Environment and Natural Resources Trust Fund
2014 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **037-B**

Removing Phosphorous and Endocrine Disruptors from our Waterways

Category: B. Water Resources

Total Project Budget: $ 493,000

Proposed Project Time Period for the Funding Requested: 2 Years, July 2014 - June 2016

Summary:

Phosphorous and Endocrine Disruptive Chemicals enter and threaten our waterways in the effluent from 500 Minnesota waste treatment plants. Pressurized heating of these effluents to 200C removes the harmful chemicals.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Chisago

City / Township:

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

PROJECT TITLE: Removing Phosphorous and Endocrine Disruptors from our Waterways

I. PROJECT STATEMENT

Why? **Pollutants** introduced to Minnesota waters in the effluent from our 500 waste treatment plants account for a significant fraction of the **phosphorus and the endocrine-disrupting compounds** that are derived from human waste, contraceptives, detergents and other chemicals from human activity. **Heating sewage sludge to high temperatures and pressure for a relatively short time will transform it into a hydrochar that absorbs phosphorous and removes it from the water while also breaking down many of the endocrine disruptors and leaving effluent water that is considerably cleaner than the starting water.** This transformation by heating is accomplished in an energy efficient process called **Hydrothermal Carbonization**. This process subjects dilute slurries, such as sewage sludge, to a temperature of 220^0C at elevated pressure for about 30 minutes. Our laboratory experiments show that **phosphorous can be reduced by as much as 90%** in waste treatment effluent. As part of the outcome**, phosphorous** will be recovered and **recycled as fertilizer.** Other researchers have shown that several **endocrine disruptors are destroyed** by Hydrothermal Carbonization. The remaining **hydrochar will be a renewable energy resource to produce electricity** for the cities that created the waste in the first place.

Goals and Outcomes: The **ultimate outcome** is restoration of our state's watersheds to the purity they once had. The **immediate outcome** is demonstrating that possibility within part of a contained watershed.

We propose to:

- **(1) Design and construct** a demonstration-scale, skid mounted hydrothermal carbonization unit and **demonstrate economic and environmental benefits** by testing at the Chisago Lakes Waste Treatment Facility and other potential locations statewide.
- (2) **Quantify** the removal level of **phosphorous and reduction of endocrine disruptors** in the effluent.
- **(3) Develop a computerized watershed model** to quantify resultant fluxes through waterways large and small and **classify the sub-watersheds according** to their **degree of present degradation,** their **prospects for restoration**, and the **benefits of restoration** to local and downstream communities based on our data.

Work Plan Appropriately qualified engineering consultants and equipment fabricators will provide engineering design and cost estimates to construct a demonstration scale hydrothermal carbonization reactor unit based on data generated in the University laboratory. We will work with municipal sewage waste provided by our collaborator, Chisago Lakes sewage treatment facility, to establish efficacy of the process and to generate sufficient quantity of the phosphorous adsorbing hydro char to test and quantify phosphorous recovery capacity. Hydrochar adsorption of heavy metals such as lead, nickel, chromium and copper that are found in waste treatment effluent will be measured to quantify the extant of removal. Reduction in endocrine disruptive chemicals will be quantified. Heat and material balances and economic evaluations will be performed for all application

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: *Perform necessary lab scale experiments to provide a contract engineering firm with sufficient data to design the demonstration hydrothermal carbonization unit.* **Budget: $ 160,000**

Laboratory experiments will establish phosphorous removal and endocrine disruptor removal efficacy for the sewage treatment effluent from the Chisago Lakes Sewage Treatment plant. They are a willing collaborator and have provided materials and guidance for preliminary testing in the past year.

Outcome	Completion Date
1. Optimum process conditions for removal of phosphorous (P) and endocrine disruptive chemicals (EDCs)	*December 2014*
2. Estimate savings in energy, chemical and capital costs due to phosphorous removal	*April 2014*
3. Construct and evaluate preliminary watershed computer model based on lab scale data.	*June 2014*
4. Engineering design and cost estimate for pilot scale hydrothermal carbonization reactor	*Jan. 2014*

Activity 2. Construct and test demonstration scale Hydrothermal Carbonization (HTC) reactor system at Chisago Lakes Waste Treatment plant. **Budget** $333,000

