Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-514

Proposal Title: Subsurface Irrigation Design

Project Manager Information

Name: Otto Strack

Organization: U of MN - College of Science and Engineering

Office Telephone: (612) 625-3009

Email: strac001@umn.edu

Project Basic Information

Project Summary: We develop tools for designing subsurface irrigation systems in Minnesota's agricultural system, helping to conserve our valuable water resources.

ENRTF Funds Requested: $363,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Water (B)

Project Location

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

Region(s): Metro, Central, NE, NW, SE, SW,

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

Statewide

When will the work impact occur?

In the Future

Narrative

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

The production of agricultural crops requires the use of large volumes of water to achieve crop yields.
The production of an acre of corn requires 2 acre-feet of water per year.
Where the soil holds little water, such as the sand plains of central Minnesota, water for crop production is mostly supplied through central pivot irrigation. Central pivot technology advanced significantly over the last 50 years but still wastes some of the water. Any waste of water reduces future groundwater supplies, detrimental to meet human and overall ecosystem needs. The conventional means of irrigation management is likely to cause the leaching of crop nutrients, such as nitrate, to groundwater resources.
The most efficient and ideal current way of irrigation is subsurface drip-irrigation, which targets the application of water directly to the crop roots, see Figures 2 and 3. This highly efficient method is ideal for crops of high value such as fruit trees, and high-value vegetable crops, but due to its relatively high cost it is not suitable for row crops such as potatoes, corn, or soybeans.
An alternative is urgently needed to reduce both water loss and potential leaching of crop nutrients such as nitrate.

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.

Our solution is to replace above-ground irrigation by subsurface irrigation, thus avoiding evaporation losses that occur in sprinkler irrigation, and reducing the potential for nutrient leaching. We propose using underground perforated pipes through which water is supplied under pressure, spaced about as in Figure 1. Such subsurface irrigation practice is currently available in Minnesota in areas where subsurface drainage is practiced in soils having a subsurface restrictive layer. The difference is that we propose that a similar concept be applied to areas where drainage is not needed but instead the soils are deep and contain no restrictive layer. In this concept the pipes are placed far enough below the surface not to be damaged by heavy farm production equipment. A newly developed mathematical formulation for flow of water in the subsurface has demonstrated that this proposed idea for subsurface irrigation is feasible, and that the formulation can be utilized in the design of the subsurface irrigation system. The parameters to adjust are:

1. Depth of pipe to water
2. Spacing of parallel pipes
3. Diameter of the pipes
4. Pressure in the pipes

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?

The new subsurface irrigation approach will provide a more efficient means of applying water to crops in areas of the state where the soil is deep and characterized as having low water holding capacity. This system will increase water use efficiency and will reduce the leaching of nitrates.

Activities and Milestones

Activity 1: Development and testing of the subsurface irrigation design tool

Activity Budget: $118,046

Activity Description:
The design tool is based on the well-known analytic element method (AEM) developed by Otto Strack. The analytic element method solves the equation for groundwater flow for specified field conditions. In this case the field condition involves perforated subsurface pipes parallel to each other in the field at a depth of several feet below the ground surface. The pipes are hooked up to a water supply and water is pumped into the pipes; the injected water then flows through the perforations into the surrounding soil. The idea is that the injected water rises above the elevation of the perforated pipes to a sufficient height where the roots of overlying plants can extract the water to meet the daily need for water consumption. The design tool will be available from Github and will be open source. The team will establish a Technical Advisory Committee (TAC) with experts from MDA, MPCA, DNR. The TAC will meet every three months while the full project team will meet monthly. Leveraging our existing relationships, we will establish a stakeholder group from cities, counties, watershed districts/organizations, and non-profits.

Activity Milestones:

Description	Approximate Completion Date
Select members of the Technical Advisory Committee (TAC)	September 30, 2026
Refine the analytic element solution and implement it in a computer program	December 31, 2026
Combine the analytic element solution with the solution for unsaturated flow above the water table.	May 31, 2027
Develop test cases for the combined programs to check that new additions meet the requirements	May 31, 2027

Activity 2: Generalization of the design tool to adapt to field conditions

Activity Budget: $120,896

Activity Description:
Generalize both the theory and its implementation and test the model. Both the theory and the program are suitable at present for an infiltration area isolated from the outside, i.e., all the water in the area is provided via the pipes and nothing comes from outside. This should be generalized to include other boundaries, such as fixed water levels, to adapt to more general field conditions where some water also comes from the outside.

