Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 040-B**

Promoting Nitrogen Removal in Channels, Floodplains, and Riparian Areas

Category: B. Water Resources

Total Project Budget: $ 390,641

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

The goal is to develop a tool to quantify nitrogen removal in floodplains and riparian areas to inform best management practices and promote clean water conditions across the landscapes of Minnesota.

Name: Miki Hondzo

Sponsoring Organization: U of MN

Address: St. Anthony Falls Laboratory, 2nd Third Ave SE

Minneapolis MN 55414-2196

Telephone Number: (612) 625-0053

Email mhondzo@umn.edu

Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Promoting Nitrogen Removal in Channels, Floodplains, and Riparian Areas

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Promoting Nitrogen Removal in Channels, Floodplains, and Riparian Areas

I. PROJECT STATEMENT

Excessive nitrogen loading in aquatic ecosystems leads to water quality issues including loss of stream biodiversity, eutrophication, and algal blooms, in addition to drinking water contamination that is expensive to treat. Soluble nitrogen from animal manure, excess fertilizer, stormwater, or pet waste ends up in runoff and is converted to nitrogen gas through a microbial process called denitrification. Small areas of enhanced denitrification activity, termed denitrification **hot spots**, frequently account for a **high percentage of nitrate removal** in surface water and wetlands. In order to maximize the removal of nitrogen and facilitate clean water in aquatic ecosystems, an overall objective is to enhance the occurrence of denitrification **hot spots** on the landscape. If managed appropriately, headwater streams, which make up approximately 85% of total stream miles, provide an opportunity to remove excess nitrogen from water before it reaches larger waterbodies. A fundamental question underlining the effectiveness of nitrate removal from surface water is: What combination of physical and chemical processes determine the formation, operation, and disappearance of denitrification hot spots in the Minnesota landscape? The goal of this project is develop a tool to quantify nitrogen removal in streams, floodplains, riparian areas, and wetlands to inform best management practices (BMPs) to maximize nitrogen removal. The BMPs include (but are not limited to) the practices that alter the timing and duration of nitrogen laden water delivery to reactive sediment surfaces and vegetation in channels, floodplains, and riparian areas. Specifically, the practices consist of tile system design, controlled drainage, water and sediment control basins, culvert sizing, and two-stage ditches.

We propose to develop a tool based on readily available spatial data (soil characteristics, flow rates, land use, etc.) to evaluate BMPs based on a mechanistic understanding of microbial denitrification rates in surface water, floodplains, and riparian areas. We will explore interdisciplinary research and integrate microbiological and hydrological methods to predict denitrification hot spots. Reducing nutrient loads in surface water requires a multifaceted approach addressing nutrient application and surface/subsurface movement and transformation, and quantifying the changing denitrification rates in flood plains and riparian areas remains a weakness in our ability to predict nitrogen removal. The findings from this research will provide guidance to maximize nitrogen removal by a) improving the efficiency of BMPs, b) designing the spatial distribution of **hots spots** on the landscape, and c) developing a practitioner tool to quantify site specific nitrogen removal by individual BMP and combination of BMPs to promote clean water conditions across the landscape of Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Quantify Microbial Denitrification in Riparian Areas **Budget: $129,464**

We will sample a subset of riparian sites across a range of land uses to quantify the range of nitrate removal rates in the field. Existing spatial data (flow rates, soil characteristics, land use) will be compiled to inform site selection and to inform the tool developed in Activity 3.

Outcome	Completion Date
1. Identify relevant spatial data sources (flow rates, soil characteristics, land use, etc.)	December 2018
2. Document the range of denitrification rates (as a report)	December 2020
3. Document the range of microbial characteristics (as a report)	December 2020

Activity 2: Quantify Denitrification Dynamics to Flooding **Budget: $135,464**

To quantify the response of nitrogen removal to inundation (flooding) frequency and duration, experiments will be conducted in four replicate controlled water level basins in the Outdoor StreamLab

(OSL), U of MN. Measurements will consist of soil properties, soil water content, soil organic matter, sediment microbiota, microorganism DNA and mRNA analysis, and nitrogen transformation. The fundamental questions addressed by these inundation experiments are: 1) How long is denitrification activity enhanced following a flood? 2) What are the linkages between inundation and microbial response?, and 3) Is there an optimum rate of pulsed inundation that will maximize denitrification? Answering these questions will lead to the development of mechanistic functional relationships describing relative denitrification rates on floodplains and riparian areas. The OSL is a unique experimental facility to answer these questions because of the high level of control (i.e. repeat flood events) and its field scale outdoor setting.

