Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-004

Proposal Title: Ditching Delinquent Ditches: Optimizing Wetland Restoration

Project Manager Information

Name: Andrew Wickert

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Can we maximize native wetland restoration while minimizing impact on human land use? Evaluating the water-resources impact of targeted agricultural ditch removal on ecosystem restoration.

Funds Requested: $199,000

Proposed Project Completion: June 30, 2025

LCCMR Funding Category: Small Projects (H)

Secondary 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.

Drainage ditches convert wetlands into farmable meadows, helping Minnesota's farmers to grow crops that feed the world. However, are all of these ditches serving beneficial use, or might some of them be harming natural wetlands without substantially benefiting agriculture?

Restoring wetlands increases natural habitat, provides water storage, and buffers extreme rainfall events to reduce flooding. Project partner Dr. Cowdery demonstrated that drainage-ditch removal stabilized the wetland ecosystem at Glacier Ridge NWR. Ditch removal increased groundwater storage and recharge by allowing wetlands to flood and their waters to seep downwards into aquifers. This redirected water once lost to runoff—a contributor to downstream flooding—into beneficial use by native prairies.

We will expand this initial success through a statewide evaluation of ditch impacts on wetlands using high-resolution lidar topography. We will identify beneficial ditches and recommend delinquent ones for removal. Until recently, such an analysis was impossible: Established hydrological algorithms ignore depressions such as lakes and wetlands. In 2020 and 2021, the Wickert lab, including partners Dr. Barnes and Dr. Callaghan, published new methods to map and route water through depressions. This knowledge and tool base makes our team uniquely poised to apply these state-of-the-art techniques towards improving Minnesota's natural environment.

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.

We will assess drainage ditches statewide using lidar topography and mapped ditch courses. We will digitally remove ditch segments and simulate the extents and volumes of the resultant restored lakes and wetlands. To identify beneficial and delinquent ditches, we will rank drainage ditches across the state based on quantitative metrics of (1) their benefit for agriculture; (2) their negative impacts on native ecosystems; (3) infrastructure and buildings that may be affected by ditch removal; and (4) hydrological benefits of ditch removal, including aquifer recharge and flood prevention. We will then communicate our results to stakeholders and decision makers, including by hosting GIS data sets of our model results in perpetuity oon the University of Minnesota's DRUM repository and presenting the results of our study via one or more easily understandable story maps.

Within this work, will develop easy-to-use GIS interfaces for our algorithms that permit us to analyze water flow involving closed depressions, which nucleate lakes and wetlands. In addition to making our work testable and reproducible, these will open the opportunity for Minnesotans to analyze and better manage our lake-filled landscape as it exists, rather than being beholden to currently-used tools designed for mountainous and unglaciated regions.

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?

Through our project, we will:

1. Determine the land use of all areas drained by surface agricultural ditches.
2. Identify where restored wetlands may reduce flooding hazards.
3. Identify delinquent ditches, which harm the ecosystem and hydrological system without producing significant human benefit.
4. Build maps and GIS data sets to share and disseminate this information to support decision-makers in responsibly implementing wetland-restoration projects.

This information will bolster the efforts of land managers and improve Minnesota's environment through targeted approaches that are cost-effective, minimize adverse impacts on human activity, and maximize ecosystem restoration.

Activities and Milestones

Activity 1: Quantify impact of drainage ditches on wetlands

Activity Budget: $105,000

Activity Description:
In this activity, we first compile GIS data sets, including the statewide 1-meter lidar data (already stitched into a seamless digital elevation model by Dr. Wickert), vector lines tracing all agricultural ditches, and data sets representing land use and built infrastructure. We then will develop methods to digitally infill and remove segments of drainage ditches, alone or in combination. By using this to modify both topography and drainage patterns, we will recalculate zones of enclosed depressions, lakes, and wetlands, and impacts of this changed surface-water storage on their surrounding ground-watersheds and groundwater levels. This full suite of model inputs and outputs, including all GIS data sets, will be published on the Digital Repository for the University of Minnesota (DRUM) in open-source formats with the support of the St. Anthony Falls Laboratory (SAFL) IT staff and University of Minnesota libraries.

