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

Project Title: **ENRTF ID:** **046-B**

Sedimental Journey: Watershed-scale monitoring of BMP effectiveness

Category: B. Water Resources

Total Project Budget: $ 972,000

Proposed Project Time Period for the Funding Requested: 3 Years, July 2014 - June 2017

Summary:

This project uses lake-sediment records to evaluate the effectiveness of best management practices in reducing sediment and nutrient loads at watershed scales over longer time periods than conventional monitoring.

Name: Daniel Engstrom

Sponsoring Organization: Science Museum of Minnesota - St. Croix Watershed Research Station

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Location

Region: Statewide

County Name: Statewide

City / Township:

_____ Funding Priorities _____ Multiple Benefits _____ Outcomes _____ Knowledge Base

_____ Extent of Impact _____ Innovation _____ Scientific/Tech Basis _____ Urgency

_____ Capacity Readiness _____ Leverage _____ Employment _______ TOTAL ______%

PROJECT TITLE: Sedimental Journey: Watershed-scale monitoring of BMP effectiveness

I. PROJECT STATEMENT

Why -- after decades of implementing best-management practices (BMPs) and spending billions of dollars -- do Minnesota rivers still run brown with silt, and lakes still turn green with algae? Nonpoint-source pollution remains Minnesota's most vexing, resistant, and unsolved water-quality problem. To counter, Minnesota now spends an additional $90M each year (the Clean Water Fund), mostly for further implementation of established BMPs, such as buffer strips, conservation tillage, bank stabilization, detention ponds, and others. ***How well have these BMPs worked so far?*** Have we made a difference? Will we?

To know, we need to monitor BMP effectiveness, and 13% of the legacy-act Clean Water Fund is appropriated for monitoring. Yet, conventional stream and lake monitoring has some inherent limitations:

- **Monitoring records are too short:** They have no baseline or reference conditions; trends are obscured by weather variability; lags in response delay measureable results.
- **Local records are spatially limited:** Field-scale monitoring for BMP effectiveness cannot be extrapolated directly to the watershed scale, which is the scale at which impairments are defined and effectiveness must be demonstrated.

This project will address these limitations by using lake sediments to extend effectiveness monitoring over long periods of time at the watershed scale. Layers of lake sediment are a chronological record of soil erosion and nutrient transport in the watershed and biological response in the lake. ***Over the last 20 years, the St. Croix Watershed Research Station has become internationally recognized for its excellence in using lake sediments to reconstruct watershed histories,*** thereby providing invaluable natural reference conditions and identifying human impacts over time. For selected sites representative of urban or agricultural water-quality management initiatives, our team of scientists will apply a comprehensive suite of proven analytical tools such as radioisotopic dating, sediment fingerprinting, algal analysis, and diatom reconstruction to determine the changes in pollutant loading over long periods of time, most critically before and after BMP implementation. In addition, we will develop emerging, innovative microscopic techniques to identify harmful algal blooms over time in the sediment record. ***Our lab will be the first, and only, to bring this new capability to Minnesota, just as it has done for the radioisotopic analysis of cores and sediment.*** This project meshes with, supports, and enhances existing agency monitoring efforts by providing alternative methods over longer time frames, thereby expanding our ability to identify and quantify the effectiveness of BMPs in improving water quality in Minnesota.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Select new sites, characterize watersheds, & document BMP histories — Budget: $141,000

First, we will search our state-wide archive of 115 lake-sediment cores to identify trends in sediment accumulation rates, and thus erosion rates, over the last century. Then, depending on watershed size and complexity, five to ten additional lake watersheds with representative BMP implementations in agricultural and urban settings will be chosen for detailed study. Site selection will mesh with state agency needs and consider existing initiatives (Sentinel Lake & Watersheds). Watersheds will be characterized for their physical features, land uses, and BMP histories in consultation with watershed-specific local agencies.

Outcome	Completion Date
1. Analysis of existing data and site-selection workshop with state agencies	*Dec 2014*
2. Compilation of watershed physical characteristics, land-use histories, & BMPs	*Sep 2015*

Activity 2: Collect and analyze 50-60 lake-sediment cores — Budget: $407,000

Fifty to sixty sediment cores (3-8 from each study lake) will be collected. Radiometric dating will determine rates of in-filling from watershed-scale soil erosion, especially during periods of dramatic changes in both agriculture and urbanization. Cores will be analyzed for the following: diatoms to assess nutrient status; surface-fallout radioisotopes to assess sediment source (fingerprints); biogenic silica to assess general algal productivity; and blue-green algal toxins, pigments, and fossil remains to assess blooms of harmful, noxious algae. This last analysis will require modest instrumentation (an inverted microscope) and consultation with Canadian researchers who are pioneering the methodology. Establishment of this expertise at the Research Station will be the first of its kind in Minnesota and plant the seeds for a lasting resource to the state.

