Environment and Natural Resources Trust Fund
2014 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **065-B**

Environmentally-Friendly Frac Sand Water Cleanup

Category: B. Water Resources

Total Project Budget: $ 812,428

Proposed Project Time Period for the Funding Requested: 2 Years, July 2014 - June 2016

Summary:

We will develop environmentally-friendly procedures for the frac-sand mining industry in Minnesota. Our technology detects and destroys the potentially hazardous chemicals used. Water is cleaned and less land used.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ Employment	_____ TOTAL _____%

PROJECT TITLE: Environmentally-Friendly Frac Sand Water Cleanup

PROJECT STATEMENT

Silica sand is prevalent in the state of Minnesota and is being increasingly mined for use in hydraulic fracturing, or fracking operations, in other states. Mining, processing, and transport of the sand brings economic development to Minnesota, but it is imperative that land, water and air quality not be negatively impacted. This proposal describes research to be conducted at the University of Minnesota to **develop a novel technology to degrade and eliminate the potentially harmful chemicals used in frac sand mining and processing**. This will allow the mining industry to better control dust, use less land, use less water, and enable cleaner water discharge. The ENRTF funds will be used only to develop the technology. Any use of the technology by private companies will be done at their expense. Moreover, the technology will be patented by the University of Minnesota and licensed, generating royalty money from the use of the technology. **These royalty monies will then be used to pay back the ENRTF funding**. The specific problem and how it will be solved is described below.

The problem:

1. Increased land use, dust production, water use, water contamination by chemicals used in sand mining
2. Chemicals are used to separate and remove the small sand grains and dust to make sand for fracking
3. Treatment of the chemicals requires very large ponds and chemical testing done in other states

The solution:

1. Develop method to test the sand mining and processing waters rapidly for the presence of the chemicals
2. Develop an environmentally-friendly and economical method to treat these water to remove the chemicals rapidly in a small working area so large ponds are not needed
3. The result: dust is controlled, water is cleaned of chemicals, and the mining operations use minimal land

The success of this research will improve Minnesota land use, air quality, and water quality. It will provide a technology that can be used by Minnesota sand mining companies. No funds will go to the mining companies; on the contrary, their future use of the developed technology will generate revenue for the State. The researchers conducting this research have so far filed more than twenty patents for related technologies, have worked with the U.S. EPA on similar technology development, and have presided over environmental cleanups of other chemicals in other states. The time is ripe to solve this new and pressing Minnesota problem.

II. DESCRIPTION OF PROJECT ACTIVITIES

In brief, technology will be developed, building on past technology for other chemicals, to test for and degrade chemicals that enter water during silica sand processing. This will clean water and minimize the land footprint as described above. The first goal is to develop methods in research laboratories at the University of Minnesota by students and postdoctoral scientists. The second goal is to scale-up the developed technology to efficiently perform with actual mining waters in the field. This will be done by working with Jordan Sands. No money will be transferred to Jordan Sands. In fact, Mr. Brett Skilbred of Jordan Sands has agreed to provide construction support, at his company's expense, to help University of Minnesota personnel implement an experimental test in an actual sand operation. This will serve as a "proof-of-principle" to show that the technology works.

	Budget:	
Activity 1: Research testing for chemical detection in U of M laboratory		**$ 139,176**
Two graduate students conduct experiments on rapid chemical test methods	Salaries yr 1-	$86,176
Use standard slow test methods to compare accuracy of rapid test methods	Machine use-	$43,000
Patent, publish research, post on University websites for public dissemination	Costs -	$10,000

Activity 2: Research methods for removing and destroying chemicals in water		**$163,038**
Two postdoctorals prepare new chemical-destroying materials	Salary yr 1-	$100,038
Test materials under a range of conditions to determine effectiveness in lab	Materials-	$53,000
Patent, publish research, post on University websites for public dissemination	Costs -	$10,000
Activity 3: Scaling-up to implement testing and treatment methods		**$323,214**
Salaries of two postdoctorals, two graduate students, undergraduate assistant	Salary yr 2-	$226,214
U Personnel travel to sites of implementation	Travel -	$7,000
Frequent discussions with consulting engineer	Consulting -	$20,000
Construction of scale-up materials in U laboratories	Build at U -	$70,000
Activity 4: Discuss with MPCA and Dept of Health on sand sites, health issues		**$0**
Activity 5: Work with Jordan Sands to implement field treatment		**$187,000**
U personnel salaries – already tallied under Activity 3	Salary -	$0
Construct 500 rapid test kits for monitoring at $150/kit	Materials -	$75,000
Manufacture chemical-destroying materials at U – 164 kg x $500/kg	Materials-	$82,000
Further consulting, travel and small materials for on-site test	Other-	$30,000

Outcome	Completion Date
1. Research testing for chemicals in U of M laboratory	June 30, 2015
2. Research methods for removing and destroying chemicals in water	June 30, 2015
3. Scaling to implement testing and treatment methods	Dec. 31,2015
4. Discuss with MPCA and Dept of Health on sand sites, health issues	Dec. 31, 2015
5. Work with Jordan Sands to implement field treatment	June 30, 2016

III. PROJECT STRATEGY

A. Project Team/Partners:

U of Minnesota – Wackett/Aksan – Project managers – The managers for this project are both Professors at the U of M with extensive experience in chemical cleanup. Collectively, we have published over 300 papers, many on the topics related to this proposal, and filed 20 patents on similar technologies.

