MINNEHAHA CREEK WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

Meeting: Citizens Advisory Committee
Meeting date: 7/7/2020
Agenda Item #: 4.2
Item type: Discussion

Title:	MCWD Climate Conversations – Watershed Modeling Tools to Support Planning Adaptation Planning
Prepared by:	Name: Brian Beck Phone: 952-471-8306 bbeck@minnehahacreek.org

Purpose:
At the July 7th, 2020 CAC meeting, staff will provide background on the development of an advanced watershed hydraulics model and machine learning model. This meeting will be used to explain how an advanced watershed model and machine learning model will be used to support the Minnehaha Creek Watershed District's (MCWD) strategic focus on building high impact capital improvements and shaping land use and water policy, to produce a measurable result in the landscape in the face of a changing climate.

Background Context:
The distribution, frequency and intensity of rainfall in Minnesota has changed and will continue to do so. The Minnehaha Creek Watershed has experienced the wettest six years ever recorded. These changes are stressing our natural and built environments, impacting pollutant loading, stream erosion, wetland function, surface and groundwater interactions, habitat, homes, public infrastructure, and businesses.

Watershed managers must accelerate monitoring, evaluating, and adapting to these changes. However, the ability to do so is hampered by sparse and static historic data sets. This makes it challenging to predict how specific areas will be impacted, and quantitatively compare potential solutions. Around the state, we are beginning to see the consequences of systems designed for stable climate patterns that no longer exist.

Fortunately, advances in data science have made it affordable to collect exponentially more data and analyze it in more sophisticated ways. These are allowing water planners around the world to understand and predict changes with unprecedented accuracy and detail, allowing for more effective use of scarce public investment to address these issues. In Minnesota, data collection has outpaced the tools used to make sense of the data. Realizing the full potential of these advances requires new systems to integrate this data to identify existing issues, forecast future ones, and guide local decisions.

MCWD Response:
MCWD is considering a program to integrate and maximize the value of recent public investments in data collection to better predict the impacts of changing precipitation across the watershed, and to pinpoint, quantify and evaluate solutions.

This program would draw on existing investments made by MCWD, U.S. Geological Survey and Hennepin County in monitoring precipitation and watershed response across the District, which will collect more than 1 million real-time data points per year for precipitation, surface and shallow ground water levels, and pollutant loading. It will integrate this local understanding with state investments in producing detailed topography of Minnesota, along with local municipal investments in digitizing storm sewer information.

The tools being proposed for development include:

Machine Learning: Drawing deep insights and revealing trends from the vast quantity of newly available remote sensing data about how shifting precipitation is changing the mass balance of water and pollution.

2-Dimensional (2D) Watershed Model: Integrating patterns revealed by machine learning with state topographic and municipal infrastructure data will provide a high resolution planning tool to pinpoint, quantitatively evaluate, and drive decisions on climate adaptation projects and policies.

Summary:
In recent years, staff have identified how precipitation patterns and the built environment have evolved around us, which has caused the District to reassess its current quantitative planning tools. This presentation will provide an overview of the District's effort to build an advanced watershed model and machine learning model that will support future project identification, project design, and flood forecasting throughout the watershed.

Supporting documents (list attachments):

- Application to LCCMR to support the development of MCWD's 2D watershed model and machine learning model

Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-090

Proposal Title: Leveraging Innovations in Data Analytics for Project Implementation

Project Manager Information

Name: Brian Beck

Organization: Minnehaha Creek Watershed District

Office Telephone: (952) 471-0590

Email: bbeck@minnehahacreek.org

Project Basic Information

Project Summary: Integrate newly-available datasets into a 21st-century planning tool that allows MCWD and its partners to forecast the impacts of changing precipitation patterns and quantitatively compare the most cost-effective solutions.

Funds Requested: $883,000

Proposed Project Completion: 2023-12-31

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

Narrative

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

Water systems throughout Minnesota were built for stable climate patterns that no longer exist. Extreme swings in precipitation are stressing our natural and built environments, impacting pollutant loading, stream erosion, wetland function, surface and groundwater interactions, habitat, and the safety of homes, public infrastructure, and businesses.

Watershed managers must help communities understand and adapt to these changes. However, the ability to do so is hampered by sparse and static historic data sets, which make it difficult to predict how specific areas will be impacted and quantitatively compare potential solutions.

