Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-392

Proposal Title: Minnesota Beaver Dams as Natural Infrastructure

Project Manager Information

Name: Emily Fairfax

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: Develop a complete and generalizable hydrologic model for Minnesota beaver dams as a form of natural infrastructure, measuring and modeling their influence on hydrologic processes and associated environmental impacts

ENRTF Funds Requested: $791,000

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?

In the Future

Narrative

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

The construction and decommissioning of human-made dams is highly regulated and monitored in Minnesota. This degree of oversight is justified - centuries of research clearly shows how influential our dam infrastructure is on lake, stream, and river hydrologic processes and ecosystems. Similar to human-made dams, beaver dams also fundamentally alter the movement of water, sediment, and nutrients in freshwater systems. However unlike human-made dams, beaver dams are natural infrastructure with limited lifespans made from natural materials (mud, stones, tree branches), range from nearly watertight to extremely leaky, and go through cycles of maintenance and disrepair as beavers come and go. Research on the physical hydrology of beaver dams is sparse - there is no functional model for beaver dam hydraulics, environmental impacts, or failure mechanisms. Thus, beaver dams are not captured in any surface or groundwater hydrology models in the state, despite the fact that there are likely tens to hundreds of thousands of beaver dams in Minnesota that have very real impacts on hydrologic processes. Understanding how beaver dams affect water quality, stormwater management, fisheries, ecosystem resilience, and lake levels all requires a robust and tunable physics-based model for how water moves over, under, and through beaver dams.

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.

Through a combination of field studies, physical modeling, and computational modeling, we will develop a quantitative hydrologic model for beaver dams in Minnesota that can be readily integrated into popular surface and groundwater modeling environments (e.g., MODFLOW, HEC-RAS, SWMM, HYDRUS). We will 1) instrument and collect hydrologic data from naturally occurring beaver dams in at least three distinct environmental contexts common in Minnesota: low gradient forest or prairie streams, high-gradient drainages (i.e. Driftless Area), and lake inlets and outlets; 2) use our field data plus other existing data (e.g., streamflow monitoring data from Minnesota Department of Natural Resources (MNDNR), water quality and macroinvertebrate data from Minnesota Pollution Control Agency (MNPCA)) to construct and calibrate a physical model of a beaver dam in an outdoor flume at the Saint Anthony Falls Lab; 3) use the physical beaver dam model to simulate the full range of potential streamflow conditions, including hydrologic extremes (droughts, floods) to the point of failure; and 4) use our field data and physical model to build a computational, physics-based hydrologic model for beaver dams that can be integrated into existing surface and groundwater modeling frameworks for evaluating beaver dam impacts.

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 primary outcome is a hydrologic model for beaver dams that integrates into existing surface water, groundwater, and ecological modeling frameworks. This will inform science-based management of Minnesota waters where beavers are (or could be) relatively abundant, and where the conservation or removal of beaver dams may alter stream hydrology and initiate cascading impacts on other natural resources. To demonstrate model use, we will combine field data with physical and computational modeling to produce case studies showing how varying levels of beaver damming can affect stream temperature, dissolved oxygen, turbidity, salinity, stormwater storage, and flood and drought resilience.

Activities and Milestones

Activity 1: Field Study of Natural Beaver Dam Hydrology and Associated Impacts in Three Minnesota Environments

Activity Budget: $255,919

Activity Description:
The objective of this activity is to create a model calibration dataset for how beavers normally alter hydrologic processes. We will collect one year of baseline data on hydrology and water quality (water temperature, dissolved oxygen, salinity) at three natural beavers dams, plus two additional years of data for model validation. We will study three dams in the following contexts: prairie or forested lowlands; high gradient drainages; and lake inlets / outlets.

Each of the three field sites will be instrumented with:

- two streamflow loggers (one upstream / one downstream of dam) to develop a flow rating curve for the beaver dam
- game cameras to observe beaver dam condition
- two water quality sensors (one upstream / one downstream of dam) to measure dissolved oxygen, water depth, and salinity
- four strings of 5 water temperature sensors (two upstream / two downstream of dam) to characterize thermal profiles with depth
- a 2x5 grid of 10 shallow groundwater wells with water level loggers in the floodplain on either side of the stream around a beaver dam (20 wells + loggers per site) to evaluate lateral hydrologic exchange

Drone and field surveys of stream form will be conducted monthly in Yr 1, then quarterly in Yr 2 and 3.

