M.L. 2019 Minnesota Aquatic Invasive Species Research Center Subproject Abstract
For the Period Ending June 30, 2023

SUBPROJECT TITLE: Building Knowledge and Capacity to Solve AIS Problems
SUBPROJECT MANAGER: Dr. Nicholas Phelps
ORGANIZATION: University of Minnesota Twin Cities
COLLEGE/DEPARTMENT/DIVISION: College of Food, Agriculture, and Natural Resource Sciences / Minnesota Aquatic Invasive Species Research Center
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FUNDING SOURCE: Environment and Natural Resources Trust Fund (ENRTF)
LEGAL CITATION: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)

SUBPROJECT BUDGET AMOUNT: $4,000,000
AMOUNT SPENT: $3,386,992
AMOUNT REMAINING: $613,008

Sound bite of Project Outcomes and Results

This project continued MAISRC's work to develop research-based solutions that can reduce the impacts of aquatic invasive species in Minnesota. Through this appropriation, MAISRC has supported 12 subprojects on many of Minnesota's most important AIS, significantly advanced our scientific understanding and ability to manage AIS, and engaged thousands of stakeholders and partners.

Overall Subproject Outcome and Results

The Minnesota Aquatic Invasive Species Research Center (MAISRC) has advanced our collective capacity to address Minnesota's aquatic invasive species (AIS) problems through rigorous and highly innovative research, informal and formal collaboration across the state and world, and translated science into action with end-user engagement and strategic communication. During this project, MAISRC supported 12 subprojects, selected based on MAISRC's comprehensive research needs assessment process and external peer-review. New tools were developed and key knowledge gaps were filled on many of Minnesota's most problematic AIS, including zebra mussels, spiny water flea, bigheaded and common carps, starry stonewort, invasive cattails, and non-native Phragmites. The accomplishments over the course of this project are many, for example, MAISRC researchers conducted the largest-ever zebra mussel control project and demonstrate successful suppression of juvenile recruitment, developed an innovative coating that prevents zebra mussel attachment, optimized molecular eDNA and sonar technologies for surveillance, created online tools for organizing county-based collaboration networks for AIS prevention, and much more. The outcomes of the research have had immediate and long-term impacts that have changed the way we manage AIS.

MAISRC continues to translate science into action through active engagement with end-users and reaches broad audiences with diverse communication strategies. The outcomes of our engagement and dissemination activities are evident, from local (e.g., lake association, county), state (e.g., MN DNR, legislature), national (e.g., federal AIS Task Force, US Geological Survey), and international (e.g., genetic biocontrol collaborative, Australian government) levels. For example, the development of the AIS Explorer, an online decision-support tool for prioritizing prevention activities, was developed in partnership with counties and disseminated broadly with

presentations, 1:1 meetings and small group workshops, and video tutorials. The tool is now being actively used to develop more effective and efficient management plans in Minnesota and replicated in other states and countries.

MAISRC will continue to develop research-based solutions to Minnesota's AIS problems and translate the science into action with support from appropriations from the Minnesota Environment and Natural Resources Trust Fund in 2021 (Phase III) and 2023 (Phase IV).

Subproject Results Use and Dissemination

Website, social media, and e-newsletter

The MAISRC website has become a resource for AIS stakeholders across the state with an average of 40,000 users visiting the site each year. MAISRC launched an Instagram account this year and engaged 80 new followers in one month. MAISRC and the AIS Detectors program also have active social media accounts on Twitter/X, Facebook, and YouTube. MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, have collected nearly 140,000 views, totalling an estimated 3,500 hours of watch time. MAISRC's Twitter/X account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders, with over 1,500 followers. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detector workshops, and share invasive species news. In addition, the MAISRC e-newsletter is currently received by over 5,000 individuals and continues to grow and share in-depth stories about MAISRC research and management tools.

Earned media

Over the course of the last five years, MAISRC has been in approximately 365 news stories in over 100 different outlets. The most common outlets have been the Star Tribune, Minnesota Public Radio, Outdoor News, and Pioneer Press. Recent local media spotlights include Fox9 and Kare11. Other notable outlets include the Associated Press and National Geographic.

Presentations, workshops/trainings, and events

Highlights from 2019-2023

- Held three AIS Research and Management Showcases to share MAISRC research updates, outcomes, and tools with 2,000+ attendees. Recordings of recent Showcase presentations can be found on the MAISRC YouTube page: https://z.umn.edu/2020ShowcasePresentations; https://z.umn.edu/2021ShowcasePresentations; https://z.umn.edu/2022ShowcasePresentations
- AIS Detectors held 31 Core Course training sessions, certifying 300 Detectors across the state and bringing the program total of certified Detectors to 465
- Hosted six Starry Trek events with 200+ volunteers participating each time. Participating volunteers have found four new starry stonewort populations, as well as new zebra mussel, Eurasian watermilfoil, freshwater golden clam, and other AIS occurrences. A map of Starry Trek search locations and findings can be viewed online: https://z.umn.edu/StarryTrekMap
- Held three online Aquatic Invasive Species Management 101 courses which has been completed by 187 participants seeking to have a better understanding of what goes into AIS management and to become more informed consumers of AIS management programs.
- Partnered with MN DNR to host three Aquatic Plant Identification workshops with 40 participants each to better learn how to identify 60+ native and invasive aquatic plants for professional development or personal enrichment.

- AIS Detectors hosted 14 webinars on AIS and MAISRC research, reaching 2,600 live attendees and collecting nearly 5,450 views on YouTube. Webinar recordings can be viewed online: https://z.umn.edu/AISDetectorsWebinars
- Partnered with local communities to host two regional in person workshops: one at the Minnesota Landscape Arboretum, bringing together stakeholders from across the state of Minnesota to strategize about invasive carp solutions. Another workshop in Cass County, MN focused on learning from successful regional efforts to control aquatic invasive species by the Leech Lake Band of Ojibwe's Division of Resource Management, local water managers, and lake enthusiasts in the area.

Reports and other materials
Highlights from 2019-2023

- Created six videos, highlighting MAISRC subproject research
  - Raising zebra mussels in the lab
  - Volunteer monitoring leads to rapid response project
  - Anti-biofouling paint inhibits spread of zebra mussels
  - Mapping zebra mussels using multibeam sonar
  - Motivations and risks of illegal baitfish release
  - Enhancing Habitat and Diversity in Cattail-Dominated Shorelines
- Produced four annual research reports, summarizing research outcomes
  - 2022 Research Report, including an online interactive report
  - 2021 Research Report, including an online interactive report
  - 2020 Research Report
  - 2019 Research Report
- Created and maintain a series of interactive maps and tracking tools
  - MAISRC Work Around the State
  - AIS Explorer
  - MAISRC Milfoil App
  - PI Charter
- A report summarizing the MAISRC-hosted common carp workshop at the Minnesota Landscape Arboretum is forthcoming. MAISRC is supporting the collaboration by hosting an email group of all attendees who wish to participate and network.

Peer-reviewed publications
Peer-reviewed publications are an essential part of MAISRC's research and dissemination activities. A full list of over 100 peer-reviewed publications can be viewed on the MAISRC publication database: z.umn.edu/ais-publications

Data Repository at the University of Minnesota (DRUM)
To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility to MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. Thus far, MAISRC has contributed 26 sets of data to the DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects utilize this platform. Some MAISRC researchers upload their data to federal databases or in publications to align with data sharing standards within their individual fields of study or journal requirements.

Environment and Natural Resources Trust Fund (ENRTF)

M.L. 2019 ENRTF Work Plan Final Report

Today's Date: September 27, 2023

FINAL REPORT

Date of Work Plan Approval: June 17, 2019

Project Completion Date: June 30, 2023

PROJECT TITLE: Building Knowledge and Capacity to Solve AIS Problems

Project Manager: Nicholas Phelps

Organization: University of Minnesota

College, Department, or Division: Minnesota Aquatic Invasive Species Research Center

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Web Address: http://www.maisrc.umn.edu/

Location: Statewide

Total Project Budget: $4,000,000

Amount Spent: $3,386,992

Balance: $613,008

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)

Appropriation Language:

$4,000,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to support the Minnesota Aquatic Invasive Species Research Center in developing solutions to Minnesota's aquatic invasive species problems through research, control, prevention, outreach, and early detection of existing and emerging aquatic invasive species threats. This appropriation is available until June 30, 2023, by which time the project must be completed and final products delivered.

I. PROJECT STATEMENT:

The Minnesota Aquatic Invasive Species Research Center (MAISRC) is working with researchers, managers, and citizen stakeholders across the state to coordinate, conduct, and implement critical research that will solve the State's aquatic invasive species (AIS) problems. In the short life of MAISRC, significant progress has already been made and research investments are leading towards solutions. However, the reality remains that the threats posed by AIS to our cherished lakes, rivers, and wetlands are real and growing. It is imperative that we remain focused on a long-term vision for research that can support effective and efficient management actions.

Support for solutions-oriented research at MAISRC has been generously provided by ENRTF in the past and has brought together 18 project managers (from UMN, UMD/NRRI, MN DNR, and USGS) and their teams pursuing 28 research projects on a range of high priority species and strategies for AIS prevention, control, and management. Previous ENRTF support also created the operational capacity to prioritize, coordinate, and support innovative research teams, as well as the outreach capacity to translate the science into management actions. As a result, MAISRC has become a national leader in the field and has advanced the science and management of AIS.

During the course of this project, we will build on ongoing success by launching 12-15 research projects. New project proposals will be evaluated through a competitive RFP process, informed by our research needs assessment and stakeholder consultation. In addition, we will provide competitive continuation support for ~~5~~ 6 existing projects that are moving in promising directions. Each project will develop an externally peer-reviewed research proposal, workplan and budget in coordination with LCCMR staff prior to launch. MAISRC staff will provide leadership on the core organizational function of the research prioritization, request for proposals, research communication, infrastructure and capacity building.

Note: This document is details research plans and reports significant accomplishments of subprojects funded by MAISRC through this appropriation. *Section III, Subproject 1* provides a brief narrative of relevant Center-related activities. In *Section III*, subprojects will be described and outcomes with corresponding completion dates will be outlined with enough detail to adequately convey the scope of work being conducted, why, and the projected impact. A table that summarizes the current status of each subproject will be included as an attachment to this work plan. Separate subproject work plans will not be required. A budget for each subproject will be attached to the overall work plan. MAISRC will maintain copies of research addenda for each subproject and make them available to LCCMR staff upon request. Subproject dissemination activities will be reported in *Section III*; overall MAISRC dissemination activities will be reported in *Section IV* of the work plan.

II. OVERALL PROJECT STATUS UPDATES:

Amendment Request November 15, 2019

Amendment 1:
Subproject 1 – Change numbered order of Activities in Subproject 1.

As a part of the transition to a new work plan template, we request to change the numbered order of Subproject 1 activities to be consistent with MAISRC's M.L. 2017 work plan. The requested change would impact the numbered order of Subproject 1 activities as follows:

Original Numbering
ACTIVITY 1: Addressing high priority AIS threats by advancing new research (new projects)
ACTIVITY 2: Continuation of promising research to advance AIS solutions (continuation projects)
ACTIVITY 3: Leadership to facilitate AIS research and collaboration (MAISRC core operations)

New Numbering
ACTIVITY 1: Leadership to facilitate AIS research and collaboration (MAISRC core operations)
ACTIVITY 2: Addressing high priority AIS threats by advancing new research (new projects)
ACTIVITY 3: Continuation of promising research to advance AIS solutions (continuation projects)

Amendment 2:
Subproject 1 – Combine Activity 2 (new projects) and Activity 3 (continuation projects) into one activity titled "Activity 2 – Advancing high priority and promising research to address AIS in Minnesota."

When MAISRC wrote the original proposal for M.L. 2019 funding, we intended to evaluate new and continuations projects separately with separate RFPs and thus, split each into their own activity in our work plan. However, after consulting with our Center Advisory Board and Technical Committee, we have been advised to evaluate new and continuation projects as a part of a single RFP. We request to combine Activity 2 (new projects) and Activity 3 (continuation projects) into one activity. Combining new and continuation projects into one RFP will provide MAISRC with the flexibility to fund projects based on the strength of their proposal and potential impact on AIS in the state, rather than being limited by separate pools of funding for new and continuation projects.

Language in the Subproject 1 project description and outcomes has been modified below to reflect this proposed change.

Amendment 3:
Subproject 1 – Change completion date for *Activity 2, Outcome 1* to January 2021 to reflect new RFP and project timeline.

With support from our Center Advisory Group, Center Fellows Group, and UMN administration, we have made the strategic decision to shift our RFP and project timeline. On the new timeline, MAISRC's RFP and launch of new projects will be aligned with the calendar year. This means that MAISRC's next RFP will be released in January 2020 with new projects selected from that RFP starting in January 2021. Shifting the RFP and project timeline will allow research teams to utilize two full field seasons during their 2-year projects, as well as alleviate administrative challenges posed by the current timeline.

To reflect this change we request to change completion date for *Activity 2, Outcome 1* to January 2021. All projects that are launched at that time will be completed before the end of M.L. 2019 funding on June 30, 2023.

Amendments Approved by LCCMR: **02/14/2020**

First Update March 1, 2020

MAISRC shifted our Request for Research Proposals (RFP) and subproject timeline from the fiscal year (July 1 through June 30) to the calendar year. In alignment with the new timeline, MAISRC released our 2020 RFP on January 2, 2020. We anticipate allocating about $1.5 million to new and continuing projects as a part of the 2020 RFP. The primary funding source for the RFP is 2019 Environment and Natural Resources Trust Fund monies that have been allocated to MAISRC (M.L. 2019).

Following a phone conversation with LCCMR staff on 3/13/2020, the final report deadline for M.L. 2019 was adjusted to September 15, 2023 to allow time for subproject final reporting and incorporation into MAISRC's overall final report.

Amendment Request February 25, 2020

Subproject 1 – Move $35,000 from *Capital Expenditures* to MAISRC Reserves, reducing the overall Subproject 1 budget from $925,000 to $890,000 and increasing the balance of MAISRC Reserves from $3,075,000 to $3,110,000.

In the development of MAISRC's M.L. 2019 work plan, $35,000 was budgeted to help purchase a new electrofishing boat to replace existing equipment that was no longer safe or effective to use. With LCCMR's approval, MAISRC purchased a new electrofishing boat (in partnership with the Dept of Fisheries, Wildlife, and

Conservation Biology at the University of Minnesota) in June 2019, using 2013 ENRTF funds. With the purchase of a new boat, the funds allocated for a new boat on M.L. 2019 are no longer needed and we request that the unused capital budget be transferred to budget reserves, to be utilized in support of MAISRC subprojects.

Amendment Approved by LCCMR: **02/25/2020**

Second Update September 1, 2020

As a result of our 2020 Request for Proposal (RFP), MAISRC has reviewed, evaluated, peer reviewed, and approved 11 new subprojects on M.L. 2019:

Subproject 22.2: Assessing and refining copper-based treatment to suppress zebra mussel populations – Dr. Diane Waller
Subproject 23.2: AIS and tourism - A socio-economic assessment – Dr. Amit Pradhananga
Subproject 25.2: Examining Motivations for Illegal Baitfish Release – Dr. Nicholas Phelps
Subproject 28.2: Enzyme-based Coatings to Suppress Priority AIS – Dr. Mikael Elias
Subproject 33: Optimizing eDNA monitoring for multiple aquatic invasive species – Josh Dumke
Subproject 35: Genetic Biocontrol of Invasive Species - Understanding Attitudes and Risk Perceptions – Dr. David Fulton
Subproject 36: RNA-interference screens for zebra mussel biocontrol target genes – Dr. Daryl Gohl
Subproject 37: Improving the efficiency of watercraft inspections through coordination and cooperation – Dr. Amy Kinsley
Subproject 38: Evaluating native Phragmites as a wastewater treatment alternative – Dr. Daniel Larkin
Subproject 39: Increasing effectiveness of bigheaded carp deterrents by carbon dioxide integration – Dr. Allen Mensinger
Subproject 40: Enhancing habitat and diversity in cattail-dominated shorelines – Dr. Amy Schrank

Subproject 25.2 was reviewed through a separate process, as guided by our Managing Director Conflict of Interest in MAISRC Proposal Funding policy. This project and work plan were approved by the MAISRC Director Project Review Committee.

One additional subproject that was selected in our 2020 RFP will be funded through an alternate funding source (non ENRTF funds) and is not included in this report:

Subproject 34: Integrating Professional and Citizen Monitoring to Improve Surveillance – Dr. John Fieberg

MAISRC and LCCMR also approved a pause to one subproject, due to COVID-19 delays:

Subproject 21.2: Field validation of mulitbeam sonar zebra mussel detection – Dr. Jessica Kozarek

Subproject 21.2 completed its first year on M.L. 2017 and will continue its second year of activities on M.L. 2019, beginning on January 1, 2021. A summary of Year 1 activities is included on MAISRC's M.L. 2017 work plan. Additional reporting on Year 2 activities will be recorded below.

Amendment Request September 1, 2020

Amendment 1:
Subproject 22.2 – Move $1,200 from Subproject 1 *Supplies-Lab and/or Field* and $219,457 from *MAISRC Reserves* to fund new Subproject 22.2 at a total amount of $220,657 for two years, beginning on January 1, 2021 and ending on December 31, 2022. This amendment will decrease the *Supplies-Lab and/or Field* budget in Subproject 1 from $20,000 to $18,800.

Amendment 2:

Subproject 21.2 – Move $214,683 from *MAISRC Reserves* to fund Year 2 of Subproject 21.2, which will begin on January 1, 2021 and end on December 31, 2021. Subproject 21.2, Year 1 was completed on M.L. 2017. Resuming Subproject 21.2 on M.L. 2019 does not increase the overall budget of the project. The pause of Subproject 21.2, due to COVID-19 impacts, was approved by LCCMR on 07/09/2020 on M.L. 2017.

Amendment 3:
Subproject 23.2 – Move $249,088 from *MAISRC Reserves* to fund new Subproject 23.2 at a total amount of $249,088 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 4:
Subproject 25.2 – Move $106,539 from *MAISRC Reserves* to fund new Subproject 25.2 at a total amount of $106,539 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 5:
Subproject 28.2 – Move $187,480 from *MAISRC Reserves* to fund new Subproject 28.2 at a total amount of $187,480 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 6:
Subproject 33 – Move $432,531 from *MAISRC Reserves* to fund new Subproject 33 at a total amount of $432,531 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 7:
Subproject 35 – Move $209,313 from *MAISRC Reserves* to fund new Subproject 35 at a total amount of $209,313 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 8:
Subproject 36 – Move $260,374 from *MAISRC Reserves* to fund new Subproject 36 at a total amount of $260,374 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 9:
Subproject 37 – Move $198,241 from *MAISRC Reserves* to fund new Subproject 37 at a total amount of $198,241 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 10:
Subproject 38 – Move $355,122 from *MAISRC Reserves* to fund new Subproject 38 at a total amount of $355,122 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 11:
Subproject 39 – Move $339,106 from *MAISRC Reserves* to fund new Subproject 39 at a total amount of $339,106 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendment 12:
Subproject 40 – Move $338,066 from *MAISRC Reserves* to fund new Subproject 40 at a total amount of $338,066 for two years, beginning on January 1, 2021 and ending on December 31, 2022.

Amendments Approved by LCCMR: **10/17/2020**

Third Update March 1, 2021

Eleven new research projects and one continuation project that were selected as a result of MAISRC's 2020 RFP, and funded by M.L. 2019, launched on January 1, 2021. As work on these projects is just beginning, we do not

have substantial updates to report at this time. However, we do request an amendment to finalize the administrative set-up of one project.

Amendment Request March 1, 2021

Subproject 36 – Adjust collaborator effort for Scott Ballantyne from the University of Wisconsin River Falls (UWRF) as referenced on the subproject budget, increasing Ballantyne's percent effort from 2 calendar months/year and 16.67% effort, to 2.38 calendar months/year and 19.38% effort. Effort for Ballantyne was initially included in the budget as an estimate, this change will align the subproject budget with the actual effort that was agreed upon with UWRF during the contract process. This amendment will have no impact on the overall budget amount for UWRF.

Amendment Approved by LCCMR: **03/15/2021**

Amendment Request May 14, 2021

Subproject 21.2 – Move $5,600 from *Personnel* to *Capital Expenditures* to provide for the purchase of a ROV (Remotely Operated Vehicle) Deep Trekker to assist with field data collection. The amendment will create a new budget line for *Capital Expenditures* and will reduce *Personnel* from $81,893 to $76,293. Savings in *Personnel* are the result of reduced technician time, as the result of the purchase and utilization of the ROV.

This subproject was significantly impacted by COVID-19 restrictions in 2020, and while restrictions continue to ease, the research team has actively sought out options that 1) reduce the number of field assistants that need to be in the field at any point in time, and 2) improve efficiency of field data collection methods. By purchasing an underwater ROV, the team can a) reduce the burden on our dive team by completing pre-survey reconnaissance with the ROV instead of the dive team, b) efficiently collect video data to support the dive team mussel and substrate surveys, thus improving overall accuracy, and c) collect valuable video data for use in communications efforts related to zebra mussel habitat and to the project. The purchase of this equipment will make Subproject 21.2's summer 2021 field data collection safer, more efficient, and more accurate.

At the completion of Subproject 21.2, the ROV will be retained by MAISRC and MAISRC staff will provide oversight of the management of the ROV, to ensure that it is being used for the purpose of advancing AIS research in Minnesota. This oversight will continue throughout the useful life of the ROV, in alignment with LCCMR's *Policy on Eligible and Ineligible Expenses.*

Amendment Approved by LCCMR: **05/20/2021**

Amendment Request June 10, 2021

Amendment 1:
Subproject 33 – Move $3,800 from Subproject 1 *Services-Lab and Medical* to Subproject 33 NNRI *Equipment/Tools/Supplies* increasing the overall Subproject 33 budget from $432,531 to $436,331 and decreasing the overall Subproject 1 budget from $888,800 to $885,000. Funds in Subproject 1 *Services-Lab and/or Field* are held for maintenance of shared lab facilities, which is now offset by rental fees for the MAISRC Containment Lab, and a portion of which can be reallocated to Subproject 33. Increased expenses in Subproject 33 NNRI *Equipment/Tools/Supplies* are the result of rising supply costs due to COVID-19 (e.g., nitrile glove, gasoline) and a change in the DNA filtering technology planned for this subproject.

Development of the sorbent kits that Subproject 33 originally intended to use for environmental DNA collection fell behind schedule and can no longer be delivered to the team on the timeline needed for field collection. As an alternative, the team plans to replace the missing sorbent kits with small syringes, in-line filter housing and filters, and desiccant beads to preserve the DNA captured on filters. This replacement method adds additional cost to the subproject but would is perfectly suited to make eDNA monitoring more accessible to citizen science

groups, local governments, and non-government organizations because the samples require no post-collection processing nor do they need to be frozen or require chemical preservative. Pairing this replacement method with more traditional water-grab methods will also determine how the alternative method performs in terms of positive detection and DNA yield of our target organisms. This amendment will impact the Subproject 1 and Subproject 33 budgets as follows:

- Move $2,450 from Subproject 1 *Services-Lab & Medical* to Subproject 33 *Supplies-Lab and/or Field: eDNA field collection*, decreasing the Subproject 1 *Services-Lab & Medical* budget from $40,243 to $37,793 and increasing the Subproject 33 *Supplies-Lab and/or Field: eDNA field collection* budget from $7,697 to $10,147.
- Move $1,350 from Subproject 1 *Services-Lab & Medical* to Subproject 33 *Supplies-Lab and/or Field: Extraction*, decreasing the Subproject 1 *Services-Lab & Medical* budget from $37,793 to $36,443 and increasing the Subproject 33 *Supplies-Lab and/or Field: Extraction* budget from $27,066 to $28,416.

Amendment 2:
Subproject 38 – Add a portable air conditioner (A/C) unit to the list of equipment in the Subproject 38 *Equipment-Non-Capital and/or Field* budget. The A/C unit was not originally planned as an equipment purchase but is necessary to prevent heat stress in the subproject's experimental Phragmites. The purchase of the A/C unit will not require a budget increase. Savings in *Equipment-Non-Capital and/or Field* that will be allocated for the A/C unit are the result of a lower than anticipated cost for the budgeted Gantry system.

Amendment 3:
Subproject 39 – The University of Minnesota Twin Cities collaborator on Subproject 39 is no longer collaborating on the subproject, resulting in the need to reorganize subproject the Subproject 39 budgets to provide for an adapted work plan. Funds allocated to the UMN Twin Cities in the Subproject 39 UMN budget will be reallocated to the Subproject 39 UMD budget as follows:

- Move the University of Illinois contract from the Subproject 39 UMN budget to the Subproject 39 UMD budget and increase the total contract amount from $89,965 to $126,585. Researchers at the University of Illinois will continue to collaborate on the subproject and will take on an expanded role, to cover a portion of the activities and expenses originally planned for the UMN Twin Cities.
- Increase the Subproject 39 UMD *Personnel* budget from $111,882 to $124,882 to provide for additional graduate assistant time to work on activities originally planned for the UMN Twin Cities.
- Increase the Subproject 39 UMN *Professional/Technical/Service Contracts-MAISRC Containment Lab* budget from $9,684 to $13,396 to provide for additional lab space in the MAISRC Containment Lab.

This reallocation of funds will zero-out the Subproject 39 UMN budget and will not affect the overall, total budget of Subproject 39 ($339,106).

Amendment 4:
Subproject 39 – The University of Minnesota Twin Cities collaborator on Subproject 39 is no longer collaborating on the subproject, resulting in the need to reorganize subproject activities to meet project outcomes. Collaborators at the University of Illinois will take on an expanded role to cover a portion of the activities originally planned for the UMN Twin Cities. To reflect this change, we request to update Activity 1 outcomes as follows:

Activity 1	
~~1. Develop an air curtain system that contains CO_2 but does not alter its ability to capture sound.~~ 1. Conduct behavioral experiments at the University of Illinois to determine the CO2 concentration necessary within an air curtain to elicit avoidance responses in fish.	~~July 2021~~ December 2021

~~2. Optimize a CO_2-enriched air curtain system to block carp passage while containing the least amount of CO_2 possible.~~ 2. Evaluate ways to incorporate CO2 into an ensonified air curtain for laboratory deployments that contains enough CO2 without impacting its ability to capture sound.	~~December 2021~~ June 2022
~~3. Determine if CO_2 injected into an ensonified air curtain enhances the effectiveness of a BAFF to block carp.~~ 3. Conduct behavioral experiments at the University of Minnesota to determine whether CO2 might enhance the effectiveness of an ensonified air curtain to block carp.	~~December 2021~~ December 2022

Amendment Approved by LCCMR: **06/17/2021**

Fourth Update September 1, 2021

Twelve research projects are underway on M.L. 2019. Updates on individual projects are included below. All twelve projects have been active in the lab and field over the last 6 months and are beginning to make progress on project outcomes.

Amendment Request September 1, 2021

Amendment 1:
Subproject 23.2 - Due to delays in survey administration caused by COVID-19, the Subproject 23.2 research team has revised their project timeline to meet work plan objectives. On this new timeline, all work will be accomplished within the grant period and the overall subproject budget will not be affected. We request to adjust the completion dates of Subproject 23.2 outcomes as follows:

Activity 1	
1. Develop survey questionnaire, sampling plan, and sampling schedule	~~April 2021~~ March 2022
2. Administer onsite surveys	~~August 2021~~ September 2022
3. Analyze onsite survey data to determine AIS impacts on tourist behaviors	~~January 2022~~ November 2022
Activity 2	
2. Recruit participants and conduct focus groups	~~October 2021~~ November 2021
Activity 3	
1. Develop questionnaire	~~December 2021~~ February 2022
2. Administer mail survey	~~May 2022~~ June 2022

Amendment 2:
Subproject 25.2 - Move $700 from Supplies-Office and Gen Operating to Professional/Technical/Service Contracts-UMN Addressing and Mailing Services. Based on recent survey experiences of collaborators at the University of Minnesota and at the MN DNR, the project team anticipated hitting their target number of survey responses more quickly, requiring fewer mailed follow up responses. However, response rates were lower than expected in all regions of the state and out of state, requiring extra funding to cover the cost of extra mailings. This amendment will impact the subproject budget by decreasing the Supplies-Office and Gen Operating budget from $3,000 to $2,300 and increasing the UMN Addressing and Mailing Services budget from $11,858 to $12,558. Budget savings in Supplies-Office and Gen Operating are the result of the research team receiving

fewer requests for paper surveys than expected, resulting in lower costs for supplies for the paper survey instrument.

Amendment 3:
Subproject 25.2 - Move $2,610 from *Travel-Domestic* to *Professional/Technical/Service Contracts-UMN Research Methodology Consulting Center*. The subproject's collaborator at the Research Methodology Consulting Center spent more time than expected on preparing the survey sample and weighting the results, and more time is required for the main data which has yet to be done. This amendment will impact the subproject budget by decreasing the *Travel-Domestic* budget from $3,000 to $390 and increasing the *UMN Research Methodology Consulting Center* budget from $3,915 to $6,525. Budget savings in *Travel-Domestic* are the result of lower than anticipated travel costs, due to conferences remaining in a virtual or hybrid format for another season due to the pandemic.

Amendment 4:
Subproject 33 - Move $1,250 in the UMN budget for boat gas from *Travel Expenses in Minnesota-Sample collection/delivery* to *Equipment/Tools/Supplies* to provide for more accurate and efficient reporting on budget expenditures. In the UMN finance system, gasoline purchases are classified as supplies. Moving the boat gas budget into *Equipment/Tools/Supplies* will provide consistency between the LCCMR approved budget and the UMN reporting system, reducing the opportunity for error in reporting. This amendment will not impact the overall budget of Subproject 33 and will impact the UMN budget by decreasing the *Travel Expenses in Minnesota-Sample collection/delivery* budget from $17,539 to $16,289 and increasing the *Equipment/Tools/Supplies* budget from $13,462 to $14,712.

Amendment 5:
Subproject 33 - Move $650 in the UMN budget for boat maintenance from *Travel Expenses in Minnesota-Sample collection/delivery* to a new budget line, *Other-Boat Maintenance*, to provide for more accurate and efficient reporting on budget expenditures. In the UMN finance system, boat maintenance costs are classified differently than travel. Moving the boat maintenance budget into *Other-Boat Maintenance* will provide consistency between the LCCMR approved budget and the UMN reporting system, reducing the opportunity for error in reporting. This amendment will not impact the overall budget of Subproject 33 and will impact the UMN budget by decreasing the *Travel Expenses in Minnesota-Sample collection/delivery* budget from $16,289 to $15,639 and increasing the *Other-Boat Maintenance* budget from $0 to $650.

Amendment 6:
Subproject 35 - COVID-19 presented a challenge to recruitment of a graduate student for Subproject 35. After two national searches, the PI was able to take on a student who began work on the project in August 2021. Due to the significant delay of starting work on this project, we request to extend the completion date of Subproject 35 from December 31, 2022 to June 30, 2023. This extension will not impact the overall budget of Subproject 35 and will impact Activity 1 and Activity 2 outcomes as follows:

Activity 1	
1. Interviews/focus groups, design of web-based survey to collect data	~~June 2021~~ December 2021
2. Pre-testing survey implementation and instrument	~~August 2021~~ February 2022
3. Survey implementation and data collection	~~December 2021~~ June 2022
Activity 2	
1. Data cleaning and weighting	~~January 2022~~ July 2022

2. Develop and assess social psychological statistical models to understand the antecedents and consequences of attitudes and risk perceptions related to the use of genetic modification to control invasive species.	~~June 2022~~ December 2022
3. Completion of final project report	~~December 2022~~ June 2023

Amendment 7:
Subproject 40 - Combine all three budget lines under Equipment/Tools/Supplies into one line, to provide more efficient and effective reporting on budget expenditures. This amendment will not change the overall Equipment/Tools/Supplies budget or the kinds of materials acquired as a part of this project, it will simply allow the project team to report expenses without having to divide single orders, taxes, etc. to fit onto three separate budget lines.

Amendments Approved by LCCMR: **10/14/2021**

Amendment Request December 14, 2021

Amendment 1:
Subproject 21.2 – Move $222 from *Printing* to *Capital Expenditures* to provide for slightly higher than anticipated purchasing costs for the ROV Deep Trekker. This amendment will impact the subproject budget by decreasing the *Printing* budget from $500 to $278 and increasing the *Capital Expenditures* budget from $5,600 to $5,822. Budget savings in *Printing* is the result of outreach activities being moved online due to COVID-19.

Amendment 2:
Subproject 21.2 – Extend the completion date of Subproject 21.2 from December 31, 2021 to June 30, 2022. Due to COVID-19 delays in field work, Subproject 21.2 requires additional time to complete data analysis and manuscript preparation in Year 2, Activities 1 and 2. This extension will not increase the overall budget of Subproject 21.2 and will impact project outcomes as follows:

- Adjust the completion date of Year 2, Activity 1, Outcome 3 from December 2021 to June 2022 to allow for data analysis and the development of a methodology to incorporate acoustic surveys into zebra mussel monitoring.
- Adjust the completion date of Year 2, Activity 2, Outcome 3 from December 2021 to June 2022 to allow for the preparation of a manuscript that documents the project results in a publicly available, peer reviewed journal.

Amendment 3:
Subproject 21.2 – Increase the *Personnel* budget from $76,293 to $82,290 (net +$5,997) to provide for additional staff time needed to complete data analysis and prepare and submit a manuscript that documents project results to a publicly available, peer-reviewed journal. This amendment will impact the subproject budget as follows:

- Move $1,389 from *Supplies-Lab and/or Field* to *Personnel*, decreasing the *Supplies-Lab and/or Field* budget from $4,093 to $2,704 and increasing the *Personnel* budget from $76,293 to $77,682. Budget savings in *Supplies-Lab and/or Field* is the result of lower than anticipated supply costs for the project.
- Move $278 from *Printing* to *Personnel*, decreasing the *Printing* budget from $278 to $0 and increasing the *Personnel* budget from $77,682 to $77,960. Budget savings in *Printing* is the result of outreach activities being moved online due to COVID-19.
- Move $3,099 from *Travel Expenses in MN-Field travel* to *Personnel*, decreasing the *Travel Expenses in MN-Field travel* from $5,844 to 2,745 and increasing the *Personnel* budget from $77,960 to $81,059. Budget savings in *Travel Expenses in MN-Field travel* is the result of lower than anticipated travel costs for field work in the 2021 season.

- Move $550 from *Travel-Upper Midwest Stream Restoration Symposium* to *Personnel*, decreasing the *Travel-Upper Midwest Stream Restoration Symposium* budget from $550 to $0 and increasing the *Personnel* budget from $81,059 to $81,609. Budget savings in *Travel-Upper Midwest Stream Restoration Symposium* is due to COVID-19 travel restrictions in 2020 and 2021 that caused a delay in the project timeline, resulting in the project team not presenting findings at conferences in 2021.
- Move $250 from *Travel-Minnesota Water Resource Conference* to *Personnel*, decreasing the *Travel-Minnesota Water Resource Conference* budget from $250 to $0 and increasing the *Personnel* budget from $81,609 to $81,859. Budget savings in *Travel-Minnesota Water Resource Conference* is due to COVID-19 travel restrictions in 2020 and 2021 that caused a delay in the project timeline, resulting in the project team not presenting findings at conferences in 2021.
- Move $431 from *Other-Supplies* to *Personnel*, decreasing the *Other-Supplies* budget from $500 to $69 and increasing the *Personnel* budget from $81,859 to $82,290. Budget savings in *Other-Supplies* is the result of lower than anticipated shipping costs for project equipment.

Amendments Approved by LCCMR: **12/16/2021**

Fifth Update March 1, 2022

Twelve research projects are underway on M.L. 2019. Updates on individual projects are included below. All twelve projects have been active in the lab and field over the last 6 months and are beginning to make progress on project outcomes.