Fortunately, advances in data science have made it affordable to collect exponentially more data and analyze it in more sophisticated ways. These advances allow water planners around the world to understand and predict changes with unprecedented accuracy and detail, allowing for more effective use of scarce public investment to address these issues. In Minnesota, data collection has outpaced the tools used to make sense of the data. Realizing the full potential of these advances requires new systems to integrate this data to identify existing issues, forecast future ones, and guide local decisions.

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.

In partnership with Hennepin County, DNR, and USGS, and with formal support from 11 partners and communities, MCWD is proposing a pioneering program to maximize the value of recent public investments in data collection.
For example, MCWD has created a remote sensor network that collects more than 1 million data points per year about surface water levels, shallow groundwater levels, and pollutant loading. State leaders have invested in mapping the detailed topography of the state. Municipal partners have digitized data about their storm sewer systems.
MCWD wants to partner with LCCMR to develop tools that bring these disparate data sets together to identify, evaluate, and drive local investment in green and gray infrastructure solutions that protect and conserve the watershed's iconic resources.
We will do so by harnessing two advances in data science:

1) Machine learning, which will draw deep insights and reveal trends from the vast quantity of newly-available remote sensing data about how shifting precipitation is changing the mass balance of water and pollutants.

2) 2-dimensional modeling, which will integrate the lessons revealed by machine learning with state topographic and municipal infrastructure data to pinpoint, quantitatively evaluate and drive decisions on climate adaptation projects and policies.

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?

- A single, continuously-updated tool that integrates previously-siloed public data sets

- A high-resolution understanding of the balance of all surface and groundwater inputs and outputs in the system, to identify environmental and public assets in need of protection

- Improved ability to predict the impact of changes in precipitation or land use, to enhance infrastructure planning

- Improved ability to quantify and compare the cost-effectiveness of potential conservation projects needed to address predicted impacts

- Optimization of Gray's Bay dam operation, reducing the ecological and property damage caused by high or low water

- More detailed flood forecasting to assist emergency management

Activities and Milestones

Activity 1: Identifying model inputs and data resources

Activity Budget: $83,500

Activity Description:
One of the most common ways watershed districts synthesize data is by developing computer models that can predict how water flows through our streams, lakes, and landscapes. In recent years, the State of Minnesota and counties have invested heavily to develop a series of high-quality standardized digital datasets about our landscape, such as topography, land use, and soils that have made model development much less labor-intensive.

Local municipalities have also invested time and resources in developing digital stormsewer infrastructure databases, however, each municipal dataset varies in data structure, complexity, and quality. Combining these 29 unique datasets into a unified watershed model has historically been labor-intensive, prohibitively expensive, and nearly impossible to maintain. Therefore, this project will include an initial discovery phase, which will be devoted to meeting with municipalities to understand the unique nature of their stormwater infrastructure dataset.

The goal of this phase is to characterize all available spatial datasets and fill remaining surficial groundwater and lake level data gaps. The scope and cost for subsequent activities may be refined based on the findings of Activity 1 to ensure that the development of the automated data processing system and watershed model will require minimal manual effort.

Activity Milestones:

Description	Completion Date
Mapped and Obtained Data from State and Regional Partners	2021-12-31

Activity 2: Building the external data information processing system

Activity Budget: $286,000

Activity Description:
Because land use and stormwater infrastructure are constantly changing, watershed managers face the recurring challenge of using tools that are not based on up-to-date information. Historically, the process of updating watershed models has been a time-intensive endeavor because all data collection and processing has been done manually. However, recent advances in data science have resulted in frameworks that automate complex data processing, which will dramatically reduce the cost of future model updates for MCWD and other public agencies throughout the state that use our process as a template for enhancing and automating their own watershed model development.

MCWD will develop a reproducible data processing system that can incorporate publicly-available datasets into a watershed modeling framework. Then, MCWD will work with technical experts to plan and build a GIS system that automatically updates based on changing landuse and infrastructure datasets to ensure the watershed model used for project identification is using the most current landscape and infrastructure information.

