

**Environment and Natural Resources Trust Fund**

# M.L. 2021 Approved Work Plan

## **General Information**

**ID Number:** 2021-223

**Staff Lead:** Rory Anderson

**Date this document submitted to LCCMR:** July 21, 2021

**Project Title:** Remote Sensing And Super-Resolution Imaging Of Microplastics

**Project Budget:** $309,000

## **Project Manager Information**

**Name:** Ardeshir Ebtehaj

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## **Project Reporting**

**Date Work Plan Approved by LCCMR:** July 20, 2021

**Reporting Schedule:** December 1 / June 1 of each year.

**Project Completion:** June 30, 2025

**Final Report Due Date:** August 14, 2025

## **Legal Information**

**Legal Citation:** M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 08j

**Appropriation Language:** $309,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota, St. Anthony Falls Laboratory, to develop and test remote sensing techniques for cost-effective monitoring of microplastics in lakes, rivers, and streams as well as in wastewater treatment plants. This appropriation is available until June 30, 2025, by which time the project must be completed and final products delivered.

**Appropriation End Date:** June 30, 2025

## **Narrative**

**Project Summary:** The research will collect samples of microplastics to establish relationships between physical and remote sensing characteristics of microplastics for cost effective monitoring of microplastics in Minnesota natural and engineered waters.

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

Plastic pollution of water resources is a growing worldwide problem and Minnesota is no exception. Global production of plastics has increased to more than 350 million metric tons per year. Plastics break down to smaller pieces called “microplastics”. Humans and wildlife consume microplastics via water and food. Ingestion of microplastics by humans results in uptake and bioaccumulation of harmful chemicals, including known carcinogens (e.g., polychlorinated biphenyls [PCBs] and polycyclic aromatic hydrocarbons [PAHs]) as well as emerging contaminants such as pesticides, pharmaceuticals, and endocrine disrupting compounds. In addition, ingested microplastics cause digestive and reproductive problems, as well as death in fish, birds, and other animals. Microplastics may even harbor pathogenic bacteria. Recent research by the US Geological Survey and U of MN indicates that high concentrations of microplastics are potentially present in Minnesota waters. Little is known; however, about the spatial distribution and heterogeneity of microplastics in Minnesota waters.   
  
To better understand and mitigate the effects of microplastics on public health and wildlife we first need to measure them in a regional scale. Modern techniques for cost effective detection and mapping of microplastics in surface waters are critically needed.

**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.**

The overarching goal of this proposed study is to advance our understanding of remote sensing properties of microplastics in surface waters. The objectives of the project are to:  
  
• Characterize physical properties of microplastics in Minnesota natural and engineered waters.   
• Conduct laboratory experiments to quantify remote sensing properties of microplastics in surface water.   
• Develop/validate drone-based and in-situ remote sensing techniques for cost effective monitoring of microplastics in rivers and lakes.  
• Disseminate the findings to stakeholders, legislators, and the public for strategic planning and awareness.

**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?**

This study will advance science to pave the ways for drone-based and satellite remote sensing and super-resolution in-situ imaging of microplastic particles. The results will lead to cost effective tools for mapping of microplastics in Minnesota waters and real-time monitoring of their concentration in inlets/outlets of wastewater treatment plants. The developed technology will inform decision makers for timely mitigation strategies and policy making to limit environmental and human health effects of related contamination in Minnesota.

## **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?** During the Project and In the Future

## **Activities and Milestones**

### **Activity 1: Laboratory experiments to determine remote sensing properties of microplastics in water**

**Activity Budget:** $50,000

**Activity Description:**Remote sensing and physical properties of microplastics are tightly connected. Groups of samples from streams, rivers and lakes (30), storm water (10), and treated wastewater effluents (10) will be collected throughout Minnesota. The goal is collect a baseline dataset that enables us to study remote sensing properties of microplastics in laboratory (activity 2) based on the type and concentration of microplastics in different water bodies (i.e., rivers vs lakes). The sampling will be conducted during low and high runoff conditions over the first year to make sure that all potential types of microplastics are properly sampled as we hypothesis that their concentration and types vary seasonally based on changes in water transport mechanism and land use. Water samples will be analyzed to determine the type of microplastics as fragments, pellets/beads, lines/fibers or foams.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Collect samples of spectral properties of microplastic in the SAFL reactors and stream lab | August 31, 2022 |
| Develop high-resolution techniques for microplastic particle imaging | March 31, 2023 |
| Data analysis to inference spectral bandwidth for sensing of microplastics using drones | April 30, 2023 |
| Dissemination of Activity 2 findings via at least 1 open access journal publications | September 30, 2023 |

