



Environment and Natural Resources Trust Fund

M.L. 2026 Final Work Plan

General Information

ID Number: 2026-200

Staff Lead: Erin Barton

Date this document submitted to LCCMR: May 18, 2026

Project Title: Evaluating Soil Health Benefits of Controlled Agricultural Drainage

Project Budget: \$249,000

Project Manager Information

Name: Mark Bowen

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

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Project Reporting

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

Project Completion: June 30, 2029

Final Report Due Date: August 14, 2029

Legal Information

Legal Citation: M.L. 2026, Chp. 104, Sec. 2, Subd. 08g

Appropriation Language: \$249,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Minnesota State University, Mankato, to study the impact of controlled tile drainage on soil health and conduct outreach and education on the potential environmental and economic benefits of controlled tile drainage.

Appropriation End Date: June 30, 2029

Narrative

Project Summary: This multi-year project compares changes to soil health over time for cultivated croplands in soybean-corn rotation with controlled and uncontrolled tile drainage installed.

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

Agricultural tile drainage utilizes a system of underground pipes to remove water from fields and soils and discharge it into streams and ditches. Tile drainage dries fields quicker and increases soil aeration, allowing for earlier planting, greater rooting depth and enhanced crop yields. In the United States, ~25% of arable land is drained, and throughout the upper Midwest ~60% of soils are drained. In Minnesota, >20,000 miles of ditches and channelized streams have been developed to accommodate drainage outflow. In the Minnesota River Basin, where this research site is situated, >50% of agricultural soils have tile drainage, with new tile drainage continually being installed.

Although tile drainage can increase crop yields, it comes with an environmental cost. Tile drainage alters watershed hydrology, resulting in more frequent flooding with higher peak discharges. Drainage outflow typically has high nutrient loads, degrading water quality. Impacts of tile drainage on soils are less clear and previous research has conflicting results. Lowering the water table can increase infiltration and soil aeration and reduce runoff and erosion, enhancing soil biodiversity and soil development. However, over time increased aeration can increase organic matter decomposition, soil compaction, and erosion, ultimately decreasing soil health and potentially reducing productivity.

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.

Environmental impacts of tile drainage may be mitigated by controlled tile drainage (CTD), which uses adjustable gates to control drainage outflow and store more water in the soil, while still providing drainage benefits. However, CTD use in Minnesota is limited due to unfamiliarity with CTD, cost concerns, and lack of data on benefits. This project would complement ongoing research by project cooperators with the Minnesota Agricultural Water Resource Center at FarmAmerica, an experimental and demonstration farm in Waseca County, Minnesota. Tile drainage was installed in Fall 2022 in four adjacent agricultural fields, with gates controlling drainage from two fields while two fields have uncontrolled drainage. Project cooperators are monitoring drainage water quality and comparing crop yields from all four fields. However, they lack the expertise and resources to monitor impacts to soil health.

To provide a more comprehensive understanding of tile drainage impacts and determine if CTD mitigates those impacts, incorporating a three-year study of soil health is proposed. Each year, soil cores will be collected throughout the four fields and evaluated for a host of soil health indicators. Soils are the foundation of agriculture and the environment; healthier soils can increase crop yields while improving water quality.

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 study will provide critical data on environmental impacts of tile drainage, a widely used practice in Minnesota to increase arable land and enhance crop yields, and the effectiveness of controlled tile drainage to reduce any potential negative impacts while maintaining or increasing crop yields. These data, particularly soil health data, are currently lacking. When coupled with water quality and economic data from project collaborators, farmers will have necessary data to design more effective drainage systems. Accordingly, a major anticipated outcome is increased adoption of controlled tile drainage to improve agricultural productivity while also protecting essential soil and water resources.

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

Activities and Milestones

Activity 1: Characterize soil health throughout two fields with controlled tile drainage and two fields with uncontrolled drainage.

Activity Budget: \$184,000

Activity Description:

The objective is to document changes in soil health over time throughout two fields with controlled tile drainage and two fields with uncontrolled drainage. Soil cores will be collected following harvest each year using a hydraulic coring machine. Approximately 10 cores will be collected from each field to a depth of ~4 feet (~1.2 m) to document changes to the entire soil profile.

