Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-276

Proposal Title: Ditches: Potential Water Storage Domain Providing Multiple Co-Benefits

Project Manager Information

Name: Jeffrey Strock

Organization: U of MN - Southwest Research and Outreach Center

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Project Basic Information

Project Summary: This research project will demonstrate that ditch management is highly effective at protecting water quality and increasing water storage on the landscape. Guidance will be developed for resource managers statewide.

Funds Requested: $1,122,000

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?

Region(s): SW

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

In 2010, Cottonwood Lake, in Lyon County, was added to the Minnesota Pollution Control Agency (MPCA) list of impaired waters for excess nitrogen (N) and phosphorus (P). Frequently, the city of Cottonwood has had to close its beach due to blue-green algae blooms that pose a health risk to swimmers and pets. The lake remains on the list of impaired waters despite efforts to improve water quality and is representative of a statewide problem.

In November 2021, the MPCA released a draft of its 2022 impaired waters list. Statewide, a total of 305 new impaired water bodies were added to the list, one of which was County Ditch 69 (CD69) that flows through the city of Cottonwood and into Cottonwood Lake. The ditch was listed for impairments that affect aquatic invertebrates and/or fish. Although the impairment designation is not tied to one specific source of pollution, it is recognized that a combination of factors including excess nutrients, low dissolved oxygen, erosion, and habitat degradation can make it difficult for fish or aquatic invertebrates to survive.

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.

Research described in this proposal will enable individuals and communities to effectively use data, improve resource management, and integrate new technologies and approaches for climate-smart agriculture and environmental sustainability. We will investigate how smart water integrated management systems (SWIMS) can be linked with weather forecasting and ditch water management (DWM) to influence water storage and water quality within segments of CD69 and Cottonwood Lake. Results will be used to simulate ditch water quantity and quality using the Soil Water Assessment Tool (SWAT); a GIS-based method will be developed to identify locations for the implementation of DWM; secondary and post-secondary education opportunities for students and Extension/public engagement with stakeholders will be used to explain the benefits of DWM on water quantity and quality. Research will also allow us to infer results to ditches in other parts of Minnesota and other states where ditches are common.

Our approach proposes to use a network of sensors for monitoring ditch water depth and outflow along with weather forecasting to manage temporary water storage in ditches outfitted with SWIMS systems. These systems can be optimized to harness and exploit natural processes within ditch systems to reduce flow and nutrient losses from agricultural watersheds.

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?

Outcomes: 1) Analysis of SWIMS benefits to surface water storage; 2) Analysis of SWIMS benefits to water quality. 3) Watershed scale modeling of broader application and associated water quality benefits of ditch management. 4) Locally validated GIS model for SWIMS placement that could be extended to anywhere in the state (or region) with the required input data. 5) Develop data driven methods for integrated weather and ditch water management using SWIMS. 6) Experiential learning and extension/public engagement activities. 7) This proposal will also position our team to be competitive for other grant opportunities.

Activities and Milestones

Activity 1: Quantify the impacts of SWIMS on ditch water storage and water quality in a small watershed.

Activity Budget: $659,292

Activity Description:
We will monitor water quantity and quality in four segments of CD69 at road crossings with existing culverts and other strategic locations if no culver is present. Two segments will be unmanaged (status quo) and will be considered as experimental control channels. Two other segments will be outfitted with SWIMS systems and will be identified as the treatment channels. We will purchase two Smart Drainage Systems® from Agri Drain (Adair, IA) and modify them for our research application. A stage-discharge rating curve will be developed for each ditch segment using a portable current meter over a wide range of flow conditions. Discharge at each site will be continuously monitored. Water level in all four channels will be continuously monitored at two locations upstream from each outlet monitoring station. Water quality analysis will include nitrate, total phosphorus, dissolved phosphorus, turbidity, temperature, pH, and oxidation-reduction potential. Daily loads will be calculated by multiplying measured daily nutrient concentration by the total daily discharge. Meteorological data including rainfall and air temperature will be measured at the experimental site closest to the center of the watershed.

