Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 066-B**

Continuous Nitrate Pollution Monitoring at the Kitchen Sink

Category: B. Water Resources

Total Project Budget: $ 276,590

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

Provide citizens with an inexpensive, automated, in-home method to instantly test their water for dangerous nitrate levels, and help them to provide these data to state agencies and decision-makers.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

7.1% of drinking water samples in Minnesota have nitrate concentrations over the EPAs safe limit

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

PROJECT TITLE: Continuous nitrate pollution monitoring at the kitchen sink

I. PROJECT STATEMENT

Groundwater **nitrate pollution is widespread** in Minnesota and can contaminate the water supply of the **1.3 million Minnesotans who depend on private wells and vulnerable municipal systems**. Currently, only a few thousand wells are annually monitored, and **this is not sufficient to connect sources of pollution with drinking water quality**. Even wells that are next to each other can have **unpredictable and widely varying nitrate concentrations** that **cross the US Environmental Protection Agency's 10 ppm nitrate limit for safe drinking water**, beyond which young children can develop "blue baby syndrome". Pesticides often accompany high nitrate loads, **making nitrate an indicator of more dangerous chemicals**.

Currently, no good household nitrate measurement system exists. Professional measurements require either a $15,000 instrument or a chemistry lab and toxic heavy metals. Citizens can bring their water to be tested at a certified facility, but the hours involved in sample transport and analysis time and the (unless subsidized) $20-40 analysis fee make this option untenable for many Minnesotans.

Our goal is to vastly improve drinking water safety by empowering communities with a site-specific and citizen-operated solution to measure localized and highly-variable nitrate concentrations. Goals:

- **Develop an inexpensive nitrate sensor that can make scheduled and on demand measurements right at the kitchen sink.** This easy-to-install sensor will attach to a user's cold water supply line under their sink and employ a recently-developed test that uses a safe corn-derived enzyme in place of heavy metals. Materials cost is $0.25 or less per test.
- **Partner with concerned citizens** who will install and field test our prototypes. Participants will be identified through Soil and Water Conservation Districts, county Environmental Service offices, personal contacts and the Minnesota Well Index.
- **Crowdsource water quality data from these citizens and their sensors**, which will connect to in-home WiFi networks and, if the user opts in, send their nitrate data to a database housed at the University of Minnesota's Saint Anthony Falls Laboratory.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Develop in-home nitrate sensor that monitors and reports nitrate pollution in tap water **Budget: $134,189**

The central goal of the project is to design and build a **mechanized nitrate test device** that supplies a safe corn-based enzyme to a water sample from the kitchen sink to cause nitrate-bearing water to change color. The device will interpret the color as a nitrate concentration, report the test results via an in-home WiFi network, and raise an alarm if the nitrate concentrations exceed the safe limit of 10 ppm. Industry standard calibrations between color and nitrate concentrations will be augmented by our own tests in conjunction with certified laboratories in Minnesota. The water sample is disposed through the drain and wastewater stream. With user consent, the device will send the nitrate test results to a publicly-accessible database at the University of Minnesota for use by environmental agencies, researchers, and concerned citizens alike.

Outcome	Comp. Date
1. Build under-the-sink nitrate sensor that replicates laboratory results, and make the design freely-available to the general public.	01/01/19
2. Develop a WiFi communication system and a public database usable by citizens, researchers, and decision-makers to ensure a safe water supply.	03/01/19
3. Develop educational materials to help citizens interpret their nitrate test results.	03/01/19

Activity 2: Field test prototype nitrate sensor with the help of 50 Minnesota citizens **Budget: $102,716**

Recruit citizens to test the first batch of prototype sensors: create a survey to gather citizen feedback on ease of use, usefulness/value, personal impact of participation, and potential improvements. Travel funds in the budget are set aside to work one-on-one with volunteers who require assistance or would like to have more direct contact with the sensor's developers.

Outcome	Comp. Date
1. Identify private well participants for volunteer nitrate monitoring (50 well sample set, for 6 months).	01/01/19
2. Build and distribute sensors, collect data, collect installation/operation feedback. Use these data as the basis for a final home nitrate sensor design.	12/01/19

Activity 3: Cost reduction and preparation for mass production to monitor a wide swath of Minnesotans' homes **Budget: $39,685**

Implement the suggested improvements collected during Activity 2 and modify the prototype for large batch production. Make our design documents publicly available online so any citizen or organization can build and use the sensor device and present our final product design to state agencies.

