MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

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Agenda Item #: 12.2
Item type: Discussion

Title: Pilot 2D Watershed Model Approach and Partnership Discussion

Prepared by: Name: Brian Beck
Phone: 952-471-8306
bbeck@minnehahacreek.org

Purpose: At the July 8th, 2021 Board of Managers meeting, staff will provide a status update on the Minnehaha Creek Watershed District two-dimensional (2D) Hydrology and Hydraulics (H&H) model, partnership discussions with the City of Edina, and the proposal to the Legislative-Citizen Commission on Minnesota Resources (LCCMR) to support the modeling effort.

Summary: On March 25th, 2021 the Minnehaha Creek Watershed District (MCWD or District) Board of Managers authorized staff to submit a proposal to the LCCMR to develop an innovative 21st century planning tool that more effectively forecasts the impact of changing precipitation patterns on the watershed, and target public investments to protect water, homes, businesses, and infrastructure.

Over the past year District staff have taken time to identify, characterize, and limit potential areas of risk related to building a state of the art H&H model for MCWD. District staff have identified four types of risk that include:

- *Organizational*: A critical first step in the modeling process is characterizing what questions need to be answered by the District before selecting and building a new H&H watershed model.
- *Technical*: There are a large number of H&H models available today that offer a wide variety of capabilities, which makes selecting the appropriate model critically important.
- *Relational*: Municipal partners will be critical in developing a District wide model. They possess a key source of data required to build the model and stand to benefit from the information produced from the model.
- *Financial*: Funding sources in the field of water resources are typically focused on implementation, which limits the potential funding sources for model development.

At the July 8th, 2021 Board Meeting, staff will provide an update on the LCCMR grant application and discuss risk management steps being taken to ensure a high quality 2D H&H model is built for the District. These steps include:

- Internal modeling needs assessment (Attachment A)
- Technical modeling needs assessment (Attachment A)
- Pilot wathershed model build
- Partnership with the City of Edina
- External funding assessment

Supporting documents (list attachments):

- Attachment A - Minnehaha Creek Watershed District Hydrologic and Hydraulic Modeling Needs Assessment

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Title:	Minnehaha Creek Watershed District Hydrologic and Hydraulic Modeling Needs Assessment
Prepared by:	Name: Brian Beck Date: May 12, 2021 Phone: 651-471-8306 bbeck@minnehahacreek.org

Background

In 2003, the Minnehaha Creek Watershed District (MCWD or District) built a watershed wide XP-SWMM hydrologic and hydraulic (H&H) model that was considered state of the art at the time (EOR, 2003). The XP-SWMM model has been used by the District in areas such as permitting assessments, project support, watershed nutrient loading estimates, flood forecasting, floodplain management in conjunction with the DNR and FEMA, and historic flood event scenario analysis.

In recent years, a series of new questions have been asked by policy makers, partner agency staff, and District staff that have pushed, or surpassed, the limits of MCWD's XP-SWMM model. However, it wasn't immediately apparent why MCWD's modeling tools could not answer the questions that were being posed, which lead to an in depth assessment of MCWD's modeling needs.

MCWD Modeling Needs Assessment

A critical first step in any modeling process is characterizing the questions that need to be answered by an organization before selecting and building a new H&H watershed model. Therefore, MCWD staff developed an internal process to characterize the needs of the organization. This process revealed that future modeling tools must quantitatively answer questions that inform policy, rules/regulation, project maintenance, climate scenarios, and projects. MCWD staff took time to evaluate and consolidate the variety of scenarios that each workgroup suggested. The consolidated scenarios included:

- Understand the location, frequency, magnitude, type (surface water, grid, or groundwater), and duration of current and future flood events
- Characterize the cost, property type, and number of individuals at risk for future flood events
- Identify the policy and projects needed to mitigate the impacts of climate change
- Characterize pre-development hydrologic conditions in major subwatersheds
- Quantify the impact of MCWD regulation under current and future scenarios
- Build capacity to accurately run short-term flood scenarios to inform emergency management and communicate to the public
- Characterize the impact of individual projects on downstream water bodies with respect to water quality and volume

In the following sections we will take a deeper dive into the underlying problems preventing the District's XP-SWMM model from answering the questions outlined above and subsequent solutions to improve future model builds.

Watershed Scale Model Feasibility Assessment

Characterizing what drivers or issues are preventing watershed districts from building models at a scale that supports regional and localized scenario analysis is the next step in the model development process. Upon reflection, the root issue appears to be that watershed districts are a regional entities that cover vast geographic areas and must rely on spatial data from other government agencies to develop models at the watershed scale. Identifying the root issue for watersheds model development helped reveal three primary drivers, which include data availability, model development approach, and reliance on 1D models.

Model Input Data Availability Problem

Problem: One of the greatest strengths of watershed districts is that they are formed on hydrologic boundaries instead of geopolitical boundaries, which uniquely positions them to manage water resources. However, this means watersheds encompass many municipal and regional entities who manage their own stormsewer networks. For example, MCWD contains 29 cities and two counties that maintain unique stormsewer infrastructure datasets. Combining these unique stormsewer infrastructure datasets into a unified watershed model has historically been labor-intensive, prohibitively expensive, and nearly impossible to maintain at a watershed scale.

