Environment and Natural Resources Trust Fund

M.L. 2023 Approved Work Plan

General Information

ID Number: 2023-004

Staff Lead: Mike Campana

Date this document submitted to LCCMR: May 21, 2023

Project Title: Ditching Delinquent Ditches: Optimizing Wetland Restoration

Project Budget: $199,000

Project Manager Information

Name: Andrew Wickert

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Project Reporting

Date Work Plan Approved by LCCMR: June 22, 2023

Reporting Schedule: April 1 / October 1 of each year.

Project Completion: June 30, 2025

Final Report Due Date: August 14, 2025

Legal Information

Legal Citation: M.L. 2023, Chp. 60, Art. 2, Sec. 2, Subd. 04a

Appropriation Language: $199,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to use new techniques to identify and rank areas statewide where targeted removal of poorly functioning drainage ditches and restoration to wetlands can provide maximum human and ecological benefits, including aquifer recharge and flood prevention.

Appropriation End Date: June 30, 2026

Narrative

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.

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 on 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.

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

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 mapped 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.

Model validation will be performed through investigation of Dr. Cowdery's restoration site on Glacier Ridge.

We expect our model to quantify broad restoration impacts well. For detailed information on sites with complex subsurface geological structure and/or other existing artificial drainage, we suggest refinement through more local modeling and measurement.

Activity Milestones:

Description	Approximate 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.

We will rank already-mapped drainage ditches only, which are predominantly the public ditches. Private ditches are generally less continuous, with more localized environmental impacts.

We will communicate with the Minnesota DNR, BWSR, and Drainage Management Team to help disseminate results to regional drainage managers.

Activity Milestones:

Description	Approximate 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	Approximate 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

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.
Our dissemination efforts include the following:
(1) Archival and access to of all generated data products provided in perpetuity through University of Minnesota
(2) Production of a story map to provide an approachable entry point to our work
(3) Building and sharing GIS applications to access and run our "Depression Hierarchy" and "Fill-Spill-Merge" algorithms
(4) Communication of results with stakeholders and land managers

All disseminated data products and publications will credit the Environment and Natural Resources Trust Fund through use of its logo and/or attribution language.

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

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, Photos, Media, Other

Title	File
University of Minnesota SPA letter of certification	0f5a7a07-98e.doc
Background Check Certification Form	d0d8be94-a1d.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Uploaded signed background-check form
Described planned data-dissemination efforts
Fixed one typo in the project narrative

Furthermore, regarding both the "revisions" here and the notes from Mike Campania, received over email:

REQUEST:
[LCCMR official request on application]
Under the Activity 2 description and the Dissemination page, can you provide more detail on the specific policymakers, stakeholders, and land managers you will be reaching out to. For example, DNR appears to work with public drainage authorities. Do you have any contacts with the state Drainage Management Team?

RESPONSE:
Thank you for this information. I have added a response to this in regards to your Question (4), sent via email. I have reached out to Rita Weaver, Chief Engineer and contact person for the Drainage Management Team, over email. I plan to follow up with her further as the project progresses (pending its being funded).

REQUEST:
[email]
1. Will your data set indicate whether a drainage ditch is part of the public drainage system or private?

RESPONSE:
Added to "Activitiy 2":

We will rank already-mapped drainage ditches only, which are predominantly the public ditches. Private ditches are generally less continuous, with more localized environmental impacts.
Modified under "Activity 1"
vector lines tracing all **mapped** agricultural ditches,

REQUEST:
[email]
2. Do you have any plans or envision any future efforts to validate the model outputs?

RESPONSE:
Added to "Activity 1":
"Model validation will be performed through investigation of Dr. Cowdery's restoration site on Glacier Ridge."

REQUEST:
[email]
3. How do you envision the model being used? Would you expect someone might decide to fill a ditch based solely on the model predictions or do you expect the model to help target areas but more detailed site-specific analysis would be done before a ditch was filled?

RESPONSE:
Added to "Activity 1":
We expect our model to quantify broad restoration impacts well. For detailed information on sites with complex subsurface geological structure and/or other existing artificial drainage, we suggest refinement through more local modeling and measurement.

REQUEST:
[email]
4. Do you currently have any contacts with people who advise or work with drainage issues in the state? Related to that, do you have specific decision-makers, stakeholders, or land managers in mind to target for dissemination or a plan on how to identify them?

RESPONSE:
Added to "Activity 2", with thanks for your above suggestion:
"We will communicate with the Minnesota DNR, BWSR, and Drainage Management Team to help disseminate results to regional drainage managers."

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you agree travel expenses must follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

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