Outcome	Completion Date
1. Quantify nitrate removal to flooding frequency	September 2020
2. Document linkages between flooding and microbial response	September 2020
3. Develop functional relationship to quantify floodplain denitrification	December 2020

Activity 3: Predicting Denitrification Hot Spots **Budget: $125,713**

We will educate our student researchers to give talks and present research results to both academic and applied audiences. A preliminary workshop will be presented at the Upper Midwest Stream Restoration Symposium (to be held in Minneapolis in 2019). This workshop will assist researchers in tool development with feedback from stream practitioners. After final tool development and testing, a final workshop will be held to present the tool's use to water resource managers (Minnesota state agencies including DNR, MPCA, and MDA) and other water resources practitioners.

Outcome	Completion Date
1. Prediction tool development	December 2018
2. Practitioner Workshop at the Upper Midwest Stream Restoration Symposium	March 2019
3. Model verification	December 2020
4. Denitrification dynamics workshop: tools and recommendations	June 2021

III. PROJECT STRATEGY

A. Project Team/Partners

University of Minnesota: St. Anthony Falls Laboratory: Dr. Miki Hondzo (Professor): Project Manager, lead modelling efforts, mentor students (field data collection); Dr. Jessica Kozarek (Research Associate): lead experimental effort in Outdoor StreamLab, mentor undergraduate students (laboratory and field experiment assistance); **Department of Soil Water and Climate and Biotechnology Institute**, Dr. Michael Sadowsky (Professor): lead microbiological measurements, mentor graduate student (microbiological measurements). The requested funding will provide support to all project partners.

B. Project Impact and Long-Term Strategy

This project is a continuation of research collaboration between SAFL and Dr. Sadowsky focused on predicting and understanding microbial denitrification hot spots and hot moments. Two previous projects, funded by the Minnesota Department of Agriculture (MDA) and the United States Department of Agriculture (USDA) have focused on fundamental research of denitrification hot spots in agricultural landscapes. This project will build off of previous research efforts in order to develop a practitioner implementation tool to quantify nitrogen removal by hot spots and BMPs and to facilitate clean water conditions on the Minnesota landscape.

C. Timeline Requirements

This project requires two full summer seasons (2019 and 2020) for field scale experiments and field data collection. Work will begin July 2018 and the final report will be completed by June 2021.

2018 Detailed Project Budget

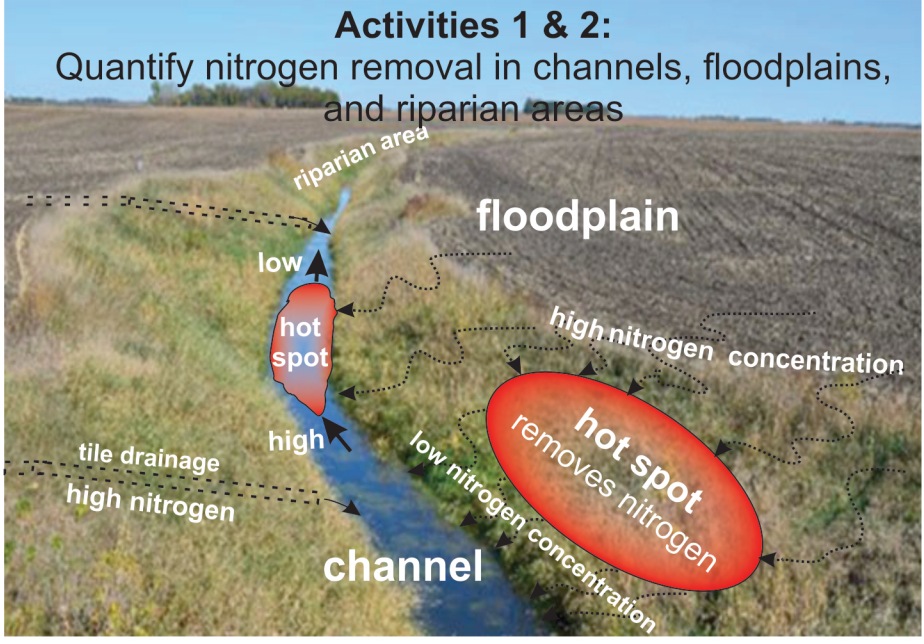
Project Title: Promoting Nitrogen Removal in Channels, Floodplains, and Riparian Areas

IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM	AMOUNT
Personnel:	$ 371,141
Research Associate: Jessica Kozarek (33.5% benefits, 26% time, yrs 1-3) $76,486	
Professor: Miki Hondzo (33.5% benefits, 8% time, yrs 1-3) $61,514	
Professor: Michael Sadowsky (33.5% benefits, 0% time, yrs 1-3) $0	
Engineering Technition (27.2% benefits, 8% time yrs 1-3) $18,159	
SAFL Graduate Student (50% time, yrs 1-2) $91,809	
Biotech Graduate Student (50% time, yrs 1-2) $91,809	
Undergraduate Reasearch Team (3 students for 12.5 weeks yrs 1-2) $31,364	
Professional/Technical/Service Contracts: *(N/A)*	
Equipment/Tools/Supplies:	
OSL Supplies (soil, carbon, chemicals, sediment, vegetation, etc.)	$ 5,000
General Laboratory Supplies (safety, glassware, etc.)	$ 1,000
LaChat Supplies (Nitrogen Analyzer)	$ 2,000
Microbial Lab Supplies	$ 7,500
Acquisition (Fee Title or Permanent Easements): *(N/A)*	
Travel:	
Travel to in-state conferences	$ 2,000
Travel to field sites	$ 2,000
Additional Budget Items: *(N/A)*	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 390,641

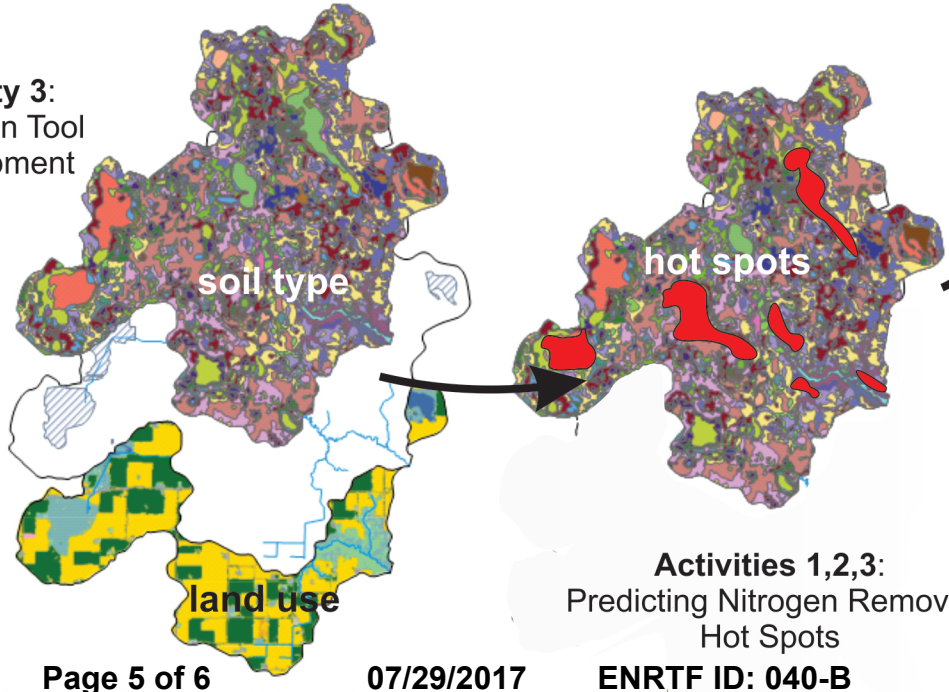
V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *N/A*	$ -	
Other State $ To Be Applied To Project During Project Period: *N/A*	$ -	
In-kind Services To Be Applied To Project During Project Period: Unrecovered UMN overhead (54% MTDC)	$ 177,907	
Past and Current ENRTF Appropriation: *N/A*	$ -	
Other Funding History:	$ -	
Measuring and modeling denitrification hot spots on agricultural landscapes, USDA AFRI PI: M. Honzdo, co-PIs: L. Liu, M. Sadowsky , J. Kozarek	$ 475,000	*In progress,*



