Final Abstract

Final Report Approved on March 6, 2026

M.L. 2022 Project Abstract

For the Period Ending June 30, 2025

Project Title: Salt Threatens Minnesota Water Quality and Fisheries

Project Manager: Mark Edlund

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Funding Source:

Fiscal Year:

Legal Citation: M.L. 2022, Chp. 94, Sec. 2, Subd. 04l

Appropriation Amount: $1,228,000

Amount Spent: $1,228,000

Amount Remaining: -

Sound bite of Project Outcomes and Results

This project tested how lakes and foodwebs respond to salt. It benefits Minnesota by showing salt management must be coupled with watershed controls to slow impacts, that foodwebs may slowly adapt to salinity to avoid catastrophic failure, and provides tools to identify and prioritize management of our most imperiled lakes.

Overall Project Outcome and Results

Freshwater salinization represents a long-term, nuanced pressure on urban lake ecosystems shaping their physical structure, biology, and chemical processes rather than producing a rapid or uniform response.

Contemporary monitoring showed that salt periodically exceeded the state's toxicity threshold in already impaired lakes. We found no strong relationship between chloride and algal growth. Instead, winter conditions were critical in setting the chloride and conductivity levels seen in the following open-water season. Modeling gave lake-specific chloride thresholds beyond which normal seasonal mixing is disrupted to prioritize management; it showed even small increases in bottom-water chloride can abnormally stabilize a lake, reduce the likelihood of normal mixing, and increase persistence of bottom water oxygen loss.

Lake sediment historical reconstructions showed more subtle signals of increased salting than expected. Biological

fossils show variable responses to changing salt concentrations, e.g., diatom assemblages and sedimentary pigments did not exhibit coherent directional trends with increasing salinity. Instead, we saw broader change associated with nutrient conditions and lake-specific histories. As such, salinization operates indirectly, influencing lake function through lake physical structure, lake mixing behavior, and internal nutrient cycling.

Sediment experiments demonstrated that phosphorus release from sediments is strongly controlled by oxygen availability in water rather than salt concentration. Under low oxygen conditions, internal phosphorus release increased. As such, salinity-enhanced stratification and bottom water oxygen loss amplifies internal nutrient release.

Genetic analyses of a keystone fish prey (Daphnia) indicated higher similarity among lakes than expected, with weak genetic differentiation/variation occurring within lakes. High gene flow between lakes represents a tradeoff for resilience to salinity; it constrains local adaptation but facilitates spread of advantageous traits. Patterns suggest human-facilitated connectivity, including recreation and lake access, may positively influence biological responses to salinization.

These findings show freshwater salinization functions as a long-term, interacting pressure that alters lakes through multiple pathways.

Project Results Use and Dissemination

Given growing concern over freshwater salinization, we actively shared project findings throughout the study and following its completion. We shared with scientific, management, and public audiences through presentations and discussions with regional water-resource and watershed partners, lake associations, contributions to professional and agency-facing forums, and public-facing outreach including museum programming, educational materials including GeoPaths at the museum, LCCMR Stories, and community engagement activities. We are developing project outcomes into peer-reviewed manuscripts, with additional publications expected to be submitted in the coming year, extending the project's impact beyond its active period.

Environment and Natural Resources Trust Fund

M.L. 2022 Approved Final Report

General Information

Date: April 13, 2026

ID Number: 2022-272

Staff Lead: Noah Fribley

Project Title: Salt Threatens Minnesota Water Quality and Fisheries

Project Budget: $1,228,000

Project Manager Information

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Project Reporting

Final Report Approved: March 6, 2026

Reporting Status: Project Completed

Date of Last Action: March 6, 2026

Project Completion: June 30, 2025

Legal Information

Legal Citation: M.L. 2022, Chp. 94, Sec. 2, Subd. 04l

Appropriation Language: $1,228,000 the second year is from the trust fund to the Science Museum of Minnesota for the St. Croix Watershed Research Station to determine chloride tipping points that lead to water-quality and food-web degradations, measure how and when lakes are salinized, identify lake and food-web resilience to chloride, and test impacts of deicing alternatives.

Appropriation End Date: June 30, 2025

Narrative

Project Summary: Salt levels are rising in Minnesota lakes, and biological impacts may be worse than we think. We determine effects on water quality and foodwebs, and how to save our lakes.

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

Road salt is essential for human safety in Minnesota, but it also damages our fisheries and lake water quality. Salinity is a threat all across the state: salty discharges come from water treatment plants, water softeners, and fertilizer, not just from busy roads in the Metro. A proposed rule change by the MN Pollution Control Agency could further increase salty discharge from new sources. Past LCCMR funding helped identify the causes of salinization and fine-tune winter de-icing, but the effects of salt on lakes — on food webs, fish, water clarity, and noxious algae — remain largely unknown.

Lakes suffering from salt pollution are often our greenest lakes, rich in nutrients, choked with algae, with oxygen loss and fish kills. In addition, salt can harm the beneficial zooplankton Daphnia, which graze on algae to clear the water, and are a critical food source supporting fisheries. We do not currently understand how sensitive to salt Daphnia are, and thus how resilient our lake foodwebs are. What happens to fisheries and water quality when Daphnia are affected? What can we do to avoid the worst effects? What should we be monitoring for? How can we adapt fisheries management to the continuing salt wave?

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We can solve this knowledge gap efficiently by comparing lakes that have been affected by salt to varying degrees. These lakes are chosen from Central Minnesota (support letter DCLA) and in the Twin Cities Metro, and provide a model for lakes across the state that could become saltier.

We will show how salt (in particular chloride) affects lake health, by using interlocking methods that illuminate each lake's present, past, and future conditions:
1) Lake surveys to determine current conditions: nutrient cycles, noxious algae, and food webs;
2) Historical analysis to determine when, why, and how much salt has changed nutrients, algae, and food webs;
3) Lake simulation experiments for "what if?" scenarios to understand how salinity alters lake oxygen and nutrients.

Because of the importance of these results to resource managers, communities, anglers, and other lake users, our proposed project also includes a robust plan for:
4) Communication of results and solutions for how to protect lakes from increasing salt.

Of great concern is identifying "tipping points," levels of salt beyond which irreparable damage to a lake occurs. And to protect fisheries, we also need to understand the early effects of salinization on Daphnia populations in our 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?

The project benefits Minnesotans by:
1) identifying lakes and food webs that have resilience to salinization, and conserving them;
2) protecting vulnerable lakes and fisheries against damage from excessive levels of salt that approach "tipping points";
3) linking ecological processes, experiments, and lake simulations to determine ways to enhance and preserve salinized lakes.

It is difficult to remove salt, so we need to learn to both manage salt at the source and manage lakes that are already

affected. Understanding these linkages and the thresholds beyond which lake quality and food webs suffer will inform policy and prioritize lakes for preservation.

