Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-206

Proposal Title: Mapping pollutant sources across land use gradients

Project Manager Information

Name: William Arnold

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: The relative importance of sources of nutrients and emerging contaminants to the Twin Cities Metropolitan area will be quantified to help make better decisions for water quality protection and improvement.

Funds Requested: $420,000

Proposed Project Completion: June 30 2025

LCCMR Funding Category: Water Resources (B)

Project Location

What is the best scale for describing where your work will take place?

Region(s): Metro

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

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

Humans have a major impact on water quality in Minnesota. All of our waterbodies carry chemicals that can impact human and environmental health. Understanding the sources and levels of the chemicals is critical to protecting and improving water quality and drinking water sources as well as ensuring healthy ecosystems. Many chemicals of interest are directly related to human activity including nutrients, emerging contaminants (such as pharmaceuticals, personal-care-products, hormones and endocrine-disrupting compounds, herbicides, and insecticides), salinity, and trace elements/heavy metals. In an urban area, like the Twin Cities, there are many sources of chemicals. Some chemicals are imported into the area via rivers and the atmosphere; some are generated within the urban area and released through wastewater, industrial, and stormwater discharges. The relative importance of the various sources is oftentimes unknown, but this information could be very useful in helping to prioritize water management and treatment decisions. To provide actionable information relevant to management and policy development, we need to understand the import and export of chemical pollutants through the urban environment to draw meaningful links between the presence of chemical inputs driven by human activities, water quality, and potential environmental impacts.

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.

This research will assess the relative importance of riverine import of nutrients, selected emerging contaminants, and other chemicals to the Twin Cities Metropolitan Area (TCMA) and compare this to the contributions from stormwater, wastewater, and atmospheric deposition (rainfall) within the TCMA. Funds will be used for collection and analysis of water samples for the construction of a mass budget of the inputs, outputs, and losses of individual chemicals in the TCMA for two years. A similar, previous approach for chloride proved very useful and demonstrated the impact deicing salts have on surface water quality. The greater TCMA has a limited number of inflow and outflow routes, ideal for the development of a mass balance on a select group of indicator pollutants to assess the sources and human activities that dictate the region's water quality. Samples will be collected from three large river sites (Mississippi River at Anoka and Hastings, Minnesota River at Jordan), as well as key wastewater discharges, stormwater runoff, and atmospheric deposition in the TCMA. Following collection, samples will be filtered, analyzed at the UMN laboratories. The chemical measurement will be supplemented by water flow to calculate loads (mass per time), which will be the basis for comparisons.

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?

The specific outcome of the proposal will be an understanding of the relative importance of different sources of water pollution. Specifically, how much of specific pollutants are imported into versus exported by the TCMA. The methodology developed will be applicable to cities and towns of various sizes throughout Minnesota. The insight gained from this research will aid policy makers and regulators in developing strategies for the preservation and improvement of waters that serve as drinking water sources and environmental resources. An important outcome is dissemination of findings to stakeholders, policy makers, regulators, and the public.

Activities and Milestones

Activity 1: Annual mass imports and exports of nutrients and emerging contaminants into/from the TCMA via the Mississippi and Minnesota Rivers

Activity Budget: $153,834

Activity Description:
The TCMA sits at the confluence of two major rivers (Mississippi and Minnesota). The Mississippi River (at Anoka) entering the TCMA drains largely undeveloped areas with some agriculture. The Mississippi River watershed (at Jordan) entering the TCMA consists largely of row-crop agriculture. The Mississippi River (at Hastings) leaving the TCMA integrates all the chemical inputs from the urban watershed. Samples from each of the gauged sites will be collected for two years during periods of high flow and low flow. Historical data, flow data, and chemical concentrations will be analyzed to guide sampling times and frequency. Water samples will be filtered prior to analysis. Emerging contaminants will be selected to identify specific inputs from urban, suburban, and agricultural areas. Target contaminants include: neonicotinoid insecticides (imidacloprid and clothianidin), herbicides (atrazine, simazine, prometon, 2,4-D, MCPA), sulfa antibiotics (specific ones are used in humans vs animals), and wastewater derived compounds (carbamazepine, artificial sweeteners). The emerging contaminants, nutrients, and major ions will be analyzed with instrumentation in the Civil, Environmental, and Geo- Engineering laboratories and in centralized core laboratories. From the measurements, annual pollutant loads, landscape yields, and average annual concentrations will be calculated for two annual periods (from October to September).