Cores will be analyzed in the Earth Systems Laboratory (ESL) at MSU, Mankato for a host of soil health indicators and shipped to an external laboratory for additional analyses. Cores will be subdivided and analyzed in the ESL for water content, bulk density, soil color, organic matter content, aggregate stability, particle size distribution, carbon mineralization potential, and nitrate content. Samples will be shipped to Ward Laboratories for analysis of approximately 20 additional properties to provide a comprehensive analysis of soil health.

The primary outcome is objective data documenting soil health in fields with controlled and uncontrolled tile drainage. These data on changes to soil health over time will be evaluated to determine how soil health is impacted by uncontrolled tile drainage and if controlled drainage mitigates those impacts. These critical data are currently lacking for farmers.

Activity Milestones:

Description	Approximate Completion Date
Collect soil cores following harvest in 2026, 2027, and 2028	October 31, 2028
Analyze soil core samples yearly in the Earth Systems Laboratory for several soil health indicators	March 31, 2029
Process soil samples yearly and submit to external laboratory for additional soil health indicators	March 31, 2029

Activity 2: Characterize landscape properties and land use history of research site

Activity Budget: \$59,000

Activity Description:

The objective is to collect detailed topographic, soils, and land use history data of the research site. Topographic data will be collected by land surveying along a grid throughout all fields using total station surveying equipment, which provides centimeter-scale data on elevation and slope. Soils will be mapped using USDA National Cooperative Soil Survey data. Land use history will be compiled using site records, historical aerial imagery, and USDA National Agricultural Statistics Service data.

The primary outcomes include a detailed digital elevation model based on survey data, a soil map, and land use history maps created in a GIS environment. These data are critical to provide context on controlled and uncontrolled drainage impacts to soil health. Minnesota is characterized by undulating topography, and it is essential to document topographic influences on water movement in controlled and uncontrolled drained soils. Mapping soils and documenting land use history will allow results from this project to be compared to and better implemented at other sites. Topographic, soil, and land use history data are critical to empower more farmers to adopt and adapt CTD practices to their specific needs and conditions to allow for greater success and ultimately more environmental and agricultural benefits.

Activity Milestones:

Description	Approximate Completion Date
Complete land surveys of all fields using total station surveying equipment	June 30, 2027
Compile land use history and soil data for all fields	June 30, 2028
Create soil and land use history maps for all fields	June 30, 2029

Activity 3: Share results on soil health impacts of controlled and uncontrolled tile drainage with farmers, agricultural consultants, conservationists, and other researchers

Activity Budget: \$6,000

Activity Description:

The objective is to share results of this research on tile drainage impacts to soil health and if controlled tile drainage (CTD) can mitigate those impacts. The ultimate goal of this project is to increase adoption of CTD by focusing on education, demonstration, and outreach to farmers, agricultural contractors, conservationists, and other researchers about the water quality, soil health, and economic benefits of CTD. There is a need for drainage water management demonstration and evaluation in southern Minnesota to provide the necessary information and outreach to encourage more farmers to adopt CTD and to tailor it to their specific needs and field conditions to further enhance soil health and crop productivity.

Outcomes include working with project collaborators to establish a drainage water management site to educate farmers, agricultural consultants, conservationists, and other researchers. Project collaborators will host a field day onsite and/or online each year to share data about the water quality and economic benefits of CTD, and we will participate to highlight and share research on tile drainage impacts to soil health and how effective CTD is at mitigating those impacts. These research outcomes will also be published in a professional journal and presented at a professional conference.

Activity Milestones:

Description	Approximate Completion Date
Participate in field days hosted by project collaborators each year to share research outcomes	March 31, 2029
Publish research outcomes in a professional journal	June 30, 2029
Present research outcomes at professional conferences	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Tim Raddatz	Minnesota Agricultural Water Resource Center	Water quality/Economic analysis and field day/meeting organizer	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.

Project collaborators at the Minnesota Agricultural Water Resource Center will host a field day onsite and/or online each year to share data about the water quality and economic benefits of controlled tile drainage, and Project Manager Bowen and research assistants will participate to highlight and share research on tile drainage impacts to soil health and how effective CTD is at mitigating those impacts.

All data will be shared with project collaborators at the Minnesota Agricultural Water Resource Center to be archived and shared on their website dedicated to this project (<https://discoveryfarmsmn.org/projects/farmamerica/>).

Outcomes of this research will be published in a professional journal.

Research outcomes will also be presented at a professional national conference and at a professional conference in Minnesota.

