Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-071

Proposal Title: Using Minnesota Timber to Mitigate Landfill Methane Emissions

Project Manager Information

Name: Brian Barry

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: Develop a landfill cover that sustainably reduces greenhouse gas emissions through natural biological processes. Test pods will be used to simulate landfill covers and demonstrate emission reductions in Minnesota's climate.

Funds Requested: $1,235,000

Proposed Project Completion: June 30 2025

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

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

Region(s): Metro, NE,

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.

The Next Generation Energy Act was signed into law in 2007 and set statutory goals for Minnesota to reduce greenhouse gas (GHG) emissions. The Minnesota Pollution Control Agency (MPCA) determined in its 2021 GHG report to the Legislature that Minnesota is not meeting these goals.

The MPCA has identified the reduction of landfill gas (LFG) as one part of an overall GHG emission-reduction strategy. LFG contains methane, a powerful GHG thirty times more potent than CO2. LFG generation is not uniform over time but fluctuates as the landfill operates and ages. LFG generation declines after landfills are closed, but GHG generation continues for decades, long after mechanical controls like flares and energy recovery are viable recovery options.

There are 20 open landfill sites and another 110 closed landfill sites in the state of Minnesota, and these landfills are responsible for 20% of the state government's GHG emissions. Current landfill cover and gas capture technologies are leaky and ineffective in the long term and many landfill sites in Minnesota cannot capture or combust LFG, while those that can will eventually stop flaring when LFG production tails off. We believe the solution can be found in Minnesota's timber resources.

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.

We seek to develop a low-cost, breathable cover that destroys methane before it is released. We will test various soil-based landfill covers charged with methane-consuming microorganisms. An array of landfill cover testing pods (LCTPs) will be constructed adjacent to an active landfill. LFG from the active landfill will applied to the LCTPs. The LCTPs will contain traditional soil amended with biochar (see attached graphic) to promote the proliferation of microorganisms. This new type of cover will increase the capacity of the landfill soil cover to mitigate methane emissions. This study is fundamental to learning what works in the Minnesota climate with available soil resources and biochar feedstock.

Biochar is a carbon-based material produced from Minnesota waste timber (e.g. balsam fir for fire mitigation, losses from the emerald ash borer) and is a carbon negative technology which offsets GHG emissions from other sources. Under our plan, one acre of landfill cover would use 120 tons of biochar, offsetting 100-350 tons of CO2 depending on factors such as transportation distance. Large-scale biochar production would create new markets for unmerchantable Minnesota timber resources, create new jobs, and potentially allow for biochar offset credits if a carbon market develops.

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) The state's GHG emission footprint will be reduced by both reducing methane emissions from landfills and by sequestering carbon via biochar usage.

2) By using biomass feedstocks for biochar production that would otherwise be considered waste, new markets will emerge for these feedstocks, which lowers the cost of handling these resources. Proper wildfire management of our national forests (balsam fir removal) is costly, and if we can lower the cost to do so by producing biochar, more effective forest management will result.

3) We will establish critical data to guide future implementations of more effective landfill covers.

Activities and Milestones

Activity 1: Design, Installation and Commissioning of LCTP Array

Activity Budget: $700,000

Activity Description:
A team from Barr Engineering will manage all aspects of this activity. In consultation and collaboration with Minnesota-based team members (Cliff Shierk, MPCA; Terry Johnson, Waste Management Inc.; Brian Barry, NRRI) and leading experts from around the country (Tarek Abichou, Florida State University; Milind Khire, UNC-Charlotte), a design for the LCTP array will be developed. This design will include safety measures such as pressure relief valves for the safe handling of flammable landfill gas, moisture and gas monitoring systems, and control systems to account for inclement weather conditions.

In addition to the design of the pods, this activity will include the construction and installation of the LCTP array at the Elk River Landfill site along with gas lines for introducing landfill gas. The pods will also be outfitted with sensors capable of being monitored remotely. Lastly, this activity will include a post-installation commissioning stage where all safety implements are tested, control of gas flow rates are confirmed, and sensors are calibrated.

Activity Milestones:

Description	Completion Date
Finalization of LCTP Array Design	October 31 2022
Installation of LCTP Array at Elk River Landfill Site	June 30 2023
Testing and Commissioning of Installed LCTP Array	July 31 2023

Activity 2: Landfill cover design of experiment (DOE), biochar production and full characterization, and LCTP charging

Activity Budget: $200,000

Activity Description:
The LCTPs will be loaded with a combination of gravel, clay, and biochar-soil mixtures with the targeted result of maximizing soil aeration, hydraulic mobility, drought resistance, and microbial community proliferation. A DOE will be completed, which will include the introduction of experimental controls, compositions and configurations of pod fill materials (e.g. biochar to soil ratios, soil depths, and clay types), and a plan for how data will be collected and analyzed to determine the methane mitigation efficacy.