Solution: In recent years, the State of Minnesota and Minnesota counties have invested heavily in developing 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. In addition, local municipalities have also invested time and resources in developing digital stormsewer infrastructure databases, which will likely have a consistent structure over time and receive regular updates.

The development of statewide and local standardized geospatial datasets within Minnehaha Creek Watershed District should dramatically reduce the amount of effort needed to develop a watershed model. Furthermore, constant data structures will make it possible to develop data processing scripts that transform geospatial data into a format that can be readily loaded by watershed models.

Model Development Approach Problem

Problem: Municipalities, regional agencies, and watershed districts typically hire a consultant to "build" an H&H model as a standalone deliverable or to support a specific planning effort. The resulting deliverable requires an immense amount of one-off manual data processing that is impossible to maintain at a high resolution. This type of model development makes model updates nearly impossible, which limits the spatial resolution of watershed models and leaves them fixed in time.

Solution: MCWD has proposed developing an automated process to transform geospatial data into the format that can seamlessly be loaded into an H&H model. Building a geospatial data processing framework will allow MCWD to more efficiently build and update high resolution models since data processing steps shouldn't change over time. Therefore, MCWD's sees the upcoming model build as creating a process to transform and aggregate geospatial data into a modeling format instead of building a one-off model.

Reliance on 1D Models

Problem: Historically, most watershed districts and municipalities have relied heavily on 1D H&H models since they have become the industry standard. One of the requirements of using 1D hydrologic models is the creation of minor subwatersheds to define how precipitation is routed to the hydraulic portion of the model. The inclusion of minor subwatersheds was a necessary workaround when watershed models were developed in the 1970s and 1980s since computers lacked the processing power to route runoff based on topography. The inclusion of subwatershed delineation to support hydrologic precipitation routing made watershed modeling computationally feasible over the past 40 years. However, minor subwatershed delineation is a time consuming process that adds yet another layer of input when developing a watershed model, which further complicates model development and maintenance.

Solution: One of the greatest limitations to 2D model implementation has been the lack of processing power in workstation computers. Recent adoption of parallel processing via graphics processing units (GPU) by watershed modeling software has made 2D models more accessible to the average watershed modeler. Therefore, adoption of 2D models at the watershed scale seems possible, which should resolve many of the historic issues that have plagued 1D model development and maintenance in the past.

2D Watershed Scale Model Feasibility Summary

Over the past decade there have been several technical advancements that have dramatically improved data collection, data storage, computational processing power, and watershed modeling software. Many of these improvements have happened slowly over time, which have been imperceptible to most water resource managers, engineers, planners, and scientists. Therefore, the confluence of technological advancements and 2D modeling software has yet to reach water resource professionals since outdated assumptions continue to drive watershed model development. MCWD staff assessed the historic issues of data availability, 1D model reliance, and model development approach to determine if a 2D model at the watershed scale is realistically possible. Based on our assessment, we believe that a 2D watershed model can be developed at a watershed scale based on recent advancements in data storage, 2D modeling accessibility, and processing power.

Modeling Technical Needs Assessment

The goal of MCWD's upcoming model development, as mentioned earlier, is focused on creating a repeatable process to develop models. Therefore, MCWD must focus the selection of 2D H&H modeling software based on two factors, which include:

- A model's ability to assimilate pre-formatted geospatial data such as landuse, stormsewer infrastructure, and LiDAR
- The model's ability to run scenarios proposed by MCWD and provide useful output that help answer policy, regulation, and project related questions

MCWD staff developed a list of model needs based on these criteria.

Model Input Needs

- It is critical that the geospatial data input can be loaded directly into the model since MCWD is developing a scripting process to transform 29 different municipal datasets into one data format that can be regularly updated in the model.
- MCWD is also developing a process to ingest other spatial data, such as LiDAR, landuse, and soils, through an automated process so that the model reflects current conditions.
- The model must be able to load spatial data in a commonly used format such as shapefiles, ESRI geodatabases, CSVs, ASCII, or other commonly used data formats.

Model Engine Requirements

- The model engine must be capable of hydrologic and hydraulic calculations.
- The model will likely be two-dimensional (2D) to characterize complex urban flooding scenarios and simplify model development by eliminating subwatershed delineation.
- The model must take into account water table based on an initial boundary condition. The groundwater portion of the model must interact with surface water features.
- The model must support GPU parallel processing to reduce model runtimes.
- The model must be able to incorporate standard water resource best management practices such as ponds, infiltration basins, etc.

Conclusions and Next Steps

The next step in the model selection process is to have an external consultant identify which modeling software packages or platforms will support the technical needs of the District. This work will include reviewing the MCWD's modeling needs, developing an assessment matrix for critical model features, and providing model recommendations to inform MCWD's future model build.

MCWD staff will then develop a pilot model located in a rural and urban area within the District boundaries. The pilot project will utilize two watershed modeling software platforms within each pilot area. The goal of developing two separate models within the same geographic areas is twofold:

- Determine which modeling software platform best meets the District needs, which will allow District staff to make decision based on multiple real world options

- Determine if the automated data processing scripts can be incorporated into different modeling platforms. This will ensure that the District will have the option to switch modeling platforms in the future, but continue to use the automated data processing workflow.

District staff will use this process to make a final decision on a modeling platform to develop a comprehensive watershed model.

References

EOR, 2003. 2003 MCWD Hydraulic, Hydrologic, and Pollutant Loading Study (HHPLS) Report: Volume I-III. Technical Report.