Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **054-B**

Removing Excess Phosphorus in Urban Lakes through Hydroponics

Category: B. Water Resources

Total Project Budget: $ 174,046

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

Develop and implement an innovative technology to remove excess nutrients from urban lakes while producing locally grown food and creating a unique platform for education and public participation.

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Sponsoring Organization: University of St. Thomas

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Location

Region: Metro

County Name: Ramsey

City / Township: Ramsey

Alternate Text for Visual:

Diagram of flow-through hydroponics garden. The 12" tall raised bed is lined with pond liner, and water is pumped into the bed from the lake by a solar-powered pump. Outflow from the bed returns to the lake, at a lower P concentration.

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

PROJECT TITLE:
Removing excess phosphorus in urban lakes through hydroponics

I. PROJECT STATEMENT

In many of Minnesota's urban lakes, water quality is degraded due to excess phosphorus (P) pollution. Despite extensive efforts to reduce P inputs into urban lakes, many of these lakes remain impaired as a result of the continued release of P from lake sediments. The purpose of this study is to explore the feasibility of **a novel, low-cost method of active nutrient removal from urban lakes** through hydroponic gardens, using a lakeside raised bed garden design (Figure 1). Turning nutrient pollution into locally grown food and flowers also will provide a unique platform for public outreach. Our preliminary trials at The University of St. Thomas indicate that it is possible to simultaneously produce nutritious vegetables and achieve P-uptake rates from lake water in excess of 22 mg P/m^2/day.

Our study will focus on Como Lake in Saint Paul, which is one of the most visited urban lakes in Minnesota and is degraded due to P levels 2-3 times higher than regulatory standards (Figure 2). In the past decade, >$2.5 million has been spent on reducing P inputs to this lake through improvements to the stormwater system, but the lack outflow from the lake combined with large amounts of P stored in lake sediment are preventing any improvements in lake water quality from these substantial public investments.

The goals of this project are:

- To develop and test an innovative technology for transforming excess nutrient from urban lakes into an economically valuable product.
- To explore the social, ecological, and economic framework for a larger-scale implementation of this approach at Como Lake and other degraded urban lakes in Minnesota.

Outcomes of this project include:

1. An analysis of the capacity, and cost-effectiveness, of hydroponic gardens to improve water quality in degraded urban lakes.
2. An analysis of stakeholders' perspectives on lake remediation methods through hydroponic gardens.
3. Public outreach to enhance citizen involvement with the improvement of local water quality.
4. A community-led project implementation model developed by local residents and partners for long-term sustainability of the strategy and for sharing with other communities.
5. The development of a broad network of partnerships including watershed districts, municipalities, neighborhood organizations, and lake associations in the Metro Region to facilitate the transfer of knowledge gained through this study.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Greenhouse experiments measuring P-uptake potential of candidate plants.* **Budget: $54,102.50**
We will use a series of greenhouse experiments at the University of St. Thomas to measure phosphorus removal rates from lake water for four different vegetables (spinach, tomatoes, basil, cucumbers) and one flower (marigolds). These results will be used to estimate P-removal under various implementation strategies, and to assess the cost effectiveness of this approach relative to other strategies. We will also conduct a series of measurements of heavy metal accumulation and bacterial content to test whether vegetables grown in urban lake water are safe for human consumption.

Outcome	Completion Date
1. Assessment of hydroponic P-removal capacity for vegetables and flowers	*September 2016*
2. Analysis of suitability of vegetables for human consumption (test for heavy metal accumulation and microbial contamination)	*September 2017*

Activity 2: *Social, economic, and environmental cost-benefit analysis of hydroponic gardens to clean urban lakes.* **Budget: $39,951.50**

We will use data from Activity 1 to calculate the amount of P removed under different implementation scenarios, and to calculate the cost per unit P removed compared to other remediation projects. We will also conduct a stakeholder analysis, including policymakers, neighborhood residents and park visitors, documenting any social barriers and benefits towards implementation of a hydroponic garden on Como Lake.

Outcome	Completion Date
1. Cost-benefit analysis of P removal through lakeside hydroponic gardens	*September 2017*
2. Stakeholder analysis of social barriers and benefits	*September 2017*

Activity 3: *Implement prototype hydroponic garden alongside Como Lake.* **Budget: $79,992.00**

A prototype hydroponic garden will be constructed along the shore of Como Lake (Figure 1) in order to validate results from the small-scale experiments conducted in Activity 1. The plants chosen for the prototype garden will be based on which species show optimum growth and P sequestration in Activity 1. Interpretive signage will describe the project to park visitors and direct them to the project website for additional information. We will work closely with CLNN's lead organizer to include community residents and local partners in shaping the project design and implementation plan into a community-led model that can be sustained for the longer term and can be shared with other communities. We will also work with Saint Paul Parks and Recreation to develop educational programs for teachers and other groups using the garden. This component of the project will be implemented in partnership with the Capital Region Watershed District and Saint Paul Parks and Recreation Department.

