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

Project Title: **ENRTF ID: 073-B**

Smart Water Resource System for Sauk River Watershed

Category: B. Water Resources

Total Project Budget: $ 214,260

Proposed Project Time Period for the Funding Requested: 2 years, July 2017 – June 2019

Summary:

Common, integrated, system for Sauk River Watershed, to gather real-time meteorological and hydrological data, predict water quantity and quality, and provide up-to-date information and decision support for water resource management.

Name: Ramnath Sarnath

Sponsoring Organization: St. Cloud State University

Address: 720 Fourth Ave S

St. Cloud MN 56301

Telephone Number: (320) 308-4960

Email rsarnath@stcloudstate.edu

Web Address

Location

Region: Central

County Name: Douglas, Meeker, Pope, Stearns, Todd

City / Township:

Alternate Text for Visual:

Schematic for the intelligent decision-support system for the Sauk River Watershed, showing data inputs, stages and outputs

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

PROJECT TITLE: Smart Water Resource System for Sauk River Watershed

I PROJECT STATEMENT

The Sauk River is an important tributary of the Mississippi with a watershed spanning five counties and covering 1,041 square miles. It is thus impossible to predict the quality or quantity of the water resources in the lower Mississippi, without an accurate characterization of the Sauk River Watershed. The **two principal obstacles** that are currently in the way of such a characterization are:
(1) Lack of a centralized platform to share meteorological and hydrological data, water quality and quantity measurements, and watershed structure information.
(2) Absence of a predictive modeling tool that integrates real-time meteorological data with hydrological behavior and watershed features.
We propose to **overcome these obstacles** by building an **intelligent system**, which would: (a) integrate data about all watershed features, (b) monitor federal, state and local sources for up-to-date meteorological and hydrological data, (c) analyze the data by applying hydrological principles that capture the interrelationships between all the measurements, (d) make predictions about the quality and quantity of water resources available in the watershed, and (e) visualize the results. This system will be designed to serve as a shared, easily accessible, decision-support platform for all governmental agencies. Such a project is **critical right now** for the following reasons:
(1) Rapid development in the Sauk River watershed has resulted in excessive runoff, poor base flow and heavy erosion, which has led to the river being classified as impaired. We are facing an immediate need to predict and reduce flooding, improve the quality of drinking water, enhance water storage capabilities on the land, improve soil health, and measure effectiveness of conservation efforts.
(2) The proposed system will be easily adaptable for several watersheds in southern and western Minnesota with similar geological characteristics. It would thus provide vital support to the efforts of the Minnesota Board of Water and Soil Resources to implement the "One Watershed, One Plan" legislation.

II PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Construct an integrated database for watershed structures **Budget: $65,000**
A developed watershed contains many stormwater structures, drainage ditches, and structures for transportation, irrigation, agriculture, and energy generation. This data needs to be structured, for efficient querying and easy updating of the structures' properties, performance, operation, and maintenance. This activity will collect the necessary information from the appropriate state and local agencies, create a structured database for the Sauk River Watershed, and validate its performance.

Outcome	Completion Date
1. Multisource data integration of existing drainage structures	November 30, 2017
2. Hydraulic data analysis and classification	January 31, 2018
3. Creation and operational testing of the database	July 31, 2018

Activity 2: Build a mechanism for data collection, integration and remote sensing **Budget: $73,200**
Many of rain, stream and well gauges deployed in the Sauk River Watershed belong to different government agencies. We need an automated mechanism to collect these public domain data for water resource management analysis. A small scale version of this was recently developed at St. Cloud State University. The proposed mechanism will support application of remote sensing techniques for measuring water depletion by evapotranspiration from irrigated and natural systems. This activity will also investigate and incorporate the use of drones for erosion control inspection and data gathering.

