



Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-095

Proposal Title: Evaluating Locally Sourced BIOCHAR for Restoring Impaired Waterbodies

Project Manager Information

Name: Dan Breneman

Organization: Minnesota Pollution Control Agency

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Project Basic Information

Project Summary: Laboratory research on St. Louis River sediments will evaluate biochar as an amendment for managing moderate-level contamination in aquatic habitats, introducing potential market opportunities for Minnesota's wood product industries.

Funds Requested: \$278,000

Proposed Project Completion: June 30 2025

LCCMR Funding Category: Water Resources (B)

Project Location

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

Region(s): NE

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.

Minnesota aquatic resource managers need innovative ways to cost-effectively address moderate levels of contamination in impaired lakes and streams when full-scale remediation is not warranted. Activated carbon is commonly used to treat contaminants in water treatment plants and is known to effectively decrease exposure to aquatic organisms. However, highly-engineered activated carbon is cost-prohibitive in many situations, and the sustainability of similar materials in aquatic applications is not well understood. Biochar has similar qualities to activated carbon and could be a cheaper option for obtaining the same results, thus improving aquatic habitat in Minnesota with a co-benefits to the state's forestry and wood products industries.

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.

Biochar is produced by heating biomass in the absence of oxygen, and has many environmental benefits: it can treat water, enhance plant growth, and prevent CO₂ emissions by locking carbon into a charcoal-like material. While biochar could provide a cost-effective and sustainable alternative to activated carbon, its performance in aquatic sediments is poorly understood. Therefore, testing and evaluating a Minnesota biochar product could accelerate opportunities for use in aquatic ecosystem recovery.

This project will evaluate biochar performance in aquatic habitats and provide recommendations to apply biochar as a sustainable and effective remediation amendment in impaired surface waters. We will develop and test biochars produced from Minnesota forestry byproducts in the laboratory, and evaluate contaminant-sequestration performance and the effects on aquatic plant growth in microcosms. Our findings will inform production of locally-sourced materials that boost aquatic habitat restoration.

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?

Outcomes from this study will be performance measures and product development recommendations for using locally-sourced biochar as a sediment amendment when restoring aquatic habitats. This work will offer better management options for protecting Minnesota natural resources by identifying cost-effective alternatives for controlling surface water contamination and decision tools for improving restoration effectiveness. An additional outcome will be new market opportunities to sustainably utilize Minnesota forestry residues in a way that improves water quality and reduces greenhouse gas emissions. These wide-reaching benefits will lead to better habitat quality, increased recreational opportunities, and communities reinvesting in local economies along our waterfronts.

Activities and Milestones

Activity 1: Laboratory production and testing of biochar to assess contaminant-sequestration properties

Activity Budget: \$90,697

Activity Description:

The objective of this activity is to select the most promising Minnesota-sourced biochar feedstock materials for further material development. This activity will consist of two experimental tasks: (a) material collection, processing, and characterization, and (b) laboratory batch experiments to assess contaminant-sequestration performance.

Task 1a: Various forestry residues will be collected from facilities in Minnesota and converted to biochar at the laboratory scale in a tube furnace at NRRI. Feedstocks will be processed using varying production parameters, including process temperature and post-production surface treatments. The resulting biochars will be characterized for physical and chemical properties, such that easily measurable properties can serve as performance indicators and inform material selection.

Task 1b: The produced biochars will be screened for their contaminant-sequestration performance in laboratory batch experiments. Contaminants to be analyzed will include mercury as well as potential co-contaminants such as dioxins. We will also determine if any potentially harmful contaminants leach from the biochars, such as polyaromatic hydrocarbons (PAHs). This data will allow researchers to identify the most promising biochar materials to further evaluate in vegetated mesocosm experiments (see Activity 2).

Activity Milestones:

Description	Completion Date
Review existing biochar data and current research	September 30 2022
Collect feedstocks and produce and characterize biochars	January 31 2023
Perform laboratory tests to evaluate contaminant-sequestration performance	June 30 2023

Activity 2: Evaluating contaminant-sequestration performance in mesocosm experimental chambers and documenting the effects of selected biochar on aquatic plant growth

Activity Budget: \$174,715

Activity Description:

Activity 2 will assess the contaminant-sequestration performance of biochar in mesocosms under realistic environmental conditions. By this approach, complex geochemical interactions can be monitored under more controlled settings. Similarly, experiments will be conducted in the NRRI greenhouse to evaluate plant growth. Activity 2 will consist of two tasks: (a) assembling mesocosms and measuring contaminant-sequestration performance and plant growth and (b) interpreting results to inform resource managers making habitat improvement decisions.

