Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 072-B**

Phosphorus Behavior in Northern Minnesota Watersheds

Category: B. Water Resources

Total Project Budget: $ 274,059

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

Phosphorus loads to and cycling in Northern Minnesota watersheds is poorly understood. Differences in phosphorus cycling and loading will be determined in lakes where the phosphorus behavior significantly differs.

Name: Carl Isaacson

Sponsoring Organization: Bemidji State University

Address: 1500 Birchmont Dr NE

Bemidji MN 56601

Telephone Number: (218) 755-4104

Email cisaacson@bemidjistate.edu

Web Address

Location

Region: Central, Northwest, Northeast

County Name: Becker, Beltrami, Cass, Clearwater, Crow Wing, Hubbard, Itasca, Koochiching, Otter Tail, St. Louis, Wadena

City / Township:

Alternate Text for Visual:

Simple graphic describing proposed phosphorus cycling in Minnesota lakes.

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

PROJECT TITLE: Phosphorus Behavior in Northern Minnesota Watersheds

I. PROJECT STATEMENT

The economic and recreational opportunities afforded by the lakes and rivers of Northern Minnesota are vital to the region. But the availability of these opportunities are directly linked to water quality, which has decreased significantly over the last several decades, and increased phosphorus loads are a major contributor to this decline. In northern Minnesota there are watersheds in which one lake has elevated phosphorus levels while the phosphorus levels in lakes immediately upstream and downstream are not elevated.

We simply do not know what factors make impacted lakes more susceptible to increased phosphorus concentrations, or how the phosphorus cycle differs between lakes with elevated and non-elevated phosphorus levels in the same watershed.

Thus, there is a need to understand how phosphorus flows through Northern Minnesota lakes and how phosphorus is cycled in northern Minnesota lakes so that we can better target management of this nutrient to improve and maintain lake health.

Goal 1: Apportion mass flows of phosphorus in Northern Minnesota Watersheds.

Currently the Minnesota Pollution Control Agency (MPCA) uses monthly grab samples as their water monitoring protocol for sampling Minnesota surface waters. This sampling protocol does not allow the MPCA to determine mass flows of phosphorus in a particular lake or watershed. Human activities such as landscaping and private septic fields are known sources of phosphorus in Northern Minnesota lakes, yet lakes within a watershed are very differently affected by phosphorus loads to these waters. This project will use *in situ* phosphorus monitors to quantify phosphorus flows in northern Minnesota watersheds and will determine if the phosphorus load to a lake comes from human activities on the lake or other activities taking place upstream of the lake.

Goal 2: Cycling of phosphorus in Northern Minnesota Lakes.

Phosphorus concentrations vary greatly with time and with depth within a lake, and we are just now beginning to understand how lake dynamics determine the behavior of phosphorus in watersheds. Phosphorus speciation is controlled by both chemical and biological factors, with phosphorus loss from the terrestrial environment to the aquatic environment being largely in the form of particulate phosphorus, while soluble reactive phosphorus and biologically available phosphorus may be the drivers of biological production in Northern Minnesota lakes. Additionally, shallow lakes have been showing increased incidence of elevated phosphorus concentrations, while vertical lake phosphorus profiles have long exhibited dramatically increased phosphate levels in deeper portions of lakes. This project will aim to determine how phosphorus cycles in Northern Minnesota lakes and determine which factor(s) predispose a lake to accumulate phosphorus and become eutrophic.

Results from this project will provide new information allowing for improved ability to set and meet management objectives for phosphorus loads to lakes in northern Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Mass flows of Phosphorus in Northern Minnesota Watersheds **Budget: $129537**

We will use deploy a suite of *in situ* phosphorus monitors in a mobile network to measure phosphorus mass flows in watersheds which have lakes with elevated phosphorus levels and other lakes that do not have elevated phosphorus levels across northern Minnesota. Candidate watersheds include the Buffalo Watershed (near Detroit Lakes), Crow Wing River (south of Nevis), the Upper Mississippi River (near Bemidji), and Home Brook (near Brainerd), and the Water Hen Creek (South of Mountain Iron), although other watersheds may be considered. These watersheds range from areas with little, some and significant human impacts. Of particular interest in these watersheds are lakes with elevated phosphorus levels immediately upstream of lakes that do not have elevated phosphorus levels. By determining phosphorus mass flows in these watersheds, we will be able to calculate a phosphorus budget for these phosphorus impacted lakes and determine if the high levels of phosphorus originate in the lake and along it shore, or if the elevated levels of phosphorus originate upstream. To ensure that data generated through the use of *in situ* phosphorus monitors is valid, duplicate samples will be analyzed by RMB labs in Detroit Lakes, a state certified laboratory. As our study includes lakes which are

influenced by a variety of land uses, hydrology, and water chemistry present across northern Minnesota, our goal is to be able to elucidate parameters that help determine phosphorus mass flows in many northern Minnesota lakes, and may be generalizable to lakes outside the study area.

