Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2017 LCCMR Work Plan

Date of Submission: October 7, 2016

Date of Next Status Update Report: January 1, 2018

Date of Work Plan Approval:

Project Completion Date: June 30, 2019

Does this submission include an amendment request? __

PROJECT TITLE: Maximizing the Benefits of Water Reuse

Project Manager: Satoshi Ishii

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Location: Statewide

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$148,000**
	Amount Spent:	**$0**
	Balance:	**$148,000**

Legal Citation: M.L. 2017, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:
[To be inserted following the MN Legislative Session in Spring 2017. This will be blank for the initial submission and will be provided to you at a later date.]

I. PROJECT TITLE: Maximizing the Benefits of Water Reuse

II. PROJECT STATEMENT:

The goal of this project is to maximize the potential of water reuse in Minnesota by eliminating barriers to water reuse implementation. Reusing water will improve water quality through better stormwater management and reduce demands on groundwater aquifers. Quality of reclaimed water (i.e., treated wastewater/stormwater for reuse purposes) needs to be maintained to assure safe water reuse. However, there is no water quality standard for water reuse for various purposes such as toilet flushing, vehicle washing, irrigation and final product rinse. On some occasions, sophisticated and expensive treatment is used to create reclaimed water with quality possibly higher than necessary for flushing a toilet. The cost of water reuse systems may be reduced by utilizing design components that minimize pathogens. By quantitatively detecting multiple human pathogens in Minnesota water reuse systems, we will have data for use in setting water quality standards and making design recommendations.

The specific goals of this work are to:

1. System Design: Collect information on design elements (including water source, storage, and treatment devices) for the 24 water reuse systems within the state (see Activity 1 for detail).
2. Pathogens: Quantitatively detect multiple human pathogens in the 24 water reuse systems. Compare pathogen data among the reuse systems.
3. Risk Assessment: Relate the pathogen data to health risk through quantitative microbial risk assessment (QMRA) in order to ensure the health and safety of the public is protected.
4. Recommendations: Make recommendations about water quality standards and treatment design to set a clear path for water reuse in Minnesota.

This project will be done with a team of scientists/engineers from the University of Minnesota (U of M) and the Minnesota Department of Health (MDH). The U of M previously developed innovative tools to quantify multiple pathogens (both bacteria and viruses) in many water samples. By taking advantage of these tools, the team can comprehensively analyze the safety of water reuse and relate system design to pathogen occurrence. Based on these results, the MDH can set a standard for water reuse and make system design recommendations.

The need for this work is supported by national reports that conclude understanding the occurrence and fate of human pathogens in graywater and stormwater is a primary research need. Thus, we have a unique opportunity in Minnesota to contribute to advancing water reuse both in Minnesota and across the country.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of Status as of January 1, 2018:

Project Status as of Status as of July 1, 2018:

Project Status as of Status as of January 1, 2019:

Project Status as of Status as of July 1, 2019:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Water sample collections

Description:

The goal of this activity is to collect various recycled water samples. Samples collected in this activity will be used to quantify pathogen concentrations in Activity 2.

Water samples will be collected from 24 water reuse systems around the state. Final site selection will depend on the owner's agreement to participate in the study. Most of the water reuse systems are located in the metro area (18 research sites), but there are examples in Northeast (3 sites), Central (2 sites), and Southern MN (1 site). The reused water at these systems is used for various purposes such as toilet flushing (4 sites), vehicle washing (2 sites), irrigation (11 sites), and other industry usages (7 sites).

The preferred sample sites include a mixture of public and privately owned locations with various designs, treatment techniques, and end uses. For example, one potential site is located on the University of Minnesota campus in the Twin Cities. At this site, precipitation is collected from the 17th Avenue Residence Hall roof and surrounding sidewalk for use primarily in flushing toilets, but also for irrigation. Taking samples from this site under different weather conditions will help expand our understanding of microbial dynamics at this site.

Other potential systems to include are locations where precipitation is collected for various purposes, such as flushing toilets, turf irrigation, washing vehicles or washing stadiums. For example, the St. Paul Saints stadium in St. Paul, MN and Twins stadium in Minneapolis, MN could provide examples of systems located at similar venues but with differing collection systems, treatment trains, and end uses. Additional examples of water reuse systems that could be studied include several municipally-owned systems that collect stormwater for irrigating city properties or park areas. Possible examples include irrigation systems in the cities of Centerville, Cottage Grove, St. Anthony Village, or Woodbury, MN. A vehicle washing facility at St. Louis County, MN, that uses rainwater in the washing process could provide data about this additional type of end use. Further, a new graywater system at Lake Vermillion State Park would provide an excellent opportunity to learn more about microbial populations in a graywater system in Minnesota. The diversity of the systems' designs and treatment techniques will help to broaden understanding of microbial populations in water reuse systems in Minnesota's diverse settings and variable weather conditions.

We anticipate collecting samples from each reuse system on two different occasions, sampling at the source, after treatment and distributed water as appropriate for the site (24 locations x 2 time points x 3 types = 144 samples). Tap water collected from several drinking water treatment facilities will be used as negative control samples.