Task 2a: Mesocosms will be filled with sediment and biochar at different volume compositions. Water in the mesocosms will be continuously recirculated to facilitate faster equilibration, with water quality, sediment, and plant growth measured regularly over a two year testing period. Mercury, organic co-contaminants, and potentially leached organic contaminants will be measured in water and sediment samples. Plant growth will be qualitatively monitored during the experiments, and at the completion of the experiments, biomass will be determined quantitatively.

Task 2b: Results from the study of contaminant sequestration and plant growth and will be analyzed and interpreted in

the context of the needs of resource managers. Appropriate thresholds for contaminant sequestration and for aquatic vegetation growth will be determined through feedback from resource management partners and compared to study results.

Activity Milestones:

Description	Completion Date
1. Assemble mesocosm test chambers with sediment, biochar treatment, and seed with aquatic vegetation	May 31 2023
2. Monitor contaminant concentrations and aquatic plant growth	September 30 2024
3. Data analysis and interpretation of results to inform resource managers	June 30 2025

Activity 3: Outreach activities to investigate larger-scale demonstration opportunities by facilitating biochar application scenarios and exploring possible MN commercialization partners

Activity Budget: \$12,588

Activity Description:

Building on results from Activities 1 and 2, the Outreach/Scoping activity will complete a feasibility assessment of biochar formulations tailored to aquatic sediments. Logistics involving ‘scaling-up’ production with potential commercialization partners will be determined through the Outreach effort. Our evaluation of the technical (laboratory and mesocosm study in Activities 1 and 2) and economic feasibility of biochar will help lay the groundwork for justifying larger scale production and applications in a pilot-scale demonstration.

Activity 3 will produce recommendations in the form of a feasibility case study using biochar as an amendment in a pilot-scale demonstration project in the St. Louis River estuary. This analysis will serve as a template for future scenarios where biochar would be an alternative for managing low-level contamination during habitat restoration efforts. We will present the results of the study at regional conferences including the Minnesota Water Resources Conference, the St Louis River Summit, Midwest Ecological Society of America, and disseminate the results through peer-reviewed publications.

Outcomes from Activity 3 will be an effective “de-risking” evaluation of biochar manufacturing and better understanding applied technology. With our results as a basis, we expect a future partner could scale-up production and identify applications more confidently.

Activity Milestones:

Description	Completion Date
1. Document product development opportunities to enhance technology transfer	June 30 2024
2. Perform a cost analysis for incorporating biochar in a pilot-scale demonstration	December 31 2024
3. Outreach and public presentations to further develop biochar applications	June 30 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Bridget Ulrich, PhD.	Natural Resources Research Institute, University of Minnesota Duluth	Principle Investigator for Activity 1 responsible for product development, laboratory testing tailored product, and data analysis interpretation. Dr. Ulrich's research expertise is the application of low-cost materials for water treatment, and she specializes in removal of organic contaminants including PFAS.	Yes
Nate Johnson, PhD.	University of Minnesota Duluth, Swenson College of Science and Engineering	Principle Investigator for Activity 2 responsible for measuring tailored product performance and greenhouse plant growth, and data analysis interpretation. Dr. Johnson is an Associate Professor of Civil Engineering at UMD and specializes in mercury contamination and environmental geochemistry.	Yes
Jeff Jeremiason, PhD.	Gustavus Adolfus College	Responsible for oversight of mercury analysis for Activities 1 and 2. Dr. Jeremiason is a Professor of Chemistry and Environmental studies at Gustavus Adolfus College, and specializes in mercury dynamics in aquatic environments.	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?

Results from this study will document biochar performance in aquatic habitats. Measuring material performance and production recommendations will demonstrate opportunities to use locally-sourced biochar when restoring degraded aquatic ecosystems. With an eye towards Minnesota-based biochar feedstocks, this study will identify opportunities to use a locally derived product for modifying sediment geochemistry and enhancing aquatic macrophyte growth during habitat restoration. This study will initiate technology transfer by exploring commercialization partners for Minnesota sourced materials, and determine the feasibility of a tailored biochar product being used in a pilot-scale restoration project.

Project Manager and Organization Qualifications

Project Manager Name: Dan Breneman

Job Title: State Program Administrator, Principal

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

Dan Breneman has 30 years of experience administering contract funds and managing scientific research studies. After nearly 20 years with the Natural Resources Research Institute at the University of Minnesota Duluth coordinating laboratory and field research, Mr. Breneman has served with the Minnesota Pollution Control Agency since 2012.

