Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-257

Proposal Title: Breaking the PFAS Cycle with a Full-Scale Demonstration

Project Manager Information

Name: Andrew McCabe

Organization: Barr Engineering Co.

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Project Basic Information

Project Summary: This full-scale pilot will evaluate supercritical water oxidation (SCWO) for managing PFAS in biosolids and water treatment residuals. SCWO can destroy PFAS in a variety of wastes and recover energy.

Funds Requested: $1,724,000

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?

Region(s): Central

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.

PFAS are ubiquitous contaminants, impacting Minnesota's water resources. Efforts are accelerating on the state and federal level to understand the extent of PFAS contamination. Regulatory actions are accelerating with the EPA proposing drinking water MCLs and CERCLA hazardous substance designations. To protect Minnesota's water resources, we will need sustainable ways to manage and destroy PFAS, particularly in residuals from water and wastewater treatment, to break the PFAS cycle.

Water resource recovery facilities (WRRFs) receive industrial and municipal wastewater containing PFAS. PFAS partition into biosolids at WRRFs, and traditional management methods like composting, land application, and sewage sludge incineration do not destroy PFAS and may promote their environmental spread.

Up to 20% of U.S. drinking water systems may need advanced treatment or alternative water sources to meet proposed PFAS MCLs. Granular activated carbon and anion exchange resin, both available technologies, can remove PFAS from drinking water. Once the capacities of these media are exhausted, they are typically disposed of and replaced.

Municipalities throughout Minnesota will likely require PFAS destruction options for these waste streams. The only PFAS destruction technologies currently applied at municipal scales require high temperatures, significant external energy, have no installations in Minnesota, and carry significant regulatory uncertainty.

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.

Supercritical water oxidation (SCWO) has been widely applied for waste management and has the potential to mineralize PFAS, produce clean water for beneficial reuse, and recover valuable nutrients and energy from waste. This project is a full-scale demonstration pilot of SCWO to destroy PFAS as an initial step in evaluating this promising PFAS destruction option for future implementation in Minnesota. Our team's goal is to evaluate the ability of SCWO to destroy PFAS in a range of wastes while remaining energy neutral. A long-term outcome could be PFAS destruction facilities using SCWO and accepting residuals from a variety of sources, including wastewater treatment utilities seeking alternative biosolids management options and drinking water treatment utilities upgrading to meet proposed MCLs.

PFAS destruction using SCWO has been tested in academic research and small-scale installations but needs additional, full-scale vetting of the PFAS destruction efficiency and options for disposal or reuse of treated water and solids. Thus, the need to progress toward full-scale implementation falls less to academic research and more in the area of engineering application and logistics. Our team is well positioned to successfully complete this project based on our experience implementing innovative infrastructure projects.

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?

Sustainable options are needed to manage PFAS, both in biosolids from municipal wastewater treatment and in sorption media from drinking water treatment. Project outcomes will demonstrate the potential benefits of implementing SCWO for PFAS waste management in Minnesota. Implementing PFAS destruction reduces the potential load of PFAS that could be routed back to the environment, preserving the state's natural resources, improving water quality, and reducing potential for human exposure. Applying SCWO at a WRRF takes advantage of existing conventional biological treatment that already concentrates PFAS into biosolids. SCWO has the potential to recover valuable nutrients from biosolids while mineralizing PFAS.

Activities and Milestones

Activity 1: Work plan development, equipment procurement, and pilot system installation

Activity Budget: $719,200

Activity Description:
Project partners will work together to design and procure the pilot equipment and install it onsite at the St. Cloud Nutrient, Energy and Water Recovery Facility (NEW RF). The team will develop plans for pilot operation, sampling and data quality, data management, and waste management.

The driving hypothesis for this project is that SCWO can mineralize PFAS while recovering energy from biosolids and other wastes. The specific objectives are to:

1. Evaluate the operability of SCWO and ongoing maintenance costs.
2. Evaluate the efficiency of PFAS mineralization.
3. Evaluate the efficiency of energy recovery and viable use options.
4. Evaluate the potential value of the nutrient content of residual solids and potential for beneficial reuse as a soil amendment.
5. Evaluate the quality of the condensate water and identify options for beneficial reuse.

Barr Engineering will manage the project and subcontracts. A project principal from Barr Engineering will also be responsible for the delivery of this project and project quality control. 374Water will provide equipment and labor for commissioning and later operations. St. Cloud will facilitate logistics associated with equipment and labor for commissioning and later operations. St. Cloud will facilitate logistics associated with equipment installation.

Activity Milestones:

Description	Approximate Completion Date
Pilot study work plan completion	September 30, 2024
Equipment Procurement (delivery of all pilot equipment to demonstration site)	December 31, 2024
Installation of pilot equipment	March 31, 2025
Pilot system commissioning	April 30, 2025

Activity 2: Operation of SCWO demonstration pilot to evaluate PFAS mineralization, energy recovery, and nutrient recovery

Activity Budget: $937,600

Activity Description:
Pilot testing will occur in a series of phases to evaluate SCWO operation and performance with respect to PFAS fate and destruction, energy efficiency, and beneficial reuse of the effluent streams. Phases will include operation using St. Cloud NEW RF biosolids and sorption media from Minnesota water treatment plants as individual feedstocks as well as phases with mixed feedstock. Data collection will include sampling for targeted PFAS, organic fluorine and total fluoride measurements, and general water quality in feedstocks and treated effluents (including the exhaust air, condensate water, residual solids, and effluent water). Operational data, energy use and recovery, and potential for beneficial reuse of the condensate water and solid residuals will be evaluated as well.