Upon completing the DOE, the Materials and Chemistry Lab at NRRI will identify a biomass feedstock suitable for producing a biochar with optimal properties for use in a methane mitigation landfill cover. These properties (e.g. field capacity, surface area, cation exchange capacity) will be optimized in concert with the NRRI Biomass Conversion Laboratory, which will be producing all of the biochar for the project. Feedstock choices will focus on readily available Minnesota waste timber. By utilizing otherwise useless feedstocks, the cost of introducing biochar will be minimal and could also result in the emergence of a market for these species. Examples of such feedstock would include beetle-infested urban trees (emerald ash borer) or balsam fir removed during forest fire mitigation efforts

Activity Milestones:

Description	Completion Date
Completion of DOE for LCTP array demonstration	October 31 2022

Identification of appropriate biochar feedstock and production conditions via thorough biochar characterizations from small batch production runs	December 31 2022
Completion of large-scale biochar production runs for LCTP array demonstrations complete with physical property assessments	May 31 2023
Physical loading of LCTPs with prescribed configurations outlined by DOE	August 31 2023

Activity 3: Baseline determinations, periodic data collections, data interpretation and reporting

Activity Budget: $335,000

Activity Description:
Once the LCTP array has been commissioned, installed and pods charged with landfill cover material, data collection and monitoring can ensue. Baseline data will first be established prior to the introduction of landfill gas. The LCTP array will then be monitored periodically over the span of 12+ months upon landfill gas introduction for information such as soil moisture, hydraulic mobility, soil aeration, microbial community population and gas flux quantification.

Gas flux and soil moisture measurements can be monitored remotely via networked data collectors powered by solar with battery backups. The microbial community populations, however, will require frequent visits to the LCTP array site to collect soil samples. Microbial community characterizations of landfill cover soils over time will be performed at the Environmental Microbiology and Biotechnology Lab (UMD) using next-generation sequencing and functional gene analyses for identification and quantification of the various methane-consuming microorganisms.

Finally, after all data has been collected, the data will be interpreted with the consultation of world-leading experts. For example, Drs. Tarek Abichou and Milind Khire will lead efforts in interpretation of the moisture and gas flux data. After data interpretation is complete a report will be produced giving complete and summarized assessments of the LCTP performances.

Activity Milestones:

Description	Completion Date
Complete baseline determinations for microbial communities and gas flux in the absence of landfill gas	September 30 2023
Midpoint (after 6 months) assessment of data to confirm functioning microbial communities and to check sensor calibrations	March 31 2024
Completion of data collection for year-long program.	September 30 2024
Final project report completed, including complete data interpretations and recommendations for future endeavors.	June 30 2025

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?

We have designed our LCTP array to provide information which will directly guide application of improved, next-generation landfill cover designs. Additionally, the investment into the construction of the LCTP array will allow for reuse after this study for further optimization and alternative pod compositions, allowing for further, future improvements. Upon successfully demonstrating the effectiveness of LCTPs at treating LFG, this asset can be effectively leveraged to attract funds for more research or demonstration efforts from funding sources such as the DOE or NSF.

Project Manager and Organization Qualifications

Project Manager Name: Brian Barry

Job Title: Chemistry And Materials Science Program Leader

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

Dr. Barry earned his Ph.D. in Inorganic Chemistry from the University of Iowa in 2010 and has dedicated his efforts towards environmentally impactful research at every stop along the way. His Ph.D. thesis was on developing novel electrode materials for next-generation batteries, his post-doctoral work at Sandia National Laboratories looked at developing catalysts capable of activating carbon dioxide (CO_2) and during his time spent as an Assistant Prof. of Chemistry (St. Mary's in Halifax Nova Scotia & UW-Platteville) he researched ways to chemically modify natural chemicals found in wood. Currently Dr. Barry is the manager of the chemistry labs at NRRI and is responsible for managing operations, delivering research solutions and fundraising through grant applications to keep his labs operational. Dr. Barry has a long history of managing research and demonstration projects funded at both the state and federal levels and is well suited to manage the program detailed here.