Mr. Breneman has represented the MPCA on local dredge material committees and coordinated research studies for the Area of Concern Program (AOC) through the Remediation Division's Lake Superior Unit. To date, Dan has managed over \$3 million in contractual obligations working with academia, natural resource agencies, and engineering/technical consultants. As the MPCA Restoration Coordinator, Mr. Breneman has collaborated with a host of Federal, State, and local organizations to implement multi-million dollar habitat construction projects in the estuary, being recognized with

a State Government Innovation Award sponsored by the Bush Foundation in 2016, and a 2018 MPCA Gordie Award for Innovation.

Organization: Minnesota Pollution Control Agency

Organization Description:

The Minnesota Pollution Control Agency (Agency) monitors environmental quality throughout the State, offers technical and financial assistance, and enforces environmental regulations. The Agency evaluates, conducts research, and identifies and addresses those impairments that can affect human health and the environment. A dedicated staff of over 800 employees in seven offices, develop statewide policy, inspect and enforce State statutes, and support collaborative partnerships to advance environmental stewardship.

The Agency has made Minnesota a national model for environmental protection. The results are observed in cleaner air, land and water over the last 40 years. These results were possible because the Agency's statutory authority has invested in the State's prized natural resources, leveraging the state Legislature commitments through collaborations with Federal organizations, State resource agencies, local governments, industry, environmentalists, and the public. Core values instilled in a dedicated Agency staff include measuring success by the environmental quality, and quality of citizen's lives, with decisions and policies supported by data and analysis. The MPCA is committed to a mission that protects and improves the environment and human health, and is a national leader in delivering services that support communities, ecosystems, and a thriving economy.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Dan Breneman		Project Manager			24%	0.3		\$12,800
							Sub Total	\$12,800
Contracts and Services								
Dr. Bridget Ulrich	Professional or Technical Service Contract	NRRI Project Coordinator, Activity 1				0.24		\$32,528
Dr. Nate Johnson	Professional or Technical Service Contract	UMD-CE Project Coordinator, Activity 2.				0.48		\$23,319
Post-Doctoral Associate	Professional or Technical Service Contract	NRRI, Project Investigator				1		\$48,800
Masters Degree Student	Professional or Technical Service Contract	UMD-CE, Graduate Studies Collaborator				1.5		\$51,830
UMD-CE, Student Worker	Professional or Technical Service Contract	Undergraduate Student Research Assistant				0.99		\$19,266
Matthew Young	Professional or Technical Service Contract	NRRI, Researcher, biochar production				0.06		\$5,000
Allison Byrd	Professional or Technical Service Contract	NRRI, Researcher, material analysis				0.15		\$9,719

Alex Karchrov	Professional or Technical Service Contract	NRRI, Researcher, chemical analysis				0.06		\$4,390
Gustavus Adolphus College	Sub award	Dr. Jeff Jeremiason, Chemistry Department, Laboratory Analytics				-		\$30,000
Twin Ports Testing	Sub award	Material Sample Characterization				-		\$2,090
TBD, Staff Researcher	Professional or Technical Service Contract	NRRI, Researcher, ,material production				0.08		\$7,188
							Sub Total	\$234,130
Equipment, Tools, and Supplies								
	Tools and Supplies	General Laboratory Supplies	reagents, solvents, and other expendable testing supplies					\$30,000
	Tools and Supplies	Parcel Shipping	Over-night shipping sediment samples					\$300
							Sub Total	\$30,300
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Other	UMD Fleet Services	event-based field crew and research vessel transportation					\$770
							Sub Total	\$770

Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$278,000

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	USEPA, Great Lakes Restoration Initiative Grant Number GL00E02287-0 to MPCA. Contractual award to Nate Johnson, PhD., UMD-CE, on behalf of The Regents of the U of M, PO Box 1450, Minneapolis, MN 55485, Project Tracking Number- PRO2019001	Assessing restoration effectiveness- Evaluating Bioaccumulative Risk to Support BUI removal	Secured	\$187,500
			Non State Sub Total	\$187,500
			Funds Total	\$187,500

Attachments

Required Attachments

Optional Attachments

Support Letter or Other

Title	File
Duluth Seaway Port Authority Support Letter	fec75cd1-2cb.pdf
Harbor Technical Advisory MIC Support Letter	0d107c5f-bcc.pdf
City of Duluth Support Letter	2821f625-f25.pdf
Fond du Lac Support Letter	b8c31275-43b.pdf
City of Superior Support Letter	633b30e2-9f9.pdf
University of Minnesota Duluth-SPA	8587c797-96e.pdf

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?

No