Outcome	**Completion Date**
1. Collection and analysis of lake-sediment cores	*Oct 2014-Sep 2016*
2. Establishment of Center for Harmful Algae Research in Minnesota (CHARM lab)	*Mar 2015*

Activity 3: Quantify BMP effectiveness by linking land to water **Budget: $302,000**

First, time trends identified in the sediment cores will be statistically related to trends in the watershed land-use and BMP implementation. For example, is there a trend that corresponds to the impact that BMPs have had in counteracting the large-scale mechanization of agriculture, application of inorganic fertilizer, and expansion of row-crop acreage? Second, selected study watersheds will be modeled to better integrate all factors affecting the production and transport of nonpoint-source pollution from the landscape to our waterways. These models, constrained to past conditions by the sediment-core data, will help explain relative differences in apparent BMP effectiveness driven by differences in soils, topography, and climate among the study watersheds.

Outcome	**Completion Date**
1. Trend analysis to correlate sediment records to BMP implementations	*Dec 2015-Dec 2016*
2. Model analysis to mechanistically relate sediment records to landscape BMPs	*Mar 2016-Mar 2017*

Activity 4: Transfer knowledge to current and future resource managers **Budget: $122,000**

To inform resource managers, we will host a workshop in the Twin Cities to present project results to state, local, and federal agency personnel. For broader dissemination, the workshop content will be condensed into a 1- to 2-hour program to be presented later at a selected venue within each of the study watersheds to inform local officials there. Fact sheets for each study watershed will summarize results in understandable language for local officials. And, to begin training the next generation of Minnesota scientists and our future resource managers, we will continue our program that trains 3-5 undergraduates from Minnesota colleges in basic research methods and provides space for them to communicate their results at the Science Museum of Minnesota.

Outcome	**Completion Date**
1. Workshops & fact sheets: Twin Cities & study watersheds	*April 2017*
2. Science Training and Research Skills (STARS) intern program at Research Station	*August 2016*

III. PROJECT STRATEGY

A. Project Team/Partners

This project will be carried out by the PhD-level senior scientific staff of the St. Croix Watershed Research Station. Schottler and Almendinger will lead the site selection and watershed characterization; all hands will help with fieldwork; Schottler and Engstrom will date and fingerprint the cores; Edlund, Hobbs, and Ramstack will analyze the cores and establish the CHARM lab; Almendinger will manage the GIS and modeling aspects; all hands will help with data synthesis and presentation; Ramstack will coordinate the student activities.

B. Timeline Requirements

The project will require three years to complete. Site selection and watershed characterization will continue through the first year. Core collection and analysis will begin in the fall of the first year and continue into the next summer. Data synthesis will begin midway through the project and finish in the last half-year. Knowledge transfer will focus on the last 6 months, though undergraduate interns will be trained during the previous summer.

C. Long-Term Strategy and Future Funding Needs

This project helps ensure wise use of the $90M in Clean Water Funds being spent each year for the benefit of all Minnesota citizens. Knowledge transfer will encourage science-based adaptive ecosystem management by state and local officials. Although there is no long-term commitment from the state to fund further lake-core studies, should further studies be desired, they can be undertaken flexibly for as few or as many lakes as funding would allow. We anticipate that the establishment of the CHARM lab will attract research projects of all scales.

2014 Detailed Project Budget

Project Title: Sedimental Journey: Watershed-scale monitoring of BMP effectiveness

