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Technical Memorandum

To: Randy Anhorn, NMCWD Administrator
From: Janna Kieffer
Subject: 2020 Atlas 14 Model Update Documentation Memo
Date: January 10, 2021
Project: 23271819.00

1.0 Background

In the late-1990s, the Nine Mile Creek Watershed District (NMCWD) developed and calibrated a Xp-SWMM model for the Penn Lake and Skriebakken watersheds in Bloomington. In subsequent years, the NMCWD expanded its modeling efforts throughout the watershed and completed development of a watershed-wide Xp-SWMM hydrologic and hydraulic model in 2005. The model simulates conveyance of stormwater through the trunk storm sewer systems throughout the watershed and through the Nine Mile Creek system, including the North Fork, South Fork, County Ditch 34, Braemar Branch, and the Main Stem of Nine Mile Creek. The watershed-wide model included 3,065 subwatersheds, with the level of detail in the subwatershed delineations varying by city, depending on the availability of elevation data and detailed storm sewer data. The watershed-wide model was originally broken into 17 separate models due to model size and computing restrictions at the time-- 16 detailed "city" models with discharges feeding into one "creek" model.

These models were used to update flood management elevations along the creek system that were published in the NMCWD 2007 Water Management Plan and to support the update of Hennepin County FEMA flood insurance rate maps (FIRMs). The models were also used by several cities (namely Edina and Bloomington) to establish 100-year flood elevations for interior waterbodies and by several partner agencies (e.g., cities, Hennepin County, MnDOT, Three Rivers Park District) to support evaluation and design of various roadway and infrastructure improvements since 2005.

In 2013, the NMCWD updated the watershed-wide models to reflect publication of Atlas 14 precipitation frequency estimates. Results from the updated creek model were used to establish revised flood management elevations along the Nine Mile Creek system. The NMCWD has had flood management elevations in place for decades based on past computations that used future land use development projections. The historic Nine Mile Creek flood management elevations were compared to the updated Atlas 14 flood elevations, and the higher of these elevations were selected as the revised regulatory flood management elevations.

The focus of the 2013 model update efforts was on the Nine Mile Creek system, including inline lakes and storage areas. While some updates were made to the "city" models to capture and re-route additional overflows resulting from the increased precipitation, a rigorous review of revised flood elevations in ponds, wetlands, and lakes not directly tributary to the creek system was not included in the scope of the 2013-2015 project. Therefore, it was recommended at the time that the revised flood elevations for

waterbodies within the "city models" not be used for management purposes until more detailed analyses and/or review could be conducted for the "city" models.

Since the NMCWD's 2013 Atlas 14 updates (published in 2015), four of the six cities within the NMCWD (Edina, Bloomington, Richfield, Minnetonka) have completed additional Atlas 14 modeling analyses. The cities of Edina, Bloomington, and Minnetonka used the NMCWD's Xp-SWMM "city" models as a base for their Atlas 14 model updates. The City of Richfield developed a highly-detailed model using PC-SWMM software. City efforts generally have included updating the models with more current elevation and storm sewer information, adding more detail where appropriate, and conducting additional QA/QC of model results. Model results have been or are being used by these cities to identify and prioritize flood-prone areas and evaluate flood risk reduction options.

2.0 2020 Update to Watershed-wide Model(s)

At the NMCWD May 20, 2020 regular meeting, the Board approved a scope of work for Barr to complete updates to the NMCWD's watershed-wide Xp-SWMM model, including incorporating recent Atlas 14 updates completed by the cities of Edina, Richfield, Bloomington, and Minnetonka and reviewing and revising model inputs (e.g., watershed divides and storm sewer information) for Eden Prairie and Hopkins (as needed). The work tasks included in this effort are summarized below.

2.1 Updating the Eden Prairie portion of the model

At the time of original model development, the data available for the portion of the watershed in Eden Prairie was very limited. Elevation data (i.e., two-foot topographic data or a digital elevation model) was not available in electronic (GIS) format, nor was storm sewer data available throughout the city. As a result, the subwatershed delineations in this portion of the watershed were courser and there was less confidence in the accuracy of the storage information and storm sewer connections between waterbodies. Part of this area northeast of Bryant Lake was updated in 2017 as part of the Chamberlain-Cherokee modeling analysis conducted in partnership with the City of Eden Prairie.

As part of the 2020 updates, the subwatersheds for the portion of the watershed in Eden Prairie were re-delineated based on the 2011 Minnesota Department of Natural Resources (MDNR) LiDAR elevation data, storm sewer information from the City of Eden Prairie and Hennepin County, and construction drawings from NMCWD permit files where other information was not available. Hydrologic model inputs were recalculated to reflect the re-delineation of subwatershed boundaries. Stage-storage calculations and surface overflow pathways were also updated based on the MDNR LiDAR data. Data sources for various hydrologic and hydraulic model inputs are further summarized in Table 1.