Activity Milestones:

Description	Approximate Completion Date
Select and instrument three beaver dam field sites	August 31, 2026
Collect Year 1 field data to be used in physical model calibration	August 31, 2027
Collect Year 2 & Year 3 data to be used in model validation (physical and computational)	June 30, 2029

Activity 2: Simulate Streamflow Extremes and Associated Environmental Impacts in Physical Model Beaver Dammed Channel

Activity Budget: $323,542

Activity Description:
The objective of this activity is to create a physical model of a beaver dam in an outdoor flume at Saint Anthony Falls Laboratory. This model will allow us to determine physical hydrologic properties of in-stream features (i.e., beaver dams) by observing and measuring their interactions with a scaled version of probable streamflow conditions, which will be controlled by the research team via pipes and valves. We will experimentally manipulate beaver dam conditions to simulate partial and full breaches, removals, and reconstructions repeatedly under predetermined conditions, without disturbing real ecosystems. Physical modeling provides robust paired control (no beaver dam present) and impact (beaver dam present) data for use in computational modeling.
To do this, we will:

- set up a large (200-300ft) outdoor flume to simulate beaver dam impacts
- build a mock beaver dam in the flume using the same materials beavers use (stones, sticks, mud)
- calibrate the flume design, streambed materials, dam properties, and flow regime to be an accurate scaled

representation of natural beavers dams using field data from year 1

- simulate beaver dam interactions with novel flow regimes (floods, droughts) of varying intensities
- stress-test beaver dams to the point of failure and record failure mechanisms and impacts

Activity Milestones:

Description	Approximate Completion Date
Set up / construction of the outdoor flume for physical beaver dam model simulations	June 30, 2027
Outdoor flume functional assessments	August 31, 2027
Physical model calibration to Yr 1 field data	December 31, 2027
Physical modeling of beaver dam interactions with novel flow regimes	June 30, 2028
Failure point and mechanism assessments for different conditions of beaver dams	June 30, 2029

Activity 3: Develop and Test a Generalizable Computational Model of Minnesota Beaver Dam Hydrology

Activity Budget: $211,539

Activity Description:

The objective of this activity is to create a computational model for beaver dams that is easy to integrate into existing surface water, groundwater, and ecological modeling frameworks. With this, we can predict the effects of current and potential future beaver dams on stream hydrology and its associated environmental impacts. This will support stronger science-based management of Minnesota's other stream-based natural resources, including fisheries, stormwater routing, lake levels, and recreational spaces. To demonstrate model usability, we will develop case study model vignettes of beaver dam influence on water temperature, water quality (turbidity, nitrates, etc), macroinvertebrate habitat units, and stormwater storage. We will then use the model to show how conserving or removing the beaver dams would change environmental conditions.

To do this, we will:

- set up a first-order dam model template of influential factors (sinuosity, length, width, height, porosity, presence and distribution of gaps in dam) and perform sensitivity analyses in MODFLOW or similar to identify which aspects of beaver dams are most influential on hydrologic processes
- calibrate and validate the computational model with field and physical model data
- simulate beaver dam impacts on hydrologic and environmental systems of interest (e.g., water quality, habitat units, stormwater, drought resilience)

Activity Milestones:

Description	Approximate Completion Date
Set up computational model beaver dam template and perform sensitivity analyses	December 31, 2026
Computational model calibration to Yr 1 field data	December 31, 2027
Assimilate and calibrate with data from physical modeling of beaver dam interactions with novel flow	August 31, 2028
Validate computational model on Yr 2 + part of Yr 3 field data	June 30, 2029
Conduct case study vignettes demonstrating model usability for predicting beaver dam impacts on environmental systems	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Andy Riesgraf	University of Minnesota, St. Anthony Falls Laboratory	Andy is a research scientist with a background in fisheries, aquatic biology, wildlife, and hydrodynamics. He has expertise in experimental design and data acquisition in laboratory and field settings. He will co-lead development, experimental runs, and maintenance of the physical model, and field instrumentation and data collection.	Yes
Postdoctoral Researcher 1 (to be named)	University of Minnesota, St. Anthony Falls Laboratory	A postdoctoral researcher will be recruited to the Fairfax Lab for this project. Luwen Wan, currently a postdoc at Stanford University, has expressed interest in working on this research - specifically the fluid dynamics, water quality, and flow modeling - if it were to be funded. Two year appointment.	Yes
Postdoctoral Researcher 2 (Jessie Moravek)	University of Minnesota, St. Anthony Falls Laboratory	Current postdoctoral researcher, Jessie Moravek, will lead field investigations of natural beaver dams and assist in calibration of the physical model in the outdoor flume. One year appointment.	Yes
Matt Lueker	University of Minnesota, St. Anthony Falls Laboratory	Matt is a research engineer with intimate knowledge of SAFL's experimental facilities. He will help to get the experimental laboratory facility functioning (e.g., flow rates).	Yes
Dick Christopher	University of Minnesota, St. Anthony Falls Laboratory	Dick is a research scientist who is skilled in physical model design and construction. He will work closely with Andy early on in the project (Yr1) to get the experimental lab facility to specification.	Yes
Chris Milliren	University of Minnesota, St. Anthony Falls Laboratory	Chris is a research engineer with expertise in data acquisition instrumentation and their deployment. He will develop our field and lab data acquisition systems	Yes
Ben Erickson	University of Minnesota, St. Anthony Falls Laboratory	Ben is a research support technician that will provide general support during field and lab work.	Yes
Erik Noren	University of Minnesota, St. Anthony Falls Laboratory	Erik is a fabricator/welder at SAFL. He will assist in the initial lab experiment set-up and be a resource for when things need maintenance.	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?