Outcome	Completion Date
1. Select lakes for phosphorus load and cycling analysis.	7/15/2017
2. Measure phosphorus mass flows.	6/30/2020
3. Provide management recommendations for mitigating phosphorus enrichment.	6/30/2020

Activity 2:Phosphorus cycling in lakes with and without elevated phosphorus levels **Budget: $144522**

We will determine phosphorus speciation and bioavailability in lakes with elevated and non-elevated phosphate levels. Using *in situ* phosphorus monitors, we will measure phosphate flows between the limnetic and benthic zones of lakes with and without elevated phosphorus levels to determine how differently phosphorus flows within these two types of lakes. This will allow us to separate the different pools of phosphorus in these waterbodies and will allow us to make management recommendations on how to best reduce the eutrophication potential in these lakes.

Outcome	Completion Date
1. Report on the differences in phosphorus speciation and bioavailability in Northern Minnesota Lakes.	*6/30/2020*
2. Provide management recommendations to reduce eutrophication potential in Northern Minnesota Lakes.	*6/30/2020*

PROJECT STRATEGY

A. Project Team/Partners:

The PI, Dr. Carl Isaacson, environmental chemist/toxicologist at Bemidji State University will mentor 1 graduate student. The Co-PI, Dr. William Sea, environmental scientist/hydrologist will provide expertise in hydrological sampling. The PI together with numerous Watershed and Lake Associations will provide outreach to lakeshore owners and community members throughout the region.

B. Project Impact and Long-Term Strategy

The MPCA is at various steps in completing Watershed Restoration and Protection Strategies (WRAPS) for the watersheds under the proposed study. As part of the WRAPS MPCA typically develops a water monitoring program, which involves developing a sampling strategy consisting of grab samples to determine phosphorus loads in a particular lake and at the watershed level. With this type of data one can only model or estimate phosphorus loads to a watershed. Additionally, to the best of our knowledge, MPCA does not yet look at how the phosphorus cycle differs between lakes within a particular watershed. The proposed research will allow for the measurement of phosphorus loads to and cycling in Northern Minnesota Lakes. The proposed research stems from conversations that began at a June 2015 WRAPS meeting in Bemidji which involved scientists from the MPCA, DNR and local stakeholders.

The proposed work aims to garner a better understanding of phosphorus flow dynamics and cycling in Northern Minnesota Lakes. Through the knowledge gained in this project we will develop recommendations on how to optimally set standards and manage phosphorus to maintain lake health, aesthetic and property values of impacted lakes. The expected outcomes are anticipated to be applicable to lakes outside the study area, and future funding may be needed to implement these management policies on a broader scale.

C. Timeline Requirements

The proposed project will require three years to complete starting 7/1/2017 and ending 6/30/2020. We will begin collecting field data in 2017 and measure phosphorus flows and cycling each year of the project.

2017 Detailed Project Budget

Project Title: Phosphorus Behavior in Northern Minnesota Watersheds

IV. TOTAL ENRTF REQUEST BUDGET 3 years

	AMOUNT
Personnel: Isaacson PI, analyze, write, manage, outreach; 10% FTE; 81% salary/19% fringe (36 months ($15000)	$ 83,000
GRA: Data collection, analysis, writing: 100% FTE; 90% salary, 10% fringe (36 months) ($45,000)	
GRA: Tuition and Fees ($23000)	
Professional/Technical/Service Contracts:	$ -
State Certified Total Phosphorus Analysis, RMB labs Detroit Lakes, MN 200 samples for $15	$ 15
Equipment/Tools/Supplies:	$ -
8 Sea-Bird Coastal Cycle PO4 Phosphate Analyzers @ $19193 a piece	$153,544
20 Hobo temperature and light meters @ $50 a piece	$1,000
5 Flow meter meters @ $4000 a piece	$20,000
Lab supplies to perform phosphate speciation and bioavailabilty assays	$15,000
Acquisition (Fee Title or Permanent Easements):	$ -
Travel: Field travel to/from study sites, 3 yrs, miles, food and lodging	$ 1,500
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST	$ 274,059

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ -	
Other State $ To Be Applied To Project During Project Period:	$ -	
In-kind Services To Be Applied To Project During Project Period:		
Dr. Carl Isaacson will provide acccess to YSI meters and canoes	$5,000	available
Bemidji State University Department of Chemistry will provide access to ion chromatograph, UV-Vis spectrophotometer and ICP-OES instruments. 200 samples @ $50/sample	$10,000	available
MPCA Surface Water Assessment Grants for training, equipment and lab analysis to determine if a lake or stream meets water quality standards ($ amounts for 2015-2016).	$445,000	
Bemidji State University will provide indirect costs (30.7%) as in-kind match	$84,136	available
Co-PI Dr. Bill Sea will expertise in experimental design and hydrological sampling	$10,000	available
Funding History:	$ -	
Remaining $ From Current ENRTF Appropriation:	$ -	