2.2 Updating the Hopkins portion of the model

Much of the watershed-wide model located within the city of Hopkins hadn't been updated since original model development, with exception of portions of Nine Mile Creek downstream of 9th Avenue which were updated as part of the Hopkins Stream Restoration project, and the NMCWD's Atlas 14 model updates in 2013 which only included adding additional storage and/or surface overflow pathways to convey runoff from the additional precipitation.

As part of the 2020 model updates, the subwatersheds in the Hopkins portion of the model were reviewed using the 2011 MDNR LiDAR data, recent aerial imagery, and GIS storm sewer data provided by the City of Hopkins. Changes to the subwatershed delineation were made, as needed, and hydrologic model inputs were re-computed. The storm sewer conveyance network in the original model was also reviewed in comparison with GIS storm sewer data received from the City of Hopkins, and modified to reflect any significant changes or differences. Additional information on data sources for various hydrologic and hydraulic model inputs are further summarized in Table 1.

2.3 Updating the Richfield portion of the model

As mentioned previously, the City of Richfield developed a highly-detailed model in 2019 using PC-SWMM software. The level of detail included in the Richfield model is well beyond that needed for the NMCWD's watershed-wide model and merging in the large number of additional model nodes and links would have been problematic. Given this and that the model was in PC-SWMM software which would complicate model merging, the portions of Richfield that are within the watershed were reconstructed in the NMCWD's XP-SWMM model at a larger scale resolution. Many of the subwatersheds from the City of Richfield's PC-SWMM model were consolidated and hydrologic model input parameters were calculated for the consolidated subwatersheds based on data sources consistent with the City of Richfield's PC-SWMM model. The consolidated Richfield subwatersheds and associated storm sewer network were incorporated into the Edina and Bloomington portions of the model. Surface storage (i.e., stage-storage relationships for each low-lying area) and surface overflow conveyances for these areas were computed and incorporated into the model(s).

2.4 Combining updated "city" models and creek model

The updated "city" models were combined with the creek model into one watershed-wide model. This task included:

- Merging the numerous city models and creek model together, including addressing cross-connections at boundaries between the city models.
- Simulating the Atlas 14 100-year, 24 hour event and adding in new surface overflows at the boundaries, where necessary, to convey additional runoff between model boundaries.

As part of merging the models together, the subwatershed boundaries between city models and adjacent Riley-Purgatory-Bluff Creek Watershed District (RPBCWD) were compared for congruency. In several cases, subwatershed delineations at the boundaries between cities did not match up. In these areas, the subwatershed delineations were reviewed and "cleaned up" to be congruent. For these areas, it was necessary to recompute hydrologic model input parameters. Similarly, there were several areas along the boundary with the RPBCWD in Minnetonka and Eden Prairie where subwatershed boundaries did not align. Discrepancies between subwatershed delineations in these areas were evaluated and "cleaned up" based on subwatersheds from the most recent modeling efforts of RPBCWD and City of Minnetonka and communications with the City of Eden Prairie. For these areas, hydrologic model input parameters were recalculated as needed.

As previously discussed, the merged watershed-wide model represents the combination of numerous models that were originally developed as far back as the late-1990s and have been periodically updated at a varying levels of detail throughout the last two decades. As such, the data sources for model input parameters vary spatially (generally by city) and based on the time period and scope of past updates. The data sources for various hydrologic and hydraulic model input parameters are summarized by city in Table 1.

As part of merging the models together, conflicts with naming conventions of many subwatersheds and model nodes/links also had to be addressed. For example, subwatersheds in portions of Edina and Bloomington used the naming convention NMC_#. For these areas with conflicting subwatershed names, alternate names had to be assigned to the subwatershed nodes and associated hydrologic input files in the model. For other nodes/links with naming convention conflicts, alternate names were assigned by the Xp-SWMM software.

With current computing power being significantly better than it was back in 2005 when the watershed-wide models were originally developed, combining the models allows for easier and more flexible use of the model for various simulations as needs arise from the NMCWD and/or partner agencies. However, the size of the combined model requires an especially-robust version of the XP-SWMM software (an "unlimited node" version) and results in long model run times. Given this, we anticipate that the NMCWD may want to break the model into several segments for future use. As such, we identified two locations along the creek corridor where the model can be split with the least influence of tailwater. Interestingly, with exception of the South Fork upstream of the Trunk Highway (TH) 169 crossing and the Lower Valley of Nine Mile Creek, no locations were identified where a completely clean break is feasible (i.e., in the 100-year, 24-hour event, downstream (tailwater) conditions influence flows throughout most of the Nine Mile Creek system and there are many locations throughout the watershed where surface overflows flow to a different watershed than piped flows). This observation supports the importance of using a watershed-wide model.

