Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 085-B**

Our Future Drinking Water: Nitrate, Tile, and Climate

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 330,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

We will evaluate how to reduce nitrate in rural drinking water and how tile drainage and climate change impact replenishment of drinking water, i.e., groundwater recharge.

Name: James Almendinger

Sponsoring Organization: Science Museum of Minnesota

Job Title: Dr.

Department: St. Croix Watershed Research Station

Address: 16910 152nd St N

Marine on St Croix MN 55047

Telephone Number: (651) 433-5953

Email jalmendinger@smm.org

Web Address:

Location:

Region: Southeast

County Name: Dakota

City / Township: Hastings, Vermillion

Alternate Text for Visual:

Maps of land use and increased nitrate contamination in groundwater in Dakota County. Schematic of infiltrating water absorbing nitrates and traveling decades through the aquifer toward a river.

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

PROJECT TITLE: Our Future Drinking Water: Nitrate, Tile, and Climate

I. PROJECT STATEMENT

• **Summary:** ***We will evaluate how to reduce nitrate in rural drinking water and how tile drainage and climate change impact replenishment of drinking water, i.e., groundwater recharge.***

Using the Vermillion River watershed in Dakota County as our test site, we will do the following:

- Find where groundwater recharge occurs (replenishment of drinking water), and how tile drainage reduces it. *This is quantitatively unknown.*
- Find where on the landscape nitrate originates. *Spatial targeting.*
- Evaluate alternative land-management practices to reduce this nitrate, in terms of the following:
  - How much is nitrate reduced? *Testing the options.*
  - How much does it cost to reduce nitrate? Is it cost-effective? *This is usually ignored.*
  - How long will it take to see the improvement? *This is virtually unknown.*
- Evaluate what drinking water supply will be over the next 80 years. *This is virtually unknown.*

• **Rationale:**

• **Rural Minnesota deserves abundant and clean drinking water**

- The quality of rural drinking water (groundwater) is commonly compromised by nitrate pollution. We need realistic solutions based on effectiveness, cost, and response time.
- The supply of rural drinking water is reduced by tile drainage and threatened by climate change, but no one knows by how much.

• **The Vermillion River watershed in Dakota County is an important test case.**

The watershed is largely agricultural with sandy soils overlying fractured bedrock aquifers, making the area susceptible to groundwater pollution. *In the eastern watershed, most drinking-water supply wells are contaminated with nitrate above background levels and commonly above the drinking-water limit. And the problem is getting worse.*

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Quantify drinking-water replenishment and identify nitrate hotspots: *How much and how bad?*
Description: We will calculate groundwater recharge (replenishment of rural drinking water) using the Soil and Water Assessment Tool (SWAT), a watershed simulation program that accounts for complex soils, detailed agricultural practices, crop growth, tile drainage and all aspects of the hydrologic cycle (infiltration, runoff, and evapotranspiration) at a daily time step. The impact of tile drainage on recharge can be estimated by comparing simulation results with, and without, tile drainage activated. SWAT tracks nitrate through the watershed, from its application as fertilizer, storage in soils, uptake in plants, release from plant decomposition, and transport through the watershed in surface runoff or groundwater flow. SWAT will identify which subbasins are nitrate hotspots, which practices within each subbasin are the greatest nitrate generators, and how much of that nitrate is entering the shallow aquifer.
Dissemination: Report and data output to Dakota County; blog post to select newsletters.
ENRTF BUDGET: $130,000

Outcome	Completion Date
1. Build and calibrate a simulation of Vermillion River watershed	*March 2021*
2. Quantify recharge amounts and test impact of tile drainage	*September 2021*

Activity 2: Evaluate BMPs for effectiveness, response time, and cost: *What can we do? How long will it take?*
Description: SWAT can simulate a number of best management practices (BMPs) to test for which are the most effective in reducing nitrate loads to surface and groundwaters. But we feel BMPs must also be evaluated for the cost and time effectiveness. Which BMPs are prohibitively expensive? Which might provide a positive return to the farmer? And how long will it take to see a difference in the receiving waters?
Dissemination: Report to Dakota County; presentation at state conference; blog post to select newsletters.
ENRTF BUDGET: $90,000

Outcome	Completion Date
1. BMP testing for effectiveness	*February 2022*
2. Cost and response-time evaluation of most effective BMPs	*June 2022*

Activity 3: Evaluate future drinking water supply: *How will it change with climate?*
Description: Regardless of cause, climate change is already impacting Minnesota. Groundwater recharge is highly sensitive to small changes in climate: total precipitation, its intensity, its seasonality, and its temperature (snow or rain). We will extract and downscale output from Global Climate Models (GCMs) and run it through our SWAT model of the Vermillion watershed to forecast groundwater recharge over the next 80 years.
Dissemination: Report to Dakota County; presentation at state conference; blog post to select newsletters.
ENRTF BUDGET: $110,000