Outcome	Completion Date
1. Aligning various data formats and automating online data collection	March 31, 2018

2. Real time data collection system testing and operation	July 31, 2018
3. Drone application on stream and watershed erosion damage inspection	December 31, 2018

Activity 3: Implement a hydrological system for water resource quantification **Budget: $76,060**

The hydrological decision-support system would integrate the land use, soil condition, stream hydraulic characteristics, and onsite meteorology information. Using the hydrological cycle and physical principles of analysis, this system will verify or predict the quantity and quality of ground and surface water. This composite model will incorporate effects of watershed structures and integrate up-to-date hydrological and meteorological information. It will account for hydrological phenomena like evapotranspiration depletion and groundwater-surface water interflow. It will also provide the necessary analysis for the decision making team to optimize water resource management during rapid changes in weather or in the hydrological conditions. Trends indicate that we are in a period of increased climatic variability. A subsurface water conveyance inventory and hydrologic analysis for the Sauk River Watershed will provide us the necessary information for water storage opportunities and drainage request review.

Outcome	Completion Date
1. Hydrological model creation for Sauk River Watershed	July 31, 2018
2. Calibrating hydrological model with field data	December 31, 2018
3. Full spectrum hydrological data model, from water quality to flood prediction	June 30, 2019

III PROJECT STRATEGY

A. Project Team/Partners

The project team will be led by St. Cloud State University faculty, with rich experience in hydrology, data analysis, database design, remote sensing and visualization. Dr. Jeff Cheng is a hydrologist with extensive experience in hydrological modeling. Dr. Ramnath Sarnath (project manager), Dr. Mehdi Mekni and Dr. Omar Al-azzam have experience with software development, database applications, modeling and visualization. Mr. Mark Gill has experience with Geographical Information Systems, visualization and remote sensing. Ms. Lynn Nelson, from the Sauk River Watershed District, will work closely with the team to provide support and expert advice. Staff from the soil and water conservation districts will provide advice on how the system will be accessed and used. Students working on the project will gain experience in the use of hydrological databases and watershed management.

Project Partners Receiving Funds:

- Dr. Jeff Cheng [$35,000]: Hydrological modeling.
- Dr. Mehdi Mekni [$15,000]: Data analysis, database development and software development.
- Dr. Omar Al-azzam [$15,000]: Data analysis, database development and software development.
- Ms. Lynn Nelson [$3,500]: Provide expert advice on needs of Watershed District.

Project Partners Not Receiving Funds:

- Mr. Mark Gill: Geographical Information Systems, visualization and remote sensing.
- Mr. Dennis Fuchs, Mr. Tim Stieber, Mr. Jerry Hagenmiller, Ms. Holly Kovarik, and Mr. Joseph Norman: Soil and Water Conservation Districts of Stearns, Todd, Douglas, Pope and Meeker counties. Provide advice on ways in which system will be accessed and used.

B. Project Impact and Long-Term Strategy

The completed system will be **housed on hardware on the St. Cloud State University campus at least until July 2021, and will be easily accessible to all governmental agencies**. It will be **promoted across the state** through the associations for flood plain management, groundwater and erosion control.

C. Timeline Requirements

The project will start in July 2017 and continue for 24 months to allow time for data collection and processing, model calibration, and validation.