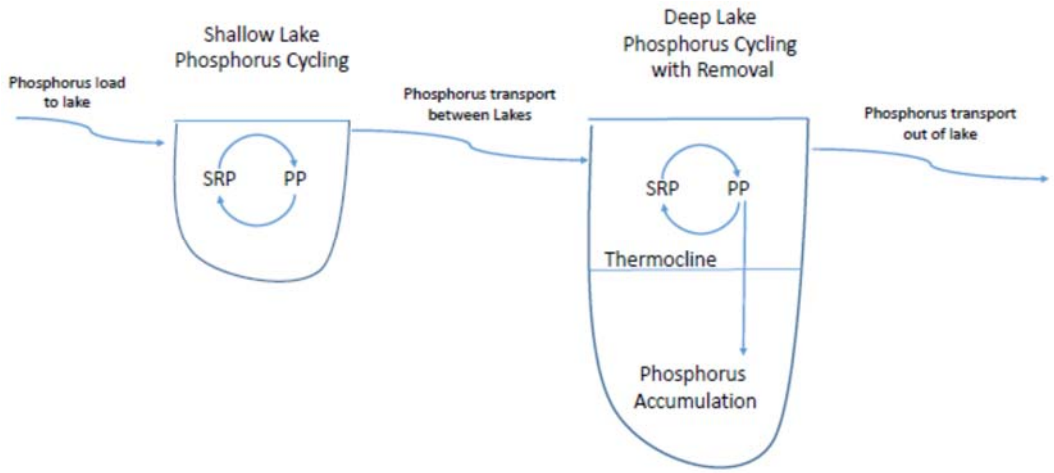

Figure 1. Difference in phosphorus cycling between soluble reactive phosphorus (SPR) and particulate phosphorus (PP) in shallow and deep lakes are hypothesized to result from sedimentation of PP through the thermocline in deep lakes.

CARL W. ISAACSON

Key Qualifications

Dr. Carl W. Isaacson is a tenure track assistant professor of Environmental Studies at Bemidji State University specializing in water quality research. The Environmental Studies Program at Bemidji State University has a strong reputation and offers MS degrees making it an excellent location to conduct research focused on water quality in Northern Minnesota.

Research Scientist, RCEES, Beijing, China 2014
Responsibilities: Develop methods for the sensitive and selective detection of engineered nanoparticles in biological and environmental matrices.
Post-Doctoral Fellow, Environmental Toxicology Department, EAWAG, Dubendorf, Switzerland, 2011-2013
Responsibilities: Study the impact of TiO_2 nanoparticle exposure to benthic systems.
Advisor: Kristin Schirmer Ph.D.
Post-Doctoral Fellow US EPA/ORD/NERL/ERD 2008-2011
Responsibilities: Develop and apply analytical methods to study the transport, behavior and toxicity of engineered nanomaterials.
Adivsor: Dermont Bouchard Ph.D.
Ph.D, Oregon State University, Department of Chemistry, 2007
Thesis Title: Quantitative Determination of Emerging Contaminants, Solvent Stabilizers and Fullerene Nanomaterials, in Biological and Environmental Systems.
Advisor: Jennifer A. Field Ph.D.
B.S. Chemistry, Bemidji State University, 2003
Advisor: Julie Larson Ph.D.

REFEREED PUBLICATIONS

Schug, H., Isaacson, C.W., Sigg, L., Adrian A. Ammann, A.A., Kristin Schirmer K. Effect of TiO_2 Nanoparticles and UV Radiation on Extracellular Enzyme Activity of Intact Heterotrophic Biofilms. *Environ. Sci. Technol.*, **2014**, *48 (19), 11620–11628*

Zhang, W., Isaacson, C.W., Rattanaudompol, U., Powell, T.B., Bouchard, D. *Fullerene nanoparticles exhibit greater retention in freshwater sediment than in model porous media*, Water Research, 2012, 46 (9) 2992–3004

Patra, M., Ma, X., Isaacson, C., Bouchard, D., Poynton, H., Lazorchak, J.M., Rogers, K.R. *Changes in agglomeration of fullerenes during ingestion and excretion in Thamnocephalus platyurus* Environ. Toxicol. Chem, 2011, 30 (4) 828–835

Isaacson, C., Zhang, W., Powell, T., Ma, X., and Bouchard, D. *Temporal Changes in Aqu/C_{60} Physical–Chemical, Deposition, and Transport Characteristics in Aqueous Systems. Environ. Sci. Technol.*, 2011, 45 (12), 5170–5177

Isaacson, C.W. Bouchard, D. *Effect of Humic Acid and Sun Light on the Generation and Aggregation State of aqu/C_{60} Nanoparticles.* Environ. Sci. Technol., 2010, 44 (23), 8971–8976