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

Activities and Milestones

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

Activity Budget: $536,091

Activity Description:
We will measure water quality and food webs monthly for two years in 15 lakes located throughout Central Minnesota and the Metro; the lakes are 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 (DNA) will be used to characterize lake food webs. We will isolate 150 Daphnia pulicaria clones (~10 per lake) and survey for genes correlated with chloride tolerance. Daphnia pulicaria, a keystone species, maintains water clarity by eating algae, and serves as preferred forage for recreational fisheries. We will also characterize each lake's cyanobacteria using DNA 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	Approximate Completion Date
Collect and isolate Daphnia clones from 15 lakes to test for adaptation to salinitiy	September 30, 2023
Measure nutrients, salinity, algae, and zooplankton for one year (2023) in 15 study lakes	December 31, 2023
Set up, deploy, and measure lake behavior using monitoring buoys in 15 lakes during 2023	March 31, 2024
Collect surface sediments in lakes to test for differences in cyanobacteria among differentially salinized lakes	March 31, 2024
Measure nutrients, salinity, algae, and zooplankton for one year (2024) in 15 study lakes	December 31, 2024
Set up, deploy, and measure lake behavior using monitoring buoys in 15 lakes during 2024	March 31, 2025
Use molecular tools to analyze lake food webs (Daphnia and cyanobacteria) for chloride tolerance	April 30, 2025

Activity 2: Use core samples to reconstruct the history and threat of salinization

Activity Budget: $472,955

Activity Description:
Every lake accumulates sediments (mud) that record its history, like a stack of newspapers. We will collect sediment core samples 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 determine the ages of each core, then reconstruct historic food webs using Daphnia remains, reconstruct past chloride and nutrients using diatoms and existing monitoring data, and reconstruct historic algae using fossil pigments and other indicators of past productivity. We will test whether increasing chloride causes reductions in the abundance of good keystone Daphnia 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	Approximate Completion Date
Collect short cores to test internal nutrient loading differences in salinized lakes vs alternative deicers	December 31, 2024
Collect, date, and subsample sediment cores from 15 lakes, recover history of salinization among lakes	December 31, 2024
Compare historical changes in water quality, salinity, and food webs among 15 study lakes	June 30, 2025
Analyze historical changes in biogeochemistry (nutrients, algae, zooplankton) of sediment cores from 15 salinized lakes	June 30, 2025

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

Activity Budget: $218,954

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 Daphnia 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 and agencies stop salt pollution before it threatens our favorite lakes and fisheries.

Activity Milestones:

Description	Approximate Completion Date
Use lake modeling tools to determine lake response and resilience to salinization	June 30, 2025
Develop reports, factsheets, and outreach to inform managers and Minnesotans on protecting their threatened lakes	June 30, 2025
Use genetic modeling tools to determine lake and food web resilience to salinization	June 30, 2025

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
The research agenda outlined here, addresses salinization across scales ranging from genes to ecosystems and from local to regional to identify critical "tipping points" not only for Minnesota lakes, but for lake ecosystems globally. From our project we anticipate that we will develop scientific publications, reports, informational factsheets, and engage social media to inform resource managers, the scientific community and lay-persons on the state and fate of Minnesota's salt-threatened 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 and communicating results at local, regional, state, and national meetings. The following specific deliverables will result from this project:
i) Final project report to LCCMR documenting results from Activities 1-3
ii) Fact sheet for broad audiences summarizing the threat, causes, implications, and management response to Minnesota's lake salinization crisis
iii) Social media posts through the outreach mechanisms and communication specialists at the Science Museum of Minnesota (e.g. https://www.smm.org/scwrs/fieldnotes) including blogs, field Facebook and Twitter posts
iv) Peer-reviewed publications (a minimum of 2-3 anticipated), presentations and technical assistance to local interest groups, county, state, and tribal agencies, and at local, state, or national meetings (e.g. lake associations, MPCA, Road Salt Symposium, MN Groundwater Association, ASLO, SFS).
We will acknowledge the Environment and Natural Resources Trust Fund through use of the trust fund logo or attribution language on all project print and electronic media, publications, signage, and other communications and outreach. We will use attribution language and social media tags found in the ENRTF Acknowledgment Guidelines.

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 work 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 foodweb 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 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 and agencies stop salt pollution before it threatens our favorite lakes and fisheries.

Other ENRTF Appropriations Awarded in the Last Six Years

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

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount	$ Amount Spent	$ Amount Remaining
Personnel										
Edlund, Senior Scientist		Project coordination, Fieldwork, Sediment Analysis, Water Quality, Diatom Analysis, reporting			43.7%	1.5		$174,600	-	-
Heathcote, Senior Scientist		Water Quality, DNA, environmental statistics, reporting			43.7%	0.75		$79,660	-	-
Myrbo, Assistant Scientist		Water and Core sampling, Core experiments, Outreach			43.7%	1.5		$152,775	-	-
Ulrich/Assistant Scientist		Lake Modeling			43.7%	0.99		$93,629	-	-
Field and Laboratory Technician		Field work and lab analyses			43.7%	1		$45,300	-	-
Science Communication Specialist		Outreach, communication, and social media			0%	0.1		$12,000	-	-
Wersebe, Post Doctoral		Daphnia genomics, molecular biology			43%	1.5		$119,500	-	-
							Sub Total	**$677,464**	**$677,464**	**-**
Contracts and Services										
University of Oklahoma or competitive bid	Service Contract	This was for collection and analysis of 150 Daphnia clones @ $1000 per clone ($150,000; University of Oklahoma or competitive bid). $27000 was used by UOk for that purpose. We request 119500 moved to personnel as we hired Wersebe from OK, and $3500 to travel to rescue Daphnia clones (seeUpdate)				0		$27,000	$27,000	-
TBD	Service Contract	Amended Lab analysis of pigments samples: Algal pigment analysis: 259 samples @ $115 ($28,750; University of				0		$28,750	$28,750	-

		Regina or competitive bid, using Auburn Univ)								
University of MN Genomics Center or competitive bid	Service Contract	Lab analysis of Daphnia DNA: 150 samples @ $80 ($12,000; University of Minnesota or competitive bid)				0		$12,000	$12,000	-
University of MN Genomics Center or competitive bid	Service Contract	Lab analysis of Cyano DNA: 16S water sample DNA sequencing: 75 samples @ $150 ($3,000; University of Minnesota or competitive bid)				0		$3,000	$3,000	-
Science Museum of Minnesota, St Croix Watershed Res Stn	Internal services or fees (uncommon)	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)				0		$78,541	$78,541	-
Science Museum of Minnesota, St Croix Watershed Res Stn	Internal services or fees (uncommon)	Lab analysis of sediment samples: 210Pb: 15 cores @ $2,500 ($37,500), loss-on-ignition: 15 @ $800 ($12,000), Sed P: 15 @ $1,875 ($28,125), Diatoms: 15 @ $4,500 ($67,500), BSi: 15 @ $825 ($12,375), Core incubations: 27 @ $5,000/treatment ($135,000), (all unit prices for analysis at SCWRS)				-		$292,500	$292,500	-
							Sub Total	**$441,791**	**$441,791**	**-**
Equipment, Tools, and Supplies										
	Tools and Supplies	Amended Lab/Field supplies	Lab/Field supplies (bottles, reagents, preservatives, consumables, duplicate field gear for AIS prevention - $20,000)					$20,000	$20,000	-
	Tools and Supplies	Monitoring buoy supplies, 15 buoy setups at $4500 each. Each buoy will have 2 PME miniDOT dissolve oxygen loggers at $1125 ea, 2 HOBO U24-001 loggers at $840 ea., 10	Component sensors for constructing and installing monitoring buoys on 15 lakes					$67,500	$67,500	-

