory (SAFL), University of Minnesota. The University of Minnesota is the State's leading research and graduate teaching institution. The University partners with communities and governmental agencies across Minnesota to engage students, faculty, and staff in addressing society's most pressing issues. The CEGE focuses on collaborative and interdisciplinary research within critical areas such as managing and sustaining water and land-use infrastructure, mitigating disasters of the natural and built environments, and designing renewable energy systems. The EcoFluids Laboratory at SAFL, developed by PI Hondzo, allows SAFL researchers to study the interactions among fundamental fluid mechanics, microbiological processes, and chemical reactions mediated by biological organisms. Hondzo's research group obtained a DJI drone three years ago to measure cyanobacterial biomass and water

temperatures in Minnesota lakes. The drone will acquire water samples in the proposed three lakes (Activity 1). Over the past 10 years, Hondzo's group has implemented a three-dimensional model for predicting water temperatures, nutrient, and cyanobacterial concentrations in lakes with complex geometries in Minnesota. The model will be instrumental in implementing Activities 2 and 3 in this proposal.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Miki Hondzo		Principal investigator			36.8%	0.24		\$69,512
Sebastian Behrens		Co-Principal Investigator			36.8%	0.24		\$56,551
Graduate students (2)		Pathogen detection and prediction			24.1%	3		\$327,089
Undergraduate student		Online pathogen tracker implementation			0%	0.12		\$51,155
							Sub Total	\$504,307
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Consumable supplies: DNR/RNA extraction, cDNA synthesis, qPCR reagents, primers, plastic ware, general lab supplies. Filed supplies: monitoring station supplies, chemicals for water sample preservation, drone-water sampler. Flow cytometry supplies: dyes, standard beads, buffer, filters	Field and laboratory supplies will be used to delect, predict, and verify pathogen concentrations in lakes					\$61,693
							Sub Total	\$61,693
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								

	Miles/ Meals/ Lodging	We anticipate three field trips across the state. Each trip will last up to two days.	The proposed field trips will be conducted to verify the proposed pathogen tracker in three lakes across the state.					\$3,000
							Sub Total	\$3,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	The outcomes of the study will be published in two research journals	Review and dissemination of the findings.					\$3,000
							Sub Total	\$3,000
Other Expenses								
		MinION rapid in field DNA Analysis	Field rapid DNA analysis and sequencing					\$40,000
		Lab Services: UMGC DNA sequencing	Collected water samples will be analyzed at the University of Minnesota DNA sequencing laboratory					\$21,000
		Flow cytometry: Instrument maintenance	The maintenance and functionality of the flow cytometer for lake water sample analysis					\$13,000
							Sub Total	\$74,000
							Grand Total	\$646,000

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				
			Non State Sub Total	-
			Funds Total	-

Attachments

Required Attachments

Visual Component

File: [8b4be2c1-3f4.pdf](#)

Alternate Text for Visual Component

Visual of the proposed project activities...

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
Endorsement: University of Minnesota	60bbcfcf-941.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

No

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

N/A

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

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

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

No

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

No

