



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-267

Proposal Title: Optimization of Water-Quality Monitoring in Surface Waters

Project Manager Information

Name: Paul Capel

Organization: U of MN - College of Science and Engineering

Office Telephone: (612) 625-3082

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Project Basic Information

Project Summary: This project will use existing high-frequency water quality data to quantify the degree of accuracy in the distribution of concentration and annual load of State and local water-quality monitoring programs.

Funds Requested: \$147,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Small Projects (H)

Secondary 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.

Monitoring streams and lakes for water quality (WQ) is critically important and an expensive endeavor that is conducted by numerous State, local, and watershed agencies, tribes, and private organizations (collectively termed agencies below). Some WQ monitoring is required by Federal and State mandates. The desired outcome of WQ monitoring of chemicals and sediment is oftentimes the distribution of concentration (mean, median, 25th, 75th percentile) and the annual load. Monitoring data is necessary for informed decision-making by water resource managers.

There are four basic sampling strategies are used by monitoring agencies in Minnesota and beyond: truly random sampling, high-flow/low flow-informed random sampling (e.g., USGS National Programs), fixed-time sampling (e.g., Ramsey County lakes), and knowledge-based targeted sampling (based on knowledge of watersheds and weather; e.g., MPCA). All of these strategies have the limitation that the true annual distribution of concentration or annual load is never known. But, the actual concentration and load value can be known at locations where high-frequency WQ data is collected. These are usually 15-minute or hourly data collected by sensors for streamflow, nitrate, salinity, turbidity, and other WQ parameters. This project will use these data to assess the degree of accuracy of the four monitoring strategies.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

Existing high-frequency WQ and streamflow data from Minnesota streams and lakes will be used to quantify the degree of accuracy for the four common monitoring strategies annual distribution of concentration or annual load. A computer program will be written to analyze the existing data and provide location-specific information for monitored streams and lakes. Many of the locations have multiple years of existing data. The multi-year data at many individual sites will be compared to provide the ability to generalize our understanding over time. The data from multiple streams, together with their watershed characteristics will be used to generalize our understanding over space.

Both the location-specific results and the generalizations will be provided to the agencies to help make better management decisions. The location-specific results will help validate the results of the current strategies that are being employed by the agencies. The true, location-specific, annual distribution of concentration and annual load can be compared their values. Location-specific information can provide insights into planning how resources will be used in future monitoring at existing locations (e.g., Should fewer or more samples be obtained to reach the desired outcome?). The results of the generalizations can provide insights in unsampled locations or unsampled years.

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?

Outcomes from this work will include a modeling tool (computer program) for State and local agencies to help optimize their WQ monitoring activities and a companion scientific journal article. This journal article will document the procedures and applications of high-frequency WQ data for informing WQ monitoring strategies. Also, an individual stream and lake-specific assessment of the accuracy of the degree of accuracy of the various monitoring strategies will be provided to the agencies to inform their future sample collection. Finally, a database of the State's high-frequency water quality data will be created and archived for future use by agencies and researchers.

Activities and Milestones

Activity 1: Organization of existing high-frequency water quality and streamflow in Minnesota stream and lakes

Activity Budget: \$15,000

Activity Description:

High-frequency WQ data is collected by numerous local, State, Federal agencies in Minnesota, as well as private organizations. These data will be collected through the national Water Quality Portal (National Water Quality Monitoring Council) and directly from the collecting organization. These data will be organized and made available through the University of Minnesota data archive.

Activity Milestones:

Description	Completion Date
Collection and organization of existing data finalized.	2021-12-31
Release of data set through University of Minnesota data archive.	2022-06-30

Activity 2: Use existing High-frequency WQ data at analyze various monitoring strategies for streams and lakes for distribution of concentration and annual load.

Activity Budget: \$87,000

Activity Description:

The high-frequency water quality and streamflow data collected in Activity 1 will be used to quantify the degree of accuracy obtained of the distribution of concentration and annual load for various hypothetical annual number of collected samples that might be collected in streams and lakes (e.g., 10, 20, 50 samples/year). Sampling strategies of will include truly random sampling, high flow/low flow-informed random sampling (e.g., USGS National Programs), fixed-time sampling (e.g., Ramsey County lakes), and knowledge-based targeted sampling (based on knowledge of watershed and weather; e.g., MPCA). Within each of these sampling strategies, specific sampling details, such as the number of annual samples, the seasonal distribution of sampling, the bias introduced by sampling only during normal work hour, and small modifications in knowledge-based sampling, will be probed. The results will be a stream and lake-specific assessment of the accuracy of the degree of accuracy of the various strategies that can be used by the collecting organization to inform their future sample collection.

Activity Milestones:

Description	Completion Date
Work with agencies to understanding the various monitoring strategies that are being used in Minnesota.	2021-12-31
Develop the computer program to conduct these analyses.	2022-06-30
Conduct the location-specific analyses of Minnesota streams and lakes.	2022-12-31
Complete journal article and provide agencies with computer program and location-specific outcomes.	2023-06-30

Activity 3: Generalize results across streams and years to provide sampling strategies for streams without existing high-frequency data.

