

Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-037

Proposal Title: Nature-Based Solutions Controlling Sedimentation and Erosion along Streambanks

Project Manager Information

Name: Michele Guala Organization: U of MN - St. Anthony Falls Laboratory Office Telephone: (612) 625-9108 Email: mguala@umn.edu

Project Basic Information

Project Summary: We will study, envision, test and deploy nature-based solutions to reduce erosion and preserve fish habitat at the side banks of Minnesota rivers

ENRTF Funds Requested: \$513,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Resiliency (A)

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.

Rivers and streams transport a lot of fine sediment and organic material, especially after heavy rain falls. Excessive sediment load affects rivers recreational and navigational use (see Pepin Lake, Spring Lake, and Sturgeon Lake). Most of this material, along with wood and debris, is eroded at the river banks (see Red River, Whitewater River, and Minnesota River Basin), where it accumulates during the low flow season. River banks are the boundaries between the river channel and the floodplain and are thus protected against erosion to ensure land conservation and fluvial infrastructure functionality for flood routing, navigation, and recreational use. Flow regions near the river banks are, however, also fish habitats to preserve. Through this project we will develop and validate a new approach for stream bank protection and restoration that utilizes natural materials, such as vegetation patches, logs, and rocks assembled to transport sediment towards the stream banks, or towards the flood plain, depending on the stream curvature, floodplain connectivity, erosion potential, and ecological needs. We envision a smart naturalization of streams, where the energy of the flow will contribute to stabilizing the river channel and shaping the cross section as needed to protect stream banks and improve fish habitat.

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.

As part of previous grants from the National Science Foundation and the Department of Energy, we successfully developed shallow permeable vanes and submerged vertical grids in laboratory flumes allowing us to reduce flow velocity and manipulate the local transport pathway of sediment, e.g. move them laterally and create areas of preferential deposition. In this project we will extend these methods using natural materials (vegetated patches, logs, and boulders opportunely arranged near natural stream banks) to reshape the river cross section for bank erosion protection, floodplain development and connectivity, and fish habitat preservation. The project will leverage existing expertise in experimental hydraulics and the collaboration with MN agencies and stream restoration practitioners to i) identify sources of fine material along selected streams and preferred fish habitat, ii) manipulate flow and sediment transport in these critical spots to optimize the thalweg depth. To achieve this, we will survey existing bank protection systems in Minnesota rivers (Activity 1), test various solutions through laboratory experiments at St. Anthony Falls Laboratory (Activity 2), implement successful design(s) in a real stream in cooperation with MN agencies eventually providing calibrated, predictive models for stream cross section restoration that will be passed on to practitioners (Activity)

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 project goal is to establish cost-effective restoration techniques to control stream bank flow and sediment deposit patterns using nature-based solutions and leveraging on advanced knowledge of hydraulics and sediment transport. The outcomes will be a set of experimentally validated methodologies and design guidelines that will be accessible to practitioners across the state to consider, embrace, and utilize available local natural resources as plants, logs and rocks to protect side banks and preserve fish habitat, with minimal intervention. The project will positively impact land conservation, reduction in maintenance costs for stream restoration and fish habitat preservation, and improved water clarity.

Activities and Milestones

Activity 1: Review of currently implemented strategies to manage stream bank erosion, deposition, and fish habitat in rural Minnesota

Activity Budget: \$84,750

Activity Description:

In the first year we will survey various streams and rivers in Minnesota and map the implemented stream-bank erosion and restoration interventions, including selected sites on the Minnesota River, Red River of the North, Whitewater, Rum River, and 9-Mile Creek. We will classify river reaches based on the mean basin slopes and available USGS data for basic hydraulics parameterization, along with specific information on stream classification by MN agencies. The goal is to identify where streambank restoration has taken place and assess what approaches were implemented (e.g. Rosgeninspired nature-based systems, riprap, gabions, grade control systems). Outer stream velocities and depths, when possible, will be measured to generate a stream dataset. Measurements will be acquired using an ad-hoc designed measuring system featuring an acoustic doppler velocimeter and an echosounder. Installation and maintenance costs will be estimated for the deployed bank protection systems. The main objective of this Activity is to assess the cost, durability and hydraulic performance of currently deployed methods that will serve as a metric of comparison for nature-based solutions for sediment directionality.