Physical and chemical properties of the water samples (temperature, pH, turbidity, odor, biomass and chlorine concentration, etc.) will be recorded. We will also inventory and record the types of water reuse design components such as source of reuse water, storage and treatment devices used in each water system. Sources will include rainwater (from roofs), stormwater, graywater and industrial process water. Storage includes cisterns, stormwater ponds and underground storage. Treatment devices include first flush devices, disinfection such as chlorine or ozone, or filters. These components can affect water quality by affecting the ability of pathogens to collect, survive, and multiply.

Water samples (10-1,000 L depending on water quality) will be filtered on site through membrane filters to capture bacteria and viruses, and brought back to the lab in the University of Minnesota. Bacterial cells and viral particles will be detached from the membranes and pelleted by centrifugation. These pellets will be frozen and stored until used for Activity 2.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 47,000
Amount Spent: $ 0
Balance: $ 47,000

Outcome	Completion Date
1. *Sample collection and bacteria/virus concentration (144 samples)*	September 30, 2018
2. *Physical and chemical properties of the water samples*	September 30, 2018
3. *Documentation of water reuse system design*	September 30, 2018

Activity 1 Status as of January 1, 2018:

Activity 1 Status as of July 1, 2018:

Activity 1 Status as of January 1, 2019:

Activity 1 Status as of July 1, 2019:

Final Report Summary:

ACTIVITY 2: Quantitatively detect multiple human pathogens in reuse systems

Description:

In this activity, we will quantitatively detect multiple human pathogens (both bacteria and viruses) in the 144 water samples collected in Activity 1. We will target all major waterborne pathogens including *E. coli* O157, *Salmonella*, *Campylobacter*, *Shigella*, *Clostridium perfringens*, *Legionella pneumophila*, *Listeria monocytogenes*, human adenovirus, Astrovirus, Enterovirus, human Norovirus (GI, GII, and GIV genotypes), Hepatitis A virus, Hepatitis E virus, Rotavirus A, and Sapovirus. The project manager (Dr. Ishii at the U of M) has developed and optimized the microfluidics quantitative PCR chip system to simultaneously quantify these pathogens in water samples. All necessary equipment is present in the U of M, and will be used in this project.

DNA and RNA will be extracted from the cell pellets prepared from the 144 water samples in Activity 1. Pathogen-specific genes will be amplified and quantified in the microfluidic quantitative PCR chip. Based on these results, we will calculate the concentrations of pathogens per liter water. These concentration data will be used for the risk assessment in Activity 3.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 72,000
Amount Spent: $ 0
Balance: $ 72,000

Outcome	Completion Date
1. *DNA and RNA samples (144 samples)*	December 31, 2018
2. *Concentrations of multiple pathogens in water samples*	December 31, 2018

Activity 2 Status as of January 1, 2018:

Activity 2 Status as of July 1, 2018:

Activity 2 Status as of January 1, 2019:

Activity 2 Status as of July 1, 2019:

Final Report Summary:

ACTIVITY 3: Quantitative microbial risk assessment

Description:

In this activity, we will assess the potential health risks associated with the water samples through quantitative microbial risk assessment (QMRA). Risk of pathogen infection is a function of pathogen concentration in water, infectious dose of the pathogen, and a probability of pathogen exposure. We will use the pathogen concentration data obtained in Activity 2. Infectious dose is the concentration of pathogens that cause pathogen infection to 50% of human population. The infectious dose differs by pathogen and is available in the literature. The probability of pathogen exposure differs by water reuse purpose. For example, when reclaimed water is used to for irrigation to golf green, people may ingest mist generated by sprinklers. We will calculate the volume of mist people may ingest and then calculate the probability of pathogen exposure by taking pathogen concentration in the mist into account.

Based on the QMRA results (Activity 3) and water reuse system design assessment (Activity 1), we will analyze how system design components affect the microbial pathogen populations in the water. We will then recommend water quality standards and make system design recommendations using best public health and engineering practices. Benefits of water reuse will be maximized due to elimination of barriers.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 29,000
Amount Spent: $ 0
Balance: $ 29,000

Outcome	Completion Date
1. *Potential health risks of water samples*	March 31, 2019
2. *Analysis of microbial data in relation to system design*	March 31, 2019
3. *Recommend water quality and design standards for water reuse systems*	June 30, 2019

Activity 3 Status as of January 1, 2018:

Activity 3 Status as of July 1, 2018:

Activity 3 Status as of January 1, 2019:

Activity 3 Status as of July 1, 2019:

Final Report Summary:

V. DISSEMINATION:

Description:

Findings will be disseminated and archived via reports to LCCMR, peer-reviewed publications, and presentations at conferences. We will also publish recommended water quality and design standards for water reuse purposes on the Minnesota Department of Health's website or other locations as appropriate.