Activity Milestones:

Description	Approximate Completion Date
Test the model to prove the efficacy of the subsurface irrigation approach.	December 31, 2027
Testing the model's validity for inhomogeneous conditions using the numerical model	December 31, 2027
Develop a suite of test cases for the combined model to check modifications	May 31, 2028
Create a manual for the tool and for modifying and testing the design code	May 31, 2028

Activity 3: Including transient conditions and project management

Activity Budget: $124,058

Activity Description:
It will be determined how much time is needed for the water level to reach the desired elevation by modeling, if possible with AEM, otherwise numerically.

A draft and final report will provide documentation of the project to explain the proposed design tool. Following the completion of the final report, our Team will develop draft and final training slides, then conduct a one-hour workshop (recorded) on the proposed tool. The spreadsheet tool, workshop and user documentation will be stored on UMN websites. The project results and tool will be presented to audiences at Minnesota's annual Water Resources Conference and at the regional International Drainage Symposium.
Our team will provide periodic updates to the LCCMR as contracted. The updates will include documentation of the TAC meetings, status of the tasks, discussion of unexpected issues and resolutions, and any results to date.

Activity Milestones:

Description	Approximate Completion Date
Include transient flow in the model to estimate the time to reach desired water levels	December 31, 2027
Present a one-hour training webinar	April 30, 2028
Draft and final report	May 31, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
John Nieber	University of Minnesota	Project Co-PI; expert on unsaturated flow and will provide insight and assistance in the process of efficiently getting water and nutrients to the plant's roots.	Yes

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 results of the project will be two-fold:

1. A computer program suitable for design purposes, in the public domain and downloadable from Githup.
2. A manual explaining how to use the design tool.

Depending on the outcome of this work, we plan the submission of a follow-up proposal for field implementation and testing of the concept.

Project Manager and Organization Qualifications

Project Manager Name: Otto Strack

Job Title: Professor of Civil Engineering and Geomechanics at the University of Minnesota

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

Taught groundwater flow for 50 years at the CEGE department of the University of Minnesota. Completed several LCCMR projects in the past, is the author of many papers, two textbooks on groundwater flow, and a book on applied mathematics. Received the outstanding service award from the Minnesota Groundwater Association, the M. King Hubbart award from the National Groundwater Association, and is a corresponding member of the Netherlands Academy of Sciences.

Organization: U of MN - College of Science and Engineering

Organization Description:

The College of Science and Engineering is uniquely positioned to provide the vision, leadership, and intellectual capital that underwrite progress in the 21st Century. Created in 1935, the College of Science and Engineering (formerly known as the Institute of Technology) brought together the University's programs in engineering, mining, architecture, and chemistry. Today, the college is ranked among the top engineering and science academic programs in the country. The college includes 12 academic
departments offering a wide range of degree programs at the baccalaureate, master's, and doctoral levels.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Otto Strack		Project manager			36.6%	0.66		$115,795
John Nieber		Co-PI			36.6%	0.33		$55,926
graduate student		Assist with program testing and running the design tool			46.28%	1.5		$176,054
							Sub Total	**$347,775**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies needed for the graduate student to carry out his or her duties.	The primary role of the graduate student is testing the programs. This may require some electronic devices.					$15,225
							Sub Total	**$15,225**
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	**$363,000**

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	**-**

Total Project Cost: $363,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 0c9129a1-aaf.pdf

Alternate Text for Visual Component

This visual illustrates the proposed design for subsurface irrigation as well existing subsurface drip irrigation and shows the difference between existing and new....

Supplemental Attachments

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

Title	File
UofM letter of support	035f6a13-9f5.pdf

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?

N/A

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?

No

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:

Enoch Pan,CEGE grant submission administrator and John Nieber, co-PI

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

N/A