Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Work Plan (Main Document)

Today's Date: February 22, 2018

Date of Next Status Update Report: January 31, 2019

Date of Work Plan Approval: 06/05/2018

Project Completion Date: June 30, 2021

Does this submission include an amendment request? No

PROJECT TITLE: Assess and Develop Strategies to Remove Microscopic Plastic-Particle Pollution from Minnesota Water Bodies

Project Manager: Filippo Coletti

Organization: University of Minnesota

College/Department/Division: Department of Aerospace Engineering and Mechanics, St. Anthony Falls Laboratory

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Location: Statewide

Total Project Budget: $300,000

Amount Spent: $0

Balance: $300,000

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 04b

Appropriation Language: $300,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to assess, track, and develop methods to remove microscopic plastic particles that are dispersed and accumulating as pollution in Minnesota water bodies. This appropriation is subject to Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

I. PROJECT STATEMENT:

The amount of plastic waste in lakes and rivers is projected to increase, driven by the rise in plastics consumption (about 9% per year worldwide). New federal and state legislation has banned the sale of certain products containing micro-beads, but thousands of tons of micro-plastic pollution are already in our waters, and will take thousands of years to biodegrade. Scientific reports indicate that the Great Lakes, including Lake Superior, and the basin of rivers in Minnesota are polluted with billions of tiny pieces of plastic, and a 2016 report from the Friends of the Mississippi River found high concentration of micro-plastics in the river's sediment in Minnesota. These consists of mm-sized micro-beads and micro-fibers used for cleaning and personal care products or shed from clothing, which slip through the water treatment plants. The largest fraction consists of beads and fibers less than 1 mm in size, used as abrasives in products for household cleaning and personal care, but also shed from synthetic clothes during washing. These are small enough to slip through the water treatment plants. The plastic waste can also break down due to mechanical stresses and UV radiation, or agglomerate in larger flocks of various shapes and density. Such diverse structure of the particles makes it hard to predict their capability of floating or settling, and ultimately their fate. Also, because the motion of particles is influenced by the level of turbulent fluctuations in the water, plastic pollution will have a very different behavior in lakes versus streams. The plastic particles attract toxic substances (like Polychlorinated Bi-Phenyl), vector of invasive species, and enter the aquatic food chain with potentially severe consequences for the ecosystem and the population.

Micro-plastics are insidious because they come in various shapes and sizes, may agglomerate in larger flocks, and behave differently in streaming water versus still water. Because of these complexities, today it is unknown how far they travel in the waterways, how much they float or sink, and ultimately where they end up. Also, because the motions of particles are influenced by the level of turbulent fluctuations in the water, plastic pollution will have a very different behavior in lakes versus streams. Without a systematic data collection and advanced transport models, it is impossible to set up effective strategies to prevent or mitigate the environmental impacts. Indeed, presently there is no established method to limit micro-plastic impact once they enter the water system. We hypothesize that the fundamental understanding of the physical mechanisms governing micro-particle transport in recirculating and streaming water flows can enable the prediction of their fate, and therefore indicate effective removal strategy.

Using the unique facilities at the St. Anthony Falls Laboratory, we will carry out a series of laboratory and field measurements, which will inform and validate advanced computational models. In the laboratory, we will use water channel facilities. The computer simulations will use models that we have successfully used to tackle numerous flow and transport problems in marine and coastal environments. In the field, we will consider both the artificial water stream at St. Anthony Falls Lab and one Minnesota river. We will use multiple portable cameras to image the transport of plastic particles which we will release and collected at downstream locations. For each experiment, we will collect twice as many particles as we release, therefore the environmental impact will be negligible. Our capability of collecting data will be expanded by enlisting Minnesota citizen-scientists, who can provide information from the bodies of water they visit or live by, by sending picture/videos. For this purpose, we will develop a free mobile app from which quantify concentration and accumulation of micro-plastics at the time and location the message was sent.

II. OVERALL PROJECT STATUS UPDATES:

First Update January 31, 2019

Second Update June 30, 2019
Third Update January 31, 2020
Fourth Update June 33, 2020
Fifth Update January 31, 2021
Final Update June 30, 2021

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Perform laboratory measurements of plastic particle traveling in flowing water systems
Description:
This activity will develop foundational understanding of how plastic particles of different shape and size travel, float, and/or settle in streaming water under well-controlled laboratory conditions. Large flumes and water tanks at the St. Anthony Falls Laboratory will be used, reproducing a wide range of regimes occurring in natural water bodies. Tested particles will include plastic beads and fibers from commercially available products, which will be imaged while floating and settling using high-speed, high-resolution cameras

ENRTF BUDGET: $ 121,804

Outcome	Completion Date
1. Characterize micro-plastic transport in lab for varying particle type	June 2019
2. Characterize micro-plastic transport in lab for varying streaming water conditions	June 2020
3. Derive general relationship between transport velocities and physical parameters	January 2021

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ACTIVITY 2: Perform computer simulations of micro-plastic transport processes in fluvial environments
Description:
We will incorporate the findings of Activity #1 into an advanced numerical model to simulate the transport of particles through stagnant, circulating, and streaming water. The relationship for the particle transport velocities as function of flow regime and particle characteristics will be implemented in our high-resolution computer model, for which we will be using the super-computer capabilities available at the St. Anthony Falls Laboratory and at the Minnesota Supercomputing Institute. After validating the model for idealized conditions that replicate the laboratory experiments, we will use the real topography and volume flow rates of the Outdoor Stream Lab and one Minnesota river.