Pilot operation will be a collaborative effort among St. Cloud NEW RF, MnTAP, the SCWO technology vendor 374Water, and Barr Engineering. Day-to-day operation of pilot equipment will be conducted by 374Water, with support from St.

Cloud NEW RF staff, who will also be trained on basic operations as well as emergency procedures. MnTAP and Barr Engineering will conduct sampling and analysis, with Barr leading data quality and data management. Data analyses will be completed by certified external laboratories.

Activity Milestones:

Description	Approximate Completion Date
Pilot system startup	May 31, 2025
Pilot operation and testing	October 31, 2025
Completion of data reporting	December 31, 2025

Activity 3: Communication and outreach to the water and wastewater communities of Minnesota

Activity Budget: $67,200

Activity Description:
We will communicate pilot impact and results and PFAS destruction context through three primary activities:

1. Pre-pilot promotion will include communications with the MPCA, local chapters of the American Water Works Association (drinking water professional organization), and the Water Environment Federation (wastewater professional organization), with a goal of sharing planned pilot activities with utilities and listening for recommended improvements.
2. Post-pilot outreach may include guest lectures at area universities and industry events and discussions with water and wastewater utilities in the state, with a goal of sharing knowledge about PFAS destruction and piloting outcomes and listening to stakeholder needs and limitations.
3. Technical reporting and manuscript preparation will be critical to making the pilot outcomes useful for future implementation of PFAS destruction projects. This will include writing a peer-reviewed journal article that can be referenced by others as well as presenting at local conferences (e.g., Central States Water Environment Association and Minnesota Wastewater Operators Association) about results and implications for PFAS management in Minnesota.

Activity Milestones:

Description	Approximate Completion Date
Promotion of pilot goals	October 31, 2024
Community outreach about PFAS environmental cycle and pilot study results	December 31, 2025
Publication of peer-reviewed journal article reporting pilot results	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Ali Ling	Barr Engineering Co.	Technical leadership, project planning, information dissemination	Yes
Emma Larson	City of St. Cloud	Utility resource management and onsite logistics	Yes
Jacob Ethen	City of St. Cloud	St. Cloud NEW RF onsite logistics for pilot equipment installation and material handling	Yes
Sudhakar Viswanathan	374Water	Pilot equipment technology lead	Yes
David Garb	374Water	Pilot equipment and operations manager	Yes
Kelsey Klucas	MnTAP at the University of Minnesota	Coordinating onsite monitoring support and leading outreach efforts to Minnesota's Water Resource and Recovery Facility community	Yes

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?

This study will be successful if we can accurately evaluate PFAS destruction and the potential to use captured energy from wastes and reuse condensate water and residual solids. Pending favorable technology outcomes from the demonstration, we will identify and seek opportunities to apply SCWO in Minnesota. We will seek funding, potentially through the Department of Energy, the Department of Defense, state-sponsored grants, or public-private partnerships to assist with future scale-up needs including a potential regional PFAS destruction facility integrating needs of drinking water utilities, wastewater utilities, landfills, and industries. Future efforts could also investigate carbon capture potential for SCWO.

Project Manager and Organization Qualifications

Project Manager Name: Andrew McCabe

Job Title: Environmental Engineer

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

Dr. McCabe is a water and wastewater engineer with Barr Engineering Co., where he serves as technical lead and project manager for mine water treatment, PFAS water treatment, and stormwater treatment projects. Dedicated to Minnesota, he is an advocate for responsible and sustainable natural resource management. He is passionate about aquatic chemistry and trace organic contaminants in aquatic systems. He applies his expertise in physicochemical water and wastewater treatment techniques, solving real-world water problems in the municipal and industrial sectors. He serves as Barr's technical lead on PFAS water treatment technologies and manages Barr's water treatment laboratory.

Dr. McCabe has authored or co-authored six peer-reviewed journal articles and delivered eleven conference presentations. He received his PhD in 2017 from the University of Minnesota-Twin Cities, where he studied under Dr. William Arnold. He completed his BS in biochemistry and BA in chemistry both at the University of Minnesota-Duluth. During his graduate research, he studied the photochemical reactions of dissolved organic matter (DOM) and pesticides in sunlit surface waters with applications in passive treatment systems for urban and agricultural runoff. Much of his research involved characterization of DOM using spectrophotometry and high-resolution mass spectrometry. His research was partially funded by LCCMR.

Organization: Barr Engineering Co.

Organization Description:
Headquartered in Minnesota, Barr's nearly 1,000 engineers, scientists, technicians, and support specialists solve complex problems with clients in public, manufacturing, fuels, power, and mining sectors across the U.S. and around the world.

