



Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-242

Proposal Title: Freeze-thaw and flood-drought cycling on streambank erosion

Project Manager Information

Name: Kimberly Hill

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: This project will study streambank erodibility as it varies with embankment materials, vegetation, and freeze-thaw / drought-flood cycling toward reducing sediment loading and protecting near-bank infrastructure and habitat.

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.

Streambank erosion poses a serious threat to water quality and nearby infrastructure. Embankment erosion is often directly related to (and leads to) near-hillslope destabilization, restoration of which requires much work and funding from different sources in Minnesota to solve associated bank stabilization problems. Recent work indicates that much of the sediment loading in streams is associated with bank erosion. Sediment loading from streambank erosion threatens the health of Minnesota streams and the bigger bodies of water into which they feed (e.g., the Minnesota, Mississippi and St. Croix Rivers, Lake Superior, and smaller lakes throughout the state). Streambank erosion and associated sediment loading are often estimated based on static properties, but in reality can vary greatly based on temperature and moisture content of streambank materials. Freeze/thaw cycles weaken embankments through loosening surface soils and changing water content. Droughts can weaken the material in embankments through drying and cracking processes and subsequent higher water levels can dislodge loosened particles and carry them downstream. Identifying how embankment erosion responds to cycles near freezing and flood/drought cycles will improve preventative measures that will include possible time-dependent best practice responses based on these cycles.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

This project will use extensive records of hydrology, stream gauges, suspended sediment and temperature across the state to identify specific watersheds particularly prone to temperature and hydrologic cycling that correlate with streambed erosion problems. This project will build on existing measurements in these watersheds by measuring sediment loading, streambank strength, and vegetation along targeted study reaches. We will choose these stream reaches by levels of impairment, including sediment loading and/or historical records of embankment failures including some not identified as impaired. We also plan to collect measurements of streambank material, grain size distributions, temperatures, and erosion resistance to understand the impact of regional variations in freeze/thaw cycles and flood/drought cycles to sources of sediment loading from embankment erosion. We will then perform meta-data analysis on the results and disseminate to the community including regional and state-level natural resource managers.

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 project will provide much needed scientific data for state and county leaders and the general public to guide erosion and water quality mitigation efforts. Information provided will include how frequency of freeze/thaw cycling impacts bank stability and erosion associated with dynamics such as frost heave and ice-bank collisions and also how frequency of flood-drought cycles through embankment material strength changes. The results will help inform timing of mitigation efforts including local embankment stabilizing efforts as well as watershed scale expectations to help inform regional WRAPS.

Activities and Milestones

Activity 1: Compile sediment, flow, and temperature measurements.

Activity Budget: \$72,000

Activity Description:

Available suspended sediment, water temperature, and flow data will be reviewed, including data associated with TMDLs and WRAPS. Air and soil temperature, rainfall, regional flood hydrographs, and frost depths will be gathered across the state. Based on the available data, a set of 3 to 4 study watersheds will be selected, including both impaired and unimpaired watersheds. We will mine readily available data that has been rigorously validated (e.g., United States Geological Survey data). We will deploy sensors in targeted stream reaches to gather local data adjacent to eroding streambanks. In particular, we will deploy sensors in streambanks to log soil temperature to identify freeze/thaw cycles and fluctuations in water content.. Samples of stream bank materials and suspended sediment (in the streams) will be collected for more detailed study.

Activity Milestones:

Description	Completion Date
Site selection and measurement plan	March 31 2023
Quantify sediment loading, stream temperature, freeze/thaw cycling, and flood/drought cycling in study watersheds	April 30 2024

Activity 2: Field Assessment of Streambank Materials and Bank Erosion

Activity Budget: \$78,000

Activity Description:

Within each watershed in Activity 1, four sites with eroding banks will be selected for additional study. At each site, the bank materials will be assessed for local strength, water content, and vegetation cover. The erodibility of bank materials will be assessed at targeted times, e.g. after a freeze/thaw cycle, and after a very dry period. Material samples will be collected and analyzed for moisture, grain size distribution, and organic content. Clay content and type will be derived from soil surveys. The riparian vegetation will be assessed in the region for type (woody, herbaceous) and degree of coverage. Measurements will include characterization of the tree canopy, shading conditions and presence of grassy vegetation. Stream bank erosion will also be assessed in a subset of stream reaches for years immediately prior to and during the project period using aerial photos, satellite imagery, and repeat lidar where available.