Activity Milestones:

Description	Completion Date
Determination of the number of samples needed at each site based on available historical data	October 31 2022
Sampling and analysis of three major rivers for two years of annual loads	October 31 2024
Calculation of annual loads, landscape yields, and average annual concentrations of the individual chemicals	December 31 2024

Activity 2: Quantification of mass of nutrients and emerging contaminants contributed to the major rivers within the TCMA

Activity Budget: $166,333

Activity Description:
Nutrients and emerging contaminants are used, produced, or deposited within urban area such as the Twin Cities. Common sources of chemicals are wastewater discharges, stormwater runoff, atmospheric deposition, and industrial discharges. The mass of the chemicals from wastewater will be quantified by obtaining composited samples from the TCMA wastewater treatment plants with the largest discharges. The mass of the chemicals from stormwater will be quantified by obtaining samples from selected gauged stream (such as Shingle Creek) which receive large volumes of stormwater, and from other major stormwater-receiving sites (such as the inflow to Como Lake). By measuring the concentrations of the chemicals in numerous stormwaters, average concentrations under different flow conditions will be quantified. These will be paired with estimates of total TCMA stormwater volume from differences in river flows at the three major river sampling sites to calculate annual loads. The mass of the chemicals in atmospheric deposition will be determined by collecting rain at selected sites in the TCMA. The mass of some of the chemicals in industrial discharges will be estimated from records in publicly available NPDES database. All the sampling and analysis will use the same protocols as described in Aim 1.

Activity Milestones:

Description	Completion Date
Quantification of mass of nutrients and emerging contaminants contribution to the TCMA via wastewater	October 31 2024
Quantification of mass of nutrients and emerging contaminants contribution to the TCMA via atmospheric deposition	October 31 2024
Quantification of mass of nutrients and emerging contaminants contribution to the TCMA via stormwater	October 31 2024
Dissemination of results via publications and presentations	December 31 2024

Activity 3: Identify the relative importance of various sources of nutrients and emerging contaminants

Activity Budget: $99,833

Activity Description:

The relative importance of the various sources of the chemicals (imports into the TCMA, atmospheric deposition, and wastewater, stormwater, and industrial discharges) will vary due to changes in weather and season, both of which effect the flow of the water in the streams. Some of the chemicals that enter the TCMA will be transformed and lost or be stored within the riverine system. Simple simulation models will be used to help understand the relative importance of inputs from outside the TCMA, various inputs with within the area, chemical transformation, and storage within the area over time and flow conditions. Discharge, chemical concentration measurements, rate of transformation (loss), and watershed storage will be used to compare the relative importance of sources for individual chemicals over time. This knowledge can be used by water managers and policy makers to help prioritize and make better decisions for the protection and improvement of water quality.

Activity Milestones:

Description	Completion Date
Relative important of various sources during high flow and low flow periods in the rivers	December 31 2024
Estimation of transformation (loss) rates and watershed storage from the scientific literature	June 30 2025
Modeling the losses and gains of various chemicals though the TCMA	June 30 2025
Dissemination of recommendations to stakeholders, policy makers, regulators, and the public	June 30 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Paul Capel	University of Minnesota	Dr. Paul Capel will collaborate on the design and supervision of this project. His work focuses on water quality, the environmental behavior and transport of chemicals, and the importance of hydrologic flowpaths on chemical transport. He worked for the US Geological Survey for more than 30 years.	Yes
Metropolitan Council Environmental Services	Metropolitan Council Environmental Services	Assistance with wastewater sample collection	No
Regional Watershed Districts	Regional Watershed Districts	Identification of sampling sites, assistance with sample collection	No

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?

