

**Environment and Natural Resources Trust Fund**

# 2021 Request for Proposal

## **General Information**

**Proposal ID:** 2021-134

**Proposal Title:** Salt Threatens Minnesota Water Quality and Food Webs

## **Project Manager Information**

**Name:** Mark Edlund

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

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## **Project Basic Information**

**Project Summary:** Salt levels are rising in Minnesota lakes, but the biological impacts are poorly understood. We determine how salt damages water quality and food webs and how to save our lakes.

**Funds Requested:** $1,174,000

**Proposed Project Completion:** 2020-06-30

**LCCMR Funding Category:** Water Resources (B)

## **Project Location**

**What is the best scale for describing where your work will take place?** Region(s): Central, Metro,

**What is the best scale to describe the area impacted by your work?** Statewide

**When will the work impact occur?** During the Project and In the Future

## **Narrative**

**Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

We don’t know how salt affects our lake water quality and food webs. Minnesota’s lakes are under threat from an invisible enemy — increasing chloride levels from road salt and other sources like water softeners and fertilizer. And not just in urban areas, but also outstate Minnesota where population growth threatens the very reason people want to live there — our lakes and streams. Past LCCMR funding helped identify the causes of salinization and fine-tune winter deicing, but the effects of salt on food webs and water quality, especially clarity and algae, remain largely unknown. Unlike other pollutants, chloride doesn’t break down in the environment. Instead it accumulates to levels toxic to animals and plants, and alters how lakes stratify and how frequently top and bottom waters mix to restore oxygen to colder, deeper layers. We will show how chloride impacts what matters most to Minnesotans — lake biology and water quality — using intensive lake surveys combined with historical tracking of salinization effects and lake simulations to identify tipping points where salt does irreparable damage. Only by knowing these linkages and specific thresholds beyond which lake quality and food webs suffer, can we inform policy and prioritize lakes for protection.

**What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.**

We will show how salt affects the health of our lakes using:
1) intensive lake survey along a gradient of salinization to determine how nutrient cycling, noxious algae, and food webs have been altered
2) historical analysis to determine when, why, and how much salt has changed water quality and food webs
3) lake simulation and experiments to understand how salinity alters lake mixing, bottom-water oxygen, and phosphorus cycling
4) communication of results and solutions to lake users and resource managers on how to protect lakes

Lakes suffering from salt pollution are often our greenest lakes, rich in nutrients and choked with algae. Is this a consequence of how the lake is responding to the salt as lake mixing changes, or are excess nutrients simply linked to watershed inputs? We will disentangle these drivers of poor water quality.

Impairment for salt is based on chloride, an ion potentially toxic to freshwater animals. Daphnia, or waterfleas, are sentinels for chloride impacts and serve as keystone species that graze on algae to clear the water and are critical food sources supporting fisheries. We will show how chloride-induced changes in waterflea species reflect the food web health in Minnesota lakes.

**What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state’s natural resources?**

First, this project will determine chloride tipping points that lead to poor lake water quality and food web disruption, and so guide lake protection. Second, it will determine how and when our lakes became salinized to limit further degradation. Third, it will identify lakes and food webs that have resilience to salinization and should be conserved. Finally, it will link ecological processes, experiments, and lake simulations to determine ways to enhance and preserve water quality in salinized lakes. All elements are critical for preserving lake resources in the face of increasing chloride pollution.

## **Activities and Milestones**

### **Activity 1: Measure differences among lakes under varying threat of salinization with intensive monitoring**

**Activity Budget:** $482,090

**Activity Description:**We will measure water quality and food webs monthly for two years in 15 lakes located throughout Central Minnesota and the Metro and grouped in five 3-lake clusters. High frequency monitoring buoys will be deployed in all lakes to record water-column temperature, oxygen, and chloride every 30 minutes. Five lakes (Tanners, Parkers, Powderhorn, Little Johanna, Henry) are “impacted”, with chloride levels 500-1000% above background concentrations. Five lakes (Medicine, Bde Maka Ska, Beaver, Wabasso, Uhlenkolts) are “at risk” showing chloride approximately 200% above background levels, and five lakes (Minnetonka, Cedar, Phalen, Josephine, Smith) are “least impacted” but still show chloride 50-100% above background.

