Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 171-F**

Functionalized Nanomaterials to Enhance Performance of Pervious Concrete

Category: F. Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Total Project Budget: $ 131,728

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

This study aims to develop innovative pervious concrete using nanotechnology for mitigating climate change impact and enhancing ecosystems resilience in Minnesota's environment and natural resources.

Name: Zhibin Lin

Sponsoring Organization: North Dakota State University

Address: NDSU Dept. 4000, P.O. Box 6050

Fargo ND 58108-6050

Telephone Number: (701) 231-8976

Email amy.scott@ndsu.edu

Web Address http://www.ndsu.edu/research/sponsored_programs_admin/staff/

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Northwest region and statewide

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

PROJECT TITLE: *[Functionalized nanomaterials to enhance the performance of pervious concrete for climate and ecosystems resilience]*

I. PROJECT STATEMENT

1. *WHY this project needs to be done.*

   Minnesota has over 18,000 lakes, rivers and wetlands. The climate change and more frequency of mega-storm (MPR report news, 2015) highly impact the Minnesota's water quality, and environment and natural resources. The conventional manmade ground surface, including landscape, parking lot, sidewalk and roads, is impervious (U.S. Federal Highway Administration, 2003). According to the survey (Rose et al., 2003), the impervious surface areas can reach up to 30 to 45% of total land cover near urban area, while these impervious surfaces can cause severe heat island effects (Urban Heat Island, 2010; Li et al., 2012). Also, rainwater and excess urban irrigation water being directed to storm drains instead of the soil subgrade through infiltration significantly impair water quality and cause ecological degradation of streams (Kayhanian et al., 2010). Elevated water temperatures, most likely due to heating by impervious surfaces, can lead to heat shock of susceptible aquatic species in many Minnesota's lakes. Therefore, this study aims to develop innovative pervious concrete using nanotechnology for mitigating climate change impact and enhancing ecosystems resilience in Minnesota's environment and natural resources.

2. *Overall GOALS of the project and the specific, direct OUTCOMES you aim to achieve.*

   Overall goals of the project tends to mitigate the effects of climate change through the adoption of pervious concrete with functionalized nano-coating (e.g., graphene oxide, Gao et al., 2011), including significantly improved water purification, and eliminate heat island effects and create more favorable conditions for Minnesota's ecosystem components (animals and plants).

3. *HOW the project will achieve those goals.*

   Conventional pervious concrete can achieve some improvements in water (quality due to filtration effects) and mitigate heat shock. By incorporating nanomaterials (e.g., functionalized graphene oxides), pervious concrete is expected to offer enhanced performance in supporting Minnesota's green and sustainable ecosystem.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *(Climate Change Impacts and Role of Impervious Surface)* **Budget: $11,394**

Outcome	Completion Date
1. Review the impacts of climate change to Minnesota's ecosystems, measureable outcome #1 frequency of storm, thermal gradient and water quality	*7/1/16-8/31/16 (3 months)*
2. Review the role of impervious surface in climate and ecosystems, measureable outcome #2 heat island effects, heat shock, water quality and pollution (heavy metals, oils)	*9/1-10/31/16 (3 months)*

Activity 2: *(Design and Optimize Pervious Concrete)* **Budget: $11,394**

Outcome	Completion Date
1. Formulate pervious concrete mixtures, such as water-to-solid ratios, measureable outcome #1 small-scale specimen testing for wearing, and strength	*7/1/16-8/31/16 (2 months)*
2. Optimize coarse aggregate size/gradation and porosity in pervious concrete mixtures, measureable outcome #2 testing for void ratio and water permeability	*9/1-10/31/16 (2 months)*
3. Leachate studies and filtration effect analysis with pervious concrete, measureable outcome #3 contaminant removal, salinity, and pH measurement, Leachate analysis	*11/1-12/31/16 (2 months)*

Activity 3: *(Synthesize and Characterize Functionalized Nano-Coating)* **Budget: $43,076**

Outcome	Completion Date
1. Synthesize functionalized graphene oxides, measureable outcome #1 nanoparticle characterization (including hydrophilicity, mixing characteristics).	*1/1/17-5/31/17 (5 months)*
2. Testing of impervious nanoconcrete, measurable outcome#1 contaminant absorption and water permeability (also compare with results from Activity 2)	*6/1-12/31/17 (7 months)*

Activity 4: *(Develop and Characterize Functionalized Nano-Coated Pervious Concrete)* **Budget: $43,076**

