Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 077-B**

Setting Realistic Nitrate BMP Goals in Southeast Minnesota

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 444,000

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

Advanced tools are needed which provide critical timelag and feedback information for making environmental policy decisions, as Minnesota prepares to launch the Groundwater Protection Rule and nutrient reduction strategies.

Name: John Nieber

Sponsoring Organization: U of MN

Title: Professor

Department: CFANS/Bioproducts and Biosystems Engineering

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Web Address

Location

Region: Southeast

County Name: Dakota, Dodge, Fillmore, Goodhue, Houston, Mower, Wabasha, Winona

City / Township:

Alternate Text for Visual:

Distribution of nitrate contamination in groundwater in southeastern Minnesota, and illustration of the general distribution and movement of nitrate within the four major aquifers of the region.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Setting realistic nitrate BMP goals in southeast Minnesota

I. PROJECT STATEMENT

This project will provide tools for improving the ability of state agencies to assess how well nitrate reduction BMPs are working in southeastern Minnesota. Nitrate contamination of groundwater is a serious concern because of the direct impact on drinking water safety and resulting nitrate concentrations in the streams into which groundwater discharges. The karst region of southeastern Minnesota, and the sandplain region of central Minnesota are both areas where the impact is most severe due to the close connection between surface conditions and aquifers in those regions. Reducing nitrate contamination of groundwater aquifers has becoming a priority in the state because of the need to protect drinking water quality (MDA Draft Groundwater Protections Rule), and also to meet the nutrient reduction goals set by the MPCA for 2025 (25% nitrate reduction) and 2050 (45% nitrate reduction).

Various degrees of nitrate contamination are present in the four major aquifers in southeastern Minnesota (Galena, Prairie du Chien, Jordan, and Ironton-Galesville aquifers), with the shallowest, the Galena and Prairie du Chien having the highest contamination. With time nitrate is moving into the deeper aquifers (Jordan, and Ironton-Galesville aquifers). The deeper aquifers are important sources of drinking water in the region, while all four aquifers discharge to surface streams at various locations within the region.

Efforts are underway in the region to reduce nitrate leaching to groundwater through the use of improved nitrogen best management practices, but assessments as to whether those practices are being effective within the region is not clear because of the difficulty to interpret collected monitoring data. Some data shows increasing trends for nitrate concentrations, while other data shows decreasing trends. A main part of the problem with water-quality interpretation has to do with the time required for water containing nitrate to travel through the groundwater system before discharging to streams. More detailed information about the age of water in these aquifers and the time of travel of water within the aquifers is needed to be able to provide improved assessments of trends in nitrate concentrations throughout the region.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Develop decadal resolution age-dating of water in the four major aquifers in southeast Minnesota **Budget: $190,000**

Water samples will be collected mostly from wells and a few selected springs within the area represented by the inset map on the illustration. Water samples will be analyzed for determining sulfur-hexafluoride, chlorofluorocarbons, tritium and helium-3 concentrations. The sampling and analyses need to be done with extreme expert care due to the low concentrations of these elements and the need to avoid sample contamination. These data will be used to quantify the age of the aquifer water with an accuracy of $\pm$10 years, a much higher resolution than currently available. Additional sampling of streamflows, aquifers and springs will be conducted to measure chloride, nitrate, and the stable isotopes of oxygen and hydrogen. These data will be used to quantify the source of water (which aquifer the flows originate from) in the streamflows, and to help quantify travel time of water in the aquifers.

Outcome	Completion Date
1. Quantified age of groundwater in the major aquifers in southeastern Minnesota. The time resolution will be $\pm$10 years.	10/31/2020
2. Estimates of the travel time distributions of water in the major aquifers based on the chemical analyses.	03/31/2021

Activity 2: Determine travel times for flows within the major aquifers to streams based on hydraulic analyses. **Budget: $170,000**

Springshed boundaries of the four major aquifers will be delineated using geological information derived from the County Geologic Atlases available for the region. A groundwater flow model will be constructed using the detailed geological information and applied to calculation of travel time within the individual aquifers. The model will be formulated to be able to include the complex fracture flow and dissolution-channel flow

characteristic of groundwater flow in the karst region of the southeast. The model will be calibrated to match recorded flows and nitrate concentrations emerging from sampled springs. The calibrated model will then be able to be used with monitoring data to assess the impact of existing BMPs on water quality.