Due to the challenges and delays posed by COVID-19, MAISRC approved extensions for two subprojects on M.L. 2019:

- Subproject 21.2: Field validation of multibeam sonar zebra mussel detection - Dr. Jessica Kozarek (6-month extension)
- Subproject 35: Genetic Biocontrol of Invasive Species - Understanding Attitudes and Risk Perceptions - Dr. David Fulton (6-month extension)

These extensions do not increase the overall budget of the subprojects and were approved by LCCMR staff as the result of two amendment submissions. Progress reports for each extended subproject will continue to be included as a part of reporting on M.L. 2019.

Amendment Request March 1, 2022

Amendment 1:
Subproject 22.2 – Move $14,940 from *Professional/Technical/Service Contracts-Diver* to *Professional/Technical/Service Contracts-RMB Labs* to provide for additional lab services costs for expanding the subproject treatment area and increasing spatial and temporal monitoring within the treatment area. North Arm Bay of Lake Minnetonka was initially selected as a control site for this study and was sampled in 2021 for pretreatment data. However, the research team learned that North Arm Bay will be treated with herbicide in 2022, thereby eliminating it from the study. Instead, the team will use Robinsons Bay as a control bay paired with Maxwell Bay (treatment bay). Additional pretreatment sampling and sample processing will be needed for Robinsons Bay in 2022.

The research team also plans to expand the 2022 treatment from a sub-bay of Maxwell Bay to treating the whole bay. This change will increase the overall impact of the treatment on the ecosystem and provide comparable data to the 2019 treatment and data collected in St. Albans Bay (Subproject 22, M.L. 2017). By conducting a whole bay treatment, the research team can compare an even lower dose treatment in Maxwell Bay to the results of the 2019 treatment in St. Albans Bay. A whole bay treatment of Maxwell Bay will increase the amount of EarthTec QZ needed for treatment (Amendment 2) and sampling processing for invertebrates and copper tissue concentration (Amendment 1).

This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts-Diver* budget from $42,000 to $27,060 and increasing the *Professional/Technical/Service Contracts-RMB Labs* budget from $25,000 to $39,940. Budget savings in *Professional/Technical/Service Contracts-Diver* are the result of lower than anticipated dive costs in year two of the subproject. This amendment will not impact the overall subproject budget amount.

Amendment 2:
Subproject 22.2 – Move $3,885 from *Professional/Technical/Service Contracts-Diver* to *Equipment/Tools/Supplies-EarthTecQZ* to provide for higher than anticipated EarthTecQZ expenses, due to the expansion to treating all of Maxwell Bay during the 2022 field season (Amendment 1). This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts-Diver* budget from $27,060 to $23,175 and increasing the *Equipment/Tools/Supplies-EarthTecQZ* budget from $6,500 to $10,385. Budget savings in *Professional/Technical/Service Contracts-Diver* are the result of lower than anticipated dive costs in year two of the subproject. This amendment will not impact the overall subproject budget amount.

Amendment 3:
Subproject 23.2 – COVID-19 travel restrictions and other administrative challenges have made it difficult for the Subproject 23.2 research team to organize focus groups with tourism related businesses. In response to these challenges, the research team has revised their approach to this portion of engagement and data collection and will pivot to doing one-on-one interviews with business owners/operators. This pivot will require a revision to their project timeline to meet work plan objectives. On this new timeline, all work will be accomplished within the grant period and the overall subproject budget will not be affected. We request to adjust the completion dates of Subproject 23.2 outcomes as follows:

Activity 2	
1. Develop ~~focus group~~ interview materials (i.e., focus group questions, script, agenda)	~~March 2021~~ February 2022
2. Recruit participants and conduct ~~focus groups~~ interviews	~~November 2021~~ June 2022
3. Analyze ~~focus group~~ interview data	~~December 2021~~ October 2022

Amendment 4:
Subproject 25.2 – Increase the *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services* budget from $12,558 to $13,778 (net +$1,220) to provide for unanticipated expenses for returned mail from the mailed survey portion of the project. This amendment will impact the subproject budget as follows:

- Move $650 from *Travel Expenses in Minnesota* to *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services*, decreasing the *Travel Expenses in Minnesota* budget from $1,000 to $350 and increasing the *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services* budget from $12,558 to $13,208. Budget savings in *Travel Expenses in Minnesota* are the result of reduced travel during the COVID-19 pandemic.
- Move $240 from *Other-Travel Domestic* to *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services*, decreasing the *Other-Travel Domestic* budget from $390 to $150 and increasing the *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services* budget from $13,208 to $13,448. Budget savings in *Other-Travel Domestic* are the result of reduced travel during the COVID-19 pandemic.
- Move $330 from *Other-Survey Incentives* to *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services*, decreasing the *Other-Survey Incentives* budget from $8,000 to $7,670 and increasing the *Professional/Technical/Service Contracts-UMN Addressing and Mailing Services* budget

from $13,448 to $13,778. Budget savings in *Other-Survey Incentives* is the result of some survey incentives being returned to MAISRC.

Amendment 5:
Subproject 28.2 – Adjust the Subproject 28.2 completion date from December 31, 2022 to June 30, 2023. Upon reviewing the Subproject 28.2 work plan and reporting documents, we caught a discrepancy between the two on what completion date is listed. The MAISRC approved subproject work plan notes June 30, 2023 as the completion date, which is reflected in the outcomes listed in the LCCMR work plan. However, the LCCMR approved budget spreadsheet and Overall Status Update notes December 31, 2022 as the completion date. Being that project outcomes were planned according to the June 30, 2023 timeline, we request an amendment to formally change the completion date on the budget spreadsheet and Overall Status Update to reflect the 2023 date. This amendment will not impact the subproject budget or the planned scope of work for the research.

Amendment 6:
Subproject 33 – Extend the completion date of Subproject 33 from December 31, 2022 to June 30, 2023. Due to longer than anticipated lab processing times, more time is needed for genomic laboratories to generate data and for the project team to analyze and draw defensible conclusions from those data. This extension will not increase the overall budget of Subproject 33 and will impact project outcomes as follows:

- Adjust the completion date of Activity 1, Outcome 2 from March 2022 to August 2022 to allow for laboratory processing of 2021 Activity 1 samples.
- Adjust the completion date of Activity 1, Outcome 4 from December 2022 to March 2023 to allow for laboratory processing of 2022 Activity 1 samples.
- Adjust the completion date of Activity 1, Outcome 5 from December 2022 to June 2023 to allow for the dissemination of research findings.
- Adjust the completion date of Activity 2, Outcome 2 from July 2022 to December 2022 to allow for laboratory processing of 2021 Activity 2 samples.
- Adjust the completion date of Activity 2, Outcome 3 December 2022 to June 2023 to allow for the dissemination of research findings.

Amendment 7:
Subproject 33 – Move in-kind funds contributed to Subproject 33 from Ramsey County from the UMN portion of the subject budget to the NRRI portion of the budget. This internal, administrative adjustment is due to NRRI having greater capacity to manage in-kind contributions to the subproject and will not impact the scope or budget.

Amendment 8:
Subproject 33 – Move $1,000 from *Travel Expenses in Minnesota-Other* to *Travel Expenses in Minnesota-Field Travel* to provide for higher than anticipated lodging expenses when traveling for field work. This amendment will impact the subproject budget by decreasing the *Travel Expenses in Minnesota-Other* budget from $2,269 to $1,269 and increasing the *Travel Expenses in Minnesota-Field Travel* budget from $6,733 to $7,733. Budget savings in *Travel Expenses in Minnesota-Other* are the result of reduced conference travel during the COVID-19 pandemic. As many conferences have moved online, reducing the *Travel Expenses in Minnesota-Other* budget will not impact overall dissemination of research results.

Amendment 9:
Subproject 36 – Move $1,000 from *Professional/Technical/Service Contracts-UMN Veterinary Diagnostic Lab* to *Equipment/Tools/Supplies-Equipment* to provide for higher than anticipated non-capital equipment costs for algae growth cylinders. This amendment will impact the subproject budget by decreasing the

Professional/Technical/Service Contracts-UMN Veterinary Diagnostic Lab budget from $1,000 to $0 and increasing the *Equipment/Tools/Supplies-Equipment* budget from $1,221 to $2,221. Budget savings in *Professional/Technical/Service Contracts-UMN Veterinary Diagnostic Lab* are the result of the research team's strategic decision to focus on optimizing and improving a smaller number of phenotypic assays and eliminate reproductive and shell growth assays, based on early research results. A contract with the UMN Veterinary Diagnostic Lab is not needed if reproductive and shell growth assays are not being assessed. This amendment will not impact the overall scope of the project.

Amendment 10:
Subproject 36 – Move $1,194 from *Professional/Technical/Service Contracts-UMN Imaging Center* to *Professional/Technical/Service Contracts-MAISRC Containment Lab* to provide for higher than anticipated expenses for research space and growth chambers. This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts-UMN Imaging Center* budget from $3,200 to $2,006 and increasing the *Professional/Technical/Service Contracts-MAISRC Containment Lab* budget from $8,760 to $9,954. Budget savings in *Professional/Technical/Service Contracts-UMN Imaging Center* are the result of the research team's strategic decision to focus on optimizing and improving a smaller number of phenotypic assays and eliminate reproductive and shell growth assays, based on early research results. A contract with the UMN Imaging Center is not needed if reproductive and shell growth assays are not being assessed. This amendment will not impact the overall scope of the project.

Amendment 11:
Subproject 36 – Move $2,006 from *Professional/Technical/Service Contracts-UMN Imaging Center* to *Personnel* to provide for higher than anticipated personnel costs for the subproject. This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts-UMN Imaging Center* budget from $2,006 to $0 and increasing the *Personnel* budget from $100,360 to $102,366. Budget savings in *Professional/Technical/Service Contracts-UMN Imaging Center* are the result of the research team's strategic decision to focus on optimizing and improving a smaller number of phenotypic assays and eliminate reproductive and shell growth assays, based on early research results. A contract with the UMN Imaging Center is not needed if reproductive and shell growth assays are not being assessed. This amendment will not impact the overall scope of the project.

Amendment 12:
Subproject 40 – Extend the completion date of Subproject 40 from December 31, 2022 to June 30, 2023 to provide additional time for the research team to finalize data analysis, manuscripts, and other subproject outputs. This extension will not increase the overall budget of Subproject 40 and will impact project outcomes as follows:

- Adjust the completion date of Activity 3, Outcome 2 from December 2022 to June 2023 to allow for data analysis of post-cattail removal sampling.
- Adjust the completion date of Activity 3, Outcome 3 from December 2022 to June 2023 to allow for dissemination of research results.

Amendment 13:
Subproject 40 – Move $10,000 from *Professional/Technical/Service Contracts* to *Travel Expenses in Minnesota-Vehicle Rental* to provide for higher than anticipated field travel expenses in year one of the project. Due to the drought in the region, field travel to find suitable research sites required a greater number of days in the field. This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts* budget from $144,000 to $134,000 and increasing the *Travel Expenses in Minnesota-Vehicle Rental* budget from $7,180 to $17,180. Budget savings in *Professional/Technical/Service Contracts* is the result of lower than anticipated cattail removal costs. This amendment will not impact the overall scope of the project.

Amendment 14:

Subproject 40 – Move $9,000 from *Professional/Technical/Service Contracts* to *Travel Expenses in Minnesota-Field Travel* to provide for higher than anticipated lodging expenses in year one of the project, due to the need for additional travel for field work and peak summer season lodging prices. This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts* budget from $134,000 to $125,000 and increasing the *Travel Expenses in Minnesota-Field Travel* budget from $21,180 to $30,180. Budget savings in *Professional/Technical/Service Contracts* is the result of lower than anticipated cattail removal costs. This amendment will not impact the overall scope of the project.

Amendment 15:
Subproject 40 – Move $1,000 from *Professional/Technical/Service Contracts* to *Printing* to provide for the production of informational outreach materials to be shared with the public at research sites and formal presentations. All outreach materials will include funding acknowledgement to the LCCMR. This amendment will impact the subproject budget by decreasing the *Professional/Technical/Service Contracts* budget from $125,000 to $124,000 and increasing the *Printing* budget from $0 to $1,000. Budget savings in *Professional/Technical/Service Contracts* is the result of lower than anticipated cattail removal costs. This amendment will not impact the overall scope of the project.

Amendments Approved by LCCMR: **03/29/2022**

Amendment Request April 27, 2022

Amendment 1:
Subproject 37 – Extend the completion date of Subproject 37 from December 31, 2022 to June 30, 2023 to expand subproject activities and create a new Activity 5 that will foster cross-county collaboration by identifying a framework for determining financial incentives for collaboration.

Complex ecological systems are often managed based on geopolitical boundaries rather than ecological ones. As a result, managers of multiple jurisdictions need to collaborate to achieve effective, large-scale management goals. The current scope of Subproject 37 aims to quantify the benefits of state-level coordination and between-county cooperation in watercraft inspection plans to support decision-making in watercraft inspection programs. To date, the team has developed a bi-level model to determine how a state planner can efficiently allocate inspection resources to county managers to decide where to place inspection stations. Further, the team has identified future collaborations between counties to increase the efficacy of watercraft inspection programs by identifying reciprocal relationships between counties with high numbers of potentially infested boats moving between them. This amendment would build on current subproject outcomes to identify a framework for determining financial incentives for collaborations considering the heterogeneity of lakes, infestations, and economic impacts. The primary outcome of this expansion would be a developed framework where county planners can be incentivized to clean up more risky boats and consequently improve the overall outcome for each county (Completion Date: June 30, 2023).

To carry out the expansion of this project, the research team will partner with Dr. Wenbo Selina Cai at the New Jersey Institute of Technology. Dr. Cai is an Associate Professor in Mechanical and Industrial Engineering and specializes in stochastic models and optimization techniques in operations research and game theory in economics. Although Dr. Cai is at an organization out of state, she has worked on Game Theory approaches to managing invasive species, investigating intervention strategies for Emerald Ash Borer in Public and Private Forests. Her work is highly interdisciplinary and integrates knowledge and techniques from multiple fields to solve complex societal challenges allowing her to adapt to different systems, making her an ideal partner for this project. Furthermore, she has the capacity and resources available to carry out this project in the allocated time within the specified budget.

This amendment would not impact the overall budget of Subproject 37, but would require a new subaward to the New Jersey Institute of Technology that would impact the subproject budget as follows:

- Move $24,800 from *Personnel* to *Professional/Technical/Service Contracts-New Jersey Institute of Technology (NJIT)*, decreasing the *Personnel* budget from $133,241 to $108,441 and increasing the *Professional/Technical/Service Contracts-New Jersey Institute of Technology (NJIT)* budget from $0 to $24,800. Budget savings in *Personnel* are the result of the delayed hire of a post-doctoral associate to work on the project.
- Move $10,400 from *Professional/Technical/Service Contracts-Cplex/GAMS* to *Professional/Technical/Service Contracts-New Jersey Institute of Technology (NJTI),* decreasing the *Professional/Technical/Service Contracts-Cplex/GAMS* budget from $20,000 to $9,600 and increasing the *Professional/Technical/Service Contracts-New Jersey Institute of Technology (NJIT)* budget from $24,800 to $35,200. Budget savings in *Professional/Technical/Service Contracts-Cplex/GAMS* are the result of lower than anticipated costs for Cplex/GAMS software licenses, due to the unanticipated ability to do some of the subproject modeling in free software.

Amendment 2:
Subproject 23.2 – Adjust Activity 3 activities to conduct the survey of lodging owners/operators online, rather than by mail as planned. This change is due to the availability of lodging owner/operator contact information for surveying. The research team was able to secure a list of email address for owners/operators, but not mailing addresses. This change will not impact the outcomes or timeline of the subproject and will allow the survey to reach more owners/operators for a lower cost. Updates to the language of Activity 3 and outcomes are included in the Subproject 23.2 section below.

Amendment 3:
Subproject 23.2 – Move $5,000 from *Equipment/Tools/Supplies-Activity 3* to *Travel* to provide for additional costs associated with travel to and from survey sites (Ely, Alexandria, and Brainerd) in Activity 1. These funds will cover car rental, lodging, and per diem for 4 student surveyors and will facilitate additional data collection from each site. This amendment will impact the subproject budget by decreasing the *Equipment/Tools/Supplies-Activity 3* budget from $16,000 to $11,000 and increasing the *Travel* budget from $21,000 to $26,000. Budget savings in *Equipment/Tools/Supplies-Activity 3* is the result of the decision to conduct Activity 3 surveys online, rather than via mail, which reduces the cost of survey administration.

Amendment 4:
Subproject 39 – Increase the *Personnel* budget from $124,882 to $142,882 (net +$18,000) to provide for higher than anticipated personnel costs for the subproject. Experiments are on track, but the team will need the flexibility to run daily experiments over the summer and fall of 2022 to complete subproject outcomes. Therefore, additional personnel time is needed. This amendment will impact the subproject budget as follows:

- Move $12,000 from *Capital Expenditures* to *Personnel*, decreasing the *Capital Expenditures* budget from $36,000 to $24,000 and increasing the *Personnel* budget from $124,882 to $136,882. Budget savings in *Capital Expenditures* is the result of the research team building a portion of the shuttle tank set-up for the project in house, rather than purchasing from Loligo. Loligo was unable to manufacture a tank to meet project needs and it was most cost effective to build the tank in house.
- Move $6,000 from *Travel* to *Personnel*, decreasing the *Travel* budget from $15,918 to $9,918 and increasing the *Personnel* budget from $136,882 to $142,882. Budget savings in *Travel* is the result of a decrease in anticipated field travel expenses, due to the COVID-19 pandemic.

Amendments Approved by LCCMR: **06/08/2022**

Sixth Update September 1, 2022

As of June 30, 2022, one MAISRC subproject has been completed on M.L. 2019:

- Subproject 21.2: Field validation of multibeam sonar zebra mussel detection - Dr. Jessica Kozarek

A final report summary for the project is included below and an abstract will be submitted directly to LCCMR staff.

Amendment Requests September 19, 2022

Amendment 1:
Subproject 1 – Move the $136 balance from completed Subproject 21.2 to MAISRC Reserves, increasing the MAISRC Reserves balance from $30 to $166 (noted on the Overall Status Update).

Amendment 2:
Subproject 23.2 – Combine budget lines for Activity 1-3 Equipment/Tools/Supplies-Office-Gen Operating into one budget line for all supplies. With recent amendments to subproject activities and surveys, it has become difficult to split supply expenses by activity area. We request to adjust the budget to one supply budget line to improve accuracy of reporting. This amendment will not impact the overall supply budget, just how it is reported.

Amendment 3:
Subproject 33 (NRRI) – Move $1,239 from *Travel Expenses in Minnesota-Other* to *Other-Out-of-state Travel*. Conference funds in *Travel Expenses in Minnesota-Other* were intended for use at the Upper Midwest Invasive Species Conference that is usually held in Minnesota, but will be held in Green Bay, WI in 2022. This amendment will decrease the *Travel Expenses in Minnesota-Other* budget from $1,269 to $30 and increase the Other-*Out-of-state Travel* budget from $0 to $1,239. This amendment will not impact the overall budget and does not add additional conference travel to the project.

Amendment 4:
Subproject 33 (NRRI) – Move $6,000 from Personnel to Equipment/Tools/Supplies - Lad and/or Field: Extraction to provide for the purchase of additional sample processing supplies due to losses with a lab contamination event (described in Subproject 33 updates) and the overall inflation of supply cost. This amendment will decrease the Personnel budget from $173,753 to $167,753 and increase the Equipment/Tools/Supplies - Lad and/or Field: Extraction budget from $28,416 to $34,416. Budget savings in Personnel are the result of lower than anticipated personnel costs. This amendment will not impact the overall subproject budget.

Amendment 5:
Subproject 33 (NRRI) – Move $500 from Personnel to Other-Shipping to provide for higher than anticipated shipping costs for samples. This amendment would decrease the Personnel budget from $167,753 to $167,253 and increase the Other-Shipping budget from $100 to $600. Budget savings in Personnel are the result of lower than anticipated personnel costs. This amendment will not impact the overall subproject budget.

Amendment 6:
Subproject 35 – We request the adjustment of a series of outcome completion dates to account for unexpected delays in personnel effort on Subproject 35. With the following, amended dates we anticipate being able to meet all project outcomes:

- Adjust the completion date of Activity 1, Outcome 3 from June 2022 to November 2022 to allow for additional time for survey data collection.
- Adjust the completion date of Activity 2, Outcome 1 from July 2022 to January 2023 to allow for additional time for data cleaning and weighting.

- Adjust the completion date of Activity 2, Outcome 2 from December 2022 to March 2023 to allow for additional time for the development of statistical models.
- Adjust the completion date of Activity 3, Outcome 1 from August 2022 to April 2023 to allow for additional opportunity for interviews and focus groups with tribal representatives.
- Adjust the completion date of Activity 3, Outcome 2 from December 2022 to June 2023 to final reporting and documentation.

Amendment 7:
Subproject 36 – Move $19,000 from Equipment/Tools/Supplies-Lab and/or Field to Personnel to provide for additional personnel effort on the subproject through the project completion date. This amendment will decrease the Equipment/Tools/Supplies-Lab and/or Field budget from $30,905 to $11,905 and increase the Personnel budget from $102,366 to $121,366. Budget savings in Equipment/Tools/Supplies-Lab and/or Field is the result of lower than anticipated lab supply costs for the project. This amendment will not impact the overall subproject budget.

Amendment 8:
Subproject 36 – Move $2,000 from Professional/Technical/Service Contracts-UMN Genomics Center to Personnel to provide for additional personnel effort on the subproject through the project completion date. This amendment will decrease the Professional/Technical/Service Contracts-UMN Genomics Center budget from $10,500 to $8,500 and increase the personnel budget from $121,366 to $123,366. Budget savings in Professional/Technical/Service Contracts-UMN Genomics Center are the result of the UMN Genomics Center discontinuing its Sanger sequencing service. The project team will work to identify an outsourced provider for these services. This amendment will not impact the overall subproject budget.

Amendment 9:
Subproject 38 – We request an extension to adjust the completion date of Subproject 38 from December 31, 2022 to June 30, 2023.

This extension would provide more time for Activity 2, Outcome 2 (lysimetric water removal experiments). It would be advantageous to the project to allow more time for Phragmites plants to mature so that they better mimic the size of plants used in wastewater treatment facilities. More time would additionally allow the project team to include more populations in these experiments. Researchers had expected there to be clearer strong and poor performers among our experimental populations, and that they would only advance the strong performers to Act. 2, Outcome 2. However, the populations are not clearly differentiated with obvious “winners” and “losers” and it would be most informative to advance all populations to this next stage. An extension would not increase the overall budget of the project and if approved, would impact outcome completion dates as follows:

- Adjust the completion date of Activity 2, Outcome 2 from September 2022 to June 2023 to allow for more opportunity for Phragmites plants to mature.
- Adjust the completion date of Activity 3, Outcome 1 from September 2022 to June 2023 to allow for more time to collect data and conduct analysis before presenting results.
- Adjust the completion date of Activity 3, Outcomes 2 and 3 from December 2022 to June 2023 to allow for more time to collect data and conduct analysis before presenting results and preparing a publication.

Amendment 10:
Subproject 39 – We request an extension to adjust the completion date of Subproject 39 from December 31, 2022 to June 30, 2023.

This extension would provide more time for data analysis and dissemination in Activity 1. Due to an administrative delay in beginning work in partnership with the University of Illinois, the research team would benefit from additional time to process and write up results. This amendment will not impact the outcome completion dates that are currently defined for Activity 1 and would not impact the overall budget.

Amendment 11:
Subproject 39 – Move $1,221 from Subproject 1 Professional/Technical/Service Contracts-Rentals to Subproject 39 Professional/Technical/Service Contracts-MAISRC Containment Lab to provide for higher than anticipated lab costs. This amendment would decrease the Subproject 1 Professional/Technical/Service Contracts-Rentals budget from $10,000 to $8,779 and decrease the overall Subproject 1 budget from $885,000 to $883,779, then increase the Subproject 39 Professional/Technical/Service Contracts-MAISRC Containment Lab budget from $13,396 to $14,617 and increase the overall Subproject 39 budget from $339,106 to $340,327. Budget savings in Subproject 1 Professional/Technical/Service Contracts-Rentals is the result of moving the MAISRC Showcase online. This amendment will not impact the overall scope of either Subproject 1 or Subproject 39.

Amendment 12:
Subproject 40 – Allocate $2,000 in budget savings in Professional/Technical/Service Contracts-Cattail Removal to provide for use of MAISRC Containment Lab facilities. As a part of the project, the research team is adding a lab component in which soil samples are collected from study sites and examined to determine whether the seed bank composition and abundance in cattail-removed sites influences treatment outcomes. This addition to the project does not change the scope or timing of the work but will enrich the understanding of the effects of cattail removal on plant communities. This amendment will decrease the Professional/Technical/Service Contracts-Cattail Removal budget from $124,000 to $122,000 and will create a $2,000 Professional/Technical/Service Contracts-MAISRC Containment Lab Budget. Budget savings in Professional/Technical/Service Contracts-Cattail Removal is the result of much lower than anticipated contract costs for cattail removal.

Amendments Approved by LCCMR: **10/27/2022**

Amendment Request November 17, 2022

Amendment 1:
Subproject 23.2 – We request an extension to adjust the completion date of Subproject 23.2 from December 31, 2022 to June 30, 2023.

This extension would provide more time for data analysis and dissemination in Activity 1 and additional time to administer the online survey in Activity 3. Additional staff time for data analysis in Activity 1 will allow the research team to create fact sheets and other materials that outline research findings at a statewide scale, but also at a local level for communities where onsite surveys occurred. Additional staff time to administer the online survey in Activity 3 is needed due to unexpected delays in survey design and slower than expected response rates. This amendment will impact the outcome completion dates that are currently defined for Activity 1 and Activity 3 as follows:

- Add a new Outcome 4 for Activity 1, to develop factsheets for each local survey site with a completion date of June 2023.
- Adjust the completion date of Activity 3, Outcome 2 from June 2022 to February 2023 to allow for an extended period to administer the online survey.

Amendment 2:

Subproject 23.2 – To allow additional staff time to complete the expanded activities in Activity 2 and 3 (Amendment 1), we request to reallocate $15,704 in budget savings into *Personnel*. This amendment will impact the subproject budget as follows:

- Move $12,898 from *Equipment/Tools/Supplies* to *Personnel*, decreasing the *Equipment/Tools/Supplies* budget from $14,000 to $1,102 and increasing the *Personnel* budget from $209,088 to $221,986. Budget savings in *Equipment/Tools/Supplies* is the result of conducting an online survey instead of a mail survey in Activity 3.
- Move $2,806 from *Travel Expenses in Minnesota* to *Personnel*, decreasing the *Travel Expenses in Minnesota* budget from $26,000 to $23,194 and increasing the *Personnel* budget from $221,986 to $224,792. Budget savings in *Travel Expenses in Minnesota* is the result of lower than anticipated travel costs of administering onsite surveys and interviews.

Amendment Approved by LCCMR: **1/18/2023**

Amendment Request January 25, 2023

Amendment 1:
Subproject 33 NRRI – Increase the *Equipment/Tools/Supplies-Extraction* budget from $34,416 to $36,884 to provide for the purchase of additional reagents and supplies for an in-house PCR machine that was purchased by NRRI (non-ENRTF funds) and will be used to support Subproject 33. This amendment will impact the budget as follows:

- Move $2,188 from *Professional/Technical/Service Contracts-UMN Genomics Center* to *Equipment/Tools/Supplies-Extraction*, decreasing the *Professional/Technical/Service Contracts-UMN Genomics Center* budget from $2,188 to $0 and increase the *Equipment/Tools/Supplies-Extraction* budget from $34,416 to $36,604. Budget savings in *Professional/Technical/Service Contracts-UMN Genomics Center* is the result of NRRI being able to perform analyses in house, rather than contracting with the Genomic Center.

- Move $280 from *Other-Out-of-state travel* to *Equipment/Tools/Supplies-Extraction*, decreasing the *Other-Out-of-state travel* budget from $1,239 to $959 and increasing the *Equipment/Tools/Supplies-Extraction* budget from $36,604 to $36,884. Budget savings in *Other-Out-of-state travel* are the result of lower than anticipated travel expenses for the UMISC conference in Green Bay, WI.

Amendment 2:
Subproject 33 UMN – Move $5,000 from *Travel Expenses in Minnesota-Sample Collection* in the Subproject 33 UMN budget to *Personnel* in the Subproject 33 NRRI budget to support additional staff time for technicians to process samples internally at NRRI. This amendment would decrease the UMN *Travel Expenses in Minnesota-Sample Collection* budget from $15,639 to $10,639 and the overall UMN budget from $187,657 to $182,657, and increase the NRRI *Personnel* budget from $167,253 to $172,253 and the overall NRRI budget from $248,674 to $253,674. Budget savings in *Travel Expenses in Minnesota-Sample Collection* are the result of lower than anticipated travel costs for sample collection for the project.

Amendment 3:
Subproject 33 UMN – Move $2,000 from *Travel Expenses in Minnesota-Sample Collection* to *Personnel* to provide for higher than anticipated personnel costs. This amendment will decrease the *Travel Expenses in Minnesota-Sample Collection* budget from $10,639 to $8,639 and increase the *Personnel* budget from $152,723 to $154,723. Budget savings in *Travel Expenses in Minnesota-Sample Collection* are the result of lower than anticipated travel costs for sample collection for the project.

Amendment 4:

Subproject 33 UMN – Move $3,000 from *Equipment/Tools/Supplies* to *Personnel* to provide for higher than anticipated personnel costs. This amendment will decrease the *Equipment/Tools/Supplies* budget from $14,712 to $11,712 and increase the *Personnel* budget from $154,723 to $157,723. Budget savings in *Equipment/Tools/Supplies* are the result of lower than anticipated supply costs for the project.

Amendment Approved by LCCMR: **01/26/2023**

Seventh Update March 1, 2023

Nine research projects are underway on M.L. 2019. Updates on individual projects are included below. All 9 projects have been active in the lab and field over the last 6 months and are continuing to make progress on project outcomes.

In the last six months, LCCMR has approved no-cost extensions for the following subprojects:

- Subproject 23.2: AIS and tourism - a socio-economic assessment – Dr. Amit Pradhananga (new end date: June 30, 2023)
- Subproject 38: Evaluating native Phragmites as a wastewater treatment alternative – Dr. Daniel Larkin (new end date: June 30, 2023)
- Subproject 39: Increasing effectiveness of bigheaded carp deterrents by carbon dioxide integration – Dr. Allen Mensinger (new end date: June 30, 2023)

As of December 31, 2022, two MAISRC subprojects have been completed on M.L. 2019:

- Subproject 25.2: Examining Motivations for Illegal Baitfish Release – Dr. Nicholas Phelps
- Subproject 36: RNA-interference screens for zebra mussel biocontrol target genes – Dr. Daryl Gohl

Final report summaries for completed projects included below and an abstract will be submitted directly to LCCMR staff.

Amendment Requests May 9, 2023

Amendment 1:

Subproject 1 – We request approval to include catering costs for two in-person, all day and multi-day events hosted by MAISRC. The first is a common carp research implementation workshop that was held on March 16, 2023. This free day-long workshop brought together managers and policy makers to learn about MAISRC research outcomes on common carp and participate in facilitated discussions on how to implement new management recommendations to reduce the impact of carp on MN waters. The event hosted 93 registered attendees, 5 volunteer facilitators, 6 presenters, and an additional 4 MAISRC staff for a light breakfast, buffet lunch, and afternoon refreshments (coffee, tea, light snacks) as a part of the day-long program. Total catering cost is anticipated to be about $3,565 for 108 attendees ($33/person).

The second event is a two-day, regional Showcase event that is being hosted in collaboration with natural resource management and lake association partners in Cass County, highlighting MAISRC research findings that are relevant to the AIS issues in the area and the unique partnerships that MAISRC has formed with local managers. This event will be hosted June 23-24. To keep attendance costs low (or free) for attendees and make these events as accessible as possible, we request approval to use M.L. 2019 funds to offset the cost of catering for these events. Anticipated attendance will be 200 people and the estimated total catering cost for the event will be about $6,420 for a light breakfast, buffet lunch, and afternoon refreshments (coffee, tea, light snacks) as a part of the day-long conference portion of the event on June 23 ($32/person).

All catering and contracts for each event are in alignment with UMN policies for hospitality for non-employees and business meal expenses for employees.

Amendment 2:

Subproject 1 – Move $3,221 from *Equipment/Tools/Supplies-Non-Capital Equipment* to *Professional/Technical/Service Contracts-Rentals* to provide for higher than anticipated event costs through the end of the project. MAISRC is hosting two in-person events: a common carp research implementation workshop in March 2023 and a regional Showcase event in collaboration with local partners in Cass County in June 2023. Additional funds in *Professional/Technical/Service Contracts-Rentals* will provide for space rental, facilities expenses, and catering for attendees at these day-long and multi-day events. This amendment will decrease the *Equipment/Tools/Supplies-Non-Capital Equipment* budget from $8,000 to $4,779 and increase the *Professional/Technical/Service Contracts-Rentals* budget from $8,779 to $12,000. Budget savings in *Equipment/Tools/Supplies-Non-Capital Equipment* are the result of lower than anticipated equipment costs for the project.

Amendment 3:

Subproject 25.2 – Move the $31,903 balance from completed Subproject 25.2 to MAISRC Reserves, increasing the MAISRC Reserves balance from $166 to $32,069 (noted on the Overall Status Update).

Amendment 4:

Subproject 36 – Move $316 from *Personnel* to *Professional/Technical/Service Contracts-UMN Genomics Center* to provide for higher than anticipated costs for qPCR and RNA-Seq services. This amendment will decrease the *Personnel* budget from $123,366 to $123,050 and increase the *Professional/Technical/Service Contracts-UMN Genomics Center* budget from $8,500 to $8,816. Budget savings in *Personnel* are the result of lower than anticipated personnel costs through the end of the project.

Amendment 5:

Subproject 36 – Move $1,497 from *Personnel* to *Professional/Technical/Service Contracts-MAISRC Containment Lab* to provide for higher than anticipated costs for facilities rental in the MAISRC lab. This amendment will decrease the *Personnel* budget from $123,050 to $121,553 and increase the *Professional/Technical/Service Contracts-MAISRC Containment Lab* budget from $9,954 to $11,451. Budget savings in *Personnel* are the result of lower than anticipated personnel costs through the end of the project.

Amendment 6:

Subproject 36 – Move the $4,395 balance from completed Subproject 36 to MAISRC Reserves, increasing the MAISRC Reserves balance from $32,069 to $36,464 (noted on the Overall Status Update).

Amendment 7:

Subproject 22.2 – Extend the completion date of Subproject 22.2 from December 31, 2022 to June 30, 2023. Due to unexpected delays in sample processing with the contracted lab, final data is still being received. These delays have not impacted the majority of outcomes for the project or preliminary findings, but have delayed the finalization of analysis and the submission of final payment to the lab. We request to extend the end date of the subproject to allow time to finalize analysis and pay the final lab invoice for the subproject. This extension will impact the project outcomes as follows:

- Adjust the completion date of Activity 3, Outcome 6 from December 2022 to June 2023 to allow for the completion of data entry, proofing and analysis.
- Adjust the completion date of Activity 3, Outcome 7 from December 2022 to June 2023 to final the study report and peer-reviewed manuscript.

Amendment 8:

Subproject 1 – Move $28,399 from Subproject 1 *Personnel* to Subproject 22.2 USGS *Personnel* to provide for additional personnel time to explore the effect of seasonality and gametogenesis on the efficacy of copper molluscicides on adult zebra mussels. Additional funds will be used to support staff time for setting up the laboratory (April-May), conducting laboratory tests, and analyzing condition and reproductive stages (May-June). We will leverage existing, non-ENRTF funds for laboratory tests and analysis conducted in July and August. The results may prove useful for resource managers and stakeholders in deciding treatment timing. These results will also be used to supplement existing data on low-dose copper to inform a Structured-Decision Making Workshop which will be conducted in 2024 as a component of Subproject 22.3 (M.L. 2021).

