

**Environment and Natural Resources Trust Fund**

# M.L. 2020 Final Work Plan

## **General Information**

**ID Number:** 2020-085

**Staff Lead:** Corrie Layfield

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

**Project Title:** Minerals and Water: Next-Generation Technologies and New Iron Products

**Project Budget:** $450,000

## **Project Manager Information**

**Name:** Rodney Johnson

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

**Office Telephone:** (218) 788-2717

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**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: enhanced value, sustainable opportunities for Minnesota iron resources and sulfate reduction in Minnesota waters

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

The iron mining industry has a long history in Minnesota, from the direct shipping ores of the past to today’s taconite industry. As the higher quality ores have become depleted, process technologies have evolved to become more water intensive. The resulting impacts inevitably tie mining activities to regional water quality concerns.  
  
While high quality ores are gone, abundant, low-quality resources remain that are bypassed as waste rock, lean ore or tailings. Profitable use of these low-quality resources requires enhanced characterization and development of novel process technologies. To be globally competitive, new processing approaches must reduce energy and water consumption, reduce carbon and other emissions and diversify the iron product portfolio. Past state investment resulted in the present taconite industry; new investment will help Minnesota lead the future.

**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.**

A 2019 legislative appropriation and LCCMR funding initiated applied research on these two interrelated challenges. Detailed characterization of several Biwabik formation iron resource samples led to new understanding of their composition and structure. This work will continue with additional representative samples to define three types of secondary iron resources. These data will, in turn, suggest novel strategies to process these materials into iron concentrates in addition to alternate iron products for use in other applications. NRRI’s unique metallurgical expertise will be leveraged to demonstrate new metallic iron products and characterize their feasibility and market acceptance.

**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?**

Detailed characterization of Minnesota’s iron mineral resources will not only identify opportunities to take advantage of reduced quality iron resources, but will also identify opportunities to reduce water use and impacts, reduce energy consumption and reduce industry footprint while expanding the state’s iron product portfolio.

## **Project Location**

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

**What is the best scale to describe the area impacted by your work?** Region(s): NE

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

## **Activities and Milestones**

### **Activity 1: Iron formation characterization**

**Activity Budget:** $148,000

**Activity Description:**Continue the comprehensive characterization of the iron resources of the Mesabi Iron Range. The characterization includes determining mineralogy, liberation characteristics, and metallurgical response of all portions of the iron formation. The concentrates produced from the metallurgical characterization will be analyzed for chemical properties, and impurities. Thermal analysis will be conducted on a subset of the concentrates. These data will be used to focus research to develop new processing technologies and alternative iron-based products.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Milestone 1: Complete logging, sectioning, and sampling of diamond drill holes | December 31, 2021 |
| Milestone 2: Complete chemical, mineralogic and metallurgical characterization of diamond drill hole | June 30, 2022 |
| Milestone 3: Complete characterization of partially oxidized iron formation | June 30, 2022 |
| Milestone 4: Complete characterization of oxidized iron formation | June 30, 2022 |
| Milestone 5: Complete characterization of siderite-rich iron formation | June 30, 2022 |

### **Activity 2: Process development**

**Activity Budget:** $231,000

**Activity Description:**Several distinct iron material types have been identified. Bench-scale metallurgical tests will be conducted to determine baseline conditions for grinding and recovery. The bench scale studies will provide data to understand the quality of concentrate that can be produced from traditionally non-ore iron formation. The impact on water quality will be assessed during the bench scale studies. Flotation is likely to be a component of mineral recovery in the future and alternatives to amines need to be assessed. A study of surfactants will be conducted to guide flotation research in the future.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Milestone 1: Complete bench-scale process development of Hematite recovery from tailings and Oxidized iron formation | March 31, 2023 |
| Milestone 2: Complete bench-scale process development of partially oxidized iron formation | March 31, 2023 |
| Milestone 3: Complete bench-scale process development Siderite rich iron | March 31, 2023 |
| Milestone4. Compile and analyze process water chemistry | March 31, 2023 |
| Milestone 5. Complete surfactant study. | March 31, 2023 |