Outcome	Completion Date
1. Maps illustrating calculated travel time distributions of water within the four studied aquifers.	06/30/2021
2. Interpretation of the aquifer sources of water in streamflows and an assessment of the current trends in nitrate concentrations from each source.	10/31/2021

Activity 3: Develop a simple tool for estimating lag-time for nitrate transport through major aquifers. **Budget: $84,000**

A mathematical modeling tool will be developed for use in applying travel time distributions for groundwater for the determination of the lag-time required for nitrate to travel from the land surface to the aquifer discharge point.

Outcome	Completion Date
1. Report outlining the features of the modeling tool and results of testing the model for the major aquifers in southeastern Minnesota. This model will be provided to state agencies and available on-line for use by consultants and educators.	03/31/2022

III. PROJECT STRATEGY

A. Project Team/Partners

No ENRTF funding required:

Dr. John L. Nieber, Professor, Dept. of Bioprod. and Biosyst Eng. (**BBE**). Serve as project principal investigator. **Dr. David Mulla,** Professor, Dept. of Soil, Water and Climate. Assist with assessments of chemical leaching to groundwater within the region of study. **Dr. Bruce Wilson,** Professor, BBE. Assist with the probabilistic, statistical and time series analyses of flow and chemical data. **Mr. Kevin Keuhner**, Minn. Dept. of Agr. Assist with data acquisition from field sites, and work with landowners associated with BMPs.

ENRTF funding required:

Dr. Robert Tipping, Minn. Geol. Survey (**MGS**). Lead effort on water chemical sampling, and historical chemical data compilation and analysis. **Dr. Anthony Runkel**, MGS. Lead the effort on aquifer identification, characterization, and hydrogeological assessments. **Dr. Joseph Magner**, BBE. Assist with interpretation of chemical tracer data. **Assistant Research Scientist**, BBE. Manage field sampling and chemical analysis of samples. **Graduate Research Assistant**, Univ. of Minn. Assist with all aspects of the project including field sampling, data analysis, and modeling. **Undergraduate Research Assistants**, Univ. of Minn. Assist with all aspects of the project including field sampling and modeling.

B. Project Impact and Long-Term Strategy

Setting realistic planning horizons for the time required to meet water-quality standards in aquifers and streams should account for the lag time that occurs between landuse improvement and water-quality response. This project will provide a framework for interpreting water-quality monitoring data (well data and stream data) to assess the effectiveness of established BMPs. The framework will be applicable to other contaminants such as pesticides. The results of the project will provide detailed groundwater flow information also useful to other environmental management activities such as well-head protection mapping. This project should be viewed as being a piece of a larger effort that should be initiated to map the lag-time for aquifers around the entire state of Minnesota. The project will also provide support for the training of one Ph.D. graduate student and several undergraduate students.

C. Timeline Requirements

The proposed project duration will be 3.0 years.