Activity Milestones:

| Description | Approximate Completion Date |
|--|--------------------------------|
| Complete data collection of outer stream-bank protection and floodplain conservation systems in meandering streams | October 31, 2026 |
| Complete data collection on installation and maintenance costs for bank protection and stream restoration (2015-now) | October 31, 2026 |

Activity 2: Test of nature-based solutions, such as log vanes, vegetated patches and canopies to steer sediment deposition

Activity Budget: \$232,670

Activity Description:

Laboratory tests will be run in SAFL channels and flumes of different sizes, widths, and bed material compositions to quantify the performance of various nature-based bank protection systems. We require tested solutions to be assembled from local resources, such as logs, rocks, bushes, and aquatic plants, opportunely located, spaced, and shaped along the outer bank of the meander. We will use the survey dataset in Activity 1 to identify potential candidates and sites of interest that can be investigated in a scaled version in the laboratory. Stream bank protection performance will be assessed in terms of fine and coarse sand induced deposition towards the eroded bank, and flow deflection towards the central channel. It is critical to quantify how much sediment can be steered towards the outer meander bank to reduce the local velocity, scour and the stream curvature. For fish habitat protection, we will test different orientation and log arrangements to preserve the thalweg by depositing sediments towards the inner meander banks. Measurements of water elevation, bathymetry, and velocity will be frequently taken to assess the sensitivity of the stream to these interventions, and define precisely the metric to be employed when comparing various flow and sediment steering elements.

Activity Milestones:

| Description | Approximate |
|-------------|-----------------|
| | Completion Date |

| Complete laboratory investigation of submerged sediment steering vanes using logs and rocks | September 30, 2028 | | |
|---|--------------------|--|--|
| Complete laboratory investigation of near-bank vegetated patches and canopies | October 31, 2028 | | |
| Complete assessment of a representative performance metric to compare various nature-based | December 31, 2028 | | |
| solutions and designs | | | |

Activity 3: Full scale Implementation and Outreach

Activity Budget: \$195,580

Activity Description:

We will identify a river reach featuring an eroded outer bank meander or a fish habitat to restore (Activity 1), and implement our stream bank solution based on ecosystem needs and design guidance developed during the laboratory experimentation (Activity 2). We will work closely with the Minnesota DNR to choose a stream, among those previously monitored, that is unprotected, far from civil infrastructures and from historically flooded areas. We will establish continuous image-based monitoring system and frequently inspect the site, taking measurements of velocity and depth along the outer banks, under different flow discharges. New field measurements will be compared to the data acquired in Activity 1 to verify that the stream flow has improved under all aspects: e.g. bank erosion has been mitigated, fish habitat has been preserved, and flood plain connectivity has improved. Also, we will test the robustness and resiliency of our bank protection system during fall and winter seasons, which present various challenges: high flow, wooden debris, and ice. The field-scale experiment will allow us to validate our design, provide bank protection design guidelines to MN practitioners, and formulate a simple empirical model that will facilitate the preliminary design of lateral sediment steering solutions.

Activity Milestones:

| Description | Approximate Completion Date |
|--|--------------------------------|
| Identification of a natural stream subject to intense stream bank erosion or fish habitat preservation | June 30, 2029 |
| Deployment of the nature-inspired design along the streambanks and continuous monitoring of the | June 30, 2029 |
| cross-section | |
| Validation of a stream-bank protection and floodplain sedimentation numerical models to guide | June 30, 2029 |
| practitioners | |

Project Partners and Collaborators

| Name | Organization | Role | Receiving Funds |
|---------------------|--|---|--------------------|
| Jeffrey Marr | St. Anthony Falls Laboratory, UMN | Jeff Marr is the Associate Director of Engineering and Facilities at SAFL, a licensed Professional Engineer in MN, and an expert in hydraulics and sediment transport. Marr will plan the first year measuring campaign, contribute to the laboratory experiments, and will co-lead the full-scale vane deployment in a meandering stream | Yes |
| Erik Steen | University of Minnesota | Engineer | Yes |
| Chris Feist | University of Minnesota | Engineer | Yes |
| Chris Milliren | University of Minnesota | Project Manager | Yes |
| Ben Erickson | University of Minnesota | Facilities Engineer | Yes |
| James Tucker | University of Minnesota | Facilities Engineer | Yes |
| Dick Christopher | University of Minnesota | Research Engineer | 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?