		HOBO temp loggers at $50 ea., and floats/lines/hardware at $70 ea.								
							Sub Total	**$87,500**	**$87,500**	**-**
Capital Equipment										
							Sub Total	**-**	**-**	**-**
Acquisitions and Stewardship										
							Sub Total	**-**	**-**	**-**
Travel In Minnesota										
	Miles/ Meals/ Lodging	Amend Water Quality and sediment core sampling travel ($15,345), 90 days, 2 field crew, 14,340 miles, 14 days in hotel	Water Quality and sediment core sampling					$15,345	$15,345	-
	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	$2,400	-
							Sub Total	**$17,745**	**$17,745**	**-**
Travel Outside Minnesota										
	Miles/ Meals/ Lodging	one trip to OK, air travel, hotel, vehicle rental, 2 people, perdiem, to rescue Daphnia clones	Molecular analyses at UMGC failed. We need to get our Daphnia clones from UOk so that we can meet our Activity 1 goals. We request these fund to rescue and return clones to MN for culturing, harvesting and molecular analysis that can no longer be done at UOk.	X				$3,500	$3,500	-
							Sub Total	**$3,500**	**$3,500**	**-**

Printing and Publication										
							Sub Total	-	-	-
Other Expenses										
							Sub Total	-	-	-
							Grand Total	**$1,228,000**	**$1,228,000**	-

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Miles/Meals/Lodging	one trip to OK, air travel, hotel, vehicle rental, 2 people, perdiem, to rescue Daphnia clones	As described in our Mar 1 update, our efforts to do DNA sequencing on nearly 200 clones at UMGC failed. We request these funds to mount a rescue mission to bring Daphnia clones that are currently being held in maintenance mode at UOk back to MN so that we can grow them up, harvest, and get new molecular analyses completed on them so that we can meet our Activity 1, Milestones 2 and 4. Please.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount	$ Amount Spent	$ Amount Remaining
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 = $502,252)	In-kind contribution of indirects	Pending	$502,252	$502,252	-
			Non State Sub Total	**$502,252**	**$502,252**	**-**
			Funds Total	**$502,252**	**$502,252**	**-**

Attachments

Required Attachments

Visual Component

File: 21ad95aa-d99.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...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Letter of Support - Science Museum of MN	cea1a8a9-d4e.pdf
Letter of Support - Douglas Cty Lake Assoc	09daf31e-706.pdf
research addendum	5a480cd0-ef3.docx
Background Check form 2022-272	b6a40341-219.pdf
Science Museum GeoPaths training module	4ad3a5b0-8d3.pdf
Wersebe et al. 2024 Ecology and Evolution A Tale of Two Lakes	99d39f61-912.pdf
Activity 1 Final Report	6daec2e0-582.pdf
Activity 3 Final Report Updated	ae0accbe-ea3.pdf
Dissemination and Outreach Final Report	23c15d7c-2be.pdf
Activity 2 Final Report Updated	0544ac33-96b.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Please note responses to staff queries and comments:

1) Budget Please review the definitions of sole source P/T/S contracts vs. sub awards in the instructions on that page and reconsider your classification of the University of Oklahoma and UMN Genomics Center accordingly

Response: In our past LCCMR projects, we've had good experience using single source technical service contracts written to labs that do specific analyses for the project based on our positive past working relationships or using competive bids. In the case of UMN Genomics Center, this has worked well in past LCCMR projects; we anticipate the preparation and analysis of Daphnia clones by UOklahoma in Dr Weider's lab is best run that way as well, but would like to have the ability to use a competive bid if needed rather than a subaward.

2) Activities and Milestones Please add some intermediate milestones to Activity 1 to demonstrate progress over the course of the allocation, such as buoy deployment, collection of year one data, daphnia collection, etc.

Response: We've separated the monitoring milestones in Activity 1 into two milestones: data collected during lake visits (nutrients, algae, zooplankton) vs data gathered with monitoring buoys.

3) Project Collaborators It seems as if Dr. Larry Weider at University of Oklahoma should be listed as a project partner and the nature of the work with him is a sub award rather than a single source contract

Response: In our past LCCMR projects, we've had good experiences using single source technical service contracts written to labs that do specific analyses for the project based on our positive past working relationships or using competive bids. We anticipate the preparation and analysis of Daphnia clones by UOklahoma in Dr Weider's lab is best run that way as well, but would like to have the ability to use a competive bid if needed rather than a subaward. Dr Weider has also indicated his preference for this sole-source contract financial arrangement.

4) Activities and Milestones In general, each activity does not contain enough detailed milestones to demonstrate progress over the course of the project. Please revise to provide additional detail for each activity

Response: We've separated the monitoring milestones in Activity 1 into data collected during lake visits (nutrients, algae, zooplankton) vs data gathered with monitoring buoys. For Activity 2 we've added more detail to milestone 1 "Measure changes in internal nutrient loading among 15 salinized lakes vs alternative deiciers", and we've separated milestone 2 into two parts "Collect, date, and subsample sediment cores from 15 lakes" and "Analyze biogeochemistry (nutrients, algae, zooplankton) of sediment cores from 15 salinized lakes". For Activity 3, we've separated milestone 1 into two parts "Use lake modeling tools to determine lake resilience to salinization", and "Use genetic modeling tools to determine lake and food web resilience to salinization."

5) Budget Lab analysis costs: Can you explain what these costs include, especially since it appears personnel for lab analysis is already accounted for above? Is there a reason these costs are not listed in supplies for what we assume would be reagents, etc? Why are they listed as "unit costs" ?

Response: Lab analysis costs (in Other) are budgeted separately from personnel costs because they represent per sample laboratory costs charged at internal lab rates for water quality and sediment analyses. The per sample laboratory costs include labor by our laboratory technicians as part of the per sample analytical cost, which is why we have not included those staff or their time on the personnel budget lines. Personnel costs as listed cover project participants who are doing othe project related work including fieldwork, modeling, sample preparation, specialized analytical tasks and data analysis, project synthesis, coordination and communication.

6) Narrative Can you explain more how outcome #2 "Protect vulnerable lakes" is achieved with this project? Or is this project identifying lakes that need protection due to approaching a tipping point?

Response: The project design uses 15 lakes to provide two measures of how we can protect vulnerable lakes from salinization. First, the sediment records will provide us with timelines of how lakes respond to salinization in their nutrient chemistry, their algae communities, and their food webs. We hypothesize (Hypothesis 2 in Research Addendum) that lakes pass a tipping point where their water quality and food webs change to no longer supporting water quality, recreational, and fisheries/foodweb benefits. The project design includes lakes that range in salinity threat from "least impacted" to heavily "impacted"allowing us to fine tune what the tipping point of salinization is and guide agencies on how to protect lakes from reaching that point. Second, our molecular analysis of Daphnia populations from the lakes will allow us to understand the resilience of lakes and foodwebs to salinization. We hypothesize (Hypothesis 3 in Research Addendum) that lakes that are geographically grouped will be more resilient to salinization as lakes with salinity-adapted genetic variants of Daphnia will be more likely to share those variants among lakes through gene flow within geographic proximity.

7) Narrative The long-term implementation section implies this project will test impacts of deicing alternatives. We don't see that explained elsewhere. Do you mean a future project will do that?

