Environment and Natural Resources Trust Fund

M.L. 2025 Approved Work Plan

General Information

ID Number: 2025-152

Staff Lead: Lisa Bigaouette

Date this document submitted to LCCMR: June 10, 2025

Project Title: Phytoremediation of PFAS from Soil

Project Budget: $1,066,000

Project Manager Information

Name: Michael Smanski

Organization: U of MN - College of Science and Engineering

Office Telephone: (612) 624-9752

Email: smanski@umn.edu

Web Address: https://cse.umn.edu/

Project Reporting

Date Work Plan Approved by LCCMR: June 24, 2025

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: June 30, 2028

Final Report Due Date: August 14, 2028

Legal Information

Legal Citation: M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 08h

Appropriation Language: $1,066,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to use interdisciplinary research in biology, nanotechnology, chemistry, and genetic engineering to develop technology to remediate soils contaminated with per- and polyfluoroalkyl substances (PFAS). This appropriation may also be used to convene stakeholders to coordinate and advance PFAS remediation research in Minnesota. This appropriation is subject to Minnesota Statutes, section 116P.10.

Appropriation End Date: June 30, 2028

Narrative

Project Summary: This collaborative project will use interdisciplinary research at the interface of biology, nanotechnology, chemistry, and genetic engineering to remediate soils contaminated with PFAS.

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

PFAS, also known as per- and polyfluoroalkyl substances, denotes a category of synthetic compounds characterized by the presence of fully fluorinated carbon chains. Owing to their exceptional chemical stability, resistance to water and oil, and high surface activity, PFAS have found extensive application in both industrial and consumer products. However, the widespread use of PFAS has raised environmental and health concerns due to their persistence in the environment, the potential for bioaccumulation in living organisms, and associations with adverse human health effects such as infertility, endocrine disruption, abnormal development, and even cancer.

Numerous studies have focused on strategies to eliminate PFAS compounds from water sources. However, there is a notable scarcity of research critically examining the remediation of PFAS-contaminated soil, and this area warrants further attention. One common source of soil contamination involves the application of sewage solids from wastewater treatment facilities onto agricultural lands. Additionally, locations like defense sites, airports, and fire brigade training sites, where fire-fighting foams are manufactured or used, are recognized as primary contributors to PFAS contamination in soil. This is widespread pollution across the state and world. While several technologies are available for remediating PFAS-containing water, remediating soil is more challenging.

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.

Our research will advance the maturity of phytoaccumulation. Plants grown in contaminated soil will transport PFAS from the soil matrix into the aerial tissues (leaves and stems) where it can be harvested and destroyed. We take a three-pronged approach to advancing phytoaccumulation: (i) rigorous comparison of alternative plant species to measure their natural ability to take-in and transport PFAS from diverse soil types, (ii) enhancing phytoaccumulation by engineering the transpiration chain (i.e., the physiology of water movement from soil to leaves) in plants, and (iii) leveraging safe nanoparticles that free PFAS from soil particles and enhance its uptake in the phytoremediation agent. These approaches combine the most promising science and engineering that is currently available for PFAS removal from soil. This work can easily integrate new technologies developed in the future (e.g., enzymes that can degrade PFAS molecules).

A final aspect of our project will be to better align and coordinate all of the PFAS remediation research and development in Minnesota to establish a Center of Excellence. The center will facilitate synergistic work between groups, foster open communication with stakeholders, and develop technology development priorities to make future PFAS-focused funding more impactful.

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?

At the end of the multi-year project we will have new technologies for PFAS soil remediation that are ready for field trials. These technologies include phytoremediation with specific native plants, plant modification to improve the efficiency, and carbon-based nanoparticles development to improve the PFAS uptake to plants. We will have the techno-economic feasibility to estimate the initial capital and operational cost, and the duration of the plant removal of PFAS from soil at several typical pollution locations in Minnesota. This will be a multidisciplinary research team to coordinate into a center of excellence that will implement the developed technologies.