Activity Milestones:

Description	Completion Date
Develop Mapped Structure of Municipal Stormwater Data	2022-04-30

Develop Automated Intake Processing System for Municipal Stormsewer Data	2022-07-31

Activity 3: Building the 2D Waterhsed and Machine Learning Model

Activity Budget: $513,500

Activity Description:
MCWD will incorporate the data produced from the automated processing system developed in activity 2 into a high-resolution watershed model that can predict, in unprecedented detail, how water and pollutants will move through the system under current and predicted scenarios. The outcome from building the watershed model will be a tool that can help watershed managers meet their water quality, water quantity, and ecologic improvement goals.
Building this model will involve an iterative process to ensure that the automated processes developed in activity 2 can be incorporated into a high-resolution watershed planning tool. In addition, the consultant will use streamflow data collected by MCWD staff to calibrate the model to ensure it can accurately predict how water moves through the built and natural environment.

MCWD and the consultant will meet with local municipalities and engineers to communicate the use cases for the model to ensure it can be used by other entities to identify water quality, ecological, and flood reduction projects.

Concurrently, MCWD will purchase and configure a machine-learning workstation, and work with academic leaders in the field to develop a model for predicting stream water levels and flow for optimizing dam management and providing more accurate flood warnings.

Activity Milestones:

Description	Completion Date
Build and Calibrate Two Dimensional Watershed Hydrology and Hydraulics Model	2023-06-30
Develop Gray's Bay Dam Optimization Program	2023-07-31
Develop Machine Learning Model for Water Level Prediction	2023-08-31
Write Technical Report for Two Dimensional Watershed Model	2023-12-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Tim Cowdery	U.S. Geological Survey	Assist with identifying groundwater well monitoring locations, assist with groundwater data analysis, identify methods for incorporating groundwater data into 2D model, and provide oversight on 2D model build.	No
Eric Waage	Hennepin County Emergency Management	Assist with identifying groundwater well monitoring locations, incorporate groundwater well sensors into the Hennepin West Mesonet network.	No
Jason Moeckel, Joy Loughry	Minnesota Department of Natural Resources	Assist with identifying groundwater well monitoring locations and installing groundwater wells.	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?

This project will yield a sophisticated tool, drawing on state of the art data analytics, to enhance MCWD's organizational ability to partner with its member communities to identify, evaluate, and implement capital improvement projects that improve water quality, control water quantity, improve ecological integrity, and reduce flooding in the face of a changing climate. The products of LCCMR's investment are expected to help MCWD and its partners populate, focus, and prioritize capital improvement plans that will be funded locally. The long term sustainment costs for maintaining the watershed tools will be borne by MCWD.

Project Manager and Organization Qualifications

Project Manager Name: Brian Beck

Job Title: Research and Monitoring Program Manager

Provide description of the project manager's qualifications to manage the proposed project.

Education:
M.S. 2012 University of Minnesota-Duluth (Water Resources Science)
B.S. 2008 University of Minnesota Twin Cities (Environmental Science with emphasis on aquatic chemistry)

Mr. Beck is a water resource scientist with 10 years of experience quantifying the impact of landscape change on water quality and quantity at a municipal, watershed, and statewide scale. The focus of his academic and professional career has been obtaining data from disparate sources for data analysis and building quantitative tools to develop insights about complex aquatic systems. Mr. Beck's professional career in the private and public sector has been built upon developing deterministic and empirical water quality models such as P8, GWLF, HSPF, SWAT, PONDNET, CEQUAL, BATHTUB, and GLM to inform management decisions of water quality, water quantity, and ecological integrity.

Mr. Beck will oversee the development of the watershed-wide two dimensional (2D) model and machine learning model. He has extensive experience developing quantitative water quality models for cities, watershed districts, and the State of Minnesota for feasibility studies, watershed diagnostic assessments, and regional Total Daily Maximum Load studies. His blend of technical expertise in watershed modeling and understanding of local government will allow him to facilitate the interaction between watershed managers and technical consultants to ensure that the model is technically sound and can be used to inform watershed management decisions.

Organization: Minnehaha Creek Watershed District

Organization Description:
Minnehaha Creek Watershed District is a local unit of government responsible for managing and protecting the water resources in one of the largest and most heavily-used urban watersheds in Minnesota. MCWD's legal boundary encompasses about 178 square miles within the western Twin Cities metropolitan area. Of this area, about 148 square miles lie within Hennepin County and about 30 square miles lie within Carver County. To manage water resources and ecological integrity in this large area, MCWD has prioritized the need to bridge the governance gap between land use and water resource planning to achieve its goals of improving water quality, water quantity, ecological integrity, and thriving communities. MCWD's approach to bridging this gap is to understand the goals of others; apply sound science to creative solutions; and align investments, technical expertise, streamlined permitting, and collaborative planning.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
							Sub Total	-
Contracts and Services								
TBD through competitive bid	Professional or Technical Service Contract	The consulting engineer will provide technical support for data processing and model development				1.98		$803,000
							Sub Total	**$803,000**
Equipment, Tools, and Supplies								
	Equipment	Workstation computer	High end data science workstation computer for processing 2D model and machine learning algorithms.					$80,000
							Sub Total	**$80,000**
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
							Sub Total	-
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$883,000**