We will produce and share a technical report, including complete model documentation and step-by-step instructions, with managers and stakeholders (e.g. MNDNR, MNPCA) to support evidence-based beaver dam management decision making. We will share the beaver dam hydrologic model publicly in a permanent code archive (e.g., the CUAHSI Hydroshare) along with our case study vignette codes. We will share results with the public through news coverage and online articles, utilizing the St. Anthony Falls Laboratory's public relations team and Dr. Fairfax's media presence. If more work is needed (e.g. further modeling work), we will apply for additional funding.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Wind Wave and Boating Impacts on Inland Lakes	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 04c	$415,000

Project Manager and Organization Qualifications

Project Manager Name: Emily Fairfax

Job Title: Assistant Professor of Geography

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Emily Fairfax is an assistant professor in the Department of Geography, Environment, and Society as well as an Affiliate Faculty Member at the Saint Anthony Falls Laboratory, both at the University of Minnesota. Dr. Fairfax is an interdisciplinary ecohydrologist with expertise in ecosystem engineers, environmental disturbance, remote sensing, and science communication. She has 10 years of experience studying beavers and their influence on biophysical processes, in addition to extensive formal education in chemistry, physics, geology, and hydrology. Dr. Fairfax is globally recognized as a leading expert on beaver ecosystem engineering, and her research has been featured in The New York Times, The LA Times, NPR, PBS, Science Friday, BBC, and National Geographic, amongst others. Dr. Fairfax frequently partners and collaborates with state land and wildlife management agencies across the US, including MNDNR, to better understand how beavers are modifying waters, ecosystems, and landscapes in the context of a changing climate. Fairfax currently manages a productive beaver research lab with 2 postdoctoral associates, 3 PhD students, 2 masters students, 2 undergraduate students, and 2 professional research assistants.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
The St. Anthony Falls Laboratory at the University of Minnesota Twin Cities is an interdisciplinary fluid dynamics research lab that specializes in computer and physical modeling as well as education about rivers, streams, and lakes. The Department of Geography, Environment, and Society at the University of Minnesota Twin Cities is dedicated to creating and disseminating geographical and environmental knowledge through world-class research and teaching.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Emily Fairfax (PI)		Assistant Professor, PI. Lead, manage, and conduct all project activities and dissemination. Summer salary for 2 months in Yr 1 when field work and physical model set up are occurring, then 1 month each in Yr 2 and 3 to co-lead modeling work.			36.6%	0.33		$66,945
Andy Riesgraf (Research Scientist)		Researcher that will lead the establishment, experimental runs, and maintenance of the physical model. Co-leads field investigations with Fairfax. 50% time allotted to project each year for 3 years			36.6%	1.5		$169,874
Postdoctoral Associates (2)		Postdoctoral Associates (2), 100% time allotted to project for all three years. Postdoc 1 co-leads flow modeling for physical model and computational model with Fairfax for two years. Postdoc 2 co-leads field work and flume calibration with Fairfax and Riesgraf for one year.			25.9%	3		$280,573
Undergraduate Student		Undergraduate student TBD to support physical model data collection and field data collection for the duration of the project at 366 hours per year.			0%	0.54		$19,776
Matt Lueker (Research Engineer)		Research Engineer that will assist with getting the experimental laboratory facility functioning. 1 month in Yr 1 for initial set up, 0.5 months in Yr 2 and 3 for maintenance.			36.6%	0.18		$21,584
Dick Christopher (Staff Researcher)		Researcher with expertise in physical model design and construction. 3.75 months in Yr 1 for initial set up, 1 month in Yr 2 and 3 for maintenance.			36.6%	0.48		$54,318
Chris Milliren (Research Engineer)		Researcher with expertise in physical model design and construction. 1 month in Yr 1 for initial set up, 0.5 months in Yr 2 and 3 for maintenance.			36.6%	0.18		$17,992
Ben Erickson (Research Support Technician)		Research Support Technician that will provide general support throughout the project on safety training, coordination, and maintenance. 120 hrs in Yr 1 for set up, 20 hr in Yr 2 and 3 for maintenance.			32.3%	0.09		$7,467
Erik Noren (Welder / Fabricator)		Fabricator/Welder that will help with initial experiment set-up and maintenance needs. 88 hr in Yr 1 for initial set up.			32.3%	0.03		$3,777