Activity Milestones:

Description	Completion Date
Collect streambank samples	October 31 2024
Laboratory analysis of samples	December 31 2024
Create streambank erosion map	February 28 2025
Create statewide map of hydrologic cycling and freeze/thaw cycling	April 30 2025

Activity 3: Assess correlations between streambank erosion, local freeze-thaw cycles and flood-drought cycles as they vary with bank materials and vegetation.

Activity Budget: \$49,000

Activity Description:

Based on the data collected in the study watersheds in Activities 1 and 2, the current temperature (freeze-thaw cycling)

and hydrology (flood-drought cycling) conditions will be assessed, and the relationships between these cycles along with streambank materials (including vegetation), bank erosion, and sediment loads will be explored. The relationships between streambank erosion and streambank measured strength and freeze-thaw / flood-drought cycling frequencies will be determined as associated with bank materials and streambank vegetation. We will report these in the context of stream, river, and watershed impairment. Relationships developed for erosion and sediment loading in the chosen watersheds will be compared with others of qualitatively similar streambank materials and temperature and rainfall cycling to assess usefulness across a broader range of MN watersheds.

Activity Milestones:

Description	Completion Date
Presentation for MN Water Resources Conference	October 31 2024
Summary of streambank-cycling-sediment loading relationships	April 30 2025
Summary document and guidelines for similar assessments across MN	June 30 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. William Herb	University of Minnesota, St. Anthony Falls Lab	Dr. Herb will lead efforts regarding the collection and analysis of hydrologic and temperature cycling and TSS and flow measurements with the help of postdoctoral researcher, undergraduate students and SAFL staff	Yes
Dr. Jessica Kozarek	University of Minnesota, St. Anthony Falls Laboratory	Dr. Kozarek will lead efforts regarding the collection and analysis of stream gauge data, lead the students in running jet test measurements and other sediment measurements in the field.	Yes
Dr. Kimberly Hill	University of Minnesota, St. Anthony Falls Laboratory and Department of Civil, Environmental, and Geo-Engineering	Dr. Hill will be the project manager. She will work with Drs. Kozark and Herb to guide field efforts regarding the collection and analysis of data and take responsibility for appropriate dissemination. She will lead embankment material strength studies including weakening due to hydrologic and freeze/thaw cycling including frost-heave.	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 be funded?

The results of the data acquisition, mapping, and erosion correlations will be widely disseminated including web-based publication, a UMN report and/or peer reviewed journal paper to be presented at the Minnesota Water Resources Conference. This study is focused on quantifying streambank erosion dynamics due to temperature and hydrologic (freeze/thaw and flood/drought) cycles in Minnesota. Additional funding will be sought to expand these results through a sufficiently deeper understanding of the impact of local materials and geology more broadly across similar climates in the midwest and hopefully over a broader range of temperature / moisture history across the US.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Enhancing Spawning Habitat Restoration in Minnesota Lakes	M.L. 2017, Chp. 96, Sec. 2, Subd. 08e	\$294,000

Project Manager and Organization Qualifications

Project Manager Name: Kimberly Hill

Job Title: Associate Professor

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

Key Qualifications

Kimberly Hill has conducted research on sediment transport in stream and river channels for the past thirteen years. Her past projects have included particle size-dependence of sediment transport in streams, measurements of flows as they relate to entrainment of particles in streams, and stability of emergent and deposited sediments under mild wave action. She has led field projects on debris flow studies and led the development of a software tool for MnDOT (the "hill

model” in Itasca’s PFC 3d DEM code) that helped model stability of sub-pavement roadbed materials and streambank materials under rip-rap.

Education

Ph.D., Physics, University of Minnesota 1997

M.S., Physics, University of Minnesota 1996

B.S., Physics, University of Michigan 1991

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

The St. Anthony Falls Laboratory (SAFL) is an interdisciplinary fluid mechanics research and educational facility of the College of Science and Engineering at the University of Minnesota. SAFL nurtures a highly interdisciplinary research environment with faculty, students, and staff from the departments of Earth Sciences; Ecology; Mechanical Engineering and Civil, Environmental, and Geo-Engineering. The mission of SAFL is 1) to advance fundamental knowledge in engineering, environmental, geophysical, and biological fluid mechanics, 2) to benefit society by implementing this knowledge to develop engineering solutions to major environmental, water, ecosystem, health, and energy-related problems, and 3) to disseminate new knowledge to University of Minnesota students, the engineering and scientific community, and the public. SAFL is well instrumented for the study of streambank erosion and for the study of interactions between soil mechanics, fluid mechanics and temperature / hydrologic cycling with expertise and equipment for evaluating available temperature, stream gauge, and TSS along with embankment materials.. SAFL also has in-house accounting, IT and technical staff to support various aspects of the effort.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Kimberly Hill		PI			26.7%	0.09		\$10,045
William Herb		Co-PI			26.7%	0.57		\$62,641
Jessica Kozarek		Co-PI			26.7%	0.57		\$62,371
Christopher Milliren		Assist with assembly of strength of streambank apparatus. Assist with laboratory tests.			24.1%	0.06		\$5,685
Postdoctoral Researcher		Assist with field installation of sensors, data acquisition, and analysis.			20.3%	0.48		\$31,350
Undergraduate Student		Assist with laboratory tests and some field work.			0%	0.18		\$5,508
							Sub Total	\$177,600
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	supplies for building soil cohesion tester, also filters, soil temperature and humidity probes, collection vials, data loggers, turbidity meter	Field work					\$18,400
							Sub Total	\$18,400
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								

