Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-038

Proposal Title: Stormy Southern Minnesota: Future Floods, Erosion, and Management

Project Manager Information

Name: Andrew Wickert

Organization: U of MN - St. Anthony Falls Laboratory

Office Telephone: (612) 635-6878

Email: awickert@umn.edu

Project Basic Information

Project Summary: Frequent extreme floods are reshaping southern Minnesota's rivers and valleys. We aim to uncover their causes and predict future flood statistics alongside their impacts on river widening and erosion.

Funds Requested: $200,000

Proposed Project Completion: June 30, 2026

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?

Region(s): SW, SE,

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

Region(s): SW, SE,

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.

Increasing large floods across southern Minnesota are too big for river channels to hold. Nature's response is for these floodwaters to erode larger channels that will, over time, be able to carry more intense floods: southern Minnesota's rivers have increased in width by 25–100% since the mid-20th century. However, this streambank erosion damages infrastructure and degrades water and habitat quality by increasing suspended-sediment concentrations in the flow.

Attribution for this flooding remains unclear. Larger storms and a transition to a rain- rather than snow-dominated hydrology are supplying more water to southern Minnesota's rivers. Agricultural drainage, enhanced through widespread tiling, carries this water rapidly to rivers. Is either factor clearly the primary cause, or are both important?

We will examine flooding and stream erosion under a range of hydroclimatic and land-management scenarios, using data spanning southern Minnesota alongside models developed by Wickert. This will improve long-range flood forecasts by incorporating the amount and rate of water supplied to the river alongside its capacity to move this water out of the catchment. Furthermore, this approach allows us to forecast changes to river geometry and stability, and to learn what steps we can take to mitigate flooding and erosion.

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 assess past and present drivers of hydrological and landscape change to predict and help prevent future erosion and flooding.

Flood drivers:
We will obtain precipitation and streamflow data from a transect of catchments across southern Minnesota. Using a linear-reservoir hydrological model, we will analyze and isolate the effects of precipitation-pattern change (water supplied to a catchment) and agricultural drainage (speed of water delivery to the river) on flood intensity. Through this, we will produce scenarios of future river discharge under changing climate and land use.

River stability and change:
We will map changes in river width and migration rate within the study catchments using historical maps and airphotos since the early 20th century. We will combine these with in-situ measured bank strength, bank composition, channel and floodplain roughness, and channel hydraulic geometry. These serve as necessary data to set up and calibrate our model of river-width change.

Predictive modeling of flooding and erosion:
We will combine historical streamflow and channel-change data to calibrate a model of river-channel stability for each study catchment. We will then predict future floodwater levels and streambank erosion rates under variable climate and land-use scenarios and communicate our findings to land and water 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?

1. Learn whether increasing streamflows result primarily from climate change, agricultural drainage, or both.

2. Predict future streamflow under plausible climate and land-use futures.

3. Develop and build an instrument to measure streambank erodibility and characterize streambank strength across southern Minnesota

4. Assess and forecast past and future flood impacts on river-channel widening, erosion, and stability.

5. Improve long-range flood predictions by combining changes in channel conveyance capacity with changes in water delivered to rivers.

6. Communicate forecasts to land and water managers by making data and models freely available, providing technical documentation, and publishing accessible nontechnical materials.

Activities and Milestones

Activity 1: Hydrological modeling for flood prediction and attribution

Activity Budget: $59,000

Activity Description:
Increasing large floods across southern Minnesota correspond both to enhanced precipitation, including large-rainfall events, and to expanding agricultural drainage networks. Accurately predicting flood events into the future requires that we understand the individual and combined influences of these two hydrological drivers. To do so, we will first collect river-discharge records from a series of rivers across southern Minnesota, including (from west to east) the Redwood, Cottonwood, Le Sueur, Cannon, and Root Rivers. These cover a precipitation gradient from dry to wet, an agricultural gradient from wheat to soy to corn, a geological gradient from Des Moines Lobe glacial till to sedimentary bedrock, and a native-ecology gradient from prairie to deciduous forest. Second, we will assemble gridded past temperature and precipitation data products dating from the early 20th century to present for each study catchment. With these in hand, we will simulate precipitation, infiltration, groundwater and soil-zone water storage, snow processes, and streamflow using the RaVENS model developed by our group (https://github.com/MNiMORPH/RaVENS). The temperature and precipitation inputs directly address climate impacts, and we will recalibrate water storage and infiltration in the model during each decade to assess the changing impacts of artificial drainage.