Activity Budget: \$45,000

Activity Description:

The existing high-frequency water quality data used in this project has been collected over a time span of many years and across a wide ranges of stream size (mean annual discharge), watershed area, sources of water to the stream (groundwater, runoff), and land use of the watershed. The annual variability in the degree of accuracy among the sampled years for a given stream will be examined. The stream and landscape characteristics of the various watersheds will also be examined for the differences in their degrees of accuracy. These analyses will provide insights such that the outcomes of the different monitoring strategies might be able to be generalized to locations without high-frequency WQ data. If this is able to be accomplished, it could be extremely useful for the agencies for making informed decisions about allocation of monitoring resources.

Activity Milestones:

Description	Completion Date
Complete comparison of multiple streams to quantify the ability to generalize over space.	2022-06-30
Complete analyses for sites with multiple years of data to quantify the ability to generalize.	2022-12-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Randal Barnes, Professor	University of Minnesota, Department of Civil, Environmental, and Geo-Engineering	Professor Barnes will collaborate on identifying the endpoints for the analyses and provide guidance on the statistical methods used in the project. He will be a resource to the graduate and undergraduate students.	No
John Manske	Ramsey County, Environmental Services, Lake Management	Ramsey County will share their strategies for monitoring, existing high-frequency water quality data, and summaries of concentrations and loads. They will help this study to replicate their sampling strategy for our data analysis. They will receive our results and comparison of the concentration distributions and annual loads for their lakes.	No
Britta Belden, Water Resource Project Manager	Capitol Region Watershed District	Capitol Region will share their strategies for monitoring, existing high-frequency water quality data, and summaries of concentrations and loads. They will help this study to replicate their sampling strategy for our data analysis. They will receive our results and comparison of the concentration distributions and annual loads for their lakes.	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 be funded?

The results of this work will be both academic and a practical benefit for the State. A scientific paper will be published so that monitoring programs outside of Minnesota can use the technique. State (e.g., MPCA, MDA), local (Capitol Region Watershed District, Ramsey County, Lake Management), and Federal (e.g., USGS) monitoring agencies will get the results for their sampling sites and their monitoring strategies to help inform their future decisions. In addition, a summary data base of the existing high-frequency water quality data will be permanently available for research and planning purposes.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Determining Influence of Insecticides on Algal Blooms	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04a	\$350,000

Project Manager and Organization Qualifications

Project Manager Name: Paul Capel

Job Title: Adjunct Associate Professor

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

Dr. Paul Capel will be responsible for design and supervision of this study. His work focuses on the environmental behavior and transport of chemicals in the environment, and the importance of hydrologic flowpaths on chemical transport. He worked for the US Geological Survey for more than 30 years designing, conducting, and directing large-scale, water-quality field and modeling studies on pesticides and nutrients in agricultural and urban watersheds. Dr. Capel is a member of the graduate faculty in Water Resources Science. He has co-authored over 100 articles in peer

reviewed journals, reports, and books. He has served on advisory and review panels for the US Department of Agriculture, US Environmental Protection Agency, and US Department of the Interior. He has trained 20 MS and 4 PhD students, as well as numerous undergraduates.

B.A., Chemistry, 1979, Evangel College, Springfield, MO.

M.S.C.E, Civil Engineering, 1983, University of Minnesota, Minneapolis, MN.

Ph.D., Civil Engineering, 1988, University of Minnesota, Minneapolis, MN.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (<http://twin-cities.umn.edu/about-us>). The offices of the PI contain the necessary fixed and moveable equipment and facilities needed for the proposed study.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Project manager		Manage project, guide work, advise students, write final report			27%	0.18		\$37,500
graduate student researcher		Conduct the data analysis for the project, draft report			46%	0.92		\$94,900
undergraduate student researcher		Write computer code, organize existing data			0%	0.4		\$10,600
							Sub Total	\$143,000
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel to field sites, visit to agency office, water resources conference (1/yr)	receive information from agencies, present results					\$1,000

							Sub Total	\$1,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	journal charges for publications	journal charges for publications					\$3,000
							Sub Total	\$3,000
Other Expenses								
							Sub Total	-
							Grand Total	\$147,000

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				
In-Kind	University of Minnesota indirect costs	Space, accounting support, computer access	Secured	\$62,781
			State Sub Total	\$62,781
Non-State				
			Non State Sub Total	-
			Funds Total	\$62,781

Attachments

Required Attachments

Visual Component

File: [8583e691-4f5.docx](#)

Alternate Text for Visual Component

The Visual Component is a graphic with the head banner “High-frequency water quality data provides the true answer for monitoring statistics and loads.” Below that is a map of Minnesota with the sites in the Watershed Pollutant Load Monitoring Network identified. Below that is an example graph of high-frequency concentration data from a nitrate sensor for the Cedar River at Austin, Minnesota April 1 to June 1, 2018. This graph has the caption “The 35,000 samples per year from the existing high-frequency water quality sensors serve as the foundation for Project Goals 1 and 2.” One arrow from the banner points to an archery target and is captioned “Project Goal 1: High-frequency data can inform monitoring strategies and outcomes.” The 35,000 samples/year from the high-frequency sensor has a arrow that points to the bull’s eye. Other arrows for 50, 30, and 10 samples/per are progressively further away from the bull’s eye. A second arrow from the heading is captioned “Project Goal 2: Understanding high-frequency data at a few sites can be extrapolated to many sampling sites.” This caption points to few stream sites that have an existing high-frequency sensors. In turn, each of these site have arrows to a number of other sites showing that the understanding gleamed from the high-frequency data can be generalized to other areas.

