Today's Date: 02/10/2020

Date of Next Status Update Report: April 1, 2021

Date of Work Plan Approval:

Project Completion Date: 8/15/2023

Does this submission include an amendment request? __

PROJECT TITLE: Developing strategies to manage PFAS in land-applied biosolids

Project Manager: Summer Streets

Organization: Minnesota Pollution Control Agency

College, Department, or Division: Environmental Analysis and Outcomes

Mailing Address: 520 Lafayette Road North

City, State, Zip Code: Saint Paul, Minnesota 55155

Project Manager Direct Telephone Number: (651) 757-2761

Email Address: summer.streets@state.mn.us

Web Address: NA

Location: St Paul, MN

Total Project Budget: $1,000,000

Amount Spent: $0

Balance: $1,000,000

Legal Citation: M.L. 2020, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

PROJECT STATEMENT:

This project helps municipal wastewater plants, landfills, and compost facilities protect human health and the environment by developing strategies to manage per- and polyfluoroalkyl substances (PFAS) in land-applied biosolids.

Environmental contamination by PFAS is a widespread issue of global concern, and concentrations commonly found throughout Minnesota pose known risks to human and ecological health. Elevated levels of PFAS have been measured in Minnesota municipal biosolids, landfill leachate, and compost contact water. While land application of these biosolids has benefits for farming, land application is a known source of PFAS to groundwater, soil, surface water, and crops. Human health can be impacted when PFAS-contaminated water and food is consumed. There is still a lot we don't know about how PFAS moves out of biosolids and into the environment and food supplies.

Waste managers in Minnesota are already facing urgent concerns related to disposal of PFAS-contaminated wastes. They have an immediate need of tools to evaluate and manage PFAS in their land-applied waste streams. This project will focus on developing cost-effective, real world approaches for preventing, treating, and disposal of PFAS-contaminated land-applied wastes. This study will allow us to proactively manage biosolids in a way that prevents environmental contamination by PFAS.

The goals of this study are to:

1) Analyze alternative disposal and treatment options and develop tools for managing PFAS-contaminated waste streams.
2) Evaluate and characterize PFAS concentrations in land-applied biosolids; leaching from those wastes; and subsequent movement of PFAS into water and food.

II. OVERALL PROJECT STATUS UPDATES:

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project and end date (June 30, 2023) and August 15, 2023

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1 Title: Controlled plot study to evaluate leaching and uptake of PFAS

Controlled plots established at the Rosemount Research and Outreach Center in Rosemount, MN will be used to evaluate leaching under environmentally relevant conditions. The soil at this site is a Waukegan silt loam in the top two feet with a sand to gravel subsoil. A total of 8 treatments will be evaluated: 3 biosolids representing a variety of treatment types, food/household waste compost, yard waste compost, ash (incinerated biosolids), polymer-stabilized biosolids, and conventional fertilizer as a control. Each treatment will be replicated 4 times for a total of 32 plots. We already have evidence of leaching at sites where landfill leachate is land applied, so it will not be evaluated in this part of the study. All amendments, including the control fertilizer, will be analyzed for PFAS prior to land application.

Activity 1A: Field plot study - year one (April 2021 – May 2022)

In the first year, all treatments applied will meet the recommended nitrogen rate of 180 pounds of nitrogen/acre. Phosphorus, potassium, and sulfur will be applied to the conventional treatment based on soil test. For biosolids treatments, other nutrients may need to be applied based on biosolids analysis.

Corn will be grown on all plots in the first year. Corn will be harvested at the end of the growing season, and the grain and silage will be tested for PFAS.

Leaching will be measured with ceramic suction tubes. One tube will be installed in each plot to a depth of 180 cm, which is well below the root zone. Samples will be collected monthly until crop is harvested. Water collected from the suction tubes will be analyzed for PFAS at Texas Tech University (activity 2B).

Soil samples will be collected and analyzed for PFAS from each plot to a depth of 90 cm at 30 cm intervals. Sample collection will occur at 0, 75, and 150 days post-application. Soil samples will also be analyzed for total organic carbon and pH by the University of Minnesota Research Analytical Laboratory.

Activity 1B: Field plot study – year two (April 2022 – May 2023)

In the second year, no additional land application will occur and all plots will be grown in soybeans. Soybeans will be harvested and analyzed for PFAS at the end of the growing season. We will again collect leachate for PFAS analysis for the strategy used in year one.