Nitrogen removal **hot spot** is combination of environmental and microbial parameters which maximize **nitrogen removal**

Activity 3:
Prediction Tool Development



Activities 1,2,3:
Predicting Nitrogen Removal Hot Spots

Miki Hondzo, Professor
St. Anthony Falls Laboratory, Department of Civil, Environmental, and Geo- Engineering,
University of Minnesota, Minneapolis, MN 55414-2196
mhondzo@umn.edu, voice: +612-625-0053

Professional Preparation

Undergraduate	University of Sarajevo	Civil Engineering	B.Sc. 1983
Graduate	Free University of Brussels	Surface Water Hydrology	M.Sc. 1988
	University of Minnesota	Civil Engineering	Ph.D. 1992
Postdoctoral	Michigan State University	Environmental Engineering	1992-1993
	St. Anthony Falls Lab.	Experimental Fluid Mech.	1993-1995

Appointments

Full Professor, University of Minnesota, Department of Civil Engineering 2007-present
Associate Professor, University of Minnesota, Department of Civil, Environmental, and Geo- Engineering 1999-2006
Assistant Professor, Purdue University, School of Civil Engineering 1995-1999

Awards/Recognitions

2008 **Samuel Arnold Greeley Award**. Environmental Engineering Division, American Society of Civil Engineers. Award for the best research paper "Modeling heavy metal removal by plant species and sediment."

2006 "**Outstanding** *Limnology and Oceanography* **Reviewer**." Recognized by *Limnology and Oceanography* journal for reviewing service.

2000 **Rudolph Hering Meda**l. Environmental Engineering Division, American Society of Civil Engineers. Award for most valuable contribution to the increase of knowledge in the environmental branch of the engineering profession for the paper, "Diffusional mass transfer at the sediment-water interface."

1997-2002 **CAREER AWARD**, **National Science Foundation** (Division of Chemical and Transport Systems)

1997 **Founders Award** for the best paper "Long-term lake water quality predictors", appearing in the 1996 year of *Water Research*. The USA National Committee of International Association on Water Quality.

Research Interests

- Ecological fluid mechanics and environmental restoration
- Water quality and transport processes in lakes, rivers, and watersheds

Journal Publications (selected 5 relevant to the LCCMR proposal out of 80 published papers)

Missaghi, S., M. **Hondzo**, and W. Herb (2017). Prediction of lake water temperature, dissolved oxygen, and fish habitat under changing climate, *Climatic Change*, 141, 747-757.

Khosronejad, A., A. T. Hansen, J. L. Kozarek, K. Guentzel, M. **Hondzo**, M. Guala, P. Wilcock, J.C. Finlay, and F. Sotiropoulos (2016). Large eddy simulation of turbulence and solute transport in a forested headwater stream, *Journal of Geophysical Research*, 121 (1), 146-167.

Guentzel, K.S., **Hondzo**, M., Badgley, B.D., Finlay, J.C., Sadowsky, and M.J., and Kozarek J.L. (2014). Measurement and modeling of denitrification in sand-bed streams of varying land use, *Journal of Environmental Quality*, 43: 1013-1023.

O'Connor, B.L., M. **Hondzo**, and J.W. Harvey (2010). Predictive modeling of nutrient uptake: Implications for stream restoration, *Journal of Hydraulic Engineering*, 136(12), 1018-1032.

O'Connor, B. L., and M. **Hondzo** (2008). Enhancement and inhibition of denitrification by fluid-flow and dissolved oxygen flux to stream sediments, *Environmental Science & Technology*, 42(1), 119-125.

Editorship: Associate Editor: *Environmental Fluid Mechanics* journal, 2016-present.