3.0 Follow-up Items for Consideration

3.1 City of Edina 2020 Model Updates

The City of Edina has begun regularly updating their Xp-SWMM models on an annual basis. The model updates planned for 2020 include a substantial number of modifications throughout the city to incorporate changes in storm sewer configuration and subwatershed delineations based on recent capital improvement projects, private development projects, and new or additional data. These model updates were not available at the time of model merging. Upon completion of these updates by the City of Edina, the NMCWD may wish to incorporate some or all of the modifications to the watershed-wide update.

3.2 Landlocked Basin Starting Water Levels

The City of Minnetonka completed preliminary updates to their Atlas 14 models in the Nine Mile Creek watershed in April 2020. These models were subsequently used as the "best available" models for the

NMCWD model merge. Since completion of the preliminary models, the City of Minnetonka is re-considering their approach to establishing "starting" water levels in landlocked basins. When computing a flood elevation for a waterbody, the starting water level can have a significant impact, especially in landlocked basins. For waterbodies with a controlled outlet (i.e., a piped outlet or other water level control structure), the starting water level is typically assumed to be at the elevation of the pipe or control structure, as it can reasonably be expected that the water level will be at or near this elevation. For landlocked waterbodies (or low-lying areas), the starting water level is more difficult to determine, as water levels vary over time, depending on numerous factors, including precipitation patterns, underlying soil conditions, groundwater levels and the interaction of groundwater and surface water for a given waterbody. Recent wet years and high groundwater levels have highlighted the potential for dramatic variation in water levels of landlocked basins from year to year, as documented through the NMCWD's lake and groundwater well monitoring program.

The City of Minnetonka is currently conducting a modeling sensitivity analysis (Barr is assisting the City with this work) to evaluate various options for establishing starting water levels for modeling of their landlocked basins, based on review of approaches taken by several watershed districts, watershed management organizations, and municipalities throughout the metro area. Several approaches are being evaluated, including using a desktop-approximated Ordinary High Water Level (OHWL) as the starting water level (an actual OHWL can only be established by MnDNR and often requires field determination/verification). Upon consideration of the results (anticipated to be available by mid-February), the City may modify the starting water levels for the approximately 80 landlocked basins in the portion of the city within the Nine Mile Creek watershed, in which the NMCWD should consider incorporating these changes into the watershed-wide model. Upon review of the sensitivity analysis results, the NMCWD may also want to consider revising starting water levels in other landlocked basins throughout the watershed. It would be beneficial to discuss this topic with members of the NMCWD's technical advisory committee (TAC) in upcoming months.

Table 1. Documentation of data sources for 2020 updates to watershed-wide model.

