Today's Date: 14 February 2020

Date of Next Status Update Report: April 1, 2021

Date of Work Plan Approval:

Project Completion Date: June 30, 2023

Does this submission include an amendment request?

PROJECT TITLE: Unprecedented Change Threatens Minnesota's Pristine Lakes

Project Manager: Mark Edlund

Organization: Science Museum of Minnesota

College, Department, or Division: St. Croix Watershed Research Station

Mailing Address: 16910 152nd St. N.

City, State, Zip Code: Marine on St. Croix MN 55047

Project Manager Direct Telephone Number: (651) 433-5953 ext. 26

Email Address: medlund@smm.org

Web Address: www.smm.org/scwrs/people/edlund

Location: Central, Northwest, Northeast; Cook, Itasca, Koochiching, Lake, St. Louis counties

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Total Project Budget: $600,000

Amount Spent: $0

Balance: $600,000

Legal Citation: M.L. 2020, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

PROJECT STATEMENT: **Minnesota's most pristine lakes are changing unexpectedly and we don't know why!** Where we expect to find hundreds of our most beautiful and remote lakes—with little development or protected within state and national forests and parks—we instead often find green lakes, thick with noxious blooms of algae. Lakes turn green when we add nutrients to them, but in protected or remote settings, typical sources of excess nutrients (land use change, erosion, sewage) are not obvious. Based on our past work, we predict that climate change is working in concert with atmospheric deposition of nutrients to drive the changes that have already begun to affect our pristine lakes. Importantly, it is possible that by missing climate and atmospheric effects on lakes we could be misattributing the causes of blooms and misdirecting resource-management efforts and dollars.

Summary: We will determine why Minnesota's nicest lakes are unexpectedly turning green using:

1) a first of its kind in-lake and atmospheric monitoring system for Minnesota
2) historical sediment analysis to show how, when, and why pristine lakes are changing
3) lake simulations to determine which lakes are most at risk
4) communication of findings with resource managers and lake users on how and why nice lakes are changing.

Climate, weather and atmospheric deposition change everything. Sediment cores from wilderness lakes show two causes of unprecedented noxious algae growth. First, climate change results in longer ice-free season, stronger thermal stratification, increased inputs of dissolved organic carbon ("tannins"), and correlates with an alarming increased frequency of blue-green (cyanobacteria) blooms. Second, in lakes with no watershed runoff we find large increases in mineral matter and greater growth of algae (see visual). If that mineral matter and its nutrients did not come from the watershed, it must be coming from dustfall or precipitation.

Nutrients in lakes can originate from many sources—local, regional, and global. The 12 lakes (deep vs shallow lakes, across watershed size, and along an E-W transect) selected for this study will be entirely within northern Minnesota's protected areas, so we can rule out local landuse inputs. Climate change along with regional and global landuse changes well beyond Minnesota may be working in concert to change our pristine lakes. Climate affects lakes directly and indirectly to change how nutrients are cycled within lakes and their watersheds. In other regions of the US and world, dustfall is linked to eutrophication and biological changes in alpine and arctic lakes. We need to know if Minnesota's lakes are similarly imperiled by climate change and dust-borne nutrients, and rule out other potential causes of wilderness lake change so our management dollars are not wasted.

II. OVERALL PROJECT STATUS UPDATES:

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project end (June 30) and August 15, 2023

III. PROJECT ACTIVITIES AND OUTCOMES:

Activity 1: Use water and air quality monitoring to assess the cause of changing water quality in our "pristine" lakes
Description: Water quality in remote lakes is rarely monitored and air quality monitoring in Minnesota does not measure dry deposition (dustfall). We will do high resolution monitoring of water quality for 2

years on 12 state and national forest and park lakes. We will simultaneously establish a state-of-the-art dustfall network with 4-5 sites in north and central Minnesota in partnership with NADP to measure and map dustfall patterns and nutrient delivery.