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	DNR General Fund	Installing groundwater monitoring wells by DNR staff and advising MCWD on monitoring well locations for the project.	Secured	$32,000
			State Sub Total	**$32,000**
Non-State				
In-Kind	Minnehaha Creek Watershed District Tax Levy	Minnehaha Creek Watershed District staff will be contributing a total of 8084 hours of in-kind support for the project.	Secured	$365,930
Cash	Minnehaha Creek Watershed District Tax Levy	Minnehaha Creek Watershed District will be purchasing three acoustic doppler stream velocity sensors to support data collection efforts.	Secured	$37,500
Cash	Minnehaha Creek Watershed District Tax Levy	Minnehaha Creek Watershed District will be installing a minimum of 16 groundwater wells throughout the watershed to monitor groundwater levels. The water level information will be used to build the machine learning and watershed model.	Secured	$56,000
Cash	Minnehaha Creek Watershed District Tax Levy	MCWD will contract with the USGS to oversee the selection of groundwater sensor monitoring locations and the development of the 2D watershed model	Secured	$20,000
			Non State Sub Total	**$479,430**
			Funds Total	**$511,430**

Attachments

Required Attachments

Visual Component

File: 912a4994-417.pdf

Alternate Text for Visual Component

The attached graphic demonstrates how the proposed tools will convert a variety of disparate data sources into usable information to inform natural resource management decisions. It is displayed along two tracks: The first track shows how data sources about our built and natural environment – soils, topography, wetlands, hydrology, groundwater, precipitation, land cover, future land use, and storm sewer -- will be integrated into a 2-dimensional model that will predict how water moves through the landscape under a variety of scenarios.

The second track shows how large volumes of remote sensing data – precipitation sensors, water flow and level sensors, and groundwater sensors – will be processed by a machine-learning algorithm to predict how the system will respond under a variety of scenarios.

The graphic depicts how the two tracks work in parallel to produce the following outcomes: High-resolution understanding of complex watershed processes; predict impacts of changing climate; identify natural resources most in need of protection; quantitatively compare proposed projects; optimize Gray's Bay dam operation; improve flood forecasting and emergency response.

Board Resolution or Letter

Title	File
MCWD Board Resolution	9210223e-7b0.pdf

Optional Attachments

Support Letter or Other

Title	File
MN DNR Letter of Support	c68f2229-4e6.pdf
U.S. Geological Survey Letter of Support	36951d75-6b0.pdf
Hennepin County Emergency Management Letter of Support	31969ed2-c25.pdf
Hennepin County Environment & Energy Letter of Support	fb4f2fbd-bd9.pdf
City of Edina Letter of Support	e9f0d989-b37.pdf
City of Minnetonka Letter of Support	4f3cbb45-47b.pdf
City of Mound Letter of Support	8790fd8d-b88.pdf
City of Orono Letter of Support	17951e49-4a4.pdf
City of St. Louis Park Letter of Support	dd0adefb-e28.pdf
City of Victoria Letter of Support	5dd0edd0-caf.pdf
Minneapolis Park & Recreation Board Letter of Support	633ad841-145.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