Response: Perhaps this did not read perfectly well in the text in Activity 2, but we are not testing deicing alternatives on roads or impermeable surfaces. Instead, we are considering how these new "safer" alternives such as potassium acetate

behave once they reach a lake. We will be testing how “regular” chloride-based salinity affects the internal loading of nutrients from the sediment in lakes. Then we will “replicate these experiments with potassium acetate, an alternative to chloride road salt, to see if it is less harmful (Activity 2)”, i.e. compare the effect of potassium acetate on internal nutrient loading and whether it similarly can lead to loading levels that promote harmful algal blooms. We’ve also adjusted Activity 2, Milestone 1 for clarity to read “Measure changes in internal nutrient loading among 15 salinized lakes vs alternative deiciers” and provide specific details in the Research Addendum.

8) Attachments Please upload approved research addendum in PDF format

Response: Approved Research Addendum uploaded as requested.

Here are my comments on the second round of staff comments and questions (submitted 24June2022):

1 Activities and Milestones Please add some intermediate milestones to Activity 1 to demonstrate progress over the course of the allocation, such as buoy deployment, collection of year one data, daphnia collection, etc.

RESPONSE: For Activity 1, I split the monitoring into two milestones by year (2023/2024). I split the buoy deployment and analysis into two milestones by year (2023/2024). I added a milestone to separate the collection/isolation of Daphnia from their molecular analysis milestone. I added a milestone for collection of sediment for molecular analysis of cyanobacteria.

2 Attachments Please upload the completed required background check attachment per 5/23/22 email from LCCMR

RESPONSE: Uploaded completed background check as attachment

3 Dissemination Please include in the Dissemination section a statement about how Environment and Natural Resources Trust Fund 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 ENTRF Acknowledgment Guidelines.

RESPONSE: Added acknowledgement language as requested

4 Activities and Milestones Please revise/expand your activity descriptions and milestones to allow progress to be tracked during 2022 and 2023.

RESPONSE: For Activity 1, I split the monitoring into two milestones by year (2023/2024). I split the buoy deployment and analysis into two milestones by year (2023/2024). I added a milestone to separate the collection/isolation of Daphnia from their molecular analysis milestone.

5 Activities and Milestones Please add one or more milestones to Activity 1 to show experimental set-up at these lakes, sample collection, etc.

RESPONSE: For Activity 1, I split the monitoring into two milestones by year (2023/2024). I split the buoy deployment and analysis into two milestones by year (2023/2024). I added a milestone to separate the collection/isolation of Daphnia from their molecular analysis milestone.

6 Activities and Milestones Please adjust Act 1 Milestone 3: "Measure lake behavior using monitoring buoys in 15 lakes for 2 years" to be more comprehensive. An example might be: "calibrate, deploy, and monitor lake conditions using buoys in 15 lakes for 2 years to determine lake behavior "

RESPONSE: For Activity 1, Milestone 3, I split the buoy deployment and analysis into two milestones by year (2023/2024) using this language “Set up, deploy, and measure lake behavior using monitoring buoys in 15 lakes during 2023” and “Set up, deploy, and measure lake behavior using monitoring buoys in 15 lakes during 2024”

7 Activities and Milestones Act 2: Milestone 1 could use some additional clarification that links it to the activity description. For example, adding something of this nature is helpful for staff to understand what is going on "Collect short sediment cores to examine how different levels of salt and/or alternative deicers..."

RESPONSE: Changed the working of Act 2: Milestone 1 to “Collect short cores to test internal nutrient loading differences in salinized lakes vs alternative deicers”

8 Activities and Milestones In general, milestones are not very closely linked to activity objectives. Please revisit and make sure you describe the connection between the experiments and the desired outcomes such that staff can follow what you are doing to understand if progress being made in the project.

RESPONSE: See changes to Activity 1 with 4 added milestones as outlined above and more description wording. See wording changes in Act 2, Milestone 1, “Collect short cores to test internal nutrient loading differences in salinized lakes vs alternative deicers”, Act 2, Milestone 2 “Collect, date, and subsample sediment cores from 15 lakes, recover history of salinization among lakes”, Act 2, Milestone 3 “Compare historical changes in water quality, salinity, and food webs among 15 study lakes”, Act 2, Milestone 4 “Analyze historical changes in biogeochemistry (nutrients, algae, zooplankton) of sediment cores from 15 salinized lakes”. Wording of Activity 3 milestones seemed well linked to the activity description and those milestones were not changed.

9 Budget If you are not certain that U. of Oklahoma will be the service provider and may wish to bid, then please remove the "generally ineligible" designation.

RESPONSE: Changed as requested

10 Budget Please provide additional details for the monitoring buoy supplies. Are any of the individual components over $5,000? If so, they must be split into their own budget line and marked as a capital expense. If no capital expense please include some information such as "15 buoy component X for $1,200 each"

RESPONSE: I’ve added the following description on buoy costs: “Monitoring buoy supplies, 15 buoy setups at $4500 each. Each buoy will have 2 PME miniDOT dissolve oxygen loggers at $1125 ea, 2 HOBO U24-001 loggers at $840 ea., 10 HOBO temp loggers at $50 ea., and floats/lines/hardware at $70 ea.”

11 Budget Because these lab analyses are conduct in-house but charged at a certain rate, these expenses should be listed under "professional/technical contract--internal fees" and not in the "Other" section

RESPONSE: These lab analytical charges have been moved to the "professional/technical contract--internal fees" and are no longer in the "Other" section

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the Commissioner's Plan applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Not acknowledged

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Explanation & justification for Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	• Budget - Personnel • Budget - Professional / Technical Contracts • Budget - Travel and Conferences	Requesting changes to budget to accommodate contract and staffing changes (hired researcher we had been contracting), as well as urgent out-of-state travel for researchers to retrieve Daphnia samples from Oklahoma. Our contracted Oklahoma lab, which was unable to successfully complete the needed analysis, is ceasing operation and cannot return the samples to us. Further analysis of these specific clones, which can now be done in Minnesota, is crucial to the success of our research goal.	February 5, 2024	Yes	February 5, 2024
2	Amendment Request	• Other • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Attachments	The ice instability in winter 2023-24 and 2024-2025 has required additional travel needs and supplies for internal load incubations. We request transferring $3K to travel and $2K to supplies from contracting (where we saved some monies due to finding an alternative lab for sediment pigment analysis) to finish up the project.	March 24, 2025	Yes	April 3, 2025

Status Update Reporting

Final Status Update August 14, 2025

Date Submitted: December 28, 2025

Date Approved: January 2, 2026

Overall Update

The salinization of freshwater poses a significant threat to water quality, ecosystem health, and biodiversity globally. Despite the existence of chloride toxicity standards several metropolitan lakes in Minnesota have salinity levels above those intended to safeguard aquatic life. Here we've examined the intricate dynamics of freshwater salinization in 15 lakes in the Twin Cities and Alexandria, MN. Using high-frequency monitoring, paleolimnology, genomics, and lake modeling we've addressed how water quality and aquatic food webs have historically and are currently responding to salinity stress. Through these efforts, we've evaluated how lakes and their food webs are responding to increasing chloride concentrations (Activity 1), reconstructed historical food webs and water quality conditions using paleolimnological indicators such as zooplankton remains, diatoms, and fossil pigments to establish long-term context for salinity and nutrient change (Activity 2), and determined critical salt thresholds for each lake that would result in the loss of spring turnover – a key physical process that redistributes oxygen throughout the water column and subsequently impacts the food web (Activity 3).