Sunde Engineering – Kirsten Pauly, PE/PG - Consulting engineer - This specific consultant is uniquely qualified, having devoted nearly full-time to silica sand mine environmental issues over the last year. We believe that she is the most knowledgeable person in the state on the air, water, and land issues and will be invaluable for our success in implementing the test and treatment methods we seek to develop.

MPCA/MDH – The project has been discussed with MPCA Commissioner John Stine, who is enthusiastic about the project. The appropriate MPCA scientists to work with us will be identified if the proposal is funded. The Minnesota Department of Health has been notified of the project and is very keen for a rapid testing method for the sand water chemical. No funds will be transferred between agencies and U of M. However, we wish to work with State agencies to develop the most appropriate technology to protect Minnesota resources and health.

B. Timeline Requirements*:* This will be a 2-year project with the necessary development conducted in the laboratory in year one and subsequent movement and implementation to a field test in year 2.

C. Long-Term Strategy and Future Funding Needs: The project is designed to develop a novel and needed technology. The technology will be patented by the University. The technology can then be licensed by an existing or start-up company in Minnesota to serve the mining industry, helping the environment and creating new jobs. It is thus a win-win-win: (1) protecting air, water and minimizing land use, (2) potentially creating a new service company and jobs, using the technology in Minnesota and elsewhere, and (3) potentially bringing in royalty fees that can offset the investment made from the ENRTF funds.

2014 Detailed Project Budget

Project Title: Environmentally-Friendly Frac Sand Water Cleanup

IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM	AMOUNT
Personnel: **2 Postdoctoral researchers x** $81,200 salary for 2 years = $162,400 + $37,676 fringe benefits - conduct research to develop water treatment methods and implement in the field. **2 graduate students** x $101,216salary for 2 years + $71,136 fringe benefits - To develop chemical testing methods, develop a kit format and test in the field **1 undergraduate student** will be hired at a cost of $40,000 over two years to assist the senior personnel The total cost for personnel will be $412,428.	$ 412,428
Contracts: **Consulting engineer** - Ms. Kirsten Pauley, Sunde Engineering - Uniquely qualified to provide advice on silica sand mining and cleaning operations relevant to designing effective treatment process. $200/ h x 300h = $60,000	$ 60,000
Equipment/Tools/Supplies: **Tools and materials for constructing bioreactor column for chemical treatment** - $75,000 **Costs for preparing biological materials in fermentors and harvesting materials for testing -** $60,000 **Glassware, chromatography supplies, reagents, solvents -** $50,000 **Silica gel materials, catalysts, emuslion preparation materials, and mechanical testing materials -** $30,000	$ 215,000
Exrternal Analytic laboratory testing fees and costs for publication, dissemination of results: **Bid to outside testing laboratories for chemical analysis to compare our data and aclibrate -** $23,000 **Charges for publication in journals, provisional and patent filing fees** - $10,000	$ 33,000
Travel: **Automobile mileage reimbursement -** $1000 **Hotel -** $3000 **Meals -** $3000 Travel expenses will be calculated and reimbursed using standard University of Minnesota formulas.	$ 7,000
University machine laboratories fees: **Fermentation facility that grows microorganisms in 550 L quantities -** $40,000 **Machine shop fabrication of cleaning column, pipes, pumps for lab and field testing** - $35,000 **Analytical machines for NMR, gas chromatography and mass spectrometry** - $10,000	$ 85,000
	$ 812,428

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: Jordan Sands is committed to provide labor to support preparation of the field test site and help in monitoring and managing the site. It is estimated that the match in salary and material support to be **$10,000.**	$ 10,000	*Pending*
Other State $ Being Applied to Project During Project Period: Salary support is provided to the project managers as part of their Professorships at the University of Minnesota. The Professors will put part of their time onto their project that accounts for **$15,000** in matching salary support.	$ 15,000	*Pending*
In-kind Services During Project Period: None		
Remaining $ from Current ENRTF Appropriation (if applicable): Not applicable		
Funding History: The general technology for degrading chemicals has been funded by the National Science Foundation at the level of **$600,001.** This provides background technology that speeds up	$ 600,001	Secured