This amendment will decrease the Subproject 1 *Personnel* budget from $764,757 to $736,358 and the overall Subproject 1 budget from $883,779 to $855,380; and increase the Subproject 22.2 USGS *Personnel* budget from $147,157 to $175,556 and overall Subproject 22.2 USGS budget from $147,157 to $175,556. Budget savings in Subproject 1 *Personnel* are the result of delayed spending in the *Personnel* category due to the COVID-19 pandemic and the extension of the M.L. 2017 appropriation to MAISRC.

Amendment 9:

Subproject 23.2 – Move $46 from *Personnel* to *Equipment/Tools/Supplies* to provide for higher than anticipated supply costs. This amendment will decrease the *Personnel* budget from $224,792 to $224,746 and increase the *Equipment/Tools/Supplies* budget from $1,102 to $1,148. This amendment will not impact the overall budget or personnel performance for the project.

Amendment 10:

Subproject 33 NRRI – Move $640 from *Travel Expenses in Minnesota-Field Travel* to *Personnel* to provide for additional personnel time through the end of the project. This amendment will decrease the *Travel Expenses in Minnesota-Field Travel* budget from $7,733 to $7,093 and increase the *Personnel* budget from $172,253 to $172,893. Budget savings in *Travel Expenses in Minnesota-Field Travel* are the result of lower than anticipated travel costs for field work.

Amendment 11:

Subproject 33 UMN – Increase the *Personnel* budget from $157,723 to $162,255 (net +$4,532) to provide for additional personnel time for analysis and dissemination through the end of the project. This amendment will impact the subproject budget as follows:

- Move $1,278 from *Equipment/Tools/Supplies* to *Personnel*, decreasing the *Equipment/Tools/Supplies* budget from $11,712 to $10,434 and increasing the *Personnel* budget from $157,723 to $159,001. Budget savings in *Equipment/Tools/Supplies* are the result of lower than anticipated supply costs throughout the course of the project.
- Move $935 from *Travel Expenses in Minnesota-Sample collection* to *Personnel*, decreasing the *Travel Expenses in Minnesota-Sample collection* budget from $8,639 to $7,704 and increasing the *Personnel* budget from $159,001 to $159,936. Budget savings in *Travel Expenses in Minnesota-Sample collection* are the result of lower than anticipated field travel costs throughout the course of the project.
- Move $2 from *Travel Expenses in Minnesota-Field and lab training* to *Personnel*, decreasing the *Travel Expenses in Minnesota-Field and lab training* budget from $1,066 to $1,064 and increasing the *Personnel* budget from $159,936 to $159,938. Budget savings in *Travel Expenses in Minnesota-Field and lab training* are the result of lower than anticipated field travel costs throughout the course of the project.
- Move $472 from *Travel Expenses in Minnesota-Conferences and meetings* to *Personnel*, decreasing the *Travel Expenses in Minnesota-Conferences and meetings* budget from $822 to $350 and increasing the *Personnel* budget from $159,938 to $160,410. Budget savings in *Travel Expenses in Minnesota-*

Conferences and meetings are the result of lower than anticipated costs for attendance and presenting at the MN AFS conference.

- Move $1,845 from *Other-Travel Domestic* to *Personnel*, decreasing the *Other-Travel Domestic* budget from $1,845 to $0 and increasing the *Personnel* budget from $160,410 to $162,255. Budget savings in *Other-Travel Domestic* are the result of the decision not to attend the Joint Aquatic Sciences meeting in May 2022.

Amendment 12:

Subproject 35 – We request to reallocate budgeted funds for Activity 3 to increase the survey sampling effort in Activity 1, changing the sample size of the survey from n=16,000 to n=25,000. This adjustment includes a random household survey of 21,000 Minnesota households statewide to help ensure that the project can approach a sample size of n = 1200 respondents who own lake shore properties. The increased sample size will also help ensure an adequate sample size in geographic areas across the state to make meaningful generalizations across geographic areas MN. It also means that the team will contact n = 4000 anglers and boaters statewide as a part of the survey. A reallocation of funds to increase the study sample size will impact the subproject budget as follows:

- Move $2,000 from *Travel Expenses in Minnesota* to *Professional/Technical/Service Contracts* to provide for a larger survey list of MN residents, decreasing the *Travel Expenses in Minnesota* budget from $2,000 to $0 and increasing the *Professional/Technical/Service Contracts* budget from $3,000 to $5,000. Budget savings in *Travel Expenses in Minnesota* are the result of the removal of Activity 3 from the project.
- Move $1,000 from *Personnel* to *Professional/Technical/Service Contracts* to provide for a larger survey list of MN residents, decreasing the *Personnel* budget from $131,313 to $130,313 and increasing the *Professional/Technical/Service Contracts* budget from $5,000 to $6,000. Budget savings in *Personnel* are the result of lower than anticipated personnel costs.
- Move $33,592 from *Personnel* to *Printing* to provide for more surveys to be printed and mailed, decreasing the *Personnel* budget from $130,313 to $96,721 and increasing the *Printing* budget from $48,000 to $81,592. Budget savings in *Personnel* are the result of lower than anticipated personnel costs.

Amendment 13:

Subproject 38 – Increase the *Personnel* budget from $262,610 to $318,110 (net +$55,500) to provide for additional personnel time in experimental work on large phragmites plants in order to better mimic real-world conditions in wastewater treatment facilities. This amendment will impact the subproject budget as follows:

- Move $3,000 from *Travel Expenses in Minnesota-In-State Conferences* to *Personnel*, decreasing the *Travel Expenses in Minnesota-In-State Conferences* from $3,000 to $0 and increasing the *Personnel* budget from $292,610 to $295,610. Budget savings in *Travel Expenses in Minnesota-In-State Conferences* are the result of lower than anticipated travel costs for presentations and meetings with stakeholders. The research team was able to leverage stakeholder meetings that were supported by additional (non-ENRTF) funding for Phragmites work.
- Move $10,500 from *Travel Expenses in Minnesota-Field Travel* to *Personnel*, decreasing the *Travel Expenses in Minnesota-Field Travel* budget from $12,000 to $1,500 and increasing the *Personnel* budget from $295,610 to $306,110. Budget savings in *Travel Expenses in Minnesota-Field Travel* are the result of lower than anticipated field travel costs. The research team was able to leverage collections from Phragmites populations and field visits that were supported by additional (non-ENRTF) funding for Phragmites work.
- Move $12,000 from *Equipment/Tools/Supplies-Field Supplies* to *Personnel*, decreasing the *Equipment/Tools/Supplies-Field Supplies* budget from $24,500 to $12,500 and increasing the *Personnel* budget from $305,110 to $318,110. Budget savings in *Equipment/Tools/Supplies-Field Supplies* are the result of lower than anticipated supply costs. The research team was able to leverage consumables,

plant growth resources, and sampling tools that were available through the labs of the PI and collaborators.

Amendment 14:

Subproject 40 – Increase the *Personnel* budget from $135,908 to $172,227 (net +$36,319) to provide for additional personnel time analysis and dissemination through the end of the project. This amendment will impact the subproject budget as follows:

- Move $16,957 from *Professional/Technical/Service Contracts-Cattail removal* to *Personnel*, decreasing the *Professional/Technical/Service Contracts-Cattail removal* budget from $122,000 to $105,043 and increase the *Personnel* budget from $135,908 to $152,865. Budget savings in *Professional/Technical/Service Contracts-Cattail removal* are the result of lower than anticipated removal costs, based on the contractor secured for the project.
- Move $12,512 from *Equipment/Tools/Supplies* to *Personnel*, decreasing the *Equipment/Tools/Supplies* budget from $29,798 to $17,286 and increasing the *Personnel* budget from $152,865 to $165,377. Budget savings in *Equipment/Tools/Supplies* are the result of lower than anticipated supply costs throughout the course of the project.
- Move $858 from *Printing* to *Personnel*, decreasing the *Printing* budget from $1,000 to $142 and increasing the *Personnel* budget from $165,377 to $166,235. Budget savings in *Printing* are the results of lower than anticipated printing costs throughout the course of the project.
- Move $2,112 from *Travel Expenses in Minnesota-Vehicle Rental* to *Personnel*, decreasing the *Travel Expenses in Minnesota-Vehicle Rental* budget from $17,180 to $15,068 and increasing the *Personnel* budget from $166,235 to $168,347. Budget savings in *Travel Expenses in Minnesota-Vehicle Rental* are the result of lower than anticipated field travel costs throughout the course of the project.
- Move $3,880 from *Travel Expenses in Minnesota-Lodging* to *Personnel*, decreasing the *Travel Expenses in Minnesota-Lodging* budget from $30,180 to $26,300 and increasing the *Personnel* budget from $168,347 to $172,227. Budget savings in *Travel Expenses in Minnesota-Lodging* are the result of lower than anticipated field travel costs throughout the course of the project.

Amendments Approved by LCCMR: **05/16/2023**

Amendment Request June 5, 2023

Amendment 1:

Subproject 28.2 – Increase the *Personnel* budget from $152,980 to $158,480 (net +$5,500) to provide for additional personnel time to complete data analysis and reporting through the end of the subproject. This amendment will draw from budget savings in the following areas:

- Move $4,000 from *Equipment/Tools/Supplies* to *Personnel*, decreasing the *Equipment/Tools/Supplies* budget from $28,000 to $24,000 and increasing the *Personnel* budget from $152,980 to $156,980. Budget savings in *Equipment/Tools/Supplies* are the result of lower than anticipated supply costs for the project.
- Move $1,500 from *Travel Expenses in Minnesota* to *Personnel*, decreasing the *Travel Expenses in Minnesota* budget from $1,500 to $0 and increasing the *Personnel* budget from $156,980 to $158,480. Budget savings in *Travel Expenses in Minnesota* are the result of travel being covered by alternate funding and grants for students.

Amendment 2:

Subproject 28.2 – Move $5,000 from *Professional/Technical/Service Contracts-Sampling/Diving Support* to *Professional/Technical/Service Contracts-UMN Bioresource Center* to provide for the production of proteins that

were used during field trials. The production of proteins was completed in advance of field season and this amendment is to move funds to a new budget line in services, to align with how the expense is recorded in the UMN finance system. This amendment will decrease the *Sampling/Diving Support* budget from $5,000 to $0 and increase the *UMN Bioresource Center* budget from $0 to $5,000. Budget savings in *Sampling/Diving Support* are the result of the delay in the removal of sample coupons in the Duluth Superior Harbor, which will now happen in the fall of 2023 on alternate funding. This delay will not impact the overall project outcomes.

Amendment 3:

Subproject 33 NRRI – Increase the *Personnel* budget from $172,893 to $173,586 (net +$693) to provide for additional personnel time to complete data collection, analysis, and reporting through the end of the subproject. This amendment will draw from budget savings in the following areas:

- Move $200 from *Printing* to *Personnel*, decreasing the *Printing* budget from $200 to $0 and increasing the *Personnel* budget from $172,893 to $173,093. Budget savings in *Printing* are the result of a change in the planned outcomes for the project. Printing was originally budgeted for the eDNA best practices guide (Activity 2, Outcome 4), which will now be completed after the end of Subproject 33, on alternate funding. Therefore, printing funds are no longer needed on the Subproject 33 budget.
- Move $493 from *Shipping* to *Personnel*, decreasing the *Shipping* budget from $600 to $107 and increasing the *Personnel* budget from $173,093 to $173,586. Budget savings in *Shipping* are the result of lower than anticipated sample shipping costs for the project.

Amendment 4:

Subproject 35 – Reallocate funds budgeted for incentives for focus groups and mail respondents ($25,000) to adjust the survey collection model to provide for additional mailed surveys and a panel study through the Qualtrics online survey platform. Due to administrative complications with the University of Minnesota, Subproject 35 will not be able to provide survey incentives to participants, as originally planned. Instead, the research team will focus their time and remaining funds on increasing the size and demographic diversity of its pool of survey respondents, to get a broader picture of the attitudes and public perception of risk of genetic biocontrol technologies. This amendment will not change the outcomes or timeline of Subproject 35, but will impact the project budget as follows:

- Move $5,545 from *Other-Incentives* to *Personnel* to provide for additional personnel time to complete data collection, analysis, and reporting through the end of the subproject. This change will decrease the *Other-Incentives* budget from $25,000 to $19,455 and increase the *Personnel* budget from $96,721 to $102,266.
- Move $10,000 from *Other-Incentives* to *Professional/Technical/Service Contracts-Qualtrics* to provide for the collection of up to 1,000 additional survey respondents through the Qualtrics online platform. This change will decrease the *Other-Incentives* budget from $19,455 to $9,455 and increase the *Qualtrics* budget from $0 to $10,000.
- Move $9,455 from *Other-Incentives* to *Printing* to provide for an additional push of mailed surveys to increase response numbers. This change will decrease the *Other-Incentives* budget from $9,455 to $0 and increase the *Printing* budget from $81,592 to $91,047.

Amendment 5:

Subproject 40 – Move $429 from *Travel Expenses in Minnesota-Vehicle Rental* to *Personnel* to provide for additional personnel time to complete data analysis and reporting through the end of the subproject. This amendment will decrease the *Vehicle Rental* budget from $15,068 to $14,639 and increase the *Personnel* budget from $172,227 to $172,656. Budget savings in *Vehicle Rental* are the result of lower than anticipated field travel costs over the course of the project.

Amendment 6:

Subproject 40 – Move $907 from *Professional/Technical/Service Contracts-MAISRC Containment Lab* to *Professional/Technical/Service Contracts-Cattail Removal* to provide for higher than anticipated cattail removal costs, due to drought conditions in 2022 and subsequent cattail regrowth at study sites. This amendment will decrease the *MAISRC Containment Lab* budget from $2,000 to $1,093 and increase the *Cattail Removal* budget from $105,043 to $105,950. Budget savings in *MAISRC Containment Lab* are the result of in-lab activities wrapping up more quickly than anticipated and reducing the need for lab space.

Amendments Approved by LCCMR: **06/28/2023**

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

As of June 30, 2023, the final MAISRC subprojects on M.L. 2019 have been completed:

- Subproject 1: MAISRC Core Operations
- Subproject 22.2: Assessing and refining copper-based treatment to suppress zebra mussel populations – Dr. Diane Waller
- Subproject 23.2: AIS and tourism - A socio-economic assessment – Dr. Amit Pradhananga
- Subproject 28.2: Enzyme-based Coatings to Suppress Priority AIS – Dr. Mikael Elias
- Subproject 33: Optimizing eDNA monitoring for multiple aquatic invasive species – Mr. Josh Dumke
- Subproject 35: Genetic Biocontrol of Invasive Species - Understanding Attitudes and Risk Perceptions – Dr. David Fulton
- Subproject 37: Improving the efficiency of watercraft inspections through coordination and cooperation – Dr. Amy Kinsley
- Suproject 38: Evaluating native Phragmites as a wastewater treatment alternative – Dr. Daniel Larkin
- Subproject 39: Increasing effectiveness of bigheaded carp deterrents by carbon dioxide integration – Dr. Allen Mensinger
- Subproject 40: Enhancing habitat and diversity in cattail-dominated shorelines – Dr. Amy Schrank

Final reports for each project are included below and abstracts will be submitted directly to LCCMR staff.

Amendment Request September 14, 2023

Amendment 1:

Subproject 1 – Move $650 from *Professional/Technical/Service Contracts-Rentals* to *Professional/Technical/Service Contracts-Professional Services* to provide for higher than anticipated honoraria for guest speakers. This amendment will increase the *Professional/Technical/Service Contracts-Professional Services* budget from $1,150 to $1,800 and decrease the *Professional/Technical/Service Contracts-Rentals* budget from $12,000 to $11,350. Budget savings in *Professional/Technical/Service Contracts-Rentals* is the result of lower than anticipated event venue costs, largely due the postponement of in-person events during the COVID-19 pandemic.

Amendment 2:

Subproject 38 – Move $500 from *Other-Rental Greenhouse* to *Other-Rental Vapor Pressure Deficit Chambers* to provide for higher than anticipated rental costs for greenhouse space. This amendment will increase the *Other-Rental Greenhouse* budget from $7,512 to $8,012 and decrease the *Other-Rental Vapor Pressure Deficit Chambers* budget from $1,500 to $1,000. Budget savings in *Other-Rental Vapor Pressure Deficit Chambers* is the result of chamber use being provided in-kind by project partner.

Amendment 3:

Subproject 39 – Move $84 from *Personnel* to *Professional/Technical/Service Contracts-MAISRC Containment Lab* to provide for higher than anticipated lab rental costs. This amendment will increase the *Professional/Technical/Service Contracts-MAISRC Containment Lab* budget from $14,617 to $14,701 and decrease the *Personnel* budget from $142,882 to $142,798. Budget savings in *Personnel* is the result of lower than anticipated personnel costs.

Amendment 4:

Subproject 39 – Adjust the Equipment/Tools/Supplies and Capital Expenditures budgets to align with how expenses for equipment and supplies have been recorded in the University of Minnesota finance system. The original budget for Subproject 39 allocated expenses to equipment, field/lab supplies, and capital expenditures to the best of our knowledge of where expenses would fall in the UMN finance system. However, throughout the course of the project, some expenses have been designated in different categories. This amendment will bring the LCCMR project budget and UMN finance reporting system into alignment and does not allocate funds for additional purchases that were not originally planned for the project. This amendment will impact the subproject budget as follows:

- Move $8,173 from Equipment/Tools/Supplies-Lab/Field to Equipment/Tools/Supplies-Equipment, increasing the Equipment/Tools/Supplies-Equipment budget from $3,000 to $11,173 and decreasing the Equipment/Tools/Supplies-Lab/Field budget from $17,325 to $9,152.
- Move $2,612 from Capital Expenditures to Equipment/Tools/Supplies-Equipment, increasing the Equipment/Tools/Supplies-Equipment budget from $11,173 to $13,785 and decreasing the Capital Expenditures budget from $24,000 to $21,388.

III. PROJECT ACTIVITIES AND OUTCOMES:

SUBPROJECT 1: MAISRC Core Operations

Project Manager: Nicholas Phelps

Organization: Minnesota Aquatic Invasive Species Research Center

Description:

Activity 1 - Leadership to facilitate AIS research and collaboration

MAISRC was formed to strengthen the state's capacity for solving AIS problems and to do so in a collaborative, coordinated, and stable environment that allowed for long term visions to be achieved. This is being achieved through the development and implementation of a strategic plan, annual Research Showcase, biennial research needs assessments, high faculty engagement, and a supportive culture for creativity and innovation. This could not be done without the core functions of the Center. The Center is an effective and efficient way to support research on AIS for many reasons. Activity 1 will enable us to continue to provide:

Leadership and direction, critical for establishing priorities and coordinating effective response – MAISRC staff oversee the organization's fulfillment of its strategic plan, including designing and implementing the biennial Research Needs Assessment and competitive grant processes, recruiting and positioning researchers for optimal response to emerging AIS threats, coordinating scientific peer review or research proposals, financial and administrative support, and working with the Center's Advisory Board, multi-agency Technical Committee, and Center's Fellows Group.

Physical infrastructure and shared equipment and lab staffing needed to enable the research – MAISRC operates a newly renovated 10,000 square foot state of the art lab facility and will provide staffing to maintain and repair the facility, assist researchers with experiment set up and organismal husbandry, and be on call to respond to

emergencies that may threaten experimental organisms and research investments. Additionally, MAISRC staff will provide financial oversight and essential financial and grant reporting assistance to individual PIs. A portion of these costs will also be covered through individual research projects per the University's Internal Service Organization policy.

Communication of research progress and implementation of science-based outreach programs to ensure results are translated into management action – MAISRC makes results of research available and translates findings in a way that is not always possible for individual researchers to do on their own. In addition to traditional research communication (i.e. peer-reviewed manuscripts), MAISRC researchers provide opportunities to engage with stakeholders, such as at the annual MAISRC Research and Management Showcase event and stakeholder organized meetings held throughout Minnesota. MAISRC communications staff also amplify these efforts and make research progress and results accessible to the public and AIS managers through the web, newsletters, social media, seminars, webinars, brochures, and white papers. MAISRC also manages the AIS Extension program, including development of training programs and curriculum. Through this work, as well as through our technical committees and coordination teams, we ensure translation of the latest science in ways that build statewide capacity to respond to Minnesota's AIS problems.

Opportunities for state-wide cross-disciplinary research collaboration on and off campus – MAISRC creates a central focus for AIS research and has become well known for its efforts in prioritization and research productivity. This has resulted in new cross-disciplinary collaborations across the University, bringing together fields such as natural resource management, veterinary medicine, molecular biosciences, social science, genetics, and public health. Likewise, new collaborations have developed across the state and country with academic (i.e. UMD), government (i.e. USGS, watershed districts, counties), and stakeholder organizations (i.e. lake associations, AIS professionals) working together to address Minnesota's AIS problems. International scholars are also seeking opportunities to collaborate with MAISRC and visitors have come from around the world to work with our researchers (i.e. Chinese Academy of Sciences, Australia's CSIRO). Creating an environment that supports and cultivates collaboration, and in turn builds cost-effective capacity, is a major focus of MAISRC and will be continued with this project.

MAISRC's core operations are supported through June of 2021 from 2017 ENRTF. In Activity 2 of this 2019 ENRTF funding, these critical Center functions will be extended for two more years (July 2021– June 2023) and will be leveraged by University of Minnesota contributions to base salaries for tenure track faculty, space & utilities, HR functions, payroll etc. valued in excess of $1M.

Activity 2 – Advancing high priority and promising research to address AIS in Minnesota

Developing solutions to Minnesota's AIS threats must remain responsive to emerging issues and requires coordination of research efforts. In Activity 2, we will launch new projects (approximately $200k- $250k each, with 2-year durations) addressing the State's highest priority research needs on emerging and existing AIS threats, such as zebra mussels, starry stonewort and invasive carp. This will be accomplished through a competitive RFP process and projects will be informed by an inclusive and comprehensive biannual Research Needs Assessment, which has become a national model for research prioritization. The list of prioritized research needs will be available to the LCCMR and other AIS stakeholders on the MASIRC website or by request.

Building on research successes will be essential to solving Minnesota's AIS problems and is a critical aspect of MAISRC's long-term research strategy. To that end, in Activity 2 MAISRC will also launch "continuation projects" (approximately $200k- $250k each, with 2-year durations). Continuation projects will provide next-phase support for promising MAISRC research that is making progress towards real-world solutions. As one example, MAISRC researchers have made significant progress towards understanding the biology, ecology, and dispersal risk of starry stonewort – all major gaps with immediate management implications; however, testing the efficacy and selectivity of algaecides is still in the early stages and deserves attention. Without a dedicated long-term approach to move promising research forward, we risk orphaning priority needs and not fully realizing the

potential of previous research investments.

In total, MAISRC will launch 12-15 projects. Selection of new projects will be informed by an internal and external review process with scientists and AIS managers familiar with current science and need. Each proposal will be evaluated based on relevance to priorities, potential impact, scientific approach, researcher experience, funding and effort requested, and support from AIS stakeholders. This process insures that the projects selected are high priority topics for the state of Minnesota that are both scientifically rigorous and have a high likelihood of contributing to effective, actionable, solutions. Selection and support of continuation projects will be done through an annual competitive process, including thorough evaluation of progress and deliverables in the current project, internal and external peer-review of proposed research direction, and assessment of current need by AIS managers. For high quality proposals that do not get selected for funding, the MAISRC Director will discuss the feedback with investigators with the intent of building Minnesota's capacity and the potential for future collaborations, as well as identifying alternative sources of funding (as appropriate) to continue to make progress on research projects that applied for continuation.

Subproject 1 ENRTF FINAL BUDGET: $883,779

Outcomes	Completion Date
Activity 1	
1. Annual research needs assessments completed; competitive RFPs issued; peer reviews conducted; research results shared; research, trainings, and outreach performed; shared equipment procured and maintained; etc.	June 2023
Activity 2	
1. 12-15 research projects launched. New lines of research focused on high priority research needs (e.g. Economic impact assessment, prevention strategies for AIS not currently in Minnesota, rapid response tools, innovative control strategies, etc.) Continuation projects focused building on ongoing promising lines of research (e.g. genetic control of zebra mussels, optimizing prevention efforts, non-target impacts of existing control options, etc.)	January 2021
2. Research complete, solutions or next steps identified, recommendations shared	June 2023

First Update March 1, 2020

MAISRC released our 2020 RFP in January 2019. RFP priorities were largely based on the results of the Research Needs Assessment that was completed in summer 2018 (a biennial process), with review from the MAISRC Technical Committee, the Center Fellows Group, and the MAISRC Advisory Board in summer 2019. In total, MAISRC anticipates allocating about $1.5 million to new and continuing projects as a part of the 2020 RFP. The primary funding source for the RFP is 2019 Environment and Natural Resources Trust Fund monies that have been allocated to MAISRC (M.L. 2019).

Thus far, all expenses associated with drafting and launching the 2020 RFP have been supported by 2017 ENRTF funding (M.L. 2017).

Second Update September 1, 2020

In response to MAISRC's 2020 Request for Proposals (RFP) that was released in January, we received a total of 22 research proposals, requesting more than $3.4 million. Following review of pre-proposals, we encouraged multiple teams to come together on two different projects, which resulted in improved proposals, new collaborations, and more efficient use of ENRTF funds. After thorough evaluation and external peer review, we have approved 12 new subprojects -- 11 will be funded on M.L. 2019 and one will be funded through an alternate funding source (non-ENRTF funds). Summaries of the 2020 RFP selections are detailed below.

Third Update March 1, 2021

MAISRC Subprojects
MAISRC is now supporting 12 subprojects on M.L. 2019. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 9 subprojects on M.L. 2017 and 7 subprojects through alternate funding sources (non-ENRTF funds).

Research Coordination
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs.

Fourth Update September 1, 2021

MAISRC Subprojects
MAISRC is currently supporting 12 subprojects on M.L. 2019. Summaries of the progress of these subprojects are included below. In addition, MAISRC is currently supporting 4 subprojects on M.L. 2017 that received no-cost extensions due to COVID-19 delays and 4 subprojects through alternate funding sources (non-ENRTF funds).

Research Coordination
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs.

Fifth Update March 1, 2022

MAISRC Subprojects
MAISRC is currently supporting 12 subprojects on M.L. 2019. Summaries of the progress of this subproject are included below. In addition, MAISRC is currently supporting one subproject on M.L. 2017, 3 subprojects on M.L. 2021, and 2 subprojects through alternate funding sources (non-ENRTF funds).

Priority Species List
In the fall of 2021, MAISRC worked with our Technical Committee (MTC) to review and revise our list of priority species. The species review process resulted in a few modifications to the high priority species list for 2021/2022:

- Vertebrates/Fish – Added Swamp eel (*Monopterus albus/Amphipnous cuchia*) to the evaluated list; moved Rainbow smelt (*Osmerus mordax*) from the priority list to the evaluated list
- Microbes – Added Asian Fish Tapeworm (AFT) and Largemouth Bass Virus (LMBV) to the priority list and *Ovipleistophora ovariae* (Ovi-O) to the evaluated list; moved Cyprinid Herpesvirus-3 (CyHV-3) and Rickettsia-like organisms (RLOs) from the priority list to the evaluated list
- Invertebrates – Added Golden clam (*Corbicula fluminea*) to the priority list
- Plants – Added Pale yellow iris (*Iris pseudacorus*) to the priority list; moved Brittle naiad (*Najas minor*) from the priority list to the evaluated list

This revised Priority Species List was integrated into the 2022 RFP (launched January 3, 2022) and will be revised again in the fall of 2022 as a part of MAISRC's biennial Research Needs Assessment. A full list of MAISRC Priority Species for 2022 is available on the MAISRC website: https://maisrc.umn.edu/about-ais

AIS Detectors Program
The AIS Detectors program delivered multiple online educational programs in 2021. In early spring, 40 participants completed the 2021 session of AIS Management 101, a fully online, self-paced course to give participants the foundational knowledge and confidence to make aquatic invasive species management

decisions. Since January, the AIS Detectors team has hosted a monthly series of virtual networking events called "Detector Connectors" to educate and foster community among AIS Detectors volunteers. The AIS Detectors team also hosted four free webinars in 2021 that provided updates on AIS research and management. The 2021 webinars were attended by 772 people and recordings of the webinars have been viewed more than 540 additional times online. A library of recorded webinars are available on the AIS Detectors website: https://www.maisrc.umn.edu/ais-detectors/webinars

The AIS Detectors team launched an online-only version of the AIS Detectors Core Course including a special learning track for AIS professionals taking the course. The AIS Detectors course relaunch included an updated online course and harnessed a variety of learning technologies to engage participants in virtual workshops where they could practice species identification, talk through role-play scenarios, and prepare for their role as AIS Detectors. Over the course of three virtual workshops, 51 participants completed the AIS Detectors Core Course, including 11 professionals. MAISRC and University of Minnesota Extension will continue their partnership to deliver AIS Detectors programming in both online and in-person formats in the coming year.

The AIS Detectors team held Starry Trek again in August of 2021, with 206 volunteers gathering at 28 local training sites across the state for the one-day bioblitz. These volunteers collectively searched 281 public accesses at 222 water bodies for starry stonewort and other aquatic invasive species. Volunteers did not discover any new populations of starry stonewort in 2021, although they did discover a new population of Eurasian watermilfoil (*Myriophyllum spicatum*) in Dakota County, a new instance of freshwater golden clam (*Corbicua fluminea*) in Sherburne County, and a number of new records of Chinese and banded mystery snails.

Research Coordination
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs. Beginning in 2022, MAISRC added four new members to our Center Advisory Board:

- Mark Gaikowski - Director, USGS Upper Midwest Environmental Sciences Center
- Kate Hagsten - Plant Resources Program Director, Leech Lake Band of Ojibwe
- Charlene Simonson - Great Plains Division Conservation Manager, The Nature Conservancy
- Justin Townsend - Aquatic Invasive Species Coordinator, Ramsey County

MAISRC staff also continue to work in collaboration and coordinate with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, MN Invasive Species Advisory Council, State AIS Advisory Committee and the Great Lakes ANS Panel. In addition, our research teams are highly connected with a diverse network of researchers from across the state, country and world in an effort to bring together collaborative teams, advance our science in complementary ways and avoid duplication of efforts.

Sixth Update September 1, 2022

MAISRC Subprojects
MAISRC is currently supporting 11 subprojects on M.L. 2019. Summaries of the progress of this subproject are included below. In addition, MAISRC is currently supporting one subproject on 3 subprojects on M.L. 2021, and 3 subprojects through alternate funding sources (non-ENRTF funds).

One subproject on M.L. 2019 is now complete. A summary of the project's results and outcomes is included below.

Priority Species List
This summer, MAISRC worked with our Technical Committee (MTC) to review and revise our list of priority species. The species review process resulted in a few modifications to the high priority species list for 2022/2023:

- Vertebrates/Fish – Moved Common Rudd (*Scardinius erythrophthalmus*) up onto the priority list; moved Northern snakehead (*Channa argus*) from the priority list to the evaluated list
- Microbes – Added bacterial kidney disease (*Renibacterium salmoninarum*) and whirling disease (*Myxobolus cerebralis*) to the priority list and *Novel Aipenserid herpesvirus* to the evaluated list; removed baitfish viruses from the priority list and *Heterosporis* from the priority list to the evaluated list

This revised Priority Species List has been integrated into MAISRC's 2022 Research Needs Assessment. A full list of MAISRC Priority Species for 2022/2023 is available on the MAISRC website: https://maisrc.umn.edu/about-ais

Research Needs Assessment
This summer, MAISRC began our next biennial Research Needs Assessment (RNA) which aims to collaboratively and systematically identify research needs related to high-priority AIS in Minnesota. The outcomes of the RNA process are used to guide MAISRC's future research investments to ensure meaningful contributions to research-based solutions for AIS prevention, control, and management.

The RNA process begins with a public survey, in which individuals indicate their species of top concern and submit research ideas for consideration. MAISRC then coordinates a committee of 20 local and national researchers and managers who bring their unique experiences and expertise to the table, to evaluate and prioritize the submitted research ideas. The committee's work culminates in a list of 20-25 of the highest priority research needs, which are then vetted by MAISRC's Fellows Group, MN DNR, and the MAISRC Advisory Board and used to develop MAISRC's competitive Requests for Proposals (RFPs) over the next two years.

This year's RNA survey is open until September 30: https://z.umn.edu/RNA22

AIS Detectors Program
The AIS Detectors program returned to offering in-person workshops while also keeping the fully virtual option available for its AIS Detectors Core Course this year. Participants were able to choose from 6 workshop options this year, 3 virtual options and 3 in-person (offered in Alexandria, Backus, and New Brighton). Seventy-six individuals successfully completed the training with 57 completing content for community members and 13 completing the professional track. We again offered AIS Management 101, a fully online, self-paced course to give participants the foundational knowledge and confidence to make aquatic invasive species management decisions. The team also published an open access journal article about this course available at https://doi.org/10.1017/inp.2022.10. During the 2022 offering, 73 people successfully completed this course. The AIS Detectors team has continued to host a monthly series of virtual networking events called "Detector Connectors" to educate and foster community among AIS Detectors volunteers (pausing in May for a summer break). The program has hosted one webinar so far in 2022 with 214 live attendees. A library of recorded webinars is available on the AIS Detectors YouTube channel: z.umn.edu/AIStube. These recordings logged 1,945 views in the first half of 2022.

Research Coordination
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs.

MAISRC staff also continue to work in collaboration and coordination with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, MN Invasive Species Advisory Council, State AIS Advisory Committee and the Great Lakes ANS Panel. In addition, our research teams are highly connected with a diverse network of researchers from across the state, country and world in an effort to bring together collaborative teams, advance our science in complementary ways and avoid duplication of efforts.

Seventh Update March 1, 2023

MAISRC Subprojects
MAISRC is currently supporting 9 subprojects on M.L. 2019. Summaries of the progress of this subproject are included below. In addition, MAISRC is currently supporting 9 subprojects on M.L. 2021, and 4 subprojects through alternate funding sources (non-ENRTF funds).

Two subprojects on M.L. 2019 are now complete. Summaries of the projects' results and outcomes are included below.

AIS Detectors Program
At the annual Starry Trek event, hosted by the AIS Detectors program, 233 volunteers searched 289 public accesses on 248 water bodies across Minnesota. No new infestations of starry stonewort were found this year, however 13 previously unreported instances of invasive mystery snails were found by volunteers as a result of the event.

Research Coordination
MAISRC continues to work closely with our Center Advisory Board, Fellows Group, and Technical Committee to ensure high quality and high priority research and outreach is being conducted through MAISRC projects and programs.

MAISRC staff also continue to work in collaboration and coordination with many state and regional organizations including local watershed districts, county agencies, Minnesota DNR, MN Sea Grant, MN Invasive Species Advisory Council, State AIS Advisory Committee and the Great Lakes ANS Panel. In addition, our research teams are highly connected with a diverse network of researchers from across the state, country and world in an effort to bring together collaborative teams, advance our science in complementary ways and avoid duplication of efforts.

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

The Minnesota Aquatic Invasive Species Research Center (MAISRC) has advanced our collective capacity to address Minnesota's aquatic invasive species (AIS) problems through rigorous and highly innovative research, informal and formal collaboration across the state and world, and translated science into action with end-user engagement and strategic communication. During this project, MAISRC supported 12 subprojects, selected based on MAISRC's comprehensive research needs assessment process and external peer-review. New tools were developed and key knowledge gaps were filled on many of Minnesota's most problematic AIS, including zebra mussels, spiny water flea, bigheaded and common carps, starry stonewort, invasive cattails, and non-native Phragmites. The accomplishments over the course of this project are many, for example, MAISRC researchers conducted the largest-ever zebra mussel control project and demonstrate successful suppression of juvenile recruitment, developed an innovative coating that prevents zebra mussel attachment, optimized molecular eDNA and sonar technologies for surveillance, created online tools for organizing county-based collaboration networks for AIS prevention, and much more. The outcomes of the research have had immediate and long-term impacts that have changed the way we manage AIS.