Model Parameter	Bloomington	Eden Prairie	Edina	Hopkins	Minnetonka	Richfield
Starting Models	Bloomington 2017 Updated Model(s) and Penn-Skrie updated in 2019	NMCWD Eden Prairie and Creek models updated in 2014 for Atlas 14 precipitation	Edina 2019 Updated Model	NMCWD North Fork Model updated in 2014 for Atlas 14 precipitation (with updates in Minnetonka in 2018)	Minnetonka 2018 updated Model	Information collected/converted from City of Richfield 2019 PCSWMM model.
	P:\Mpls\23 MN\27\23271535 Bloomington Atlas14 Model\Deliverables\2017-12-15_FINAL Deliverables	P:\Mpls\23 MN\27\2327634\WorkFiles\XPSWMM\2013 Atlas 14 Modeling\03_Phase II Models\04_Round03_TW2\04_Round03_TW2\Eden_Prairie	P:\Mpls\23 MN\27\2327354\WorkFiles\2019\Annual CWRMP Model Updates\Final Deliverables\XPSWMM\NMC	P:\Mpls\23 MN\27\2327181\WorkFiles\CitywideModeling\NineMileCreek\02_XPSWMM\01_Model\Task 1 Existing Conditions\13_12+IncorpSWLRT100%		P:\Mpls\23 MN\27\23271692 Updates to Skrie Penn HH Model\Deliverables\2019-03-29
	P:\Mpls\23 MN\27\23271692 Updates to Skrie Penn HH Model\Deliverables\2019-03-29					P:\Mpls\23 MN\27\23271615 Richfield Storm Infrastructure\Deliverables\2019-10-01 PCSWMM Modeling\20190619 Report and Supporting Files\PCSWMM_Models\01_West\01_West\Richfield_West_Model_05292019\100YR
Hydrologic Parameters						
Subwatershed Delineation	minor changes made to align subwatershed boundaries with Richfield and Bloomington- Oxboro watershed	Revised in 2020 based on 2011 DNR LiDAR, storm sewer information provided by City of Eden Prairie and others, and NMCWD permit files (e.g., for SW LRT and other major transportation corridors).	See Reference 2	Edits made to some subwatersheds based on development. Otherwise, see Reference 4.	see Reference 3	Subwatersheds condensed based on subwatersheds from City of Richfield 2019 PCSWMM model . Some subwatersheds along Edina boundary were revised based on the Richfield PCSWMM model's subwatersheds; Minor changes were made to subwatersheds along Bloomington boundary (Penn-Skri) to align with the Richfield PCSWMM model's subwatersheds;
Impervious Area	Based on original model development. See Reference 1, Reference 4.	Impervious % assumption are based on Land Use Data provided by the city	See Reference 2	see Reference 4	see Reference 3	Subwatersheds going to/ adjusting to Edina see Reference 2; subwatersheds going to Bloomington see Reference 1;
Land Use Data	See Reference 1, Reference 4.	"current" (2020) land use was provided by the City GIS staff	See Reference 2	see Reference 4	see Reference 3	Reference 2; subwatersheds going to Bloomington
Impervious % Assumptions	See Reference 1, Reference 4.	see Reference 4	See Reference 2	see Reference 4	see Reference 3	Reference 2; subwatersheds going to Bloomington
Width	Based on original model development. See Reference 1, Reference 4.	Width is calculated using the longest flow path method	See Reference 2	Edits made to some subwatersheds based on development. Otherwise, see Reference 4.	see Reference 3	Subwatersheds going to/ adjusting to Edina see Reference 2; subwatersheds going to Bloomington see Reference 1;
Slope	Based on original model development. See Reference 1, Reference 4.	Watershed slope calculated using 2011 LiDAR	See Reference 2	see Reference 4	see Reference 3	Subwatersheds going to/ adjusting to Edina see Reference 2; subwatersheds going to Bloomington see Reference 1;
Soils data	Based on original model development. See Reference 1, Reference 4.	Soils dataset developed by NMCWD in 2019, based on SURGO.	See Reference 2	see Reference 4	see Reference 3	Subwatersheds going to/ adjusting to Edina see Reference 2; subwatersheds going to Bloomington see Reference 1;
Infiltration parameters	Based on original model development. See Reference 1, Reference 4.	see Reference 4 for method. Soils info based on SSURGO.	See Reference 2	see Reference 4	see Reference 3	Subwatersheds going to/ adjusting to Edina see Reference 2; subwatersheds going to Bloomington see Reference 1;
Other hydrologic parameters (Manning's n)	Based on original model development. See Reference 1, Reference 4.	see Reference 4	See Reference 2	see Reference 4	see Reference 3	Subwatersheds going to/ adjusting to Edina see Reference 2; subwatersheds going to Bloomington see Reference 1;
Hydraulic Parameters						
Elevation data (storage calculations and surface overflow routing)	Some storage and overflows from original model development, some based on 2011 DNR LiDAR.	Based on 2011 DNR LiDAR;	Primarily based on 2011 DNR LiDAR, but some overflow channels based on elevation data from original model development.	The subwatershed updates and some new storage areas and surface overflows are based on 2011 LiDAR. Most of the storage areas and surface overflows based on data source from original model.	Storage and some surface overflows based on 2011 DNR LiDAR. Some surface overflows based on data source from original model development. See Reference 3	Based on 2011 DNR LiDAR;

Model Parameter	Bloomington	Eden Prairie	Edina	Hopkins	Minnetonka	Richfield
Storm sewer data	Based on original model development, with some modifications made in 2017 updates. See Reference 1, Reference 4.	Based on the GIS shapefile and as built drawings provided by the City, NMCWD permit files, or assumptions using best professional judgement where the data was not available.	Based on the GIS shapefile and as built drawings provided by the City, with assumptions where the data is not available.	Primarily based on original model inputs (from City CAD data and asbuilts from the City or NMCWD permit files). Some updates made to storm sewer inputs based on GIS storm sewer data or asbuilts provided by the City of Hopkins in 2020.	Provided by the City	Based on Richfield PCSWMM model

References:

1. *Stormwater Model Update to Incorporate Atlas 14 Rainfall Depths,* Prepared for the City of Bloomington by Barr Engineering Co., December 2017

2. *2018 Comprehensive Water Resources Management Plan* , Prepared for City of Edina by Barr Engineering Co., July 2018

3. *Atlas 14 Model Updates- Nine Mile Creek Watershed (DRAFT)* , Prepared for the City of Minnetonka by Barr Engineering Co., April 2020

4. Original NMCWD watershed-wide model development. See memorandum titled *Nine Mile Creek (Hennepin County, MN) Hydrology, Preliminary Hydraulics, and GIS Data* to David Rensing, Black and Veatch dated May 17, 2005 for model documentation. Additional documentation on model methodology included in: City of Edina *Comprehensive Water Resources Management Plan* , 2003; Bloomington Use Attainability Analysis, Prepared for the Nine Mile Creek Watershed District by Barr Engineering Co., 9/1/2001