ACTIVITY 1 ENRTF BUDGET: $254,430

Outcome	Completion Date
1. *Measure nutrients and algae for two years from 12 study lakes*	*October 2022*
2. *Establish state-of-the-art dustfall monitoring network in north and central Minnesota*	*October 2022*

First Update April 1, 2021

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Activity 2: Use sediment cores to determine if our best lakes are imperiled
Description: Every lake accumulates sediments that record its history. We will collect sediment cores from the 12 study lakes and determine when and how much they have changed—their biology, nutrient levels, dust inputs—using analysis of multiple biological and geochemical measures. We will reconstruct the influence of climate and dust-borne nutrients through time on each lake to understand why they changed, when they changed, and which lakes are most imperiled.

ACTIVITY 2 ENRTF BUDGET: $286,106

Outcome	Completion Date
1. *Collect, date, and analyze sediment cores from 12 study lakes*	*January 2023*
2. *Compare historical climate and dustfall records from sediment cores with modern monitoring to determine when and why lakes are changing*	*January 2023*

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Activity 3: Use lake simulations to determine which lakes are most at risk and how to protect them
Description: Computer simulations allow us to understand how lakes have changed in the past and how they might change in the future. MINLAKE is a simulation program that estimates lake thermal and oxygen dynamics. Importantly, input variables in the program let us test interactive effects of other forces that may be affecting our protected lakes such as changing weather patterns and ice-on/off. Model results will be paired with monitoring and sediment core histories to predict which protected lakes are most at risk.

ACTIVITY 3 ENRTF BUDGET: $59,464

Outcome	Completion Date
1. Create a MINLAKE model for 12 study lakes to measure historical changes in lake function	*January 2023*
2. Develop a framework for predicting which protected lakes are at risk	*January 2023*
3. Develop scientific reports, informational factsheets, and engage social media to inform managers and lay-persons on the state and fate of Minnesota's most protected lakes	*June 2023*

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Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project end (June 30) and August 15, 2023

IV. DISSEMINATION:

Description: We will develop scientific reports, informational factsheets, and engage social media to inform resource managers and lay-persons on the state and fate of Minnesota's most protected lakes. Edlund and project personnel are periodically invited to give presentations within their organizations, to agencies, at professional meetings, and to outside groups, and they will present this work upon invitation. We will communicate the findings of this study with the public through factsheets, blogs and social media (Twitter and Facebook) accounts associated with the St. Croix Watershed Research Station. We plan on publishing the results of this work as peer-reviewed publications in relevant scientific journals.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project end (June 30) and August 15, 2023

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures, $25,000

Explanation of Capital Expenditures Greater Than $5,000: For dust monitoring, five ADS/NTN Atmospheric Deposition Samplers will be purchased and deployed at five NADP monitoring sites in north and north-central Minnesota. The five new or retrofitted automated dry deposition sampler are budgeted at a total of $25,000. All equipment will be used for its useful life for this project. If the equipment is not used or the

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project ends, we commit to pay back the Environment and Natural Resources Trust Fund an amount equal to either the cash value received or a residual value approved by the LCCMR director if the units are sold.

Explanation of Use of Classified Staff:

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours for entire duration of project: 8520	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE:4.1

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for entire duration of project:	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: 0

VI. PROJECT PARTNERS:
This project will be led by the St. Croix Watershed Research Station (Dr. Mark Edlund, Dr. Adam Heathcote, and a lake modeler). MPCA-Air Quality will advise on our air quality monitoring network, and Jesse Anderson, MPCA-Water Quality, will advise on lake choice and sampling sites.

A. Partners outside of project manager's organization receiving ENRTF funding—N/A
B. Partners outside of project manager's organization NOT receiving ENRTF funding—MPCA-Air Quality will advise on our air quality monitoring network, and Jesse Anderson, MPCA-Water Quality, will advise on lake choice and sampling sites.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:
This project establishes a new air monitoring network, provides the first baseline data on dustfall in northern Minnesota, its effect on our best lakes, and determines which lakes are at risk. This project leverages collaborations with other research groups on dustfall and previous ENRTF and NPS funding on wilderness lakes across northern Minnesota, including the DNR Sentinel Lakes and the NPS Inventory & Monitoring programs.

