



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-263

Proposal Title: Trifluoroacetic Acid in Minnesota Waters: Levels and Formation

Project Manager Information

Name: William Arnold

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Trifluoroacetic acid, the smallest PFAS, will be quantified in Minnesota waters. The maximum potential for trifluoroacetic acid formation and the chemicals that drive levels and risks will be determined.

ENRTF Funds Requested: \$591,000

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.

Trifluoroacetic acid (TFA), the smallest poly- and perfluoroalkyl substance (PFAS), has recently been revealed to be an abundant and prevalent environmental PFAS molecule. TFA represents a threat to Minnesota's water resources and wildlife, but we do not have information about its presence or sources in Minnesota. Additionally, humans may be exposed via drinking water and food, and recent evidence indicates that TFA is taken up by plants, which means it may both enter the food chain and represent a risk to crop yields. TFA is persistent and highly mobile and may come from fluorochemical production facilities, the degradation of pesticides and pharmaceuticals, and degradation of fluorine-containing refrigeration compounds released in the atmosphere. The limited data available suggests levels are rising, posing potential risks to human and ecological health. Because numerous chemicals introduced into the environment can form TFA upon degradation via natural processes and during water or wastewater treatment, we need to know not only the amount of TFA present, but also its potential to form and the specific chemicals that lead to its presence in Minnesota waters. Only then can we assess the threat TFA poses to Minnesota's water resources and provide recommendations for controlling TFA levels.

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.

Our proposed solution is to 1) measure the current baseline TFA levels in Minnesota's water resources. 2) Determine the maximum amount that could form from fluorinated chemicals present in surface water, groundwater, and the water inputs that feed these resources. 3) Identify the fluorinated chemicals present that drive TFA formation. To meet goal 1, we will collect water samples from across Minnesota by leveraging ongoing sampling. We will also engage with citizen scientists for sample collection using the University of Minnesota Driven to Discover (UMN D2D) booth at the Minnesota State Fair. Because there are numerous sources of TFA, it is important to have broad coverage of surface waters, groundwater, and precipitation to understand what the likely sources are in different regions of Minnesota. To determine TFA formation potential, we will use the same samples but analyze them after exposing the water to heat and oxidizing conditions to convert all potential precursors to TFA. This will give us the maximum TFA levels to which humans, wildlife, or crops would be exposed. For waters with the highest levels of TFA or the highest formation potential, we will conduct non-targeted mass spectrometry to determine the chemicals driving the TFA.

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?

The key findings of this work will be 1) the levels and distribution of TFA in Minnesota's water resources, and 2) the maximum potential for TFA formation during natural processing or engineered treatment of water, and 3) the drivers of TFA in Minnesota. The outcomes facilitated will be assessments of 1) the threat that TFA poses to aquatic life, humans, and Minnesota's agricultural commodities; 2) the most likely sources of TFA to Minnesota's surface and groundwaters; and 3) what steps can and should be taken to minimize TFA levels in Minnesota's waters.

Activities and Milestones

Activity 1: Measure levels of trifluoroacetic acid in Minnesota surface water, groundwater, and precipitation to assess baseline levels and hotspots

Activity Budget: \$195,000

Activity Description:

Trifluoroacetic acid is likely widespread in Minnesota's surface and groundwaters due to its formation from the degradation of larger PFAS, pesticides, pharmaceuticals and accumulation in plants. Additionally, it is present in rain due to the formation of TFA via degradation of refrigerants released to the atmosphere. A broad survey is needed to understand the range of TFA concentrations present in both surface and groundwaters and assess where concentrations are highest. Additional benefits from measuring TFA are its use as an additional dating marker in groundwater dating (in relatively pristine areas, which is of interest to the MN Department of Natural Resources Groundwater Atlas) or as an indicator of pharmaceutical or pesticide pollution in human-impacted areas. Samples will be collected by our team, by leveraging ongoing sampling of other agencies and research efforts, and by citizen engagement via the UMN Driven to Discover booth at the Minnesota State Fair. We will target a spatially distributed set of surface waters and groundwaters, as well as stormwater runoff, wastewater effluents, and drinking water sources.

Activity Milestones:

Description	Approximate Completion Date
Validate low level TFA measurement protocols	December 31, 2027
Use the UMN Driven to Discover booth to collect samples of interest to the public	September 30, 2028
Collect samples from surface waters, groundwaters, and precipitation statewide	October 31, 2028
Collect samples of drinking water, stormwater, and treated wastewater	March 31, 2029
Compilation of TFA concentrations into a statewide map and dissemination of results	December 31, 2029

Activity 2: Measure trifluoroacetic acid formation potential by exposing collected samples to aggressive treatment conditions.