Outcome	Completion Date
1. Compilation of future climate data	*December 2022*
2. Quantification of groundwater recharge and nitrate pollution under future climate	*June 2023*

III. PROJECT PARTNERS AND COLLABORATORS:
This project is coordinated with, and complementary to, a sister proposal put forth by Dakota County, which will collect streamflow, tile-flow, and water-quality data to better characterize the nitrate conditions in the Vermillion watershed. Their project will also construct a groundwater model to identify source areas of selected water-supply wells, particularly those for the city of Hastings. Their data collection component will help inform our SWAT modeling effort, and the groundwater-recharge results of our SWAT model will help inform the County's groundwater model. ***Neither of our projects is dependent on the other; however both will be improved by the other.*** We will meet semi-annually to update each other on our joint progress.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:
This project will provide proof of concept for several important issues: (a) how to combine surface-water and groundwater studies, (b) how to evaluate BMPs on more realistic basis including cost and how long it may take to see results, and (c) how climate change may impact our most precious, hidden resource. We anticipate similar future projects in other sensitive study areas.

V. SEE ADDITIONAL PROPOSAL COMPONENTS:
A. Proposal Budget Spreadsheet
B. Visual Component or Map
F. Project Manager Qualifications and Organization Description
G. Letter or Resolution
H. Financial Capacity

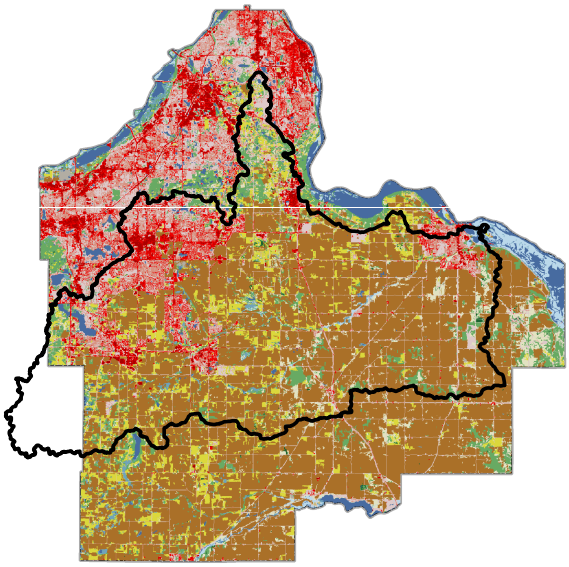
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: James E. Almendinger
Project Title: Our Future Drinking Water: Nitrate, Tile, and Climate
Organization: St. Croix Watershed Research Station, Science Museum of Minnesota
Project Budget: $330,000
Project Length and Completion Date: 3 years; June 2023
Today's Date: 15 April 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 295,000	$ -	$ 295,000
Senior Scientist 1: SWAT model construction, BMP, and climate implementation; $220,000 for 75% for 3 years (78% salary + 22% benefits)			
Senior Scientist 2: BMP selection and parameterization; climate data extraction and analysis; $75,000 for 25% for 3 years (78% salary + 22% benefits)			
Professional/Technical/Service Contracts			
Communications package (electronic blogs, social media; outreach)	$ 30,000	$ -	$ 30,000
Equipment/Tools/Supplies			
Fortran compiler; GIS license; MN Water Resources Conference fees	$ 3,500	$ -	$ 3,500
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
	$ -	$ -	$ -
Other			
MN Water Resources Conference fees (2 scientists x 3 meetings x $250 ea.)	$ 1,500	$ -	$ 1,500
COLUMN TOTAL	$ 330,000	$ -	$ 330,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Data collection by Dakota County staff -- unknown at this time		$ -	$ -	$ -

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

Science Museum of Minnesota



The Vermillion River watershed in Dakota County

Brown = cultivated crops

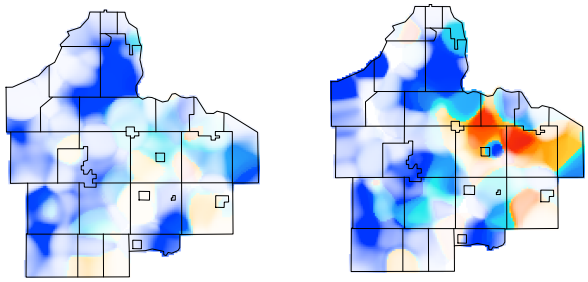
Legend

- Vermillion River Watershed
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Herbaceuous
- Hay/Pasture
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceuous Wetlands

Most wells in eastern watershed have detectable nitrate.