Organization: U of MN - Duluth - NRRI

Organization Description:

The Natural Resources Research Institute (NRRI) is a part of the University of Minnesota Duluth and employs over 130 scientists, engineers and technicians. Its mission is to deliver integrated research solutions that value our resources, environment and economy for a sustainable and resilient future.

NRRI collaborates broadly across the University system, the state and the region to address the challenges of a natural resource-based economy.

By partnering with industry, business leaders, agency decision-makers and many others, NRRI researchers frame and deliver on real-world solutions. NRRI scientists have extensive experience in managing large, interdisciplinary projects. Major objectives include the development of tools for environmental assessment and resource management. NRRI's role is as a impartial, science-based resource that develops and translates knowledge by characterizing and defining value-resource opportunities, minimizing waste and environmental impact, maximizing value from natural resource utilization and maintaining/restoring ecosystem function.

Major outcomes from NRRI projects include informing environmental management and policy and assisting industry and communities in defining and maintaining the social license to operate in natural systems. NRRI has an established mechanism for sharing outcomes through press releases, publication in peer-reviewed journals, annual reports, periodicals, and through social media channels.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Brian Barry (PI)		Project manager. Overseeing design of experiments and analysis of data and reporting.			26.7%	0.3		$38,043
Matt Young (Biomass Conversion Manager)		Biomass Conversion Lab oversight. Responsible for feedstock acquisition, packaging and delivering of biochar and liaison for BCL for meetings with project manager			24.1%	0.04		$2,699
Eric Singsaas (Project Oversight)		Oversee project in consolatory fashion. Will attend meetings and give feedback for generated reports and data summaries.			26.7%	0.03		$5,767
Oksana Kolomitsyna (chemistry lab technician)		Chemistry lab technician responsible for biochar characterization			26.7%	0.1		$7,255
Sergiy Yemets(chemistry lab technician)		Chemistry lab technician responsible for biochar characterization			26.7%	0.1		$7,653
Alex Kacharov (chemistry lab technician)		Chemistry lab technician responsible for biochar characterization			26.7%	0.1		$7,026
Jeff Kinkel (Rotary Kiln Manager)		Biomass Conversion Lab manager. Will oversee the production of biochar on rotary kiln			26.7%	0.04		$4,713
Pat Casey (kiln technician)		Rotary kiln technician responsible for running kiln for biochar production			24.1%	0.04		$4,303
Robert Hietala (kiln technician)		Rotary kiln technician responsible for running kiln for biochar production			24.1%	0.14		$8,660
Matthew Anthony (kiln technician)		Rotary kiln technician responsible for running kiln for biochar production			24.1%	0.12		$8,475
Brent Anderson (kiln technician)		Rotary kiln technician responsible for running kiln for biochar production			24.1%	0.12		$8,475
Chan Lan Chun (Co-PI)		Lead a team of scientists in analyzing the microbial communities in the soils			26.7%	0.24		$38,053

Susma Bhattarai (microbial lab manager)		Evaluate methanotrophs' activities and growth condition in soil/biochar			20.3%	1		$67,514
TBD scientist (microbial lab technician)		Molecular biological work and bioinformatics analysis for microbial community analysis			24.1%	0.69		$50,842
TBD Masters Student (microbial lab technician)		Assist in methanotrophs' activities and microbial community shift analysis			45.1%	0.62		$48,067
TBD Undergrad (microbial lab technician)		Assist infield sampling			0%	0.87		$21,528
							Sub Total	**$329,073**
Contracts and Services								
Barr Engineering	Professional or Technical Service Contract	Barr Engineering will be providing the certified engineering design for landfill cover testing pods and will construct and install these pods on site. They will be responsible for installing monitoring probes and for their calibration and upkeep. A justification for being single source will ensue if proposal is selected		X		1		$813,635
DNA sequencing (UMN-TC)	Internal services or fees (uncommon)	Illumina sequencing & supercomputer usage fees. This extractor significantly expedites the extraction of genetic material from soils and is necessary to complete the magnitude of work outlined in this proposal. This instrument will continue to be used to assess microbial communities for its entire lifetime				1		$17,000
Twin Ports Testing	Professional or Technical Service Contract	Proximate and Ultimate analysis performed for biochar samples				1		$5,000
Mastell Brothers Trailer Service, Inc.	Professional or Technical Service Contract	Trailer rental for 4 months for wood chips waiting to be pyrolyzes				1		$7,240
							Sub Total	**$842,875**