Current Status in Frac Sand Mining

To prepare frac sand…

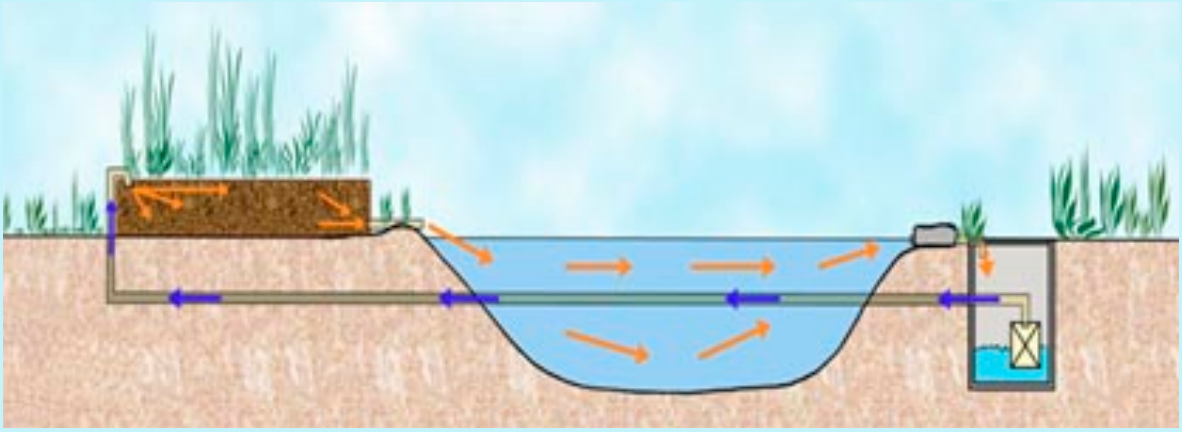
MN Sand Mine

….significant land, water, chemicals used

Water to remove dust put into multiple ponds

LCCMR-sponsored research innovations

New U Technology to Clean Water: Reducing Footprint to One Pond



Implementation of this technology will allow:

1. Rapid monitoring to follow treatment and know if chemicals have escaped
2. Making the entire operation more compact
3. Conserving water and making the water used cleaner for reuse

Project Manager Qualifications & Organization Description

Professor Lawrence Wackett (BioTechnology Institute, U of MN) is the Project Manager and he will work closely with **Professor Alptekin Aksan (Mechanical Engineering, U of MN)** to direct all aspects of the project. The qualifications of the managing professors are below. The other organizations and the consulting engineer involved in the project are also described below.

Professor Lawrence Wackett is Distinguished McKnight University Professor in the Department of Biochemistry, Molecular Biology, Biophysics and a member of the BioTechnology Institute at the University of Minnesota, Twin Cities. He obtained his Ph.D. at the University of Texas at Austin and did postdoctoral research at MIT. His current research investigates microbial biocatalysis and biodegradation reactions. He is co-founder of the web-based University of Minnesota Biocatalysis/ Biodegradation Database. He authored the textbook *Biocatalysis and Biodegradation,* published by ASM Press and subsequently translated into Chinese and sold in China by Chemical Industry Press. Wackett is a Fellow of the American Association for the Advancement of Science and the American Academy of Microbiology.

Professor Alptekin Aksan is a faculty member in the Department of Mechanical Engineering at the University of Minnesota, Twin Cities. He received his B.S. and M.S. degrees in Mechanical Engineering from the Middle East Technical University in Ankara, Turkey. He completed his Ph.D. studies on thermomechanics of collagenous tissues in Michigan State University, Mechanical Engineering Department. He worked for three years as a post-doctoral researcher in Center for Engineering in Medicine in Massachusetts General Hospital, Harvard Medical School before joining the faculty of University of Minnesota in 2005. His research interests are Bioencapsulation, Cellular Biophysics, Biothermodynamics, Biostabilization, and Bioheat/Mass Transfer.

Professors Wackett and Aksan are full-time employees at the University of Minnesota, Twin Cities in Biological Sciences and in Engineering colleges, respectively. With complementary interests, they have forged a program in biological cleanup of hazardous chemicals found in air, soil and water. In total, the two Professors have raised more than $12 million in grant funding and filed more than twenty patents and provisionals. The current project directly builds on the complementary expertise of Wackett and Aksan in making the biocatalysts that destroy the chemicals and in engineering systems that treat the chemicals quickly and economically.

Kirsten Pauley, Sunde Engineering – Ms. Pauley is a Civil Engineer employed by the Sunde Engineering, a full service civil and environmental engineering firm located in Bloomington, Minnesota. Ms. Pauley is unique in the State of Minnesota in that she is trained as a Civil Engineer, has expertise in geology, and has deeply studied environmental issues related to the Minnesota silica sand mining operations. She has many contacts within the Minnesota Pollution Control Agency (MPCA), the State Department of Health, and the mining industry. Ms. Pauley will be an invaluable component of the project as we seek to move methods developed in the laboratory into the field.

University of Minnesota, Twin Cities – The University of Minnesota provides critical infrastructure that makes the present proposal have a high likelihood of success. The combined graduate programs of Biochemistry and Mechanical Engineering consist of more than 200 graduate students to recruit to work on the present project. The students recruited by the programs are easily in the top 25% of graduate students anywhere in the country. Moreover, our best and brightest seek out projects dealing with environmental stewardship and restoration. Thus, those graduate students provide the creative minds to drive the projects and also represent the next generation of environmental scientist, trained beyond the boundaries of classical environmental scientists with a strong background in engineering and chemistry. While working on the projects, the students have access to advanced equipment within the project manager's laboratories and in all-University-access laboratories that contain state-of-the-art equipment that has been procured largely through federal research dollars. The frac sand mining issue is a pressing one for the State of Minnesota, but we feel up to the challenge of providing solutions that benefit the State and society in general.