No

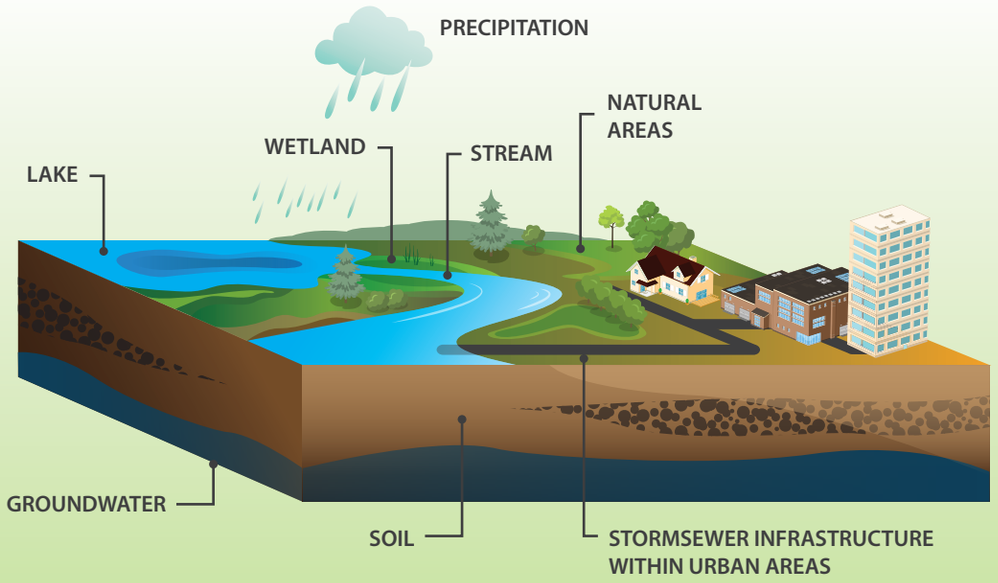
INPUTS

NATURAL ENVIRONMENT

- SOILS
- TOPOGRAPHY
- WETLAND
- STREAM ASSESSMENTS
- GROUNDWATER
- PRECIPITATION

BUILT ENVIRONMENT

- LAND COVER
- FUTURE LAND USE
- STORM SEWER

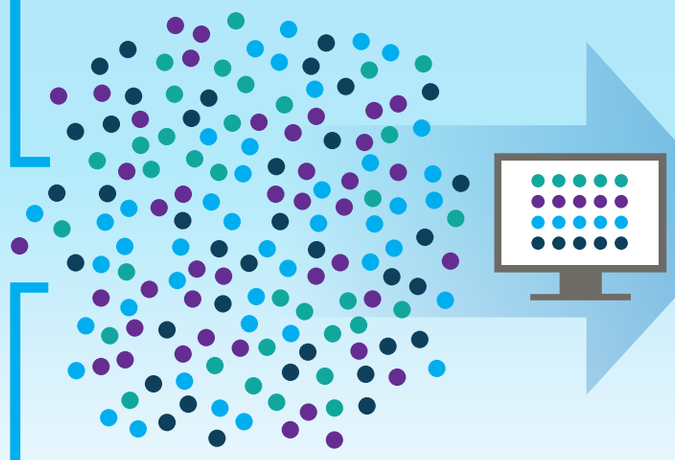


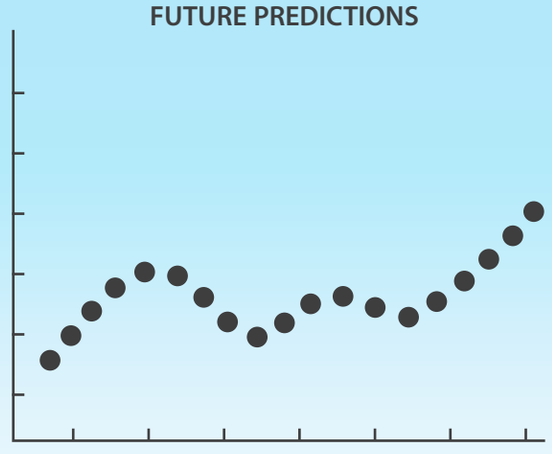
REAL TIME DATA

- HENNEPIN COUNTY PRECIPITATION SENSORS
- USGS WATER FLOW & LEVEL SENSORS
- MCWD WATER FLOW & LEVEL SENSORS
- DNR GROUNDWATER SENSORS

2D MODEL

MACHINE LEARNING





OUTPUTS

High-resolution understanding of complex watershed

Predict impact of changing climate

Identify natural resources most in need of protection

Quantitatively compare proposed projects

Optimize Gray's Bay dam operation

Improve flood forecasting and emergency response

4 Partners

MINNEHAHA CREEK WATERSHED DISTRICT · Hennepin · DEPARTMENT OF NATURAL RESOURCES · USGS science for a changing world

11 Letters of Support

DEPARTMENT OF NATURAL RESOURCES · City of Edina, Minnesota · Hennepin · City of Minnetonka · Minneapolis Park & Recreation Board · City of Mound · Orono Lake Minnetonka · Victoria · St. Louis Park Minnesota · USGS science for a changing world

$511K Matching Funds

$553K Leveraged Funds