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

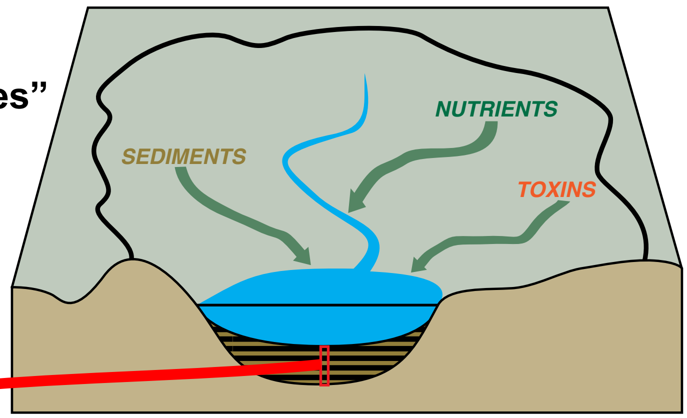
BUDGET ITEM	AMOUNT
Personnel: *(Listed alphabetically)*	**$ 660,000**
Almendinger, Senior Scientist (1 of 5); Watershed analysis, modeling; ~50% FTE for 3 yr; Salary=77%, Benefits=23% (~$132K)	
Edlund, Senior Scientist (1 of 5); Diatom & BG algae analyses; ~50% FTE for 3 yr; Salary=77%, Benefits=23% (~$132K)	
Engstrom, Research Director (1 of 1); Sediment dating; 0% FTE charged.	
Hobbs, Senior Scientist (1 of 5); Diatom & BG algae analyses; ~50% FTE for 3 yr; Salary=77%, Benefits=23% (~$132K)	
Ramstack, Senior Scientist (1 of 5); Diatom & BG algae analyses; ~50% FTE for 3 yr; Salary=77%, Benefits=23% (~$132K)	
Schottler, Senior Scientist (1 of 5); BMP summary, dating, correlations; ~50% FTE for 3 yr; Salary=77%, Benefits=23% (~$132K)	
Equipment/Tools/Supplies:	**$ 70,000**
Field supplies (tubing, tape, sample containers, misc. field gear) (~$5K)	
Lab supplies (reagents, glassware, misc. lab supplies) (~$25K)	
Data analysis supplies (data acquisition, software) (~$5K)	
Equipment: Inverted microscope for algal analysis (~35K) [unique configuration for algal analysis; to remain in service for years]	
Travel:	**$ 19,000**
5-10 BMP assessment trips, meet with local resource managers [per trip: 300 mi, 20 gal., 2 people, 1 room, 1 night] (~$4K total)	
5-10 field trips to collect lake-sediment cores [per trip: 300 mi, 20 gal., 3-4 people, 2 rooms, 2-4 nights] (~$11K total)	
5-10 trips to present results to local resource managers [per trip: 300 mi, 20 gal., 2 people, 1 room, 1 night] (~$4K total)	
Additional Budget Items: Lab analysis of sediment cores: magnetics; sediment components (organic, carbonate, inorganic fractions); radiometric dating and sediment fingerprinting (Lead-210, Cesium-137, Carbon-14, Beryllium-10); biogenic silica (algal productivity); sediment phosphorus content; particle size; diatom community; blue-green algal toxins, pigments, and fossils. [6 principal cores at $15K, 25 secondary cores at $3.5K, and 25 tertiary cores at $700] (~$195,000) Student intern stipends and on-site housing (~$28,000)	**$ 223,000**
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 972,000**

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:	$ 313,000	
Support services from Science Museum of Minnesota (lab & equipment maintenance, infrastructure, project administration), 25% of direct costs (~$243K). Engstrom's time on the project (~$70K)		
Remaining $ from Current ENRTF Appropriation (if applicable): None	$ -	
Funding History:	$ 2,011,000	

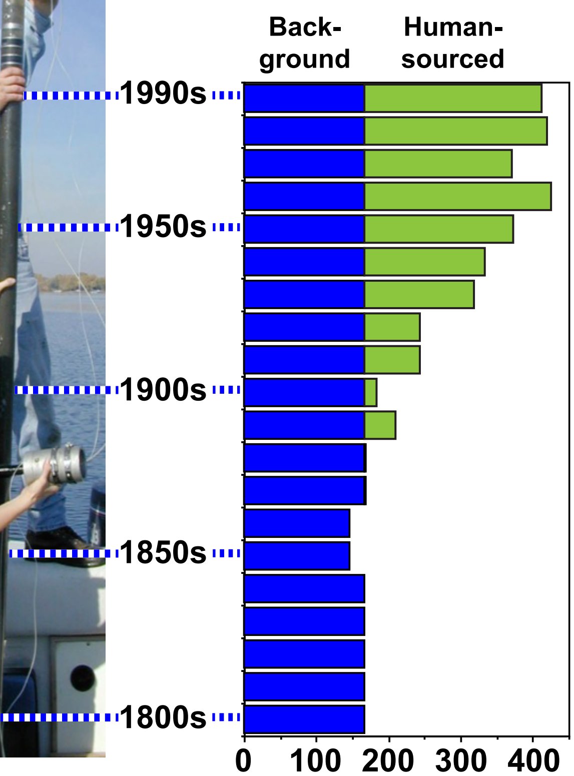
- ***Have BMPs* been effective?*** *Virtually no data exist at the watershed scale to answer this question.*
- ***Lake sediments offer a way of going back farther in time to see a more complete picture.***

Lakes collect long-term, watershed-scale "samples" *before and after* BMP implementation.