Equipment, Tools, and Supplies								
	Tools and Supplies	Microbial lab glassware and general consumables	To provide PPE, cover costs of consumables including sample vials e.g.					$12,000
	Tools and Supplies	Microbial lab reagents, kits and consumables related to DNA	Materials (containers, reagents, solvents etc.) needed for genomic analysis					$12,000
	Tools and Supplies	Microbial lab gas supplies	Cover expenses for gas cylinder rental and refills					$3,000
	Tools and Supplies	Biomass feedstock	Cover expenses for purchasing chipped wood for conversion to biochar					$2,000
	Tools and Supplies	Chemistry lab consumables	Purchase of PPE, glassware, disposables, and gases for chemical analyses					$2,152
							Sub Total	**$31,152**
Capital Expenditures								
		Qigen QiAcube	Automated DNA/RNA extractor					$20,000
							Sub Total	**$20,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Microbial Group-10 trips, 500 miles/trip, 1-2 persons/trip (1 vehicle) est. $300 total/trip	Travel from Duluth to landfill site for sample collection					$3,000
	Conference Registration Miles/ Meals/ Lodging	1 trip, 2 persons, 300 miles, lodging, per diem, registration	Attend MN Water Resources conference					$600
	Miles/ Meals/ Lodging	Management (PI) travel to and from Duluth (NRRI) and Landfill (Elk River)	Provide mileage for 10 round-trip visits (500 miles each) for 1 vehicle from Duluth to landfill and back					$3,000
							Sub Total	**$6,600**

Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Shipping of biochar	Shipping of multi-tons of material between BCL and landfill					$5,300
							Sub Total	**$5,300**
							Grand Total	**$1,235,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Barr Engineering	Professional or Technical Service Contract	Barr Engineering will be providing the certified engineering design for landfill cover testing pods and will construct and install these pods on site. They will be responsible for installing monitoring probes and for their calibration and upkeep. A justification for being single source will ensue if proposal is selected	Barr Engineering has a long-standing working relationship with both NRRI and MPCA and have experience and expertise in performing proposal tasks that cannot be found anywhere else in the state. Competitive rates from out-of-state entities will be used to affirm competitive rates offered. **This is a single source contract.**

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$659,216
			Non State Sub Total	**$659,216**
			Funds Total	**$659,216**

Attachments

Required Attachments

Visual Component

File: 845fde1b-efc.pdf

Alternate Text for Visual Component

The graphic shows a recently closed landfill which is directing gas to an array of landfill cover testing pods (LCTPs). One of the pods is then zoomed in on and a cross-section of this pod is shown highlighting the gas/moisture probes and the various layers used to fill the pod. Of those layers, the focus is on the top layer which holds biochar produced from Minnesota waste timber. These graphics are accompanied by test which highlights the problem with current landfill cover, how this pro...

Optional Attachments

Support Letter or Other

Title	File
UMD Sponsored Projects Transmittal Letter	6b8ab7ac-44f.pdf
Letter of Support Dr. Tarek Abichou	d9dce9db-777.pdf
Letter of Support Dr. Milind Khire	1d614c80-d95.pdf
Letter of Support Barr Engineering	38903c0c-e64.pdf
Letter of Support MPCA	656242d5-4cf.pdf
Letter of Support Waste Management	c8ac2421-3a8.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?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