Outcome	Comp. Date
1. Modify design to minimize costs to drop the barrier to entry for citizens to test their water. Goal: Total parts cost for 500 unit quote <$100, and <$0.20 per test for supplies.	04/01/20
3. Present sensor performance, design documents and expected sensor costs to state agencies, citizens, and water management organizations.	06/30/20

III. PROJECT STRATEGY

A. Project Team/Partners

PI Prof. Dr. Andrew Wickert will co-design the nitrate sensors, co-develop their software, use his knowledge of Minnesota's geology to help choose a suitable set of test sites, and analyze data.

co-PI Chad Sandell will manage and execute the bulk of the project. He will use his mechanical engineering expertise to develop a robust nitrate sensor that is easy to use and install, and requires minimal maintenance; network with private citizens to test the sensor, and lead reports of results.

Project Partner The Nitrate Elimination Company Inc. (NECI) (no ENRTF funds requested) developed the corn-based enzyme to test nitrate concentrations and will provide technical assistance and chemistry expertise.

B. Project Impact and Long-Term Strategy

This in-home nitrate sensor will assure water safety for concerned families while contributing to the statewide effort to effectively manage water resources. In addition to homes with private wells, this technology can be implemented in vulnerable public water supply systems across the state to ensure quick detection of nitrate contamination. The public dataset that this work will generate will allow **quick identification of polluted wells and aquifers, identification of unknown surface pollutant sources, calculations of nitrate mobility, greater citizen involvement in water conflict resolution, and more informed legislative decisions**. Outside of the home, nitrate pollution in Minnesota's lakes, rivers, and groundwater is an additional growing concern, and the proposed design could be converted with minimal changes into a device suitable for field data collection.

C. Timeline Requirements

Project will be completed in 36 months. The first 1.5 years are needed to develop the sensor. The following year is required to build 50 prototype units, field test them with the help of citizen volunteers, and analyze the results. During the final 6 months, the project team will communicate with state agencies while improving the sensor based on citizen feedback and preparing it for mass production.

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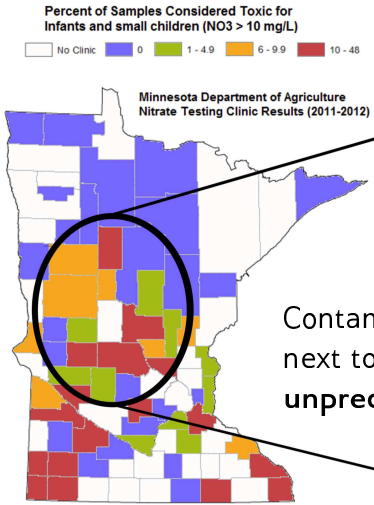
IV. TOTAL ENRTF REQUEST BUDGET 3 years

