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

Project Title: **ENRTF ID: 043-B**

Sediment and Storm-Water Effects on Lake Superior

Category: B. Water Resources

Total Project Budget: $ 428,859

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

Summary:

UMD scientists will quantify effects of storm inflows on Lake Superior's water quality and ecology (plankton and fish productivity), sharing these results with resource managers to refine stormwater mitigation strategies.

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Sponsoring Organization: U of MN - Large Lakes Observatory

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Location

Region: Northeast

County Name: Cook, Lake, St. Louis

City / Township:

Alternate Text for Visual:

Satellite image of the Lake Superior study site showing sediment inputs from an extreme storm event and pictures of the glider, sonar, and water sampling gear to be used in the project.

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

PROJECT TITLE: Sediment and storm-water effects on Lake Superior

I. PROJECT STATEMENT

A team of scientists from the University of Minnesota Duluth will quantify effects of storm inflows on Lake Superior's water quality and food webs, sharing these results with resource managers to refine stormwater mitigation strategies. Projections of ongoing climate change indicate that increased storminess is likely to be the "new normal" in our region, and meteorological records are showing more early summer rain and bigger storms. For example, 5 of the 12 "megastorms" recorded in Minnesota since 1866 have occurred since 2002.

How does this change in storminess affect the big lake? More storminess means more delivery of nutrients, colored dissolved organic matter (CDOM), and sediment from flooding rivers. We have a small dataset from the 2012 Duluth Flood showing that poor light penetration (due to turbidity and CDOM) reduced algal/phytoplankton biomass within the most impacted waters, but the very high nutrient content of these waters stimulated algal growth at plume edges, where enough light was available.

In this project we will evaluate the net effects of increased storminess on algal production, and we will determine the responses of microbes, zooplankton, and fish to the resulting changes in water clarity and food availability. In-lake sensors, satellite imagery, and direct measurements ("storm chasing") will be used to examine processes within the volume of the lake impacted by a given storm event. Additional observations will be made on a scheduled basis (once in spring, once in late summer, and once in fall) using the R/V Blue Heron, which hosts an extensive array of gear for sampling and analyses.

Our results will help natural resource managers from federal, state and local agencies develop smart flood mitigation strategies that deal effectively with the changing timing and severity of rain events. Should efforts focus on reducing inputs of nutrients or sediment? Should resources be directed toward addressing stream flow, impervious surfaces, or lakeshore erosion?

Lake Superior—10% of Earth's surface liquid freshwater—is among Minnesota's greatest natural resources. It has real economic impacts as part of a "highway" from the oceans to the US Midwest and as an outstanding location for recreation and tourism. This project's goal is to optimize its health as climate changes.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Unmanned surveys of the extent of storm-water & sediment impacts.* **Budget: $106,391**

Satellite imagery and autonomous underwater vehicle surveys will map storm-water impacts on 625,000 acres of western Lake Superior. Effects of storm events on key habitats, including those of juvenile fish, will be scaled as a function of storm severity.

Outcome	Completion Date
1. Surveys of sediments, CDOM, and chlorophyll by area (satellite imagery on a daily-to-weekly basis) and depth (using an autonomous underwater glider-at least 4 surveys of 3 to 5 days duration per year).	*December yearly*
2. Survey results will be used to scale effects as a function of storm strength (National Weather Service data). This will require computer-modeling by a post-doctoral researcher.	*June in Years 2 and 3*

Activity 2: *Storm chasing to directly measure inputs into lake waters.* **Budget: $ 201,536**

We will compare key water quality and biological parameters inside and outside of impacted waters. We will use the R/V Kingfisher, a small research boat that can be quickly transported to affected areas for "storm chasing."

Outcome	Completion Date
1. Quantification of turbidity, colored dissolved organic matter, and phosphorus and nitrogen inputs from storm events (analysis of 4 to 5 storm events per year).	*June yearly*

2. Measurements of chlorophyll concentrations, primary production, respiration, and near-surface zooplankton abundance (20 small boat cruises per field season)	*June yearly*
3. Measurements of storm impacts on carbon cycling (pH, outgassing of carbon dioxide, etc).	*May 2020*

Activity 3: *Storm effects on food webs from plankton to fish.* **Budget: $84,134**

We will examine how flood impacted waters affect bacterial, plankton and fish communities (small boat work and 6 days of sampling per field season from the R/V Blue Heron).

Outcome	Completion Date
1. Measuring phytoplankton growth and microbial respiration inside and outside of flood-impacted waters	*June yearly*
2. Measuring zooplankton abundance and key species inside and outside of plumes	*June yearly*
3. Sonar surveys of fish abundance and location inside and outside of the plumes	*June yearly*
4. Using results from Activities 1-3 for predictive models of storm impacts on Lake Superior	*May 2020*

Activity 4: *Sharing results with resource managers and the interested public.* **Budget: $36,798**

This will be coordinated with ongoing Minnesota Sea Grant efforts.

