Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 111-B**

Predicting Contaminant Transport in Fractured Aquifers

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 350,664

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

We will develop a practical tool for accurately quantifying and predicting contaminant transport in fractured aquifers. The tool will help more efficiently and economically manage many active groundwater contamination sites.

Name: Peter Kang

Sponsoring Organization: U of MN

Job Title: Assistant Professor

Department: Department of Earth Sciences

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Minneapolis MN 55455

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Web Address: pkkang.com

Location:

Region: Metro, Northeast, Southeast

County Name: Anoka, Blue Earth, Carlton, Chisago, Cook, Dakota, Fillmore, Goodhue, Hennepin, Houston, Isanti, Lake, Le Sueur, Mower, Olmsted, Pine, Ramsey, Rice, Scott, St. Louis, Wabasha, Washington, Winona

City / Township: Minneapolis

Alternate Text for Visual:

Fractures control groundwater flow in most of the Twin Cities area and Greater Minnesota. Groundwater contaminant transport will be predicted and visualized to aid sustainable water resources management.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Predicting Contaminant Transport in Fractured Aquifers

I. PROJECT STATEMENT

We will develop a powerful tool that can predict contaminant transport in fractured aquifers. The developed tool will greatly aid to more economically and efficiently remediate contaminated groundwater sites in Minnesota. Groundwater contamination of fractured aquifers is an urgent problem as exemplified by the recent settlement of $850 million between the state of Minnesota and the 3M Company and the construction of a new $4.5 million groundwater treatment plant in Edina-St. Louis Park. Although contaminated fractured aquifers are widespread in Minnesota, no practical tools for predicting contaminant transport in fractured aquifers are currently available. The principal investigator of this project has developed a predictive tool for subsurface contaminant transport over the past 10 years, and the co-investigator of this project has extensive experience in Minnesotan fractured aquifers. This state-of-the-art tool has been documented in multiple journal publications and has shown great promise by predicting tracer tests at a fractured bed rock site in France.

The tool will be first applied and validated at the Platteville Formation, from which a previously funded Environmental Trust Fund project has accumulated a large amount of data on fractured rock properties and flow (Runkel, 2016-2019). To successfully implement the tool, we need a good understanding of fracture flow properties and field tracer experiment results. Fracture flow properties accumulated from the previous Environmental Trust Fund project and past investigations provide the basis for an accurate model of how groundwater flows through the fractured Platteville Formation. A contaminant transport tool will be constructed using this flow model and field tracer experiments that will be conducted at several monitoring wells on the University of Minnesota campus.

Once validated, the tool will be extended to predict contaminant transport at a contaminated fractured bedrock site where supporting field data exist. Potential sites include Superfund sites in southeastern and northeastern Minnesota, where contaminant flow in fractured bedrock has proved to be particularly difficult to predict. The validated tool will be packaged into a simple software that can be freely downloaded and run on a personal computer. The tool and supporting documentation will be freely available to interested users. Time-lapse images of contaminant plume migration will help land and water resource managers both understand and communicate results of their remediation work. Prospective users of the tool include both local and state water resource managers, including the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH) and the Department of Natural Resources (DNR). We have discussed this proposal with the state agencies.

This project includes several activities:

- Synthesize fracture flow properties and construct a flow model
- Conduct field tracer experiments and construct a tool for contaminant transport prediction in the Platteville formation.
- Apply and validate the tool at a contaminated fractured aquifer site where supporting field data exist.
- Publish a user-friendly tool for contaminant transport prediction.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Synthesizing fracture flow properties and constructing a flow model of the Platteville formation

A flow model of the Platteville formation will be generated by synthesizing fracture flow properties and the results from the prior Environmental Trust Fund Platteville Project.

ENRTF BUDGET: $ 80,409

Outcome	Completion Date
1. Synthesize fracture flow properties of the Platteville formation	March 2021

2. Develop a flow model for the Platteville Formation	August 2021

Activity 2: Validate the flow model and contaminant transport prediction tool by conducting tracer tests on the University of Minnesota campus.

Single well injection-extraction tracer experiments and cross borehole tracer experiments will be conducted at multiple depths to validate the Platteville Formation flow and transport model. The validated model will then be converted into a user-friendly tool capable of predicting contaminant transport in similar geologic settings.

ENRTF BUDGET: $ 136,934

Outcome	Completion Date
1. Conduct tracer transport experiments at multiple boreholes at multiple depths	November 2021
2. Construct a contaminant transport tool based on the numeric flow model	June 2022

Activity 3: Applying the tool at a contaminated fractured aquifer site

A potential site for the tool application is currently under discussion with the state agencies. The tool will be applied at the selected contaminated field site.

