



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-571

Proposal Title: Linking Land Use, BMPs, and Groundwater Nitrate Levels

Project Manager Information

Name: Susan Colvin

Organization: Minnesota State Colleges and Universities - Minnesota State University Mankato

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Project Basic Information

Project Summary: This project will improve our understanding of how best management practices (BMPs), land use, and precipitation impact nitrate concentrations in a shallow aquifer with rapid response times in Southeastern Minnesota.

ENRTF Funds Requested: \$150,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Small Projects (G)

Secondary Category: Water (B)

Project Location

What is the best scale for describing where your work will take place?

Region(s): SE

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 is essential for providing baseflow for perennial streams and rivers and a critical source of agricultural and drinking water supply, providing over 75 per cent of the potable supply in some regions (Lerner and Harris 2009). Groundwater is reliant upon precipitation and surface water for recharge. It is intricately connected to the landscape above it and highly influenced by land use. However, the relationship between land use and contaminants in groundwater can be difficult to assess due to varying rates of turnover in groundwater layers of various depths and the strong influence of patterns in precipitation (Kuehner et al. 2025; Zheng et al. 2020). Recent work in southeastern Minnesota has made a correlation between land use and BMPs with groundwater nitrate levels possible by identifying residence time in the aquifers of this region (Kuehner et al. 2025). We will examine these relationships in the shallower, younger Galena Group, which is predicted to have a relatively swifter response time to nitrate contamination. Understanding these relationships in the context of heavier precipitation, predicted to increase for Minnesota, is also critical. These findings can be used to better understand BMP effectiveness and support statewide policy development for southeastern Minnesota's highly vulnerable groundwater.

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.

Formerly, the lack of information on groundwater residence time and the difficulty of linking land use to contamination levels has limited the ability to detect nitrate level response from the implementation of BMPs or change in land use. Kuehner et al. (2025) identified shallow aquifers in the Galena Group (layers of limestone underlain by shale, in southern Minnesota) as highly responsive to nitrate contamination with land use change. In this study we hope to use high resolution land use and land cover techniques (Vallet et al. 2024; Banerjee et al. 2025) in concert with precipitation data, and spring, stream, and well water quality data to more effectively understand the interconnection between the effectiveness of best management practices (BMPs) such as buffers and strip till, and land use cover such as wetlands and forest with precipitation and nitrate levels. Land use linear regression models have been used to predict nitrate concentrations in groundwater across a region, with a high level of accuracy (Banerjee et al. 2025). Accurate predictions of nitrate concentrations in groundwater will serve public health needs and provide greater assurance for the effectiveness of utilizing BMPs and land use practices to decrease nitrate levels.

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?

This project will provide greater assurance regarding the relative effectiveness of land use practices and BMPs. Research findings will help to inform relevant rulemaking, such as the Groundwater Protection Rule, as well as provide a baseline for future BMP effectiveness monitoring. More broadly, this study will support improved long-term prediction of nitrate levels in deeper aquifers and other regions of the state after gaining a more accurate assessment of the impact of BMP's and land use on nitrate levels.

Activities and Milestones

Activity 1: Land use and BMPs GIS analysis

Activity Budget: \$52,198

Activity Description:

To generate high spatial-resolution land cover maps, multi-year NAIP airborne imagery with 0.6m or 1m resolution will be used. In addition, freely accessible Sentinel-2 satellite images with 10m resolution (which can be pan-sharpened to 2.5m) will also be used to monitor seasonal land cover change and vegetation growth. Object-based image analysis, machine learning, and deep learning methods will be evaluated and compared. The most accurate method will be adopted to classify the NAIP and Sentinel-2 images into various land use and land cover classes, including cultivated cropland, fallow field/ bare soil, forest, grassland, wetland, urban impervious surfaces, and water. The classification will be iteratively refined and validated using in-situ field land cover data. Accuracies of the land use and land cover classification maps will be assessed. Moreover, we will integrate LiDAR-based digital elevation model (DEM) and soil data with the NAIP and Sentinel-2 imagery to identify and extract key structural BMPs, such as contour farming, grassed waterways, and riparian buffers, along with CRP land in the study area.