Activity Milestones:

Description	Completion Date
Compile GIS data sources: Lidar topography, drainage ditches, land use	August 31, 2023
Develop computer code to systematically digitally infill ditches	February 28, 2024
Compute changes in wetland extent and water storage as a result of selective ditch removal	October 31, 2024
Compile, archive, and disseminate model results	December 31, 2024

Activity 2: Rank drainage ditches

Activity Budget: $74,000

Activity Description:
We will develop a ranking system with four subsets to evaluate the impact of drainage-ditch removal: (1) restored lake and wetland ecosystems and associated water resources; (2) flood protection; (3) impacted agricultural land; (4) impacted built infrastructure. We will algorithmically score each the impact of removing ditch segments and/or sets of ditch segments. Based on this computer-aided scoring, we will then generate composite scores and rank the ditches from the most beneficial to the most delinquent. These rankings will also be published in DRUM for use by stakeholders and decision makers. They will be linked with their corresponding model outputs from Activity 1.

Following completion of this ranking, we will generate a story map to illustrate our ranking process with geographical examples drawn from across the state. Using these results, we will engage policymakers, stakeholders, and land managers in the areas of the state where drainage-ditch removal ranked as a possible benefit.

Activity Milestones:

Description	Completion Date
Develop criteria for benefits and detriments of ditch removal and wetland-area change	June 30, 2024
Quantify and map land-use types influenced by the removal of the drainage-ditch segment(s)	January 31, 2025
Score each ditch removal for both beneficial (ecosystem, flooding) and detrimental (agriculture, infrastructure) impacts	March 31, 2025
Build composite rankings and recommendations for "delinquent ditch" removal	April 30, 2025
Share raw ranking data and story map	June 30, 2025

Activity 3: Produce GIS tools for hydrological analyses that explicitly include and analyze lake and wetland geographic structure

Activity Budget: $20,000

Activity Description:
We will build cross-platform GIS tools to allow easy ("point-and-click") access to the tools developed by Wickert's research group and collaborators in order to analyze closed depressions and their impacts on lake and wetland extents. Current packages for hydrological analyses remove closed basins, including lakes, making them inappropriate for many of Minnesota's landscapes. By including these lake basins explicitly, we will add capacity for GIS and hydrological analyses in the state that extends beyond the scope of this project.

Our algorithms and the associated code and application approaches are described in the following papers:

Barnes, R., Callaghan, K. L., and Wickert, A. D.: Computing water flow through complex landscapes – Part 2: Finding hierarchies in depressions and morphological segmentations, Earth Surf. Dynam., 8, 431–445, https://doi.org/10.5194/esurf-8-431-2020, 2020.

Barnes, R., Callaghan, K. L., and Wickert, A. D.: Computing water flow through complex landscapes – Part 3: Fill–Spill–Merge: flow routing in depression hierarchies, Earth Surf. Dynam., 9, 105–121, https://doi.org/10.5194/esurf-9-105-2021, 2021.

We will create interfaces and documentation for these tools through three of the leading commercial and open-source GIS packages: QGIS, ArcGIS, and GRASS GIS.

Activity Milestones:

Description	Completion Date
Create cross-platform GIS plug-ins	September 30, 2023
Test and build documentation for GIS plug-ins	December 31, 2023
Official plug-in release	February 28, 2024

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Hima Hassenruck-Gudipati	University of Minnesota	Postdoctoral Research Fellow	Yes
Kerry Callaghan	University of Illinois Chicago	Assistant Professor	No
Richard Barnes	Lawrence Berkeley National Laboratory	Postdoctoral Research Scientist	No
Timothy Cowdery	US Geological Survey	Hydrogeologist	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 will:

(1) publish GIS data and a story map on regions of lakes and wetland drained by ditches. These data will include critieria and rankings of ditches' effectiveness (or delinquency).