Molecular analyses will be used to characterize lake food webs. We will isolate 300 Daphnia pulicaria clones (~20 per lake) and survey for genes correlated with chloride tolerance. Daphnia pulicaria, a keystone waterflea species, maintains water clarity by controlling algae and serves as preferred forage for recreational fisheries. We will also characterize each lake’s cyanobacteria using molecular tests to determine if genetic diversity of noxious algae is also correlated with chloride tolerance. Threshold changes in water quality and food web genetic diversity will define chloride tipping points for Minnesota lakes.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Measure nutrients, salinity, algae, zooplankton, and lake behavior for two years in 15 study lakes | 2020-04-30 |
| Use molecular tools to analyze lake food webs for chloride tolerance | 2020-06-30 |

### **Activity 2: Use sediment cores to reconstruct the history and threat of salinization**

**Activity Budget:** $472,955

**Activity Description:**Every lake accumulates sediments that record its history. We will collect sediment cores from 15 study lakes and determine when and how much they have changed in response to salinization—their food webs, biology, nutrient and chloride levels—by analyzing multiple chemical and biological indicators. We will date each core with natural radioisotopes, then reconstruct historic food webs using zooplankton remains, reconstruct past chloride and nutrients using diatoms and existing monitoring data, and reconstruct historic algae using fossil pigments and other indicators past productivity. We will test whether increasing chloride causes reductions in the abundance of good keystone waterflea species, degrades the food web, and leads to poor water quality.

When salty snowmelt enters lakes, it flows downward and smothers the bottom, depleting the oxygen, releasing phosphorus, and turning lakes green with noxious algae. We will experiment in the lab on short sediment cores to test how different levels of salt and dissolved oxygen affect sediment release of phosphorus. We will also replicate these experiments with potassium acetate, an alternative to chloride road salt, to see if it is less harmful.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Measure changes in sediment internal nutrient loading in salinized lakes | 2020-06-30 |
| Compare historical changes in water quality, salinity, and food webs in 15 study lakes | 2020-06-30 |
| Collect, date, and analyze sediment cores from 15 lakes | 2020-06-30 |

### **Activity 3: Identify critical salinity thresholds to stabilize the food web: reduce algae blooms and protect resilient food webs**

**Activity Budget:** $218,955

**Activity Description:**Lake and genetic simulation tools coupled with experiments will help solve the lake salinization crisis. We will mathematically simulate dense salty layers in lakes that cause low-oxygen bottom waters to determine critical thresholds of road salt or potassium acetate that cause density layers to form. This gives watershed managers scientifically based targets for reducing deicer applications and fixing lakes.

We determine resilience of lake food webs to salinization by measuring genetic relatedness of Daphnia populations among lakes. Study lakes are grouped into clusters, allowing us to explore how chloride-impacted lakes will exchange genes at different spatial scales. We will identify waterflea populations that have “desired” genes and how likely these genes will be transported to other lakes, increasing lake resilience to increasing chloride—in short, this activity will determine which lakes are at risk for water quality and food web collapse and how we can fix them.

Through reporting, presentations, and outreach (lake associations, MPCA, Road Salt Symposium, MN Groundwater Association), we will spread our findings to help communities stop salt pollution before it threatens our favorite lakes and fisheries.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Develop reports, factsheets, and outreach to inform managers and Minnesotans on protecting their threatened lakes | 2020-06-30 |
| Use lake and genetic modeling tools to determine lake and food web resilience to salinization | 2020-06-30 |

## **Long-Term Implementation and Funding**

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?**This project will determine chloride tipping points that lead to water quality and food web degradation, measure how and when lakes were salinized, identify lake and food web resilience to chloride, and test impacts of deicing alternatives. This information is needed at state and local levels to guide lake management and protection. We build on previous ENRTF funding and leverage collaborations with other research groups, agencies, and stakeholders. Through reporting, presentations, and outreach (newsletters, MPCA, Road Salt Symposium, MN Groundwater Association), we will spread our findings to help communities stop salt pollution before it threatens our favorite lakes and fisheries.