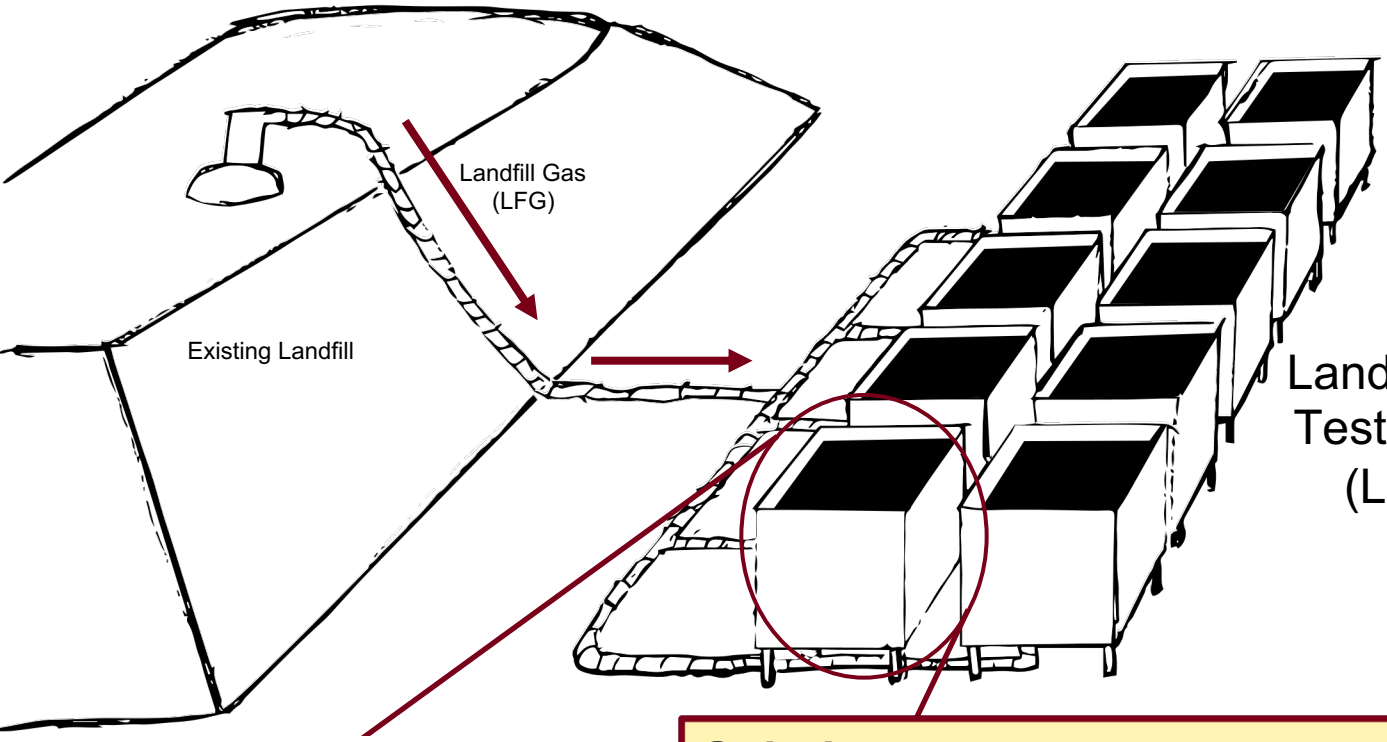
Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

PROJECT TITLE:

Using Minnesota Timber to Mitigate Landfill Methane Emissions

Problem: Current landfill covers are ineffective at preventing emissions of the powerful greenhouse gas, methane, even at waste-to-energy landfill sites.

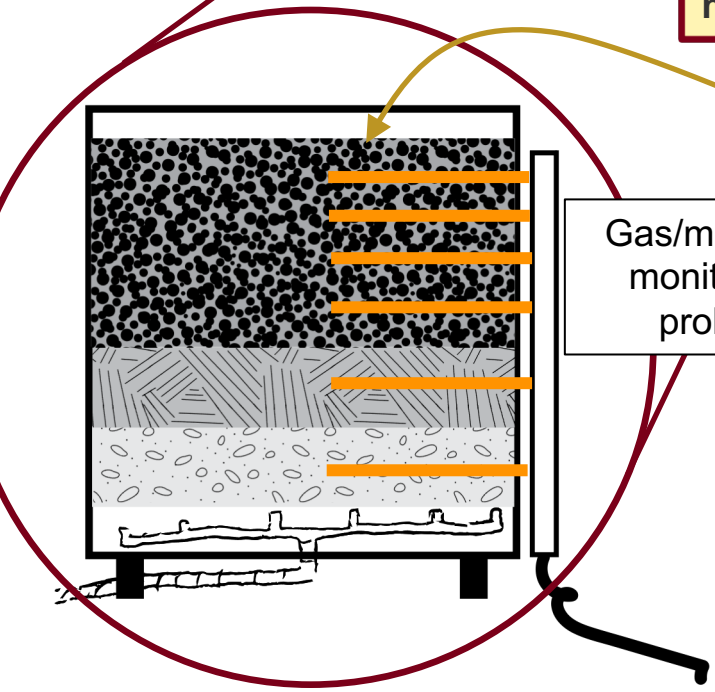
WASTE MANAGEMENT



Landfill Cover Testing Pods (LCTPs)

ELK RIVER LANDFILL SITE

Solution: Open, breathable cover consisting of a biochar-amended soil which hosts microorganisms that feed on methane.



Gas/moisture monitoring probes

Biochar from Minnesota waste timber

Minnesota Benefits:

- Long-term (decades) methane mitigation
- Cheap, sustainable solution
- Carbon sequestration via biochar usage
- New markets for Minnesota timber

Natural Resources Research Institute
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