MAISRC continues to translate science into action through active engagement with end-users and reaches broad audiences with diverse communication strategies. The outcomes of our engagement and dissemination activities are evident, from local (e.g., lake association, county), state (e.g., MN DNR, legislature), national (e.g., federal AIS Task Force, US Geological Survey), and international (e.g., genetic biocontrol collaborative, Australian government) levels. For example, the development of the AIS Explorer, an online decision-support tool for prioritizing prevention activities, was developed in partnership with counties and disseminated broadly with presentations, 1:1 meetings and small group workshops, and video tutorials. The tool is now being actively used to develop more effective and efficient management plans in Minnesota and replicated in other states and countries.

MAISRC will continue to develop research-based solutions to Minnesota's AIS problems and translate the science into action with support from appropriations from the Minnesota Environment and Natural Resources Trust Fund in 2021 (Phase III) and 2023 (Phase IV).

SUBPROJECT 21.2: Field validation of multibeam sonar zebra mussel detection (Year 2)

Project Manager: Dr. Jessica Kozarek

Organization: University of Minnesota Twin Cities, St. Anthony Falls Laboratory

Description: This project is Phase II of a project to test the utility of a swath mapping system, multibeam sonar, for detecting and quantifying the presence and abundance of invasive mussels at a very large scale. Current methods for detection of zebra mussel colonies rely on time consuming and expensive diving surveys, video imaging, or sampling of veligers (larvae) in the water. Survey sampling design would be much more efficient given spatially extensive information on the presence/absence of zebra mussel beds. Such remote sensing would also facilitate early detection and warning in rivers, lakes and reservoirs through routine monitoring, or to follow changes in zebra mussel density (boom-bust cycles). Phase I of this project, laboratory experiments, revealed sufficient differences in acoustic response (echo) of mussels (native and zebra) and the supporting sediment that we are able to develop an empirical approach to zebra mussel detection. Phase II of this study will test the use of this and other acoustic signatures to detect and map zebra mussel beds in the field, incorporating a larger range of variables, such as a greater range of mussel densities and substrate mixtures, water depths and temperatures.

Year 1 activities for Subproject 21.2 were funded on M.L. 2017, which ended on June 30, 2020. Year 2 activities continue on M.L. 2019 funding, beginning on January 1, 2021.

Subproject 21.2 ENRTF FINAL BUDGET: $228,764

M.L. 2017, Chp. 96, Sec. 2, Subd. FINAL BUDGET: $14,247
M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6a FINAL BUDGET: $214,517

Year 1 Outcomes	**Completion Date**
Activity 1	
1. Establish survey protocols and team coordination with pilot mussel study	December 2019
Activity 2	
1. Coordination with MAISRC and UMN Extension on media efforts, committees	June 2020
2. Annual MAISRC Showcase Event	September 2020

Year 2 Outcomes	**Completion Date**
Activity 1	
1. Comparison of spatial distribution as mapped by acoustic survey and diving surveys	December 2021
2. Characteristic roughness scales of mussel beds	December 2021
3. Develop methodology to incorporate acoustic surveys into zebra mussel monitoring.	June 2022
Activity 2	
1. Coordination with MAISRC and UMN Extension on media efforts, committees	December 2021
2. Acoustic detection of mussels workshop	December 2021
3. Prepare manuscripts for publication	June 2022

Second Update September 1, 2020

No activity from July 1 – December 31, 2020. Status update on subproject activities through 06/30/2020 are recorded on the Sixth Update August 31, 2020 report on M.L. 2017.

Third Update March 1, 2021

This subproject launched Phase II on January 1, 2021. The research team is currently making plans and writing protocol for the 2021 field season. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

After the pause in this project due to COVID-19 in 2020, the research team re-convened in January 2021 and finalized the field sampling plan to collect multibeam sonar data followed by mussel and substrate surveys conducted by a SCUBA team and/or using an underwater ROV (remotely operated vehicle). The underwater ROV allowed all scouting to be completed remotely and reduced the burden on the SCUBA team, as well as providing video verification of the SCUBA surveys. This plan consists of two field campaigns, one in a zebra mussel infested lake and one in a river with high densities of native mussels, with zebra mussels present. We completed the first campaign in June 2021 in White Bear Lake, selected for its range of substrates from silt to cobble and rock. During this campaign we collected data at 22 transects, each 20 m long broken into 1 m x 1 m quadrats. Each transect was surveyed by multibeam sonar 36 times (3 replicates of 12 setting combinations) before substrate and mussel density was surveyed along the transect. Data processing is underway from the first field campaign. The second field campaign, to be completed in August 2021, is planned for the St. Croix River near Lakeland, MN. This site was selected due to the high native mussel densities and range of substrates. Once complete, the research team will develop a data driven model relating acoustic backscatter to relative mussel coverage and substrate, a necessary step to utilizing multibeam sonar to map zebra mussel beds.

The research team coordinated with MAISRC outreach and communications to conduct a project interview and collect background video of the field work in progress.

Fifth Update March 1, 2022

The goal of this research phase is to develop a data-driven methodology to relate acoustic backscatter from multibeam sonar to substrate (sand, gravel, etc.) and relative mussel density (high, medium, low) categories and to identify limitations to the utilization of multibeam sonar for mussel surveys. The research team completed two field campaigns in the Summer of 2021 designed to gather robust datasets along 20 m transects including: a) multibeam sonar data with varying acoustic settings (pulse length and frequency), video documentation of substrate utilizing an underwater remotely operated vehicle (ROV), and c) diver visual surveys of substrate and mussel density at 1 x 1 m resolution. We visited a zebra mussel infested lake with a wide range of substrate types (White Bear Lake) and a stretch of the St. Croix with high densities of native mussels. For each transect, the data were averaged to a 2 x 2 m grid and assigned a category (sand high-mussel density, or sand low-mussel density for example) and the data were converted to real-world coordinates to relate to the sonar surveys. Multibeam sonar data were post-processed to remove erroneous points and vegetation or any points within the water column and the cleaned datasets were converted to 5 x 5 cm backscatter mosaics (gridded data of the backscatter strength for each sonar setting). The data were then compared using a two different data driven models that relate acoustic backscatter to the assigned category for data at each ground truth location (2 x 2 m grid from the diver survey). These models are being used to map relative mussel density and substrate that will serve as the basis for the next phase.

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

Current methods for detection of invasive zebra mussels give an incomplete picture of mussel distribution in a waterbody. Diving surveys may miss areas where mussels are present while plate sampling or sampling for

larvae in the water column may indicate mussels are present, but not their location. Video or photographic surveys are limited by water clarity. To overcome these challenges, this study evaluated the potential for utilizing advanced acoustic techniques, specifically multibeam sonar, to enhance mussel monitoring by developing and validating methods to map habitat (sediment type) and relative mussel density at a large scale. This project is the second phase of a three-phase project. Phase I consisted of controlled experiments in a laboratory setting to develop initial data-driven classification models relating acoustic backscatter to sediment type and mussel densities. This phase, Phase II, tested and further refined these methods in the field. Field work was conducted in two sites, a lake site with zebra mussels and a river site with high densities of native freshwater mussels and zebra mussels. At each site, multibeam sonar data were collected with varying acoustic settings over transects that were surveyed by an underwater remotely operated vehicle to capture video and a dive team to record relative mussel density and sediment type. This detailed dataset across a range of sediment types and mussel densities provided the basis for the evaluation of data-driven models to relate acoustic backscatter from multibeam sonar to relative mussel density. Results from this phase indicate high accuracy of classification in field conditions as well as highlighting some challenges to surveying such as vegetation. In the next phase, Phase III (ongoing), researchers will utilize these methods to map large areas in both waterbodies, will develop and disseminate methods, processing codes and documentation and will compare multibeam sonar to other monitoring methods.

SUBPROJECT 22.2: Assessing and refining copper-based treatment to suppress zebra mussel populations

Project Manager: Dr. Diane Waller

Organization: U.S. Geological Survey, Upper Midwest Environmental Science Center

Description: Resource managers are experiencing pressure from communities concerned by the changes brought on by established zebra mussel populations and are faced with making the best decisions they can, given available information. The copper-based molluscicide EarthTec QZ is registered for open water application and has been previously used at the maximum allowable concentration to control zebra mussels in Minnesota lakes. The goal of this project is to provide decision-making support for the use of copper in lake management for controlling zebra mussel veligers with a copper-based molluscicide in select, high value habitats while minimizing non-target impacts. We will determine minimal effective treatment concentrations of copper to suppress zebra mussel recruitment and evaluate beneficial and adverse impacts to the ecosystem.

The study will be conducted in a central Minnesota lake that has an established zebra mussel population. In the first year, we will compile historical monitoring data and conduct pre-treatment sampling of the biotic communities and water chemistry in the lake to characterize the status of the lake before copper treatment. We will use the biotic ligand model (BLM) to predict the lake-specific minimum toxic copper concentration for zebra mussel veligers. A lake-side toxicity trial will be conducted in a mobile laboratory to test the predicted effective concentration for veliger suppression and evaluate toxicity to select sensitive native species. In the second year, we will conduct an in-lake application of low-dose copper at the minimum effective concentration that was determined in lake-side trials. A before-after comparison will be used to assess zebra mussel recruitment and nontarget community responses between treated and control sites in the lake. The results will be compared with the 2019 low-dose copper treatment and 2-year post-treatment monitoring in Lake Minnetonka.

The Minnesota Department of Natural Resources, local governmental units, lake associations and others involved in invasive species management can use information from this project to assess the feasibility of low-dose copper treatments for managing zebra mussel populations. A strategy that targets the veliger life stage has economic and ecological advantages over treatments that target adult mussels and may be feasible for bays and small lakes. This project will also inform management decisions on the frequency of copper treatments for managing zebra mussel populations while minimizing the risk to nontarget organisms. An evaluation of the biotic ligand model will determine whether it can be used to refine copper applications specific to individual waterbodies.

Subproject 22.2 ENRTF FINAL BUDGET: $220,657

Outcomes	Completion Date
Activity 1	
1. Two-year post-treatment sampling of zebra mussel density, zooplankton and macroinvertebrate communities and chlorophyll A in Lake Minnetonka.	October 2021
2. Analysis of two-year post-treatment zebra mussel density, zooplankton and macroinvertebrate communities and chlorophyll A in Lake Minnetonka.	July 2022
3. Study report and peer-reviewed manuscript	December 2022
Activity 2	
1. Lake selection, approved study permits, study area delineation, MNDNR and stakeholder engagement.	July 2021
2. Surveys of zebra mussel, zooplankton, phytoplankton, native mussels and macroinvertebrate communities and measurement of algal productivity.	October 2021
3. Assessment of background copper concentration in water, sediment and native mussels.	December 2021
4. Model lake-specific copper toxicity using the biotic ligand model.	July 2021
5. Lake-side toxicity trials with veligers and nontarget organisms.	September 2021
6. Determination of minimum effective copper concentration for zebra mussels and toxicity to nontarget species.	December 2021
7. Summary and analysis of preassessment survey data and lake-side toxicity trials	May 2022
Activity 3	
1. Pretreatment collection of veliger/zooplankton tows, benthic invertebrate samples, phytoplankton samples, zebra mussel and native mussel surveys, water chemistry samples, secchi disk readings, and chlorophyll samples.	July 2022
2. Placement of nontarget fish and unionid mussels, adult zebra mussels, and zebra mussel plate samplers in control and treatment sites.	July 2022
3. Application of EarthTec QZ in treatment site and monitoring water chemistry and short-term survival assessments of caged animals, zooplankton, phytoplankton and benthic invertebrate abundance and composition, and copper concentration in sediment, phytoplankton, zebra mussels and unionid mussels	August 2022
4. Post-treatment assessments of zooplankton, macroinvertebrates, phytoplankton, native mussels and zebra mussel settlement.	November 2022
5. Listening session and development of decision -support tool	December 2022
6. Complete data entry, proofing and analysis.	June 2023
7. Prepare study report and peer-reviewed manuscript	June 2023

Third Update March 1, 2021

This subproject launched on January 1, 2021. The research team is currently making plans, writing protocol, and applying for permits for the 2021 field season. Pelican Lake in Crow Wing County was selected as the study site and researchers will also be hosting a webinar in March for area residents to learn more about the project. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

Our goal is to refine effective treatment levels of copper for zebra mussel suppression and assess short- and long-term effects of copper on native biota and zebra mussel recruitment. We continued to evaluate the long-term effects of a low dose copper treatment that was applied to St. Alban's Bay, Lake Minnetonka, 2019, and summarized results of 1-year post-treatment data on veliger density and native invertebrate communities. These data were provided to the Minnesota Department of National Resources (MNDNR) to inform selection of potential sites for an in-lake treatment in 2022.

We selected two sites in Lake Minnetonka, Maxwell and North Arm bays, as our in-lake study areas. We sampled the bays in June 2021 to characterize veliger density, zoo- and phytoplankton and benthic invertebrates, and water chemistry at the sites. Water chemistry information will be input to the biotic ligand model to estimate an effective copper concentration for veliger suppression in an in-lake open water treatment. Data on veliger density and native biotic communities will provide a baseline for after treatment comparisons.

The site for a lake-side toxicity trial was selected on Pelican Lake, Crow Wing County, MN. We held an open house for Pelican Lake residents to present our research and answer questions about the use of low dose copper for zebra mussel control. A mobile laboratory was configured for the lake-side toxicity trial with nontarget fish and invertebrates and zebra mussels. Water chemistry samples from Pelican Lake were analyzed in late June and input to the biotic ligand model to determine copper concentrations to test in the lake-side trial.

Fifth Update March 1, 2022

Our goal is to develop lake-specific, low-dose copper treatments for zebra mussel suppression that minimizes impacts to native biota and maximizes ecosystem benefits. We completed 2 years of post-treatment monitoring of the 2019 low dose copper treatment in St. Alban's bay, Lake Minnetonka. The results showed that the treatment effectively reduced the population for at least 1 year after treatment; mussels reestablished in the treated bay in 2021. One year after treatment, native biotic community composition was similar to pretreatment levels; analysis of the 2021 data on native communities in in progress.

We conducted a lake-side trial at Pelican Lake to evaluate the predictive value of the biotic ligand model (BLM) to estimate a minimum lethal concentration of copper to veligers. We evaluated the effects of three copper concentrations (less than, equal to, and greater than the predicted lethal concentration) to veligers and seven nontarget organisms in a 10-d exposure. Data were summarized and dose response analyses are underway. Veliger data from the lake-side trial and later lab trial were inconclusive and prevented estimation of a minimum lethal copper concentration. However, toxicity data for *Daphnia* were robust and will be used to verify predictions of the BLM. Together, data from the lake-side trial will guide decisions on a concentration and application method for open water treatment in 2022.

We completed pretreatment sampling to characterize zebra mussel settlement, biotic community composition and water chemistry of selected study bays in Lake Minnetonka. We found abundant zebra mussel settlement in both bays. Water chemistry parameters will be input to the BLM to estimate an effective copper treatment in 2022. One bay was eliminated from further study because of a planned herbicide treatment in 2022. We propose using a bay (Robinsons) that we have monitored for 3 years to serve as a control.

Sixth Update September 1, 2022

Our goal is to develop lake-specific, low-dose copper treatments for zebra mussel suppression that minimizes impacts to native biota and maximizes ecosystem benefits. The results of 2 years of post-treatment monitoring of the 2019 low dose copper treatment in St. Alban's Bay, Lake Minnetonka were compiled and analyzed. A manuscript was drafted to disseminate the results of the 2019 study. Funds were obtained to continue monitoring St. Alban's Bay for a third year and will help our understanding of zebra mussel recolonization after suppression.

The results of the lake-side trial on Pelican Lake Plans were summarized and a draft manuscript of the trial was prepared. The information from the trial expanded and strengthened data on the nontarget impacts of copper and was used to inform a copper concentration for the 2022 treatment. The Pelican Lake trial did not produce valid veliger toxicity data. Therefore, we planned to repeat the veliger trial in July 2022, concomitant with the bay-wide treatment, to determine lethal copper treatments for veligers in acute exposures.

Plans to conduct a shoreline treatment in Maxwell Bay, Lake Minnetonka with EarthTec QZ were developed and finalized. Meetings were held with Minnesota Department of Natural Resources (MNDNR) staff to discuss treatment scenarios and methods for monitoring zebra mussels and native communities. We held a public open house to provide information and address questions about MAISRC and USGS zebra mussel control research and details of the 2022 treatment in Maxwell Bay. We completed pre-treatment (baseline) sampling of the biotic community and water chemistry in the reference bay (North Arm) and treatment bay (Maxwell), Lake Minnetonka. These data are important for understanding the "after" impact of the low-dose copper treatment. All required permits for the 2022 season were approved and will allow us to conduct the treatment on time.

Seventh Update March 1, 2023

Post-treatment monitoring of St. Alban's Bay, Lake Minnetonka was scheduled to be completed in 2021. However, additional funds were received for Year 3 post-treatment monitoring in St. Alban's Bay. Settlement plates were retrieved in August and October from the five sampling locations to measure zebra mussel settlement in 2022. Sample analysis was completed copper water concentration and chlorophyll a concentration. Water chemistry/quality parameters were summarized. Zebra mussel samples were enumerated and analysis is underway. Zooplankton and benthic invertebrate samples are being processed by RMB laboratories and results are expected by March 2023.

EarthTec QZ was applied from July 20 to August 1 to Maxwell Bay, Lake Minnetonka. Post treatment monitoring was conducted in the reference and treatment. Samples were collected for analysis of copper concentration, chlorophyll *a*, water chemistry, adult zebra mussel survival and copper tissue concentration, native mussel survival, growth, condition, and copper tissue concentration, community composition of macroinvertebrates, zooplankton, and phytoplankton, and sediment copper concentration. Zebra mussel settlement plates were retrieved in August and October. Sediment copper samples are being processed and analysis is expected to be completed by March 1. Zebra mussel settlement plates were processed and ash-free dry weight analysis is underway. Macroinvertebrate samples were sorted and identification is underway. A dive survey of resident adult zebra mussels in the treated bay was completed before treatment and 60 days post-treatment. Preliminary results indicate a reduction in zebra mussel density 60 days after the treatment. Analysis of phytoplankton was completed at a contract lab and analysis is underway; zooplankton sample results are pending. Posttreatment data entry and analysis are occurring as sample processing is completed.

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

Zebra mussels are one of the most problematic invasive species in Minnesota lakes. Once established in a lake, eradication of mussels is unlikely, and managers may take a "live with them" approach. An alternative strategy is to drastically reduce the population by curtailing recruitment of the larvae, or veliger. Copper-based products (e.g., EarthTec QZ) have been used in partial-lake treatments at the maximum allowable concentration to effectively kill zebra mussels. Because copper can be toxic to native species, managers are hesitant to use copper products without weighing the trade-offs. Much lower copper concentrations could kill veligers with less risk to native species. We aimed to refine copper treatment concentrations to control zebra mussels while minimizing the risk to native species. We determined how long a mussel population is suppressed after low-dose copper treatments and the short and long-term impacts to native species.

A low-dose copper treatment applied in 2019 to a 160-acre bay reduced both adults and veligers in years 0-1; zooplankton abundance was reduced in the short-term but had recovered at 1 year. Mussel density gradually

increased in years 2-3, indicating that retreatment would be necessary to prevent repopulation in subsequent years.

A lake-side trial expanded knowledge about copper toxicity to native fish, native mussels, and zooplankton. We used these results to select minimum copper concentration for a second open water treatment in July 2022 to a 300-acre bay. The treatment killed 100% of adult mussels and reduced recruitment of veligers in the bay. In 2023, we will conduct follow-up monitoring of zebra mussel densities and native species communities.
Our project shows the immediate and long-term effectiveness of low-dose copper for managing established mussel populations and level of risk to native species. The information will be used to guide decision making with stakeholders for invasive mussel management in Minnesota.

Our project shows the immediate and long-term effectiveness of low-dose copper for managing established mussel populations and level of risk to native species. The information will be used to guide decision making with stakeholders for invasive mussel management in Minnesota.

SUBPROJECT 23.2: AIS and tourism - A socio-economic assessment

Project Manager: Dr. Amit Pradhananga

Organization: University of Minnesota Twin Cities, Dept of Forest Resources

Description: Invasive species can have a serious impact on the ecological, economic, and cultural resources of tourism-dependent communities. However, there is still much we do not know about the impacts of aquatic invasive species (AIS) on tourism. Tourism in Minnesota is highly varied, but has a very strong natural resource component. As tourism is a $16 billion industry in Minnesota (Explore MN, 2020a), tourists reducing visitation due to ecological impacts of AIS could be a serious concern, particularly in local and regional areas that rely on nature based tourism. Tourists, even if not direct users of recreational sites, could also represent a potential source for AIS management funding. While resource managers are becoming more aware of the ecological concerns regarding AIS, the economic and social impacts of AIS are less well known. Recent work by project investigators has shed some light on these issues, finding that Minnesota recreationists are willing to pay a daily fee of $10 for local AIS management. Further, public perceptions about AIS and its risks are linked to dollar value placed on AIS management (Levers and Pradhananga, 2020a, 2020b). However, few studies have explored the economic and social impacts of AIS on tourism; the ones that come closest are oriented at very specific sites and types of recreationists (Marbuah et al., 2014; Levers and Pradhananga, 2020). In the above referenced project, the principal investigators gathered important information about perceptions and willingness to pay for AIS management. The survey respondents in that study were primarily boaters and anglers, thus focusing on specific types of recreationists. We build on this work by examining the social and economic value of AIS management among another key stakeholder group: Minnesota tourists and tourism-related businesses.

The overall goal of this project is to quantify and analyze the socio-economic impact of AIS on Minnesota tourists and tourism related business owners. Achieving this goal will provide a fuller picture of the impacts of AIS in Minnesota-- a state with substantial nature based tourism. To achieve our goal, we propose three specific objectives:

1. To assess tourists' a) behavior, values, and perceptions as they relate to AIS, b) their willingness to pay for AIS management in Minnesota, and c) future behavior as a response to AIS infestation levels.
2. To investigate lodging owner/operators' perspectives on and concerns of AIS, AIS management, and support for policy.
3. To compare tourist related data with outcomes from the investigators' previous projects investigating recreationists', lakeshore owners', and general residents' AIS values, AIS perceptions, and willingness to pay for AIS management (MAISRC Subproject 23 & USGS Award No. G16AP00064, Modification No. 0006).

To meet these objectives, we will gather information from three activities: 1) Onsite survey of tourists to determine Minnesota tourists' economic, recreational, and cultural values associated with AIS, 2) Interviews with tourism-related business owners to assess preparedness to respond to AIS, and 3) ~~Mail~~ Online survey of lodging owners/operators to examine their perspectives on AIS.

Project findings will have broad relevance for natural resource professionals, policymakers, and planners who work in the area of AIS policy and management, as well as in recreation management. Findings from the surveys can be used by MAISRC, University of Minnesota Extension, Explore Minnesota, and other stakeholders to develop effective communication campaigns that speak to the values and concerns of Minnesota's tourists. Legislators may be interested in the results given the substantial size of the tourism industry in Minnesota. Furthermore, the surveys could be used by AIS managers as a template to monitor and track social and economic factors associated with AIS management.

Subproject 23.2 ENRTF FINAL BUDGET: $249,088

Outcomes	Completion Date
Activity 1	
1. Develop survey questionnaire, sampling plan, and sampling schedule	March 2022
2. Administer onsite surveys	September 2022
3. Analyze onsite survey data to determine AIS impacts on tourist behaviors	November 2022
4. Develop factsheet for each survey site	June 2023
Activity 2	
1. Develop interview materials (i.e., focus group questions, script, agenda)	February 2022
2. Recruit participants and conduct interviews	June 2022
3. Analyze interview data	October 2022
Activity 3	
1. Develop questionnaire	February 2022
2. Administer online survey	February 2023
3. Analyze survey data	August 2022

Third Update March 1, 2021

This subproject launched on January 1, 2021. Project managers are currently building their team and are beginning work on subproject objectives. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

We have conducted literature review to inform survey development for Activity 1 (onsite survey of tourists). We have also identified potential sites for survey administration. We have developed focus group materials (e.g., focus group questions, script) and will be recruiting participants and conducting focus groups between September to December 2021 (Activity 2). The focus groups will be used to collect qualitative data about business owners' perspectives on the impacts of AIS on tourism, and their preparedness and capacity to respond to AIS impacts. For Activity 3 (survey of lodging owners/operators), we are conducting literature review to inform survey design. Findings from the focus groups (Activity 2) will also be used to inform the survey in activity 3.

Due to uncertainties with COVID, we have changed our sequence and timeline of activities. We delay onsite survey administration from summer 2021 to summer 2022 since onsite surveys require face-to-face contact with

participants. To make progress on project objectives, we will be conducting focus groups from September to December 2021, as initially planned. We will administer surveys with lodging owners/operators from March to June 2022, earlier than initially planned. This will give us the time needed to plan and administer onsite survey between June and September 2022.

Fifth Update March 1, 2022

We have conducted literature review for activities 1 (onsite survey of tourists), 2 (focus groups with tourism businesses), and 3 (mail survey of lodging owners/operators). We have developed focus group materials including focus group questions and script, as well as a stakeholder list to recruit participants (activity 2). We have faced challenges in recruiting participants for focus group. To address this, we have reached out to the Minnesota Tourism Center and Explore Minnesota Tourism. Both the organizations have agreed to connect us with businesses in the study areas. We have developed a draft survey that will be administered with lodging owners/operators across Minnesota and obtained a list of businesses for survey administration (activity 3). We have also begun work in drafting a survey that will be administered with tourists in three study areas: Brainerd lakes area, Alexandria lakes area, and Ely.

Sixth Update September 1, 2022

We have significant progress on data collection in all three activities. We have developed and administered an onsite survey of tourists in Alexandria, Brainerd, and Ely, and have obtained more than 500 completed surveys from tourists (Activity 1). In activity 2, we have conducted 17 interviews with tourism-related business owners/operators and have started data analysis. We have also developed and administered an online survey of tourism-related businesses across Minnesota and have obtained 285 completed surveys. Next steps are to analyze quantitative survey data collected from activities 1 and 3 to examine tourist and tourism business owner perspectives on AIS, and AIS impacts on tourism. We will also be conducting qualitative analysis of interview data collected in activity 2 to document business owner perspectives about AIS impacts on tourism, and business' capacity to respond and adapt to AIS impacts.

Seventh Update March 1, 2023

We have completed survey data collection in Activity 1, and interview data collection in Activity 2. We reached out to businesses in January 2023 to increase the sample size of business owners/managers in Activity 3. We administered an onsite survey of tourists in Alexandria, Brainerd, and Ely and obtained 900 completed surveys. Survey findings show that while most tourists believe aquatic invasive species are a problem in Minnesota and believe that AIS pose risks to aquatic habitat and recreational opportunities, only a small minority of respondents are less likely to visit the area in the future because of the presence of aquatic invasive species (Activity 1). Next steps in Activity 1 include further data analysis including in-depth analysis of tourists' willingness to pay for AIS management. We will also prepare factsheets tailored to each survey site and share them with local stakeholders including tourism offices and chamber of commerce. In Activity 2, we conducted interviews with 17 tourism-related business owners/managers (e.g., resort owners, outfitters). We are conducting in-depth analysis of interview data. In Activity 3, we have received 290 completed surveys from tourism-related business owners across the state.

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

Minnesota tourism has a strong natural resource component. Yet, Minnesota's natural resources are negatively impacted by invasive species, which in turn can have serious consequences for Minnesota's tourism industry. However, not much is known about the perspectives of visitors and Minnesota's tourism-related businesses on aquatic invasive species (AIS). In this project, we collected data on visitor and business values and perceptions about AIS and AIS management, and visitors' willingness to pay for AIS management. We conducted an onsite survey of visitors in Alexandria, Brainerd, and Ely, an online survey of businesses, and interviews with business owners/operators. Findings suggest that both visitors and businesses believe that AIS is a problem in Minnesota and that it poses risks to natural resources in Minnesota. Most visitors surveyed were willing to pay an

additional fee ranging between one to fifteen dollars. However, visitors are likely to continue to visit the study areas despite the risks of AIS. Thus, messaging around natural resource impacts may be more effective. From the survey and interviews of businesses, we found that businesses do not perceive a direct risk of AIS to their business and believe that they lack the resources needed to address AIS. Businesses either already communicate with their customers about AIS or are willing to do so. However, they believe that there is a lack of targeted programs that engage businesses in AIS management. These findings suggest that there is a need to assess and communicate any potential risks of AIS to the tourism industry. Businesses lack the resources to address AIS, but many are interested in learning more about how to address AIS impacts. Therefore, efforts are needed to engage with businesses and build their capacity to address AIS.

SUBPROJECT 25.2: Examining Motivations for Illegal Baitfish Release

Project Manager: Dr. Nicholas Phelps

Organization: University of Minnesota Twin Cities, Dept of Fisheries, Wildlife, and Conservation Biology

Description: The intentional release of live baitfish has been identified as a behavior with high likelihood of spreading important AIS, including fish pathogens, which may be accidentally introduced when otherwise innocuous native species are released. The purpose of this research is to quantify the influence that anglers' attitudes, norms, and perceptions have on their bait disposal choices and inform improved communication and management strategies for reducing the illegal release of live baitfish in Minnesota. Using a psychometric survey of a random subsample of Minnesota anglers, we will evaluate the ability for the Theory of Planned Behavior to explain illegal bait release intentionality across different segments of the angling population. We will then estimate the results of management approaches aimed at the social-psychological factors that are particularly determinative of bait release behavior using the quantitative risk assessment framework previously developed by our research group. Unsurprisingly, the factors that motivate particular fishing behaviors are not homogenous across all people and may be moderated by personal characteristics such as demographics, degree of participation in the specified activities, trust in the management agency, or value orientations. These differences result in a heterogeneous uptake of recommended AIS-preventing behaviors and correspondingly heterogeneous distribution of risk factors across the angling population. Risk communication and management that ignores this heterogeneity and is targeted at only one type of angler may fail to reach the anglers that are actually responsible for the risky behaviors, which may explain why angler education efforts often fail to significantly reduce risky behaviors.

This project directly addresses an identified need for social science-informed management to target the behavioral dimensions of AIS spread via the large and complex baitfish pathway. Our research is, to our knowledge, the first to quantify pathogen introduction risk for the live bait pathway in Minnesota and the first to incorporate the behavioral science dimension within the risk model. We will explicitly evaluate the potential efficacy of realistic management strategies using our previously developed risk assessment model (Subproject #25.1), which will provide decision support for managers interested in reducing AIS and pathogen introduction risk. These results will be made available in two published manuscripts and at least two conferences, but we also anticipate several opportunities for sharing directly with state resource managers engaged in similar efforts.

Subproject 25.2 ENRTF FINAL BUDGET: $106,539

Outcomes	Completion Date
Activity 1	
1. Online survey questionnaire finalized	January 2021
2. Completion of survey administration and all follow-ups	April 2021
3. Base Theory of Planned Behavior model estimation and identification of additional explanatory constructs, if necessary	July 2021

Activity 2	
1. Identify moderating variables and delineate sub-groups of anglers	April 2021
2. Complete multigroup SEM and parameterize sub-group models	August 2021
3. Draft of manuscript describing results of Activities 1 and 2	February 2022
Activity 3	
1. Identify 2-3 promising management strategies in consultation with MNDNR	September 2021
2. Quantify the effects of implementing these strategies on overall pathogen introduction risk	June 2022
3. Peer reviewed manuscript describing results and management implications	December 2022

Third Update March 1, 2021

This subproject launched on January 1, 2021. Project managers are beginning work on subproject objectives. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

Over the last six months, we contacted 8,000 anglers via three mailed letters and one email to complete a survey examining the motivations and attitudes towards live baitfish release in Minnesota. So far, we have received over 1,400 responses. Preliminary data analysis suggests that although most anglers intend to follow regulations regarding live baitfish release, 30% of respondents indicated they were 'just as likely as not' to release their leftover live baitfish in the future (slightly higher than Phase I responses). Furthermore, the release behavior is widespread and common across geographic locations and different types of anglers. We will soon send a final email reminder and provide paper surveys to the few anglers who have requested them, which will allow us to finalize this stage of the project and direct our full effort towards data preparation and analysis. We encountered an unexpected, extremely long delay in receiving the angler license data necessary for creating our mailing list and contacting anglers, and as a result, are approximately 6 weeks behind our planned schedule. In addition, we received significantly lower response rates than expected in the initial wave of survey recruitment, requiring a greater number of follow up reminders than was originally budgeted. In this report, we have requested an amendment to the budget to cover additional mailing and consulting expenses associated with this low response rate and ensure a quality final sample.

Fifth Update March 1, 2022

Over the last six months, we completed data collection, data cleaning, and factor analysis for our survey examining the motivations and attitudes towards live baitfish release in Minnesota. We received a total of 1,706 responses, 1,092 of which were suitable for factor analysis. We have completed the initial exploratory factor analysis and have determined that we have sufficient support for our three-factor model of the Theory of Planned Behavior to proceed with the confirmatory factor analysis and structural model. Preliminary examination of demographic differences show that younger anglers and anglers in greater Minnesota are more likely to engage in risky behaviors, including past importation and release of live baitfish. Additionally, younger anglers are more likely to report intent to release live baitfish, and social norms are correlated with bait release intention, indicating that peer-mediated messaging discouraging baitfish release may have promise for risk reduction. We are in conversation with the MNDNR regarding their recent county-level pilot projects and will continue to incorporate insights from those projects as we finalize our social-psychological model and integrate those results with our statewide risk model.

Sixth Update September 1, 2022

We completed the analysis of angler survey data using the Theory of Planned Behavior (TPB), which posits that behavioral intent is predicted by a person's attitudes, subjective norms, and perceived behavioral control

regarding the behavior. In our study system, the behavior of interest was release of live baitfish by recreational anglers. We found that 28% of surveyed anglers at least "slightly agree" that they expect to release their leftover live baitfish in the future, confirming previous research and indicating that baitfish release is an ongoing concern. We also completed the structural equation modeling and moderator analysis. Across all anglers, subjective norms were the most important variable explaining live baitfish release intent. Norms were most strongly correlated with an angler's interest in being like other anglers, suggesting that normative messages communicating that most anglers follow the rules could be effective. We also found that knowledge of bait disposal regulations was strongly correlated with intent to dispose of bait properly, suggesting that improving awareness could reduce baitfish release. Positive attitudes towards release were also a significant predictor of release intent, and were most strongly correlated with beliefs that release would provide food for wild fish and promote strong baitfish populations. Perceived behavioral control was not a significant predictor in our study.

Our TPB model explained 66% of the variance in baitfish release intent, indicating that this model is doing a good job explaining baitfish release among Minnesota anglers, and insights from this study could be used to guide management. In particular, our results support communication campaigns to increase awareness and promote proliferation of proper bait disposal via social networks. We confirmed anglers are generally interested in being good resource stewards, so harnessing this tendency could go a long way in protecting Minnesota fisheries from harmful fish pathogens introduced by illegal baitfish release practices.

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

Release of live baitfish by anglers has long been identified as a potential pathway for the spread of invasive species, but little was known about reasons for this behavior. In Minnesota, live baitfish release is illegal, but a 2018 survey of anglers found 20% of bait users release their baitfish, prompting concerns that there may be substantial risk of AIS and pathogen introduction (McEachran et al. 2022). The purpose of this study was to explore the social-psychological determinants of baitfish release behavior among Minnesota anglers. Our objectives were to identify the major determinants of baitfish release using the Theory of Planned Behavior (TPB) in the general angling population, compare these determinants across subgroups of anglers, and explore implications of these findings for angler-focused communications and management. We used a mail push to online survey design to collect data from Minnesota anglers, measuring their attitudes, subjective norms, and perceived behavioral control determinants of baitfish release intent. We used structural equation modeling to estimate the determinants of behavioral intent across demographic subgroups of anglers. We found 28% of surveyed anglers at least "slightly agree" that they expect to release their leftover live baitfish in the future, confirming previous research and indicating that baitfish release is an ongoing concern. Across all anglers, subjective norms were the most important variable explaining live baitfish release intent. Norms were most strongly correlated with an angler's interest in being like other anglers, suggesting that normative messages communicating that most anglers follow the rules could be effective. In particular, our results support communication campaigns to increase awareness and promote proliferation of proper bait disposal via social networks. Anglers are generally interested in being good resource stewards, so harnessing this tendency could go a long way in protecting Minnesota fisheries from harmful AIS and fish pathogens introduced by illegal baitfish release practices.