(2) generate cross-platform and GIS interfaces for our "depression hierarchy" and "fill–spill–merge" algorithms to analyze closed depressions—lakes and wetlands—in landscapes.

(3) communicate our findings with state and regional residents, land managers, and decision makers, so they can use our evaluation and ranking to guide action.

Any direct restoration work would require community involvement, consensus-building, and new funding for implementation.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Landslide Susceptibility, Mapping, and Management Tools	M.L. 2017, Chp. 96, Sec. 2, Subd. 03i	$500,000

Project Manager and Organization Qualifications

Project Manager Name: Andrew Wickert

Job Title: Associate Professor

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Wickert earned his S.B. in Earth, Atmospheric, and Planetary Science from MIT (2008) and his Ph.D. in Geology from the University of Colorado Boulder (2014). He has 15 years of experience working to understand how rivers, lakes, and wetlands integrate across Earth's surface, and currently manages more than $1.5M in water-oriented federal projects. His pertinent technical expertise includes GIS algorithm and package development, land and stream surveying,

geomorphic assessment and mapping, and scientific computing in five programming languages that includes work on supercomputer clusters. This work will build off of his group's recent collaborative creation of a toolkit to analyze depressions on landscapes and water flow through them; these are the requisite underlying tools to analyze water flow across most of Minnesota's landscapes. He is currently the McKnight Land-grant Assistant Professor of Earth-surface processes at the University of Minnesota.

Organization: U of MN - College of Science and Engineering

Organization Description:
The Saint Anthony Falls Laboratory (SAFL) is a world-renowned research facility for environmental fluid mechanics and related fields. This 4,880-square-meter facility is built into the side of St. Anthony Falls in downtown Minneapolis, whose water it uses to run some of the largest hydraulics experiments in the world. In addition to direct experimentation with flowing water, SAFL hosts a diverse group of scientists and engineers who work on environmental fluid mechanics as it applies to the atmosphere, climate, land surface, sediments, and biological processes. The faculty, staff, and students at SAFL spread their efforts across both basic scientific advances and work with immediate applications to infrastructure, the environment, and societal needs. The current SAFL director is Prof. Lian Shen, with Michele Guala as the associate director for research and Jeff Marr as the associate director for engineering and facilities.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Coordination of work and overarching objectives; algorithmic, programming, and communications support as needed			25%	0.16		$28,556
Postdoctoral Research Scientist		Quantitatively analyze and assess the hydrological and agricultural/infrastructural impacts of drainage ditches			25%	2		$142,000
Communications Manager		Build and share story map; communicate with stakeholders; co-build GIS tool documentation			22%	0.22		$17,444
IT and Data Management		Managing data and model-output uploads, archival, and useful dissemination			22%	0.12		$11,000
							Sub Total	**$199,000**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$199,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

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: 535cecd8-8dc.pdf

Alternate Text for Visual Component

Ditch removal increases wetland extent and groundwater storage across a watershed. We will evaluate the benefits of drainage-ditch removal on environmental restoration and flood-hazard reduction while also evaluating potential consequences for agriculture and infrastructure, using newly in-house-developed hydrological analysis tools designed to map networks of lake and wetland basins....

Optional Attachments

Support Letter or Other

Title	File
University of Minnesota SPA letter of certification	0f5a7a07-98e.doc

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?