Outcome	Completion Date
1. Meetings with resource managers; presentations to the Twin Ports Freshwater Folks, a group of water quality professionals from academia, government and tribal agencies.	*ongoing*
2. Our outreach coordinator will provide social media updates (4 per year) and schedule mass media interviews for the interested public.	*ongoing*
3. Two "Science on Deck" days per year (where the RV Blue Heron is moored by the Great Lakes Aquarium and the crew and PIs host tours and activities. Attendance per event: 200 to 300 people as based upon last 2 years of data).	*Summer 2018, Summer 2019*

III. PROJECT STRATEGY

A. Project Team/Partners

Requesting Trust Fund Support: University of Minnesota Duluth Large Lakes Observatory: Elizabeth Minor (project management, biogeochemistry), Robert Sterner (biological productivity, nutrient cycling, phytoplankton ecology) Erik Brown (carbon cycling), Jay Austin (physical processes, glider management, mapping), Richard Ricketts (ship operations; logistics), **UMD Biology**: Donn Branstrator (zooplankton ecology), Tom Hrabik (fish ecology), **UMD UMN SeaGrant**: Sharon Moen (public outreach).
Partners not requesting Trust Fund Support: MPCA: Brian Fredrickson; **MN-DNR:** Cory Goldsworthy, **Lake County SWCD:** Dan Schutte; **US-EPA:** Joel Hoffman.

B. Project Impact and Long-Term Strategy

Our goals: to evaluate storm impacts on Lake Superior food webs; to use this information to improve management strategies for the Lake watershed. Data will be compared with post-flood studies in 2012 and previous LCCMR-funded work. We will coordinate with the USGS (river/stream gaging data) and the US EPA.

C. Timeline Requirements

A 3-year project enables field sampling in late summer of Year 1, a full field season in Year 2, a partial field season in Year 3, and time to perform the necessary modelling and analysis in Years 2 and 3. "Science on Deck" days in years 2 and 3 will share results with the interested public and K-12 school groups.

2017 Detailed Project Budget

Project Title: Impact of increasing storm inputs on Lake Superior

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: salary (78%) and benefits (22%) for 2 technicians, 1 chemical, 1 biological. Each would contribute 8.3% FTE in year 1; 25% FTE in Year 2 (which contains the most field sampling); and 17% FTE in year 3.	$72,730
Personnel: graduate student summer support at 50% FTE for 4 students in Years 2 and 3 (salary 85% and benefits 15%); the students will be supported by TAships in the academic year. 2 of these students will be performing biogeochemical analyses (one focused upon carbon and nutrient analyses, the other on primary production and chlorophyll analyses). The other 2 students will be involved in zooplankton and fish surveys.	$64,284
Personnel: Post-doctoral support, 25% FTE in Years 2 and 3 (salary 82% and benefits 18%)	$35,107
Personnel: Outreach coordinator, 8.3% FTE in Years 2 and 3 (Salary 78% and benefits 22%)	$15,624
Personnel: Summer undergraduate student support for 2 people, both at 50% FTE, in Years 1 and 3 (100% salary, no benefits).	$11,143
Equipment/Tools/Supplies: outreach supplies	$624
Equipment/Tools/Supplies: Lab and field supplies. This covers the purchase of supplies such as: vials for our 2000 samples ($1250), nitrile gloves for clean sample handling ($2000), reagents such as hydrochoric acid used in cleaning glassware and preserving samples ($1100 per year), filters for isolating particles ($1.09 per filter, we need ~ 2000 so $2009), plankton net mesh ($165 per net), nitrogen and CO2-free air for clean sample handling, tank rental charges for these gases (approx $60 per month), ultra pure water ($45 per liter), carboys for short term storage of large volume samples prior to filtering ($173 each). Note: prices based upon Fisher Scientic website prices as of 03/14/16.	$21,267
Additional Budget Items: Laboratory analyses (TOC, DOC, nutrients, chlorophyll, TIC, etc). We are assuming 2001 samples to be collected during this project and and average analytical cost of $7.80 per sample	$15,608
Additional Budget Items: Glider communication (telephone). $50 per day times 20 days per year (4 deployments of 5 days each). Cost in Year 1 is $1000. Cost in Year 2 (assuming 4% inflation) is $1040; cost in year 3 (with inflation estimate) is $1081	$3,121
Additional Budget Items: Glider maintenance. 1 calibration each year of the project to ensure that the data is accurate. Note: a new glider costs $200,000 and there are very few companies that make them. This one has to go back to its manufacturer for calibration each year, at an estimated cost of $3300 for a 2 week test of its systems. $503 are budgeted for shipping.	$10,403
Additional Budget Items: R/V Blue Heron time (4 days at $9500 per day in year 1, 8 days in year 2, adjusted for inflation increases, 4%, and 4 days in year 3, adhusted for inflation by 4%)	$158,140
Additional Budget Items: Boat time (small boat): 10 trips at $500 per trip in Year 1, 20 trips with a 4% inflation of the price in year 2, 10 trips (again inflation adjusted by 4% in Year 3).	$20,808
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$428,859