SUBPROJECT 28.2: Enzyme-based Coatings to Suppress Priority AIS

Project Manager: Dr. Mikael Elias

Organization: University of Minnesota Twin Cities, BioTechnology Institute

Description:

Overall goals: We propose to test and develop a new coating that can mitigate the spread of sessile invasive species while minimizing non-target impacts.

Problem to be addressed: Replace current toxic antifouling coatings with coatings containing a non-toxic, antifouling, biological molecule to mitigate the spread of sessile invasive species while minimizing non-target impacts.

Biofouling is a natural phenomenon that sticks on structures, boats, docks, anchors. It adds costs to Minnesota's industries, and is a vector for the spread of numerous invasive species in Minnesota waters. A current way of fighting biofouling involves using metals that are harmful to the environment. We propose to determine the efficacy and potential of a new generation of coatings containing a non-toxic, antifouling, biological molecule. These coatings could help mitigate the spread of sessile invasive species not only in coastal and inland waterways but also on industrial equipment surfaces, while minimizing non-target impacts.

We will take advantage of our technical (unique engineered, highly stable and active enzymes, unique formulations) and scientific (e.g. finding that lactonase induces changes in microbial communities) advances to evaluate the potential of this technology to replace toxic biocides currently used to limit biofouling. Coated samples will be submerged in the field and samples will be analyzed using microscopy, organisms will be quantified and measured, and surface microbial communities will be determined to infer the importance of signaling.

Projected benefits: Biofouling is a main vector for the spread of aquatic invasive species. Current antifouling solutions are both partly effective and highly toxic to the environment. Using proof-of-concept funding LCCMR, we showed that our enzyme-based coatings not only inhibit fouling but also the adhesion of some AIS, including Zebra mussels. Our proposal aims at evaluating the antifouling performances of a novel, non-toxic technology using enzymes to disrupt microbial signaling (50/50 applied/fundamental). This enzyme-based coatings could help mitigate the spread of sessile invasive species in Minnesota and beyond. Moreover, the comprehensive description of microbial signaling disruption will enlighten our understanding of the importance of signaling in complex biological processes. The potential of this technology is such that we have established contacts with established coating companies, as well as local stakeholders. Results will guide the translational strategy for this technology, and MAISRC resources will be leveraged to perform high value experiments.

Subproject 28.2 ENRTF FINAL BUDGET: $187,480

Outcomes	Completion Date
Activity 1	
1. Improve coating antifouling properties (increase the enzymatic activity of coating)	January 2022
2. Improve coating durability (<5%/month of activity reduction while submerged)	June 2022
Activity 2	
1. Coupon preparation and installation in the different sites	June 2021
2. Sampling and analysis of the coupons.	June 2023
3. Dissemination of the project's outcomes and findings	June 2023

Third Update March 1, 2021

This subproject launched on January 1, 2021. The project manager is currently building their team and is beginning work on subproject objectives. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

In this project period, we have improved our enzymatic coating formulation process and produced coatings where enzyme leakage is reduced by ~10-fold. We have initiated and conducted field experiments in a variety of experimental sites in Minnesota to evaluate the ability of lactonase-based coatings to inhibit the adhesion of

aquatic invasive species on surfaces. This included real-world scenarios, such as painting on a boat. Preliminary samples analysis shows that the differently formulated enzymatic coatings reduces the adhesion of Zebra mussels. Additional sampling, coupled with sequencing, will be used to relate changes in biofouling rates to alterations in bacterial community composition and provide unique and critical insights on the importance of signal disruption in biofouling.

Fifth Update March 1, 2022

We have improved our enzymatic coating formulation process and produced coatings where enzyme leakage is reduced by ~10-fold, as well as developed new formulations and enzymatic assays that allow us to track more accurately enzymatic activity in coatings. We have conducted field experiments in a variety of experimental sites in Minnesota to evaluate the ability of lactonase-based coatings to inhibit the adhesion of aquatic invasive species on surfaces. This included real-world scenarios, such as painting on a boat. Preliminary samples analysis shows that the differently formulated enzymatic coatings reduces the adhesion of Zebra mussels. Additional sampling, coupled with sequencing, will be used to relate changes in biofouling rates to alterations in bacterial community composition and provide unique and critical insights on the importance of signal disruption in biofouling.

Sixth Update September 1, 2022

Our main achievements in this project period have been to work on optimizing our enzymatic coatings. We have evaluated the ability of our enzyme to be a viable coating additive, by testing its ability to remain active in a variety of coatings bases, namely silicone, epoxy, and acrylic. Remarkably, we obtained coatings where the enzymatic activity is nearly constant over 5 months, whether the coating is kept in dry conditions or in water. This is significant progress from previous formulations that possessed significant leaking rates. Additionally, we coated a boat on the Duluth Superior Harbor, and are projecting to place more samples in our sites this summer, as well as sampling 2-years old samples from Lake Minnetonka. Sampling, coupled with sequencing, will be used to relate changes in biofouling rates to alterations in bacterial community composition and provide unique and critical insights on the importance of signal disruption in biofouling.

Seventh Update March 1, 2023

We have improved our enzymatic coating formulation process and produced coatings where enzyme leakage is reduced by ~10-fold, as well as developed new formulations and enzymatic assays that are stable and active in wet and dry conditions for at least 250 days. We have conducted field experiments in a variety of experimental sites in Minnesota to evaluate the ability of lactonase-based coatings to inhibit the adhesion of aquatic invasive species on surfaces. This included real-world scenarios, such as painting on a boat. Preliminary sample analysis shows that the differently formulated enzymatic coatings significantly reduce the adhesion of Zebra mussels until 9 months of submersion. Analysis of samples collected after 14 and 24 months showed no statistical difference between treatments. This contrasts with our recently completed analysis of our Lake Superior dataset, where statistical significance of the lactonase treatment was observed at 21 months. Differences between site conditions, fouling rates and water quality could explain these discrepancies, which we propose to first analyze via the comparison of surface microbiome changes. Analysis for the Lake Superior experiment was completed and revealed that surface community changes with lactonase and the abundance of key microbes involved in biocorrosion are decreased. For the Mississippi and Tonka Bay samples, samples will be sequenced soon. Additional sampling, coupled with sequencing, will be used to relate changes in biofouling rates to alterations in bacterial community composition and provide unique and critical insights on the importance of signal disruption in biofouling.

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

Biofouling is a natural phenomenon that sticks on structures, boats, docks, anchors. It adds costs to Minnesota's industries and is a vector for the spread of numerous invasive species in Minnesota waters. A current way of fighting biofouling involves using metals in coatings and this is harmful to the environment. The goals of this

project were to advance and characterize an eco-friendly coating that can reduce pollution and contribute to the control of biofouling and aquatic invasive species.

Enzymatic formulations were evaluated in 'real-world' conditions, in the field, including on boat hulls. Different coatings bases, such as acrylic and silicone, as well as materials were used. Results were encouraging and validated our initial observations: the enzyme-based coatings reduced biofouling, including the attachment of Zebra mussels for up to 9 months in submersion in the field. This included high-fouling sites such as Lake Minnetonka. In parallel, we performed the optimization of coating formulations and successfully developed biological coatings that are durable and remain active for over 250 days in dry or wet conditions. This is important because it demonstrates the possibility of using these biologicals as coating additives and suggests that these new formulations will outperform initial coatings and show increased field durability. Lastly, surface microbial community analysis reveals that the presence of enzymes in the coating alters the microbial population structure, and this may relate to the observed reduction in fouling and adhesion of AIS. In particular, we show how the enzyme reduces the presence of specific bacterial groups involved in biocorrosion, such as

Sulfate-Reducing Bacteria (SRBs). Insights into these mechanisms are critical because they will allow to altered enzymes to specifically affect bacterial groups of interest while minimizing the impact on other groups. Overall, these results provide evidence of long-term activity in high-fouling environments and more durable formulations. Insights into the mechanism of action contribute to our understanding of the roles of aquatic microbes and their involvement in complex biological processes such as biocorrosion and biofouling. A non-toxic antifouling coating could help preserve the MN environment, particularly for populations that depend on aquatic resources. As regulation drives the antifouling market towards eco-friendly coatings, it is expected that will provide a competitive advantage to local boat manufacturers, help reduce the economic burden on the MN maritime industry caused by ZM and fouling, and ultimately help reduce the spread of sessile AIS.

SUBPROJECT 33: Optimizing eDNA monitoring for multiple aquatic invasive species

Project Manager: Josh Dumke

Organization: University of Minnesota Duluth, Natural Resources Research Institute

Description: Monitoring lakes for aquatic invasive species (AIS) is critical to prevent their spread, however, physically searching for many different AIS requires considerable expense. Environmental DNA (eDNA) could be an effective and inexpensive monitoring technique capable of detecting multiple AIS through water samples, but eDNA is a relatively new science, and optimal methods for its use as an AIS monitoring tool need to be developed before widespread application and acceptance.

Project goals: Our objectives are to 1) determine the effects of lake characteristics and sampling season on AIS detection probability, and to 2) optimize field and laboratory methods for maximizing detection probability of AIS from water samples. We will validate and optimize eDNA methods for early detection of zebra mussel, spiny water flea, rusty crayfish, and Common Carp. We will develop protocols for sampling each species using eDNA, and provide recommendations for sampling multiple species simultaneously. Our products will benefit resource managers, lake associations, researchers, and others.

How we will succeed: Objective 1 questions will be answered by visiting 21 lakes which span a range of abiotic characteristics. These lakes will be sampled repeatedly over the open-water season. Thus, we will be able to determine how lake characteristics and species life history interact to influence optimal timing of eDNA sampling for simultaneous detection of multiple AIS. For objective 2, we will conduct paired tests of filter materials, pore sizes, sample collection locations, and water volumes among 5 lakes to determine which methods are most efficient at capturing eDNA. We will also compare molecular and extraction methods upon a subset of samples.

Why this is important: Little information exists to guide the development of widespread, multi-species eDNA monitoring for AIS. We will answer critical questions regarding the optimal amount of sampling effort, timing, sample location, as well as field and laboratory methods for detecting AIS across a range of lake types and AIS abundances. Our results will guide the development of protocols and guidelines for widespread monitoring to establish statistically valid estimates of AIS prevalence, and for early detection efforts. Our final product will make recommendations about which eDNA sample methods and strategies are optimal when detecting our target aquatic invasive species in Minnesota. This will be given to managers, AIS specialist, and non-government organizations guidance and confidence when using eDNA as a monitoring strategy.

Subproject 33 ENRTF FINAL BUDGET: $436,331

Outcomes	Completion Date
Activity 1	
1. Sample 13 lakes in 2021 for Activity 1	November 2021
2. Complete laboratory processing of 2021 Activity 1 samples (n=715)	August 2022
3. Sample 8 lakes in 2022 for Activity 1	November 2022
4. Complete laboratory processing of 2022 Activity 1 samples (n=440)	March 2023
5. Dissemination of findings (final report, best practices guide, MS in prep, conferences)	June 2023
Activity 2	
1. Sample 5 lakes in 2021 for Activity 2	October 2021
2. Complete laboratory processing of 2021 Activity 2 samples (575 qPCR + 125 ddPCR)	December 2022
3. Dissemination of findings (final report, MS in prep, conferences)	June 2023
4. Creation and dissemination of eDNA best practices guide *Will be created after the end date of Subproject 33 (M.L. 2019) and Subproject 33.2 (non-ENRTF funds) on alternate, non-ENRTF funding.*	September 2024

Third Update March 1, 2021

This subproject launched on January 1, 2021. The project managers are currently making plans and writing protocol for the 2021 field season. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

We created an outreach flier to distribute to interested agency personnel and citizens which describes our project, goals, and PI contact information. This has made it much easier to describe what we are doing and gain acceptance by Bands, lake owners, and agency personnel. Dr. Larson (team member at U IL) developed a probe for previously primer-only eDNA assay for rusty crayfish, which will improve specificity for rusty crayfish among populations of other crayfish species. Dr. Larson also traveled to Duluth and St. Paul, MN for hands-on training of NRRI and UMN teams when collecting eDNA water samples, filtering samples, and laboratory practices. At the time of this report the NRRI and UMN teams almost completed 3 of 5 lake visits (last lake will be sampled in a few days) to 13 Minnesota lakes for Activity 1, and 2 of 5 lake visits for Activity 2.

COVID-19 impacted our ability to recruit graduate students to the project right away, as campuses were mostly shut down and students were hesitant to begin a new program in the midst of remote learning. We resolved this problem by extending our timeline for recruitment and delaying GRA appointments for one semester. UMN and NRRI teams each discovered great candidates and hired them onto the project as temp/casual employees until their GRA appointments started. COVID-19 also interrupted supply chains making standard lab supplies (like

nitrile gloves) difficult and expensive to acquire. However, all supplies are now in-hand for the 2021 field season, so our field sampling and laboratory processing schedule is on track.

Fifth Update March 1, 2022

We completed all sample collections scheduled for the 2021 field season. Our teams visited 13 lakes 5 times to meet Activity 1 objectives, collecting a total of 975 water samples. In addition, we collected 600 samples from 5 lakes to meet Activity 2 objectives. At the time of this report DNA extractions are 50% complete for Activity 1 samples, and qPCR to quantify DNA of our target AIS will begin soon. Dr. Eric Larson at U IL has received 160 samples for a DNA preservation and extraction comparison test (a component of Activity 2), and processing of those samples is underway. NRRI and UMNTC teams are preparing for the 2022 field season by ordering supplies and finalizing which 8 lakes will be sampled in 2022 for Activity 1. We also met our scheduled outcomes for 2021 field sampling to visit 13 lakes for Activity 1, and 5 lakes for Activity 2.

COVID-19 continues to impact availability of supplies, including molecular grade water, filters, and centrifuge tubes. For the 2022 season we plan to place supply orders far in advance to mitigate delays experienced in 2021. The NRRI team detected lab contamination which affected the extractions of some Activity 1 samples. The contamination source was identified, eradicated, and steps have been implemented to reduce contamination risk in the future. The project team has worked together on detecting the contamination early, investigating cause, and planning solutions through regular project meetings. Extractions will be repeated for the affected samples with no loss of data.

Sixth Update September 1, 2022

We have completed 3 of the 5 sample visits for most of the 2022 scheduled lakes. We have progressed well with 2021 Activity 1 eDNA samples (n=715): DNA extractions are 100% complete, qPCR of common carp is 100% complete, and qPCR for rusty crayfish is 78% complete. Quantitative PCR of zebra mussel and spiny waterflea from 2021 samples will begin soon, and DNA extraction of 2022 Activity 1 samples has begun. Activity 2 samples collected in 2021 (n=580) are 40% extracted and qPCR of target AIS is underway. Last fall we shipped 160 eDNA samples to Dr. Eric Larson at UIL. All of those samples have been extracted, and qPCR is 100% complete for rusty crayfish and zebra mussel.

In the last 6 months the project team has been recovering from a lab contamination event described in our January 2022 progress report. Lab staff completed an investigation into affected samples, repeated the extractions required, and made procedural improvements to reduce risk of future contamination. This was a necessary task, but it did take time and money away from our processing of 2021 samples. The NRRI lab also lost our lead technician, and reduced lab staffing has challenged our ability to keep up with sample processing. We've taken three actions to increase the rate of sample processing: 1) 165 samples from 2022 will be sent to Dr. Eric Larson at UIL to reduce the workload upon the NRRI lab, 2) NRRI is in process of hiring a technician to increase lab staff, and 3) UMNTC graduate student Chris Rounds will work for three weeks in the NRRI lab on 2022 extractions.

Seventh Update March 1, 2023

We have completed all field sampling obligations among both project activities. Thus, what remains is generating data from field samples at NRRI and University of Illinois (UIL) labs. Activity 1: total extractions from 2021 and 2022 samples is 98% complete (1131 extractions done of 1155). Quantitative PCR (qPCR) of four species (common carp, rusty crayfish, zebra mussel, and spiny waterflea) for 2021 and 2022 samples is 52% complete (2420 qPCR done of 4620). Activity 2: 580 samples were collected in 2021 in support of Activity 2. DNA extractions of those samples is 100% complete, and qPCR for our four target AIS is also 100% complete. Eric Larson at UIL and his graduate student, Samantha Garcia, have completed their laboratory processing from a subset of Activity 2 samples (n=160) comparing preservation and DNA extraction methods. We also collected water samples from lakes in support of both activities to classify lake characteristics and help interpret eDNA

performance. Laboratory analysis of total nitrogen, total phosphorus, and major cations and anions has been completed. What we have yet to do is spend a few days reviewing water chemistry data, finish qPCR for Activity 1, and complete digital PCR on 125 Activity 2 samples. Activity 1 Outcome #3 “Sample 8 lakes in 2022…” has been met.

Laboratory processing timelines stated in the work plan have been difficult to meet due to past delays of contamination, lab staff who have left, and delays in some supplies required for qPCR. Both NRRI and UIL labs continue to work at maximum capacity, so all outcomes will be met by project end, with a goal of having the data stated above complete by April 2023.

In addition, the project team has held conversations with multiple Minnesota stakeholders (staff within MNDNR and several Soil and Water Conservation Districts, as well as lake association representatives) about what content prospective users of an eDNA guide consider required and desired information about the use of eDNA for aquatic invasive species detection. From those conversations the team has determined that there is considerable interest in an eDNA guide relevant to Minnesota waterbodies and specific to the species of concern within the state, a scope which is larger than what was planned as a part of Activity 2, Outcome 3. The content and design of a guide which meets these stakeholder expectations and contributes toward application of eDNA monitoring for AIS in Minnesota merits more effort and attention than solely a dissemination byproduct of Subproject 33, as planned in Activity 2.

Therefore, Activity 2, Outcome 3 will not be completed as planned as a part of Subproject 33 and will instead be completed in 2024. Delaying the creation of the eDNA guide will allow the research team time to incorporate three student theses that will be completed in 2023 and 1-3 publications that will be past peer review in 2024, as well as relevant findings of Subproject 33.2 which ends on December 31, 2023 (non-ENRTF funds), all in addition to Subproject 33 results. Overall, this adjustment in the dissemination plan will allow the research team and MAISRC to offer a product which is more useful and impactful in the state of Minnesota. MAISRC has committed to fund the creation of a more extensive eDNA guide in 2024 on alternate (non-ENRTF) funding and will share the end product with the LCCCMR and the public upon its completion. This change has been noted in the table out outcomes from Subproject 33.

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

Cost-effective monitoring for aquatic invasive species (AIS) is critical for quantifying AIS prevalence and for early detection of new invasions, but monitoring Minnesota’s thousands of lakes is impossible using traditional survey methods. Environmental DNA (eDNA) is a sensitive tool which could help screen lakes for multiple AIS. However, eDNA is a relatively new science and we needed to better understand what field and laboratory methods work best for AIS detection in Minnesota. Our first goal (Activity 1) was to determine when four different species (Zebra Mussel, Rusty Crayfish, Spiny Waterflea, and Common Carp) had the greatest detection probabilities over the open water season, and use that information to identify an optimal sampling period when high detection probabilities overlap. We collected a total of 1,050 samples from 21 lakes and found that all species were more detectable in the middle of summer when lakes were stratified. Our second goal (Activity 2) was to compare several different methods of collecting and processing organismal DNA to determine what combination of methods would maximize likelihood of AIS detection during early establishment. We have determined significantly more DNA is detected when using larger water grabs (1000 mL) and finer pore size filters (1 µm). We also found that significantly more DNA was extracted from samples stored in a lysis buffer (CTAB) and extracted by a phenol-chloroform-isoamyl (PCI) procedure than samples stored in ethanol and extracted with a Qiagen kit. Samples quantified with digital PCR had significantly more AIS detections than samples quantified with conventional qPCR in particular for water samples containing low concentration of the target AIS gene. Collectively, our results provide guidance on where, when, and how to collect and amplify DNA for four AIS prevalent in Minnesota.

SUBPROJECT 35: Genetic Biocontrol of Invasive Species - Understanding Attitudes and Risk Perceptions

Project Manager: Dr. David Fulton

Organization: University of Minnesota Twin Cities, Dept of Fisheries, Wildlife, and Conservation Biology

Description: A web-based survey will evaluate Minnesotans' attitudes and risk perceptions related to the use of genetic modification techniques for the control of invasive species. Very little is known about public attitudes or risk perceptions concerning the use of genetic modifications for aquatic invasive species control. The purpose of this proposed project is to better describe public understanding and attitudes towards the use of advance genetic modification techniques as control tools for invasive species. To thoroughly address the purpose, this research must investigate attitudes towards these techniques within the context of specifically understanding attitudes toward the invasive species and their impacts. Recent research on the human and social dimensions of invasive species provides guidance for the design of the proposed research. Although a robust literature concerning the human and social dimensions of invasive species management and governance has developed, there is limited research specific to the use of genetic techniques to control invasive species. This study addresses that gap in research and represents a crucial upstream evaluation of public attitudes and perceptions that will enable subsequent engagement to develop governance in the use of genetic technology for these purposes in Minnesota.

This project will provide baseline information about Minnesota residents' attitudes and risk perceptions toward genetic modification techniques as an approach for managing aquatic invasive species. The outcomes of this study include improving knowledge of the preferences and risk perceptions of using these techniques among the general population of Minnesota, tribal communities, and specific stakeholder and user groups such as anglers and boaters in the state. The focus will be on attitudes and risk perceptions toward using genetic modification to help control invasive species in general as well as two specific, widespread invasive species: common carp and zebra mussels. In addition, the project will help clarify the social psychological antecedents and consequences of these attitudes and risk perceptions. Focus groups and interviews will be used to assist survey design, and we will use mixed-modal surveys with web-based data collection. We will also implement a discrete choice experiment within the survey to better understand the attributes driving choices concerning the use of genetic technology. A total of 3200 surveys are targeted for completion from the Minnesota general public, lakeshore homeowners, anglers, and boaters. The objectives of this study are:

1. To understand the attitudes, risk perceptions, and level of support for using genetic techniques in controlling two invasive aquatic species in Minnesota (e.g., common carp and zebra mussel)
2. To understand the antecedents/consequences to attitudes, risk perceptions, and level of support for using genetic techniques in these two specific cases
3. To understand the general preferences for using genetic techniques in the management of invasive species in Minnesota, the antecedents/consequences of these preferences, and the population heterogeneity related to these preferences
4. To explore and gain an initial understanding of potential concerns of tribal communities in Minnesota with using genetic techniques for invasive species control.

Subproject 35 ENRTF FINAL BUDGET: $209,313

Outcomes	Completion Date
Activity 1	
1. Interviews/focus groups, design of web-based survey to collect data	December 2021
2. Pre-testing survey implementation and instrument	February 2022
3. Survey implementation and data collection	November 2022
Activity 2	

1. Data cleaning and weighting	January 2023
2. Develop and assess social psychological statistical models to understand the antecedents and consequences of attitudes and risk perceptions related to the use of genetic modification to control invasive species.	March 2023
3. Completion of final project report	June 2023
Activity 3 *Engagement of tribal communities on genetic techniques for invasive species control will occur in collaboration with regional partners, through funding provided by the Great Lakes Restoration Initiative.*	

Third Update March 1, 2021

This subproject officially launched on January 1, 2021 and work will begin in the next few weeks. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

The realities of COVID-19 presented a challenge in recruiting a PhD student to work on this project beginning in January 2021. After a national search, I identified and recruited a PhD student with a strong background in invasive species and invasive species management and the social sciences to work on the project, Kiley Davan. Kiley has matriculated into the PhD program in Conservation Sciences, relocated to the Twin Cities from the University of Tennessee, and she formally join the project effective August 1, 2021. The delay in student recruitment into the project has shifted the project timeline by 6 months, but we are beginning to make progress in study design. Given the delay, we will be requesting a no cost extension to the project, with a final completion date of June 30, 2023.

We have started preliminary design of the web-based surveys using information from a review of literature that Kiley conducted during the spring of 2021, prior to her formally joining the project. We have also initiated organization and implementation of interviews and focus groups to inform the content of the surveys. We have scheduled initial survey design meetings with key partners from the Minnesota DNR.

Fifth Update March 1, 2022

We are nearing completion of the design of the web-based surveys using information from a review of literature that Kiley Davan conducted during spring and fall of 2021. We have completed interviews with university researchers and state agency staff to inform the content of a web-based elicitation survey that is being implemented in February 2022. This web-based elicitation survey is being used in lieu of focus groups to ensure relevance of the survey to target populations. We shifted to online elicitation surveys to replace data collection from focus groups due to the continued uncertainty of scheduling face-to-face meetings with the COVID-19 pandemic. This elicitation survey was pretested during December 2021 and revised during January 2022. In addition, key portions of the primary web-based survey have been designed based on the existing literature, reviewed by other researchers with survey research expertise, and we will finalize the draft survey instrument and pretest it by March 2022. We anticipate that final survey implementation and data collection will be complete by June 30, 2022.

We have begun preliminary contacts with tribal biologists to begin efforts for Activity 3.

Sixth Update September 1, 2022

We are in the process of revising the design of the web-based surveys using information from a pre-tests and peer reviews conducting on our draft survey instrument during the spring of 2022. We have completed interviews with university researchers and state agency staff to inform the content of a web-based elicitation survey that is being implemented and these interviews indicated that our original design of using stated choice

experiments would not be successful given the lack of certainty in what genetic control technologies could be implemented and how they would be implemented into natural systems. For this reason, we have shifted the design of the questionnaire to focus on presenting informative scenario vignettes concerning the use of genetic control technologies in specific hypothetical scenarios. We now anticipate that final survey implementation and data collection will be complete by November 30, 2022.

Seventh Update March 1, 2023

We are in the process of finalizing and implementing the web-based surveys using information from a pre-tests and peer reviews conducting on our draft survey instrument during the spring of 2022. The design of the questionnaire to focus on presenting framing scenarios vignettes concerning the use of genetic control technologies in specific hypothetical scenarios and providing information concerning the potential outcomes of genetic biocontrol for zebra mussels and common carp. We now anticipate that final survey implementation and data collection will be complete by March 15, 2023.

Due to unexpected delays to Activity 1 and 2 during the course of the project, work on Activity 3 was delayed as well. Given the amount of time left before the end of the project (June 30, 2023), MAISRC and the research team have made the strategic decision to focus on engaging tribal perspectives in collaboration with regional partners funded by the Great Lakes Restoration Initiative, rather than moving forward with Activity 3 as planned. Making this strategic shift will ensure that engagement with Tribal Nations on potential genetic biocontrol technologies is done in a way that opens time and space for critical conversations and learning and avoids overlap between efforts. This work will continue past the subproject end date of June 30, 2023. Progress on regional engagement efforts will be provided, as relevant, as a part of future Subproject 1 updates. This change has been noted in the table out outcomes from Subproject 35.

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

Recent advances in applied synthetic biology techniques hold promise for genetic biocontrol of aquatic invasive species (AIS) such as zebra mussel and common carp. If such techniques are developed, public attitudes and risk perceptions may influence if and how they are implemented. This project provides baseline information about Minnesota residents' attitudes and risk perceptions toward the use genetic modification techniques for managing aquatic invasive species. The three objectives of this effort were to:

1. understand the attitudes, risk perceptions, and level of support for using genetic techniques to control common carp and zebra mussels in Minnesota;
2. understand what other factors influence attitudes, risk perceptions, and level of support for using genetic control techniques for common carp and zebra mussels;
3. understand the general preferences for using genetic techniques in the management of invasive species in Minnesota and the diversity in the Minnesota population related to these preferences.

Data were collected by contacting a random sample of households in Minnesota and random samples of Minnesota resident licensed anglers and permitted boaters and directing them to a web-based survey hosted by the University of Minnesota. A total of 3676 Minnesota residents participated in the survey, including n = 2,365 general residents, n = 560 known licensed anglers, and n = 751 known permitted boaters. Overall, a majority of respondents (>65%) held positive attitudes toward genetic biocontrol of AIS in general and specifically for common carp and zebra mussels. While a majority of respondents (>65%) perceived risks and concerns with using genetic biocontrol to manage AIS, common carp, and zebra mussels, a larger majority also perceived benefits (>75%), and a majority (> 60%) believed that the benefits at least slightly outweighed the risks. Genetic biocontrol of AIS, common carp, and zebra mussels was supported by a large majority (>75%) of respondents.

SUBPROJECT 36: RNA-interference screens for zebra mussel biocontrol target genes

Project Manager: Dr. Daryl Gohl

Organization: University of Minnesota Genomics Center

Description: This project will develop methods of RNA-interference (RNAi) for disrupting the expression of genes that are important for the spread and establishment of invasive populations of zebra mussels. The results will reveal genetic weak points, and will establish tools and methods for effective RNAi-based biocontrol technologies that could potentially be scaled up to open water applications in the future. Minnesota has focused its efforts on prevention of zebra mussel spread. State, county and local programs for educating lakeshore property owners and recreational users, for training lake service providers, and for inspecting and decontaminating watercraft improve each year, but still each year more Minnesota lakes and streams are newly infested with zebra mussels. In addition to short-distance spread in clusters of invaded lakes near Detroit Lakes, Brainerd, and Alexandria, long-distance transport is spreading mussels to more pristine regions—most recently, to Red Lake and Lake of the Woods.

Some lakes that are caught soon after they are infested may respond to chemical controls. But about three to five years after a lake is colonized, dense clusters of mussels become so widely distributed within the lake, that the costs and risks to native species of chemical pesticides makes their application impractical. Genetic methods may be effective alternatives in these well-established water bodies. CRISPR/Cas9-induced mutations can be spread to high frequency in pest populations by "gene drives;" this includes mutations that are very harmful (e.g. those that kill male offspring). This theoretical expectation has been borne out by results from laboratory-population experiments (for example in *Aedes aegypti*: the mosquito that carries Zika virus). Yet the risks for spread to native biota are considered to be so high, that environmental release of CRISPR/Cas9 for invasive species control is not a viable option, at present. Moreover, effective methods for culturing genetically modified zebra mussels do not currently exist, making the application of CRISPR/Cas9 less practical in zebra mussels at present.

RNAi technologies are considered safer because the genome of the target species is not altered and in most cases, RNAi effects are not passed to offspring. Instead of mutating an organism's DNA, RNAi works by blocking the expression of genes controlling important biological processes, leading to fitness effects and suppressed population growth of the invasive species. Finally, RNAi-based biocontrol is particularly well suited for zebra mussels since it does not require long-term propagation of the modified mussels. Instead, RNAi reagents are delivered to mussels by feeding them microbes expressing the interfering RNA, which the mussels filter out of the water.

We laid the groundwork for research on RNAi for biocontrol by sequencing and assembling the 16 chromosomes of the *Dreissena polymorpha* genome. This genomic map allowed us identify a long list of target genes involved in critical processes. This is the first step in any genetic biocontrol technology, because the DNA sequence of a target gene must be known so that RNAi (or CRISPR/Cas9) reagents can be designed to recognize that gene. The zebra mussel target genes we chose are involved in processes that are critical for growth and invasive spread—for example, genes controlling growth and calcification of shells, genes that build the "byssal threads" that mussels use to attach to boats or to vegetation on the bottom of lakes, and genes that protect cells from damage under heat stress that occurs every summer in Minnesota. We also identified genes whose knockdown is likely to lead to high mortality, such as genes that control function of the nervous system. RNAi approaches have been applied in many other animals (including other oysters or mussels), but our work represents the first application of this technique in zebra mussels.

This proposal aims to apply RNAi to identify genetic weak points in zebra mussels and to develop the tools to manipulate these critical genes as a stepping-stone towards targeted genetic biocontrol efforts. First, we will create the molecular biology reagents and methods for knocking down dozens of target genes. Then, we will deliver these reagents to live mussels, cultured in the laboratory, and test for a range of molecular and phenotypic effects.

Subproject 36 ENRTF FINAL BUDGET: $260,374

Outcomes	Completion Date
Activity 1	
1. Identify target genes in zebra mussel genome and design dsRNA expression plasmids.	June 2021
2. Produce dsRNA expression plasmids and create and archive bacterial strains.	December 2022
3. Verify inducibility of dsRNA constructs.	December 2022
Activity 2	
1. Establish laboratory rearing protocols and tests for feeding, reproductive output, survival, shell growth, and byssal thread attachment).	December 2021
2. Treat zebra mussels with RNAi reagents developed in activity 1, then run the tests above to determine the phenotypic effects of RNAi treatments.	December 2022
3. At the same, verify that RNAi treatments block the expression of target genes, using RT-qPCR amplification or direct RNA-Sequencing	December 2022

Third Update March 1, 2021

This subproject launched on January 1, 2021. The project managers are currently making plans, writing protocol for work in the MAISRC Containment Lab, and are beginning work on subproject objectives. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

This project aims to test whether RNA interference (RNAi) can be used to manipulate the expression of genes in zebra mussels through the delivery of double-stranded interfering RNA produced by bacteria or algae which are fed to zebra mussels. In the initial phase of this project, we have chosen 21 initial target genes to use to test this novel approach. The selection of these target genes was aided by the existence of the zebra mussel genome (a previous MAISRC-funded project). To maximize the chances of seeing a phenotype in initial experiments, target genes were chosen to span a range of crucial biological processes and to target a number of different tissues. Most of this initial batch of RNAi constructs (16/21) have been made and sequence verified. Since early June, we have been collecting and working with zebra mussels in the MAISRC containment laboratory and are beginning to establish functional assays for filtration and attachment that will allow us to measure the effects of exposure to the RNAi constructs.

Fifth Update March 1, 2022

In the first half of 2021, we identified initial target genes spanning a range of crucial biological processes and made bacterial dsRNA expression constructs. Over the past six months, we have been working with zebra mussels in the MAISRC Containment Laboratory to establish functional assays for filtration, growth, and attachment that will allow us to measure the effects of exposure to the RNAi constructs. We have also been developing assays to verify the expression of the dsRNA constructs in bacteria. We have conducted preliminary tests where zebra mussels were exposed to dsRNA-expressing bacteria and scored for filtration and attachment. Initial results indicate that constructs targeting the translational regulator (CPEB4) and a byssal thread protein (Dpfp1) are able to disrupt surface attachment (to varying degrees). Future work will focus on verifying target gene knock-down by RT-qPCR, refining and establishing additional phenotypic assays, optimizing dosing and delivery strategies, and identifying and testing additional RNAi targets.

Sixth Update September 1, 2022

In the first half of 2022, we were unable to conduct additional mussel experiments (with the exception of one in late June as we did not have access to mussels until early June). During this period, we designed and carried out molecular analysis of samples studied in 2021. In addition, we designed and cloned additional RNAi constructs

for an expanded set of target genes and using alternative expression backbones. We also cloned additional Dpfp1 constructs to allow us to test the specificity of the phenotypic effects of Dpfp1 RNAi that we observed in fall of 2021. Ongoing work this summer includes working to reproduce the phenotypes observed last fall, establishing a phenotypic assay for spawning which will be used to test the ability of RNAi against target genes such as the serotonin receptor to inhibit spawning, optimizing dosing and delivery strategies, and testing additional RNAi targets.

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

This project aimed to test whether RNA interference (RNAi) can be used to manipulate the expression of genes in zebra mussels through the delivery of double-stranded interfering RNA (dsRNA) produced by bacteria which are fed to zebra mussels.

The major objectives of this project were to:

1) Produce bacterial strains expressing dsRNA targeting zebra mussel genes involved in critical processes and verify the successful production of dsRNA.
2) Establish phenotypic assays and carry out RNA interference screens for genes affecting zebra mussel feeding success, survival, reproductive function, shell growth, and byssal thread attachment.