2019 Detailed Project Budget

Project Title: Setting realistic nitrate BMP goals in southeast Minnesota

IV. TOTAL ENRTF REQUEST BUDGET 3 years

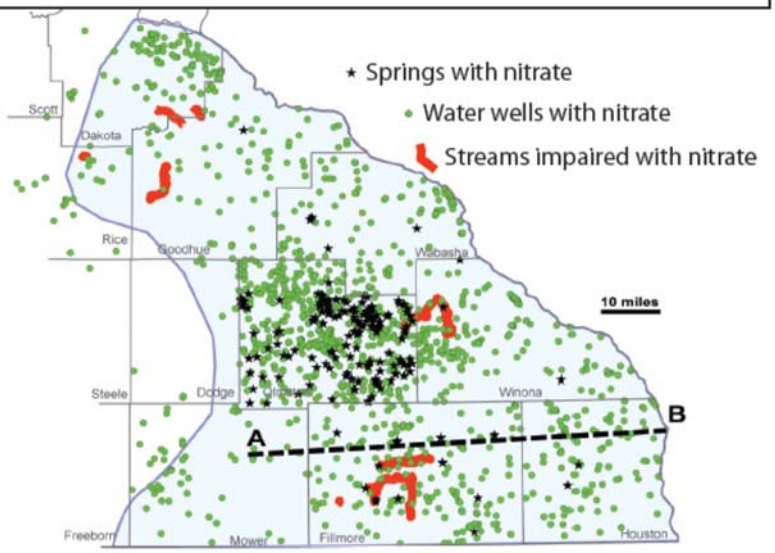
BUDGET ITEM	AMOUNT
Personnel:	
Robert Tipping; Hydrogeologist/hydrogeochemist, Minnesota Geological Survey. Lead effort on water chemical sampling, and historical chemical data compilation and analysis. 72.6% salary, 27.4% fringe. 13% of full time, soft money, 7/1/19-6/30/22.	$ 39,000
Anthony Runkel; Hydrogeologist, Minnesota Geological Survey. Lead the effort on aquifer identification, characterization, and hydrogeological assessments. 72.6% salary, 27.4% fringe. 13% of full time, soft money,7/1/19-6/30/22.	$ 41,000
Joseph Magner; Hydrogeologist, University of Minnesota, Department of Bioproducts and Biosystems Engineering. Assist with effort on travel time estimation and evaluation of geochemical analysis results. 66.5% salary, 33.5% fringe. 8% of full time, soft money,	$ 20,000
Senior Scientist, University of Minnesota, Department of Bioproducts and Biosystems Engineering. Manage field sampling activitiesdel. 72.6% salary, 27.4% fringe. 8% of full time, soft money, 7/1/19-6/30/22.	$ 40,000
Graduate Research Assistants; One Ph.D. Assist with all aspects of the project. 61% salary, 39% fringe. 50% of full time, 7/1/19-6/30/22.	$ 149,000
Undergraduate Research Assistants; Number to be determined. Assist with all aspects of the project. 100% salary, 0% fringe. 100% of full time in summer, 25% full time in school year, 7/1/19-6/30/22.	$ 18,000
Professional/Technical/Service Contracts: Age-dating of water samples. Subcontract with the USGS, Minnesota Water Science Center Office. The water samples will be tested for elements that are extremely difficult to analyze, and the sampling itself requires a very specific skill possessed by a very limited group of scientists. Water sample analysis cost, for 10 samples and 1 replicate, four chemical constituents (sulfur-hexafloride, chloroflorocarbon, tritrium and helium-3) analyzed for each sample, is $21,890 ($1,990 per sample). Cost for sample collection and analysis of sample analytical results for age-dating of water, $89,709; this includes travel costs, salary for USGS researchers, and equipments	$ 112,000
Equipment/Tools/Supplies: Miscellaneous lab supplies need for bottles for collecting samples, batteries on equipment, other misc supplies, repairs and calibration of equipment, etc.	$ 2,000
Travel: Travel will be limited to visiting field sites to collect water samples and monitor streamflows, and to participate in meetings with agency staff and stakeholders to present results of the project activities.	$ 5,000
Other: Chemical analysis of water samples; includes nitrates, specific conductivity, chloride, oxygen-18 and deuterium; $18,000.	$ 18,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 444,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period	N/A	
Other State $ To Be Applied To Project During Project Period	N/A	
In-kind Services To Be Applied To Project During Project Period	N/A	
Indirect costs/facilities administration (54%)	$168,153	*secured*
Match, USGS, Water Science Center, Mounds View, Minnesota.	$37,043	*to be secured*
Funding History: Proposed project builds on County Atlas mapping in southeastern Minnesota, funded through ENRTF going back to the early 1980's, with additional funding coming from Clean Water Fund for Winona and Houston County mapping. The project also builds on a recently completed investigation of bedrock controls on nitrate distribution in southeastern Minnesota streams, paid for by the Minnesota Pollution Control Agency through funds acquired from The Minnesota Clean Water Fund.		completed
Remaining $ From Current ENRTF Appropriation	N/A	