Outcome	*Completion Date*
1. Construct and shake down demonstration scale hydrothermal carbonization unit	*July 2015*
2. Generate data from statistically designed tests at Chisago Lake Waste Treatment plant and determine optimum process conditions for phosphorous removal and endocrine disruptor remediation	*Sept. 2015*
3. Complete watershed computer model and develop implementation blueprint for state	*June. 2016*
4. Confirm economic benefits of hydrothermal carbonization phosphorous recovery and complete energy balance	*June 2016*

Note: The pilot scale hydrothermal carbonization unit is skid mounted so that when testing is completed at Chisago Lakes Treatment facility it is intended that it be moved to other facilities around the state for similar testing and demonstration as future funding permits. The intention is to obtain sufficient proof of economic and environmental benefits to encourage commercialization of the technology.

III. PROJECT STRATEGY

A. Project Team/Partners

The following team members will receive funds:

U. of Mn.Faculty and staff members are Dr. Ken Valentas, Adj. Professor, Biotechnology Institute, as P.I. and project manager to provide overall direction, process engineering expertise and coordinate cross-functional activities. Graduate student (to be named), Dr. Clarence Lehman, Adj. Professor, Ecology, Evolution and Behavior (EEB). Research technician or grad. student (to be named) to assist in constructing water shed model. Some services will be contracted with engineering consultants

The following will not receive funds:

. The Chisago Lakes Sewage treatment facility will provide sewage samples, routine analytical tests and technical counsel

B. Timeline Requirements

Two years of funding is requested. We expect that generation of process design data and engineering design will take the first year and on site testing, data analysis, and computer modeling will be completed in year 2.

C. Long-Term Strategy and Future Funding Needs

Successful conclusion of this project will provide a basis and rationale for implementation of this technology at waste treatment plants, both large and small, across the State. The demonstration unit is skid mounted to be easily transported to other sites around the State to quantify the benefits both environmental and economic. The computer watershed model will identify areas of greatest opportunity for improvements to our waterways.

2014 Detailed Project Budget

Project Title: removing Phosphorous and Endocrine Disruptors from our Waterways

IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM	AMOUNT
Personnel: Ken Valentas, Adjunct Professor, Project Manager, P.I. @12% FTE for 2 years, $33,00, 7.4% Fringe, 92.% salary.	$33,000
Claerence Lehman, Adjunct Asocs. Professor, formulate computer watershed model, 20%FTE, $24,000, 33.6 Fringe, 66.4% salary	$24,000
Graduate stuent or Post-doc (to be named) conduct HTC experiments, assisst in testing, sample preparation, conduct analytical tests for endocrine disruptors., 100% FTE for 1 year, $46,000, 20% fringe, 80% salary	$46,000
Graduate student or post doc (to be named) algorithm adevelopment and computer programming for water shed model, 100% FTE for 9 months , $32,000, 20% fringe, 80% salary	$32,000
Contracts:Bruce Engineering, Process Engineering and capital cost estimating expertise and experience with high pressure equipent to act in capacity of "owners Representative" for University	$ 5,000
Engineering Design Firm (to be named) Design skid mounted 500 gallon hydrothermal carbonization reactor. Bids will be solicited from firms qualified to work in area of high pressure reactor design	$ 28,000
Equipment/Tools/Supplies: 500 gallon skid mounted hydrothermal carbonization reacor unit. Capable of operation up to 100 atm. (1500 psig) and temperatures up to 700 F. *Actual cost will depend on engineering design. Estimate here is with 10% contingency factor*	$ 308,000
Travel: Travel between University and waste treatment facilities, in state.	$ 2,000
Additional Budget Items: Analytical tests for phosphorous, heavy metals and specific harmful chemicals and degradation products of same. Consummable supplies,: chemicals, filter materials , filter aids and the like	$15,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 493,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period:	None	
Other State $ Being Applied to Project During Project Period:	None	
In-kind Services During Project Period: Routine analytical testing and assistance of waste treatment technician at Chisago county waste treatment facility	$ 20,000	*Pending*
Remaining $ from Current ENRTF Appropriation (if applicable):	None	
Funding History: *Indicate funding secured prior to July 1, 2014, for activities directly relevant to this specific funding request, including past ENRTF funds. State specific source(s) of funds.*	$ -	