Due to the difficulty of cultivating zebra mussels in captivity throughout their entire life cycle, genetic biocontrol methods that rely on producing heritable genetic changes in zebra mussels (such as gene drives) are currently not viable approaches. This project began to test an approach for manipulating zebra mussel gene expression with RNAi. We established a number of phenotypic assays to begin to investigate the effects of dsRNA feeding. We constructed several dozen bacterial strains that expressed dsRNA targeting zebra mussel genes and tested them in a repetitive reattachment assay. No reproducible effects on zebra mussel reattachment were observed in these experiments, suggesting that either the nature of the RNAi trigger (dsRNA versus small hairpin RNA) or the delivery mechanism (feeding bacteria) were not able to produce an attachment defect in zebra mussels. Future work will focus on testing additional RNAi triggers, additional delivery mechanisms (transfection into tissue culture cells, injection, or algal delivery), additional phenotypic tests, and more extensive molecular testing of transcript knock-down. The preliminary data from this project and phenotypic assays we have established have led to additional funding from the U.S. Department of Defense's Strategic Environmental Research and Development Program (SERDP). This funding will enable continued progress on efforts to develop genetic biocontrol tools for this damaging invasive species.

SUBPROJECT 37: Improving the efficiency of watercraft inspections through coordination and cooperation

Project Manager: Dr. Amy Kinsley

Organization: University of Minnesota Twin Cities, Dept of Veterinary Population Medicine – Ecosystem Health Division

Description: Since 2015, the Aquatic Invasive Species Prevention Aid program has provided counties in Minnesota with $10 million a year to prevent or limit the spread of nonnative aquatic species. Each county's government makes decisions on how its allocation of those funds are spent. Watercraft inspection is an example of one such activity that most counties engage in as it is seen as a way to prevent AIS infestations, conduct passive surveillance, and promote awareness of AIS. During inspections, survey data is collected about the location of boating activities, which has been used to develop boater movement networks across all of the waterbodies in MN. The power of these networks has been harnessed through the development of county-level watercraft inspection plans that outline the optimal location of watercraft inspections for each county in the state. However, more work remains to uncover the potential benefits of cooperation across counties and the role that state-level coordination can play in reducing redundancy in effort, leading to increased efficiency and

efficacy. Therefore, the overarching goal of this proposed project is to quantify the benefits of state-level coordination and between-county cooperation in watercraft inspection plans to support decision-making in watercraft inspection programs.

Subproject 37 ENRTF FINAL BUDGET: $198,241

Outcomes	Completion Date
Activity 1	
1. Statewide coordination scheme with optimal locations for watercraft inspections	May 2021
2. County-level inspection scheme with optimal locations for watercraft inspections	May 2021
3. Varying levels of coordination between the statewide inspection efforts and county-level efforts	October 2021
Activity 2	
1. Cooperation networks for each county in the state	May 2021
2.Interactive dashboard model code for collaboration networks	September 2021
Activity 3	
1. A description of boater type and their impact on the overall boater movement network	March 2020
2. Quantification of the impacts of boater movement estimate variability in the decision optimization outputs	December 2021
Activity 4	
1. Workshop series	September 2021 September 2022
2. Updated online dashboard to include county collaboration networks and optimal coordination	December 2022
3. Participation on MAISRC committees	Duration of project
Activity 5	
1. Create a game-theoretic framework where county planners can be incentivized to clean up more risky boats and consequently improve the overall outcome for each county	June 2023

Third Update March 1, 2021

This subproject launched on January 1, 2021. Project managers are currently building their team and are beginning work on subproject objectives. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

In the past six months, we estimated the benefits and costs of coordination between state and county-level planning for Minnesota (Activity 1) and constructed cooperation networks based on optimal county-wide inspection schemes that maximizes the number of boats inspected from infested to uninfested waters within-, into-, and out of- each county, considering reciprocal boat movements between each pair of counties in the state (Activity 2). For Activity 1 we have produced, 1. An optimal statewide coordination scheme; 2. An optimal county-level inspection scheme; and 3. Varying degrees of coordination between the statewide inspection efforts and county-level efforts. We found that when comparing the of bi-level solutions with those for a problem in which the state planner locates inspection resources to achieve a state-level objective shows that the cost of disagreement between state- and county-level objectives can lead to substantial costs. For Activity 2, we

have generated 1. Cooperation networks for each county in the state; and 2. Code for the collaboration networks to implement in the interactive dashboard. We found that four distinct collaboration networks formed when we considered the top three connections of reciprocal boat movements at the county level with and average network size of 4.5 counties.

We are in the process of writing manuscripts for both Activities 1 and 2 and have partial drafts available. We are also in the process of hiring a post-doc to support Activities 3 and 4. We anticipate that we will remain on track for the remainder of the work with outputs of a sensitivity analysis in the Spring and Winter of 2021 and participation in MAISRC workshops in Fall of 2021 and 2022. We also plan to update the online dashboard by Winter 2022 with no expected delays.

Fifth Update March 1, 2022

Over the last six months we have achieved the expected outcomes for Activity 1 and 2. We have made minor changes to the previous models to account for an addition focal species (Activity 1) and refined our definition of risky boats to account for species specific infestations (Activity 2). We have hired and trained in a post-doctoral researcher to develop and implement both the integer programming and network-based models. In addition, we have secured data to begin our sensitivity analysis on boater movement type. Lastly, we have developed mock-ups (a visual overview) of the AIS Explorer modifications that will be produced to share our collaboration outputs with county AIS manager.

Sixth Update September 1, 2022

Over the last six months, we have focused on disseminating our research findings for Activities 1 and 2 and developing partnerships to expand our research efforts. We have submitted a paper describing our work in Activity 1, which presents a bi-level model for determining how a state planner can efficiently allocate watercraft inspection resources to county managers, who then decide where to locate inspection stations. We have stored our data for this Activity in the Data Repository for U of M (DRUM), a publicly available repository. We completed our analysis for Activity 2, which focuses on fostering county-level collaborations, and we presented our work in Activities 1 and 2 to the DNR invasive species staff meeting and county managers at a DNR public engagement workshop focused on multi-organizational collaborations. We also submitted an abstract, which was accepted, to present this work at a regional conference in October 2022. For Activity 4, we have cleaned and de-bugged our code, which identifies potential county collaborations and will be used to modify AIS Explorer, an interactive online dashboard. Lastly, we have received an amendment request to shift some of our budget towards expanding our work through a collaboration with Selina Cai from the New Jersey Institute of Technology to expand our efforts to understand the benefits of collaboration and cooperation by using a Game Theory approach.

Seventh Update March 1, 2023

Over the last six months, we have focused on disseminating our research findings for Activities 1 and 2 and have expanded our research efforts to include an additional activity. We have published a paper describing our work in Activity 1, which presents a bi-level model for determining how a state planner can efficiently allocate watercraft inspection resources to county managers, who then decide where to locate inspection stations. We have stored our data for this activity in the Data Repository for U of M (DRUM), a publicly available repository. We completed a draft manuscript for Activity 2, which focuses on fostering county-level collaborations, and we presented our work in Activities 1 and 2 to the Upper Mississippi Invasive Species Conference in Green Bay, Wisconsin. For Activity 4, we have developed a test site for the AIS Explorer updates and are in the process of finalizing the design. Lastly, we have expanded our work through a collaboration with Selina Cai from the New Jersey Institute of Technology to expand our efforts to understand the benefits of collaboration and cooperation using a Game Theory approach.

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

Recreational watercraft have been shown as an important pathway of AIS spread. As a result, watercraft inspections have become an important component of AIS prevention, with programs operating at the state level by the Minnesota Department of Natural Resources and the local level primarily by counties funded through the AIS Prevention Aid. However, the sheer number of recreational boats moving across the landscape and the large number of waterbodies that can be a source or recipient of AIS make watercraft inspection a particularly difficult program to manage efficiently. In this project, we aimed to quantify the benefits of watercraft inspection plans focused on state-level coordination and between-county cooperation. We developed 1) a state-level model in which a state planner selects lakes for inspection stations throughout Minnesota, 2) a bi-level model in which a state planner allocates inspection resources to county managers, who decide where to locate inspectors according to local objectives, 3) a collaboration model in which groups of counties share portions of their inspection budgets, and 4) a game theoretical model for allocation of inspectors where county planners share information about their decisions. The state-level model revealed that over 95% of risky boats could be inspected with about 400 inspectors. The bi-level model suggested that allocating resources to county planners reduced the inspection of risky boats by 10-20% percent relative to the optimal strategy from the state-level model. The collaboration model provided evidence that groups of counties working together may yield efficiency gains over non-collaborative or county-focused strategies but may be less efficient than an optimal state-level strategy. Further, our game-theory model revealed that collaborative solutions are more efficient than allocations made without information sharing but less efficient than allocations made with budget sharing. These results can guide AIS policy, prevention, and management and can be adapted to additional species.

SUBPROJECT 38: Evaluating native Phragmites as a wastewater treatment alternative

Project Manager: Dr. Daniel Larkin

Organization: University of Minnesota Twin Cities, Dept of Fisheries, Wildlife, and Conservation Biology

Description: An obstacle to statewide control of invasive *Phragmites australis* (common reed) in Minnesota is its continued use for dewatering biosolids in wastewater treatment facilities (WWTFs), a "green technology" leveraging invasive *Phragmites'* exceptional ability to take up water and transpire it to the atmosphere. Development of an alternative to invasive *Phragmites* is essential for eliminating WWTF source populations that can drive reinvasion in Minnesota despite efforts to control it across the landscape. Native *Phragmites* (*P. australis* ssp. *australis*) is an obvious alternative, but its use in WWTFs to date has produced mixed results. The goal of our proposed research is to support WWTFs' transition away from invasive *Phragmites* by systematically seeking native *Phragmites* strains with high dewatering ability, addressing MAISRC priority B. 8.

Native *Phragmites* ideally suited for dewatering would exhibit a suite of traits that enable it to remove water at high rates. Our proposed activities are a series of measures and experiments spanning from the field to the lab to identify native *Phragmites* that has these qualities. We note that we cannot define a precise benchmark (e.g., "native *Phragmites* must remove 80% as much water as invasive *Phragmites*") as WWTFs' needs vary with their engineering, storage capacity, and the needs of the communities they serve. Instead we will estimate how close we can get to the benchmark of invasive *Phragmites* and provide this information to WWTF operators and engineers to guide their transition planning. We will first characterize a relatively large number of candidate native genotypes and then select promising ones for further investigation of water removal at different growth stages. If successful, this research would benefit AIS control in Minnesota by advancing toward a safe alternative to invasive *Phragmites* in WWTFs.

Objectives
1. Select native *Phragmites* source populations and controls for testing
2. Experimentally evaluate performance of native *Phragmites*
3. Disseminate results to WWTF operators and other stakeholders

Subproject 38 ENRTF FINAL BUDGET: $355,122

Outcomes	Completion Date
Activity 1	
1. Candidate robust native populations identified	July 2021
2. Plant material for experimental work acquired	August 2021
Activity 2	
1. Common garden early vigor and gas exchange experiments	December 2021
2. Lysimetric water removal experiments	June 2023
Activity 3	
1. Present results at MAISRC Showcase and Wastewater Operations Conference	June 2023
2. Coordinate with MAISRC and Extension on media, communications, and service	June 2023
3. Prepare journal article for publication	June 2023

Third Update March 1, 2021

This subproject launched on January 1, 2021. The project managers are currently making plans and writing protocol for the 2021 field season. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

Activities completed for the initial phase of subproject 38 (Evaluating Native *Phragmites* as a wastewater treatment alternative) include harvesting plant material for propagation from 10 populations of *Phragmites australis*. Rhizomes from 8 populations of native and 1 population of invasive *Phragmites* were harvested for the project. The native populations were selected from 47 populations that were genotyped during Subproject 32. The native populations were chosen from geographically dispersed locales around Minnesota, and include populations that we categorized as especially robust, others that represent more typical growth (stature, density) of native *Phragmites*, and one population that can be described as having a weak growth habit. Because evidence of hybridization was documented in Minnesota *Phragmites* populations during the genotyping study, and some of the hybrids have a native phenotype, it was important to determine the nativity of populations that will be candidates for wastewater treatment alternatives. It is hoped that use of local genotypes will reduce potential negative impacts to the environment from spread of invasive populations or introduction of native populations from other states that might not be as well-adapted to Minnesota's climate and environment. In addition, comparing water removal capacity across disparate populations collected throughout Minnesota will broaden our portfolio of plant materials to identify high-functioning genotype for use in wastewater treatment facilities.

A literature review was conducted in the initial phase of the project, with researchers using published literature to establish protocols for multiplying the clonal material required for the forthcoming water removal experiments. Containers and growth media for establishing the rhizomes and for growing out the plants have been set up in the Plant Growth Facility at the University of Minnesota, where the populations from around the state will be grown in a common garden experiment. Sensors for monitoring the growth environment are being set up and calibrated.

Fifth Update March 1, 2022

Activities completed for this reporting period include propagating the plant material for the 10 experimental populations of *Phragmites australis*. This work provided some insights into the opportunities and challenges of scaling up propagation for installing native *Phragmites* in reed beds. Although rhizomes are typically used by practitioners to establish reed beds, stem cuttings were more effective for generating clones for this research.

Six of the native populations could be established; the others did not establish well enough to be used in Activity 2. Replicates for 7 populations (6 native populations plus 1 invasive control) were grown in a common garden, i.e., all populations were grown under the same conditions in a growth chamber to isolate population-level, genetic differences from potentially confounding environmental differences across the locations they were collected from. After several months of growth under these controlled conditions, we measured plants' physical traits, including plant height, shoot number, total leaf area, and biomass and evaluated their water-removal capacity using gas exchange and stomatal conductance measures. Each of these parameters relate to the ability of the plants to transpire water, and thus function well for biosolids dewatering. The capacity of the native *Phragmites* populations to transpire water will be compared to that of the invasive population. These data have not yet been analyzed. An additional test of water removal capacity, lysimetric water removal, will then be conducted on the high-performing populations. These measures are scheduled for summer 2022.

Sixth Update September 1, 2022

Activities completed for this reporting period include a preliminary analysis of the plant traits that may impart high water-removal capacity to *Phragmites*. By performing experiments under controlled conditions in a common garden (growth chamber), genetic differences were distinguishable from differences due to environmental variation. Data collected and evaluated in the last reporting period included physical traits, such as plant height, shoot number, total leaf area, and biomass and directly measured water-removal capacity based on gas exchange and stomatal conductance measures. Each of these parameters relate to the ability of *Phragmites* to transpire water, and thus function effectively for dewatering biosolids. Analysis of these data highlighted a key advantage of invasive *Phragmites* for dewatering relative to native *Phragmites*: substantially and significantly greater leaf area. Further analysis of transpiration, stomatal conductance, photosynthesis, and water use efficiency data collected at the leaf level highlighted additional differences between invasive and native *Phragmites*. However, these differences were small in magnitude compared to the copious leaf area produced by invasive *Phragmites*. Work to further characterize stomatal density and area in native and invasive *Phragmites* is ongoing. Vascular morphology will also be measured and evaluated as a parameter that may affect transpiration. An additional test of water removal capacity, lysimetric water removal, will also be conducted. These measures are scheduled for late summer 2022.

Seventh Update March 1, 2023

Our experiments and analysis to date highlight a simple but pivotal advantage of invasive *Phragmites* (relative to native) for use in wastewater treatment facilities' reed beds: its significantly greater leaf area. "Pound for pound," the native subspecies dewaters at a similar rate, but the copious growth of invasive *Phragmites* simply produces higher leaf density per unit area. The results of recent gravimetric measurements will shed more light on this functional comparison. Replicates of 6 populations of native *Phragmites* and 1 population of invasive *Phragmites* were grown out in large containers in the Plant Growth Facility throughout the fall. In mid-winter, gravimetric measurements were conducted to evaluate water removal on a whole plant level over a period of 24 hours. Biomass was harvested immediately after the gravimetric measurements to evaluate dry weight of stems and leaves. Data from previous gas-exchange measurements conducted in the growth chamber, as well as data related to stomatal density, stomatal area, and vascular morphology is currently being analyzed by graduate student researcher Robert Pennington.

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

An obstacle to statewide control of the invasive plant *Phragmites australis* ssp. *australis* (European common reed) in Minnesota is its continued use for dewatering biosolids in wastewater treatment facilities (WWTFs). Marketed as a "green technology," invasive *Phragmites* has an exceptional ability to take up water and transpire it to the atmosphere. However, development of an alternative to invasive *Phragmites* is essential for eliminating WWTF source populations that can drive reinvasion in Minnesota despite efforts to control it. Native *Phragmites* (*P. australis* ssp. *americanus*) is an obvious alternative, but its use in WWTFs to date has produced mixed results. Our research supports WWTFs' transition away from invasive *Phragmites* by systematically seeking native

Phragmites strains with high dewatering ability. Experiments to assess the comparative transpiration rates of native *Phragmites* to that of invasive *Phragmites* were undertaken to find an optimal substitute. Two experimental approaches were used to assess dewatering capacity in greenhouse grown native and invasive *Phragmites*. First, we used a gas exchange measurement system (LiCOR 6800) to quantify water loss through transpiration and stomatal conductance at the leaf level. Next, we conducted a 'gravimetric screening' method, where transpiration rate was estimated at the whole-plant level using a large balance to measure water loss. Plant total leaf area and biomass were measured to enable comparison of evaporative surface area between populations. Our findings confirm that invasive *Phragmites* removes more water than native *Phragmites*. This is primarily due to its greater growth rate and biomass, which yields higher leaf area, and thus greater evaporative surface. When normalized by total leaf area, some native populations were as effective as the invasive population in removing water via transpiration. However, it is unlikely that native populations could ever achieve the high density and biomass of invasive *Phragmites* in-situ in a reed bed setting. Acceptability of native *Phragmites* as a dewatering alternative will depend on individual WWTF's biosolids storage capacity and through rates. For some facilities, native *Phragmites* is likely sufficient, while others will need to consider alternative technologies to transition away from invasive *Phragmites*.

SUBPROJECT 39: Increasing effectiveness of bigheaded carp deterrents by carbon dioxide integration

Project Manager: Dr. Allen Mensinger

Organization: University of Minnesota Duluth, Dept of Biology

Description: The project's goals are to enhance and/or develop new barriers using carbon dioxide to deter the range expansion of invasive bigheaded carp. These fish continue to migrate northward and present a danger to Minnesota's aquatic habitat. The locks and dams on the Mississippi river present strategic bottlenecks where nonphysical deterrents can be deployed to prevent upstream carp migration. Acoustic deterrents have shown promise but are not completely effective. Two different strategies will be examined simultaneously to increase the effectiveness of acoustic deterrents by augmenting them with carbon dioxide. Bigheaded carp display strong aversion to the gas and, if successful, the combination of sound and CO_2 will increase the effectiveness of acoustic deterrents. The first objective will augment a bioacoustics bubble barrier by injecting CO_2 into the sound/bubble curtain. The second objective with use acoustic conditioning to train the fish to associate sound with CO_2, which will prolong the fish's aversion to broadband sound while simultaneously decreasing the frequency of CO_2 application. Both objectives are targeted to be deployed at the downstream lock gate at dams on the Mississippi River.

Subproject 39 ENRTF FINAL BUDGET: $340,327

Outcomes	Completion Date
Activity 1	
1. Conduct behavioral experiments at the University of Illinois to determine the CO2 concentration necessary within an air curtain to elicit avoidance responses in fish.	December 2021
2. Evaluate ways to incorporate CO2 into an ensonified air curtain for laboratory deployments that contains enough CO2 without impacting its ability to capture sound.	June 2022
3. Conduct behavioral experiments at the University of Minnesota to determine whether CO2 might enhance the effectiveness of an ensonified air curtain to block carp.	December 2022
Activity 2	
1. Determine the CO_2 concentration needed for fish deterrence.	June 2021
2. Determine the effective duration of broadband sound.	December 2021
3. Determine if conditioning the bigheaded carp to associated sound with increasing CO_2 concentrations can extend the effective duration of acoustical deterrents.	August 2022

4. Determine if reinforced conditioning can re-establish extended duration of acoustical deterrents.	August 2022
5. Determine if conditioned fish can influence the behavior of naïve conspecifics.	December 2022
Activity 3	
1. MAISRC service and outreach.	December 2022

Third Update March 1, 2021

Project managers are currently building their teams, writing protocol for work in the MAISRC Containment Lab, and are beginning work on subproject objectives. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

We have established an active laboratory in the MAISRC Containment Lab. The graduate student conducting the project has moved from Duluth to St. Paul and has initiated preliminary experiments. We have purchased the small tank shuttle system and it is currently in operation in the MAISRC facility. Bigheaded and silver carp were acquired from the USGS and we are currently testing the response of these fish to carbon dioxide. The pH and carbon dioxide probes have been calibrated and the video tracking software has been installed. The sound system has also been installed and preliminary sound mapping is transpiring. A larger shuttle system is currently being fabricated by Red Ewald Inc and is scheduled to be delivered in the coming months. There have been some delays in the manufacture of the larger shuttle system due to personnel changes at the company however these appeared to be resolved.

Fifth Update March 1, 2022

The fish behavior shuttle box has been constructed and sound and carbon dioxide conditioning trials were initiated this fall. The larger shuttle tank manufacture was delayed by the pandemic but has arrived and will be assembled in the near future. Sound mapping has been completed in the shuttle box and sound pressure levels have been calibrated. The fish tracking software has been installed and which allows fish position and swimming speeds to be calibrated.

Single day conditioning (three exposures in one day) and lower intensity pure tone stimulus seemed to have marginally effects on fish displacement and deterrent. Preliminary results of extended conditioning (2 to 3 days) and increased sound intensities (~125 dB) have greatly increased deterrence and will be the standard from this point forward.

Dr. Brooke Vetter, a recent hire at St. Thomas University has been assisting with the project at no cost to the grant. The experiments have provided training opportunities for four of her undergraduate students to date. Training has been provided for two graduate students.

The pandemic continues to present a challenge as there have been significant delays in acquiring parts and supplies. Additionally, the smaller speakers purchased for the shuttle box failed numerous times and delays were sustained in finding a new vendor that had miniature speakers in stock.

Sixth Update September 1, 2022

Activity 1
Outcomes 1 and 2 are complete and behavioral experiments at the University of Minnesota are currently underway. Due to an administrative delay in starting Activity 1 in partnership with the University of Illinois, we have submitted an amendment request to extend the completion date of Activity 1 to allow for data analysis and drafting a manuscript of results.

Activity 2
The trials in the small shuttle tank have been concluded. The carp showed evidence of conditioning in the first week following the conditioning (carbon dioxide and sound) and fish would leave the sound chamber quickly however this behavior became inconsistent over the course of the month. This was attributed to lack of sound refuge in the opposite chamber. It also appeared that fish location at the time of sound onset effected escape time. We also noted a different behavior, freezing, that may be associated with conditioning. If this persists, it may be effective in lock and dams settings where the fish will not be able to swim upstream and/or the current will carry the fish downstream.

The much larger second shuttle tank was constructed and trials are underway in this arena. Based on the small shuttle trials, the goals for the larger tank is to determine if conditioning can persist for up to a week instead of a month. We have sound mapped the larger tank and noted that the opposite end to the sound source does provide sound refuge.

Dr. Brooke Vetter, a recent hire at St. Thomas University has been assisting with the project at no cost to the grant. The experiments have provided training opportunities for five of her undergraduates students to date. Training has been provided for two graduate students.

Two abstracts were submitted and the results will be presented at the "The effects of noise on aquatic life conference" in July 2022.

Seventh Update March 1, 2023

The effects of carbon dioxide and sound conditioning were examined in the large shuttle tank. Carbon dioxide continued to be a strong deterrent and resulted in the fish rapidly leaving the shuttle tank or becoming unresponsive. Fish were conditioned with sound and carbon dioxide and the conditioned fish departed the tank earlier when confronted with sound only and stayed away from the sound source longer indicated that acoustic conditioning has the potential to increase the effectiveness of both carbon dioxide and sound.

The circular tanks continue to be challenging to create the proper sound gradient to direct the fish away from the sound. We again observed fish freezing instead of swimming away from the sound due to the confusing sound scape. While this behavior will be equally effective in the field as negative phonotaxis, as the fish would either not move upstream or be carried downstream by the current, the shuttle tank was not designed to take advantage of this previously unseen behavior. We are looking forward to building on the foundations from these experiments and running them in the model lock and dam that will be constructed this spring that will be better suited for quantify the effectiveness of the deterrents (Phase II, M.L. 2021).

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

Invasive bigheaded carp continue to expand their range throughout Midwestern waterways and deterrents to prevent upstream migration are currently being investigated. Dams provide natural barriers to migration however adjacent lock chambers can allow invasive fish passage. However the locks result in bottlenecks for fish migration and are ideal spots to install deterrents. This study investigated the effects of adding carbon dioxide to a bubble barrier and conditioning carp to associate an acoustic deterrent with carbon dioxide. Addition of carbon dioxid to bubble curtains showed promise at enhancing the ability of a the deterrent to block the passage of common and bigheaded carp under laboratory conditions. Bigheaded carp were classically conditioned to associate sound with carbon dioxide release and their behavior was assessed in two choice shuttle chambers. Following conditioning, carp exited the sound chamber and delayed their return compared to non conditioned fish. Taken together, these studies show that carbon dioxide has the potential to enhance bubble barrier or acoustic deterrents under laboratory conditions. Managers should consider adding carbon dioxide enhancement to proposed barriers, however care must be taken to restrict use to gas reserves already available from industrial sources to avoid the need to generate or release additional carbon dioxide into the

atmosphere. Future studies should investigate fish passage in larger tanks, model lock and dams and/or outdoor ponds.

SUBPROJECT 40: Enhancing habitat and diversity in cattail-dominated shorelines

Project Manager: Dr. Amy Schrank

Organization: Minnesota Sea Grant

Description: We will quantify and clarify whether or not hybrid/narrowleaf cattail removal can increase plant diversity and benefit fish communities in nearshore lake ecosystems and how these effects vary regionally in Minnesota, information that is currently unknown. To accomplish this, we will experimentally remove sections of cattail in up to 24 lakes across Minnesota's major ecoregions and measure environmental, vegetation, and fish responses.

Objectives:

1) Understand the little known effects of hybrid/narrowleaf cattail on the ecological dynamics of nearshore lake communities across Minnesota.
2) Determine if small-scale cattail removal can increase plant diversity and heterogeneity and positively affect fish abundance and diversity.
3) Compare the regional effects of cattail removal on nearshore lake ecosystems.

Nearshore aquatic plants are an important source of biodiversity in Minnesota lakes and are critical to fish communities, including important game species (walleye, bass, pike, sunfish, etc.) and forage fishes (minnows, darters, etc.). Fishes using nearshore, vegetated habitat usually prefer a combination of emergent, floating-leaved, and submerged plants for spawning, rearing, refuge, and feeding habitat. In Minnesota, hybrid/narrowleaf cattail (hereafter cattail) have expanded in nearshore lake communities, altering environmental conditions and displacing other plant species. Cattail acts as an "ecosystem engineer" by replacing diverse wetland and aquatic plant communities with a more homogenous environment dominated by tall, dense, difficult-to-penetrate cattail and its litter (dead cattail). As plant diversity is reduced, research suggests that fish diversity may decline, though it is unknown if this occurs in cattail dominated, nearshore lake ecosystems in Minnesota. Despite the negative impacts of dense cattail in many habitats, in some Minnesota lakes (e.g. shallow southern lakes where other species struggle to survive), cattails play crucial roles by providing vegetated habitat and preventing erosion. Thus, the extent to which cattails are detrimental or beneficial to nearshore habitats is likely to vary across the state.

Subproject 40 ENRTF FINAL BUDGET: $338,066

Outcomes	Completion Date
Activity 1	
1. Select up to 24 lakes in each of three ecoregions, enroll landowners via MOU if needed, and obtain MNDNR permits.	June 2021
2. Recruit a graduate student and two undergraduate technicians.	June 2021
3. Complete pre-cattail removal sampling and document with photo and video.	August 2021
Activity 2	
1. Contract with local companies to remove cattail at all sites.	August 2021
2. Remove cattail in all study lakes.	November 2021
3. Analyze pre-cattail removal data and hire two technicians for 2020 field season.	May 2022
Activity 3	

1. Complete post-cattail removal sampling (environmental variables, plants, and fishes) and document sampling with photos and video.	September 2022
2. Complete data analysis.	June 2023
3. Write reports, manuscripts, and complete and disseminate outreach materials.	June 2023

Third Update March 1, 2021

This subproject officially launched on January 1, 2021 and work will begin in the next few weeks. More detailed updates will be provided in the September 1, 2021 update as more work will be accomplished at that time.

Fourth Update September 1, 2021

We have assembled our project field team for summer 2021. We hired a fisheries research assistant this spring, who began to plan the logistics of the project and initiated coordination with MN DNR fisheries and aquatic plant management staff to collaborate on site selection. We advertised for, interviewed, and selected two graduate students who began working on the project on this summer. To complete our field team for summer 2021, we also hired one undergraduate field technician. We have acquired the sampling permits needed from the MN DNR, the University of Minnesota, and Voyageurs National Park and the field team has been visiting Minnesota lakes to find suitable sites for the project. Environmental, fish, and plant sampling has been completed at two lakes in Voyageurs National Park (Rainy Lake and Lake Kabetogama) with the help of park staff. The field team is continuing to scout suitable lake sites as they sample confirmed sites.

Activity 1, Outcome 1 is nearly complete as we have tentatively selected the lakes we will sample during the project. The field team continues to visit potentially suitable lakes during field sampling to find other sample sites as needed throughout the summer. Activity 1, Outcome 2 is complete as we have hired two graduate students and one undergraduate technician. Activity 1, Outcome 3 is in progress as pre-cattail field sampling is ongoing; the team is documenting progress with photos and video.

Site selection is an ongoing process and is taking longer than we estimated. To address this, we are continuing to select sites as we sample established sites to ensure that we are not missing suitable lakes by focusing only on sampling.

Fifth Update March 1, 2022

Environmental, fish, and plant sampling was completed in August of 2021. We sampled paired sites at nine lakes: Rainy, Kabetogama, First Crow, Second Crow, Long, Belle Taine, Big Marine, Maud, and Coon lakes. In addition to finishing field sampling as scheduled, we completed cattail removal at all planned sites in each lake. Analysis of our first summer of data is ongoing and we are well prepared to return to our sites in summer 2022 to collect our post-cattail removal data.

Activity 1: All outcomes of Activity 1 have been completed. Outcome 1: We selected our sample lakes, completed one MOU for one landowner, and obtained the necessary MNDNR permits for both fish sampling and cattail removal. Outcome 2: This was completed during the previous reporting period. Outcome 3: We have completed pre-cattail removal field sampling and documented this with photos and video.

Activity 2: Outcome 1 is complete, we contracted with Jacob Holman at Lakes Aquatic Weed Removal to remove cattails at all sites. Outcome 2 is complete; cattails were removed at all study sites. Outcome 3 is in progress as data analysis continues and we plan for hiring one technician during summer 2022.

We were able to overcome the difficulty of site selection by persistence and our research team found suitable sampling sites despite drought conditions.

Sixth Update September 1, 2022

Our summer 2021 field sampling data have been summarized and presented to a variety of audiences including the Minnesota DNR and Minnesota lake associations. Post-cattail removal sampling of environmental variables, plant and fish communities is ongoing during the summer 2022 field season. The research team has been in the field sampling Big Marine and Coon Lakes in the Twin Cities metro area and will continue sampling our nine study lakes through September of 2022. During the field season the team has distributed our informational postcard to interested members of the public and recipients have been appreciative and enthusiastic about the opportunity to learn more about the project. Finally, we hired our summer 2022 research technician, Dylan Dahn, an undergraduate from the University of Minnesota Duluth, in June of 2022.

Our sampling is proceeding on schedule though we have rearranged some sampling dates due to the high spring water levels in Voyageurs National Park and the closure of some boat launches. Because of the drought late last summer, some of our cattail removed sites have experienced some regrowth because stems were not submerged fully during winter and spring. However, we are still able to proceed with summer 2022 sampling and it appears that even with some regrowth we may see treatment effects.

Activity 2: Outcome 3 is complete. We have analyzed our data from our pre-cattail sampling season in preparation for our final analysis once we collect the data from our post-cattail removal sampling. We have hired our 2022 field technician.

Activity 3: Outcome 1 is in progress as the research crew is currently sampling our nine lakes to collect post-cattail removal environmental, plant and fish data. Our sampling will be completed on schedule. Outcomes 2 and 3 will be in progress after the sampling season is finished.

Seventh Update March 1, 2023

Our team has finished post-cattail removal sampling of water quality, plants, and fishes at our nine study lakes in August of 2022. Now that we have completed both our pre and post cattail removal sampling, we are working on data analysis and writing.

Over the last six months we have continued to disseminate information about our project by distributing our informational postcard to interested members of the public both at the boat launch and at a number of lake association meetings. We delivered five presentations or workshops on cattail and our project progress over this reporting period. This included a virtual presentation to the Minnesota DNR invasive species, aquatic plant management, and shallow lakes staff, an in-person presentation at the Rainy Lake Property Owners association, a virtual presentation at the MAISRC showcase, and two field events for lake property owners and the public at Long Lake in Becker County and Big Marine Lake in Washington County. We have also completed production of one video about our project and that has been disseminated through the MAISRC YouTube channel.

Activity 3: We have completed outcome 1 as we finished our post-cattail removal sampling (environmental variables, plants, and fishes) at the end of August 2022 and we documented our sampling with photos and video.

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

Nearshore aquatic plants are an important source of biodiversity in Minnesota lakes and critical to sustaining healthy fish communities. Invasive hybrid/narrowleaf cattail (hereafter cattail) have expanded in nearshore lake communities, altering environmental conditions and displacing native plant species. Cattails replace diverse native plant communities with a homogenous environment dominated by tall, dense, difficult-to-penetrate cattail and its litter (dead cattail). To determine if cattail removal can benefit Minnesota lakes, our project objectives were to:

1) Understand the little known effects of invasive cattails on nearshore lake communities across Minnesota.
2) Determine if small-scale cattail removal can increase plant diversity and positively affect fish communities.
3) Compare the regional effects of cattail removal on nearshore lake ecosystems in Minnesota.

To address our objectives we compared environmental variables and plant and fish communities at cattail retained and cattail removed sites in nine lakes across Minnesota. We studied sites both before and after mechanical cattail removal to determine how removal affected plants and fishes in these nearshore regions. We found that removing cattails resulted in increased dissolved oxygen and increases in native plants in nearshore zones. In addition, we observed changes in fish community including increasing fish abundance and more minnow species at some removal sites. Our results suggest that mechanical cattail removal has the potential to restore nearshore lake ecosystems with minimal negative effects to other species. Removing cattail allows increased dissolved oxygen into nearshore zones and provides space for native plants to regrow to create high quality fish habitat. Furthermore, spreading these relatively small cattail removal sites across lakes may have cumulative benefits to fish communities by increasing the overall habitat area available to fishes in a lake. Our data can be used directly by the MNDNR to make policy and management decisions about cattail removal for lake restoration in Minnesota.

IV. DISSEMINATION:

Description: The Minnesota Aquatic Invasive Species Research Center provides a platform for information and new research findings about AIS to be widely disseminated. This is accomplished through the annual public Research and Management Showcase event, reports, brochures, website, Facebook and Twitter, Extension programming, Advisory Board, Technical Committee, seminars, talks, and via peer reviewed publications and student theses. Additionally, MAISRC organizes a publicly available and indefinite data repository ("MAISRC-DRUM") in partnership with the UM Libraries for data related to ongoing and completed MAISRC projects.

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

First Update March 1, 2020

No activity to report at this time. All MAISRC communication and dissemination activities are currently occurring under 2017 ENRTF funding, until funding completion on June 30, 2021. A summary of activities is included in the M.L. 2017 report.

Second Update September 1, 2020

No activity to report at this time. All MAISRC communication and dissemination activities are currently occurring under 2017 ENRTF funding, until funding completion on June 30, 2021. A summary of activities is included in the M.L. 2017 report.

Third Update March 1, 2021

No activity to report at this time. All MAISRC communication and dissemination activities are currently occurring under 2017 ENRTF funding, until funding completion on June 30, 2021. A summary of activities is included in the M.L. 2017 report.

Fourth Update September 1, 2021

No activity to report at this time. All MAISRC communication and dissemination activities occurred on 2017 ENRTF funding, through June 30, 2021. A summary of activities is included in the M.L. 2017 report.