Activity Milestones:

Description	Approximate Completion Date
Preliminary products of multitemporal high-resolution land cover maps	October 31, 2027
Preliminary products of structural BMPs and CRP maps	February 28, 2028
Accuracy assessment and products refinement	June 30, 2028

Activity 2: Activity 2: Water quality monitoring

Activity Budget: \$56,674

Activity Description:

Water quality monitoring summary – Water will be monitored for water quality (springs, wells, and streams) with in situ measures taken with a Yellow Springs Instruments (YSI) EXO 2 sonde to measure dissolved oxygen percentage (DO%), total suspended solids (TSS), pH, temperature in degrees Celsius, and chlorophyll $\mu\text{g/L}$. Physical water quality samples will be taken at each site and brought back the lab for further analysis of total nitrate, total phosphate, and orthophosphate through EPA methods. Ideally, analysis will take place at MNSU campus after 10% of samples are analyzed at MVTL, New Ulm for Quality Assurance. Lab analysis at MNSU provides additional learning opportunities for the graduate student and intern. Sites will be selected after consultation and in conjunction with Fillmore SWCD who have recently completed new BMP projects.

Activity Milestones:

Description	Approximate Completion Date
Aggregate data for existing sites and identify additional sites to target specific BMPs.	October 31, 2027
Year 1 Water Quality	October 31, 2028
Data analysis and summary report	June 30, 2030

Activity 3: Development of Land Use, Precipitation, and Water Quality Model

Activity Budget: \$18,000

Activity Description:

Using the high-resolution land use and land cover maps, we will use a step-wise linear regression method to develop a catchment-scale model for mapping and predicting nitrate concentrations in groundwater across the study area. To account for environmental and management influences, predictor variables will include: land use/land cover, bedrock, soils, BMPs, precipitation, slope, and other factors such as presence or distance to manure and septic. Model performance will be evaluated using a combination of k-fold cross-validation and predictive error metrics. Additionally, because heavy storms can trigger sudden spikes in pollutants unrelated to BMP performance, dummy variables will be created for extreme weather events to isolate the impact of sudden spikes. Further, to address local variations and assess the impact of BMPs within different geological and topographical settings, geographically weighted regression (GWR) analysis will also be used. The local coefficient surfaces and R-square maps will allow policymakers to visualize where nitrate distribution and sensitivity are highest and to determine which townships require the most intensive BMP implementation.

Activity Milestones:

Description	Approximate Completion Date
Model performance will be evaluated using a combination of k-fold cross-validation and predictive error metrics.	October 31, 2028
Additionally, because heavy storms can trigger sudden spikes in pollutants unrelated to BMP performance, dummy variables	October 31, 2028
Build the global step-wise linear regression model	February 28, 2029
Build the local geographically weighted regression (GWR) model	June 30, 2029
We will use geographically weighted regression analysis to assess impact of BMPs	October 31, 2029
Use local coefficient surfaces and R-square maps to allow visualization of nitrate distribution	April 30, 2030

Activity 4: Educational Outreach designed for different user groups: local and regional partners and area youth.

Activity Budget: \$23,128

Activity Description:

We will work with local conservation partners, state researchers and other experts to synthesize findings for the general public to help citizens understand the connection between land use, best management practices and groundwater nitrate levels. This step is critical to help citizens understand the connections between land management and groundwater contamination. The team will create summary materials (e.g. a pamphlet) and present findings at local meetings. We will also design and provide experiential learning activities for K-12 students.

Activity Milestones:

Description	Approximate Completion Date
Design, write, illustrate, and produce a citizen-friendly pamphlet and additional materials that summarize findings.	May 31, 2030
Present findings at five (5) meetings including public-facing meetings (e.g. SWCD and county).	June 30, 2030
Design experiential activities to educate local youth (I.e.g. ISD 77 students, YMCA)	June 30, 2030
Publish Findings in Peer-Reviewed Journal	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Fei Yuan	Minnesota State University Mankato, Department Chair for Department of Geography	Dr. Fei will be the lead for high-resolution land use analyses and land use regressions. She has multiple published papers on assessing nitrogen with remote sensing and GIS techniques. She also has experience in impervious surface mapping, precision agriculture applications, and the study of environmental impacts associated with urbanization.	Yes
Dr. Don Friend	Minnesota State University - Mankato, Department of Geography	Project Advisor on geography with a specialty in groundwater. Dr. Friend has studied a variety of systems, including grasslands, mountain slopes, and glaciers at a global scale. He has also worked on impacts of phosphates and water quality monitoring in the Blue Earth River using hyperspectral data and field measurements.	Yes
Dr. Mriganka De	Minnesota State University - Mankato, Department of Biological Sciences	Dr. De is a soils biologist with an extensive background evaluating the impact of Best Management Practices (BMPs) on biologic, physical, and chemical properties of soil. He also has an array of current work and publications investigating the impact of BMPs, sewage, and manure on nitrate levels.	Yes
Kimberly Musser	Minnesota State University Water Resources Center	Kim will provide Technical Assistance, Site Planning, and Outreach Coordinator. Kim has worked on the impacts of BMPs on water quality extensively. She currently leads several research projects and large outreach efforts. She works with many different watershed groups and has authored reports on Minnesota and other MN river basins.	Yes
Kendra Daby	Minnesota State University Water Resources Center	Kendra will serve as a project advisor for project planning and outreach coordination. Kendra is an effective grant planner and an integral component in implementing work plans	Yes
Anthony Runkel	Lead Geologist Minnesota Geological Survey	Tony will provide critical insight on site selection and data interpretation from wells. Tony's collaboration will help us ensure the integrity of model structuring and model interpretation. He has published extensively on sedimentary geology as well as on SE MN geology and springs.	No