	Miles/ Meals/ Lodging	1 to 2 trips to field sites each year calculated based on mileage to a variety of watersheds throughout Minnesota.	Install sensors, acquire data on streambank strength and erosion, record data from temperature probes, take sample grabs from stream and streambanks, record type and degree of vegetation					\$3,000
							Sub Total	\$3,000
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
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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	\$109,450
			Non State Sub Total	\$109,450
			Funds Total	\$109,450

Attachments

Required Attachments

Visual Component

File: [c55ea161-156.pdf](#)

Alternate Text for Visual Component

The graphic is centered map of the State of Minnesota with the watershed districts labeled and its major watershed basins identified by color. The Minnesota map is bordered by images identify the two central themes of the proposal: freeze-thaw cycling and its effects on streambank erosion and drought-flood cycling and the associated effects of streambank erosion. Measurements of bank strength, sediment loading, and streambank erosion before and after cycling will inform how frequency of cycl...

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?

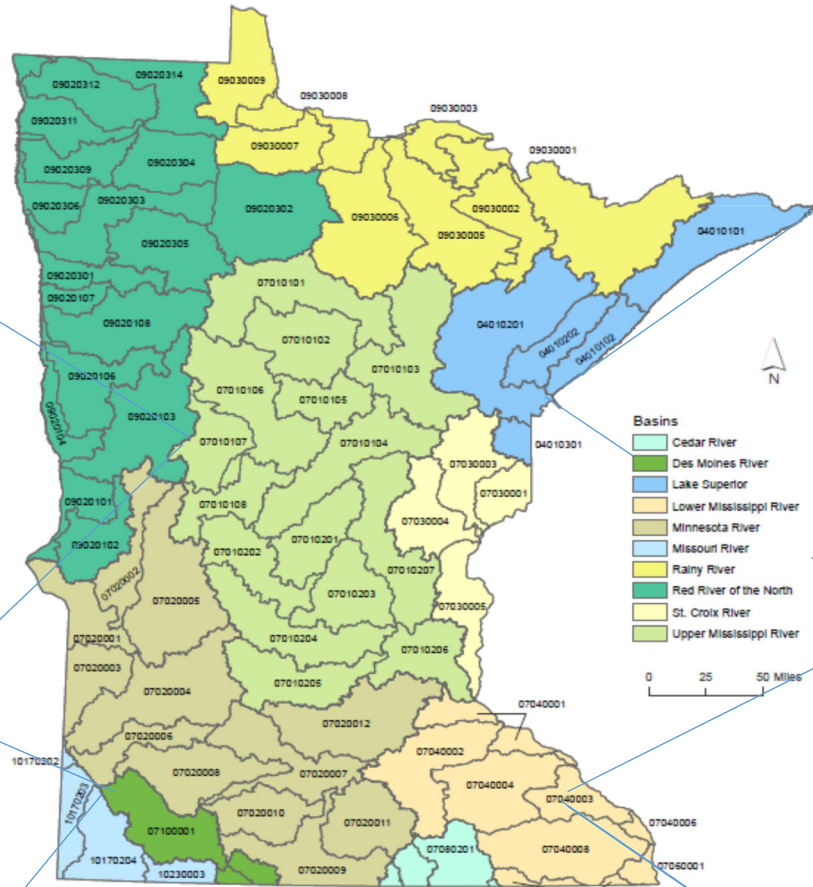
Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Freeze-Thaw and Flood-Drought Cycling on Streambank Erosion – Variations with Watershed? Bank Materials? Vegetation?

Basins and Major Watershed 8-Digit HUC Numbers in Minnesota



Measurements of bank strength, sediment loading, and streambank erosion before and after cycling will inform how frequency of cycling should impact restoration and management.