Activity Milestones:

Description	Approximate Completion Date
Baseline climate, water storage, flow, and water quality measurements	May 31, 2025
Installation of Smart Water Integrated Management Systems on two segments (treatment)	December 31, 2025
Monitoring climate , water storage, flow, and water quality measurements	June 30, 2028

Activity 2: Predict how SWIMS can impact watershed scale flow and nutrient export by employing a watershed scale modeling approach

Activity Budget: $110,985

Activity Description:
In order to simulate watershed scale responses to weather and ditch management, a SWAT model will be developed to represent the Yellow Medicine River Watershed upstream of the experimental ditch site. The SWAT model will be calibrated and validated using flow and water quality data measured at various points that correspond with field measurements conducted for this study as well as other nearby available datasets. Simulating Ditch Management: The calibrated and validated model will be used to simulate the same ditch management practices that are present in the field sites described above. Where possible, model outputs will be linked to measured values in order to ensure that the model is simulating water quality benefits in a reasonable manner. Specific measurements from the monitored ditches will be used to parameterize the channel characteristics of the SWAT model and in-stream nutrient transformations will be simulated by the QUAL2E water quality routines in the model. When used in conjunction with monitoring data, SWAT modeling can be used to simulate the water quality benefits that are realized with managed ditches.

Activity Milestones:

Description	Approximate Completion Date
Graduate Research Assistant training on SWAT modeling	December 31, 2026
Calibrate and validate SWAT model	June 30, 2027
Present results, develop and publish paper	June 30, 2028

Activity 3: Develop a method to inventory drainage ditches and to identify suitable locations for ditch water management using a GIS approach.

Activity Budget: $197,941

Activity Description:
Using the dataset from Activity 1 and model predictions from Activity 2, as well as existing ditch and LiDAR datasets, we will develop a model to predict the suitability for the placement of new SWIMS systems. Our model will consider factors such as ditch slope, catchment area, road crossings, public access, network distance to impaired waterbodies, soil type, and other factors to create a suitability model. We will also use the Agricultural Conservation Planning Framework (ACPF) toolbox for ArcGIS that leverages high-resolution geo-spatial data to help local farming communities better address their soil and water conservation needs. The ACPF helps producers, landowners, and local stakeholders identify conservation practices, like SWIMS, that can streamline conservation planning and help serve as the foundation for watershed plans.

Activity Milestones:

Description	Approximate Completion Date
Develop GIS tools and models for suitability of ditches in CD69 watershed	June 30, 2025
Extend GIS tools to ditches statewide	December 31, 2025
Apply SWIMS to ACPF model	June 30, 2026

Activity 4: Remote water and climate data monitoring, acquisition, transmission, and processing for managing ditch water storage and water quality.

Activity Budget: $146,782

Activity Description:
Our smart ditch water management network will incorporate a variety of sensors to monitor ditch water levels, flow rates, weather conditions, and precipitation forecasting. By harnessing the power of machine learning (ML), these systems will be used to predict and manage water levels in response to varying weather conditions and precipitation forecasts and intelligently manage ditch storage capacity in anticipation of major storm events or periods of peak runoff. For instance, by combining real-time data on ditch water depth and temperature conditions (above-freezing or below-freezing) with forecasted precipitation, ML models would determine the optimal adjustments to the water management system, such as opening or closing gates or valves, to ensure adequate storage capacity and minimize the risk of flooding. This enables the proactive lowering of water levels behind the SWIMS to create additional ditch storage capacity before significant storm events or peak runoff periods. This promotes the formation of inundated, vegetated, in-ditch/off-ditch storage systems, potentially expanding the system's biologically reactive and carbon-rich surface area and increasing the denitrification potential. In this way, ML is used to analyze real-time data, make informed decisions, and optimize the management of water resources in response to changing weather conditions, ultimately enhancing the water

Activity Milestones:

Description	Approximate Completion Date
Data Collection and Integration	June 30, 2025
Machine Learning Model Development	December 31, 2025
Setting infrastructure for Model Deployment	June 30, 2026

Activity 5: Education and engagement for students and stakeholders of the benefits of soil, water, and nutrient management and conservation.

Activity Budget: $7,000

Activity Description:

The secondary and post-secondary student focused component will incorporate findings into existing classroom curricula, enhancing educational programs through experiential learning opportunities and case studies with problem solving exercises. In addition, we will develop extension/engagement information about the field sites and the practice of DWM. The field research site will provide a valuable experiential learning opportunity, as the practice of managing ditches is still uncommon and unique. In addition to in-person field trips offered to students, a broader population of students can learn from these sites through virtual field trips that can be incorporated into many courses. We will combine the in-person and virtual field trips with real field data and interactive problem-solving exercises to create teaching modules that can be used in classrooms. We will also develop a fact sheet describing DWM that can be used in extension/outreach programming to stakeholders. Results of the field research and modeling will be shared with commodity groups, agency personnel, and the public through visits to the experimental research sites, news releases, webinars, and workshops. Finally, we will work with the North Central Region Water Network to extend this information to a broad network of Extension specialists and educators in the region.