Activity Budget: \$175,000

Activity Description:

Because TFA is not a primary pollutant, its concentration will be driven by the presence of other chemicals that lead to TFA when they degrade under natural conditions or during water treatment. Our past work has shown that oxidizing conditions, similar to those used in drinking water or advanced wastewater treatment, convert various fluorinated chemicals into TFA. Examples of relevant chemicals to Minnesota are the lampricide TFM (3-trifluoromethyl-4-nitrophenol), the pharmaceutical fluoxetine, and the insecticide sulfoxaflo. We will develop a protocol to determine a specified set of laboratory conditions that maximize TFA formation. The amount of TFA produced will be "TFA formation potential", and it will be useful in assessing the maximum exposure and risk of a water source. The TFA formation potential will be measured on the water samples collected in Activity 1, allowing comparison of TFA levels present versus their potential to form in waters ranging from pristine to human impacted.

Activity Milestones:

Description	Approximate Completion Date
Test a suite of oxidizing conditions for TFA formation to optimize efficiency	March 31, 2028
Perform TFA formation tests on the samples from Activity 1	December 31, 2029
Assess how location affects the ratio of TFA present to TFA formation	March 31, 2030
Identify hotspots of TFA formation potential	March 31, 2030

Activity 3: Identify the most important TFA precursors and sources for surface and groundwaters

Activity Budget: \$221,000

Activity Description:

Identifying key drivers of TFA formation will allow assessment of actions that could be taken in terms of remedial actions, guidance on chemical use, or water/wastewater treatment to minimize TFA levels. Although there are many potential TFA precursors in inputs to our surface and groundwaters, agrochemicals and pharmaceuticals with trifluoromethyl groups are likely the most significant contributors due to their high volume of use across Minnesota. The importance will only continue to increase, as six new medications were approved in 2025 that have potential to form TFA. Many of these potential TFA precursors are currently tracked by the Minnesota Department of Agriculture PFAS registry and the Minnesota Department of Health contaminants of emerging concern list. Based on locations identified with high TFA levels in Activities 1 and 2, we will perform non-targeted analysis on representative samples from these sites to identify specific compounds that drive TFA formation. This will be done by analyzing samples before and after exposing them to TFA formation potential treatment conditions and assessing which fluorine containing chemicals are degraded. We expect that the sample suite will include 1) precipitation, 2) surface waters impacted by stormwater runoff, and 3) wastewater effluents.

Activity Milestones:

Description	Approximate Completion Date
Compile database of likely TFA precursors	June 30, 2028
Optimized extraction method and untargeted mass spectrometry analysis for TFA precursors	December 31, 2028
Identify fluorinated compounds in water samples that likely contribute to TFA formation potential	December 31, 2029
Manuscript publication	March 31, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
William Pomerantz	University of Minnesota, Department of Chemistry	Expert on analysis of fluorinated chemicals, advising and mentoring student and postdoctoral researcher, data analysis and synthesis	Yes
Rene Boiteau	University of Minnesota, Department of Chemistry	Expert on non-targeted mass spectrometry for chemical identification and quantification, advising and mentoring student and postdoctoral researcher, data analysis and synthesis	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.

Results will be implemented via communication with MPCA, DNR, and other agency scientists, watershed managers, and routine reporting. Given the current interest in TFA, we will provide information about TFA levels to those that collected the samples as soon as results are available through a website or email. Results will also be disseminated via open access peer-reviewed journal articles to maximize visibility. We will connect with the stakeholders through the Minnesota Water Conference, the Minnesota Stormwater Seminar Series and other avenues. The collected data will be made available in the Data Repository of the University of Minnesota to maximize availability. We will acknowledge the Environment and Natural Resources Trust Fund through use of the trust fund logo and/or attribution language on all disseminated works.

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 develop interactive web pages with maps to provide data in a readily available, understandable form. Communication with sampling partners and stakeholders will allow assessment of any risks that TFA poses at specific sites so that appropriate communication and action steps can be taken. We will make a recommendation regarding future monitoring of TFA in plants/crops. If long term environmental monitoring is needed, state agencies and other governmental organizations can design and fund programs to meet the desired outcomes based on this work. If additional work is needed, other federal, state, and local funding will be pursued.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Finding, Capturing, and Destroying PFAS in Minnesota Waters	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 04d	\$478,000
Fluorine Beyond PFAS: Pesticide and Pharmaceutical Degradation	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 04f	\$400,000