Activity 1

We completed two years of monitoring activities on 15 study lakes. Thermal stratification, not current chloride levels, remained the primary control on mixing and oxygen dynamics. Most lakes, even with elevated chloride, mixed in spring and developed hypoxia in line with thermal stratification length and sediment oxygen demand. Exceptions were Brownie and Little Johanna (meromictic) and Tanners and Parkers, with shorter oxygenated periods and early anoxia. This may signal these lakes are approaching critical thresholds, which aligns with our modeled tipping points (Activity3), and a subset are close to regime shifts (lake turnover failure). Elevated bottom water chloride correlated with higher bottom-water SRP; salt can intensify internal loading in lakes. While phosphorus remains sequestered until mixing, eventual release could trigger blooms and oxygen loss-a positive feedback loop. Biological indicators, including zooplankton and Daphnia genetics, showed no major shifts yet; short monitoring windows limit detection of slower ecological responses or annual weather variability. Concluding, monitoring provided encouraging evidence that many lakes remain physically resilient presently, but also a cautionary tale for those that are not. Proactive salt management and continued vigilance are essential to safeguard lake mixing and water quality before the subtle stress of salinization enters an acute crisis. *(This activity marked as complete as of this status update)*

Activity 2

To reconstruct the history and threat of salinization we targeted sediment core collection and analysis from 15 lakes. We collected between 1.0 and 1.8 meters of sediment from each lake to recover 150-200 years of sediment accumulation. Cores were sectioned and underwent multiple analyses (geochemistry, dating, biologicals) that showed lakes undergoing various levels of salinization all exhibit regional patterns of lake stress from Euroamerican settlement and urbanization, but more nuanced salinity impacts to lakes that are simultaneously enduring continued nutrient and climate impacts. Individual lakes show evidence of direct salinity impacts ranging from meromixis (Little Johanna, Tanners, Brownie) to diatom indicators of salinity. However, lake responses are much more muted than we hypothesized; lakes are responding to salinity, but in conjunction with other stressors. Strong paleolimnological evidence of recent enhanced stratification dominates the study set, stratification that likely reflects increased salinity and climate drivers working in concert with continued nutrient loading (both internal and external) in many of the study lakes. The nuanced effects of salinity are further manifested in biogeochemical paleorecords, we do not find chronic salinity impacts, but aquatic

communities undergoing restructuring and adaptation rather than abrupt extirpation.
(This activity marked as complete as of this status update)

Activity 3

To reconstruct salinization history over 150-200 years we collected and analyzed cores from 15 lakes with multiple analyses (geochemistry, dating, biologicals) that showed lakes undergoing various levels of salinization exhibit regional patterns of lake stress from Euroamerican settlement and urbanization, but more nuanced salinity impacts because they are simultaneously enduring continued nutrient and climate impacts. Individual lakes show evidence of direct salinity ranging from meromixis (Little Johanna, Tanners, Brownie) to diatom salinity indicators. Strong paleolimnological evidence of recent enhanced stratification dominates the dataset; stratification changes reflect increased salinity and climate drivers in concert with continued nutrient loading (internal and external) in many study lakes. The nuanced salinity effects are further manifested in biogeochemical paleorecords; we do not find chronic salinity impacts, but aquatic communities undergoing restructuring and adaptation rather than abrupt extirpation. To guide modeling efforts, we incubated cores under oxic/anoxic conditions to show anoxic sediments released substantially more phosphorus than oxic sediments (Act3 attachment). Efforts to test alternative deicers, including the leading alternative, potassium acetate, were curtailed because it was shown more toxic to aquatic life than sodium chloride, and because internal phosphorus loading is a density and hypoxia driven process, not a property of the deicing compound.
(This activity marked as complete as of this status update)

Dissemination

At the Science Museum of Minnesota, we strive to bring our science and projects to broad audiences ranging from professional presentations to kids' programming on the floor of the Science Museum. With this ENRTF funding, we have disseminated information on Minnesota lakes undergoing salinization using peer-reviewed publication (Ecology and Evolution, with additional manuscripts in prep.), presentations to professional audiences at state and national meetings (ASLO, MN Waters Conference, AGU) and invited university seminars (UW-Stout), presentations to Minnesota agencies concerned with salt impacts (MNDNR, ALASD), collaboration with local water resource agencies (ALASD, Douglas County Lake Association, Minneapolis Parks, Minnehaha Creek WD, Ramsey County, Three Rivers WD, Nine Mile Creek WD, etc.) and the University of Minnesota Urban Ecology program (NSF), development of fact sheets, articles, and blog posts for lay audiences, and we tabled at least five community events on the Museum floor. Significant efforts included development of STEM modules to help train our next generation of scientists (GeoPaths-NSF), and mentoring of an honors science student from Wayzata High School. All events, communications, publications, and outreach material highlighted support from ENRTF funding.

Status Update Reporting

Status Update March 1, 2025

Date Submitted: March 24, 2025

Date Approved: April 3, 2025

Overall Update

Our final efforts continue to be be directed at delivering outcomes on all aspects of the project. We have wrapped up monitoring of 15 target lakes. We have collected zooplankton from all lakes and cloned our target species, Daphnia pulicaria, from each lake. We recently received our molecular sequences back from UMGC and will complete our assessment of Daphnia resilience across salinized lakes. We have collected sediment cores from 15 of the 15 lakes to date. These sediment cores have undergone initial subsampling, cores have been dated, and are in the analysis phase to develop historical timelines of how each lake has changed during the course of salinization. We have worked to assemble our research team and stakeholders including reaching out to resource managers, hiring two new research fellows, and meeting with stakeholder groups such as the Douglas County Lakes Association, the Alexandria Lakes Area Sanitation District, the MNDNR, Mpls Parks, Three Rivers Park District, MCWD, Ramsey Co, and the Urban Ecology group at UMN. Finally, we have begun publishing results (uploaded) and leveraged opportunities through the Science Museum of Minnesota in both outreach and STEM education (uploaded).

Activity 1

Efforts on Activity 1 focused on wrapping up 2 successful years of monitoring activities from June-October with monthly water quality sampling and buoy deployment. Analyses of those samples and data from 2023 are complete; final analysis of 2024 samples continues. Note that the buoy on Medicine Lake was not recovered, perhaps lost or stolen; we'll make a final effort to recover after iceout. We also collected the cyanobacterial samples from surface sediments and have added a subproject on methane production in salinized lakes that engages our environmental research fellow at the station. Monitoring and methane work were presented at the 2024 MN Water Resources Conference. Molecular sequences from cyanobacterial samples are nearly completed. Earlier problems encountered in Activity 1, to isolate, clone, grow, Daphnia for molecular analyses have now been completed, molecular sequences generated, and are being analyzed.

Activity 2

Activity 2 targeted sediment core collection from 15 lakes during winter 2022, 2023 and summer 2024 (Milestones 2-4). We collected between 1.0 and 1.8 meters of sediment from each lake to recover 200 years of sediment accumulation. Cores were sectioned into subsamples for analyses (geochemistry, DNA, biologicals) and are undergoing various geochemical analysis and final Pb-210 sediment dating. Dating records are completed for 13 cores; we immediately begin the full suite of analyses on biogeochemical clues preserved in each lake to document how lakes and foodwebs have changed during salinization. For Milestone 1, we were able to collect short sediment cores to test internal nutrient loading among lakes from only 3 lakes in winter 2023-24 because of poor ice conditions; in winter '24-'25 short cores for sediment incubation were recovered from 8 of 9 remaining lakes, again hindered by poor ice by early March. The last few months of our project are focused on data synthesis and reporting. The ice instability in winter 2023-24 and 2024-2025 has required additional travel needs and supplies for incubations. We request transferring $3K to travel and $2K to supplies from contracting (where we saved some monies) to finish up the project.