2017 Detailed Project Budget

Project Title: *Smart Water Resource System for Sauk River Watershed*

IV. TOTAL ENRTF REQUEST BUDGET 2 years *(24 months)*

BUDGET ITEM	AMOUNT
Personnel:	$ -
Dr. Jeff Cheng: Hydrologic modeling; 23% FTE per year; total includes approx. 80% salary and 20% fringe	$ 35,000
Dr. Sarnath Ramnath: Project manager; 9% FTE per year; total includes approx. 80% salary and 20% fringe	$ 20,000
Dr. Mehdi Mekni: Data analysis and software development; 9% FTE per year; total includes approx. 80% salary and 20% fringe	$ 15,000
Dr. Omar Al-azzam: Data analysis, database development and software development; 9% FTE per year; total includes approx. 80% salary and 20% fringe	$ 15,000
Graduate Assistants (1 full-time positions for each of the 2 academic years, 1FTE includes stipend of $10,000/year and tuition of $5,900/year, additional summer stipends of $6,000 per year for 2 years) or Research Associates (.5 FTE for each of the two years at $18,250 salary plus 20% fringe = $21,900/year)	$ 43,800
Undergraduate Student Employees: 3 students at 20 hours/week for 4 semesters (56 weeks total), $12/hour	$ 40,320
Professional/Technical/Service Contracts:	$ -
Contract with Sauk River Watershed District; Ms. Lynn Nelson will provide expert advice on the needs of the Watershed District	$ 3,500
Equipment/Tools/Supplies:	$ -
Drone System and GPS Controller for remote sensing and data collection; 3 sets at $4,000 each (1 for hydrologic testing, 1 for soil sampling, 1 for erosion control inspection)	$ 12,000
Software for Geographical Information Systems and Hydrological Modeling Systems	$ 10,000
Server to house the smart system for watershed modeling	$ 5,000
Equipment rental for land surveying	$ 2,000
Hardware and software systems maintenance, repair, and upkeep	$ 3,000
Printing/paperwork/office supplies	$ 1,000
Travel:	$ -
Mileage - travel to and from data collection sites; $0.47/mile, 12,000 miles	$ 5,640
Attend conferences on Flood Plain Management, Groundwater and Erosion Control to explain the system; $500 each, 3 meetings per year (6 total)	$ 3,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 214,260

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*	$ -	
Other State $ To Be Applied To Project During Project Period: *N/A*	$ -	
In-kind Services To Be Applied To Project During Project Period:	$ -	
Because the project is overhead-free, laboratory space, electricity, and other overhead costs are provided in kind. The SCSU indirect rate is 12%	$ 25,711	Secured
Mr. Mark Gill: Develop Visualization platform using Geographical Information System, incorporate remote sensing technology, and provide technology support; 12 days per year (equivalent to 7% FTE in 12 month contract) for each of the two years; total includes approx. 72% salary and 28% fringe	$ 10,000	Secured
Funding History: *N/A*	$ -	
Remaining $ From Current ENRTF Appropriation: *N/A*	$ -	