Project Manager and Organization Qualifications

Project Manager Name: William Arnold

Job Title: Professor

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

Dr. William Arnold is a Distinguished McKnight University and the Joseph T. and Rose S. Ling Professor in the Department of Civil, Environmental, and Geo- Engineering at the University of Minnesota. He received his B.S. in Chemical Engineering from MIT in 1994 his M.S. in Chemical Engineering from Yale in 1995, and a Ph.D. in Environmental Engineering from The Johns Hopkins University in 1999. He has supervised 25 Ph.D. students and 24 M.S. students. He has been studying the fate of micropollutants, including pharmaceuticals, pesticides, and PFAS compounds in aquatic environments for twenty years. As part of these studies, he has evaluated the presence and removal of various CECs in Minnesota's waters, including past work supported by the ENRTF. His work has specifically focused on how sunlight in natural and engineered systems leads to transformation of pollutants. He has also evaluated how organic matter from wastewater or stormwater produces reactive species that can degrade contaminants when exposed to sunlight. Past ENTRF funded work has been impactful to Minnesota, particularly work on triclosan and quaternary ammonium compounds.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota (UMN) is one of the largest, most comprehensive, and most prestigious public universities in the United States. The College of Science and Engineering (CSE) at the University of Minnesota is ranked among the top engineering and science academic programs in the country. The college includes 12 academic departments, including the Department of Civil, Environmental, and Geo- Engineering (CEGE) and Department of Chemistry, offering a wide range of degree programs at the baccalaureate, master's, and doctoral levels. Researchers within the CSE and CEGE are on the leading edge of finding ways to solve some of the world's pressing environmental issues problems by protecting water resources, developing new forms of environment-friendly energy, and developing a strong national infrastructure. The College of Science and Engineering also offers students a rigorous, world-class education tailored to their interests and goals. CEGE at UMN is known for its pioneering work in analytical, computational, and experimental work to assess and solve environmental problems. We practice research excellence grounded in rigorous fundamentals for wide-ranging applications. The laboratories in CEGE and centralized research facilities have the necessary space and equipment to perform the proposed work.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Principal Investigator-William Arnold		Lead project, advise researchers, analyze data, reporting			27%	18		\$70,675
Co-Investigator - William Pomerantz		Advise researchers, lead NMR analyses, analyze data			27%	9		\$28,353
Co-Investigator - Rene Boiteau		Advise researchers, mass spectrometry analyses, lead precursor identification			27%	12		\$25,298
Postdoctoral Researcher		Lead Lab Efforts for Activities 1 and 2			21%	2		\$164,083
Graduate Student		Lead analyses for Activity 1, Assist with Activities 2 and 3			45%	1.5		\$186,029
Undergraduate researcher		assist graduate student and postdoctoral researcher with laboratory work			0%	0.6		\$20,375
							Sub Total	\$494,813
Contracts and Services								
Agilent Technologies	Service Contract	The mass spectrometers needed for the project required routine maintenance to ensure operation. Because all activities rely on these instruments, consistent operation is critical to success				0.15		\$44,500
							Sub Total	\$44,500
Equipment, Tools, and Supplies								
	Tools and Supplies	Laboratory supplies, including chemicals, chromatography and NMR supplies, glassware, analytical standards, extraction cartridges, and personal protective equipment for researchers	The lab supplies are necessary to perform the proposed experiments.					\$31,988
	Tools and Supplies	Materials for sample acquisition via the UMN Driven to Discover booth at the MN State Fair	supplies and instructions for distribution to fairgoers to collect samples					\$2,699

							Sub Total	\$34,687
Capital Equipment								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Four registrations at the Minnesota water conference and associated parking	Presentation of results to the community					\$2,000
	Miles/ Meals/ Lodging	4 overnight trips for two people for sampling. Costs include hotels and 300 driving miles	Sample collection					\$3,000
							Sub Total	\$5,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Printing	Open access journal fees	Ensure that publications are freely accessible					\$10,000
							Sub Total	\$10,000
Other Expenses								
		Shipping costs	Postage costs for citizens and partners to ship samples					\$2,000
							Sub Total	\$2,000
							Grand Total	\$591,000

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	Waived University of Minnesota Indirect costs	Utilities, space, project support	Secured	\$293,000
			Non State Sub Total	\$293,000
			Funds Total	\$293,000

Total Project Cost: \$884,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [2404162f-367.pdf](#)

Alternate Text for Visual Component

Storm clouds, a field, and wastewater plant are shown as potential sources of trifluoroacetic acid to surface- and ground-water. These waters containing trifluoroacetic acid are shown to impact fish/wildlife, crops, and humans. A large arrow shows samples will be used to measure trifluoroacetic acid and figure out its sources....

Supplemental Attachments

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

Title	File
UMN Letter	c7b2926a-3f1.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:

Enoch Pan, Christina Doherty

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