Outcome	Completion Date
1. Construction of prototype hydroponic garden alongside Como Lake	*May 2018*
2. Development of educational materials and public programs	*June 2018*

III. PROJECT STRATEGY

A. Project Team/Partners

This project will be led by Dr. Gaston Small (UST Biology Department), and Dr. Maria Dahmus (UST Environmental Studies Program). We are partnering with Janna Caywood, lead organizer of the Como Lake Neighbor Network, and the City of Saint Paul, Department of Parks and Recreation, Natural Resources section.

B. Project Impact and Long-Term Strategy

Our proposal is for a feasibility study of a low-cost method of actively removing excess phosphorus from Minnesota lakes while generating an economically viable end product and serving as a unique platform for public education and community involvement in lake restoration. Similar technology is currently used for removing nutrients from aquaculture and wastewater systems, and our preliminary data suggest that hydroponic farming can similarly be adapted to urban lakes. If our feasibility study shows that hydroponic farming can be a viable method of reducing lake nutrient pollution, there is tremendous potential to scale up the implementation of hydroponic farming at Como Lake in order to achieve significant P reductions, and to apply the technology to other urban lakes that face problems with excess nutrients.

Our preliminary research on this topic has been supported by internal funding through the University of St. Thomas. We have applied for an EPA People, Prosperity, and the Planet (P3) grant that would fund a small portion of this research (that budget is limited to $15,000). LCCMR funding is needed to conduct a full feasibility study.

C. Timeline Requirements

This study will be conducted over three years, because two complete growing seasons are required.

2015 Detailed Project Budget

Project Title: Removing excess phosphorus in urban lakes through hydroponics

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Gaston Small, Principal Investigator. 1 month salary (8.33% effort) per year plus 7.65% benefits for 3 years.	$ 22,779.00
Maria Dahmus, co-Principal Investigator. 1 month salary (8.33% effort) per year plus 7.65% benefits for 3 years.	$ 22,779.00
Undergraduate research assistants (summer). 3 students @ 40 hrs/week x 12 weeks x $10.00/hr for 3 years. 7.65% benefits.	$ 46,506.00
Undergraduate research assistants (academic year). 3 students @ 6 hours/week x 29 weeks x $10.00/hr for 3 years.	$ 15,660.00
Contracts:	
Janna Caywood (Como Lake Neighbor Network): Professional services to facilitate neighborhood communication and outreach. 50 hours/year at $60/hour x 3 years	$ 9,000.00
Equipment/Tools/Supplies:	
Hach Phosphax phosphate analyzer (2 @ $14,391.00 each)	$ 28,782.00
Field sampling supplies (bottles, tubing, filters)	$ 6,000.00
Lab supplies (reagents, standards, gloves)	$ 8,000.00
Materials for prototype hydroponic garden unit	$ 6,000.00
Additional Budget Items:	
Software license renewal fees for modeling software (Matlab and STELLA)	$ 1,200.00
Software license fees for qualitative data analysis (NVIVO 10)	$ 1,340.00
Survey materials (printing, envelopes)	$ 2,000.00
Materials for outreach/education (e.g. signs, pamphlets)	$ 4,000.00
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 174,046.00

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period		
EPA People, Planet, and Prosperity (P3) grant	$ 15,000.00	Pending
Academic year salary and fringe benefits for 2 undergraduate student researchers will be provided by the University of St. Thomas each year (10 hours/week x 32 weeks X $10/hours totaling $19,200	$ 19,200.00	Pending
In-kind Services During Project Period:		
Janna Caywood (Como Lake Neighbor Network): donating additional 50 hours/year @ $60/hour x 3 years	$ 9,000.00	Secured

Figure 1. Diagram of flow-through hydroponics garden. The 12" tall raised bed is lined with pond liner, and water is pumped into the bed from the lake by a solar-powered pump. Outflow from the bed returns to the lake, at a lower P concentration.