Implementation will occur through publication of findings in open access peer-reviewed literature and communication of results to partners, stakeholders, policy makers, regulators, and the public. The results and model will be of interest to watershed districts and the Minnesota Pollution Control Agency.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Solar Driven Destruction of Pesticides, Pharmaceuticals, Contaminants in Water	M.L. 2014, Chp. 226, Sec. 2, Subd. 03a	$291,000
Antibiotics and Antibiotic Resistance Genes in Minnesota Lakes	M.L. 2014, Chp. 226, Sec. 2, Subd. 03e	$300,000
Assessing Neonicotinoid Insecticide Effects on Aquatic and Soil Communities	M.L. 2016, Chp. 186, Sec. 2, Subd. 04e	$400,000
Assessment of Surface Water Quality With Satellite Sensors	M.L. 2016, Chp. 186, Sec. 2, Subd. 04i	$345,000
Assessment of Household Chemicals and Herbicides in Rivers and Lakes	M.L. 2017, Chp. 96, Sec. 2, Subd. 04a	$236,000
Water Quality Monitoring in Southeastern Minnesota Trout Streams	M.L. 2017, Chp. 96, Sec. 2, Subd. 04d	$500,000
Mapping Antibiotic Resistance in Minnesota to Help Protect Environmental, Animal, and Human Health	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04h	$750,000
Determining Influence of Insecticides on Algal Blooms	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04a	$350,000
Benign Design: Environmental Studies Leading to Sustainable Pharmaceuticals	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04b	$415,000
Improving Drinking Water for Minnesotans through Pollution Prevention	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04f	$345,000
Protecting Minnesota Waters by Removing Contaminants from Wastewater	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04g	$250,000
Managed Aquifer Recharge	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04t	$350,000

Project Manager and Organization Qualifications

Project Manager Name: William Arnold

Job Title: Professor

Provide description of the project manager's qualifications to manage the proposed project.
Distinguished McKnight University and Joseph T. and Rose S. Ling Professor and Associate Head
Department of Civil, Environmental, and Geo- Engineering, University of Minnesota
B.S., Chemical Engineering, 1994, Massachusetts Institute of Technology, Cambridge, MA.
M.S., Chemical Engineering, 1995, Yale University, New Haven, CT.
Ph.D., Environmental Engineering, 1999, The Johns Hopkins University, Baltimore, MD.
Dr. William Arnold will be responsible for overall project coordination and supervision and design of the field sampling and reactivity studies. He has been studying the fate of pharmaceutical and pesticide compounds in aquatic environments for twenty years. As part of these studies, he has determined the transformation rates and identified reaction products of numerous compounds. Recent work in collaboration with Dr. Capel has shown that different neonicotinoid insecticides are present in agricultural versus urban areas. He has published over thirty peer-reviewed papers on pesticide and pharmaceutical fate since 2003, and he is the co-author of a textbook on water chemistry published in 2011. Dr. Arnold is a Fellow of the University of Minnesota Institute on the Environment, an Associate Fellow of the Minnesota Supercomputing Institute, and a member of the graduate faculty in Water Resources Science.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States. The laboratories and offices of the PI and co-PIs contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
William Arnold		Project Manager			24.5%	0.18		$53,253
Paul Capel		Project co-manager			24.5%	0.18		$53,253
Graduate Student		Sample collection, processing, data collection and interpretation			44.6%	1.5		$158,494
Undergraduate student 1		assist with sample collection and processing			0%	0.9		$22,500
undergraduate student 2		Assisting with data processing and analysis			0%	0.9		$22,500
							Sub Total	**$310,000**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Laboratory supplies, including chemical standards, glassware, extraction cartridges, solvents, and materials	Necessary for collection and processing of samples for analysis					$40,000
	Tools and Supplies	Laboratory services and instrument maintenance	Fees for the use or maintenance of instrumentation used to quantify the chemicals in the samples					$55,000
							Sub Total	**$95,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**

Travel In Minnesota								
	Miles/ Meals/ Lodging	100 local trips, 1 person ~ 50 miles	collection of water samples					$4,000
	Conference Registration Miles/ Meals/ Lodging	conference registration, travel, and lodging for PIs and students	dissemination of results and engagement of stakeholders					$3,000
							Sub Total	**$7,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Open access fees	Fees for open access publication of 3 or 4 journal articles					$8,000
							Sub Total	**$8,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$420,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	The indirect (facilities and administrative) costs that would be associated with the project are an in-kind contribution	operation of facilities and administrative support	Secured	$201,500
			State Sub Total	**$201,500**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$201,500**

Attachments

Required Attachments

Visual Component

File: 614795d8-200.pdf

Alternate Text for Visual Component

Isometric drawing of a city outlined by a mass budget control volume with inflows consisting of the Mississippi River, Minnesota River, storm water, and effluent from a wastewater treatment plant, and atmospheric deposition and the Mississippi River as the sole outflow from the region. The city is overlaid with storm clouds and rainfall, generating runoff and interacting with the atmospheric compartment....