Activity 3

Activity 3 is directed at lake modeling, dissemination, and synthesis of genetic analysis to determine lake resilience to salinization. On Milestone 2, we developing partnerships, communication, and outreach. Social media focused on fieldwork through SCWRS/SMM Facebook/Instagram pages. We attended professional meetings to coordinate with other groups working on lake salinity issues (NALMS, ASLO, MN Waters Conference) and engaged MDNR and MPCA

agency representatives. We've reached out to the Univ of MN Urban Ecology NSF-funded project to link our and their efforts on Metro Lakes, the Douglas Co Lakes Association and Alexandria Area Sanitation District to partner on our outstate lake efforts. We continue to share samples with the Urban Ecology team. We met and coordinated with other monitoring groups in the field/meetings including Mpls Parks, Ramsey Co, Three Rivers Park Dist, MCWD. Finally, the project has also been the focus of several inreach and outreach communications at the Science Museum of Minnesota to make the various museum groups (Exhibits, STEM Ed) aware of this project resulting in STEM programming and several outreach events. We are currently wrapping up data generation and synthesizing lake models and genetic models to better understand lake tipping points and resilience to salinization.

Dissemination

We worked to engage stakeholders and resource managers at NALMS, ASLO, and MN Water Conferences and agency presentations (Edlund/Sauer) to MNDNR and Alexandria Lakes Area Sanitation District. We met with stakeholder groups including the Douglas County Lakes Association, Alexandria Lakes Area Sanitation District, Mpls Parks, Ramsey Co, Three Rivers Park Dist, and MCWD to provide project updates and solicit input. We coordinated sampling efforts and project design and goals with the NSF-funded Urban Ecology group at UMN; students learned sediment coring techniques and how to leverage this LCCMR project. We maintained an active Facebook and Instagram presence at the Science Museum of Minnesota/SCWRS to highlight fieldwork and sampling during our project efforts. We engaged a HS junior from Wayzata who did an Honors project on ecological function and data analysis of West Metro salty lakes. Our post-doc published our first manuscript that sets the strategy for analysis of Daphnia adaption and lake resilience (uploaded). Finally we included inreach and outreach programming events at the museum to highlight this project. These have led to development of STEMEd programs directed at youth in our KAYSC (uploaded GeoPaths learning module) and tabled events on the museum floor.

Status Update Reporting

Status Update September 1, 2024

Date Submitted: October 25, 2024

Date Approved: November 19, 2024

Overall Update

Our initial efforts continue to be be directed at four aspects of the project. We chose our 15 target lakes including 12 in the Metro and 3 near Alexandria. We have collected zooplankton from all lakes and cloned our target species, Daphnia pulicaria, from each lake. We ran into problems with the initial samples and molecular analyses at the Univ of MN Genomics Center and requested a budget amendment to rescue zooplankton clones at the Univ of Oklahoma this spring. We have collected sediment cores from 15 of the 15 lakes to date. These sediment cores have undergone initial subsampling and are in the analysis phase to begin developing historical timelines of how each lake has changed during the course of salinization. We have worked to assemble our research team and stakeholders including reaching out to resource managers, hiring two new research fellows, and meeting with stakeholder groups such as the Douglas County Lakes Association, the Alexandria Lakes Area Sanitation District, the MNDNR, Mpls Parks, Three Rivers Park District, MCWD, Ramsey Co, and the Urban Ecology group at UMN. Finally, we have leveraged opportunities through the Science Museum of Minnesota in both outreach and STEM education.

Activity 1

Please note that problems were encountered in Activity 1, Milestones 4 and 2, requiring an earlier amendment. Specifically, our efforts to isolate, clone, grow, and harvest Daphnia were successful, but the molecular analyses run by UMGC were unsuccessful. We arrange a trip by staff to Oklahoma to rescue and rehabilitate the zooplankton clones. We grew the clones up, harvested, and will do second molecular analysis to ensure we are able to meet Milestones 4 and 2. Other efforts on Activity 1, have focused on 2 successful years of monitoring activities from June-October with monthly water quality sampling and buoy deployment. Analyses of those samples and data from 2023 are complete; final sample collection and analysis of 2024 samples continues. We also collected the cyanobacterial samples from surface sediments and have added a subproject on methane production in salinized lakes that engages our environmental research fellow at the station. Her work was presented at the MN Water Resources Conference.

Activity 2

Activity 2 efforts targeted sediment core collection from all 15 lakes during winter 2022-2023 and summer 2024 (Milestones 2-4). We collected between 1.0 and 1.8 meters of sediment from each lake to recover 200 years of sediment accumulation. Cores have been sectioned into subsamples for multiple analyses (geochemistry, DNA, biologicals) and they are now undergoing various geochemical analysis and Pb-210 sediment dating. Dating records are completed for 10 cores; we immediately begin the full suite of analyses on biogeochemical clues preserved in each lake to document how lakes and foodwebs have changed during salinization. For Milestone 1, we were able to collect short sediment cores to test internal nutrient loading among lakes from only 3 lakes (Smith, Henry, Uhlenkolts) in winter 2023-24 because of poor ice conditions. We will use winter 24-25 to collect short cores for sediment incubation in the remaining lakes.

Activity 3

Activity 3 is directed at lake modeling, dissemination, and synthesis of genetic analysis to determine lake resilience to salinization. We focused on Milestone 2: developing partnerships, communication, and outreach. Among those activities have been social media on fieldwork adventures through SCWRS/SMM Facebook and Instagram pages. We attended professional meetings to coordinate with other groups working on lake salinity issues (NALMS, ASLO, MN Waters Conference) and engaged agency representatives at the 2023 MNDNR Fish Academy at Camp Ripley. We've reached out to the Univ of MN Urban Ecology NSF-funded project to link our and their efforts on Metro Lakes, the Douglas Co Lakes Association and Alexandria Area Sanitation District to partner on our outstate lake efforts. Students on the Urban

Ecology team joined us for sediment coring and water quality sampling and we continue to share samples. We met and coordinated with other monitoring groups in the field including the Mpls Parks, Ramsey Co, and Three Rivers Park Dist, MCWD. Finally, the project has also been the focus of inreach and outreach at the SMM to make the various museum groups (Exhibits, STEM Ed) aware of this project resulting in STEM programming and several outreach events.

Dissemination

We worked to engage stakeholders including reaching out to resource managers at the NALMS and MN Water Conference and a presentation (Edlund) on the project at the 2023 MNDNR Fish Academy (Camp Ripley). We met with stakeholder groups including the Douglas County Lakes Association to provide project updates and solicit assistance with fieldwork from association members and Alexandria student groups. We collaborated with the Alexandria Lakes Area Sanitation District presenting twice at their semiannual monitoring meeting. We coordinated sampling efforts and project design and goals with the NSF-funded Urban Ecology group at UMN; students joined us in the field to learn sediment coring techniques and how they might leverage this LCCMR project. We met with other monitoring groups in the field including the Mpls Parks, Ramsey Co, Three Rivers Park Dist, and MCWD. We maintained an active presence on social media (Facebook and Instagram) at the Science Museum of Minnesota/SCWRS to highlight fieldwork and fun sampling that takes place during our project efforts. Finally we included inreach and outreach programming events at the museum to highlight this project. These have led to development of STEMEd programs directed at youth in our KAYSC and tabled events on the museum floor.