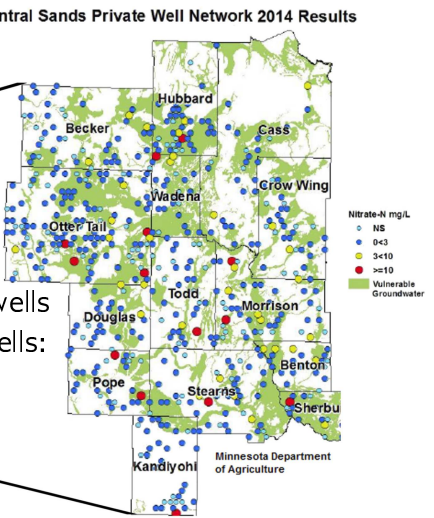
BUDGET ITEM	AMOUNT
Personnel	**$ 241,340**
PI Wickert: 74.8% salary, 25.2% benefits, 8% FTE (1 summer month) years 1 and 2, and 4% FTE (2 summer weeks) year 3 ($27,123)	
co-PI Sandell:78.5% salary, 21.5% benefits, all 3 years at 80% FTE; this high time percentage is required to maintain a consistent "face of the project" who develops the instrument and interfaces with the local community ($214,217)	
Professional/Technical/Service Contracts	**$ 6,000**
Certified lab (Pace Analytical Services) Lab nitrate testing fees ($6,000)	
Equipment/Tools/Supplies	**$ 27,750**
Device hardware, prototypes and field units (housing, tubing, gaskets, actuators, circuit boards, batteries, wires: $1050/prototype, 25 units ($26,250)	
Assay reagents for 6000 tests ($1500)	
Travel	**$ 500**
Travel to sample collection sites and nitrate testing labs for prototype testing, field test sites when needed ($500)	
Additional Budget Items	**$ 1,000**
Prototype field test shipping costs: postage, packaging, instructions/survey printouts ($1,000)	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 276,590**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
Other State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
In-kind Services To Be Applied To Project During Project Period	**$ 205,482**	**(mixed)**
The light electronics component of Andrew Wickert's lab will provide assembly equipment and supplies ($3,000), circuit board control software (estimated $40,000 development cost), and electronics schematics that will be the starting point for the sensor design (estimated $15,000 development cost).	$ 58,000	Secured
Volunteer citizen scientists will preform equipment installation and product review of the field test units ($20/hour).	$ 3,000	Pending
The University of Minnesota's Facilities and Administrative rate is 52% of modified total direct costs (total direct less graduate student fringe, capital equipment, subawards over $25,000 and on-site facilities rental). The University will provide office space, IT services, and administrative / financial services in support of the project.	$ 144,482	Secured
Funding History: N/A	$ -	N/A
Remaining $ From Current ENRTF Appropriation: N/A	$ -	N/A

Is my water safe?





Contaminated wells next to clean wells: **unpredictable**

7.1% of samples above the safe limit for nitrate

Testing each well is the only way to be certain

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Professor Wickert joined the Department of Earth Sciences and the Saint Anthony Falls Laboratory at the University of Minnesota in August 2015, following a postdoctoral research position in the Institute for Earth and Environmental Science at the Universität Potsdam in Germany. He is also a graduate advisor in the Water Resources Sciences program at the University of Minnesota. His water resources research focuses on the development of innovative instrumentation to improve measurements and reduce costs and build observational networks. As a native of Minnesota who cares passionately for its lands, waters, and people, he is committed to understanding and improving the natural environment in his homeland and our interactions with it.

Wickert integrates the effects of climate and **land-use change on the Earth's surface**, and recently co-authored a review of the state of the science at this critical intersection. In his past work, he **developed inexpensive open-source data loggers** that have been used to understand **denitrification in the Mississippi River delta and the Gulf of Mexico dead zone**, measure the effects of frost on hillslope shape and soil development across Colorado, monitor glacier melt in Alaska, and gauge streams in Argentina. He also builds instruments to photograph and measure how hillslopes erode and change following wildfire. All of these designs are open-source and available for professional and citizen science. He has also worked with GPS stations across the Midwest to understand how the load of the continental glaciers from the last ice age warped Earth's crust and have affected the Mississippi River is ways that continue to be seen today. On a broader scale, he continues work towards continental-scale water balances to understand how changing climate and melting ice sheets can affect global ocean circulation.

In his teaching, Wickert has **taught future state scientists about the glacial geology of Minnesota**, supported the University of Minnesota's geology club, and helped to plan the University of Minnesota geology field camps. He is currently planning new courses on geomorphology – the science of how landscapes form and change – and computational methods in Earth sciences; both of these are tied tightly to hydrology.

Prior to his postdoctoral position in Potsdam, Germany, Wickert received his Ph.D. in geology from the University of Colorado Boulder (2014), his S.B. in Earth, Atmospheric, and Planetary Science from MIT (2008), and his high school diploma from Harding Senior High School on Saint Paul's east side (2004).

Saint Anthony Falls Laboratory, University of Minnesota (Twin Cities)

Research at the historic Saint Anthony Falls Laboratory (SAFL), part of the College of Science and Engineering at the University of Minnesota, is focused at the intersection of fluid dynamics with major societal challenges in energy, environment and health. SAFL scientists and engineers integrate experiments in the laboratory and field with advanced computational tools and theory to obtain innovative, science-based solutions to real-world fluid-flow problems.