Soil samples will be collected and analyzed for PFAS from each plot to a depth of 90 cm at 30 cm intervals. Sample collection will occur at 0, 75, and 150 days post-application. Soil samples will also be analyzed for total organic carbon and pH by the University of Minnesota Research Analytical Laboratory.

ACTIVITY 1 ENTRF Budget: $358,000

Outcome	Completion Date
1. Activity 1A: Field plot study – year one (April 2021 – May 2022)	*May 1, 2022*
2. Activity 1B: Field plot study – year two (March 2022 – May 2023)	*May 1, 2023*

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project and end date (June 30, 2023) and August 15, 2023

ACTIVITY 2 Title: Laboratory investigation of PFAS fate and transport, and identification of 325 novel PFAS compounds

Activity 2A: Sample collection

MPCA staff will collect biosolids, incinerated biosolids (ash), from WWTPs, compost, and contact water from compost facilities. MPCA staff will collect soil, groundwater, and crops from controlled plots (activity 1) where biosolids, compost, ash, and control fertilizer have been land applied.

MPCA staff will ship samples to Texas Tech University for analysis (activity 2B). Shipping costs are included in the budget.

Activity 2B: Sample analysis and identification of novel PFAS

Samples collected in activity 2A will be extracted and concentrations of a minimum of 32 PFAS will be quantified. Select samples with elevated PFAS concentrations will be subject to further analysis using high resolution mass spectrometry (HRMS). Results will be compared with an existing mass spectral library of ~325 PFAS. The majority of these 325 compounds do not have analytical standards, thus the results will be applied in two primary ways. First, they can be used to determine the occurrence of a broad suite of PFAS, which can be used to drive future decisions regarding which PFAS may need to be the focus of more detailed studies or management efforts. Second, results can be used semi-quantitatively to determine relative increases or decreases in concentration. In some cases, structurally similar PFAS that have analytical standards may be used to estimate concentrations of these compounds on an order of magnitude level.

Activity 2C: Soil column study of PFAS leaching and mobility in field-collected soils

Land applied biosolids may introduce PFAS into the environment that subsequently leach to groundwater, runoff to surface water, and/or undergo plant uptake. Sorption processes may strongly influence transport, but it has been studied for only a subset of PFAS. Factors that may influence PFAS sorption include compound chain length, soil organic carbon, soil ion exchange capacity, pH, and aqueous divalent cation concentration.

In addition to sorption, precursors are also influenced by transformation, and this has been shown to increase perfluoroalkyl acid (PFAA) concentrations in biosolids-amended soils. For example, studies of transformation in various environmental media have shown that fluorotelomer-based compounds can degrade to PFCAs (e.g. PFOA) with an equal or lesser number of fluorinated carbons. Terminal degradation products of perfluoroalkyl sulfonamide derivatives are PFSAs (e.g. PFOS) of the same chain length.

PFAS leaching and mobility in biosolids-amended soils will be studied in laboratory investigations utilizing soil columns packed with field collected materials. Prior to using field-collected materials, the project team will utilize PFAS-spiked system to establish and validate a consistent methodology that can be used for cross-comparison of PFAS leaching. This method will then be applied to field collected materials from different types of land application sites (e.g. biosolids vs. compost vs. ash-amended soils), and may also be used to evaluate leaching of stabilized materials (e.g. polymer-stabilized biosolids).

ACTIVITY 2 ENTRF Budget: $350,000

Outcome	Completion Date
1. Activity 2A: Sample collection	*November 1, 2022*
2. Activity 2B: Sample analysis and identification of novel PFAS	*May 1, 2023*
3. Activity 2C: Soil column study of PFAS leaching and mobility	*December 15, 2021*

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project and end date (June 30, 2023) and August 15, 2023

ACTIVITY 3 Title: PFAS split sample analysis

A total of 50 samples across all relevant media and field sites will be collected by MPCA staff and will be analyzed by SGS Axys Analytical Services for 33 PFAS under the current state contract. Samples analyzed will be split samples, with the matching split being analyzed at Texas Tech University (activity 2B). The purpose of the split samples is to validate and verify Texas Tech's quantitative analytical method results.

ACTIVITY 3 ENTRF Budget: $32,000

Outcome	Completion Date
1. Activity 4: Analysis of 50 samples	*May 1, 2023*

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project and end date (June 30, 2023) and August 15, 2023

ACTIVITY 4 Title: Developing PFAS management solutions and costs for municipal wastewater, municipal biosolids, landfill leachate and compost contact water

Activity 4A: PFAS treatment and destruction technology evaluation

The Request for Proposals (RFP) will encourage the state and national design community to apply for funds to complete an analysis of PFAS treatment and destruction options. The RFP contracting process will be managed by the MPCA contract staff, reviewed by MPCA engineers and will comply with all state and federal regulations. The final candidate will be selected by a committee of MPCA engineering staff and municipal wastewater engineers under the guidance of the MPCA contract unit. Once the best candidate is selected, funds and necessary design information will be delivered to the contractor by the MPCA.

