



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

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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

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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
Milestone 4: 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 H ₂ ; Reduction of blast furnace pellets	June 30, 2023
Milestone 2: Iron reduction using H ₂ ; Reduction of green balls with biocarbon	June 30, 2023

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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.

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Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified 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

8/25/2021

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

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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.

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Non ENRTF Funds

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

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Attachments

Required Attachments

Visual Component

File: [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
Institutional Letter	37928ebd-1f6.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Minor edits were made.

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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?

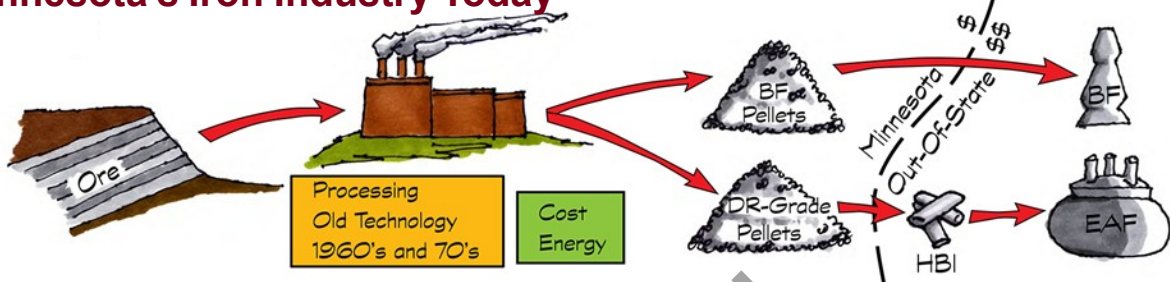
Yes, Sponsored Projects Administration

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Minnesota's Iron of the Future

Minnesota iron resources are changing. We have to innovate and adapt by expanding our portfolio of Iron products and keeping value in the state.

Minnesota's Iron Industry Today



BF - Blast Furnace
DR - Direct Reduced
EAF - Electric Arc Furnace
HBI - Hot Birquetted Iron

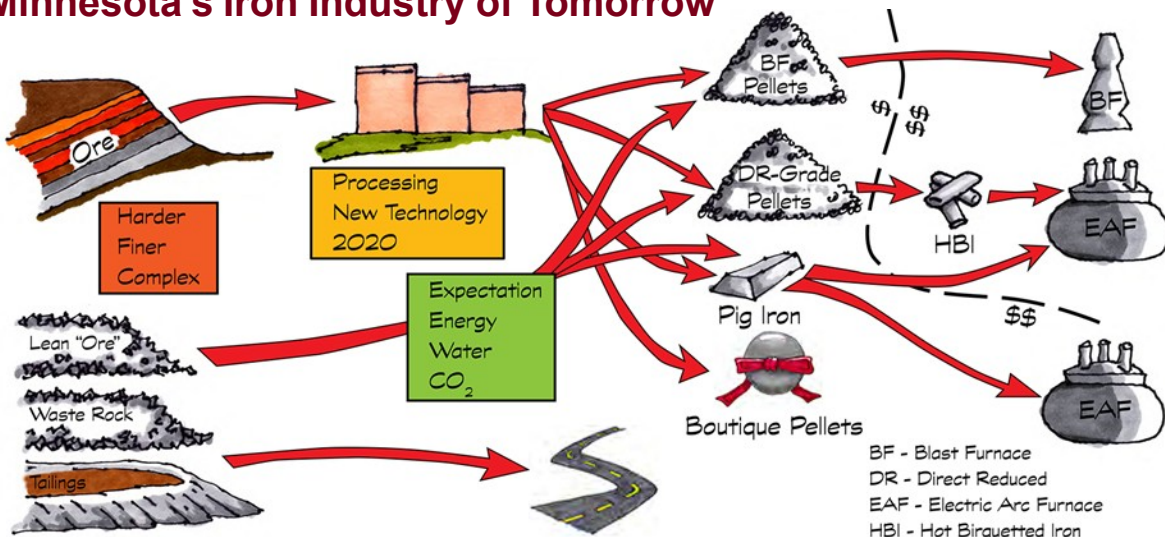
Challenges facing the Minnesota iron industry today:

1. **Resource:** Declining quality and reserves of the iron ore resource
2. **Economic:** Increased energy costs for production
3. **Limited Portfolio:** Single low-margin product which accesses only 30% of the steel industry overall
4. **Regulatory:** Increasingly stringent water quality and air emission standards

Goals and Impacts for Minnesota's Next Gen Iron Industry:

- **Jobs:** Job development for today and tomorrow
- **Profits:** High-value products developed in state
- **Economic Development:** A high-tech portfolio of iron products
- **Sustainability:** Potential for a carbon-neutral iron industry in Minnesota

Minnesota's Iron Industry of Tomorrow



BF - Blast Furnace
DR - Direct Reduced
EAF - Electric Arc Furnace
HBI - Hot Birquetted Iron