TOWN

RAW SEWAGE

WASTE TREATMENT PLANT

PHOSPHOROUS

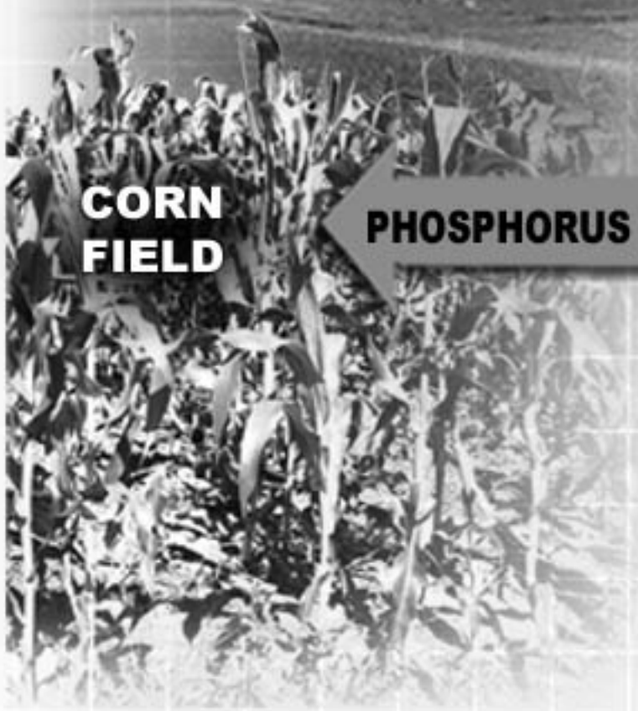
ENDOCRINE DISRUPTORS

TREATED SEWAGE WITH RETAINED PHOSPHORUS (P)

HYDROTHERMAL CARBONIZATION PROCESS

CLEAN WATER

HYDROCHAR + PHOSPHORUS (P)



CORN FIELD

PHOSPHORUS RECYCLE AS AGRICULTURAL FERTILIZER

SEPARATE

HYDROCHAR

RENEWABLE ENERGY SOURCE TO PRODUCE ELECTRICITY

STREAM

MONGMBY

Project Manager Qualifications

Kenneth Valentas is Adjunct Professor in the Biotechnology Institute (BTI) at the University of Minnesota. Previously he was Director of the BTI for 16 years and Associate Director for two years. Prior to joining BTI, Valentas was Sr. Vice President of Engineering at Pillsbury/Grand Met, and in total spent 24 years in industry at Sinclair Oil, General Mills and Pillsbury/Grand Met. He holds nine patents related to process engineering.

His PhD in Chemical Engineering is from the University of Minnesota under Regents Professor and former head Neal Amundson. Valentas is a recognized expert in process engineering and the author of two books on the subject. His research while at the BTI has focused on renewable energy with particular emphasis on thermochemical processing and hydrothermal carbonization (HTC) of biomass.

As Director of the BTI and Sr. Vice President of Engineering at Pillsbury, Valentas has gained particular expertise in managing teams of inter-disciplinary researchers and engineers in complex projects. The most recent pertinent experience relevant to this proposed project was his role as principal investigator and project manager for two state funded Biofuel Feasibility Studies[1,2]. A few pertinent peer reviewed publications are listed below (3), (4), (5)

Valentas will serve as *P.I.* and project manager to provide overall direction and coordinate cross-functional activities, write reports and make presentations as required.

(1) Valentas et al (2009) "White Earth Biofuels Feasibility Study", 94pp., Funded by MNDA under Minnesota statute 48A.10.
(2) Valentas et al (2009), "Chisago, Isanti and Pine Counties Biofuels Feasibility Study",90pp., Funded by MNDA under Minnesota Session Laws 2007 Chapter 45.

Copies of (1) and (2) are posted at www.bti.umn.edu

(3) Biomass & Bioenergy 2010, 34, 875-882; "Hydrothermal carbonization of microalgae"
(4) Applied Energy 2011, 88(10), 3286-3290; "Hydrothermal carbonization of microalgae. II. Fatty acid, char and algal nutrient products"
(5) Biomass & Bioenergy 2011, 35, 2526-2533; "Hydrothermal carbonization of distiller's grains"

Organization Description

The University of Minnesota is the state's main research and graduate teaching institution. Our university has been repeatedly ranked number-one in the nation for Ecology/Environment and Chemical Engineering, based on the citational influence of its scientific publications.