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

Activities and Milestones

Activity 1: PFAS soil remediation with natural and enhanced plant species

Activity Budget: $666,000

Activity Description:
First, we will use greenhouse studies with spiked PFAS to measure the phytoremediation potential of different native plants. The screening of plant species will focus on crops in order to identify plants that possess strong accumulation capacity of PFAS in plant biomass, extensive root structures for effective contaminant uptake, and rapid growth. Second, we will select 3-5 representative species to study cropping conditions. Soil will be collected at several highly polluted sites to understand the PFAS phytoremediation process and how they can integrate with the current agricultural system. For instance, places like Gofer Landfill near Fairmont, Martin County MPCA reported with PFAS levels more than 1300 times higher than the state's acceptable levels for safe drinking water, will be chosen to sample soils for the greenhouse study. We will also examine the potential to enhance plant uptake by engineering genes in the transpiration chain. Finally, a techno-economic analysis of phytoremediation, including cropping of the promising plant strains and processing under optimal conditions, will be carried out in order to reveal the economic feasibility of this approach. We will be able to estimate the duration needed to achieve PFAS remediation from a certain specific contamination site like Gofer Landfill.

Activity Milestones:

Description	Approximate Completion Date
Screening of 5-10 plant species for phytoremediation of PFAS	June 30, 2026
Study cropping conditions impacts on the phytoremediation of PFAS, like nanoparticles and soil	June 30, 2026
Biomass processing and techno-economic analysis	June 30, 2028
Enhance PFAS phytoaccumulation by modulating the transpiration chain	June 30, 2028

Activity 2: Carbon-based nanoparticles to solubilize PFAS for enhanced plant uptake

Activity Budget: $390,000

Activity Description:
PFAS are very stable chemicals, attaching to soil particles. This activity will leverage the molecule-loading nanoparticle concept to facilitate remediation of PFAS and take advantage of plant uptake/transport of PFAS-loaded nanoparticles to achieve phytoremediation. With 20+ years of research evaluating nanoparticle performance, it is clear that nanoscale materials with emergent physicochemical properties can be designed to avoid harm to biological systems and to promote organism health. Additionally, research in the last five years has demonstrated that nanoparticles can be taken up by plants (through leaves or roots) and actively transported throughout the plant. One common application of nanomaterials is to load and disguise molecular cargo while transporting it through biological systems, for example, delivering systemically toxic chemotherapeutic or drug molecules to target tissue within an organism. The nanomaterials that will be employed in this research are called carbon dots, chosen because they can be made from a range of low-cost small molecule starting materials in relatively simple, scalable microwave-based reactions and because they have no demonstrated negative biological impacts. Specifically, in this activity, we will systematically screen six different carbon dot formulations for their affinity for PFAS and add the best-performing carbon dots to the activity 1 plant-based studies.

Activity Milestones:

Description	Approximate Completion Date

Synthesize carbon dots and evaluate PFAS affinity to choose the best-performing carbon dot	June 30, 2025
Scale up optimal carbon dot production for field-scale work	June 30, 2026
Add optimized carbon dots to cropping and plant transpiration field studies focused on PFAS phytoremediation	June 30, 2028

Activity 3: Coordination of PFAS remediation work in Minnesota to develop a Center of Excellence

Activity Budget: $10,000

Activity Description:

Minnesota played a central role in the development of PFAS materials. With its pride in protecting its abundant natural water resources (lakes, rivers, wetlands), many of which are now contaminated with unsafe levels of PFAS, Minnesota stands to play a central role in developing new technologies to rid the environment of PFAS contamination. We will work with leaders in the University of Minnesota's Office of the Vice President of Research to identify all researchers in the statewide University of Minnesota system that have active projects related to PFAS remediation. ENRTF has sponsored several research projects at UMN. We will organize a two-day workshop/symposium in 2026 to convene all these researchers to (i) share current research progress towards PFAS remediation with oral talks and poster sessions, and (ii) organize a system-wide Center of Excellence. Different stakeholders, like MPCA, MDA, industry representatives, local municipalities and community leaders, will be invited to attend the symposium for panel discussions on how to implement these technologies.

The strength-in-numbers that will come from organizing a Center of Excellence will make Minnesota researchers more competitive for large federal contracts for PFAS remediation. It will also establish Minnesota as a global leader in this regard.

