

**Environment and Natural Resources Trust Fund**

# M.L. 2020 Final Work Plan

## **General Information**

**ID Number:** 2020-083

**Date this document submitted to LCCMR:** August 25, 2021

**Project Title:** Minerals and Water: Demonstration of Three Sulfate Reduction Technology Applications

**Project Budget:** $300,000

## **Project Manager Information**

**Name:** Meijun Cai

**Organization:** U of MN - Duluth - NRRI

**Office Telephone:** (218) 788-2686

**Email:** mcai@d.umn.edu

**Web Address:** https://www.nrri.umn.edu/

## **Project Reporting**

**Date Work Plan Approved by LCCMR:**

**Reporting Schedule:** April 1 / October 1 of each year.

**Project Completion:** June 30, 2023

**Final Report Due Date:** August 14, 2023

## **Legal Information**

**Legal Citation:** M.L. 2021, First Special Session, Chp. 6, Art. 5, Sec. 2, Subd. 20a3

**Appropriation Language:** The appropriation in Laws 2019, First Special Session chapter 4, article 2, section 2, subdivision 8, paragraph (c), Sauk River Dam Removal and Rock Rapids Replacement, in the amount of $2,768,000, no longer needed for its original purpose is transferred as follows:  
  
(3) $750,000 is transferred to the Board of Regents of the University of Minnesota for academic and applied research through the MnDRIVE program at the Natural Resources Research Institute to develop and demonstrate technologies that enhance the long-term health and management of Minnesota's mineral and water resources. Of this amount, $300,000 is to support demonstration of three sulfate reduction technologies for improved water quality, and $450,000 is for continued characterization of Minnesota iron resources and for developing next-generation technologies and iron products. This research must be conducted in consultation with the Mineral Coordinating Committee established under Minnesota Statutes, section 93.0015;  
  
(d) Transfers and Availability  
The transfers under this subdivision are effective June 30, 2021, and the transferred amounts are available until June 30, 2023.

**Appropriation End Date:** June 30, 2023

## **Narrative**

**Project Summary:** Applied research and demonstration of three sulfate reduction in Minnesota waters

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

Sulfate concentration is a challenge across the state due to a restrictive water quality standard for sulfate of 10mg/L in wild rice waters. Meeting this or a modified water quality standard is a special challenge, especially in systems with relatively low (<300 mg/L) sulfate concentrations. Existing technologies (e.g., reverse osmosis; ultrafiltration) can achieve this standard, but are expensive and generate significant waste products. New tools are required to provide economically viable technologies in support of Minnesota’s industries and wastewater treatment facilities. NRRI has tested several technologies for reducing sulfate in water bodies, including chemical precipitation technology via barite precipitation, microbial treatment, and development of novel carbon-based sorption materials. This project will test the effectiveness of sulfate reduction technologies and assess economic costs associated with their deployment.

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

On the basis of this past funding, NRRI is proceeding to pilot three technologies for reducing sulfate in water bodies: chemical precipitation; microbial treatment, and novel carbon-based materials to absorb sulfate ion. Two trailer-based pilot systems have been constructed to deploy the chemical precipitation system and a microbial treatment system. These will be deployed in tandem for demonstration at regional sites to determine effectiveness and quantify costs in real-world applications. The novel carbon sorbent materials will be evaluated first in the laboratory using pit lake water samples and will be piloted when the proper activity is achieved.

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

Technologies to reduce sulfate in Minnesota’s waters that are both effective and affordable for municipal and industrial water treatment challenges offer new tools to manage and remediate impacts on regional water resources. Demonstration of these approaches in different combinations should provide options for a range of sulfate challenges.

## **Project Location**

**What is the best scale for describing where your work will take place?** Statewide

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

**When will the work impact occur?** In the Future

## **Activities and Milestones**

### **Activity 1: Minerals and Water: Demonstration of Three Sulfate Reduction Technology Applications**

**Activity Budget:** $300,000

**Activity Description:**Two trailer-based pilot systems will be deployed at one mining pit lake to test and refine the chemical treatment system and the biological reactor system on site. The field pilot trial will be performed by biological and chemical processes to reduce sulfate concentrations below 10 mg/L. The run will be conducted for a duration of 4-6 months when temperature is above freezing point. The performance of the treatment systems will be evaluated through water chemistry, operational parameters, and waste management. A series of laboratory tests will be conducted to remove sulfate anions from the same mining pit lake water using the functional carbon materials with introduced anion exchange properties. The performance of the functional carbon materials will be evaluated using equilibrium and column tests. The water chemistry, ability to lower concentration of sulfate anions in the presence of competing anions (selectivity) as well as breakthrough capacity will be measured and reported. Costs associated with each treatment system will be documented to estimate operational costs.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Milestone 1: Deploy the trailer based pilot systems on the site | June 30, 2022 |
| Milestone 2: Completion of the field pilot trial of the chemical treatment process | June 30, 2023 |
| Milestone 3: Performance evaluation of biological treatment system to reduce sulfate concentration from a minepit | June 30, 2023 |
| Milestone 4: Performance evaluation of the functional carbon materials with anion exchange properties to remove | June 30, 2023 |