### **Activity 2: Sample and characterize physical properties of microplastics in Minnesota waters**

**Activity Budget:** $180,000

**Activity Description:**Microplastics of various types and concentration will be introduced into the outdoor reactors and experimental stream facilities at the Saint Anthony Falls Laboratory (SAFL) to resemble the boundary conditions and flow regimes of lakes and rivers, respectively. A new hyperspectral spectroradiometer will be purchased and installed over the reactors and the outdoor stream facilities to measure the far field remote sensing signals of microplastics from visible to near infrared wavelengths. The results will reveal connections between the remote sensing signals and concentration, size distribution and types of microplastics. In parallel an RGB camera (available at SAFL) with zoom-in lens in the near field will be deployed for super-resolution imaging of individual microplastic particles.   
  
The former experiment will identify a few key wavelengths that can be used by commercial lightweight cameras on drones (e.g. MicaSens Altum, available with SAFL drone) to quantify and map microplastic type and abundance in the field. The latter experiment will serve as the ground truth for interpreting remote sensing signals, validation and in-situ measurements of microplastics with high degree of accuracy.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Water samples collected, analyzed for microplastic types and abundance | September 30, 2021 |
| Data analyzed and physical characteristics are determined based on the sampled groups | January 31, 2022 |
| Dissemination findings of Activity 1 via 1 open access journal publications | May 31, 2022 |

### **Activity 3: Design, deploy and validate the developed remote sensing techniques in the field**

**Activity Budget:** $79,000

**Activity Description:**Based on the activities 1-2, we will design the remote and in-situ sensing platforms including both the hardware and data processing software to detect the type and estimate the concentration of microplastics. We test and validate the platforms in two stages. First, we conduct controlled experiments in the laboratory, knowing the concentration of microplastics released. Second, based on the data in activity 1, we will identify a watershed and key areas with high concentration of microplastics as well as a wastewater treatment plant to deploy the remote sensing platforms for data collection and validation in the field.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Hardware and software developments for the remote sensing platforms | September 30, 2023 |
| Deploying the platforms in the field | May 31, 2024 |
| Dissemination of Activity 3 findings via at least 1 open access journal publications | July 31, 2024 |
| Validation and analysis of the field data | July 31, 2024 |

## **Project Partners and Collaborators**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Organization** | **Role** | **Receiving Funds** |
| Jiarong Hong | University of Minnesota | Dr Hong is an associate Professor of Mechanical Engineering. Dr. Hong will be responsible for developing in-situ imaging of microplastics in water. | 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 findings of the project will be published in reputable journals of the field and will be presented not only in national conferences but also local public seminars in Minnesota to increase public awareness about the pollution problem of microplastics. To that end. we will arrange annual public seminars at SAFL to inform the public about the plastic pollution and update citizens of Minnesota about the research and actions we are taking at SAFL to understand and mitigate this important health problem. All the seminars will be recorded and will be broadcast online. The collected data will be shared publicly using the Data Repository for University of Minnesota (DRUM) to foster research advancement in the field.   
  
At the same time, the team will reach out to the Minnesota Pollution Control Agency and update the division of microplastic pollution about the findings and explore future opportunities for advancing the project into large-scale cost effective monitoring of microplastics in Minnesota waters. The support from the Natural Resources Trust Fund will be acknowledged through use of the Trust Fund logo in the presentations and will be directly acknowledged in publications per the ENTRF 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 be funded?**This project will provide a new and easily deployable tool for statewide remote sensing of microplastics in rivers and lakes and also pave the ways for future commercial technology developments for satellite remote sensing. The results provide capabilities to the state agencies to establish technology and guidelines to control and reduce microplastics at the sources, advance our storm water management systems and treatment plants to protect public from this emerging treat.  
The project also pave the ways to target federally funded projects in near future such the one (https://nsf.gov/pubs/2020/nsf20050/nsf20050.jsp?org=NSF).