## **Other ENRTF Appropriations Awarded in the Last Six Years**

|  |  |  |
| --- | --- | --- |
| **Name** | **Appropriation** | **Amount Awarded** |
| Determining Risk of a Toxic Alga in Minnesota Lakes | M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06f | $200,000 |
| Tracking and Preventing Harmful Algal Blooms | M.L. 2016, Chp. 186, Sec. 2, Subd. 04a | $500,000 |

## **Project Manager and Organization Qualifications**

**Project Manager Name:** Mark Edlund

**Job Title:** Senior Scientist

**Provide description of the project manager’s qualifications to manage the proposed project.**1. Education
Ph.D. 1999 University of Michigan, (Natural Resources & Environment)
M.S. 1992 University of Michigan, (Natural Resources)
B.S. 1987 University of Minnesota (Biochemistry)

2. Positions
2007- Sr. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2002-07 Assoc. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2000-02 Ass’t. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2004- Adjunct Professor, Water Resources Science/Earth Sciences, U of Minnesota
1987-99 Research Ass’t I, Center for Great Lakes and Aquatic Sciences, U of Michigan

3. Research Expertise
Aquatic biology, limnology, paleolimnology, and phycology; environmental drivers of ecological change; lake sediment records to understand short- and long-term environmental change. 20-yr record of federal, state, and local project management to get results.
Current Research:
• Biomonitoring of lakes in Great Lakes region National Parks
• Water quality in Lake of the Woods
• Understanding and predicting harmful algal blooms (HABs)

4. Publications (of more than 100)
 Strock, K.E., Saros, J.E., McGowan, S., Edlund, M.B. and Engstrom D.R. 2019. Response of boreal lakes to changing wind strength: Coherent physical changes across two large lakes but varying effects on primary producers over the 20th century. Limnology and Oceanography https://doi:10.1002/lno.11181
 Edlund, M.B., Schottler, S.P., Reavie, E.D., Engstrom, D.R., Baratono, N.G., Leavitt, P.R., Heathcote, A.J., Wilson, B. and Paterson, A.M. 2017. Historical phosphorus dynamics in Lake of the Woods (USA-Canada) – Does legacy phosphorus still affect the southern basin? Lake and Reservoir Management 33: 386-402.
 Edlund, M.B., Almendinger, J.E., Fang, X., Ramstack Hobbs, J., VanderMeulen, D.D., Key, R.L. and Engstrom, D.E. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. Water 9(9),1-34

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

**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. The St. Croix Watershed Research Station the environmental research center of the SMM with the mission “we do the science that helps make our rivers and lakes clean” through research and outreach. 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.

## **Budget Summary**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Category / Name** | **Subcategory or Type** | **Description** | **Purpose** | **Gen. Ineli gible** | **% Bene fits** | **# FTE** | **Class ified Staff?** | **$ Amount** |
| **Personnel** |  |  |  |  |  |  |  |  |
| Edlund/Senior Scientist |  | Sediment Analysis, Water Quality, Diatom Analysis |  |  | 45.5% | 1.5 |  | $174,600 |
| Heathcote/Senior Scientist |  | Water Quality, DNA, environmental statistics |  |  | 45.5% | 0.75 |  | $79,660 |
| Myrbo/Assistant Scientist |  | Water and Core sampling, Core experiments, Outreach |  |  | 45.5% | 1.5 |  | $152,775 |
| Ulrich/Assistant Scientist |  | Lake Modeling |  |  | 45.5% | 0.99 |  | $93,629 |
| Field and Laboratory Technician |  | Field work and lab analyses |  |  | 45.5% | 1 |  | $45,300 |
| Science Communication Specialist |  | Outreach and social media |  |  | 0% | 0.1 |  | $12,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$557,964** |
| **Contracts and Services** |  |  |  |  |  |  |  |  |
| University of Oklahoma | Professional or Technical Service Contract | Collection and analysis of 300 Daphnia clones @ $320 per clone ($96,000; University of Oklahoma or competitive bid) |  | X |  | 0 |  | $96,000 |
| University of Regina | Professional or Technical Service Contract | Lab analysis of pigments samples:Algal pigment analysis: 225 samples @ $150 ($33,750) |  |  |  | - |  | $33,750 |
| University of Minnesota | Professional or Technical Service Contract | Lab analysis of Daphnia DNA: 300 samples @ $40 ($12,000; University of Minnesota or competitive bid) |  |  |  | - |  | $12,000 |
| University of Minnesota | Professional or Technical Service Contract | Lab analysis of Cyano DNA: 16S water sample DNA sequencing: 75 samples @ $150 ($3,000; University of Minnesota or competitive bid) |  |  |  | - |  | $3,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$144,750** |
| **Equipment, Tools, and Supplies** |  |  |  |  |  |  |  |  |
|  | Tools and Supplies | Lab/Field supplies | Lab/Field supplies (bottles, reagents, preservatives, consumables, duplicate field gear for AIS prevention - $18,000) |  |  |  |  | $18,000 |
|  | Tools and Supplies | Monitoring buoy supplies | Component sensors for constructing and installing monitoring buoys on 15 lakes |  |  |  |  | $67,500 |
|  |  |  |  |  |  |  | **Sub Total** | **$85,500** |
| **Capital Expenditures** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Acquisitions and Stewardship** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Travel In Minnesota** |  |  |  |  |  |  |  |  |
|  | Miles/ Meals/ Lodging | Water Quality and sediment core sampling ($12,345), 84 days, 2 field crew, 11,340 miles, 14 days in hotel | Water Quality and sediment core sampling |  |  |  |  | $12,345 |
|  | Conference Registration Miles/ Meals/ Lodging | MN Lake Conference Outreach (i.e., Minnesota Water Resources Conference), formal presentation + booth for dissemination of project results results, 3 in-state conferences at $800 each | formal presentation + booth for dissemination of project results results |  |  |  |  | $2,400 |
|  |  |  |  |  |  |  | **Sub Total** | **$14,745** |
| **Travel Outside Minnesota** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Printing and Publication** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Other Expenses** |  |  |  |  |  |  |  |  |
|  |  | Lab analysis of water samples: TN/TP, DIN/SRP, DOC, DIC, chlorophyll a, chloride: 420 samples @ $187 ($78,540) (unit prices for analysis at SCWRS) | Lab analysis of water samples |  |  |  |  | $78,541 |
|  |  | Lab analysis of sediment samples: 210-Pb (dating): 15 cores @ $2,500 ($37,500) (unit price for analysis at SCWRS) loss-on-ignition: 15 cores @ $800 ($12,000) (unit price for analysis at SCWRS) Sed P: 15 cores @ $1,875 ($28,125) (unit price for analysis at SCWRS) Diatoms: 15 cores @ $4,500 ($67,500) (unit price for analysis at SCWRS) BSi: 15 cores @ $825 ($12,375) (unit price for analysis at SCWRS) Core incubations: 27 treatments @ $5,000/treatment ($135,000) | Lab analysis of sediment samples |  |  |  |  | $292,500 |
|  |  |  |  |  |  |  | **Sub Total** | **$371,041** |
|  |  |  |  |  |  |  | **Grand Total** | **$1,174,000** |