Fifth Update March 1, 2022

2021 Research Highlights
To share highlights from MAISRC's work over the last year, our staff created a 2021 Research Report that includes project updates and big-wins from our research teams. Hard copies of the report were provided to key stakeholders and all LCCMR members. An online version of the report was broadly shared through MAISRC's communication channels. To view an online version of the report, visit:
https://z.umn.edu/2021MAISRCstorymap

Additional MAISRC communication and dissemination activities occurred on 2017 ENRTF funding in 2021. A summary of activities is included in the M.L. 2017 report.

Sixth Update September 1, 2022

Thus far in 2022, MAISRC researchers have given 31 presentations to state and local managers, community groups, and students, reaching an estimated total audience of 1,525 people. In addition, MAISRC's Research Outreach Specialist (supported by non-ENRTF funds) hosted or participated in 30 engagement events with stakeholders, including local, state, and federal managers, lake associations, watershed organizations, and community groups during the reporting period, focusing on the translation of MAISRC research into action at the local level. MAISRC's email and social media audiences have also continued to grow, and website use continues to be strong.

Additional MAISRC communication and dissemination activities occurred on 2017 ENRTF funding in 2022. A summary of activities is included in the M.L. 2017 final report.

AIS Research and Management Showcase
MAISRC will be hosting our annual AIS Research and Management Showcase as an online conference on September 21, 2022. Details about breakout sessions and registration is available on our website: https://maisrc.umn.edu/showcase. In addition to the online conference, MAISRC staff and researchers will be hosting an in-person lab tour on the MAISRC Containment Lab facilities on September 22, 2022.

New MAISRC Staff
In the last 6 months, MAISRC has welcomed two new members to our staff:

Ethan O'Brien, Communications Manager
Ethan joins MAISRC with 15 years of communications and design experience; half of which with the Medical School at the University of Minnesota. As MAISRC's Communications Specialist, his primary role is to communicate research progress and accomplishments to MAISRC's varied audiences, continue to develop robust platforms for the dissemination of MAISRC's research findings, and coordinate events like the Research & Management Showcase.

Alex Bajcz, Quantitative Ecologist
Alex joins MAISRC with 10 years of experience in quantitative and computational ecological research. As MAISRC's first Quantitative Ecologist, Alex will serve as a resource for data management/sharing and will provide support and training on quantitative methods for MAISRC researchers including applied statistics, modeling, simulation, and application development. The Quantitative Ecologist role is supported by state funds appropriated to MAISRC and will support subprojects and initiatives that are funded on M.L. 2019.

Seventh Update March 1, 2023

Public Presentations

In 2022, MAISRC researchers gave 35 presentations to state and local managers, community groups, and students, reaching an estimated total audience of 1625 people. These engagements were a mix of in-person and online talks but most were targeted to Minnesota audiences, with some national and international audiences. Presentations were given at community meetings, academic conferences and professional meetings, as well as speaking events to students, youth groups, and local conferences. Highlights in 2021 include two hybrid cattail field tour and researcher Q+A events in Becker County and Washington County, another zebra mussel control open house with researchers at Lake Minnetonka, as well as local conferences like the Whitefish Area Property Owner's AIS Roundtable and a day-long AIS mini-conference in Detroit Lakes. MAISRC research teams also continue to regularly present updates on their work to members of the DNR Invasive Species Unit staff, the State AIS Advisory Committee, and DNR Fisheries Program staff.

AIS Research and Management Showcase
In September 2022, MAISRC hosted our annual Research and Management Showcase as an online conference. As a part of the event, researchers and over 190 attendees were able to connect and discuss current research studies and management tools. By continuing to host the Showcase online, we have been able to break down geographic and time barriers and expand the accessibility of our content to attendees throughout the state and beyond. Showcase presentations were once again recorded and broadly disseminated. To date, the 2022 Showcase recordings have been viewed over 600 times online. In addition, the 2021 Showcase recordings have collectively gained an additional 784 views over the last year, bringing them to 2,159 total. To view the recorded presentations, visit: z.umn.edu/2022ShowcaseVideos

Data Repository at the University of Minnesota (DRUM)
To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility to MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. In total, the DRUM currently contains 24 sets of data from MAISRC subprojects and partnership projects. In 2022, we uploaded 7 new sets of data in DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects utilize this platform. Some MAISRC researchers upload their data to public federal databases or in open-access publications to align with data sharing standards within their individual fields of study or journal requirements.

Peer-Reviewed Publications
Recent MAISRC publications include:

Kinsley, A.C., R.G. Haight, N. Snellgrove, P. Muellner, U. Muellner, M. Duhr, and N.B.D. Phelps. 2022. AIS Explorer: Prioritization for watercraft inspections-A decision-support tool for aquatic invasive species management. Journal of Environmental Management https://doi.org/10.1016/j.jenvman.2022.115037
MAISRC Subproject 37 (M.L. 2019)

Whitty, J. M., Riesgraf, A. T., Zielinski, D. P., & Sorensen, P. W. (2022). Movements of a model fish, the common carp, through a generic Mississippi River lock and dam demonstrate how fish swimming performance, behavior, and discharge driven flow fields determine fish passage rates in ways that can be predicted and modified using fish passage models. River Research and Applications, 38(4), 670–683. https://doi.org/10.1002/rra.3942
MAISRC Subproject 3 (M.L. 2013)

Riesgraf, A., Finger, J., Zielinski, D., Dennis III, C., Whitty, J., & Sorensen, P. (2022). Evaluation of a broadband sound projected from the gates of a navigation lock in the Mississippi River shows it to be a weak deterrent for common carp and unable to block passage. Management of Biological Invasions, 13(1), 220–232. https://doi.org/10.3391/mbi.2022.13.1.13
MAISRC Subproject 3 (M.L. 2013)

Hundt, P. J., White, L. A., Craft, M. E., & Bajer, P. G. (2022). Social associations in common carp (Cyprinus carpio): Insights from induced feeding aggregations for targeted management strategies. Ecology and Evolution, 12, e8666. https://doi.org/10.1002/ece3.8666
MAISRC Subproject 4.3 (M.L. 2017)

McEachran, M.C., Hofelich Mohr, A., Lindsay, T., Fulton, D.C. and Phelps, N.B.D. (2022), Patterns of Live Baitfish Use and Release among Recreational Anglers in a Regulated Landscape. North Am J Fish Manage, 42: 295-306. https://doi.org/10.1002/nafm.10747
MAISRC Subproject 25.2 (M.L. 2019)

Glisson, W., Contreras-Rangel, R., Bishop, W., & Larkin, D. (2022). Laboratory evaluation of copper-based algaecides for control of the invasive Macroalga Starry Stonewort (nitellopsis obtusa). Management of Biological Invasions, 13(2), 303–325. https://doi.org/10.3391/mbi.2022.13.2.04
MAISRC Subproject 8 (M.L. 2013)

Weber, M., Larkin, D., & Mulcahy, P. (2022). Creating informed consumers of aquatic invasive species management programs through online education for nonprofessionals. Invasive Plant Science and Management, 15(1), 41-48. doi:10.1017/inp.2022.10
MAISRC Subproject 10 (M.L. 2013)

Weber, M. M., & Cibulka, D. (2022). Overwinter survival of Corbicula fluminea in a central Minnesota Lake. PLOS ONE, 17(7). https://doi.org/10.1371/journal.pone.0271402
MAISRC Subproject 41 (non-ENRTF funding)

A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

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

Summary of Activities January 1 – June 30, 2023:

Newsletter and Social Media
MAISRC and the AIS Detectors program have active social media accounts on Facebook, Twitter/X, Instagram, and YouTube. For the period of January 1 – June 30, 2023, MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, had nearly 6,000 views, totalling over 300 hours of watch time. MAISRC's Twitter/X account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders. MAISRC recently launched an Instagram account, which gained 80 followers in its first month. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detector workshops, and share invasive species news. In addition, the MAISRC e-newsletter is currently received by over 5,000 individuals and continues to grow and share in-depth stories about MAISRC research and partnerships.

Earned Media
MAISRC's current media presence is growing. MAISRC coordinated with producers of local television show, Prairie Sportsman, to produce several TV segments on Minnesota's aquatic invasive species. Using the latest research, these educational segments were broadcast on local PBS channels and informed the public about the current state of AIS management happening in their backyard.

As a part of all media interactions, we continue to emphasize the value of the ENRTF and its impact on AIS research in Minnesota. Media highlights include:

Spielman, T. (2023, February 15). Research looks at most effective ways to spend money designated to fighting aquatic invasive species. *Outdoor News*. https://www.outdoornews.com/2023/02/15/research-looks-at-most-effective-ways-to-spend-money-designated-to-fighting-aquatic-invasive-species

Yoo, A. S. (2023, August 11). Help look for invasive species in Minnesota lakes next weekend. *Kare11.com*. https://www.kare11.com/article/news/local/breaking-the-news/help-look-for-invasive-species-minnesota-lakes-next-weekend/89-dff47beb-de31-4495-8b71-ed8007bfe8a2

MAISRC Website
Almost 18,000 users visited the MAISRC website through June 2023. The most visited pages concerned zebra mussel control, common carp, and Eurasian watermilfoil.

Peer-Reviewed Publications
A full list of MAISRC publications can be viewed on our website: https://www.maisrc.umn.edu/publications

Summary of Overall Dissemination Activities:

Website, social media, and e-newsletter
The MAISRC website has become a resource for AIS stakeholders across the state with an average of 40,000 users visiting the site each year. MAISRC launched an Instagram account this year and engaged 80 new followers in one month. MAISRC and the AIS Detectors program also have active social media accounts on Twitter/X, Facebook, and YouTube. MAISRC and AIS Detector's videos on YouTube, including webinars and project spotlights, have collected nearly 140,000 views, totalling an estimated 3,500 hours of watch time. MAISRC's Twitter/X account has grown into a popular means of connecting researchers, legislators, community organizations and nonprofits, and other AIS stakeholders, with over 1,500 followers. Social media posts continue to disseminate research findings, highlight behind-the-scenes project activities, promote MAISRC events and AIS Detector workshops, and share invasive species news. In addition, the MAISRC e-newsletter is currently received by over 5,000 individuals and continues to grow and share in-depth stories about MAISRC research and management tools.

Earned media
Over the course of the last five years, MAISRC has been in approximately 365 news stories in over 100 different outlets. The most common outlets have been the Star Tribune, Minnesota Public Radio, Outdoor News, and Pioneer Press. Recent local media spotlights include Fox9 and Kare11. Other notable outlets include the Associated Press and National Geographic.

Presentations, workshops/trainings, and events
Highlights from 2019-2023

- Held three AIS Research and Management Showcases to share MAISRC research updates, outcomes, and tools with 2,000+ attendees. Recordings of recent Showcase presentations can be found on the MAISRC YouTube page:
    - https://z.umn.edu/2020ShowcasePresentations
    - https://z.umn.edu/2021ShowcasePresentations
    - https://z.umn.edu/2022ShowcasePresentations
- AIS Detectors held 31 Core Course training sessions, certifying 300 Detectors across the state and bringing the program total of certified Detectors to 465
- Hosted six Starry Trek events with 200+ volunteers participating each time. Participating volunteers have found four new starry stonewort populations, as well as new zebra mussel, Eurasian watermilfoil, freshwater golden clam, and other AIS occurrences. A map of Starry Trek search locations and findings can be viewed online: https://z.umn.edu/StarryTrekMap

- Held three online Aquatic Invasive Species Management 101 courses which has been completed by 187 participants seeking to have a better understanding of what goes into AIS management and to become more informed consumers of AIS management programs.
- Partnered with MN DNR to host three Aquatic Plant Identification workshops with 40 participants each to better learn how to identify 60+ native and invasive aquatic plants for professional development or personal enrichment.
- AIS Detectors hosted 14 webinars on AIS and MAISRC research, reaching 2,600 live attendees and collecting nearly 5,450 views on YouTube. Webinar recordings can be viewed online: https://z.umn.edu/AISDetectorsWebinars
- Partnered with local communities to host two regional in person workshops: one at the Minnesota Landscape Arboretum, bringing together stakeholders from across the state of Minnesota to strategize about invasive carp solutions. Another workshop in Cass County, MN focused on learning from successful regional efforts to control aquatic invasive species by the Leech Lake Band of Ojibwe's Division of Resource Management, local water managers, and lake enthusiasts in the area.

Reports and other materials
Highlights from 2019-2023

- Created six videos, highlighting MAISRC subproject research
  - Raising zebra mussels in the lab
  - Volunteer monitoring leads to rapid response project
  - Anti-biofouling paint inhibits spread of zebra mussels
  - Mapping zebra mussels using multibeam sonar
  - Motivations and risks of illegal baitfish release
  - Enhancing Habitat and Diversity in Cattail-Dominated Shorelines
  - Currently filming for additional videos to be released, focusing on MAISRC partnerships
- Produced four annual research reports, summarizing research outcomes
  - 2022 Research Report, including an online interactive report
  - 2021 Research Report, including an online interactive report
  - 2020 Research Report
  - 2019 Research Report
- Created and maintain a series of interactive maps and tracking tools
  - MAISRC Work Around the State
  - AIS Explorer
  - MAISRC Milfoil App
  - PI Charter
- A report summarizing the MAISRC-hosted common carp workshop at the Minnesota Landscape Arboretum is forthcoming. MAISRC is supporting the collaboration by hosting an email group of all attendees who wish to participate and network.

Peer-reviewed publications
Peer-reviewed publications are an essential part of MAISRC's research and dissemination activities. A full list of over 100 peer-reviewed publications can be viewed on the MAISRC publication database: z.umn.edu/ais-publications

Data Repository at the University of Minnesota (DRUM)
To continue providing leadership in the AIS research field and to ensure proper stewardship and accessibility to MAISRC research data, MAISRC maintains a publicly accessible data repository in collaboration with the University Digital Conservancy. Thus far, MAISRC has contributed 26 sets of data to the DRUM, available here: https://conservancy.umn.edu/handle/11299/197773

Note: The MAISRC DRUM was established to ensure that all MAISRC data is made publicly available. However, not all MAISRC projects utilize this platform. Some MAISRC researchers upload their data to federal databases or in publications to align with data sharing standards within their individual fields of study or journal requirements.

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than $5,000:

- Subproject 21.2 – *ROV (Remotely Operated Vehicle) Deep Trekker ($5,822):* this subproject was significantly impacted by COVID-19 restrictions in 2020 and the research team actively sought out options that 1) reduced the number of field assistants that need to be in the field at any point in time, and 2) improve efficiency of field data collection methods. By purchasing an underwater ROV, the team a) reduced the burden on our dive team by completing pre-survey reconnaissance with the ROV instead of the dive team, b) efficiently collected video data to support the dive team mussel and substrate surveys, thus improving overall accuracy, and c) collected valuable video data for use in communications efforts related to zebra mussel habitat and to the project. The ROV will be retained by MAISRC at the conclusion of the subproject and MAISRC staff will provide oversight of the management of the ROV, to ensure that it is being used for the purpose of advancing AIS research in Minnesota.

- Subproject 39 – *Two Loligo Aquatic shuttle tank systems ($36,000)*: state of the art fish behavioral systems that include the ability to precisely control and measure CO_2 levels and are equipped with automatic fish tracking devices. Two systems allowed the testing of both small and large carp simultaneously. The conditioning and behavior are time intensive and the ability to run two sets of experiments concurrently provided end users with the information much more quickly than a single system would allow. These systems will be retained by MAISRC at the conclusion of the subproject for use by future MAISRC projects. Both fish and invertebrates can be tested using the systems, as well as other stimuli.

Explanation of Use of Classified Staff:

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

Enter Total Estimated Personnel Hours for entire duration of project: 58,594	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 28.17

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

Enter Total Estimated Contract Personnel Hours for entire duration of project: 707	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: 0.34

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding

All contractors and collaboraters outside of the UMN are selected in compliance with UMN contracting and subaward guielines.

- Subproject 21.2 – *Macalester* College: Dr. Daniel Hornbach, Chair and Professor in Dept. of Environmental Studies; Mark Hove; Dr. Kelly Macgregor, Professor in Dept. of Geology will collaborate on this project.

- Subproject 21.2 – *U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center (GCMRC):* Dr. Paul Grams, Research Hydrologist. Grams' research group specializes in physical and ecological studies in freshwater river systems. GCMRC has extensive experience in the use of multibeam sonar systems for mapping shallow river systems and is among the very few research facilities that are developing methods for acoustical bed substrate classification.
- Subproject 22.2 – *U.S. Geological Survey, Upper Midwest Environmental Sciences Center:* Dr. Diane Waller, Research Fishery Biologist, is the PI for Subproject 22.2.
- Subproject 22.2 – *RMB Laboratories:* RMB Laboratories will provide analysis of plankton, macroinvertebrate, and water chemistry. RMB Labs was contracted for testing for Phase I of this study (Subproject 22 on M.L. 2013) and was selected to complete lab work for Phase II to provide consistency and access to the type of testing required for the study.
- Subproject 33 – *University of Illinois Urbana-Champaign:* Dr. Eric Larson, Assistant Professor in Dept of Natural Resources and Environmental Sciences. Dr. Larson will collaborate with colleagues at the University of Minnesota regarding methodology, analysis, and interpretation results, and process a subset (20% of total samples; n=350) of eDNA samples at his laboratory at the University of Illinois Urbana-Champaign as an external validation on the majority of eDNA samples processed at the University of Minnesota, Duluth. Dr. Larson will also test the effect of preservation and extraction method upon DNA yield from a subset of samples. Dr. Larson will travel to Minnesota for one week during the first summer of the project (2021) to assist in training of University of Minnesota technicians and graduate students for eDNA sampling. The project will benefit from having Dr. Larson's expertise and laboratory to provide quality control and ensure we complete all our sample processing on time.
- Subproject 36 – *University of Wisconsin River Falls:* Dr. Scott Ballantyne, Professor in Dept of Biology. Dr. Ballantyne will help identify target genes, design experiments to optimize RNAi, oversee the production of dsRNA and GFP expressing bacterial strains, and guide the assays for zebra mussel feeding and survival.
- Subproject 36 – *Dr. Michael McCartney (private consultant):* will provide guidance and hands-on effort on the collection, husbandry, and phenotypic analysis of zebra mussels, and will assist in the scientific oversight of the UMGC technician carrying out the in vivo testing.
- Subproject 37 – *Epi Interactive:* Epi Interactive specializes in data visualization through the development of user-interfaces. For this subproject, Epi will expand the dashboard created in Subproject 31 in order to disseminate the results of the collaboration network analysis.
- Subproject 39 – *University of Illinois Urbana-Champaign:* Dr. Cory Suski, Professor in the Dept of Natural Resources and Environmental Sciences, and Dr. Clark Dennis (postdoctoral researcher). Dr. Suski is an expert on the effects of carbon dioxide on fishes and will help train and supervise research staff on the subproject. Dr. Dennis recently received his PhD from the UMN and is an expert on the BAFF. He will conduct most of the experiments in Activity 1.

B. Partners outside of project manager's organization NOT receiving ENRTF funding

- Subproject 1 – *MAISRC Center Advisory Board:* Advisory Board members are primarily external appointees who provide guidance and input to the Director and Associate Director.
- Subproject 1 – *Minnesota Department of Natural Resources:* MAISRC scientists and leadership coordinate with DNR in multiple ways as formalized in a memorandum of understanding, signed in 2013.
- Subproject 40 – *Minnesota Department of Natural Resources:* Shane McBride, Aquatic Plant Management Coordinator, will provide advice on lake selection and help with landowner

coordination. Donna Dustin, Fisheries Research Biologist, will provide advice on lake selection and aquatic plant mapping.

- Subproject 40 – *Voyageurs National Park:* will provide logistical support for travel to sites, cattail removal at study sites, and staff time for study treatments and data collection.

VII. LONG-TERM - IMPLEMENTATION AND FUNDING:

MAISRC was established to build long-term research capacity with support from the ENRTF. We have been able to leverage the initial financial support, most notably through the UMN (faculty positions, ICR) and external grant support. However, to ensure MAISRC continues to focus on the state's priorities and solutions-oriented research, additional ENRTF support is crucial.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted March 1 and September 1 each year of the project
- A final report and associated products will be submitted between June 30 and September 15, 2023

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

B. Visual Component or Map

C. Parcel List Spreadsheet – N/A

D. Acquisition, Easements, and Restoration Requirements – N/A

E. Research Addendum

Environment and Natural Resources Trust Fund
Minnesota Aquatic Invasive Species Research Center-- Subproject List

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Project Manager: Nicholas Phelps
Project Title: Building Knowledge and Capacity to Solve AIS Problems
Organization: University of Minnesota
College/Department/Division: Minnesota Aquatic Invasive Species Research Center
Project Budget: $4,000,000
Project Length and Completion Date: 4 Years; June 30, 2023
Current Date: September 27, 2023

Subproject Number	Subproject Title	Species	Project Manager	LCCMR Approval Date	Subproject End Date	Budget	Amount Spent	Balance	Status (select from dropdown menu)	Abstract Received
1	MAISRC Core Operations	Multiple	Nicholas Phelps	6/17/2019	6/30/2023	$ 855,380	$ 360,010	$ 495,370	Complete	**x**
21.2	Field validation of mulitbeam sonar zebra mussel detection (Year 2)*	Zebra mussels, Quagga mussels	Jessica Kozarek	7/1/2019	6/30/2022	$ 214,517	$ 214,517	$ 0	Complete	**x**
22.2	Assessing and refining copper-based treatment to suppress zebra mussel populations	Zebra mussels	Diane Waller	10/17/2020	6/30/2023	$ 249,056	$ 247,266	$ 1,790	Complete	x
23.2	AIS and tourism - A socio-economic assessment	Common carp, Zebra mussels, Starry stonewort	Amit Pradhananga	10/17/2020	6/30/2023	$ 249,088	$ 248,256	$ 832	Complete	x
25.2	Examining Motivations for Illegal Baitfish Release	Baitfish viruses	Nicholas Phelps	10/17/2020	12/31/2022	$ 74,636	$ 74,636	$ -	Complete	x
28.2	Enzyme-based Coatings to Suppress Priority AIS	Zebra mussels, Quagga mussels	Mikael Elias	10/17/2020	6/30/2023	$ 187,480	$ 187,480	$ -	Complete	x
33	Optimizing eDNA monitoring for multiple aquatic invasive species	Spiny water flea, Zebra mussels, Quagga mussels, Faucet snails, Rusty crayfish, Common carp	Josh Dumke	10/17/2020	6/30/2023	$ 436,331	$ 436,331	$ -	Complete	x
35	Genetic Biocontrol of Invasive Species - Understanding Attitudes and Risk Perceptions	Common carp, Zebra mussels	David Fulton	10/17/2020	6/30/2023	$ 209,313	$ 181,262	$ 28,051	Complete	x
36	RNA-interference screens for zebra mussel biocontrol target genes	Zebra mussels	Daryl Gohl	10/17/2020	12/31/2022	$ 255,979	$ 255,979	$ -	Complete	x
37	Improving the efficiency of watercraft inspections through coordination and cooperation	Zebra mussels, Starry stonewort, Eurasian watermilfoil, Spiny water flea	Amy Kinsley	10/17/2020	6/30/2023	$ 198,241	$ 198,241	$ -	Complete	x
38	Evaluating native Phragmites as a wastewater treatment alternative	*Phragmites australis*	Daniel Larkin	10/17/2020	6/30/2023	$ 355,122	$ 335,620	$ 19,502	Complete	x
39	Increasing effectiveness of bigheaded carp deterrents by carbon dioxide integration	Silver carp, Bighead carp, Grass carp, Black carp	Allen Mensinger	10/17/2020	6/30/2023	$ 340,327	$ 310,464	$ 29,863	Complete	x
40	Enhancing habitat and diversity in cattail-dominated shorelines	Hybrid/narrow leaf cattail	Amy Schrank	10/17/2020	6/30/2023	$ 338,066	$ 336,930	$ 1,136	Complete	x
	MAISRC Reserves		*Nicholas Phelps*	*6/17/2019*	*6/30/2023*	*$ 36,464*	$ -	*$ 36,464*		x
						$ 4,000,000	**$ 3,386,992**	**$ 613,008**		

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Subproject Budget - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Project Manager: Nicholas Phelps
Subproject Title: MAISRC Subproject 1: MAISRC Core Operations
Organization: University of Minnesota Twin Cities
College/Department/Division: Minnesota Aquatic Invasive Species Research Center
Subproject Budget: $855,380
Subproject Length and Completion Date: 4 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Revised Budget 09/15/2023	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)	**$ 736,358**	**$ 736,358**	**$ 335,719**	**$ 400,639**
PI/Project Manager- Phelps: $150,387 salary, $47,850 benefits (35% fringe rate) 50% FTE x 2 years FTE				
Co-Project Manager- Mattke: $159,935 salary, $55,977 benefits (35% fringe rate) 100% FTE x 2 years FTE				
Comm. & Admin Assistant: $112,488 salary, $32,622 benefits (29% fringe rate) 100% FTE x 2 years FTE				
Aquatic Laboratory Tech: $95,381 salary, $27,660 benefits (29% fringe rate) 75% FTE x 2 years, FTE TOTAL:				
1 Grad Student: $45,791 salary, $21,063 benefits (37% tuition, 9% fringe) 50% FTE x 2 years, FTE TOTAL: 1				
2 Undergraduate Students: $15,600 salary (0% fringe rate) 25% FTE x 2 years each, FTE TOTAL: 1				
Professional/Technical/Service Contracts	**~~$ 72,593~~**	**$ 72,593**	**$ 18,587**	**$ 54,007**
Services - Office & Gen Oper: printing/duplication, mailing, printer repairs, audio visual associated with seminars & conferences, conf. calls, surveys, insurance for shared equipment (pontoon, trailer) etc.	$ 8,000	$ 8,000	$ 6,157	$ 1,843
Services - Lab & Medical: reserve funds for support of MAISRC Containment Lab ISO; well permits, discharge licenses and fees, preventative maintenance and maintenance of shared lab facilities.	$ 36,443	$ 36,443	$ -	$ 36,443
Professional Services & Contracts: fees or honoraria for guest lecturer and speakers, etc.	~~$ 1,150~~	$ 1,800	$ 1,800	$ -
Repairs - Lab & Field: shared equipment; boats, transmitters, receivers, PCR machines, etc.	$ 15,000	$ 15,000	$ 3,110	$ 11,890
Rentals: space, facilities, and catering for conferences and outreach/dissemination events (e.g. annual Showcase, common carp workshop)	~~$ 12,000~~	$ 11,350	$ 7,519	$ 3,831
Equipment/Tools/Supplies	**$ 30,079**	**$ 30,079**	**$ 3,161**	**$ 26,918**
Supplies - Office and Gen Operating: paper, toner, folders, brochures, displays	$ 6,500	$ 6,500	$ 431	$ 6,069
Supplies - Lab and/or Field: piping, glue, gas, hoses for shared washdown and laboratory facilities; anesthesia, fish, fish food, gas for boats, replacement helio & LED bulbs for experiments; tanks, reagents, sampling supplies, and other consumables	$ 18,800	$ 18,800	$ 1,003	$ 17,797
Equipment - Non-Capital Lab and/or Field: storage containers; computer, software; trap nets, seine nets, dip	$ 4,779	$ 4,779	$ 1,727	$ 3,052
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**	**$ -**
Electrofishing Boat - portion of new electrofishing boat to be matched by additional funds (est $35,000)	$ -	$ -	$ -	$ -
Travel Expenses in Minnesota	**$ 16,000**	**$ 16,000**	**$ 2,543**	**$ 13,457**
Mileage, lodging, registration and meals for investigator travel to one conference a year to present findings; research needs assessment participants; consulting researchers; meetings and field work. All travel expenditures will be in alignment with UMN travel policy.	$ 16,000	$ 16,000	$ 2,543	$ 13,457
Other	**$ 350**	**$ 350**	**$ -**	**$ 350**
Telecommunications: voicemail service for MAISRC researchers and staff	$ 350	$ 350	$ -	$ 350
COLUMN TOTAL	$ 855,380	$ 855,380	$ 360,010	$ 495,370

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget		Spent	Balance
Non-State:		$ -		$ -	$ -
State: M.L. 2019 Chp. 4, Art. 1, Sec. 3, Subd. 3 -- MAISRC Legislative Appropriation		$ 1,020,000	$ 1,020,000	$ 961,356	$ 58,644
In kind:		$ -		$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget		Spent	Balance
Current appropriations: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a -- Aquatic Invasive Species Research Center -		$ 1,187,652	$ 1,187,652	$ 1,108,868	$ 78,784
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a -- Aquatic Invasive Species Research Center		$ 1,372,730	$ 1,372,730	$ 1,351,424	$ 21,306

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2017, M.L. 2019 Budget - Final
Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a; M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Jessica Kozarek
Subproject Title: MAISRC Subproject 21.2: Field validation of multibeam sonar zebra mussel detection
Organization: University of Minnesota Twin Cities
College/Department/Division: Saint Anthony Falls Laboratory
M.L. 2017 Subproject Budget: $14,247
M.L. 2019 Subproject Budget: $214,517
M.L. 2017 Subproject Length and Completion Date: 1 Year; June 30, 2020
M.L. 2019 Subproject Length and Completion Date: 1 Year; June 30, 2022
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Year 1: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 12,283**	**$ 12,283**	**$ -**
Subproject Manager (Jessica Kozarek); Researcher 6; $40,327($29,652 salary, $10,675 benefits at 36% benefit rate); 20%FTE for 2 years			
Associate Engineer (Chris Milliren); Camp Plan/Eng/Safe Prof 2; $27,184 ($21,223 salary, $6,261 benefits at 29.5% benefit rate); 20%FTE for 2 years			
Field Assistant (TBD); Temp/Casual; $12,612 ($11,656 salary, $956 benefits at 8.2% benefit rate);			
Instrumentation Specialist (Erik Steen); Job Class; $8,572 ($6,619 salary, $1,953 benefits at			
Student Researcher (TBD); Undergraduate; $5,181 ($5,181, $0 at 0%benefit rate); 10%FTE for 2 years			
Professional/Technical/Service Contracts	**$ 1,898**	**$ 1,898**	**$ -**
Matthew Kaplinski, private contractor ($59,562) - Lead acoustic remote sensing	$ -	$ -	$ -
USGS/Paul Grams ($10,000) - Provide acoustic equipment and advise field work	$ -	$ -	$ -
Macalester College/Daniel Hornbach, Kelly MacGregor, Mark Hove ($53,359) - Mussel and sediment surveys. Provide research vessel and SCUBA equipment.	$ 1,898	$ 1,898	$ -
Equipment/Tools/Supplies	**$ 66**	**$ 66**	**$ -**
Supplies - Lab and/or Field: Instrumentation mount, sediment lab supplies, power (batteries),	$ 66	$ 66	$ -
Equipment - Non-Capital Lab and/or Field: *NA*			
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
ROV (Remotely Opertated Vehicle) Deep Trekker			
Printing	**$ -**	**$ -**	**$ -**
Printing workshop materials	$ -	$ -	$ -
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
Field travel and expenses	$ -	$ -	$ -
Travel for one team member to present research findings and connect with practitioners at the Upper Midwest Stream Restoration Symposium in Feb 2020. Estimated cost includes $350 for conference registration and $200 for lodging, in alignment with UMN travel policy.	$ -	$ -	$ -
Travel for one team member to present overall research findings at the Minnesota Water Resource Conference in Oct 2020. Estimated cost includes $250 for conference registration, in alignment with	$ -	$ -	$ -
Other	**$ -**	**$ -**	**$ -**
Supplies - Office and Gen Operating: Instrumentation shipping	$ -	$ -	$ -
COLUMN TOTAL	$ 14,247	$ 14,247	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:				
Past appropriations: M.L. 2013, Chp. 52, Sec. 2, Subd. 06a MAISRC Subproject 21.1 - Early detection of zebra mussels using multibeam sonar		$ 96,549	$ 96,175	$ 374

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Diane Waller
Subproject Title: MAISRC Subproject 22.2: Assessing and refining copper-based treatment to suppress zebra mussel populations
Organization: U.S. Geological Survey
College/Department/Division: Upper Midwest Environmental Science Center
Subproject Budget: $249,056 ($175,556 USGS; $73,500 MAISRC)
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 175,556	$ 175,556	$ -
Research fishery biologist (Diane Waller); $17,006 ($11,826 salary, $5,180 benefits at 44% benefit rate); 0.04 FTE for 2 years			
Biologist (Todd Severson); $35,236 ($23,783 salary, $11,453 benefits at 48% benefit rate); 0.12			
Biologist (Matt Meulemans); $34,670 ($26,670 salary, $8,000 benefits at 30% benefit rate);			
Biologist (Jeremy Wise); $32,239 ($23,636 salary, $8,603 benefits at 36% benefit rate); 0.14 FTE			
Biologist (Matt Barbour); $28,006 ($22,067 salary, $5,939 benefits at 27% benefit rate); 0.13			
Professional/Technical/Service Contracts	$ -	$ -	$ -
Equipment/Tools/Supplies	$ -	$ -	$ -
Capital Expenditures Over $5,000	$ -	$ -	$ -
Printing	$ -	$ -	$ -
Travel Expenses in Minnesota	$ -	$ -	$ -
Other	$ -	$ -	$ -
COLUMN TOTAL	$ 175,556	$ 175,556	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: USGS Personnel - Principal Investigator - 0.04 FTE, $11,826 salary, $5,180	secured	$ 17,006	$ 17,006	$ -
In kind: USGS Equipment/Tools/Supplies	secured	$ 64,735	$ 64,735	$ -
In kind: USGS Travel	secured	$ 21,896	$ 21,896	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a MAISRC Subproject 22: Copper-based control - zebra mussel settlement and non-target impacts		$ 215,326	$ 215,326	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Nicholas Phelps
Subproject Title: MAISRC Subproject 22.2: Assessing and refining copper-based treatment to suppress zebra mussel populations
Organization: University of Minnesota Twin Cities
College/Department/Division: MAISRC
Subproject Budget: $249,056 ($175,556 USGS; $73,500 MAISRC)
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ -**	**$ -**	**$ -**
Professional/Technical/Service Contracts	**$ 63,115**	**$ 61,325**	**$ 1,790**
RMB Laboratories - Analysis of plankton, macroinvertebrate, and water chemistry. RMB Labs was contracted for testing for Phase I of study, was selected to complete lab work for Phase II to provide consistency and access to the type of testing required for the study. Selection of RMB Labs is in alignment with UMN contracting guidelines.	$ 39,940	$ 39,940	$ -
Diver TBD - Dive services for field work	$ 23,175	$ 21,385	$ 1,790
Equipment/Tools/Supplies	**$ 10,385**	**$ 10,385**	**$ -**
Supplies - Office and Gen Operating: N/A	$ -		$ -
Supplies - Lab and/or Field: EarthTecQZ	$ 10,385	$ 10,385	$ -
Equipment - Non-Capital Lab and/or Field: N/A	$ -		$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 73,500	$ 71,710	$ 1,790