## **Project Partners and Collaborators**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Organization** | **Role** | **Receiving Funds** |
| Rolf Weberg | Natural Resources Research Institute, UMD | NRRI Executive Director, Dr. Rolf Weberg, who is on the Minerals Coordinating Committee, will review project progress for comment and potential collaboration at regularly scheduled Minerals Coordinating Committee meetings | No |

## **Dissemination**

**Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.**We anticipate building partnerships with the agencies and industrial partners during our field pilot trial and lab tests. The results will be shared with the partners to seek suggestions and recommendations for the applications of the treatment systems in the real world. The research findings will be disseminated to the public, agencies and industry through reports, workshops and conference presentations that will acknowledge the ENRTF funding of the project.

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

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?**With funds from 2016 and 2019 Minnesota Legislative investment, Industry, and internal funding, NRRI sulfate team has successfully demonstrated three sulfate reduction technologies in the laboratory; one trailer based system has been deployed for field pilot trials. Lessons learned from the past and ongoing tests will refine the system process and material development for wide applications in industrial and natural environments. Application of the permanent university trust fund is another potential source to bridge any funding gaps.

## **Budget Summary**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Category / Name** | **Subcategory or Type** | **Description** | **Purpose** | **Gen. Ineli gible** | **% Bene fits** | **# FTE** | **Class ified Staff?** | **$ Amount** |
| **Personnel** |  |  |  |  |  |  |  |  |
| George Hudak |  | Principal Investigator |  |  | 25.09% | 0.02 |  | $3,612 |
| Meijun Cai |  | Project manager and lead of chemical treatment project |  |  | 25.09% | 0.3 |  | $28,284 |
| Chan Lan Chun |  | Lead of biological treatment project |  |  | 25.09% | 0.1 |  | $14,590 |
| Lucinda Johnson |  | Part of the project management team |  |  | 25.09% | 0.02 |  | $4,557 |
| Adrian Hanson |  | Technical advisor |  |  | 25.09% | 0.3 |  | $7,013 |
| Shashi Rao |  | Co-lead of chemical treatment project |  |  | 25.09% | 0.08 |  | $9,456 |
| Igor Kolomitsyn |  | Lead of material modification project |  |  | 25.09% | 0.2 |  | $25,216 |
| Erik Hendrickson |  | Lab technician for material modification project |  |  | 22.3% | 0.22 |  | $15,074 |
| Sara Post |  | Field operation of the chemical treatment project |  |  | 22.3% | 0.8 |  | $5,467 |
| Jeff Kinkel |  | Mechanical Engineer |  |  | 25.09% | 0.06 |  | $8,167 |
| Jack Grochowski |  | Mechanical Engineer |  |  | 25.09% | 0.1 |  | $10,963 |
| Jerald Henneck |  | Lab technician |  |  | 22.3% | 0.2 |  | $16,378 |
| Matthew Mlinar |  | Mlinar will provide project management support and serve as a part of the project management team for this grant |  |  | 25.09% | 0.04 |  | $5,235 |
| Anthony Masching |  | Mechanical maintenance |  |  | 22.3% | 0.1 |  | $7,570 |
| TBD Field Tech, temp/casual |  | Field operation of the chemical treatment project |  |  | 6.91% | 0.2 |  | $7,488 |
| Undergraduate Researcher |  | Lab and field support |  |  | 0% | 0.32 |  | $7,546 |
| Matthew Berens |  | Field operation for the biological treatment project |  |  | 17.28% | 0.6 |  | $36,814 |
| Summer Graduate Student |  | Laboratory support |  |  | 18.96% | 0.02 |  | $128 |
| TBD Researcher 1 |  | Field operation for the biological treatment project |  |  | 22.3% | 0.4 |  | $19,855 |
|  |  |  |  |  |  |  | **Sub Total** | **$233,413** |
| **Contracts and Services** |  |  |  |  |  |  |  |  |
| David Sersha JR | Professional or Technical Service Contract | ~$100/hr, set up the field connection, make any electrical modification and disconnect the electrical connection. Mr. Sersha continued contract has been utilized on multiple NRRI projects. His years working onsite allows for a familiarity of our operations. |  |  |  | 0.02 |  | $3,000 |
| Intuitech | Professional or Technical Service Contract | Consulting with Intuitech for any system issue. ~$150/hr, pilot system consulting. Intuitech is the manufacturer of the customized pilot systems. Intuitech provides support consulting for their product |  |  |  | 0.02 |  | $1,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$4,000** |
| **Equipment, Tools, and Supplies** |  |  |  |  |  |  |  |  |
|  | Tools and Supplies | Supplies for the system modification or site connection | Including pumps, pipes, tanks, valves, pressure meters, and any possible changes to be made to the pilot system |  |  |  |  | $18,000 |
|  | Tools and Supplies | Laboratory and chemical supplies | Lab supplies, bottles, vials, chemicals, gloves, filter membrane, pipet, and other supplies that may be needed during laboratory work |  |  |  |  | $18,287 |
|  |  |  |  |  |  |  | **Sub Total** | **$36,287** |
| **Capital Expenditures** |  |  |  |  |  |  |  |  |
|  |  | Potentiostat | Used for electrochemical analysis to monitor biological sulfate reduction and redox mediator during the biological sulfate treatment. | X |  |  |  | $8,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$8,000** |
| **Acquisitions and Stewardship** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Travel In Minnesota** |  |  |  |  |  |  |  |  |
|  | Miles/ Meals/ Lodging | Field visit (15 times/month) \*5 month\* total miles per trip (~154 miles) = $6,462. Additional money for sample dropping to the external lab, travel from Duluth to Coleraine facility | Travel needed between Duluth and Coleraine NRRI sites to perform testing and transporting samples. GSA rates will be used while traveling. |  |  |  |  | $7,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$7,000** |
| **Travel Outside Minnesota** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Printing and Publication** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Other Expenses** |  |  |  |  |  |  |  |  |
|  |  | Shipping Costs | Sample shipping to external labs | X |  |  |  | $300 |
|  |  | External lab measurement | External lab measurement for samples |  |  |  |  | $5,000 |
|  |  | Data plan | Data plan for remotely access the control panels, and the data plan for onsite video cameras | X |  |  |  | $3,000 |
|  |  | Electricity | Cost of electricity for the field pilot trial occurring at a remote site off campus |  |  |  |  | $3,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$11,300** |
|  |  |  |  |  |  |  | **Grand Total** | **$300,000** |