Most physical soil cores and samples will be processed and consumed during laboratory analysis. Any remaining samples will be archived in the Earth Systems Laboratory at Minnesota State University, Mankato until completion of the project in case follow-up analyses are necessary. Soil properties naturally change and samples degrade over time, so long-term archiving of soil samples is not applicable.

The Environment and Natural Resources Trust Fund will be acknowledged through use of the trust fund logo or attribution language on project presentations, print and electronic media, publications, and other communications per the ENRTF Acknowledgment Guidelines.

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?

The ultimate goal is to increase adoption of CTD throughout Minnesota by focusing on education, demonstration, and outreach. There is a need for CTD demonstration and evaluation in Minnesota to empower more farmers to adopt and adapt CTD practices to their needs and conditions. This project meets this need by establishing a research and demonstration site and providing comprehensive water quality, soil health, and economics data. Working with project cooperators, field days and outreach events will be held each year of the project to highlight project outcomes. Results will be published in a professional journal and presented at professional conference.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Fulltime Graduate Research Assistant		Lead assistant for soil coring and soil sample processing and analysis; assist with land surveying; participate in outreach and education activities. The graduate research assistant will be provided an \$18,000 stipend and 18 credits of tuition (~\$10,000/year) per year for three years for the equivalent of 20 hours of work per week during fall, spring, and summer sessions. The % Benefits rate of 38% includes 18 credits of tuition and fringe (7.65% of summer salary).			38%	3		\$87,000
Halftime Graduate Research Assistant		Lead research assistant for land surveying and soil and land use history mapping; assist with soil coring and soil sample processing and analysis; participate in outreach activities. The graduate research assistant will be provided a \$9,000 stipend and 9 credits of tuition (~\$5,000/year) per year for three years for the equivalent of 10 hours of work per week during fall, spring, and summer sessions. The % Benefits rate of 38% includes 9 credits of tuition and fringe (7.65% of summer salary).			38%	1.5		\$44,000
Project Manager		Train research assistants; plan and coordinate all work; supervise all field work and laboratory analyses; purchase all equipment and supplies; analyze all data; manage budget; participate in all outreach activities			24%	0.18		\$21,000
							Sub Total	\$152,000
Contracts and Services								
Ward Laboratories, Inc.	Service Contract	Ward Laboratories will provide laboratory analysis of soil samples for variables that the Earth Systems Lab does not have the capabilities to complete and for which it is cost prohibitive to purchase necessary equipment (e.g., micronutrients) but are critical to understand how tile drainage impacts soil health.		X		0		\$11,000

							Sub Total	\$11,000
Equipment, Tools, and Supplies								
	Tools and Supplies	Field supplies and consumables (e.g., soil tubes and caps, trowels, GPS units, batteries, tape measures, soil color charts, sample containers, labels) and servicing soil coring machine for coring expeditions.	A variety of tools and consumables as well as servicing the soil coring machine are necessary to collect soil cores, conduct land surveys, and complete site descriptions.					\$25,000
	Tools and Supplies	Lab supplies and consumables (e.g., beakers, crucibles, reagents, probes, calibration standards, labels, sample containers, etc.).	A variety of supplies and consumables are necessary to process and analyze samples in the Earth Systems Laboratory.					\$27,000
							Sub Total	\$52,000
Capital Equipment								
		Thermo Scientific GENESYS 40 Visible Spectrophotometer (plus supplies)	A visible spectrophotometer is used to measure several properties related to soil health, including carbon content, nitrogen and phosphorus concentrations, pH, and more.	X				\$14,000
		Thermo Scientific LindbergBlue 18.4 L Muffle Furnace (plus supplies)	Allows for soil samples to be analyzed for organic matter content	X				\$12,000
							Sub Total	\$26,000
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Mileage for ~12 trips to the research site per year for three years, ~60 miles round trip per trip, with 2-4 people per trip.	It is necessary to regularly drive to the research site to collect soil cores, conduct land surveys, complete site descriptions, monitor the site for change, and participate in outreach and education activities.					\$2,000

