Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-110

Proposal Title: Predicting Contaminant Movement in Minnesota's Fractured Aquifers

Project Manager Information

Name: Peter Kang

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: We develop and demonstrate an easy-to-use software program that predicts the fate and movement of contaminants such as PFAS, chloride, nitrate, and pathogens in Minnesota's fractured aquifers.

ENRTF Funds Requested: $650,000

Proposed Project Completion: June 30, 2028

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.

Groundwater supplies about 80% of Minnesotans' drinking water and is critically important for irrigation. However, Minnesota is experiencing serious groundwater problems due to a dramatic increase in water demand and pervasive contamination issues. In particular, groundwater contamination due to nitrate, PFAS, and pathogens poses a significant risk to public health and the environment. Conventional groundwater models over-simplify fracture flow, and as a result, often fail to accurately predict contaminant transport. The recent $850 million settlement between the state of Minnesota and the 3M Company over PFAS contamination is a representative example: the recently documented extent of the PFAS contamination plume in the eastern Twin Cities area is far greater than that predicted by conventional models. This was because high permeability fractures allowed contaminants to spread much faster than was expected. Groundwater systems are often composed of fractured rocks (rocks with cracks and other large cavities), and fractured aquifers in the Twin Cities area serve over one-half of the drinking water for its 3 million citizens. Accordingly, there is an urgent need for practical software that can more accurately forecast the movement of contaminants in fractured aquifers.

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 goal is to develop a practical and easy-to-use software program that can predict contaminant transport in Minnesota's fractured aquifers. Using the software, users can predict the travel time of contaminants in aquifers by entering several basic inputs (e.g., groundwater level, fractured rock type). The software will be validated at two field sites and packaged so that state agencies and groundwater consulting companies can use it (see support letters). For example, the software will allow one to better evaluate the efficacy of improved agriculture practices on groundwater quality. The project focuses on two fractured limestone rock formations: the Platteville Formation, which is critical to the Twin Cities, and the Prosser and Cummingsville Formations, which are critical to the southeast Minnesota region. We will conduct field dye tracing and cutting-edge hydraulic testing to gather necessary site-specific data, building upon fracture flow properties accumulated from previous Environmental Trust Fund projects. This information will guide the development of three-dimensional numerical models. Finally, the modeling results will be used to develop the software program that predicts contaminant travel time.

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 project will improve the prediction of contaminant migration through fractured aquifers, which is essential for protecting, remediating, and managing the state's water resources. Particularly, the project will generate hydrogeologic information necessary to understand how contaminants move through fractured rock formations. Among the major outcomes of the project will be an easy-to-use software program that can be run on standard computers. The software will enable predictions of the travel time distribution of contaminants, thereby providing water resource managers with critical information and making results more accessible to the public. In addition, the project will strengthen the hydrogeology curriculum at UMN.

Activities and Milestones

Activity 1: Characterizing fracture flow and contaminant transport properties of the Platteville formation

Activity Budget: $233,976

Activity Description:
The main goal of Activity 1 is to characterize the hydrogeologic properties of the Platteville Formation at a level of detail necessary for the development of the numerical model described in Activity 3. First, existing information on the hydrogeologic properties of the Platteville Formation from previous Environmental Trust Fund projects and other past investigations will be collected and synthesized. Additional field experiments will be conducted at a fractured Platteville site at the UMN campus. For fractured aquifers, recent scientific advances show that it is essential to measure hydrogeologic properties from discrete zones in wells rather than traditional whole-well measurements. Modular hydraulic packer-and-port systems (MHPS) will be utilized to obtain hydrogeologic data from discrete zones in wells using advanced sensors like fiber optics. The developer of the MHPS system (Prof. Warren Barrash) will support the field campaigns and the technology transfer. The site has ideal conditions for both teaching and research: groundwater at the site is contaminated with hydrocarbons, and multiple consulting reports with extensive hydrogeologic information are available, along with many monitoring wells. Fractured rock exposures are not only accessible at a nearby river bluff but also in an underground cavern where contaminated groundwater leaks through fractures in the ceiling.

Activity Milestones:

Description	Approximate Completion Date
Synthesize the existing fracture flow and transport properties of the Platteville formation	December 31, 2025
First field campaign to characterize fracture flow and transport properties of the Platteville formation	September 30, 2026
Second field campaign to further characterize fracture flow and transport properties of the Platteville formation	September 30, 2027
Develop a 3D hydrogeologic framework of the Platteville formation	October 31, 2027

Activity 2: Characterizing fracture flow and contaminant transport properties of the Prosser and Cummingsville Formations

Activity Budget: $220,454

Activity Description:
In SE Minnesota, nitrate contamination of karst aquifers is an urgent environmental issue. In 2023, EPA issued a letter urging Minnesota to develop a long-term solution to reduce nitrate concentrations in groundwater. The primary objective of Activity 2 is to characterize the hydrogeologic properties of the karstic Prosser and Cummingsville Formations, which will be used to develop the numerical model described in Activity 3. The Bear Spring area in Olmsted County will be used as a target field site. The Bear Spring area is located within the Zumbro River Watershed, where the Minnesota Geological Survey has completed subsurface geologic mapping that will serve as an important basis for model development. The site already has dye tracing information, and additional field dye tracing will be conducted to determine the flow connectivity between sinkholes and springs and to characterize the travel time distribution of contaminants. By completing this project, we will be able to better understand nitrate fate and transport in the karst aquifers of SE Minnesota. Field dye tracing campaigns will be conducted in collaboration with John Barry, a hydrogeologist at the Minnesota Department of Natural Resources, and the newly collected data will be added to the Minnesota Groundwater Tracing Database.