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Category/Name** | **Subcategory or Type** | **Description** | **Justification Ineligible Expense or Classified Staff Request** |
| **Capital Expenditures** |  | Potentiostat | The biological treatment used in the project is a biofiltration integrated with electrochemical cells which stimulate and sustain biological sulfate reduction. For the treatment system, the potentiostat is used as an electric instrument that controls the cell potential and measures variable current as an essential component of the system. This will be also used to conduct electrochemical analysis for redox active chemicals in the treatment system through the life of the instrument. **Additional Explanation :** The Potentiostat purchased with the project will continue to be used for the water treatment in relation to sulfate reduction and its associated processes in the lab and field. |
| **Other Expenses** |  | Shipping Costs | Sample shipping to external labs , including labs in the Twin Cities for chemical and physical measurement which are not able to be done locally |
| **Other Expenses** |  | Data plan | The site is located in a remote location (60 miles away) where no Wi-Fi is available. Cellular data will be the only way for remote access. The remote access allows controlling the system remotely, therefore reducing the field visit times and keep the system run smoothly. |

### **Non ENRTF Funds**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Category** | **Specific Source** | **Use** | **Status** | **Amount** |
| **State** |  |  |  |  |
|  |  |  | **State Sub Total** | **-** |
| **Non-State** |  |  |  |  |
|  |  |  | **Non State Sub Total** | **-** |
|  |  |  | **Funds Total** | **-** |

## **Attachments**

### **Required Attachments**

#### ***Visual Component***

File: [8048b91b-692.pdf](https://lccmrprojectmgmt.leg.mn/media/map/8048b91b-692.pdf)

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

The graphic describes the sulfate remediation, municipal treatment mobile unit, and the minelands treatment...

### **Optional Attachments**

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

|  |  |
| --- | --- |
| **Title** | **File** |
| Background Check | [015f5e9e-370.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/015f5e9e-370.pdf) |
| Institutional Letter | [c85d0358-602.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/c85d0358-602.pdf) |

## **Difference between Proposal and Work Plan**

#### ***Describe changes from Proposal to Work Plan Stage***

Minor editing

## **Additional Acknowledgements and Conditions:**

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

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

**Do you agree travel expenses must follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?**   
 Yes, I agree to the Commissioner's Plan.

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

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

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**   
 No

**Does your project include original, hypothesis-driven research?**   
 No

**Does the organization have a fiscal agent for this project?**   
 Yes, Sponsored Projects Administration