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.

To ensure results of any research are being shared with entities that can use the results to improve management of resources in Minnesota we will attend state-level meetings and present project results. We will endeavor to present at the DNR Roundtable, Water Resources Conference, MN American Fisheries Society Meeting.

- To ensure longevity of any collections or products made possible with this source of funding.

We will archive the student thesis to the MNSU library and generate a scientific publication.

- To promote changes in behavior to better protect, conserve, or enhance Minnesota's environment and natural resources. We will educate K-12 students and the public with outreach activities and ideally animation and video.
- To share with Minnesotans in an accessible way the work being accomplished with help from the Environment and

Natural Resources Trust Fund.

We will endeavor to produce an animation, video, and stickers for K-12 and college students.

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?

Findings and results will be prepared for several different audiences. Results on assessment of land use, precipitation, and BMPs will be written up for publication in a peer-reviewed journal to be accessible to the scientific community.

Nitrate contamination is a global environmental issue our work will hopefully contribute towards BMP development and policy. Findings and results will be distributed regionally at both scientific and public meetings. Easy to read and understand pamphlets will be designed for and distributed to a broad audience.

Project Manager and Organization Qualifications

Project Manager Name: Susan Colvin

Job Title: Assistant Professor of Environmental Science and Interim Director of Regenerative Resources and Agrisciences

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

Dr. Colvin has led multiple diverse field and lab projects across several states focused on aquatic ecosystem health. She recently worked on a contract with GreenSeam, monitoring water quality on Long Lake, MN, including assessing nitrate and phosphorus contribution from tile drainage. She also served as PI on a project sampling populations of imperiled darters and their habitat in spring-fed karst systems of Northwestern Arkansas as part of a State Wildlife Grant.

Additional projects include sampling fish and sediments for radionuclides adjacent to Arkansas Nuclear One for the Arkansas Department of Health and Entrainment Ichthyoplankton verification for GBMc and Associates to assess Clean Water Act Section 316(b) compliance for Plum Point Energy Station's National Pollutant Discharge Elimination System (NPDES) Permit. Dr. Colvin has mentored numerous students with projects focused on aquatic ecosystems and has a strong publication record regarding aquatic ecosystem health and policy. She annually participates in multiple youth outreach events for local high and middle schools and collaborates with the Water Resources Center of MNSU on a variety of outreach projects. Dr. Colvin is an active member of the American Fisheries Society, Society of Freshwater Science, and other aquatic science communities, she serves on multiple committees for these organizations and on the Fish and Wildlife Advisory Committee for the Minnesota DNR.

Organization: Minnesota State Colleges and Universities - Minnesota State University Mankato

Organization Description:

Minnesota State University, Mankato promotes learning through effective undergraduate and graduate teaching, scholarship, and research in service to the state, the region and the global community. Minnesota State Mankato will be known as a university where people expect to go further than they thought possible by combining knowledge and the passion to achieve great things. Our foundation for this vision is our heritage of both dedicated teaching and the direct application of knowledge to improve a diverse community and world. We will achieve it by actively nurturing the passion within students, faculty and staff to push beyond possibility on the way to realizing dreams. Minnesota State University, Mankato is an innovative, student-centered learning community that values:

- Integrity and respect in the way we conduct ourselves;
- Diversity in who we are and what we do;
- Access to our programs and services that create opportunities for all to pursue their dreams.
- Responsibility to those we serve by providing an education that inspires solutions to society's challenges; and
- Excellence in our academic and non-academic pursuits.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Susan Colvin		Overall Project Lead, Site Selection, Field Work, Analysis			24%	0.13		\$12,105
Mriganka De		Project Lead BMPs, Soil Component, Site Selection, Water Quality Analysis			24%	0.05		\$6,654
Donald Friend		Project Involvement: Geography and Groundwater			24%	0.03		\$5,562
Fei Yuan		Project Lead High Resolution Spatial Data and Spatial Analysis			24%	0.03		\$5,059
Kim Musser		Project Organization and Outreach			36%	0.05		\$5,834
Kendra Daby		Grant Budget and Outreach			36%	0.05		\$4,094
Graduate Student		Spatial Analysis and Field Work			0%	2.5		\$59,577
Intern		Help with field work, lab water quality analyses, spatial analyses			0%	0.5		\$8,160
							Sub Total	\$107,045
Contracts and Services								
Minnesota Valley Testing Laboratories	Service Contract	Lab analysis of water quality samples for quality control.				-		\$9,600
Xylem	Service Contract	Xylem will calibrate our YSI EXO 2 Sonde.				-		\$705
							Sub Total	\$10,305
Equipment, Tools, and Supplies								
	Tools and Supplies	Water Quality Equipment	Nitrate, Total Phosphorus, and Orthophosphate testing requires consumables for each test as well as water bottles for sampling (these can be reused).					\$4,699

	Equipment	Field Gear	Field technicians will need waders, boots, piezometers, storage containers/coolers, ice for water samples, data sheets, safety equipment, and other field gear.					\$3,500
	Tools and Supplies	Outreach Supplies	We will produce pamphlets for distribution to the public, host outreach events for K-12 students, attend public meetings.					\$1,000
							Sub Total	\$9,199
Capital Equipment								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel to Field Locations in MNSU Biological Sciences Truck (\$3.60/11 (fuel per gallon/# miles per gallon) * 200 miles (Roundtrip Mankato to Field Sites) * 4 per month * 8 months * 2.5 years) + Travel to New Ulm MVTL from Mankato 12 times (60 miles roundtrip)	This travel is necessary to collect water samples over the 2.5 years of the grant and take 10% to New Ulm from Mankato Minnesota Valley Testing Laboratories					\$5,236
	Other	Daily Truck Use Fee \$40 (6 days per month * 8 months * 2 years)	The Department of Biological Sciences charges \$40 per day for use of the truck					\$3,840
	Miles/ Meals/ Lodging	Travel to Field Locations (0.725 * 150 miles * 20 trips)	When the Biological Sciences truck is unavailable we will have to use personal vehicles					\$2,175
	Conference Registration Miles/ Meals/ Lodging	Present Research Findings at Conferences in Minnesota such as the Minnesota Water Resources Conference	Presenting research					\$2,200
							Sub Total	\$13,451
Travel Outside Minnesota								

	Conference Registration Miles/ Meals/ Lodging	Attendance and presentations presented by 2-3 researchers (PI plus graduate students)	Formal presentation of findings at scientific meetings such as the Society for Freshwater	X				\$8,000
							Sub Total	\$8,000
Printing and Publication								
	Publication	Publication Fees	Fees to publish research findings.					\$2,000
							Sub Total	\$2,000
Other Expenses								
							Sub Total	-
							Grand Total	\$150,000

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	Attendance and presentations presented by 2-3 researchers (PI plus graduate students)	This is for formal presentation of findings at meetings whose conferences do not meet in Minnesota such as Society of Freshwater Science.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	Indirect Costs to Minnesota State University - Mankato	Operating Costs - 12% of total grant	Secured	\$18,000
In-Kind	Minnesota State University - Mankato	Hourly Equipment Use Hach Spectrophotometer (will save money on outside lab expenses)	Secured	\$18,750
In-Kind	YSI EXO 2 Sonde USE	\$25 per sample per 15 sites for 10 visits for 2.5 years	Secured	\$9,375
In-Kind	Labor costs from geology expert Anthony Runkel - Interim Director and Lead Geologist for the Minnesota Geological Survey	2 days at 8 hours per year at \$50 per hour for 2.5 years	Secured	\$2,000
			State Sub Total	\$48,125
Non-State				
			Non State Sub Total	-
			Funds Total	\$48,125

Total Project Cost: \$198,125

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [34ffaaf1-f7f.pdf](#)

Alternate Text for Visual Component

This is a map of the potential study sites for this project in western Fillmore County. We will select additional sites to provide greater accuracy in assessing the impact of land use and BMPs on nitrate as well as potentially assessing new BMPs recently instituted by Fillmore SWCD....

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 Commissioner's Plan 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:

Anne Ludvik MNSU Fei Yuan MNSU

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