Barr has been working on PFAS-related issues at a national level since the early 2000s, when we helped the PFAS-manufacturing industry develop an understanding of the extent of their perfluorooctanoic acid (PFOA) use and its fate in multiple manufacturing processes. Since that initial project, Barr has helped numerous clients across the country and around the world manage the complexity of PFAS. Our work includes treating drinking water and wastewater, remediating soil, managing landfill leachate, and addressing stormwater and groundwater contamination for PFAS. Our PFAS water treatment design portfolio spans over two decades, with projects in municipal and industrial applications. To meet client needs and evolving regulatory requirements, our team is constantly evaluating existing and emerging PFAS treatment and remediation technologies in a variety of media and site conditions. This includes a recent study of commercially viable treatment technologies for the Minnesota Pollution Control Agency.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Engineering Project Manager		Project management, team coordination, data management coordination, budget tracking, progress tracking			70%	0.4		$92,000
Engineering Technical Lead		Technical leader, project planning, and reporting lead			70%	0.12		$34,000
Engineering Project Principal/Technical Reviewer		Fiscal responsibility for sponsoring organization, project oversight, quality control, and project delivery			70%	0.04		$12,000
Engineering Support		Data management, data quality, and onsite monitoring and commissioning support (split between multiple staff, estimating 3-5 individuals)			70%	0.14		$94,000
							Sub Total	**$232,000**
Contracts and Services								
St. Cloud Nutrient, Energy and Water Recovery Facility	Sub award	Utility resource management, onsite logistics, installation support, operation support, and outreach. Support for approximately 2-4 individuals.				0.14		$36,000
Minnesota Technical Assistance Program (MnTAP)	Sub award	MnTAP will provide intern support to assist with sample collection and pilot monitoring. MnTAP will also take a lead role in outreach to Minnesota's wastewater community. This sub-award will support one MnTAP staff engineer and one intern.				0.14		$41,000
374Water	Professional or Technical Service Contract	374Water will provide the SCWO equipment as well as engineering support. They will provide operations support for 8 hrs/day for the duration of the pilot, plus assistance installing the pilot. The contract amount includes equipment rental for 6 months plus support from two 374Water engineers and onsite operators.				0.24		$800,000
Contract Laboratories (TBD)	Professional or Technical	Commercial laboratory testing fees for general water quality analyses, waste characterization,				0		$300,000

	Service Contract	and PFAS analyses on the wastes, water, and air streams. Commercial laboratories will provide analytical testing, laboratory reports to support data management, and data quality reports.						
Vonco II	Professional or Technical Service Contract	Disposal of solids produced from SCWO unit				-		$30,000
Mechanical and electrical contractor (TBD)	Professional or Technical Service Contract	Electrical and mechanical contractor for installation of equipment, piping, and electrical. Equipment demobilization and demolition.				0		$170,000
							Sub Total	**$1,377,000**
Equipment, Tools, and Supplies								
	Equipment	Tanks for waste receiving and effluent water storage	Tanks to store and prepare feed wastes ahead of the SCWO reactor and tanks to store effluent water.					$40,000
	Equipment	Feed and effluent pumps	Pumps to transfer sludge from St. Cloud's biosolids storage tanks to the SCWO reactor and pumps to transfer effluent water.					$20,000
	Equipment	Solids dewatering equipment	Equipment to separate residual solids and effluent water					$10,000
	Equipment	Ancillary equipment, piping/hoses, and electrical equipment	Includes process piping, electrical equipment, and instrumentation					$25,000
	Equipment	Co-fuel (diesel for system start-up) and tank	Start-up fuel for SCWO reactor. Co-fuel is needed to heat and pressurize the system at start-up.					$5,000
							Sub Total	**$100,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								

	Miles/ Meals/ Lodging	Amount includes mileage for round trip from the Twin Cities to St. Cloud (140 miles) for one Barr or MnTAP staff to visit the demonstration site two times per week during system installation, start-up, and operation. Day trips only.	Barr and MnTAP staff will regularly visit the site to observe and assist with equipment installation. During pilot operation, staff will be collecting samples and assisting with system troubleshooting.					$10,000
							Sub Total	**$10,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication of one open access peer-reviewed journal article	Publication of an open access peer-reviewed journal article will allow results from the pilot test to be accessible to a broad community interested in alternative PFAS management options.					$5,000
							Sub Total	**$5,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$1,724,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

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: 7bbe808c-bcb.pdf

Alternate Text for Visual Component

This figure shows PFAS routing from industrial and community uses to wastewater and drinking water facilities, where residuals from these facilities may impact natural resources. Supercritical water oxidation (SCWO) has the potential to aid in breaking the PFAS environmental cycle....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
St. Cloud Letter of Support	bda6db36-092.pdf
MnTAP Letter of Support	34f45fa2-095.pdf
City of Bemidji Letter of Support (drinking water GAC treatment)	a705e9da-58d.pdf
Vonco II Waste Management Letter of Support	2b3ed282-c2f.pdf
Letter of Commitment from Barr Engineering	4335b4ee-494.pdf
374Water Letter of Support	0c26e178-261.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