ENRTF BUDGET: $ 132,051

Outcome	Completion Date
1. Validate computational simulations of particle transport against lab measurements	June 2020
2. Perform predictions of the transport of plastic particles in real river settings.	January 2021
3. Identify locations of accumulations enabling effective strategies for removal	June 2021

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ACTIVITY 3: Collect field data and engage citizen-scientists
Description:
We will perform field measurements of plastic particles transport, in the same water bodies investigated by numerical simulations in Activity #2. We will place plastic particles of known size and shape (as used in laboratory experiments and computer simulations) and image them with multiple cameras at various downstream stations. We will use few tens of particles per type, which we will collect with trawls at the downstream locations. After comparing with the simulations, we will use the validated computational tool to provide general guidelines to predict transport and fate of the various particle types. These will be tested through the particle release/collection process. Our capability of collecting data will be greatly expanded by enlisting Minnesota citizen scientists. This will be facilitated by diffusing a free mobile app with which any user can send images and videos from which quantify concentration and accumulation of micro-plastics at the time and location the message was sent.

ENRTF BUDGET: $ 46,145

Outcome	Completion Date
1. Measure micro-particle transport in real river settings.	June 2020
2. Validate computational simulations of particle transport against field measurements	January 2021
3. Increase public awareness by engaging citizen scientists using mobile app	June 2021

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IV. DISSEMINATION:

Description:
The scientific and societal outcomes of the proposed projects will be a prediction tool on the transport of micro-plastics in Minnesota rivers and lakes, which can be used by State agencies. The collected data will be shared with federal and state agencies through a user-friendly web interface, providing guidelines to wisely allocate resources to remove the pollution and mitigate the ecologic impacts. Additionally, we will hold virtual workshops to help agency members familiarize with the tools developed in this project. The research findings will be disseminated through presentations, and local media outlets, and will be leveraged in educational efforts including the SAFL outreach program towards middle school students from Native American tribes in northern Minnesota.

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V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget spreadsheet

Explanation of Capital Expenditures Greater Than $5,000: Six portable digital cameras will be used to record presence and motion of plastic particles at various locations along the considered river. This is the bare minimum number of cameras needed to document the presence and traveling velocity of particles over a significant river segment. The imaging resolution and frame rate need to be sufficient to detect the particles and track their speed. Commercial cameras with such capabilities are listed at about $1,000.

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours: 8,528	Divide by 2,080 = TOTAL FTE: 4.1

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours: N/A	Divide by 2,080 = TOTAL FTE: N/A

B. Other Funds: N/A

VI. PROJECT PARTNERS: N/A

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The scientific and societal outcomes of the proposed projects will be a powerful tool to reduce plastic water pollution, in that it will inform state agencies on where and how to remove harmful micro-plastics from our waters. The collected data will be shared with federal and state agencies through a user-friendly web interface, providing guidelines to wisely allocate resources to remove the pollution and mitigate the ecologic impacts. The information will be used to inform consumers' choice, support legislative action, and influence corporate responsibility, ultimately preserving the aquatic ecosystem and population of Minnesota. Further funding to extend the scope of this work will be sought through the National Science Foundation, the U.S. Geological Survey, and the National Institutes for Water Resources, which all supports annual call for proposals to focus on water quality problems.

VIII. REPORTING REQUIREMENTS:

- **The project is for 3 years, will begin on July 1 2018, and end on June 30 2021.**
- **Periodic project status update reports will be submitted January 31 and June 30 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2021.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

B. Visual Component or Map
D. Research Addendum (internally peer-reviewed by U of M specialists)

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2018 Budget Spreadsheet

Project Title: Assess and Develop Strategies to Remove Microscopic Plastic-Particle Pollution from Minnesota Water Bodies

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 04b
Project Manager: Filippo Coletti
Organization: University of Minnesota
College/Department/Division: Department of Aerospace Engineering and Mechanics, St. Anthony Falls Laboratory
M.L. 2018 ENRTF Appropriation:
Project Length and Completion Date: 3 years, to be completed on June 30 2021
Date of Report: 22 February 2018

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	TOTAL BUDGET	AMOUNT SPENT	TOTAL BALANCE
BUDGET ITEM			
Personnel (Wages and Benefits)	$291,500		$291,500
1 graduate student at 50% FTE for 3 years; 1 postdoctoral fellow at 100% FTE for 2 years; 1 technician at 12.5% FTE for three years; PI Filippo at 5% FTE for 3 years; co-PI Lian Shen at 3% for 3 years.			
Equipment/Tools/Supplies	$1,500		$1,500
Supplies for laboratory and field measurements			
Capital Expenditures Over $5,000	$6,000		$6,000
Portable cameras for particle imaging			
Travel expenses in Minnesota	$1,000		$1,000
Field deployment on a river in Minnesota			
COLUMN TOTAL	**$300,000**		**$300,000**