							Sub Total	**$642,306**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Excavator Rental for Outdoor Flume Shaping and Set Up (Activity 2). $1310 per week for 4 weeks	Move soil during outdoor flume shaping to construct physical model beaver dammed channel.					$5,240
	Tools and Supplies	HOBO Temperature Loggers x 60 5 per temperature profile string, two strings upstream and two strings downstream at each of the three ponds instrumented in Activity 1. $120 per sensor	Record water temperature continuously with depth at field sites					$7,200
	Tools and Supplies	HOBO Data Shuttle for offloading field data from sensor x 1	Retrieve data from HOBO sensors					$399
	Tools and Supplies	Fondriest Non-Contact Flow Sensor x 6 1 upstream and 1 downstream at each of the three ponds instrumented as described in Activity 1. $5000 per sensor	Record streamflow above and below beaver dams in field study					$30,000
	Tools and Supplies	HOBO MX800 Data Logger with Conductivity, Depth, and Dissolved Oxygen sensors ($2709 per unit) x 6 1 upstream and 1 downstream of each of the three instrumented ponds as described in Activity 1	Record conductivity, water level, and DO above and below beaver dams in field study					$16,254
	Tools and Supplies	HOBO Water Level Loggers ($385 per unit) x 60 for monitoring groundwater levels in a grid around each instrumented beaver pond as described in Activity 1	Record water level depth in shallow groundwater wells continuously at field sites to assess lateral hydrologic exchange					$23,100
	Tools and Supplies	Wildlife game cameras ($200 per unit) plus locks ($50 per unit) x 18 3 upstream and 3 downstream of each instrumented beaver pond as described in Activity 1	Record physical state of beaver dams via timelapse photography and observe beaver activity status at field sites					$4,500
	Tools and Supplies	Miscellaneous replacement batteries, cables, casings, memory cards, etc. for field instruments as described in Activity 1	Field instrument maintenance					$1,511
	Tools and Supplies	Flume Set Up Materials: Membrane EPDM Firestone pond liner ($15,000 total, priced per area), Pipe and Plumbing ($5000), Mag Meter ($3390), Head and Tail Box ($2500), Flood Tank ($2600), Data Loggers	Set up the outdoor flume for physical beaver dam modeling					$38,490

		and Housing ($6000), Soil ($2000), Vegetation ($2000) for Activity 2 physical modeling						
							Sub Total	**$126,694**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Monthly visits for PI Fairfax, Riesgraf, and Postdoctoral Associates, and undergraduate assistant to 3 field sites in Yr 1, quarterly visits in Yr 2 and 3. Planned 1-2 nights at each site per visit for instrumentation maintenance, data collection, drone and field surveys. Mileage at GSA rate of $0.70/mile plus lodging. Estimated at $1000 per visit (4 people at $250/per person per visit inclusive of mileage, lodging, and meals).	Travel to collect data from field sites and perform instrument maintenance. Exact locations and distances to be determined upon final selection of field sites. Field sties will be selected to meet study objectives and keep travel within budget proposed.					$20,000
							Sub Total	**$20,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Peer-reviewed publication, page charges. Publications that waive most page charges will be preferred.	Receive peer review and disseminate our results to the scientific community.					$2,000
							Sub Total	**$2,000**
Other Expenses								
							Sub Total	**-**

							Grand Total	**$791,000**

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				
Cash	University of Minnesota unrecovered indirect cost return (54% MDTC)	$791,000 direct total x 0.54 = $427,140 unrecovered IDC	Secured	$427,140
			Non State Sub Total	**$427,140**
			Funds Total	**$427,140**

Total Project Cost: $1,218,140

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 816736d5-d69.pdf

Alternate Text for Visual Component

This graphic titled “Beaver Dams as Natural Infrastructure” states the problem and proposed solution at the top of the page, then three drawings: one of a natural beaver dam instrumented with sensors, one of a physical model beaver dam with similar sensors, and then one of a computer model dam...

Supplemental Attachments

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

Title	File
UMN Letter	6b4af34c-3fc.pdf
Minnesota Coalition of Lake Associations Letter of Support	2cd938cb-3f5.pdf
Brown's Creek Watershed District Letter of Support	ebecb0dd-fd5.pdf
Valley Branch Watershed District Letter of Support	1aeb50b0-471.pdf
Dakota County Parks Letter of Support	ba02106a-ac1.pdf
Vermillion River Watershed Joint Powers Organization Letter of Support	94ebdc8f-40e.pdf
Beaver Institute Letter of Support	c668817e-409.pdf
Trout Unlimited Letter of Support	883d6b8a-b48.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?

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?

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:

Andy Riesgraf (Saint Anthony Falls Laboratory)

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