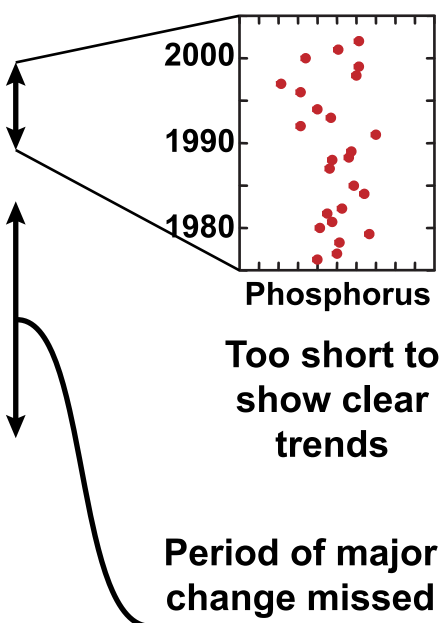


Each slice of a lake-sediment core is a slice of watershed history.

Lake-core data:



Stream-monitoring data:



Too short to show clear trends

Period of major change missed completely by monitoring data

**BMPs are best management practices, such as buffer strips, conservation tillage, and detention ponds, designed to keep our rivers and lakes clean.*

PROJECT MANAGER QUALIFICATIONS

Daniel R. Engstrom

1. *Education*

Ph.D.	1983	University of Minnesota, Minneapolis (Ecology)
M.S.	1975	University of Minnesota, Duluth (Zoology, minor: Botany)
	1971-73	University of Wisconsin, Madison (Zoology: Limnology)
B.A.	1971	University of Minn., Duluth (Zoology, minor: chemistry) Magna cum Laude

2. *Positions*

1999-	Director, St. Croix Watershed Research Station, Science Museum of Minn.
1995-99	Sr. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
1990-	Adjunct Professor, Dept. of Earth Sciences, University of Minnesota
2004-	Adjunct Professor, Water Resources Science, Univ. of Minnesota
1983-95	Research Associate, Limnological Research Center, Univ. of Minnesota

3. *Research Expertise*

My research centers on the use of lake sediment records to understand long-term environmental change, particularly the effects of human activities on water quality, atmospheric chemistry, and biogeochemical processes. Areas of current research include: (1) Atmospheric mercury deposition and cycling; (2) Historic nutrient and contaminant loading to the Mississippi River; and (3) Geochemical fingerprinting of suspended sediment in agricultural watersheds.

4. Recent Publications (of more than 120)

Anger, C.T., C. Sueper, D.J. Blumentritt, K. McNeill, D.R. Engstrom, and W.A. Arnold. 2013. Quantification of triclosan, chlorinated triclosan derivatives, and their dioxin photoproducts in lacustrine sediment cores. Environmental Science & Technology DOI 10.1021/es3045289

Drevnick, P.E, D.R. Engstrom, C.T. Driscoll, E.B. Swain, S.J. Balogh, N.C. Kamman, D.T. Long, D.G.C. Muir, M.J. Parsons, K.R. Rolfhus, and R. Rossmann. 2012. Spatial and temporal patterns of mercury accumulation in sediment records from across the Great Lakes Region. Environmental Pollution 161: 252-260.

Engstrom, D.R., J.E. Almendinger, and J.A. Wolin. 2009. Historical changes in sediment and phosphorus loading to the upper Mississippi River: mass-balance reconstructions from the sediments of Lake Pepin. Journal of Paleolimnology 41: 563-588.

Engstrom, D.R., E.B. Swain, and S.J. Balogh. 2007. History of mercury inputs to Minnesota lakes: influences of watershed disturbance and localized atmospheric deposition. Limnology and Oceanography 52: 2467-2483.

ORGANIZATION DESCRIPTION

The ***Science Museum of Minnesota*** (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. Its mission is to invite learners of all ages to experience their changing world through science. The ***St. Croix Watershed Research Station*** (SCWRS) the environmental research center of the SMM with the mission to foster, through research and outreach, "a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide." The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.