### **Classified Staff or Generally Ineligible Expenses**

|  |  |  |  |
| --- | --- | --- | --- |
| **Category/Name** | **Subcategory or Type** | **Description** | **Justification Ineligible Expense or Classified Staff Request** |
| **Contracts and Services** - University of Oklahoma | Professional or Technical Service Contract | Collection and analysis of 300 Daphnia clones @ $320 per clone ($96,000; University of Oklahoma or competitive bid) | This project involves a partnership with University of Oklahoma. Larry Weider's lab is the only facility with the capacity to clone and analyze Daphnia to address the food web questions we test in this proposal.**This is a single source contract.** |

### **Non ENRTF Funds**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Category** | **Specific Source** | **Use** | **Status** | **Amount** |
| **State** |  |  |  |  |
|  |  |  | **State Sub Total** | **-** |
| **Non-State** |  |  |  |  |
| In-Kind | All indirect project costs are provided in-kind by the Science Museum of Minnesota (federal indirect rate 40.09% on all direct costs = $480,206) | In-kind contribution of indirects | Pending | $480,206 |
|  |  |  | **Non State Sub Total** | **$480,206** |
|  |  |  | **Funds Total** | **$480,206** |

## **Attachments**

### **Required Attachments**

#### **Visual Component**

File: [06ac72e7-fcf.pdf](https://lccmrprojectmgmt.leg.mn/media/map/06ac72e7-fcf.pdf)

#### **Alternate Text for Visual Component**

Salt levels are rising in Minnesota lakes, but the biological impacts are poorly understood. We determine how salt damages water quality and food webs and how to save our lakes

### **Optional Attachments**

#### **Support Letter or Other**

|  |  |
| --- | --- |
| **Title** | **File** |
| Institutional letter of support, Science Museum of MN | [60166516-f1e.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/60166516-f1e.pdf) |
| SF990, Institutional tax exempt form | [3aad2c1f-434.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/3aad2c1f-434.pdf) |

## **Administrative Use**

**Does your project include restoration or acquisition of land rights?**
 No

**Does your project have patent, royalties, or revenue potential?**
 No

**Does your project include research?**
 Yes

**Does the organization have a fiscal agent for this project?**
 No