Outcome	Completion Date
1. Deposit and optimize the nano-coating on pervious concrete, measureable outcome #1 measurement of coating thickness, and uniformity.	*1/1/18-2/28/18 (2 months)*
2. Determine permeability of the nano-coated pervious concrete, measureable outcome #2 testing for void ratio and water permeability.	*3/1-5/31/18 (3 months)*
3. Conduct contaminant removal and leachate studies, measureable outcome #3 contaminant removal, salinity, and pH measurements.	*6/1-12/31/18 (7 months)*

Activity 5: *(Implement Functionalized Nano-Coated Pervious Concrete in Field)* **Budget: $22,788**

Outcome	Completion Date
1. Evaluate the nano-coated pervious concrete's mechanical performance, measureable outcome #1 surface durability, abrasion resistance and fatigue resistance.	*7/1/18-6/30/19 (12 months)*
2. Micro and nanoscale strength and structure evaluation, measurable outcome #1 nanoindentation data from Atomic Force microscopy and macro/nanoscale structural analysis using electron microscopy. These data will help in designing the next generation of pervious concrete.	*7/1/18-6/30/19 (12 months)*

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. Zhibin Lin from North Dakota State University (NDSU) will lead this project at NDSU. He will oversee the project and participate in all aspects of the project, with particular focus on the Activities 2, 3, 4 and 5. Lin's expertise is in cement/concrete, advanced cement-based material and material sustainability. Dr. Achintya Bezbaruah will be responsible for synthesis of functionalized nano-coating for use in pervious concrete in Activities 1, 3, 4 and 5. Bezbaruah's research expertise is environmental nanotechnology.

B. Project Impact and Long-Term Strategy

Project Impact: a) on storm runoff management: the new pervious concrete will effectively accommodate the more frequent climate change, and material degradation, b) on environmental sustainability: the new pervious concrete and its implementations will mitigate the pollution, improve water quality and reduce heat shocks to species in rivers and lakes, and reduce noise and heat island effects. Dissemination of the project results will be presented to practice engineers at LCCMR and Minnesota's environment and natural resources, cement and concrete materials companies, and pavement design and consulting companies through Journal papers, presentations, and seminars. Long-Term Strategy: it will be desirable to long-term monitor the performance of the proposed pervious concrete. Thus the research team tends to submit further proposal to the LCCMR in the future, or pursue further financial support from DOTs or Federal for achieving this goal.

C. Timeline Requirements

This project is expected to have a duration of 36 months.

2016 Detailed Project Budget

Project Title: *[Functionalized nanomaterials to enhance the performance of pervious concrete for climate and*