ENRTF BUDGET: $ 92,565

Outcome	Completion Date
1. Perform site characterization to obtain flow and transport properties	December 2022
2. Apply the tool at a contaminated field site	March 2023

Activity 4: Publishing a user-friendly tool

The established tool will be released as an open-source software that can be easily downloaded and executed in personal computers. Training sessions will be given at State agencies such as MPCA, DNR and MDH to help interested parties or individuals to utilize the tool.

ENRTF BUDGET: $ 40,756

Outcome	Completion Date
1. Publish a user-friendly tool that can be easily downloaded and executed	June 2023
2. Give tutorial presentations to interested parties	June 2023

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Anthony Runkel	Chief Geologist	Minnesota Geological Survey	Co-Investigator and responsible for field site identification and hydrogeological assessments.
Jessica Meyer	Assistant Professor	University of Iowa	Technical suport for tracer and aquifer testings. Prof. Meyer's unique expertise in borehole logging and tracer tests will be critical to this project.

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

The proposed tool will assist current practices of groundwater contamination management. The tool can be extended to different sites. We will seek collaborations with agencies such as MPCA and MDH and actively apply for further research grants (federal, state and industry) to continue extending our predictive tool across the Minnesota. If this proposal gets funded, PI Kang will commit $30K of his research startup funds.

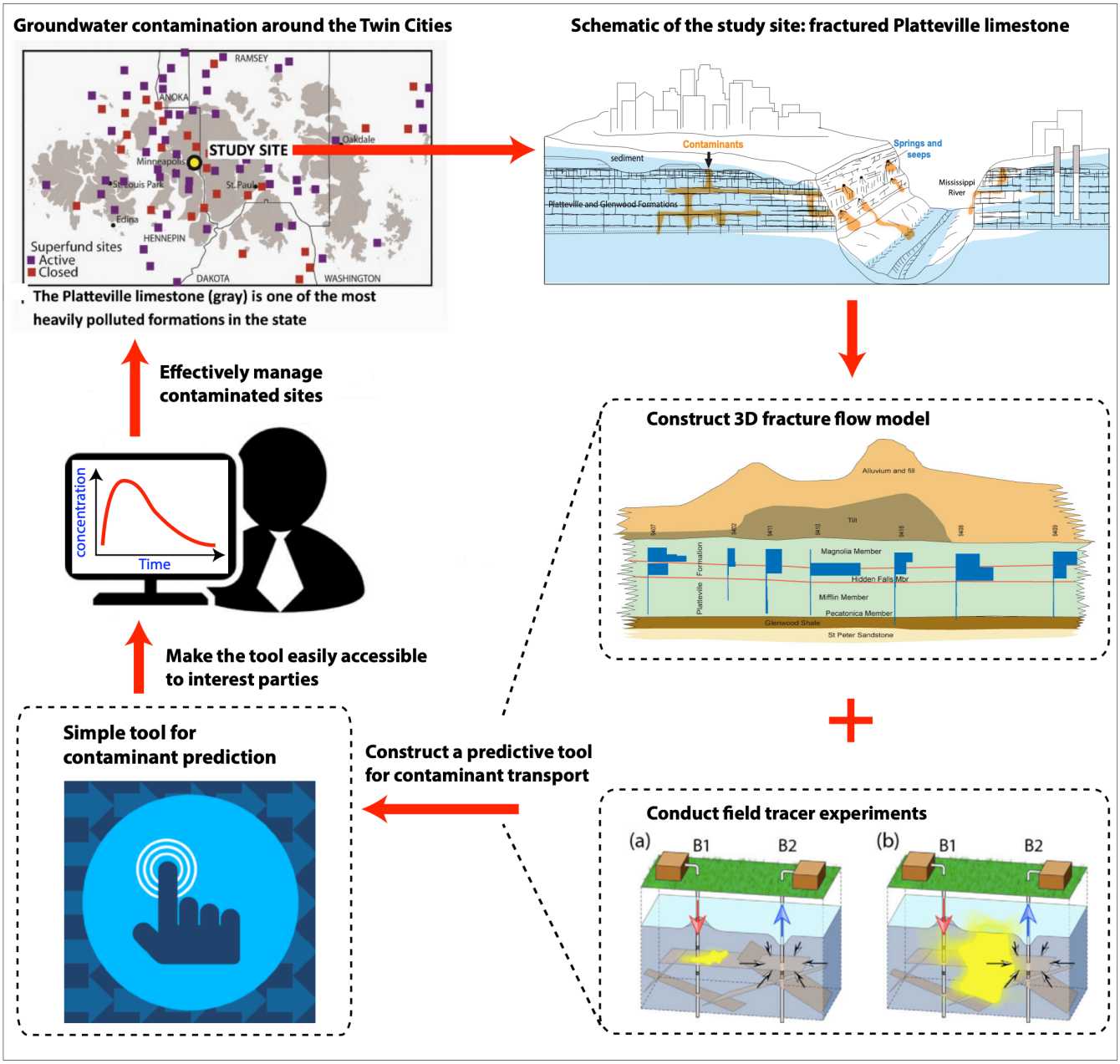
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Peter Kang
Project Title: Predicting Contaminant Transport in Fractured Aquifers
Organization: University of Minnesota
Project Budget: $350,664
Project Length and Completion Date: 36 months, June 30, 2023
Today's Date: 4/8/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET		Budget	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)		$ 295,795		$ 295,795
Dr. Peter K. Kang, PI (75% salary, 25% benefits), 4% FTE	$19,201			
Dr. Anthony Runkel (78% salary, 22% benefits), 12% FTE, Co-Investigator	$43,475			
Scott Alexander, (78% salary, 22% benefits), 15% FTE	$36,312			
Dr. Seonkyoo Yoon, postdoctoral associate (81% salary, 19% benefits), 25% FTE	$52,984			
1 Graduate Students (57% salary, 43% benefits), 50% FTE	$143,823			
Professional/Technical/Service Contracts				
Technical support from Dr. Jessica Meyer at the University of Iowa. Dr. Meyer is a leading expert in fractured aquifer characterization and tracer tests. Dr. Meyer will help conducting and interpreting		$ 19,869		$ 19,869
Equipment/Tools/Supplies		$ 32,000		$ 32,000
Flexible borehole liners and related equipment* (for tracer experiments)	$22,000			
*(3 blank liners $6000; 1 MLS liner $10,000; 3 well caps $1500; extraction equip $4500)				
Cost for a double packer and sensors	$6,000			
Cost for additional monitoring points	$4,000			
Capital Expenditures Over $5,000				
Fee Title Acquisition				
Easement Acquisition				
Professional Services for Acquisition				
Printing				
Travel expenses in Minnesota				
in-state (multiple field trips to visit contaminated field sites), per UMN policy		$ 3,000		$ 3,000
Other				
COLUMN TOTAL		$ 350,664		$ 350,664