Requested funding will be used to support both research and outreach activities. The main product will be a streambank control module, hosted on a SAFL webpage, that will be shared with practitioners and MN agencies during the project, and accessible to all at the end. The module will include all the experimental results, a simple numerical model for preliminary design, and a set of guidelines on how to implement the nature-based solutions in a river section. The website will allow users to upload and share project details thus establish a community to extending the project impacts into the future.

Project Manager and Organization Qualifications

Project Manager Name: Michele Guala

Job Title: Professor (Full)

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

Michele Guala is a professor in the Department of Civil, Environmental and Geo Engineering at UMN (Twin Cities), and a faculty member, and former associate director, at SAFL. His research primarily focuses on experimental fluid dynamics, river morphodynamics, and particle turbulence interactions in geophysical flows. He has used extensively (and published on) all the SAFL facilities and flumes required for this experimental investigation. Dr. Guala will supervise one PhD student dedicated to the project and will join him/her for all the field measurements, along with budgeted SAFL support staff. Guala's NSF Career proposal (2014-2019) has been centered on geophysical flow control in fluvial environment, and his recent grant with DOE (PI J. Marr) was on sediment diversion channel for hydropower dams, so at the very core of what is proposed here to extend the sediment steering knowledge to natural streams for reduced erosion and improved fish habitat.

Recent published works on the topic include:

1) Chien-Yung Tseng; Jiyong Lee; Michele Guala; Mirko Musa (2024) "Experimental Tests of Lateral Bedload Transport Induced by a Yawed Submerged Vane Array in Open-Channel Flows", ASCE J. of Hydraulic Engineering 150 (6), 2) Jiyong Lee, Jeff Marr, Michele Guala (2022) "On Sediment Mass Flux Directionality Induced by Yawed Permeable Vanes under Near-Critical Mobility Conditions" ASCE J. of Hydraulic Engineering 148 (10), 04022019 PI Guala and co-PI Marr have been collaborating for years, more recently on a DOE sponsored project and the resulting publications.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

The University of Minnesota is one of the largest, most comprehensive, and prestigious public universities in the United States. The St. Anthony Falls Laboratory (SAFL) has been the leading laboratory in US for the study of river flows, hydraulics, and sediment transport, exporting flume design and measuring systems to many research partners and institutions over the last 30 years. Several National Academy members, from Gary Parker to Efi Foufoula, spent a considerable portion of their academic career at SAFL. Many prominent US scientists in the field of environmental fluid mechanics, sediment transport, fluvial geomorphology and hydraulics have been trained at SAFL, as PhD students and postdocs. In terms of the specific project activities proposed here, SAFL provides and maintains the laboratory flumes and the meandering channels that are critical for testing nature-inspired streambank restoration systems. Additionally, SAFL engineering staff have supported and designed field measurement systems deployed from boats, canoe, bridges, autonomous vehicles and buoys. Their expertise will be critical for reaching field sites and monitoring a variety of meandering streams in MN.

Budget Summary

| Category / | Subcategory | Description | Purpose | Gen. | % | # | Class | \$ Amount |
|--------------------------------------|-----------------------|--|--|-------|--------|------|--------------|-----------|
| Name | or Type | | | Ineli | Bene | FTE | ified | |
| Personnel | | | | gible | TITS | | Staff? | |
| Michele Guala | + | | | | 36.6% | 0.45 | | \$82.615 |
| Inff Marr | + | | | | 36.6% | 0.45 | | \$16 971 |
| Frik Steen | + | Engineer | | | 36.6% | 0.27 | | \$40,971 |
| Dick | <u> </u> | Posoarch Engineer | + | | 26.6% | 0.00 | | \$8,410 |
| Christonher | | | | | 50.076 | 0.10 | | \$19,105 |
| James Tucker | | Facilities Engineer | | | 32.3% | 0.21 | | \$25,123 |
| Ben Erickson | | Facilities engineer | | | 32.3% | 0.12 | | \$21,392 |
| Undergraduate Student | | Undergraduate researcher | | | 0% | 0.36 | | \$26,918 |
| Graduate | | Graduate Student Researcher | | | 23.2% | 1.5 | | \$177,050 |
| Chris Milliren | | Project Manager | | | 36.6% | 0.27 | 1 | \$27,324 |
| Chris Feist | | Facilities Engineer | | | 36.6% | 0.15 | | \$17,957 |
| | | | | | | | Sub Total | \$452,925 |
| Contracts and Services | | | | | | | | |
| | | | | | | | Sub Total | - |
| Equipment, Tools, and Supplies | | | | | | | | |
| | Tools and Supplies | sand, laboratory instrumentation support structures, repairments of flumes, sediment recirculation systems, and laboratory equipment | This amount is based on historical costs for i) changing bed material composition for SAFL flumes with erodible sand bed, ii) the correct deployment of measuring systems in the flumes, and iii) the maintenance of the equipment used. All these costs are primarily related to research activity 2. | | | | | \$20,725 |
| | | | | | | | Sub Total | \$20,725 |
| Capital Expenditures | | | | | | | | |