IV. TOTAL ENRTF REQUEST BUDGET *[3]* **years**

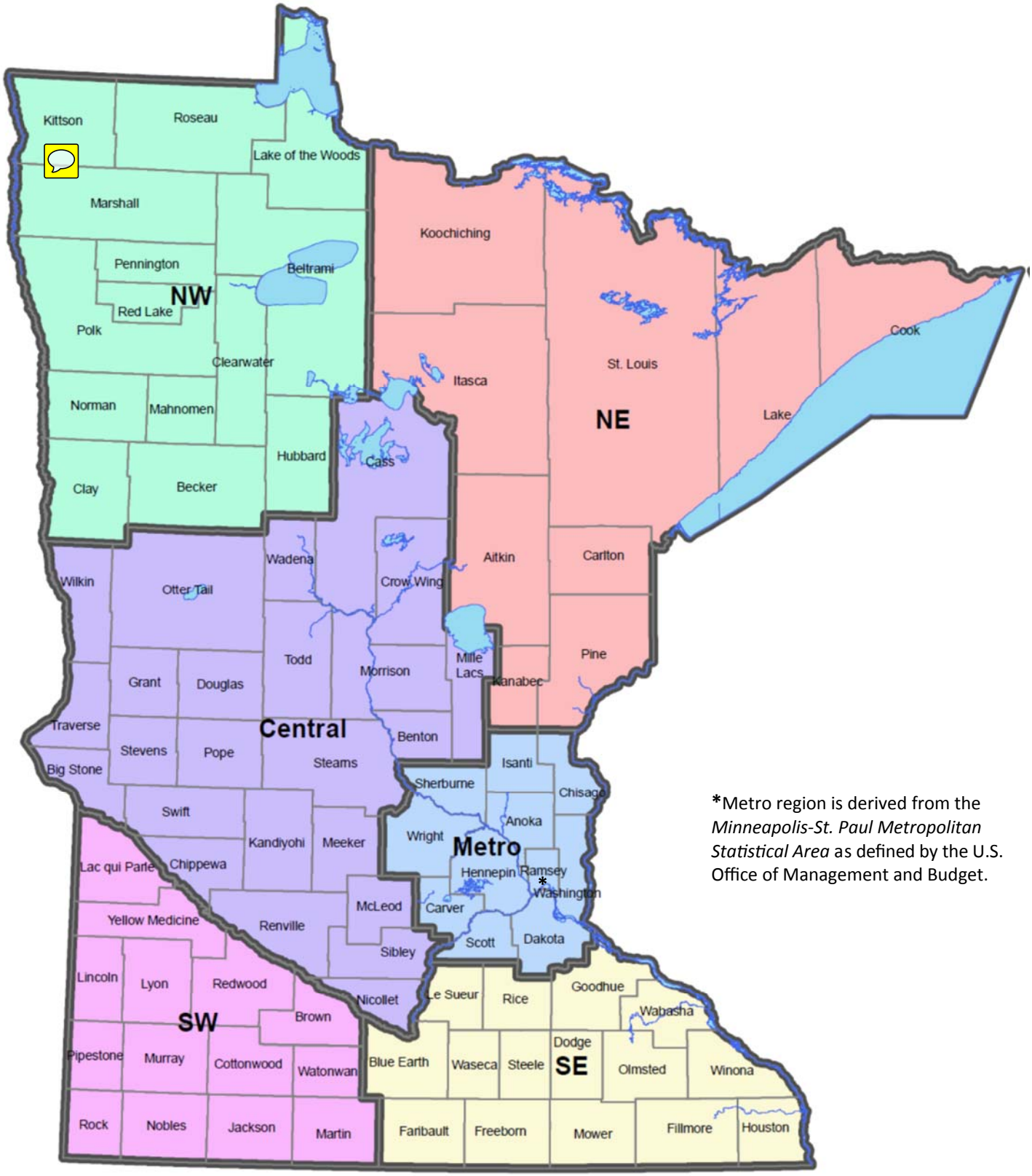
BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel: *Two Full-time faculty (Zhibin Lin, Achintya Bezbaruah): $24,000/person toward salary, $7,200/person toward benefits, one month/year/person to the project, and 2 full-time faculty.*	$ 62,400
Personnel: *One full-time graduate student: $50,400 toward salary, $1,512 toward benefits, twelve months/year to the project (totally thirty-six months).*	$ 51,912
Personnel: *One part-time undergraduate student based on hourly payment: $7,200 toward salary, $216 toward benefits, nine months/year to the project (totally twenty-seven months).*	$ 7,416
Professional/Technical/Service Contracts: *N/A*	$ -
Equipment/Tools/Supplies: Purchasing nanoparticle (e.g., graphite) for synthesis of nano coating, and purchasing cement/aggregate/plywood, and other supplies for pervious concrete	$ 10,000
Acquisition (Fee Title or Permanent Easements): *N/A*	$ -
Travel: *N/A*	$ -
Additional Budget Items: N/A	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 131,728

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

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: *IN/A*	$ -	*N/A*
Funding History: *N/A*	$ -	N/A
Remaining $ From Current ENRTF Appropriation: *N/A*	$ -	*N/A*

Minnesota (by geographic region)

Use for determining region location for proposal submission form (see p.9)



*Metro region is derived from the *Minneapolis-St. Paul Metropolitan Statistical Area* as defined by the U.S. Office of Management and Budget.

PROJECT TITLE: *[Functionalized nanomaterials to enhance the performance of pervious concrete for climate and ecosystems resilience]*

Project Manager Qualifications & Organization Description

Project Manager Qualifications

Dr. Zhibin Lin is assistant professor at Dept. Civil and Environmental Engineering, North Dakota State University. Dr. Lin will serve as the Principle Investigator on the project. He has served as a research scientist and PI on several DOTs (WisDOT, MnDOT, and NDDOT), FHWA, and Industry sponsored projects. Dr. LIn has published over 40 refereed and conference publications and reports in the field of advanced cement-based materials and durability. Dr. Lin is an active member of several technical committees and serves as a member of the editorial board of three international journals. He is the secretary of the American Concrete Institute Committee 523, and member of subcommittees of 447 (Finite Element Analysis of Reinforced Concrete Structures) and 446 (Fracture Mechanics of Concrete).

Organization Description

The Engineering Laboratories, Electron Microscopy Lab, Environmental lab and machine shop at North Dakota State University has sufficient equipment and facilities to successfully complete the proposed research tasks.