	Conference Registration Miles/ Meals/ Lodging	Project manager Bowen and research assistants will present results of this research at a professional conference in Minnesota.	The purpose is to share the outcomes of this research with scientific/agricultural communities in Minnesota that can advance and implement controlled tile drainage projects. It has the added benefit of providing both research assistants with critical experience preparing and disseminating research and expands their professional network.					\$3,000
							Sub Total	\$5,000
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Project manager Bowen will present results of this research at one professional, national conference.	The purpose is to share the outcomes of this research with the broader scientific community.	X				\$3,000
							Sub Total	\$3,000
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$249,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Ward Laboratories, Inc.	Service Contract	Ward Laboratories will provide laboratory analysis of soil samples for variables that the Earth Systems Lab does not have the capabilities to complete and for which it is cost prohibitive to purchase necessary equipment (e.g., micronutrients) but are critical to understand how tile drainage impacts soil health.	This was the laboratory used to collect baseline/pilot data, and it is important to collect and analyze samples using the exact same protocols to ensure that changes to data are a result of tile drainage, not a result of changing laboratories. Further, no lab in the state provides as comprehensive a suite of variables in their analysis. Given that is not known how tile drainage impacts soils, it is important to collect data on as many variables as possible. Ward Labs provides data on more than 20 variables with their "Routine Soil Analysis" test.
Capital Equipment		Thermo Scientific GENESYS 40 Visible Spectrophotometer (plus supplies)	This instrument will expand the capabilities of the Earth Systems Laboratory to include critical analyses of carbon and nutrient content for this project and potential future projects. Carbon and nutrients are key indicators of soil health and are essential measurements for this project. The equipment will be available to all users in the Earth Systems Laboratory free of charge for the duration of its useful life, which should be many years. It will also be used to provide important training for students pursuing a career in natural resources. Additional Explanation : This instrument will be housed in the Earth Systems Laboratory at MSU, Mankato. It will be maintained by Project Manager Bowen for the duration of its useful life. The machine is capable of analyzing a range of soil properties, so it will be highly impactful for student and faculty research. It will be available for students, faculty, and the community to analyze soil samples. For community members (e.g., regional farmers), samples will be analyzed and results provided free of charge. Students will be trained and be able to analyze samples free of charge. Faculty and external researchers will also be provided access to the equipment at no charge, though they will be responsible for providing or replacing consumables. This instrument will also be used in several courses (e.g., Soil Conservation, Water Resource Management), providing students with hands-on experience using an industry standard piece of equipment, which will provide important training for a career in natural resources.
Capital Equipment		Thermo Scientific LindbergBlue 18.4 L Muffle Furnace (plus supplies)	This instrument will expand the capabilities of the Earth Systems Laboratory to include critical analyses of organic matter content for this project and potential future projects. Organic matter content is a key indicator of soil health, often considered the most critical indicator, and is essential for this project. The equipment will be available to all users in the Earth Systems Laboratory free of charge for the duration of its useful life, which should be many years. It will also be used to provide important training for students pursuing a career in natural resources. Additional Explanation : This instrument will be housed in the Earth Systems Laboratory at MSU, Mankato. It will be maintained by Project Manager Bowen for the duration of its useful life. The machine is capable of analyzing soil samples via "loss-on-ignition" for a variety of elements, but primarily organic matter and carbon content of soils. It will be

			highly impactful for student and faculty research. It will be available for students, faculty, and the community to analyze soil samples. For community members (e.g., regional farmers), samples will be analyzed and results provided free of charge. Students will be trained and be able to analyze samples free of charge. Faculty and external researchers will also be provided access to the equipment at no charge, though they will be responsible for providing or replacing consumables. This instrument will also be used in several courses (e.g., Soil Conservation, Soil Geomorphology), providing students with hands-on experience using an industry standard piece of equipment, which will provide important training for a career in natural resources.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Project manager Bowen will present results of this research at one professional, national conference.	Findings, results, and outcomes of this research will be presented and shared with the broader scientific community.

Non ENRTF Funds

Category	Specific Source	Use	Status	\$ Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Total Project Cost: \$249,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [0bf29ca8-1db.pdf](#)

Alternate Text for Visual Component

Map showing location of the research site at FarmAmerica in Waseca County, Minnesota; research site divided into four fields (N, MN, SW, and SE) (yellow lines) with tile drain lines (blue lines) and water drainage control structures (triangles); and pictures of initial soil core collection at the research site....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Letter of Support Minnesota Agricultural Water Resource Center	48ec1864-3ba.pdf
Research Addendum-2026-200_Final	a3ea682e-60c.docx

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Since only one person is allowed to present out of state once per project, the out of state conference budget was reduced from \$6,000 to \$3,000 and an additional budget item of in state conference travel of \$3,000 was added to support project manager Bowen and research assistants to share results of this research with relevant professionals in Minnesota. This is a budget neutral change and allows the results of this project to be more broadly distributed.

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?

Yes

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 project:

N/A

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