Optional Attachments

Support Letter or Other

Title	File
High-frequency water quality data can inform monitoring strategies	2213d99b-ae8.pdf
Univ MN Letter of Intent	19aa9234-f9f.docx

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

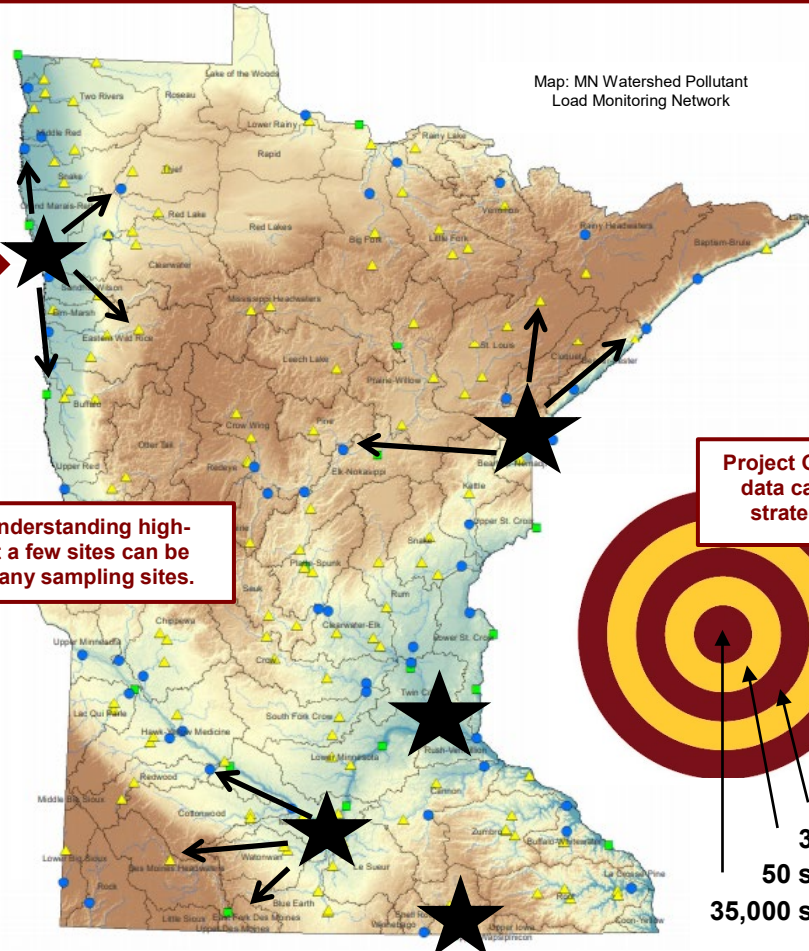
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

High-frequency water quality data provides the true answer for monitoring statistics and loads.

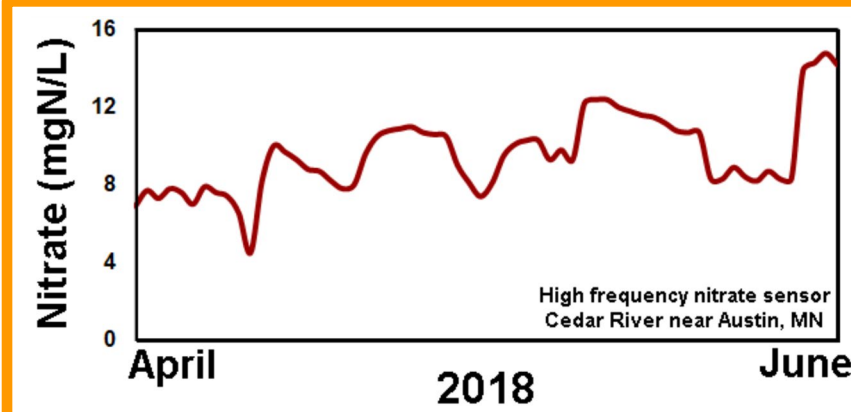


Project Goal 2: Understanding high-frequency data at a few sites can be extrapolated to many sampling sites.

Project Goal 1: High-frequency data can inform monitoring strategies and outcomes.



- 10 samples
- 30 samples
- 50 samples
- 35,000 samples



The 35,000 samples per year from the existing high-frequency water quality sensors serve as the foundation for Project Goals 1 and 2.