Activity Milestones:

Description	Approximate Completion Date
Synthesize the existing fracture flow and transport properties of the Prosser and Cummingsville formations	December 31, 2025
First field campaign to characterize flow and transport properties of the Prosser and Cummingsville formations	September 30, 2026
Second field campaign to further characterize flow and transport properties of the Prosser and Cummingsville	September 30, 2027
Develop a 3D hydrogeologic framework of the Prosser and Cummingsville formations	October 31, 2027

Activity 3: Develop a practical software for predicting contaminant transport in fractured aquifers and incorporate findings into college-level hydrogeology courses

Activity Budget: $195,570

Activity Description:

The hydrogeologic characterization from Activities 1 and 2 will be turned into three-dimensional (3D) numerical models that simulate groundwater flow and contaminant transport. The development of numerical models, which reflect the complexity of fractured rocks, will be guided by field data obtained from dye tracing and hydraulic testing. The next phase involves quantifying contaminant travel time distributions using the developed numerical models. Based on modeling results, user-friendly software capable of predicting contaminant travel time distributions will be developed. Using this software, users can input basic hydrogeologic information and obtain travel time distribution predictions, simplifying the complex process of modeling contaminant transport in fractured aquifers. The software will be made available to users via a publicly available data repository for UMN, and will be in a format that can be easily integrated into more traditional models currently used across the state. An additional step will be to integrate the outcomes of the project into UMN's hydrogeology courses and online tutorials. This curriculum is designed to equip future hydrogeologists with the knowledge and tools necessary for tackling the challenges of groundwater management and protection. A new generation of hydrogeologists will be trained as a result of this project.

Activity Milestones:

Description	Approximate Completion Date
Develop and validate 3D flow and transport numerical models at the two field sites	December 31, 2026
Simulate diverse fractured rock scenarios to quantify contaminant travel time distributions	June 30, 2027
Develop an user-friendly software program that predicts contaminant travel time distribution	December 31, 2027
Disseminate project outcomes and the software to state agencies, consulting companies, and other interested parties.	June 30, 2028
Develop teaching curriculum and incorporate into college-level hydrogeology courses	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Anthony Runkel	Minnesota Geological Survey	Dr. Runkel is Lead Geologist of the Minnesota Geological Survey and conducts research that targets geologic controls on groundwater flow. Dr. Runkel will support aquifer characterization and field hydraulic testing.	Yes
Chloé Fandel	Carleton College	Dr. Fandel is a karst hydrogeologist, and Fandel will support activities related to the modeling of a karst spring site in SE Minnesota.	Yes
Warren Barrash	Boise State University	Dr. Barrah will support field activities involving the modular hydraulic packer-and-port system.	Yes
John Barry	Department of Natural Resources	Mr. Barry will support activities related to field dye tracing in SE Minnesota.	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?

As a result of this project, practical software that predicts groundwater contaminant migration will be produced, and a particular focus of the PI will be to continue and expand collaborations with state agencies (MPCA, DNR, and MDH) so that the software can be implemented across the state. Examples of uses by state agencies and consultants include improvement in wellhead protection plans to protect public drinking water supplies and forecasting the transport of contaminants such as PFAS and nitrate to inform planning and mitigation efforts. Also, the topic is of great interest to federal agencies, which will be potential funding sources.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Managed Aquifer Recharge	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04t	$350,000
Mapping Aquifer Recharge Potential	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 04h	$391,000

Project Manager and Organization Qualifications

Project Manager Name: Peter Kang

Job Title: Associate Professor

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

Professor Kang is a hydrogeologist and computational geoscientist whose research focuses on the physics of groundwater flow and contaminant transport. Kang is an associate professor in the Department of Earth Sciences at the University of Minnesota-Twin Cities. Prior to joining UMN, Kang was a postdoctoral associate in the Earth Resources Laboratory (ERL) at MIT, received his Ph.D. in hydrology from MIT (2014), and obtained his BSc in Civil, Urban & Geosystem engineering at Seoul National University with summa cum laude (2008). During his postdoc period at MIT ERL, Kang developed a predictive model for fluid flow and tracer transport through fractured media and also collaborated with geophysicists to characterize fractured aquifers.

Kang has diverse and in-depth research experiences in groundwater-related topics, including subsurface contaminant transport, fractured aquifer characterization, and aquifer storage and recovery. In particular, Kang has been leading managed aquifer recharge projects to provide solutions for securing sustainable water resources. Kang and his research

group combine theoretical, numerical, and field methods to develop models that can predict groundwater flow and contaminant transport. Kang made several major contributions in that area, developing new models and novel field experiments both to advance physical understanding and to address important, real-world applications. His achievements in the field have been recognized by various internal and external awards, such as the NSF CAREER award and the McKnight Presidential Fellow Award from the University of Minnesota.