Activity Milestones:

Description	Approximate Completion Date
Select final study catchments based on gathered and quality-checked streamflow data	September 30, 2024
Obtain and tabulate gridded data products for each catchment	October 31, 2024
Test model simulations and update code as needed	December 31, 2024
Complete all model runs	February 28, 2025
Analyze changing terrestrial hydrology for climate- and land-use impacts on rivers	April 30, 2025

Activity 2: Channel planform change, field characterization, and river-width model calibration

Activity Budget: $96,000

Activity Description:
We will (1) characterize river-channel hydraulic and geotechnical properties in the field, (2) map historic river-channel change and erosion since the early 20th century, and (3) use these data alongside past streamflow records (Activity 1) to calibrate our river-width model (https://github.com/MNiMORPH/OTTAR) to each field site.

In the field, we will measure channel hydraulic geometry, bed and bank sediment grain size (as a measure of resistance to transport), cohesive strength of muddy streambanks (common in southern Minnesota), and channel and floodplain roughness (important to link streamflow to flow depth, and hence, stress exerted on banks). This field work requires that we engineer and build a device to measure streambank strength, which we will base off of work by Dunne et al. (2019: https://eartharxiv.org/repository/view/849/).

Additionally, we will map channel banklines from historic maps and airphotos from the early 20th century to present. These provide changes in river width and planform.

Finally, we will use both field and remotely sensed data to compute bank stresses, channel width/stability, and erosion across southern Minnesota rivers. By calibrating our data-constrained model runs (OTTAR) to these rivers, we will characterize their response to changing flood regime.

Activity Milestones:

Description	Approximate Completion Date
Design and construction of bank-strength-measurement device	April 30, 2025
Field measurements of streambank strength, sediment size, channel and floodplain roughness, and hydraulic geometry	October 31, 2025
Channel bankline mapping and planform analysis	October 31, 2025
Model-based calibration and characterization of study-river width response to past flooding	February 28, 2026

Activity 3: River stability, flood, and erosion forecasts

Activity Budget: $45,000

Activity Description:
We predict future channel widening and erosion based on scenarios of future changes to climate and artificial drainage.

We will first combine the compiled historical precipitation and temperature data products with ensemble predictions from climate models used in the IPCC AR6. We will statistically resample our precipitation data products into likely future scenarios under the range of possible climate futures.

We will then generate a set of possible land-drainage futures, ranging from (a) present-day conditions to (b) reversion to prior conditions (e.g., from drainage-system removal or restoration of wetlands) to (c) continued expansion of artificial drainage networks.

Using these scenarios, we will develop a set of potential streamflow futures until the year 2100. We will use these projected streamflows to drive our data-calibrated river-width model (OTTAR) and quantify bank erosion. With both streamflow and channel-geometry futures in hand, we will generate statistical predictions of flooding under each of these hydrogeomorphic scenario sets.

Finally, we will communicate the results of our scenarios to provide a practical on-the-ground guide to erosion and flooding futures from hydroclimatic and artificial drainage change. This may offer opportunities to mitigate and/or adapt to future floods and river-channel erosion.

Activity Milestones:

Description	Approximate Completion Date
Acquire and assemble IPCC AR6 climate-model ensemble outputs	December 31, 2024
Generate statistically downscaled river-discharge futures	April 30, 2025
Simulate future channel widening and erosion under the range of future climate and land-drainage scenarios	March 31, 2026
Generate a set of flood futures based on combined hydroclimatic, artificial drainage, and geomorphic change	April 30, 2026
Communicate the results and degree to which flood and erosion mitigation may be possible	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jabari Jones	University of Minnesota	Geomorphologist: Mapping river change, characterizing river and floodplain attributes, and mentoring undergraduate-student researcher	Yes
Xue Feng	University of Minnesota	Hydrology advisor: Data sets, modeling approaches, and watershed processes	No

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?