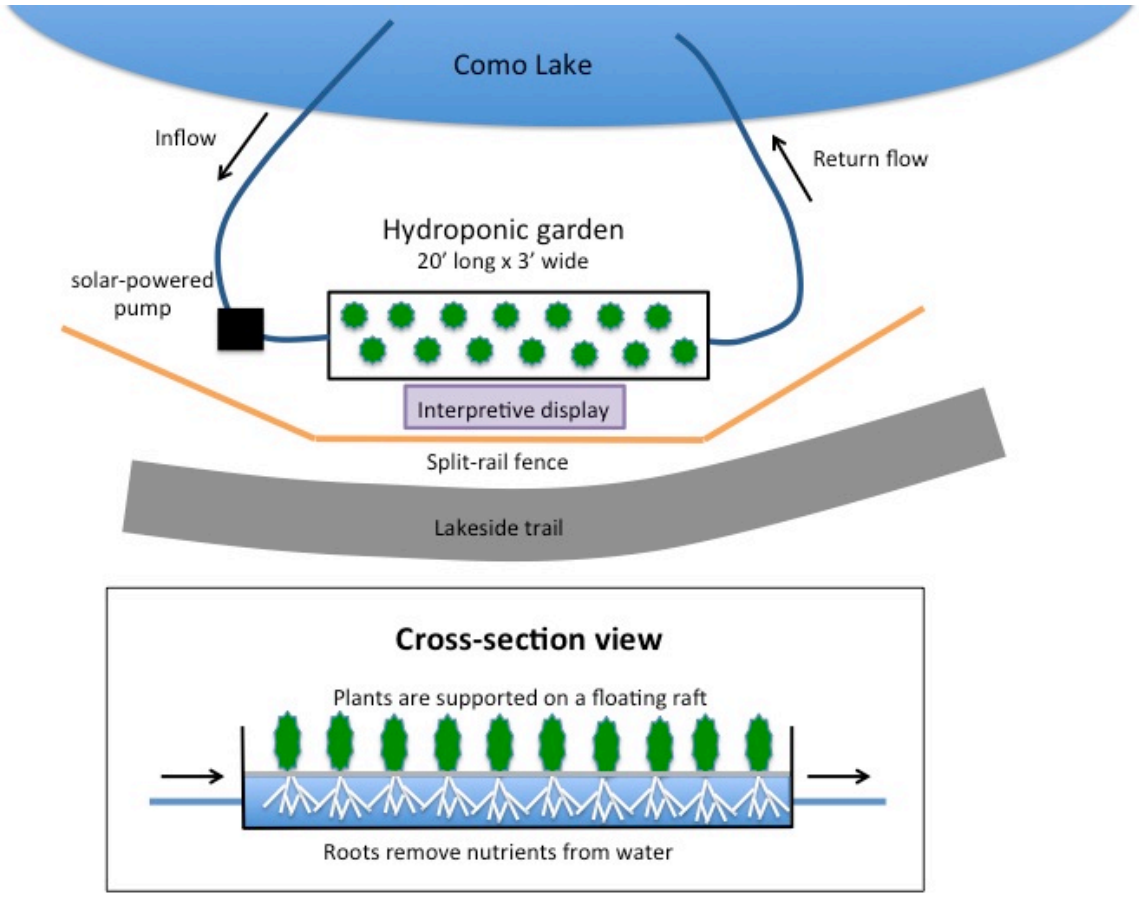

Figure 2. Como Lake in Saint Paul, MN. The 68-acre lake is fed by storm water and is listed as impaired due to phosphorus levels 2-3 times higher than the regulatory standard. The star shows the proposed location of the prototype garden.

Project Manager Qualifications and Organization Description

Gaston Small, University of St. Thomas – Dr. Small is an ecosystem ecologist whose research focuses on mitigating the effects of nutrient pollution in lakes and rivers. He is an assistant professor in the Biology Department at the University of St. Thomas (2012-present), and has published 20 peer-reviewed articles since 2008. He has served as a reviewer for eight different scientific journals, and has served on review panels for the National Science Foundation and the Wisconsin Water Resources Institute. He previously worked as a postdoctoral researcher at the University of Minnesota on a series of projects studying nutrients in the Great Lakes. Dr. Small received his Ph.D. in Ecology from the University of Georgia in 2010.

In the proposed project, Dr. Small will be responsible for leading the phosphorus uptake experiments and modeling efforts, and in training and supervising undergraduate researchers.

Maria Dahmus, University of St. Thomas –Dr. Dahmus' research focuses on the interdisciplinary study of coupled social systems and ecosystems, specifically the social dimensions of urban ecosystems and citizen participation in environmental policymaking. She has published peer-reviewed articles in journals related to these issues, including *Urban Ecosystems* and *Landscape and Urban Planning*. She coordinates curricular sustainability initiatives for the College of Arts and Sciences at the University of St. Thomas and teaches in the Environmental Studies program. She also serves as a consultant for the Master Water Stewards program. She previously worked as a postdoctoral researcher at the University of Minnesota studying the social dimensions of nutrient fluxes in urban ecosystems with the Twin Cities Household Ecosystem Project. Dr. Dahmus received her Ph.D. in Environmental Studies from the University of Wisconsin in 2011.

In the proposed project, Dr. Dahmus will be responsible for leading the stakeholder analysis and the community educational outreach efforts, in collaboration with the Como Lake Neighborhood Network.

The University of St. Thomas – Founded in 1885, UST emphasizes values-based education and career preparation, with a focus on solving community problems through education and service-learning programs. 56% of UST students receive need-based *scholarship or grant* aid. The largest private university in Minnesota (11,000 students, 461 full-time faculty), it offers bachelor's degrees in 85 major fields of study and 45 graduate degree programs, and is ranked as a National University. UST's Science Division has ca $5.7 million of capital equipment, nearly half of which is owned/maintained by Biology. Faculty members in Biology receive $5000 annually to support research, plus additional funds to hire two full-time undergraduate researchers each summer. UST also offers stipends and housing grants for student research during the academic year and summer.