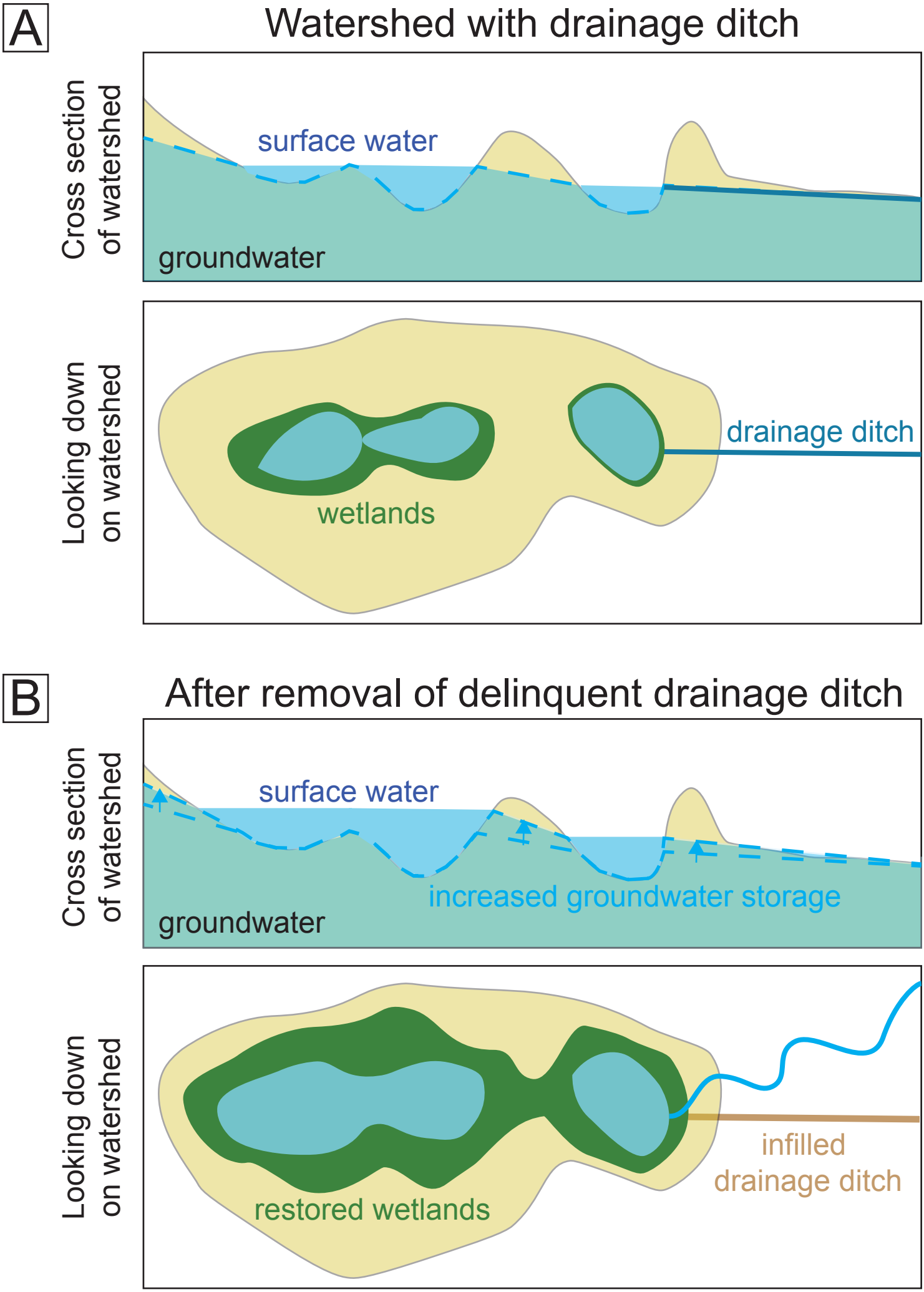
N/A

Does your project include original, hypothesis-driven research?

No

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration


A
Watershed with drainage ditch
Cross section of watershed
surface water
groundwater
Looking down on watershed
drainage ditch
wetlands
B
After removal of delinquent drainage ditch
Cross section of watershed
surface water
increased groundwater storage
groundwater
Looking down on watershed
infilled drainage ditch
restored wetlands