Data and model outputs will be shared via the Data Repository for University of Minnesota (DRUM) and web resources from the St. Anthony Falls Laboratory (SAFL). Alongside our science-team members, the SAFL Communications Manager will aid in presenting the key results through a research summary, press release, storymap, and social-media outreach. Communication materials will be designed for both technical and nontechnical audiences. We will send results to watershed-district and natural resource managers whose jurisdiction aligns with each of our study catchments.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Land-Use and Climate Impacts on Minnesota's Whitewater River	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 03h	$199,000

Project Manager and Organization Qualifications

Project Manager Name: Andrew Wickert

Job Title: Associate Professor

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

Dr. Wickert (research-group website: https://mnimorph.science/) earned his S.B. in Earth, Atmospheric, and Planetary Science from MIT (2008) and his Ph.D. in Geology from the University of Colorado Boulder (2014). He has 15 years of experience working to understand how sediment is transported and river systems change, and currently manages more than $3M in river-related federal projects. His pertinent technical expertise includes land and stream surveying, geomorphic assessment and mapping, hydrological model development, fluid mechanics, and scientific computing to archive and analyze large data sets. He developed both the hydrological (github.com/MNiMORPH/RaVENS) and geomorphic (github.com/MNiMORPH/OTTAR) models to be used in this project. He has participated in and used data from global climate modeling research, similar to the use of the IPCC AR6 model runs noted in this proposal, and furthermore has experience with the proposed gridded data products for past temperature and precipitation. His research group is experienced in both field and remotely sensed research on rivers, and has both the equipment and the expertise required to successfully complete the proposed field research. Dr. Wickert is Associate Professor of Earth-surface processes in the Department of Earth & Environmental Sciences and at the St. Anthony Falls Lab of the University of Minnesota.

Aiding Dr. Wickert will be Jabari Jones and Dr. Xue Feng. Jones has broad experience in watershed science and geomorphology, and especially in river response to flooding. Dr. Feng, professor of hydrology, will advise data-assembly and modeling efforts.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
The Saint Anthony Falls Laboratory (SAFL) is a world-renowned research facility for environmental fluid mechanics and related fields. This 4,880-square-meter facility is built into the side of St. Anthony Falls in downtown Minneapolis, whose water it uses to run some of the largest hydraulics experiments in the world. In addition to direct experimentation with flowing water, SAFL hosts a diverse group of scientists and engineers who work on environmental fluid mechanics as it applies to the atmosphere, climate, land surface, sediments, and biological processes. The faculty, staff, and students at SAFL spread their efforts across both basic scientific advances and work with immediate applications to infrastructure, the environment, and societal needs. The current SAFL director is Prof. Lian Shen, with Michele Guala as the associate director for research and Jeff Marr as the associate director for engineering and facilities. Marr and a member of the SAFL engineering staff will design and construct the bank-erosion-measurement device. Communications Manager Clare Boerigter will support data and study-result dissemination in ways that are appropriate for both technical and nontechnical audiences.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Andrew Wickert		Project manager; faculty			27%	0.04		$7,345
Jabari Jones		Geomorphology lead			25%	0.08		$10,976
Postdoctoral Research Associate		Assembling data, hydrological modeling, geomorphic modeling			20%	1.84		$129,708
Engineering Manager		Coordinating construction of bank-strength-measurement device			27%	0.02		$3,140
Associate Engineer		Design, construction, and testing of bank-strength-measurement device			24%	0.19		$18,253
Communications Manager		Generating materials to disseminate project outcomes			24%	0.08		$6,798
Undergraduate Researcher		River-channel mapping and analysis; field assistance			0%	0.62		$19,200
							Sub Total	**$195,420**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Field notebooks and consumables	Recording data on river geometry, bank strength, and conditions					$100
	Tools and Supplies	Waders and wading boots	Accessing streams during surveys					$300
	Tools and Supplies	Materials to build bank-strength-measurement device	Characterize the stress at which stream banks start to erode: Predictions of flood impacts					$781
							Sub Total	**$1,181**
Capital Expenditures								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	1800 miles	Travel to streams across southern Minnesota for field characterization at $0.655/mile					$1,179
	Miles/ Meals/ Lodging	15 nights lodging (camping)	Overnight camping during trips to field sites, as needed, at $30/person/night					$450
	Miles/ Meals/ Lodging	Per diem: 15 days, $59/day, 2 people	Meals and incidental expenses while traveling to field sites and performing field research					$1,770
							Sub Total	**$3,399**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$200,000**

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: d35d9ec1-13f.pdf

Alternate Text for Visual Component

Water discharge increases significantly since the early 20th century in (west to east) the Redwood, Cottonwood, Le Sueur, Cannon, and Root River watersheds.

Landscape change from the early 20th century to present: Increasing storms, more rain instead of snow, erosion and river widening, agricultural drainage, transition to larger single-crop farms....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
UMN SPA Letter of Endorsement	bfb539d6-26d.doc

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

Does your project include the design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No