Kang is also passionate about teaching, mentoring, and raising public awareness about water-related issues. Kang teaches general hydrogeology, field hydrogeology, fluid earth dynamics, and computational methods in Earth Sciences. His contribution to teaching was recognized by George Taylor Career Development Award from the University of Minnesota.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
Saint Anthony Falls Laboratory (SAFL) at the University of Minnesota functions at the intersection of science and engineering to collaborate solutions to real-world fluid flow problems. SAFL serves as a resource for departments across the Twin Cities campus, the statewide University system, and the broader research community. Our connections and collaborations reach across the country and all over the world. We partner with local, state and federal agencies; private consulting firms; businesses of many kinds; technical associations; and other educational institutions to expand knowledge and solve problems. Research at SAFL is categorized into four primary categories: renewable energy; earth surface, water, and life; global environmental change; and biomedical and fluid mechanics.

Our mission is threefold:
1. To advance fundamental knowledge in engineering, environmental, geophysical, and biological fluid mechanics by conducting cross-cutting research that integrates disciplines in science and engineering;
2. To benefit society by implementing this knowledge to develop physics-based, affordable, and sustainable engineering solutions to major environmental, water, ecosystem, health, and energy-related problems; and
3. To disseminate new knowledge to UMN students, the engineering and scientific community, and the public by educational and outreach activities and partnerships with government and industry.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Peter Kang		PI and project manager; will be in charge of overall project management and tasks related to modeling and outreach.			37.1%	0.15		$26,673
Civil Service Employee (Jana Kramer)		Support field work related activites			33.5%	2.25		$100,848
Graduate Student (Benefits include 25.1% health + tuition)		Aquifer characterization and numerical modeling of a karst spring site in SE MN.			55%	1.5		$164,664
Tony Runkel		Support aquifer characterization and hydraulic testing.			33.5%	0.15		$29,164
SAFL engineer		Support field instrumentation			33.5%	0.06		$71,614
Graduate Student		Numerical modeling of the Platteville formation and software development			20%	2		$78,037
							Sub Total	**$471,000**
Contracts and Services								
Carleton College	Sub award	Dr. Chloé Fandel has strong expertise in karst hydrogeology. Dr. Fandel will support activities related to the modeling of a karst spring site in SE Minnesota. Her budget includes out of state travel				0.99		$30,000
Boise State University	Professional or Technical Service Contract	Dr. Warren Barrah will support activities related to field activities involving the modular hydraulic packer-and-port system.				0		$50,000
Research Analytical Laboratory at UMN	Internal services or fees (uncommon)	Water chemistry analysis for quantification of cation and anion concentrations				-		$6,500

							Sub Total	**$86,500**
Equipment, Tools, and Supplies								
	Tools and Supplies	Tools and supplies for field experiments and lab analysis	To purchase tools and supplies necessary for conducting field tests and lab analysis					$14,500
	Equipment	Field equipment for planned field experiments (fiber optics, packers, pumps, flowmeter, pressure transducers, autosamplers, data loggers, multiparameter sonde)	To conduct hydraulic testing and dye tracing with accurate measurement					$67,000
							Sub Total	**$81,500**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Other	Travel costs to visit field sites. Four field trips per year per site are planned to conduct field experiments.	To visit field sites for sensor deployment, data collection, and site characterization.					$6,000
							Sub Total	**$6,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Domestic conference trip for 2 people	Conference travel for disseminating project outcomes, networking, and collecting project related information	X				$5,000
							Sub Total	**$5,000**
Printing and Publication								

							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$650,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Domestic conference trip for 2 people	This travel is to participate in a formal presentation of project findings at the American Geophysical Union (AGU) conference. AGU is a major conference for MAR-related topics. Important information can be acquired, and project outcomes can be disseminated by attending and presenting at the conference.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $650,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 6dca2657-647.pdf

Alternate Text for Visual Component

Minnesota urgently needs a practical tool that can predict the movements of contaminants in aquifers. Through this project, we develop and demonstrate an easy-to-use software program that predicts the fate and movement of contaminants such as PFAS, chloride, nitrate, and pathogens in Minnesota's fractured aquifers....

Supplemental Attachments

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

Title	File
Support letter from Barr	ad18cfd3-6f3.pdf
Support letter from Geosyntec	ce671a09-4ea.pdf
Support letter from Bay West	8860f00d-92c.pdf
Support letter from Freshwater	a15c7b9c-ae3.pdf
Support letter from Minnesota Department of Health	e88d8f39-1d7.pdf
Support letter from Metropolitan Council	b221e3a0-790.pdf
SPA letter UMN	b3b9c24b-24b.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

Yes, Sponsored Projects Administration

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:

Jon Jee, University of Minnesota, jonjee@umn.edu; Victoria Troxler, University of Minnesota, vtroxler@umn.edu