Status Update Reporting

Status Update March 1, 2024

Date Submitted: February 5, 2024

Date Approved: February 5, 2024

Overall Update

Our efforts continue to be be directed at four acitivities. We chose our 15 target lakes including 12 in the Metro and 3 near Alexandria. We collected zooplankton from all lakes and cloned our target species, Daphnia pulicaria, from each lake. We ran into problems with the initial samples and molecular analyses at the UMGC and use this update to also request a budget amendment to rescue zooplankton clones at the Univ of Oklahoma, a lab that is closing and without other safe transport options. We collected sediment cores from 13 of the 15 lakes to date. These sediment cores have undergone initial subsampling and are in the analysis phase to begin developing historical timelines of how each lake has changed during the course of salinization. We have worked to assemble our research team and stakeholders including reaching out to resource managers, hiring two new research fellows, and meeting with stakeholder groups such as the Douglas County Lakes Association, the Alexandria Lakes Area Sanitation District, the MNDNR, Mpls Parks, Three Rivers Park District, MCWD, Ramsey Co, and the Urban Ecology group at UMN. Finally, we have leveraged opportunities through the Science Museum of Minnesota in outreach and STEM.

Activity 1

Please note that problems were encountered in Activity 1, Milestones 4 and 2, requiring an amendment request. Specifically, our efforts to isolate, clone, grow, and harvest Daphnia were successful, but the molecular analyses run by UMGC were unexpectedly and disappointingly unsuccessful. Furthermore, the lab in OK is closing, thus we request an amendment to Contracts to move $3500 to travel to arrange a trip by staff to Oklahoma to rescue and rehabilitate the zooplankton clones that are maintained there as no other transport means is safely available. We will grow the clones up, harvest, and go through a second molecular analysis in MN to ensure we are able to meet Milestones 4 and 2. We also request to move $119500 in Contracts to Personnel as we hired the person at the Science Museum who was leading the efforts in Oklahoma, keeping these funds in MN. Other efforts on Activity 1, have focused on a successful year of monitoring activities from June-October with monthly water quality sampling and buoy deployment. Analyses of those samples and data continue through the winter months. We also plan to collect the cyanobacterial samples from surface sediments during this winter (if ice conditions are safe).

Activity 2

Activity 2 efforts targeted sediment core collection from 13 of 15 lakes during winter 2022-2023 (Milestone 2). Cores were collected from all lakes except Minnetonka and Bde Maka Ska; we hope to collect those cores this winter if ice conditions allow. We collected between 1.0 and 1.8 meters of sediment from each lake to recover a couple hundred years of sediment accumulation. Most cores have been sectioned into subsamples for multiple analyses (geochemistry, DNA, biologicals) and they are now undergoing various geochemical analysis and Pb-210 sediment dating. Once dating records are completed for each core we immediately begin the full suite of analyses on biogeochemical clues preserved in each lake to document how lakes and foodwebs have changed during salinization. Cores from the remaining 2 lakes will be collected from from the ice during the 2023-24 winter (BdeMakaSka, Minnetonka) or from boats during the open-water season if ice conditions do not improve. Similarly we planned to focus on Milestone 1 this winter if ice conditions remain safe by collecting short cores for sediment incubation to test internal nutrient loading among lakes. If ice conditions remain poor, we will have to initiate these efforts asap after ice out.

Activity 3

Activity 3 is directed at lake modeling, project dissemination, and synthesis of genetic analysis to determine lake resilience to salinization. We have focused on milestone 2: developing partnerships, communication, and outreach.

Among those activities have been social media on fieldwork adventures through SCWRS/Science Museum of Minnesota Facebook and Instagram pages. We have attended professional meetings to coordinate with other groups working on lake salinity issues (NALMS, MN Waters Conference) and engaged agency representatives at the 2023 MNDNR Fish Academy (Camp Ripley). We've reached out to the Univ of MN Urban Ecology NSF-funded project to link our and their efforts on Metro Lakes, the Douglas Co Lakes Association and Alexandria Area Sanitation District to partner on our outstate lake efforts. Students on the Urban Ecology team joined us for sediment coring and water quality sampling. We met and coordinated with other monitoring groups in the field including the Mpls Parks, Ramsey Co, and Three Rivers Park Dist, MCWD. Finally, the project has also been the focus of several inreach and outreach communications at the Science Museum of Minnesota to make various museum groups (Exhibits, STEM Ed) aware of this project resulting in STEM programming and several outreach opportunities.

Dissemination

We worked to engage stakeholders including reaching out to resource managers at the NALMS and MN Water Conference and a presentation (Edlund) on the project at the 2023 MNDNR Fish Academy (Camp Ripley). We met with stakeholder groups including the Douglas County Lakes Association to provide project updates and solicit assistance with fieldwork from association members and Alexandria student groups. We collaborated with the Alexandria Lakes Area Sanitation District with presentation at their semiannual monitoring meeting. We coordinated sampling efforts and project design and goals with the NSF-funded Urban Ecology group at UMN; students joined us in the field to learn sediment coring techniques and how they might leverage this LCCMR project. We met with other monitoring groups in the field including the Mpls Parks, Ramsey Co, Three Rivers Park Dist, and MCWD. We maintained an active presence on social media (Facebook and Instagram) at the Science Museum of Minnesota/SCWRS to highlight fieldwork and fun sampling that takes place during our project efforts. Finally we included inreach and outreach programming events at the museum to highlight this project. These have led to development of STEMEd programs directed at youth in our KAYSC and tabled events on the museum floor.

Status Update Reporting

Status Update September 1, 2023

Date Submitted: October 2, 2023

Date Approved: October 4, 2023

Overall Update

Our initial efforts continue to be be directed at four aspects of the project. We chose our 15 target lakes including 12 in the Metro and 3 near Alexandria. We have collected zooplankton from all lakes and cloned our target species, Daphnia pulicaria, from each lake and prepared ample material for ongoing molecular analyses. We collected sediment cores from 13 of the 15 lakes to date. These sediment cores have undergone initial subsampling and entered the analysis phase to begin developing historical timelines of how each lake has changed during the course of salinization. Finally, we have worked to assemble our research team and stakeholders including reaching out to resource managers, hiring two new research fellows, and meeting with stakeholder groups such as the Douglas County Lakes Association, the MNDNR, Mpls Parks, Three Rivers Park District, Ramsey Co, and the Urban Ecology group at U of MN.

Activity 1

Efforts on Activity 1 have focused on collection, isolation, and culturing of Daphnia clones from our 15 study lakes. At each lake we collected zooplankton with a special net, returned them to the lab, and quickly isolated multiple individuals of Daphnia pulicaria from each lake. They were then fed and maintained until they began cloning themselves are which time we move to larger and larger vessels to generate more individuals. Lake cultures that have reached full biomass are concentrated following treatment with antibiotics and Daphnia are frozen in anticipation of molecular analyses. We have now sent all clones into the UMGC for upcoming extraction and analysis. One lake, Uhlenkolts in central MN does not have abundant Daphnia pulicaria but will still be part of our project lake set. Several Metro lakes were swapped due to low or absent D. pulicaria populations (e.g. Snail swapped for Josephine, Brownie for Powderhorn). Monitoring activities began in June with monthly water quality sampling and buoy deployment. Sampling will continue into October at which time we will download our buoy data and sample for cyanobacterial genomics.