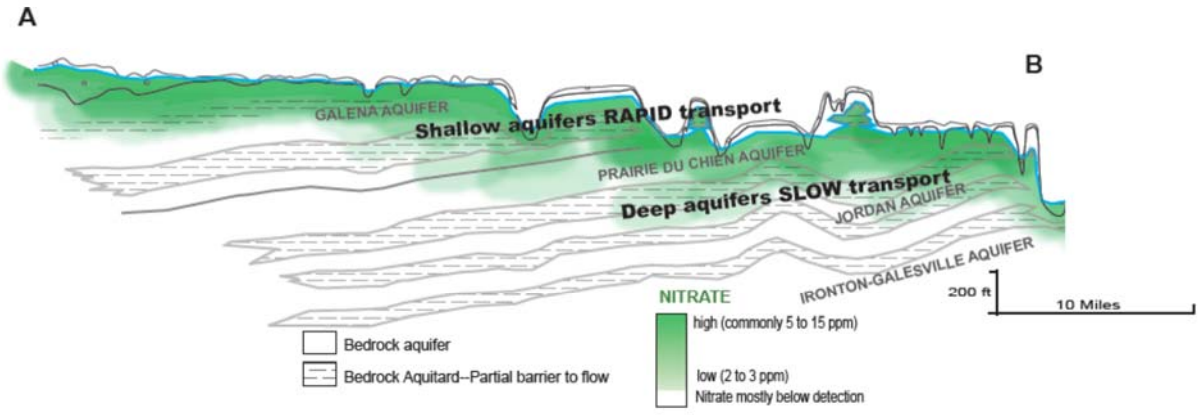
SETTING REALISTIC NITRATE BMP GOALS IN SOUTHEAST MINNESOTA

NITRATE AND OTHER CONTAMINANTS ARE COMMMON IN GROUNDWATER OF SOUTHEASTERN MINNESOTA



KNOWING THE RATE OF NITRATE MOVEMENT IS CRUCIAL FOR MEASURING THE EFFECTIVENESS OF BEST MANAGEMENT PRACTICES

NITRATE TRAVELS AT VERY DIFFERENT RATES THROUGH THE VARIOUS AQUIFERS



OUR PROJECT WILL CALCULATE THE TRAVEL TIMES FOR NITRATE THROUGH SE MINNESOTA AQUIFERS

PROJECT RESULTS WILL PROVIDE A TOOL FOR WATER MANAGERS TO SET REALISTIC BEST MANAGEMENT PRACTICE GOALS

Project Manager Qualifications & Organization Description

PI:

Name: John L. Nieber
Title: Professor
Degrees: 1972, B.S., Forest Engineering, Syracuse University
1974, M.S., Civil and Environmental Engineering, Cornell University
1979, Ph.D., Agricultural Engineering, Cornell University
Licensed Professional Engineer: Minnesota
Certified Professional Hydrologist: American Institute of Hydrology
Affiliation: Department of Bioproducts and Biosystems Engineering, University of Minnesota
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John Nieber has over 35 years of experience working as a professional hydrologist in conducting teaching and research activities related to hydrology and water quality. In the 1980's he collaborated on research involving remote sensing of soil moisture and is currently advising a graduate student on a self-funded project using GRACE satellite data, and meteorological and hydrologic data to characterize changes in water storage within the Minnesota River Basin. He managed a LCCMR project on freshwater sustainability from 2007-2009, from which maps of groundwater recharge were derived. The work resulting in three publications in the scientific literature and has influenced freshwater sustainability planning activities within Minnesota. One student, Dr. Heidi Peterson received her Ph.D. degree as a result of support from this project. In 2014 Dr. Nieber took a 5-month sabbatical leave to the University of Padova in Italy to study the topic of travel time distributions for water in watersheds. The purpose was to learn techniques that could be used to estimate the lag time required for contaminants to be flushed out of watershed surface waters, soils and groundwater. John Nieber has managed numerous other projects as well, including being the manager of a five-year contract with the MPCA for the Impaired Waters Program. He is the author of over 70 refereed articles in the scientific literature.

Organization:

The University of Minnesota Twin Cities campus is one of the Big Ten universities. It ranks very highly in many of its programs including its College of Food, Agriculture and Natural Sciences, and it College of Sciences and Engineering. It has excellent library resources and its resources for supercomputing are exceptional. In addition to all of the high quality features at the University of Minnesota, faculty at the University of Minnesota have developed excellent working collaborative relationships with scientists and engineers at the state and federal agencies within Minnesota.