The contractor will, at a minimum, review the feasibility of the selected technology categories in Table 1 with respect to treating PFAS in municipal wastewater, biosolids, landfill leachate and compost contact water. The goal is to understand all preliminary advantages and disadvantages of each selected approach in order to rank them and find the most feasible treatment technology that can both remove PFAS from the media of interest and also fully destroy the removed PFAS. Feasibility will be defined as a holistic evaluation of the technology considering relative costs, design, operation, waste stream handling, and other life-cycle analysis concerns such as greenhouse gas emissions. In the analysis, eliminating a technology for lack of feasibility is just as important as finding an alternative that is feasible. The contractor will also be required to evaluate the feasibility of developing regional strategies to address PFAS treatment and destruction. For example, technologies listed in Table 1 (e.g. incinerators) could be too complicated and expensive for a single entity to build and maintain but could be done more cost-effectively on a regional basis where resources are pooled.

The MPCA has selected the treatment alternatives listed below but this list should not be considered exhaustive. The contractor will demonstrate having evaluated whether other treatment alternatives not listed might be feasible or whether linking several treatment alternatives in new ways might generate a new feasible alternative. The contractor must demonstrate that they understand that the list below represents categories, and that the specifics of the technologies within each category must be illuminated in the alternative analysis. This activity should not involve collecting any water samples or physically evaluating treatment technologies at the bench or pilot scale. The goal of this activity is a white paper level analysis of feasibility.

The contractor will be provided with PFAS treatment goals for the given media (wastewater, biosolids, landfill leachate, and compost contact water). The contractor will, to the extent possible, determine how each treatment technology would work across the range of provided treatment goals and media of interest.

A presentation of the most feasible treatment alternatives to a panel of engineering experts will be required. The panel of experts will include MPCA staff and engineering experts from outside the MPCA. A written summary evaluating each alternative with the selection of the most feasible alternative for a municipal wastewater treatment plant (WWTP) will be the deliverable for activity 4. The deliverable will be completed in journal-ready format suitable for submission to a peer-reviewed academic journal.

Table 1. The minimum categories of PFAS treatment technologies required for review in activity 4.

Technology Category	Technology Type
Flocculation/Coagulation	Alum
	Polyaluminum Chlorides
	Ferric Salts
	Covalent Bound Hybrid Coagulants
	Specialty Coagulants
	Electrocoagulation
Sorption	Granular Activated Carbon
	CNT and Graphene
	Colloidal Activated Carbon
	Ion Exchange Resins
	Biochar
	PAC/Alum/Kaolinite
	Clay Minerals
Redox Chemistry	Solvated Electrons
	Catalyzed H2O2
	Ozone
	Activated Persulfate
	Photolysis
	Electrochemical
	Sonochemical
	Plasma
	Zero Valent Iron
	Alkaline Metal Reduction
	Thermal Induced Reduction
Membrane Filtration	NF & RO Membranes
	Ultrafiltration
Biodegradation	Fungal Enzymes
	Bacterial Enzymes
	Biotransformation
	Phytoremediation
Pollution Prevention	Pollution Prevention Strategies
Thermal Treatment	Incineration
	Direct-fired Desorption
	Indirect-fired Desorption

Activity 4B: Cost development and design analysis

The candidate will select the two most promising PFAS treatment and destruction systems from Activity 4A and develop cost estimates for representative wastewater plants, biosolids, landfills and compost facilities. The cost estimate should take the form of cost curves that will explain how PFAS treatment costs vary as a function of system size, treatment volumes, disposal methods and levels of PFAS treatment and destruction.

The goal of this analysis would be to unearth implementation concerns only discoverable through initial design and to get a better sense of costs and relevant implementation concerns. The information found in this preliminary analysis would be used to inform the final deliverable with respect to costs and design considerations.

A facility plan level analysis as defined in the ten state standards (section 11; http://www.10statesstandards.com/wastewaterstandards.pdf) will be used as a guide to the level of analysis required for developing cost curves. Detailed design (e.g. sewering, electrical, structural, pumping, etc.), financing methods, construction schedules, population projections, and environmental review will not be required. Unit operation train diagrams and general flow diagrams will be required. A conceptual understanding of the proposed system design, operation and maintenance should be the goal of activity 4B.