| | | A boat/kayak mounted acoustic doppler velocimeter (ADV) and necessary additional equipment, e.g. sonar. and dedicated acquisition laptop, to measure river depth and streamwise velocity. | The purpose is to collect stream bank bathymetry and flow velocity for selected cross sections in selected MN streams as part of activity 1 and 3. | X | | \$20,000 |
|------------------------------------|-------------|---|--|---|----------------|-----------|
| | | | | | Sub Total | \$20,000 |
| Acquisitions and Stewardship | | | | | | |
| | | | | | Sub Total | - |
| Travel In Minnesota | | | | | | |
| | Other | 1 travel to American Geophysical Union conference (USA) per year in addition to 30 local (MN) trips to streams and rivers | The expenses will cover the field work required to survey selected stream cross-sections (activity 1) and deploy a nature based stream bank protection system (activity 3) | | | \$15,350 |
| | | | | | Sub Total | \$15,350 |
| Travel Outside Minnesota | | | | | | |
| | | | | | Sub Total | - |
| Printing and Publication | | | | | | |
| | Publication | 2-3 publication fees at the anticipated costs of 1000-2000\$ per article | Some journals require publication fees. Depending on the subject, we should have the opportunity to use the best venue to share our results | | | \$4,000 |
| | | | | | Sub Total | \$4,000 |
| Other Expenses | | | | | | |
| | | | | | Sub Total | - |
| | | | | | Grand Total | \$513,000 |

Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or | Description | Justification Ineligible Expense or Classified Staff Request |
|---------------|----------------|--------------------------------------|---|
| | Туре | | |
| Capital | | A boat/kayak mounted acoustic | The new field instrumentation and data acquisition system are necessary for activities 1 |
| Expenditures | | doppler velocimeter (ADV) and | and 3 |
| | | necessary additional equipment, e.g. | Additional Explanation : The field measuring system will be dedicated to the study of |
| | | sonar. and dedicated acquisition | streams and river in Minnesota. After the duration of the project it will be maintained and |
| | | laptop, to measure river depth and | managed by SAFL (UMN) and will be available to other researchers for similar specific |
| | | streamwise velocity. | purposes. |
| | | | |

Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|-----------|-----------------|---|-----------|-----------|
| State | | | | |
| | | | State Sub | - |
| | | | Total | |
| Non-State | | | | |
| In-Kind | Unrecovered F&A | Support of SAFL Facilities where research will be conducted | Secured | \$211,935 |
| | | | Non State | \$211,935 |
| | | | Sub Total | |
| | | | Funds | \$211,935 |
| | | | Total | |

Total Project Cost: \$724,935

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component File: 26de58d6-64c.pdf

Alternate Text for Visual Component

The graphic show how natural installations, inspired by preliminary laboratory experiments, can be used to steer sediment towards the stream outer banks to prevent erosion, or towards the stream inner bank to improve fish habitat and improve flood plain connectivity....

Supplemental Attachments

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

| Title | File |
|--|-------------------------|
| UMN sponsored project office authorization to submit | <u>a3ff3158-6e2.pdf</u> |

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?

Yes, I understand the UMN Policy on travel 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?

Yes, Sponsored Projects Administration

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:

Angela Boutch, Administrative Manager Saint Anthony Falls Laboratory and Victoria Troxler, Principal Grants and Contracts Officer Sponsored Projects Administration, UMN (see attached letter of authorization to submit)

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