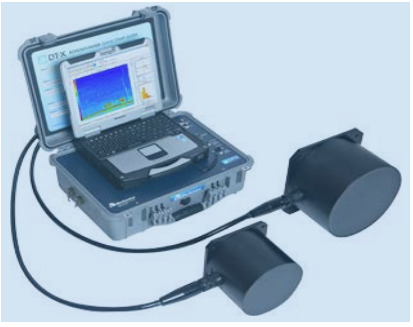
V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: money for a shared EPA-LLO post-doc, who is partially funded (3 months per year by this proposal)with the remainder of the 3 year salary plus fringes from EPA funds.	$100,275	Secured
Other State $ To Be Applied To Project During Project Period:	N/A	N/A
In-kind Services To Be Applied To Project During Project Period: These are the indirect costs that the university would normally charge for this project but which are waved.	$ 230,829	Secured
Funding History:	N/A	N/A
Remaining $ From Current ENRTF Appropriation:	N/A	N/A

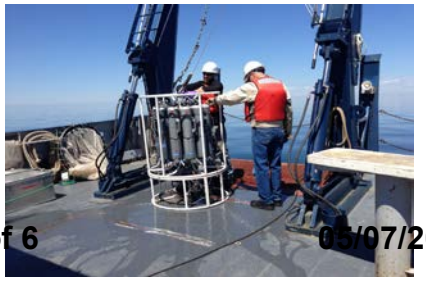
Satellite image of proposed study location in western Lake Superior. Note sediment plumes from storm inputs (MODIS data from June 26, 2012; NOAA CoastWatch-Great Lakes Region).

Tools we will use in our study (all currently available at UMD):

Underwater autonomous glider for mapping sediment and colored dissolved organic matter inputs, and biological responses.



Sonar instrument for assessing fish stock in Lake Superior (Biosonics Dtx split beam sonar unit).



Water sampler and plankton net on the UMD research vessel Blue Heron

Project Manager Qualifications

Elizabeth Minor is a Professor in the Department of Chemistry and Biochemistry and at the Large Lakes Observatory at the University of Minnesota Duluth. She has published more than 40 peer-reviewed scientific articles in well-regarded journals and has held grants from the National Science Foundation, SeaGrant, the National Oceanic and Atmospheric Administration, and the American Chemical Society PRF program. She is currently Department Head for the Department of Chemistry and Biochemistry and is also a current board member for the Association for the Sciences of Limnology and Oceanography (ASLO). She was actively involved in an LCCMR project (coordinating the field work) from 2012-2016 under the management of Erik Brown.

Organizational Description

The **Large Lakes Observatory** (LLO) is a research institute at the University of Minnesota Duluth. LLO was established in 1994 to make systematic use of oceanographic techniques in lake studies. We have grown (currently 12 faculty members) to have a global outlook and an international reputation with field programs and collaborators on 6 continents. In addition to housing a vibrant graduate program (we have attracted students from Malawi, Tanzania, Uganda, Ghana, China, Malaysia and the Netherlands), LLO provides unique research opportunities to undergraduates; in the past few years UMD undergraduates have participated in field programs in Indonesia, Mexico, Malawi, as well as on Lake Superior. Close ties have been formed with institutes in Canada, Uganda, France, Norway, Kyrgyzstan, Kenya, Nicaragua, Malawi, Tanzania and England, as well as with many universities within the United States. We are working to understand how lakes function, how they behaved in the past, and what will happen to them in the coming years.

The LLO operates the largest university-owned research vessel in the Great Lakes. The R/V Blue Heron was purchased with LCMR support in 1997, and is the only member of the University National Oceanographic Laboratory System (UNOLS) on the Great Lakes. The ship is outfitted with state-of-the-art research equipment that provides unique capabilities for observing Lake Superior. Although LLO is the lead organization on this proposal, researchers from other parts of the University of Minnesota Duluth, the US EPA, and the Minnesota Department of Natural Resources will be involved in the collaborative research we propose.