VIII. REPORTING REQUIREMENTS:
- Project status update reports will be submitted April 1 and October 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2023

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:
A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum

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Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Mark Edlund
Project Title: Unprecedented change threatens Minnesota's pristine lakes
Organization: St. Croix Watershed Research Station, Science Museum of Minnesota
Project Budget: $600,000
Project Length and Completion Date: 3 years; June 30, 2023
Today's Date: 2/14/2020

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 372,320	$ -	$ 372,320
Edlund, Senior Scientist: Sediment Analysis; 41% FTE for 3 yrs; Salary=54.5%, Benefits=45.5% ($140,858 over 3 years); this is a grant-funded position			
Heathcote, Senior Scientist: Water/Air Quality, DNA; 41% FTE for 3 yrs; Salary=54.5%, Benefits=45.5% ($126,602 over 3 years); this is a grant-funded position			
TBD, Assistant Scientist: Lake Modeling; 27% FTE for 2 yrs; Salary=54.5%, Benefits=45.5% ($48,713 over 2 years); this is a grant-funded position			
Field and Laboratory Technicians:1 temporary field and laboratory technician; 50% FTE for 2 yrs; Salary=54.5%, Benefits=45.5% ($45,396 over 2 years); these are temporary grant-funded position			
Science Communication Specialist: Outreach and social media; 4.8% FTE for 2 yrs; Salary=100%, Benefits=0% ($10,751 over 2 yrs); this is a grant-funded position			
Professional/Technical/Service Contracts			
Lab analysis of dust samples: Dust chemistry (mass, P frac, N): 120 samples @ $100 ($12,000; Utah State University or competitive	$ 42,000	$ -	$ 42,000
Lab analysis of pigments samples: Algal pigment analysis: 120 samples @ $125 ($15,000; University of Regina or competitive bid)			
Lab analysis of Cyano DNA: 16S sediment DNA sequencing: 12 cores @ $1,250 ($15,000; University of Minnesota or competitive			
Equipment/Tools/Supplies			
Lab/Field supplies (bottles, reagents, preservatives, consumables - $7,500) Monitoring buoy supplies, 12@$2,000 ($24,000)	$ 31,500	$ -	$ 31,500
Capital Expenditures Over $5,000			
Dust Monitoring, ADS/NTN Atmospheric Deposition Samplers, 5 @ $5000 ($25,000)	$ 25,000	$ -	$ 25,000
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Atmospheric Monitoring and Network setup ($2,500) 1 trip, 2 scientists, 6 days, 1000 miles to north central Minnesota	$ 28,500	$ -	$ 28,500
Sediment core collection ($6,000), 2 coring trips, 2-3 field crew, 10 days and 850 miles/trip to northern Minnesota			
Water Quality monitoring ($20,000), 6 water quality trips, 2-3 field crew, 10 days and 850 miles/trip to northern Minnesota			
Other			
Lab analysis of water samples: TN/TP, DIN/SRP, DOC, DIC: 96 samples @ $112 ($10,752) (unit prices for analysis at SCWRS)	$ 100,680	$ -	$ 100,680
Lab analysis of sediment samples: 210-Pb (dating): 12 cores @ $2,500 ($30,000) (unit price for analysis at SCWRS) loss-on-ignition: 12 cores @ $800 ($9,600) (unit price for analysis at SCWRS) Sed P: 12 cores @ $1,590 ($19,080) (unit price for analysis at SCWRS) Diatoms: 8 cores @ $3,156 ($25,248) (unit price for analysis at SCWRS) BSi: 8 cores @ $750 ($6,000) (unit price for analysis at SCWRS)			
COLUMN TOTAL	$ 600,000	$ -	$ 600,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ 270,780	$ -	$ 270,780
All indirect project costs are provide in-kind by the Science Museum of Minnesota (federal indirect rate 45.13% on all direct costs = $270,780)				
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Tracking and Preventing Harmful Algal Blooms M.L. 2016-186-2-04a: $593,000, Jul 2016-Jun 2019	$ 141,867	$ 593,000	$ 451,133	$ 141,867