## **Budget Summary**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Category / Name** | **Subcategory or Type** | **Description** | **Purpose** | **Gen. Ineli gible** | **% Bene fits** | **# FTE** | **Class ified Staff?** | **$ Amount** |
| **Personnel** |  |  |  |  |  |  |  |  |
| Undergraduate Student |  | Undergraduate Student |  |  | 0% | 0.06 |  | $10,000 |
| Graduate Student |  | Graduate Student |  |  | 44% | 1.5 |  | $152,410 |
| Research Scientist |  | Research Scientist |  |  | 24% | 0.18 |  | $15,266 |
| Jiarong Hong |  | Co PI |  |  | 27% | 0.12 |  | $21,737 |
| Ardeshir Ebtehaj |  | PI |  |  | 27% | 0.12 |  | $18,632 |
|  |  |  |  |  |  |  | **Sub Total** | **$218,045** |
| **Contracts and Services** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Equipment, Tools, and Supplies** |  |  |  |  |  |  |  |  |
|  | Tools and Supplies | Nylon mesh sieves and mixed cellulose ester membrane filters. | conducting the field sampling |  |  |  |  | $7,500 |
|  |  |  |  |  |  |  | **Sub Total** | **$7,500** |
| **Capital Expenditures** |  |  |  |  |  |  |  |  |
|  |  | A Spectroradiometer with spectral range 350-2500 nano-meter with resolution 2 to 8 nano-meter. | To determine the key wavelengths needed for drone sensing using light weight cameras ALREADY available at SAFL. |  |  |  |  | $76,078 |
|  |  |  |  |  |  |  | **Sub Total** | **$76,078** |
| **Acquisitions and Stewardship** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Travel In Minnesota** |  |  |  |  |  |  |  |  |
|  | Miles/ Meals/ Lodging | Travel to sites for sampling of microplastics in rivers, lakes and wastewater treatment outlets. The cost covers using SAFL trucks and deploying the SAFL boats. | Sample microplastics in Minnesota waters and use them for laboratory experiments to determine their remote sensing properties. |  |  |  |  | $3,627 |
|  |  |  |  |  |  |  | **Sub Total** | **$3,627** |
| **Travel Outside Minnesota** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Printing and Publication** |  |  |  |  |  |  |  |  |
|  | Publication | Activities 1 will lead to 1 publications in reputable open access journals of the field. | Dissemination of knowledge to the community |  |  |  |  | $1,250 |
|  | Publication | Activities 2 will lead to 1 to 2 publications in reputable open access journals of the field | Dissemination of knowledge to the community |  |  |  |  | $1,250 |
|  | Publication | Activities 3 will lead to 1 to 2 publications in reputable open access journals of the field | Dissemination of knowledge to the community |  |  |  |  | $1,250 |
|  |  |  |  |  |  |  | **Sub Total** | **$3,750** |
| **Other Expenses** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
|  |  |  |  |  |  |  | **Grand Total** | **$309,000** |

### **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 | Unrecovered F&A | Support of SAFL facilities where research will be conducted. | Secured | $139,062 |
|  |  |  | **Non State Sub Total** | **$139,062** |
|  |  |  | **Funds Total** | **$139,062** |

## **Attachments**

### **Required Attachments**

#### ***Visual Component***

File: [ad6e9dde-a37.pdf](https://lccmrprojectmgmt.leg.mn/media/map/ad6e9dde-a37.pdf)

#### ***Alternate Text for Visual Component***

The graphics show samples of different types of microplastics in water, spectroradiometric experiments in outdoor stream facility at SAFL and drone-based remote sensing of microplastics over river and lakes....

### **Optional Attachments**

#### ***Support Letter or Other***

|  |  |
| --- | --- |
| **Title** | **File** |
| The new quote for the spectroradiometer | [bc79eb5f-a4d.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/bc79eb5f-a4d.pdf) |
| Research Addendum | [d290665c-60d.docx](https://lccmrprojectmgmt.leg.mn/media/attachments/d290665c-60d.docx) |
| background checks | [fe111bbd-681.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/fe111bbd-681.pdf) |

## **Difference between Proposal and Work Plan**

#### ***Describe changes from Proposal to Work Plan Stage***

We have not changed the content of the proposal and will strive to deliver the promised goal and objectives of the proposal. We mainly reduced the requested summer salaries for the PI and Co-PI and removed 25% of the requested graduate assistant. This might reduce the number of promised publications to 3 to 4 papers in the reputable journals of the field instead of 5 to 6.  
We have primarily budgeted for an ASD spectroradiometer that is not longer in production. The new product is way more expansive but will provide a much better measurement quality and will benefit the quality of research significantly and foster other remote sensing research activities at the Saint Anthony Falls Laboratory. We attached the new quote. We appreciate the opportunity.   
  
We have carefully incorporated all the feedback received from all reviewers and the LCCMR staffs in the revised addendum.   
  
Sincerely, Ardeshir

## **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?**   
 Yes

**Do you agree travel expenses must 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 agree to the Commissioner's Plan.

**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