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

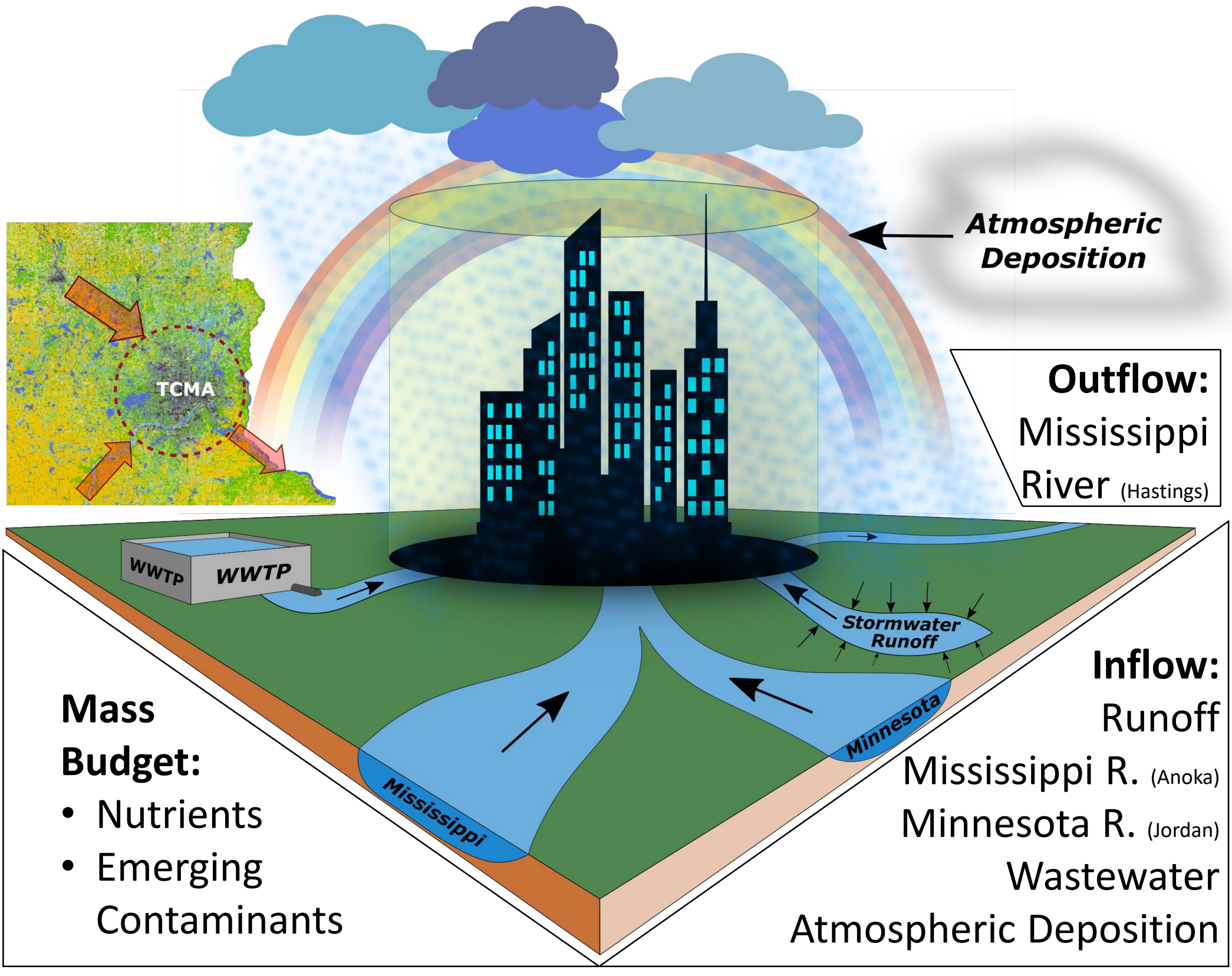
N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration



Key Outcomes:

- Quantify annual loads of nutrients and emerging contaminants in rivers, stormwater, wastewater effluent, and atmospheric deposition into, within, and through the Twin Cities Metropolitan Region.
- Assess the relative importance of contributing compartments to water quality.
- Provide actionable information for water management and policy development.