Activity Milestones:

Description	Approximate Completion Date
Develop experiential learning materials for secondary and post-secondary students	December 31, 2025
Develop information materials for stakeholders	December 31, 2025
Carryout learning and information programs	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Vipin Kumar	University of Minnesota	Dr. Kumar will support and advise the GRA student hired to work with the Data Science component of the project. Will assist with data analysis and interpretation, report and publication writing and presentations at meetings and conferences.	Yes
Brent Dalzell	USDA-ARS and Adjunct Assistant Professor	Dr. Dalzell will support and co-advise the GRA student hired to work with the SWAT modeling component of the project. Will assist with data analysis and interpretation, report and publication writing and presentations at meetings and conferences.	No
Joel Nelson	University of Minnesota	Mr. Nelson will support the GRA student hired to work with the GIS modeling component of the project. Will assist with data analysis and interpretation, report and publication writing and presentations at meetings and conferences.	Yes
Elliot Vaughan	Southwest Minnesota State University	Dr. Vaughn will provide support for the Education component of the project. Will assist with experiential learning conceptual design and development.	No
Courtney Snyder	Lyon County Soil and Water Conservation District	Ms. Snyder will liaison between researchers and educators, and the stakeholders in the project area near Cottonwood, MN.	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?

We intend to maintain current and develop new partnerships as part of the project. We will engage new groups like the MN DOT and Lakeview School. We will also continue to engage with the MN Viewers Association (ditch viewers), DNR and MPCA in this project. It is hopeful that results from this project will enable SWIMS to become one of the acceptable practices for adoption in the revised MN nutrient Reduction Strategy aimed at achieving nutrient reduction in Minnesota watersheds. This proposal will also position our team to be competitive for other grant opportunities (e.g., USDA and NSF).

Project Manager and Organization Qualifications

Project Manager Name: Jeffrey Strock

Job Title: Professor

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

Dr. Strock is a Soil Scientist and Professor in the Department of Soil, Water, and Climate at the University of Minnesota. He is located at the Southwest Research and Outreach Center near Lamberton, MN. Dr. Strock is an expert in soil-water relations and has over 30 years of experience in the areas of soil hydrology and agricultural drainage. He has published more than 100 publications in peer-reviewed journals, conference proceedings, and book chapters. Dr. Strock is a Senior member of the graduate faculty in Soil, Water, and Climate, an Associate graduate faculty member in Water Resources Science, and Associate member of the graduate faculty in Sustainable Agriculture Systems. He is also a Fellow of the Soil and Water Conservation Society.

Dr. Strock's research activities are focused on diversified cropping systems and agricultural drainage water management. He directs a field-based research program focused on vadose zone hydrology, agricultural drainage, and understanding

water and nutrient mobility, uptake, storage, transformation, and losses in agricultural systems. More specifically, he seeks to understand how variations in climate and land use drive physical, chemical, and ecological water and nutrient cycling in agricultural landscapes, with emphasis on nitrogen and phosphorus. Dr. Strock's approach strongly relies on field sampling, laboratory analyses, and statistical models to characterize mechanisms, processes, and solutions that result in productive, profitable, resilient, and environmentally sound agricultural systems.

Organization: U of MN - Southwest Research and Outreach Center

Organization Description:
The University of Minnesota is a top 10 U.S. public research university with world-class academics, award-winning faculty, and state-of-the-art facilities. Researchers and students uncover new knowledge and find solutions to some of the most complex challenges facing society today. The University's threefold mission of research and discovery, teaching and learning, and outreach and public engagement is carried out on multiple campuses and throughout the state. The research described in this proposal will take place through the support of the Southwest Research and Outreach Center, near Lamberton. The University's Research and Outreach Centers (ROCs) are part of the College of Food, Agricultural and Natural Resource Sciences (CFANS) and represent the College and University's mission to respond to the needs of all Minnesotans. ROCs are strategically located throughout the state to provide research and outreach tailored to each region. The ROCs support research that enhances the quality of agricultural production, the environment, renewable energy, and human health and disseminate the benefits of this research to the public.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Researcher 2		Activity 1: Field research equipment installation, maintenance, data collection.			32%	1		$76,765
Researcher 5		Activity 1: Field research maintenance, data collection, analysis, and interpretation			36.8%	1		$90,738
Joel Nelson		Activity 3: Assist graduate student with GIS model development			32%	1		$96,365
Vipin Kumar		Activity 4: Advise computer science/data science graduate student			36.8%	0.02		$7,920
Graduate Research Assistant		Activity 4: Data Science using Machine Learning development and application			24.1%	1		$112,458
Graduate Research Assistant		Activity 3: GIS model development and application			24.1%	1		$101,576
Graduate Research Assistant		Activity 2: SWAT model calibration and validation			24.1%	1		$104,985
Graduate Research Assistant		Activity 1: SWIMS field data collection, analysis, synthesis, and integration			24.1%	2		$207,265
Temporary/Casual (Summer Intern)		Activity 1: Field data collection.			8.3%	1		$24,566
							Sub Total	**$822,638**
Contracts and Services								
To Be Determined	Professional or Technical Service Contract	Installation of SWIMS systems in the field				0.1		$15,000
							Sub Total	**$15,000**
Equipment, Tools, and Supplies								