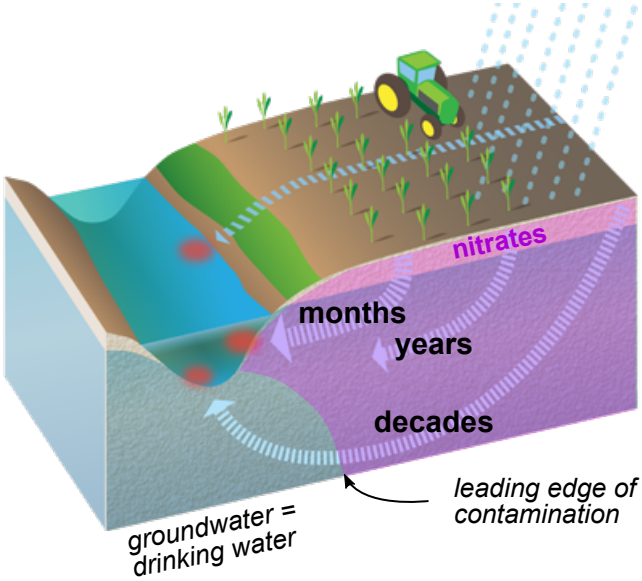
It's getting worse.

1991 2016



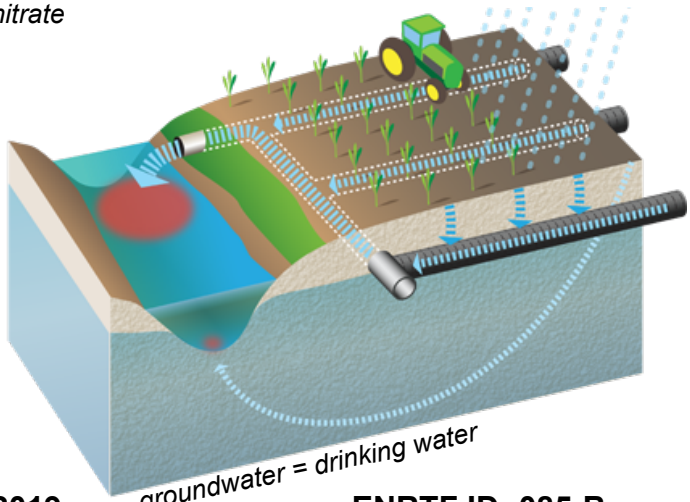
Yellow to red = exceeds 10 ppm drinking-water limit

Maps courtesy of Bill Olsen, Dakota County Environmental Resources Department. Nitrate concentrations in wells 50 ft below water table.



- What can be done?
- How long will it take?
- How much will it cost?

- What does tile drainage do?
- What will climate change do?



PROJECT MANAGER QUALIFICATIONS

James E. Almendinger, Ph.D.

Education

1988	Ph.D., Ecology. University of Minnesota, Minneapolis, MN 55455
1978	B.A., Botany. Ohio Wesleyan University, Delaware, OH 43015

Positions

2017-	Director, St. Croix Watershed Research Station, Science Museum of Minnesota
1995-2017	Senior Scientist, St. Croix Watershed Research Station, Science Museum of Minnesota
2000-	Adjunct Associate Professor, Univ. of Minn.: Water Resources Science Program; Dept. of Earth Sciences; and Dept. of Fisheries, Wildlife and Conservation Biology
1990-95	Hydrologist, U.S. Geological Survey, Mounds View, MN.

Research Expertise

My research interests focus on land-water interactions, including the hydrology of lakes, streams, and wetlands; the impact of humans on watersheds; and the hydrologic effects of climate change. I have experience with a variety of hydrologic computer models, including groundwater, watershed, and geochemical models. Research projects have included inferring past climate from lake and groundwater levels; quantifying the anthropogenic flux of sediment and nutrients exported from the upper Mississippi Basin; investigating the effects of urbanization on trout streams; and uncovering the way lakes change naturally over time.

Recent Publications

Edlund, M.B., **J.E. Almendinger**, X. Fang, J.M. Ramstack Hobbs, D.D. VanderMeulen, R.L. Key, and D.R. Engstrom. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. Water 9, 678. doi: 10.3390/w9090678.

Almendinger, J.E., and J.S. Ulrich. 2017. Use of SWAT to estimate spatial scaling of phosphorus export coefficients and load reductions due to agricultural BMPs. Journal of the American Water Resources Association (JAWRA). DOI: 10.1111/1752-1688.12523.

Almendinger, J.E., M.S. Murphy, and J.S. Ulrich. 2014. Use of the Soil and Water Assessment Tool to scale sediment delivery from field to watershed in an agricultural landscape with topographic depressions. Journal of Environmental Quality 43: 9-17. DOI: 10.2134/jeq2011.0340.

Schottler, S.P., J. Ulrich, P. Belmont, R. Moore, J. Lauer, D.R. Engstrom, and **J.E. Almendinger**. 2013. Twentieth century agricultural drainage creates more erosive rivers. Hydrological Processes: 1-11.

ORGANIZATION DESCRIPTION

The ***Science Museum of Minnesota*** (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. Its mission is to inspire learners, inform policy, and improve lives through science. The ***St. Croix Watershed Research Station*** (SCWRS) the environmental research center of the SMM with the mission to foster, through research and outreach, "a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide." The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.