Status as of January 1, 2018:

Status as of July 1, 2018:

Status as of January 1, 2019:

Status as of July 1, 2019:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview:

***This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report.**

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 123,000	1 project manager at 8% FTE for two years; one graduate research assistant at 50% FTE for two years; 1 undergraduate research assistant at 100% FTE for 5 months.
Equipment/Tools/Supplies:	$20,000	General lab supplies ($3,000), membrane filters ($3,000), water sample analysis ($2,000), DNA/RNA extraction kits ($2,000), reagents for qPCR ($4,000), use of UMGC's facilities for microfluidic qPCR ($6,000)
Travel Expenses in MN:	$5,000	In-state travel to collect water samples: Mileage $4000; meals $1,000
TOTAL ENRTF BUDGET:	**$148,000**	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than $5,000: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 1.5

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

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
N/A		$	
State			
University of Minnesota	$56,000	$0	In-kind contribution of indirect costs not charged to this project
Minnesota Department of Health	$32,000	$0	In-kind salary for Anita Anderson and Nancy Rice
TOTAL OTHER FUNDS:	**$88,000**	**$0**	

VII. PROJECT STRATEGY:

A. Project Partners:

Partners receiving ENRTF funding: N/A

Partners NOT receiving ENRTF funding

- Timothy LaPara (Professor at the Department of Civil, Environmental, and Geo- Engineering, the University of Minnesota): Providing technical support (Activities 1, 2, and 3)
- Anita Anderson (Principal Engineering Supervisor at the Drinking Water Protection Unit, Minnesota Department of Health): Providing advice on water sample collection (Activity 1) and recommending water quality and design standards for water reuse systems (Activity 3)
- Nancy Rice (Research Scientist at the Health Risk Assessment Unit, Minnesota Department of Health): Providing advice on QMRA (Activity 3)

B. Project Impact and Long-term Strategy:

This project will maximize the potential of water reuse to conserve Minnesota's groundwater and improve surface water quality by providing the pathogen data needed to eliminate barriers to water reuse. This project will provide assurances to the public, regulators and system owners that water reuse can become common practice without negative effects on public health and safety and provide design information to reduce cost.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
Clean water fund	September 1, 2014 to December 31, 2016 (no-cost extension being requested to June 30, 2017)	$200,000
Total		$200,000

VIII. REPORTING REQUIREMENTS:

- **The project is for 2 years, will begin on July 1, 2017, and end on June 30, 2019.**
- **Periodic project status update reports will be submitted January 1 and July 1 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2019**.

IX. VISUAL COMPONENT or MAP(S): See attached visual

Environment and Natural Resources Trust Fund
M.L. 2017 Project Budget

Project Title: *Maximizing the Benefits of Water Reuse*

Legal Citation: *Fill in your project's legal citation from the appropriation language - this will occur after the 2017 legislative session.*

Project Manager: *Satoshi Ishii*

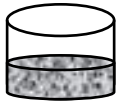
Organization: *University of Minnesota*

M.L. 2017 ENRTF Appropriation: $ *148,000*

Project Length and Completion Date: *2 Years, June 30, 2019*

Date of Report: *9/14/2016*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Water sample collections***			***Quantitatively detect multiple human***			***Quantitative microbial risk assessment***				
Personnel (Wages and Benefits)	$37,000	$0	$37,000	$57,000	$0	$57,000	$29,000	$0	$29,000	$123,000	$123,000
Satoshi Ishii, Project Manager: $27,000 (75% salary, 25% benefits) 8% FTE each year for 2 years											
Graduate research assistant: $87,000 (55% salary, 45% benef 50% FTE for 2 years											
Undergraduate research assistant: $9,000 (100% salary, 0% benefits); 100% FTE in summer for 5 months											
Equipment/Tools/Supplies											
General lab supplies ($3,000), membrane filters ($3,000), water sample analysis ($2,000), DNA/RNA extraction kits ($2,000), reagents for qPCR ($4,000), use of UMGC's facilities for microfluidic qPCR ($6,000)	$5,000	$0	$5,000	$15,000	$0	$15,000				$20,000	$20,000
Travel expenses in Minnesota											
In-state travel to collect water samples: Mileage $4000; meals $1,000	$5,000	$0	$5,000							$5,000	$5,000
COLUMN TOTAL	**$47,000**	**$0**	**$47,000**	**$72,000**	**$0**	**$72,000**	**$29,000**	**$0**	**$29,000**	**$148,000**	**$148,000**

Source water		Collection and Storage	Test Water (Pre-Treatment)	Treatment	Test Water (Post-Treatment)	Analyze/ Characterize	Set a Clear Pathway	Benefit Resources
 Graywater (sinks, shower, tub, laundry)	→	Collection surface, storage type (cistern, pond, underground tank) 	Water sampling  →	Examples: filtration, ultraviolet light, ozone, chlorine, or none →	Water sampling  →	Quantify human pathogens  → Perform Quantitative Microbial Risk Assessment and Design Analysis	Make recommendations for water quality and design →	Protect groundwater resources and improve water quality by maximizing the potential for water reuse
 Stormwater								
Industrial Processes 								

Maximizing the Benefits of Water Reuse