Activity Milestones:

Description	Approximate Completion Date
Identify all PFAS remediation research and development in Minnesota	December 31, 2025
Hold 2-day workshop to establish a PFAS Remediation Center of Excellence	August 31, 2026
Develop a forward-looking best practices for PFAS remediation with Center of Excellence partners	August 31, 2026
Develop a forward-looking best practices for PFAS remediation with Center of Excellence partners	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Bo Hu	UMN - CFANS	co-PI	Yes
Michael Smanski	University of Minnesota	co-PI; leading the work to enhance plant uptake of PFAS	Yes
Christy Haynes	University of Minnesota	co-PI	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
The research results will be submitted for publication in peer-reviewed journals. Our team will engage with local industry partners about potential applications of this technology. We intend to present the results as they are compiled via LCCMR reporting, publishing in scientific and engineering journals and conference presentations. The research team will prioritize dissemination at conferences in Minnesota. ENRTF will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgment Guidelines.

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?
The project will have broad impact in academia and industry. The results will provide fundamental knowledge on how native and modified plants mobilize and uptake PFAS in the soil and how the carbon dot will facilitate the plant uptake. The possible applications will lead to new ways to treat these environmental toxins from the contaminated soil. It will have broad impacts to superfund sites cross the state and the nation, foster collaborations among different disciplinaries toward a center of excellence, and we pursue financial support at the center level at different regional and national programs like the USDA and EPA.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Extracting Deicing Salt from Roadside Soils with Plants	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04i	$360,000
Building Knowledge and Capacity to Solve AIS Problems	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 06a	$4,000,000
Novel Nutrient Recovery Process from Wastewater Treatment Plants	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 04b	$200,000
Building Knowledge And Capacity For AIS Solutions	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 06e	$3,750,000
Phytoremediation for Extracting Deicing Salt	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 08g	$451,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Faculty member (Haynes)		PI, , leading the overall project as well as carbon dot design and performance evaluation as described in activity 2			37.1%	0.12		$46,116
Faculty member (Smanski)		Co-I; leading engineering of plant transpiration chain for enhanced PFAS uptake			37.1%	0.12		$30,420
Faculty (Hu)		Co-PI, Bo will work on the selection of plant species, study of growth conditions, and techno-economic analysis of phytoremediation of PFAD from soil			37.1%	0.12		$62,937
Researcher 5		To work on the portion of the project managed by Co-PI Hu. The researcher will work with greenhouse studies to screen native and modified plant species, investigate their growth conditions to affect the phytoremediation efficiency, and eventually develop a techno-eocnomic analysis of the whole phytoremediation process to remove PFAS from soil.			37.1%	2.25		$251,749
Researcher 5		Plant engineer who will perform the plant transpiration chain engineering to enhance PFAS uptake under the mentorship of co-PI Smanski			37.1%	3		$251,749
1.5 graduate students		Skilled Chemistry graduate students will design, synthesize, and characterize carbon dots with PFAS affinity, they will quantify carbon dot performance, develop a scaled-up synthesis of the optimized formulation, and work with the Hu and Smanski researchers to apply carbon dots to crop studies			49.2%	2.25		$255,693
							Sub Total	**$898,664**
Contracts and Services								
University of Minnesota	Internal services or fees (uncommon)	Repair and maintenance of previously existing capital and non-capital equipment to be used on this project via UMN instrument repair shop.				0.03		$3,060
University of Minnesota	Internal services or	Scientific services needed for this project will be provided by UMN core facilities, including				0.75		$72,464

	fees (uncommon)	greenhouse space, DNA sequencing, and analytical services.						
							Sub Total	**$75,524**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supplies; including chemicals, enzymatic and genetic reagents, lab media, disposable labware, PPE, etc.	for research use					$88,752
							Sub Total	**$88,752**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging							$3,060
							Sub Total	**$3,060**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$1,066,000**

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				
In-Kind	Typically charged overhead/indirect costs for Univ of MN research	To pay for indirect costs such as laboratory space and furnishings, utilities costs, financial and admin support,	Pending	$558,242
			Non State Sub Total	**$558,242**
			Funds Total	**$558,242**

Total Project Cost: $1,624,242

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: c19f2a94-4ba.pdf

Alternate Text for Visual Component

Attached is a summary image showing the use of carbon dots for plant-based phytoaccumulation of PFAS by native and engineered plants....

Supplemental Attachments

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

Title	File
submission letter	56dbe41e-9c7.pdf
2025-152 Research Addendum_revised final	8f812e67-355.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

A dissemination plan was added. The 'other' funds were moved to the service category

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

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?

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

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 project:

Christy Haynes, Bo Hu, Heather Steen

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