Activity 2

Activity 2 efforts have targeted sediment core collection from 13 of 15 lakes during winter of 2022-2023. Cores were collected from all lakes so far except Minnetonka and Bde Maka Ska. We collected between 1.0 and 1.8 meters of sediment from each lake to recover a couple hundred years of sediment accumulation. Most cores have been sectioned into subsamples for multiple analyses (geochemistry, DNA, biologicals) and they are now undergoing initial geochemical analysis and Pb-210 sediment dating. Once dating records are completed for each core we immediately begin the full suite of analyses on biogeochemical clues preserved in each lake to document how lakes and foodwebs have changed during salinization. Cores from the remaining 2 lakes will be collected from a boats during the open-water season (Bde Maka Ska) or from the ice during the 2023-24 winter (Minnetonka).

Activity 3

Activity 3 is focused on lake modeling, project dissemination, and synthesis of genetic analysis to determine lake resilience to salinization. Our Activity 3 efforts have only focused on milestone 2: developing partnerships, communication, and outreach. Among those activities have been social media posts on fieldwork adventures through the SCWRS and Science Museum of Minnesota Facebook and Instagram pages. We have also attended several professional meetings to coordinate with other groups working on lake salinity issues (NALMS meeting in Mpls) and engaged agency representatives at the 2023 MNDNR Fish Academy held at Camp Ripley. We've reached out to the Univ of MN Urban Ecology NSF-funded project to link our and their efforts on Metro Lakes and the Douglas Co Lakes Association to partner on our outstate lake efforts. Students on the Urban Ecology team joined us for sediment coring and water quality sampling. We met and coordinated with other monitoring groups in the field including the Mpls Parks,

Ramsey Co, and Three Rivers Park Dist. Finally, the project has also been the focus of several inreach communications at the Science Museum of Minnesota to make the various museum groups (Exhibits, STEM Ed) aware of this project to assist in developing programming.

Dissemination

We have worked to engage stakeholders in this project including reaching out to resource managers at the recent NALMS meeting in Minneapolis and using a presentation (Edlund) on the project at the 2023 MNDNR Fish Academy held at Camp Ripley. We met with stakeholder groups such as the Douglas County Lakes Association to provide project updates and solicit assistance with fieldwork from association members and Alexandria student groups. We coordinated sampling efforts and project design and goals with the the recently establish NSF-funded Urban Ecology group at U of MN. We met with other monitoring groups in the field including the Mpls Parks, Ramsey Co, and Three Rivers Park Dist. Students from the Urban Ecology project joined us in the field to learn sediment coring techniques and how they might leverage this LCCMR project in their studies. Finally we have maintained an active presence on social media platforms (Facebook and Instagram) at the Science Museum of Minnesota and the St. Croix Watershed Research Station to highlight fieldwork and fun sampling that takes place during our project efforts.

Status Update Reporting

Status Update March 1, 2023

Date Submitted: March 30, 2023

Date Approved: April 18, 2023

Overall Update

Our initial efforts have been directed at four aspects of the project. We first visited the target lakes and have landed on 15 lakes as our study sites including 12 in the Metro area and 3 that are closer to Alexandria area. Next we collected zooplankton from all lakes and cloned our target species, Daphnia pulicaria, from each lake to prepare ample material for molecular analyses. Third we have collected sediment cores from 11 of the 15 lakes to date. These sediment cores have been entered into the initial subsampling and analysis phase to begin developing historical timelines of how each lake has changed during the course of salinization. Finally, we have worked to assemble our research team and stakeholders including reaching out to resource managers, hiring a new research fellow, and meeting with stakeholder groups such as the Douglas County Lakes Association and the Urban Ecology group at U of MN.

Activity 1

Efforts on Activity 1 have focused on collection, isolation, and culturing of Daphnia clones from our 15 study lakes. At each lake we collected zooplankton with a special net, returned them to the lab, and quickly isolated multiple individuals of Daphnia pulicaria from each lake. They were then fed and maintained until they began cloning themselves are which time we move to larger and larger vessels to generate more individuals. Lake cultures that have reached full biomass are concentrated following treatment with antibiotics and Daphnia are frozen in anticipation of molecular analyses. We expect to send all clones into the UMGC in late April/early May for analysis. One lake, Uhlenkolts in central MN does not have abundant Daphnia pulicaria but will still be part of our project lake set. Several Metro lakes were swapped due to low or absent D. pulicaria populations (e.g. Snail swapped for Josephine, Brownie for Powderhorn). Monitoring activities have been limited to site selection and permit applications (Mpls Parks). We will be assembling monitoring buoys in the next few weeks in anticipation of deploying them shortly after ice-out and initiating our 2023 lake monitoring program!

Activity 2

Activity 2 efforts have targeted sediment core collection from 11 of 15 lakes during winter of 2022-2023. Cores were collected from all lakes so far except Minnetonka, Brownie, Cedar, and Bde Maka Ska. We collected between 1.0 and 1.8 meters of sediment from each lake to recover a couple hundred years of sediment accumulation. Most cores have been sectioned into subsamples for multiple analyses (geochemistry, DNA, biologicals) and they are now undergoing initial geochemical analysis and Pb-210 sediment dating. Once dating records are completed for each core we immediately begin the full suite of analyses on biogeochemical clues preserved in each lake to document how lakes and foodwebs have changed during salinization. Cores from the remaining 4 lakes will be collected from boats during the open-water season this year.

Activity 3

Activity 3 is focused on lake modeling, project dissemination, and synthesis of genetic analysis to determine lake resilience to salinization. At this early stage in the project, our Activity 3 efforts have only focused on milestone 2: developing partnerships, communication, and outreach. Among those activities have been multiple social media posts on fieldwork adventures through the St Croix Watershed Research Station and Science Museum of Minnesota Facebook and Instagram pages. We have also attended several professional meetings to coordinate with other groups working on lake salinity issues (NALMS meeting in Mpls) and engaged agency representatives at the 2023 MNDNR Fish Academy held at Camp Ripley. We've reached out to the Univ of MN Urban Ecology NSF-funded project to link our and their efforts on Metro Lakes and the Douglas Co Lakes Association to partner on our outstate lake efforts. Several students on the Urban Ecology team joined us for winter sediment coring. Finally, the project has also been the focus of several

inreach communications at the Science Museum of Minnesota to make the various museum groups (Exhibits, STEM Ed) aware of this project to assist in developing programming and outreach.

Dissemination

We have worked to engage stakeholders in this project including reaching out to resource managers at the recent NALMS meeting in Minneapolis and using a presentation (Edlund) on the project at the 2023 MNDNR Fish Academy held at Camp Ripley. We met with stakeholder groups such as the Douglas County Lakes Association to provide project updates and solicit assistance with fieldwork from association members and Alexandria student groups. We coordinated sampling efforts and project design and goals with the the recently establish NSF-funded Urban Ecology group at U of MN. Students from the Urban Ecology project joined us in the field to learn sediment coring techniques and how they might leverage this LCCMR project in their studies. Finally we have maintained an active presence on social media platforms (Facebook and Instagram) at the Science Museum of Minnesota and the St. Croix Watershed Research Station to highlight fieldwork and fun sampling that takes place during our project efforts.