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered F&A calculated at 54%		$ 163,454	$ -	$ 163,454
PI Kang will invest his research start up fund to this project		$ 30,000		$ 30,000
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
Understanding Bedrock Fracture Flow to Improve Groundwater Quality (PI: A. Runkel): M.L. 2016, Subd. 04g (complete June 2019)		$ 183,000	$ 183,000	$ -

Predicting Contaminant Transport in Fractured Aquifers

Peter K. Kang, University of Minnesota



- Fractures control groundwater flow in most of the Twin Cities area and Greater Minnesota. Groundwater contaminant transport will be predicted and visualized to aid sustainable water resources management.

Peter K. Kang
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Professor Kang is a hydrogeologist and computational geoscientist whose research focuses on groundwater flow and subsurface contaminant transport. Kang joined the Department of Earth Sciences at the University of Minnesota-Twin Cities in August 2018, following a research scientist position at Korea Institute of Science & Technology (KIST) in South Korea. Prior to his research scientist position, 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).

Kang has diverse and in-depth research experiences in groundwater related topics including subsurface contaminant transport, subsurface characterization, and aquifer storage and recovery. Kang and his research group combines theoretical, numerical and field methods to develop models that can predict flow and contaminant transport in subsurface. Kang made several major contributions in that area, developing new models and novel field experiments for subsurface contaminant characterization.

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 reservoirs. As a research scientist at KIST, Kang led a large-scale managed aquifer recharge project in a confined aquifer to secure sustainable water resources for a metropolitan city.

Kang is also passionate about teaching, mentoring and increasing public awareness in water resources related issues. Kang teaches general hydrogeology, field hydrogeology, fluid earth dynamics, and computational methods in Earth Science.

Department of Earth Sciences, University of Minnesota - Twin Cities

The University of Minnesota is a highly ranked public research university offering a wide range of undergraduate and graduate programs. Dr. Kang belongs to the Department of Earth Sciences in the College of Science and Engineering. The department includes about 25 full faculty members and it awards bachelors, masters, and doctorate level degrees in Earth Sciences and various sub-disciplines, including hydrogeology. A number of on-going research projects in the department focus on water resources issues in Minnesota.