### **Activity 3: Production of iron with reduced reliance on fossil fuels**

**Activity Budget:** $71,000

**Activity Description:**We will investigate use of green hydrogen and biomass to reduce blast furnace pellets.

**Activity Milestones:**

|  |  |
| --- | --- |
| **Description** | **Completion Date** |
| Milestone 1: Iron reduction using H2; Reduction of blast furnace pellets | June 30, 2023 |
| Milestone 2: Iron reduction using H2; Reduction of green balls with biocarbon | 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 will communicate with industry, agencies and academic partners through technical presentations, reports, and technical papers to share results of this collaborative research. All public-facing research dissemination for this project will acknowledge the ENRTF funding for 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?**This project is part of a long-term effort to define, develop, demonstrate and commercialize technologies to support future Minnesota mineral opportunities with reduced carbon footprint, water utilization, effluents and energy consumption while also driving a higher value product portfolio. The results of this project will be used to define ongoing development efforts and attract funding from external sources including the federal government, industry partners and the state of Minnesota. Permanent University Trust Funds may also be applied towards this support.

## **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% | 0.1 |  | $18,063 |
| Rodney Johnson |  | Project Manager |  |  | 25.09% | 0.46 |  | $74,008 |
| Matthew Mlinar |  | Mlinar will provide project management support and serve as a part of the project management team for this grant |  |  | 25.09% | 0.1 |  | $13,091 |
| Sara Post |  | Data Management |  |  | 22.3% | 0.08 |  | $5,467 |
| TBD Geologist |  | Geologist |  |  | 25.09% | 0.04 |  | $4,118 |
| Brett Spigarelli |  | Process Metallurgist and Pyrometallurgist |  |  | 25.09% | 0.4 |  | $52,992 |
| Shashi Rao |  | Process Metallurgist |  |  | 25.09% | 0.26 |  | $30,735 |
| Basak Anameric |  | Pyrometallurgist |  |  | 25.09% | 0.16 |  | $23,326 |
| Patrick Casey |  | Laboratory Technician Supervisor |  |  | 22.3% | 0.04 |  | $3,207 |
| Donald Reiser |  | Laboratory Technician |  |  | 22.3% | 0.44 |  | $33,915 |
| Joseph Cannella |  | Laboratory Technician |  |  | 22.3% | 0.16 |  | $12,113 |
| Richard Bellefy |  | Laboratory Technician |  |  | 22.3% | 0.1 |  | $7,570 |
| Michael Swanson |  | Laboratory Technician |  |  | 22.3% | 0.18 |  | $13,906 |
| Steven Zaitz |  | Laboratory Technician |  |  | 22.3% | 0.1 |  | $7,725 |
| David Haugen |  | Laboratory Technician |  |  | 22.3% | 0.1 |  | $7,424 |
| Stephen Monson Geerts |  | Geologist |  |  | 25.09% | 0.16 |  | $15,607 |
| Julie Mutchler |  | Laboratory Supervisor |  |  | 22.3% | 0.18 |  | $14,593 |
| Gregory Gargano |  | Laboratory Technician |  |  | 22.3% | 0.2 |  | $15,795 |
| James Gould |  | Laboratory Technician |  |  | 22.3% | 0.04 |  | $2,417 |
| Igor Kolomitsyn |  | Chemist |  |  | 25.09% | 0.16 |  | $20,172 |
| TBD Laboratory Technician, temp/casual |  | Laboratory Technician |  |  | 6.91% | 0.02 |  | $680 |
| TBD Undergraduate Student Technician |  | Student Technician |  |  | 0% | 0.01 |  | $546 |
| TBD Scientist, faculty |  | Research Scientist |  |  | 25.09% | 0.02 |  | $2,889 |
| TBD Post Doc |  | Laboratory Technician |  |  | 17.28% | 0.02 |  | $1,226 |
| TBD Summer Graduate Student |  | Laboratory Technician |  |  | 18.96% | 0.02 |  | $130 |
|  |  |  |  |  |  |  | **Sub Total** | **$381,715** |
| **Contracts and Services** |  |  |  |  |  |  |  |  |
| SEM/Microprobe, UMN Campus | Internal services or fees (uncommon) | Microprobe lab at the UM-TC campus. This lab offers non-destructive chemical analyses of solids. The electron microprobe is capable of quantitatively measuring the abundance of all elements from B to U and combines micron-scale chemical analyses with scanning electron microscopy, capable of large- and small-scale element mapping of specimens |  |  |  | 0.02 |  | $5,408 |
| Expert Process Solutions (XPS) | Professional or Technical Service Contract | Conducting thermal analyses on products that are produced at NRRI (concentrate) |  | X |  | 0.02 |  | $15,750 |
| Pace Analytical | Professional or Technical Service Contract | Pace Analytical will perform Water analyses - process water conducting thermal analyses on products that are produced at NRRI (concentrate) |  | X |  | 0.02 |  | $10,000 |
| ALS Global | Professional or Technical Service Contract | Chemical analysis - iron ore and products. Continuation of previously bid contract. ALS Global was selected for continuity of certified chemical analyses. ALS Global was the lab used for the LCCMR – Western Mesabi Iron resources of the Future |  |  |  | 0.02 |  | $31,794 |
|  |  |  |  |  |  |  | **Sub Total** | **$62,952** |
| **Equipment, Tools, and Supplies** |  |  |  |  |  |  |  |  |
|  | Tools and Supplies | Laboratory supplies | Laboratory consumables - sample bags, labels, etc. |  |  |  |  | $1,600 |
|  |  |  |  |  |  |  | **Sub Total** | **$1,600** |
| **Capital Expenditures** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Acquisitions and Stewardship** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Travel In Minnesota** |  |  |  |  |  |  |  |  |
|  | Miles/ Meals/ Lodging | Project manager and key personnel mileage for quarterly discussions | Local travel to iron ore operations to discuss research with clients. GSA rates will be applied |  |  |  |  | $1,933 |
|  |  |  |  |  |  |  | **Sub Total** | **$1,933** |
| **Travel Outside Minnesota** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Printing and Publication** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Other Expenses** |  |  |  |  |  |  |  |  |
|  |  | Shipping | Cost of shipping samples to be analyzed | X |  |  |  | $1,800 |
|  |  |  |  |  |  |  | **Sub Total** | **$1,800** |
|  |  |  |  |  |  |  | **Grand Total** | **$450,000** |