The contractor should also generally comment on whether new construction would be required for each scenario or whether a conventional treatment system could be retrofitted to treat PFAS. The MPCA will provide theoretical specifications for retrofit considerations. The facility plan documents do not need to go into specific design of retrofitted plants; a general comment on the feasibility of retrofitting the representative WWTPs for treating sulfate is all that will be required.

A presentation of the results to a panel of engineering experts will be required in addition to presentation at regional conferences. The panel of experts will include MPCA staff and engineering experts from outside the MPCA. The written deliverable will be completed in journal-ready format suitable for submission to a peer-reviewed academic journal.

ACTIVITY 4 ENRTF BUDGET: $260,000

Outcome	Completion Date
1. MPCA publically issues RFP	*July 1, 2020*
2. MPCA finalizes candidate selection and initiates project kick-off	*November 1, 2020*
3. Activity 4A complete – PFAS technology ranking	*August 31, 2021*
4. Activity 4A and 4B complete – Final costs and technology ranking deliverable	*June 30, 2022*

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project and end date (June 30, 2023) and August 15, 2023

IV. DISSEMINATION:

Description:

The Minnesota Environment and Natural Resources Trust Fund (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 Acknowledgement Guidelines.

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project and end date (June 30, 2023) and August 15, 2023

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

None

Explanation of Capital Expenditures Greater Than $5,000:

Explanation of Use of Classified Staff:

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

Enter Total Estimated Personnel Hours for entire duration of project:	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE:

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

Enter Total Estimated Contract Personnel Hours for entire duration of project:	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE:

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding

B. **Activity 1:** Dr. Carl Rosen at the University of Minnesota has extensive experience in conducting controlled plot studies to evaluate crop agronomics.
Activity 2: Dr. Jennifer Guelfo at Texas Tech University is the leading expert in PFAS leaching from soils. She has PFAS measurement capabilities that are not possible in Minnesota without $1 million in new instrumentation.
Activity 3: SGS Axys Analytical Services is currently under state contract. This lab has been used by the state for over a decade and delivers high quality, dependable results.
Activity 4: Minnesota-based consulting firm selected by competitive RFP.

C. Partners outside of project manager's organization NOT receiving ENRTF funding
    a. Municipalities
    b. County governments

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

This project will support the long-term implementation goals of Minnesota to ensure appropriate disposal of wastes in Minnesota and to safeguard drinking water for current and future needs. This is a one-time funding request and no additional future support is envisioned.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted April 1 and October 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2023

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

B. Visual Component or Map

C. Parcel List Spreadsheet

D. Acquisition, Easements, and Restoration Requirements

E. Research Addendum

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Summer Streets
Project Title: Developing strategies to manage PFAS in land-applied biosolids
Organization: Minnesota Pollution Control Agency
Project Budget: $1,000,000
Project Length and Completion Date: 3 years; 2023
Today's Date: 02/10/2020

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Professional/Technical/Service Contracts			
Activity 1: Controlled plot study to evaluate leaching and uptake of PFAS. Dr. Carl Rosen, University of Minnesota. Single source.	$ 350,000		$ 350,000
Activity 2: Laboratory investigation of PFAS fate and transport, and identification of 325 novel PFAS compounds; Dr. Jennifer Guelfo, Texas Tech University. Single source.	$ 342,000	$ -	$ 342,000
Activity 3: PFAS split sample analysis.SGS Axys Analtyical Services, Ltd. Current state contract. Single source.	$ 25,000		$ 25,000
Activity 4: PFAS treatment and destruction technology evaluation; competitive RFP	$ 260,000		$ 260,000
Equipment/Tools/Supplies			
Sample shipping, general sampling equipment and disposables including sample bottles, gloves, solvents,	$ 18,000	$ -	$ 18,000
	$ -	$ -	$ -
	$ -	$ -	$ -
Travel expenses in Minnesota			
12 trips to field sites by car, all expenses per Commissioner's plan	$ 2,000	$ -	$ 2,000
2 MPCA staff presenting at 2 in-state conferences. All expenses per Commissioner's plan.	$ 3,000		$ 3,000
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 1,000,000	$ -	$ 1,000,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: MPCA staff time equivalent to one FTE per study year	Secured	$ 360,000	$ -	$ 360,000
University of Minnesota overhead	Pending	$ 182,000	$ -	$ 182,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

Project 098-B: Developing strategies to manage PFAS in land-applied biosolids