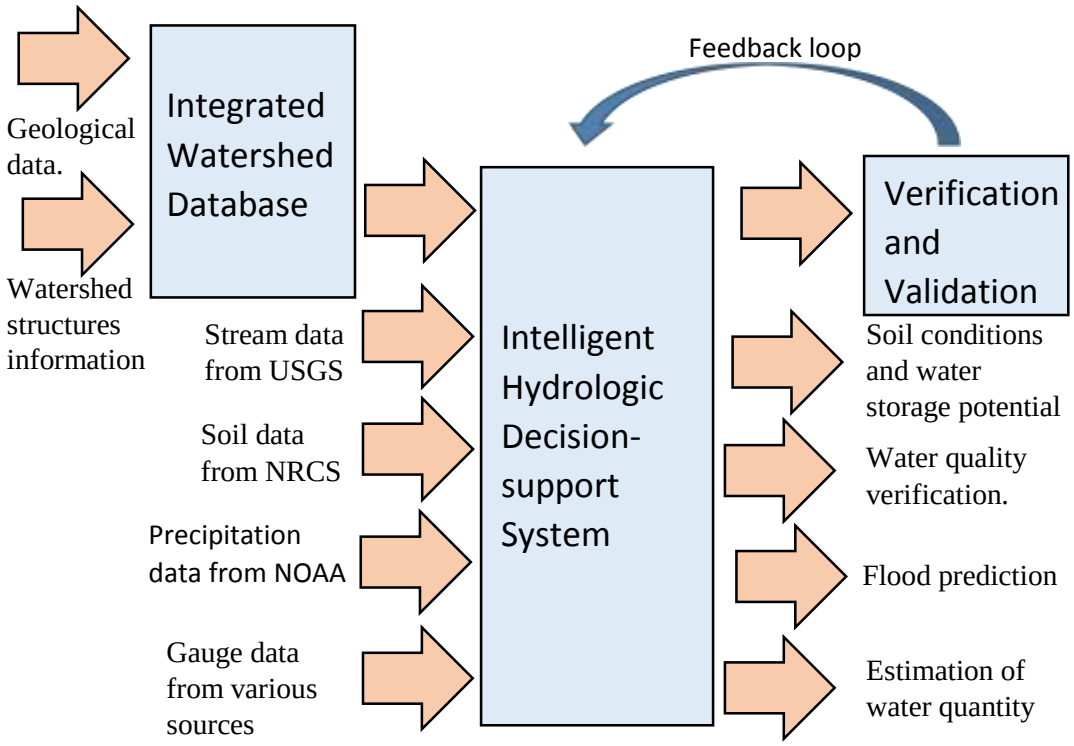

Figure 1. Schematic for automated watershed management system. The Integrated Watershed Database is built using geological data and information about the built-up structures on the watershed. This database is used by the Intelligent Hydrologic Decision-support System, which also receives live data on precipitation, soil conditions, and gauges. This system can be queried to obtain information about various aspects of water quantity and quality. The output of the system is also verified and validated, and this feedback is used to improve the quality of the predictions of the hydrologic system.

Project Manager Qualifications & Organization Description:

The project team will be led by Professor Ramnath Sarnath. He holds a B.Tech degree in Civil Engineering and an M.Tech degree in Computer Science from the Indian Institute of Technology, New Delhi. He has a Ph.D. degree in Computer Science from the State University of New York at Buffalo. He has extensive administrative experience, expertise in software design and has worked with algorithm development for large data sets.

Dr. Jeff Cheng is an associate professor of Hydrology at St. Cloud State University. He received his BS, MS and PhD degrees in Civil Engineering from the University of Colorado at Denver, CO. He has extensive training and experience in watershed management, hydrological analysis, floodplain management, and hydropower regulation, and has successfully completed several projects for governmental and corporate agencies. He is a licensed professional engineer in several states.

Dr. Mehdi Mekni is an assistant professor at St. Cloud State University. He obtained his PhD and MSc degrees in Computer Science and Software Engineering from Laval University, Quebec, Canada. Dr. Mekni has been involved in several environmental research projects in Canada with Geoide (Network of Centers of Excellence in Geomatics). Dr. Mekni has also an extensive industrial experience in the design and development of complex and large scale information systems. His main research interests include modeling and simulation involving artificial intelligence and spatial analysis techniques.

Dr. Omar Al-Azzam is an assistant professor at St. Cloud State University. He obtained his PhD from North Dakota state university, Fargo, ND. Dr. Al-Azzam has worked in several predictive modeling research projects, such as, predicting gene ontology from protein domains, predicting gene location and constructing consensus genome maps. In addition, Dr. Al-Azzam has experience in environmental applications such as flood prediction and simulation. Dr. Al-Azzam main research interests include: software development, database applications, data mining, bioinformatics, big-data analytics and modeling.

Mark Gill is the director of the SCSU Visualization Lab. He holds an M.S. in Software engineering and has 20 years of experience in the realm of 3D visualization, Virtual Reality, and high-performance data presentation. Over the course of his career, Mark has developed, or overseen the development of several ‘big data’ or time-sequenced visualization projects, which would fall in line with the goals and deliverables of this proposal. He also has experience with drone operation, and use of Geographical Information Systems.

SCSU has undergraduate programs in Hydrology, Computer Science and Software Engineering, and an MS program in Computer Science. The small scale mechanism for automatic data collection, described under Activity 2 of this proposal was created by a Computer Science MS student working under Dr. Cheng. The Integrated Science and Engineering Laboratory Facility (ISELF) building provides the facilities needed for this project. A high speed data link is available to campus, so that the server housing the proposed system can be easily accessed by all agencies.