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: Hennepin County - funds contributed for field work/diving	secured	$ 20,000	$ 20,000	$ -
Non-State: Private Donations - funds for Zebra Mussel Research Fellowship to support salary/fringe for graduate student	secured	$ 92,000	$ 85,992	$ 6,008
State: 2017 MAISRC Legislative Appropriation from Heritage Enhancement Fund-funds for additional project support	secured	$ 421	$ 421	$ -
State: 2019 MAISRC Legislative Appropriation from Heritage Enhancement Fund-funds for additional project support	secured	$ 3,361	$ 3,361	$ -
State: 2021 MAISRC Legislative Appropriation from Heritage Enhancement Fund-funds for additional project support	secured	$ 46,218	$ 36,966	$ 9,252
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a MAISRC Subproject 22: Copper-based control - zebra mussel settlement and non-target impacts		$ 215,326	$ 215,326	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Amit Pradhananga
Subproject Title: MAISRC Subproject 23.2: AIS impacts on tourism: A socio-economic assessment
Organization: University of Minnesota Twin Cities
College/Department/Division: Dept of Forest Resources
Subproject Budget: $249,087
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 224,746**	**$ 223,915**	**$ 831**
Researcher 6 (Pradhananga); $23,640 ($17,319 salary, $6,321 benefits at 36.5% benefit rate); 10% FTE per year for 2 years			
Researcher 5 (Levers); $34,806 ($25,499 salary, $9,307 benefits at 36.5% benefit rate); 20% FTE per year for 2 years			
Post-doctoral Researcher (1 Post-doc, TBD); $129,841 ($103,541 salary, $26,300 benefits at 25.4% benefit rate); 100% FTE per year for 2 years			
Undergraduate Research Assistants (4 students, TBD); $20,800 ($20,800 salary, $0 benefits at 0% benefit rate); 25% FTE per year for 2 years			
Professional/Technical/Service Contracts	**$ -**	**$ -**	**$ -**
Equipment/Tools/Supplies	**$ 1,148**	**$ 1,147**	**$ 1**
Supplies - Office and Gen Operating: Supplies for survey administration, interviews, and training materials (recording equipment, printing, particiant recruitment)	$ 1,148	$ 1,147	$ 1
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ 23,194**	**$ 23,194**	**$ -**
Field Travel and Expenses: Travel: Travel within Minnesota to collect onsite survey data from tourist sites across Minnesota (Activity 1) - 20 trips, approximately 4-5 overnights per trip for 4 students and 1-2 researchers, 300-500 miles per round trip; Travel within Minnesota to conduct focus groups with tourism-related businesses (Activity 2) - 6-8 overnight trips, 300-500 miles per round trip, lodging and per diem for 2 researchers and 1-2 students. Travel funds will be used to pay mileage (total of 26-30 trips, 300-500 miles per trip), accommodations (approx. 60 overnight stays for 4 students, 1-2 researchers, 1-2 rooms per night, approximately $100 per room/night) and per diem costs for researchers, and undergraduate students (per diem per day of surveying, total of at least 45 survey	$ 23,194	$ 23,194	$ -
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 249,088	$ 248,256	$ 832

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

OTHER ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Nicholas Phelps
Subproject Title: MAISRC Subproject 25.2: Examining motivations for illegal baitfish release
Organization: University of Minnesota Twin Cities
College/Department/Division: Dept of Fisheries, Wildlife, and Conservation Biology
Subproject Budget: $74,636
Subproject Length and Completion Date: 2 Years; December 31, 2022
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 44,170**	**$ 44,170**	**$ -**
Graduate Research Assistant (Meg McEachran); $48,828 total ($40,724 salary, $8104 tuition and fringe at 19.9% benefit rate); 0.50 FTE for 18 months			
Postdoctoral Associate (TBD); $20,913 total ($16,675 salary; $4,238 fringe rate at 25.4%); 0.3 FTE for 12 months			
Survey Design Support (LATIS: Abbey Hammel); Job Class; $370.70 (at $38.02 s+f hourly equivalent, 31.8% fringe rate; 1.25% FTE weekly for 19.5 weeks)			
Survey Design Support (LATIS: Thomas Lindsay); Job Class; $655.20 (at $67.20 s+f hourly equivalent, 36.5% fringe rate; 1.25% FTE weekly for 19.5 weeks)			
Professional/Technical/Service Contracts	**$ 17,829**	**$ 17,829**	**$ -**
UMN Research Methodology Consulting Center/Ethan Brown ($3,915; 45 hours at $87/hour) - Data collection, management, and analytical support; technical support for structural equation modeling, analysis, and interpretation. Selected in alignment with UMN contrating policy.	$ 4,350	$ 4,350	$ -
UMN Addressing and Mailing Services - Postage + labor costs for 8,000 survey invitations, 8,000 follow-up reminders, 4,000 second reminders. Selected in alignment with UMN contracting policy.	$ 13,479	$ 13,479	$ -
Equipment/Tools/Supplies	**$ -**	**$ -**	**$ -**
Supplies - Office and Gen Operating: Miscellaneous project supplies (i.e. lab note books, external hardrive, flash drive, etc.	$ -	$ -	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ 4,712**	**$ 4,712**	**$ -**
Printing cost estimates for 8,000 survey invites, 8,000 follow-up reminders + 4,000 second reminders from UMN Printing Services	$ 4,712	$ 4,712	$ -
Travel Expenses in Minnesota	**$ 105**	**$ 105**	**$ -**
Travel - MN: Travel for one project team member to present at one in-state conference. Includes poster printing ($100), registration ($300), mileage ($100), lodging ($300), per diem ($200), in alignment with UMN travel policies.	$ 105	$ 105	$ -
Other	**$ 7,820**	**$ 7,820**	**$ -**
Travel - Domestic: Travel for project team member to present at one national conference (3-5 nights). Includes registration ($600), travel ($600), lodging ($1,200), per diem ($500), and poster printing ($100), in alignment with UMN travel policies.	$ 150	$ 150	$ -
Survey Incentives: $1 bill incetives for survey respondents (8,000 total)	$ 7,670	$ 7,670	$ -
COLUMN TOTAL	$ 74,636	$ 74,636	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriations:		$ -	$ -	$ -
Past appropriations: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a MAISRC Subproject 25: What's in Your Bucket? Quantifying AIS Introduction Risk		$ 84,094	$ 84,094	$ -
M.L. 2018, Chp. 82, Sec. 2, Subd. 06a MAISRC Subproject 25: What's in Your Bucket? Quantifying AIS Introduction Risk		$ 111,642	$ 101,540	$ 10,102

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Mikael Elias
Subproject Title: MAISRC Subproject 28.2: Enzyme-based Coatings to Suppress Priority AIS
Organization: University of Minnesota Twin Cities
College/Department/Division: BioTechnology Institute
Subproject Budget: $187,480
Subproject Length and Completion Date: 2.5 years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 158,480**	**$ 158,480**	**$ -**
Project Manager/PI (Elias); $6,961 ($5,100 salary; $1,861 benefits at 36.5% benefit rate); 0.02 FTE for			
Co-PI (Hicks); $7,493 ($5,489 salary; $2,004 benefits at 36.5% benefit rate); 0.02 FTE for 2 years			
Researcher 6; $90,560 ($66,344 salary; $24,216 benefits at 36.5% benefit rate); 0.25 FTE for Year 1; 1.0 FTE for Year 2			
Postdoctoral Fellow; $47,966 ($38,250 salary; $9,716 benefits at 25.4% benefit rate); 0.75 FTE for 1			
Professional/Technical/Service Contracts	**$ 5,000**	**$ 5,000**	**$ -**
Sampling/Diving Support (Contractor TBD) - Coupons installation in the Duluth Superior Harbor to perform the experiments proposed in Activity 2.	$ -	$ -	$ -
UMN Bioresource Center - production of proteins to be used in field testing	$ 5,000	$ 5,000	$ -
Equipment/Tools/Supplies	**$ 24,000**	**$ 24,000**	**$ -**
Supplies Lab and/Field - Funds are for producing and optimizing lactonase enzyme materials for lab testing, as well as routine lab supplies (chemicals, flasks, pipettes, disposable plasticware, for example test tubes and petri plates, as well as media needed for production of molecular biology reagents made in the lab). Core facility costs (DNA sequencing and protein production): will cover costs associated with the production of our biofouling inhibitor and with 'reading' the DNA of microbial	$ 24,000	$ 24,000	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
Field Travel and Expenses - Travel in field sites in Minnesota. Travel and expenses will include mileage and per diem in alignment with UMN travel policies.	$ -	$ -	$ -
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 187,480	$ 187,480	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Faculty salary time paid by the UMN that will be devoted on the project over the rest of summer months and University indirect cost match (54% mtdc)	secured	$ 99,350	$ 89,343	$ 10,007

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations: M.L. 2017, Chp. 96, Sec. 2, Subd. 06a MAISRC Subproject 28: Evaluating Innovative Coatings to Suppress Priority AIS		$ 51,234	$ 51,234	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Josh Dumke
Subproject Title: MAISRC Subproject 33: Optimizing eDNA monitoring for multiple AIS
Organization: University of Minnesota Duluth
College/Department/Division: Natural Resources Research Institute
Subproject Budget: $436,331 ($253,674 NRRI, $182,657 UMN)
Subproject Length and Completion Date: 2.5 years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 173,586**	**$ 173,586**	**$ -**
Josh Dumke; 9742R5, P&A; $35,212 ($25,797 salary, $9,415 benefits at 36.5%); 0.2 FTE for 2 years			
Chan Lan Chun; 9403, Faculty; $19,872 ($14,559 salary, $5,313 fringe at 36.5%); 0.25 FTE for 2 years			
Robert Hell; 4946, BU; $17,844 ($13,539 salary, $4,305 benefits at 31.8 %); 0.175 FTE for Year 1; 0.08 FTE for Year 2			
Holly Wellard Kelly; 4946, BU; $8,912 ($6,762 salary, $2,150 benefits at 31.8%); 0.071 FTE for 2 years			
Graduate Student; 9521/9572; $86,572 ($44,804 salary, $41,768 benefits at 19.9% fringe, $21.06/hour tuition reimbursement); 0.5 FTE Academic Year 1, 0.5 FTE Academic Year 2; 0.5 FTE Summer Year 1 and 0.5 FTE Summer Year 2			
Undergraduate Technician; 2226; $5,341 ($5,341 salary, $0 benefits at 0%); 0.11 FTE for 2 years			
Professional/Technical/Service Contracts	**$ 24,868**	**$ 24,868**	**$ -**
Erik Larson U of Illinois - Larson will collaborate with colleagues at the UMN regarding methodology, analysis, and interpretation of results, and process a subset (20% of total samples; n=350) of eDNA samples at his laboratory at the University of Illinois Urbana-Champaign as an external validation on the majority of eDNA samples processed at the UMD. Larson will also test the effect of preservation and extraction method upon DNA yield from a subset of samples. Selected in alignment with UMN contracting guidelines.	$ 24,868	$ 24,868	$ -
UMN Genomics Center - ddPCR user fee ($2,188) - ddPCR - droplet digital PCR for quantification of DNA copy number when very little DNA is in the environment. 25% of Y1 OBJECTIVE 2 samples will pair qPCR with ddPCR (assuming qPCR will occur in Y1, and ddPCR will occur in Y2). ddPCR: 500 obj 2 samples x 0.25 = 125 samples x 3 species x $5.06/sample/species ($1898)+ 25 x 1 species (SLRE common carp) x $5.06/sample/species ($127) + required training ($163). Selected in alignment with	$ -	$ -	$ -
Equipment/Tools/Supplies	**$ 47,031**	**$ 47,031**	**$ -**
Supplies - Lab and/or Field: eDNA field collection supplies (filters, funnels, forceps, baggies); wet suits and snorkel kits; gas for work boat; batteries, write in rain paper, pencils, markers; bleach for disinfection; nitrile gloves; ETOH preservative; PPE (sunscreen, bug spray, polarized safety glasses). NRRI team visiting 7 lakes over project period for Obj 1 and 2.	$ 10,147	$ 10,147	$ -
Supplies - Lab and/or Field: Extraction - amplification and extraction of DNA required for all samples (n=1,650); qPCR - quantification of DNA copy number required for all samples per species (1,650 x ave 3.8 species is n=6,220); ddPCR - droplet digital PCR for quantification of DNA copy number when very little DNA is in the environment (125 samples x ave 3.2 species is n=400).	$ 36,884	$ 36,884	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
			$ -
Printing	**$ -**	**$ -**	**$ -**
Printing outreach handouts at UMN or UMD Print shop (quantity 200 at est. $1/ea)	$ -	$ -	$ -
Travel Expenses in Minnesota	**$ 7,123**	**$ 7,123**	**$ -**
Field Travel and Expenses: Y1 visit 5 lakes for objective 2 and visit 3 lakes for objective 1. Y2 visit 2 lakes for obj 1. All obj 1 lakes visited 5 times as day-trips. Two weeks lodging, per diem, mileage to sample Lake of the Woods, Vermilion, and Shagawa for objective 2 in Y1 ($5,806). Two 2-day trips for graduate student to travel to UM Genomic Center for ddPCR sample processing ($927). Current GSA	$ 7,093	$ 7,093	$ -
Other Minnesota Travel - Attend MAISRC showcase (300 mi x $0.575)+($10/day truck fee) each year ($366).	$ 30	$ 30	$ -
Other	**$ 1,066**	**$ 1,066**	**$ -**
Shipping ($100) - Shipping of preserved samples to Eric Larson lab at U of Illinois	$ 107	$ 107	$ -
Out-of-state travel: Conference travel to send 2 NRRI project members to Upper Midwest Invasive Species (UMISC) conference in Green Bay to present findings	$ 959	$ 959	$ -
COLUMN TOTAL	$ 253,674	$ 253,674	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered Indirect Costs	Secured	$ 116,024	$ 116,024	$ -
In kind: Ramsey County - Contribution towards the project for eDNA-related supplies	Secured	$ 2,386	$ 2,386	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Gretchen Hansen
Subproject Title: MAISRC Subproject 33: Optimizing eDNA monitoring for multiple AIS
Organization: University of Minnesota Twin Cities
College/Department/Division: Dept of Fisheries, Wildlife, and Conservation Biology
Subproject Budget: $436,331 ($253,674 NRRI, $182,657 UMN)
Subproject Length and Completion Date: 2.5 years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 162,255**	**$ 162,255**	**$ -**
Gretchen Hansen; 9403, Faculty; $18,338 ($13,435 salary, $4,903 benefits at 36.5%); 0.2 FTE for 2			
Graduate Student; 9521/9572; $92,823 ($50,018 salary, $42,805 benefits at 19.9% fringe, $21.06/hour tuition reimbursement); 0.5 FTE Academic Year 1, 0.5 FTE Academic Year 2; 0.5 FTE Summer Year 1 and 0.5 FTE Summer Year 2			
Technician; 8354R4, CS; $41,562 ($31,534 salary, $10,028 benefits at 31.8%); 0.33 FTE for 2 years			
Professional/Technical/Service Contracts	**$ -**	**$ -**	**$ -**
Equipment/Tools/Supplies	**$ 10,434**	**$ 10,434**	**$ -**
Supplies - Lab and/or Field: eDNA field collection supplies (filters, funnels, forceps, baggies); batteries, write in rain paper, pencils, markers; bleach for disinfection; nitrile gloves; ETOH preservative; PPE (sunscreen, bug spray, polarized safety glasses). Sample collection/delivery - 10 metro area lakes and 6 remote lakes, 5 times/year. Metro sampling costs based on $15 in boat gas per visit. Remote lakes will be sampled 5 times (all lakes sampled on same multi-day trip), and costs estimated as $100 in boat gas per trip. UMN team visiting 16 Objective 1	$ 10,434	$ 10,434	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ 9,118**	**$ 9,118**	**$ -**
Field Travel and Expenses: Sample collection/delivery - 10 metro area lakes and 6 remote lakes, 5 times/year. Metro sampling costs based on $28.75 in mileage costs per visit. Remote lakes will be sampled 5 times (all lakes sampled on same multi-day trip), and costs estimated as $287.50 in mileage, 2 nights lodging for 2 people at $180/night, 3 days of meals for 2 people at standard per diem rate of $54/day (actual costs will be reimbursed). Also included is $236 in mileage costs for driving samples to Duluth for lab analysis.	$ 7,704	$ 7,704	$ -
Field Travel and Expenses: Field and lab training - travel to Duluth for a training and coordination meeting. Costs estimated as $178.25 in mileage costs, 2 nights lodging for 2 people @$150/night, and meal costs as 2 travel days @$45/day and 1 full day @$54/day for 2people (actual costs will be	$ 1,064	$ 1,064	$ -
In-state conferences and meetings - MN AFS, lake association meetings, DNR meetings. Costs estimated as $207.58 in mileage, $150 in conference registration fees, 2 nights lodging at $160/night, and meal costs as 2 travel days @$45/day and 1 full day @$54/day (actual costs will be reimbursed). Travel expenses are in alignment with UMN travel policy.	$ 350	$ 350	$ -
Other	**$ 850**	**$ 850**	**$ -**
Shipping costs to send filters to lab	$ 200	$ 200	$ -
Travel - Domestic: Travel for one team member to present results at a national conference (e.g., Joint Aquatic Sciences meeting in May 2022 in Grand Rapids, MI). Costs calculated as $405 airfare, $450 conference registration, 4 nights lodging @$180/night, and 5 days of meals at $54/day (costs are estimated, actual expenses will be reimbursed). Travel expenses are in alignment with UMN	$ -	$ -	$ -
Boat Maintenance: Sample collection/delivery - 10 metro area lakes and 6 remote lakes, 5 times/year. Metro sampling costs based $10 in boat maintenance costs per visit. Remote lakes will be sampled 5 times (all lakes sampled on same multi-day trip), and costs estimated as $30 in boat	$ 650	$ 650	$ -
COLUMN TOTAL	$ 182,657	$ 182,657	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered Indirect Costs	Secured	$ 84,759	$ 84,759	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: David C. Fulton
Subproject Title: MAISRC Subproject 35: Genetic biocontrol of invasive species: understanding attitudes and risk perceptions
Organization: University of Minnesota Twin Cities
College/Department/Division: Dept of Fisheries, Wildlife, and Conservation Biology
Subproject Budget: $209,313
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 102,266**	**$ 102,266**	**$ -**
Graduate Research Assistant (TBD); $93,693 ($49,978 salary, $43,715 benefits at 19.9% benefit rate); 0.5 FTE for 2 years			
Postdoc Research Associate(TBD); $37,620 ($30,000 salary, $7,620 benefits at 25.4% benefit rate); 0.5 FTE for 1 years			
Professional/Technical/Service Contracts	**$ 16,000**	**$ 7,890**	**$ 8,110**
List of MN residents from commercial vendor (TBD) - A random household sample of n = 6000 adult Minnesota residents is needed to develop a probabilistic sample that will enable study results to be generalized back to the adult, general public study population. List will be used to contact potential general public respondents to the study questionnaire. Unlike for anglers and boaters, a publicly available, open source sample of the general public is not available, so common research practice is to purchase a high quality, random sample from private sector sources that create and maintain such lists for use in marketing and policy research. We will obtain quotes from at least 3 private sector vendors using address-based sampling to ensure the most competitive pricing.	$ 6,000	$ 3,820	$ 2,180
Qualtrics - Collection of up to 1,000 additional survey respondents through Qualitrics survey platform.	$ 10,000	$ 4,070	
Equipment/Tools/Supplies	**$ -**	**$ -**	**$ -**
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ 91,047**	**$ 71,106**	**$ 19,941**
UMN Mailing and Printing Services ($48000) - Print & mail a total of 48,000 envelopes and contact letters for the survey pre-test and final data collection (3 rounds)	$ 91,047	$ 71,106	$ 19,941
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
			$ -
Other	**$ -**	**$ -**	**$ -**
Incentives for focus groups ($9000, 18*10*$50) and mail respondents ($16,000*$1)	$ -		$ -
COLUMN TOTAL	$ 209,313	$ 181,262	$ 28,051

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Salary and benefits for David Fulton 10% of $190,000 for 2 years ($38,000)		$ 38,000	$ 38,000	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Daryl M. Gohl, PhD.
Subproject Title: MAISRC Subproject 36: RNA-interference screens for zebra mussel biocontrol target genes
Organization: University of Minnesota Twin Cities
College/Department/Division: University of Minnesota Genomics Center
Subproject Budget: $255,979
Subproject Length and Completion Date: 2 Years; December 31, 2022
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 119,633**	**$ 119,633**	**$ -**
PI (Daryl Gohl); Researcher 7; $28,788 ($21,090 salary, $7,698 benefits at 36.5% benefit rate); 0.083 FTE for 2 years			
Technician (TBD); Researcher 2/3; $62,212 ($45,577 salary, $16,635 benefits at 36.5% benefit rate); 0.5 FTE 6 calendar months effort/year for 2 years			
Work Study Student (TBD); $9,360; 3 calendar months effort/year for 2 years			
Professional/Technical/Service Contracts	**$ 122,694**	**$ 122,694**	**$ -**
Scott Ballantyne, PhD, University of Wisconsin River Falls (2.38 calendar months/year, 19.38% effort, $26,214/year): Will help identify target genes, design experiments to optimize RNAi, oversee the production of dsRNA and GFP expressing bacterial strains, and guide the assays for zebra mussel feeding and survival. Selection of Ballantyne as a collaborator is in alignment with UMN contracting	$ 52,428	$ 52,428	$ -
Michael McCartney, PhD (2 calendar months/year, 16.67% effort, $25,000/year): Will provide guidance and hands-on effort on the collection, husbandry, and phenotypic analysis of zebra mussels, and will assist in the scientific oversight of the UMGC technician carrying out the in vivo testing. Selection of McCartney as a collaborator is in alignment with UMN contracting guidelines.	$ 49,999	$ 49,999	$ -
UMN Genomics Center: Will provide qPCR and RNA-Seq services for quantifying RNAi knock-down efficacy. Due to the UMGC discontinuing its Sanger sequencing service, we will use an alternative outsourced provider (Azenta Life Sciences) for this service. We also anticipate spending some of these funds at either the University Imaging Center or the CTSI Histology lab.	$ 8,816	$ 8,816	$ -
UMN Veterinary Diagnostic Lab: Histology services for characterizing reproductive phenotypes.	$ -		$ -
UMN Imaging Centers: Electron microscopic characterization of shell phenotypes.	$ -		$ -
MAISRC Containment Lab - Rental of BSL2 research space and growth chambers (2 13-week	$ 11,451	$ 11,451	$ -
Equipment/Tools/Supplies	**$ 11,905**	**$ 11,905**	**$ -**
Supplies - Lab and/or Field: Synthetic DNA constructs for dsRNA production, competent cells for making dsRNA-producing bacterial strains, RNA extraction reagents, oligonucleotide and probe synthesis for qPCR quantification, miscellaneous lab consumables and labware, field supplies for	$ 10,665	$ 10,665	$ -
Equipment - Non-Capital Lab and/or Field: algal growth cylinders	$ 1,240	$ 1,240	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ 1,747**	**$ 1,747**	**$ -**
Field Travel and Expenses: Field travel for collection of samples from 4 study sites. Estimated 34 trips/year. Estimated total milage cost for two year study is $2,000.	$ 1,747	$ 1,747	$ -
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 255,979	$ 255,979	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Supplies for constructing zebra mussel collection devices	secured	$ 563	$ 563	$ 0

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Amy Kinsley
Subproject Title: MAISRC Subproject 37: Improving the efficiency of watercraft inspections through coordination and cooperation
Organization: University of Minnesota Twin Cities
College/Department/Division: Dept of Veterinary Population Medicine - Ecosystem Health Division
Subproject Budget: $198,241
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 108,441**	**$ 108,441**	**$ -**
Amy Kinsley, Assistant Professor, $62,174 ($45,549 salary, $16,625 benefits at 36.5% benefit rate); 0.21 FTE for 2 years			
Post-doc; Post-doc, $71,067 ($56,672 salary, $14,395 fringe 25.4% benefit rate); 0.55 FTE for 2 years			
Robert Haight; Research Forester; $0; 10% unpaid FTE for 2 years			
Professional/Technical/Service Contracts	**$ 89,800**	**$ 89,800**	**$ -**
Epi-Interactive: Epi-Interactive specializes in data visualization through the development of user-interfaces and created the dashboard that will be expanded during this project. The dashboard will be used to disseminate the results of the collaboration network analysis. Selection of Epi-Interactive as a contractor is in compliance with UMN contracting guidelines.	$ 45,000	$ 45,000	$ -
Cplex/GAMS software: License for the Cplex/CAMS software is needed to run the decision optimization model to estimate the benefits and costs of allocating watercraft inspectors for the entire state of Minnesota, described in Objective 1. We will update and maintain our Cplex/GAMS license to support optimization analyses and any needed revisions for the duration of the project. The license is approximately $10,000/year for a total of $20,000 for two years.	$ 9,600	$ 9,600	$ -
New Jersey Institute of Technology (NJIT): Collaboration with Dr. Wenbo Selina Cai in order to build a game-theoretic framework where county planners can be incentivized to clean up more risky boats and improve the overall outcome for each county.	$ 35,200	$ 35,200	$ -
Equipment/Tools/Supplies	**$ -**	**$ -**	**$ -**
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ -**	**$ -**	**$ -**
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 198,241	$ 198,241	$ -

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State: M.L. 2019 Chp. 4, Art. 1, Sec. 3, Subd. 3 -- MAISRC Legislative Appropriation	Secured	$ 100,000	$ 99,500	$ 500
In kind:		$ -	$ -	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final

Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Daniel Larkin
Subproject Title: MAISRC Subproject 38: Evaluating native *Phragmites* as a wastewater treatment alternative
Organization: University of Minnesota Twin Cities
College/Department/Division: Dept of Fisheries, Wildlife, and Conservation Biology
Subproject Budget: $355,122
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Revised Budget 09/15/2023	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)	**$ 318,110**	**$ 318,110**	**$ 305,514**	**$ 12,596**
D. Larkin, PI, Associate Professor: $13,728, (73% salary, 27% benefits) 0.038 FTE for years 1 and 2 (2 weeks summer salary per year for 2 years)				
W. Sadok, Co-PI, Assistant Professor: $12,773, (73% salary, 27% benefits) 0.038 FTE for years 1 and 2 (2 weeks summer salary per year for 2 years)				
J. Bohnen, Research Fellow: $166,085, (73% salary, 27% benefits) 1 FTE for years 1 and 2				
Graduate research assistant: $92,824 (52% salary, 48% benefits during academic year, 85% salary and 15% benefits during summer), 0.50 FTE for 2 years				
Undergraduate research assistant to assist with field and laboratory experiments and measurements, total of 600 hours ($12 per hour, 0% fringe rate).				
Professional/Technical/Service Contracts	**$ -**	**$ -**	**$ -**	**$ -**
Equipment/Tools/Supplies	**$ 26,500**	**$ 26,500**	**$ 20,879**	**$ 5,621**
Supplies - Lab and/or Field: Supplies/maintenance of Li6800, pots, containers, growing media, microscopy supplies, and related supplies and consumables for carrying out water-removal experiments and associated measurements. Containers, shovels, gardening supplies, transect tapes, sampling frames, and other consumables and supplies for collecting field data and plant materials and	$ 12,500	$ 12,500	$ 11,757	$ 743
Equipment - Non-Capital Lab and/or Field: Precision balances, Gantry system for weight measurements to estimate water removal, and portable air conditioner unit to prevent heat	$ 14,000	$ 14,000	$ 9,122	$ 4,878
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**	**$ -**
Printing	**$ -**	**$ -**	**$ -**	**$ -**
Travel Expenses in Minnesota	**$ 1,500**	**$ 1,500**	**$ 1,278**	**$ 222**
Field Travel and Expenses: Single-day and overnight trips throughout Minnesota for in situ field measures and collection of materials for experiments. Trips will typically include two project personnel who, for COVID-19 safety, will travel in separate vehicles and, when applicable, lodge in separate rooms. Approximately 24 trips, each averaging 200 miles round trip at $0.55 per mile (x2 vehicles). Lodging for 16 nights over the course of the project at GSA rate of $96 per night (x2 rooms). Per diem for 32 dates at either $55 (full day) or $41.25 (travel day) (x2 people). Travel expenses in	$ 1,500	$ 1,500	$ 1,278	$ 222
In-state Conferences/Meetings: Single-day and overnight trips in Minnesota for meetings with stakeholders and presentations at outreach and scientific meetings (e.g., UMISC, State of Water Conference). Meetings will typically include two project personnel who, for COVID-19 safety, will travel in separate vehicles and, when applicable, lodge in separate rooms. Approximately 4 trips, each averaging 200 miles round trip at $0.55 per mile (x2 vehicles). Lodging for 6 nights over the course of the project at GSA rate of $96 per night (x2 rooms). Per diem for 8 dates at either $55 (full day) or $41.25 (travel day) (x2 people). Travel expenses in alignment with UMN travel policy.	$ -	$ -	$ -	$ -
Other	**$ 9,012**	**$ 9,012**	**$ 7,949**	**$ 1,063**
Rental of dedicated greenhouse space in the CFANS Plant Growth Facility ($313/month for two years)	~~$ 7,512~~	$ 8,012	$ 7,949	$ 63
Rental of Vapor Pressure Deficit chambers and high-throughput small balance system ($500/month for 3 months)	~~$ 1,500~~	$ 1,000	$ -	$ 1,000
COLUMN TOTAL	$ 355,122	$ 355,122	$ 335,620	$ 19,502

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget		Spent	Balance
Non-State:		$ -		$ -	$ -
State:		$ -		$ -	$ -
In kind: UMN Sadok Lab (Dr. Walid Sadok) - Vapor Pressure Deficit Chambers	secured	$ 1,500		$ 1,500	$ -

OTHER ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget		Spent	Balance
Current appropriation:		$ -		$ -	$ -
Past appropriations:		$ -		$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Allen Mensinger
Subproject Title: MAISRC Subproject 39: Increasing effectiveness of bigheaded carp deterrents by carbon dioxide integration
Organization: University of Minnesota Duluth
College/Department/Division: Dept of Biology
Subproject Budget: $339,106
Subproject Length and Completion Date: 2.5 Years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Revised Budget 09/15/2023	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)	~~$ 142,882~~	$ 142,798	$ 137,925	$ 4,873
Project Manager/PI (Allen Mensinger); $30,880 ($22,623 salary, $8,257 benefits at 36.5% benefit rate); 0.083 FTE for 2 years				
Graduate Assistant (Culotta); $81,002 ($39,747 salary, $41,255 benefits, benefit rate including tuition); 0.5 FTE for 2 years				
Graduate Assistant (Schrope); $13,000 ($10,843 salary, $2,157 benefits ar 19.9% benefit rate; 0.5 FTE for 1 year				
Professional/Technical/Service Contracts	~~$ 141,202~~	$ 141,286	$ 128,827	$ 12,459
MAISRC Containment Lab - Rental of fish bays and included equipment	~~$ 14,617~~	$ 14,701	$ 14,701	$ -
University of Illinois ($126,585) - Contract includes Manager/Collaborator Dr. Cory Suski ($3,000 salary/benefits; 0.02 FTE for 1 year), Post-Doctoral Researcher ($60,667 salary/benefits; 0.7 FTE for 1.5 years), Lab/Field Supplies ($36,521), travel to Minnesota research site ($6,025), and travel to one national fisheries meeting to present research results ($1,710)	$ 126,585	$ 126,585	$ 114,126	$ 12,459
Equipment/Tools/Supplies	~~$ 20,325~~	$ 22,937	$ 22,937	$ -
Supplies - Office and Gen Operating: N/A	$ -	$ -	$ -	$ -
Supplies - Lab and/or Field: Carp, feed, carbon dioxide and compressed air cylinder rental, gas regulators, tubing and diffusers, plumbing, nets, water test kits, holding tanks	~~$ 17,325~~	$ 9,152	$ 9,152	$ -
Equipment - Non-Capital Lab and/or Field: Custom shuttle tank (made by PI) for large fish including 2 x 3 m fiberglass tanks, one rectangular passage tank, and associated plumbing	~~$ 3,000~~	$ 13,785	$ 13,785	$ -
Capital Expenditures Over $5,000	~~$ 24,000~~	$ 21,388	$ 16,488	$ 4,900
Two Loligo Aquatic shuttle tank systems for CO2 experiments	~~$ 24,000~~	$ 21,388	$ 16,488	$ 4,900
Printing	$ -	$ -	$ -	$ -
Travel Expenses in Minnesota	$ 11,918	$ 11,918	$ 4,287	$ 7,631
Field Travel and Expenses - Overnight travel between Duluth and Twin Cities. PI will visit MAISRC once per month (3 day weekend with 2 night lodging) and graduate student will visit UMD one overnight trip per month to facilitate collaboration between PI, student, and MAISRC. An additional week of lodging for the PI to set up the experiments in MAISRC Containment Lab. Total 48 trips for duration of the project. Includes lodging, mileage, and per diem in alignment with UMN travel policy.	$ 9,918	$ 9,918	$ 4,287	$ 5,631
In-State Conferences/Meetings - Travel support for PI and student to attend instate meetings (i.e. MN DNR annual meeting) to disseminate research results. Includes registration fees, lodging, and mileage in alignment with UMN travel policy.	$ 2,000	$ 2,000	$ -	$ 2,000
Other	$ -	$ -	$ -	$ -
		$ -		$ -
COLUMN TOTAL	$ 340,327	$ 340,327	$ 310,464	$ 29,863

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget		Spent	Balance
Non-State:		$ -		$ -	$ -
State:		$ -		$ -	$ -
In kind: Mensinger/UMD will provide all acoustics equipment for sound trials including speakers, amplifiers, hydrophones, recording equipment, and 3 axis accelerometers to measure both sound pressure and particle motion.	secured	$ 10,000		$ 10,000	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget		Spent	Balance
Current appropriation:		$ -		$ -	$ -
Past appropriations:		$ -		$ -	$ -

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final
Legal Citation: M.L. 2019, 1st Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 6(a)
Subproject Manager: Amy J Schrank
Subproject Title: MAISRC Subproject 40: Enhancing habitat and diversity in cattail-dominated shorelines
Organization: Minnesota Sea Grant
College/Department/Division: N/A
Subproject Budget: $338,066
Subproject Length and Completion Date: 2.5 years; June 30, 2023
Today's Date: September 27, 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	**$ 172,656**	**$ 171,520**	**$ 1,136**
Project Manager (A. Schrank); Assistant Extension Professor; $18,156 ($13,301 salary, $4,855 at 27% benefit rate); 0.08FTE for 2 years			
Project Co-manager (D. Larkin); Assistant Professor; $13,728 ($10,057 salary, $3,671 benefits at 27% benefit rate); 0.04 FTE for 2 years			
Graduate Research Assistant (TBD); Graduate Student; $92,824 (52% salary, 48% benefits during the academic year, 85% salary, 15% benefits during the summer); 0.50 FTE for 2 years			
Two undergraduate research assistants (10 weeks during the summer, $14 per hour): $11,200 (100% salary, 0% benefits summer), 0.19 FTE for 2 years			
Professional/Technical/Service Contracts	**$ 107,043**	**$ 107,043**	**$ -**
Cattail removal: Contractors throughout the state will be selected based on the University of Minnesota contracting procedures for competitive bidding.	$ 105,950	$ 105,950	$ -
MAISRC Containment Lab: Use of plant bench in lab to assess seed bank composition	$ 1,093	$ 1,093	$ -
Equipment/Tools/Supplies	**$ 17,286**	**$ 17,286**	**$ -**
Supplies - Lab and/or Field: Gee minnow traps 480@$13.10 = $6288, 1200 ft rope = $288 ; temperature loggers, 48 x $144 = $6912, dissolved oxygen loggers, 6 @ $1335 = $8010, YSI professional plus meter plus sensors = $3300; Rite in the Rain paper, buckets, sharpies,	$ 17,286	$ 17,286	$ -
Capital Expenditures Over $5,000	**$ -**	**$ -**	**$ -**
Printing	**$ 142**	**$ 142**	**$ -**
Printed outreach materials - informational postcard for public audience in the field, project handout for public presentations	$ 142	$ 142	
Travel Expenses in Minnesota	**$ 40,939**	**$ 40,939**	**$ -**
Field Travel - Vehicle Rental: ($1005 per month for 3 months + 0.23 per mile for 2500 miles) * 2	$ 14,639	$ 14,639	$ -
Field Travel - Lodging for 3 people: ($94 per night for 60 nights) x2 = $11,280, per diem for 3 people: $55 per day for 60 days over 2 years = $9900	$ 26,300	$ 26,300	$ -
Other	**$ -**	**$ -**	**$ -**
COLUMN TOTAL	$ 338,066	$ 336,930	$ 1,136

OTHER FUNDS CONTRIBUTED TO THE SUBPROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Voyageurs National Park will provide logistical support in the form of cattail treatment, boats and fuel for transportation, and staff time for study site treatments and data collection		$ 50,000	$ 50,000	$ -
In kind: MDNR will provide 60 hours of in-kind support for APM Coordinator Shane McBride and 150 hours of in-kind support for Fisheries Research Biologist Donna Dustin		$ 20,040	$ 20,040	$ -

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -

Pending LCCMR Approval
In Progress
Complete