	Tools and Supplies	Field tools and supplies including but not limited to solar panels, batteries, encolsures, auto samlers	Data collection					$56,000
	Tools and Supplies	Laboratory consumables, distilled water, reagents, glassware	Water sample analysis supplies (mainly for phosphorus).					$6,000
							Sub Total	**$62,000**
Capital Expenditures								
		Smart Water Integrated Management System	Primary water management devices in ditch channels for water storage management	X				$20,000
		Water sensors	These sensors are for conitnuous measurement of water characteristics, for example, nitrate, temperature, turbidty/sediment.	X				$145,000
							Sub Total	**$165,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Annual MN Water Resources Conference	Registration for Graduate Research Assistants attendance and presentation of results.					$1,600
	Conference Registration Miles/ Meals/ Lodging	Annual Minnesota Water Resources Conference	Registration for PI and other researchers to attend conference					$1,600
	Other	Travel between reseasrch site and Lamberton (SWROC): 48 round trips (0.655 x 110 mile round trip)	Set up research sites, data collection, maintenance. Meetings with stakeholders. Participation in Education meeting at Lakeview School.					$3,238
	Other	Travel between reseasrch site and St. Paul (UMN): 24 round trips (0.655 x 110 mile round trip)	Research sites data collection, maintenance. Meetings with stakeholders. Participation in Education meeting at Lakeview School.					$4,680

							Sub Total	**$11,118**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	One trip for Activity 2 Graduate Research Assistant	Student will attend formal SWAT model training	X				$3,000
	Conference Registration Miles/ Meals/ Lodging	Annual professional society conferences	Registration for Graduate Research Assistants attendance and presentation of results.	X				$6,000
	Conference Registration Miles/ Meals/ Lodging	Annual professional society conferences	Registration for PI/co-PI's attendance and presentation of results.	X				$12,000
							Sub Total	**$21,000**
Printing and Publication								
	Publication	Publication of data in open-access, peer-reviewed journals and preparation of bulletins.	Disemination of information					$9,000
							Sub Total	**$9,000**
Other Expenses								
		Telecommunication fees	Communicaiton charges for remote sensing/telemetry for remote data collection					$4,400
		Computer Science network recovery charges	Cost recovery for network and computer charges.					$4,844
		Education expenses	Education expenses for experiential learning and adult learning.					$7,000
							Sub Total	**$16,244**
							Grand Total	**$1,122,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Smart Water Integrated Management System	These structures are essential for ditch water storage management. **Additional Explanation :** This infrastructure will be used beyond the project by the Lyon Co. Soil and Water Conservation District to continue to manage water for storage and water quality.
Capital Expenditures		Water sensors	These sensors help reduce labor and the water quality analysis costs by using a sensor in place of water sample collection, storage, and analysis. **Additional Explanation :** These sensors can be used for site monitoring beyond the scope of the project.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	One trip for Activity 2 Graduate Research Assistant	The SWAT training is not held in Minnesota which necessitates out of state travel for model training.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Annual professional society conferences	Outside travel for Graduate Research Assistant professional development.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Annual professional society conferences	Outside travel for PI/co-PI professional development.

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: 4dac45fd-21e.pdf

Alternate Text for Visual Component

Visual consists of seven panels. Panels one through three provide details on project location within Minnesota. Panel four and five illustrates a SWIMS system with embedded sensors and Data Science integration. Panel six is a diagram of GIS layering. Panel seven shows the important characteristics of Experiential Learning....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
Letters of Support	1cc1ee44-7cd.pdf
Institutional Support Letter	3b12781b-36c.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?

Yes, Sponsored Projects Administration

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?

Yes

Do you certify that background checks are performed for background check crimes, as defined in Minnesota Statutes, section 299C.61, Subd. 2, on all employees, contractors, and volunteers who have or may have access to a child to whom children's services are provided by your organization?

Yes