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Category/Name** | **Subcategory or Type** | **Description** | **Justification Ineligible Expense or Classified Staff Request** |
| **Contracts and Services** - Expert Process Solutions (XPS) | Professional or Technical Service Contract | Conducting thermal analyses on products that are produced at NRRI (concentrate) | XPS was chosen for thermal analysis because there are very few labs offering this service and offer rapid turn around. Prices were compared to other companies for previous (non-LCCMR) projects. The standard University of Minnesota contract bidding process will be used when required. **This is a single source contract.** |
| **Contracts and Services** - Pace Analytical | Professional or Technical Service Contract | Pace Analytical will perform Water analyses - process water conducting thermal analyses on products that are produced at NRRI (concentrate) | Pace is a local lab for water analysis. Water analysis requires a local lab and we have used Pace in other non-LCCMR projects. Prices were compared to other companies for previous (non-LCCMR) projects. The standard University of Minnesota contract bidding process will be used when required. **This is a single source contract.** |
| **Other Expenses** |  | Shipping | XPS, Pace Analytical, and ALS Global are external laboratories and shipping will be required to get the samples to these laboratories and assure analyses in a timely manner. |

### **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: [4631c6f5-00a.pdf](https://lccmrprojectmgmt.leg.mn/media/map/4631c6f5-00a.pdf)

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

The graphic describes the challenges facing Minnesota iron industry today and the goals and impacts for Minnesota's Next Gen Iron Industry...

### **Optional Attachments**

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

|  |  |
| --- | --- |
| **Title** | **File** |
| Background Check | [fbcc5ff8-4f5.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/fbcc5ff8-4f5.pdf) |
| Institutional Letter | [37928ebd-1f6.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/37928ebd-1f6.pdf) |

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

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

Minor edits were made.

## **Additional Acknowledgements and Conditions:**

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

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

**Do you 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