Item 5Bii.
Additional information

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Memorandum

To: Bassett Creek Watershed Management Commission
From: Barr Engineering Co.
Subject: Watershed-wide XP-SWMM Model
Date: June 5, 2013
Project: 23/27-0051.13

Introduction

The Bassett Creek Watershed Management Commission (BCWMC) has updated the hydrologic and hydraulic (HEC-1 and HEC-2) models created for the watershed to the XP-SWMM modeling software. XP-SWMM is a powerful and user-friendly software package that incorporates both hydrology and hydraulics in one modeling program, determines flood elevations, calculates channel flow rates and velocities, and effectively models backwater conditions and complex outlet structures. Several subwatersheds were previously modeled in XP-SWMM where more detailed modeling was required. The intent of updating the models to XP-SWMM was to create a tool for the BCWMC and the cities to use when evaluating how changes to the watershed effect flow rates in Bassett Creek.

This memorandum summarizes the conversion of the HEC-1 and HEC-2 models to XP-SWMM and revisions to the model inputs.

Modeling Methodology

The HEC-1 and HEC-2 modeling methodology was incorporated into the XP-SWMM model where feasible, though some modifications were made for this analysis. The Sweeney Lake Branch Watershed and other areas that had previously been converted to XP-SWMM (DeCola Ponds in Golden Valley, Wirth Lake watershed in Minneapolis/Golden Valley, 3rd Avenue Inflow in Minneapolis) were not modified at this time; therefore these existing detailed models were incorporated into the overall XP-SWMM model, without further review. Following is a summary of how the watershed runoff and hydraulic routing parameters were modified in the XP-SWMM analysis.

- ***Watershed Divides:*** Generally, watershed divides remained the same scale as the HEC-1 model in areas where detailed modeling had not been completed. Divides were updated using storm sewer information provided by individual cities and current 2-foot topography from the United States Army Corps of Engineers (USACE). The detail of the storm sewer data provided varied from city to city, so it was necessary to make assumptions on the drainage network in some areas where less-detailed data was provided. In areas where previous XP-SWMM models have been created, watersheds are divided on a smaller scale, but were not changed as part of this update.

- ***Curve Numbers:*** Curve numbers were modified to reflect the updated watershed divides. Curve numbers were further modified during the calibration process.

- ***Time of Concentration:*** Time of concentration was recalculated for each watershed using Friend's Equation, because using this equation resulted in lag times that more closely reflected those used in the original HEC-1 model, than the use of other methods of calculating time of concentration. Time of concentration was modified during the calibration process.

- ***Watershed Storage:*** Storage along Plymouth Creek, North Branch of Bassett Creek, the Bassett Creek Main Stem, and in major water bodies was recalculated based on the 2-foot topographic data.

- ***Channel Cross-section Geometry:*** Channel cross-section geometry in Plymouth Creek, North Branch of Bassett Creek, and the Bassett Creek Main Stem was updated based on the current 2-foot topographic data.

- ***Bridge and Culvert Information:*** Bridges and culverts along Plymouth Creek, North Branch Bassett Creek, and the Bassett Creek Main Stem were updated where plans were available. For watersheds tributary to Bassett Creek, the culvert at the watershed outlet was included in the XP-SWMM model if the culvert information was available. If culvert information was not available, or the outlet of the watershed was a natural overflow, the 2-foot topographic data was used to represent a natural overflow section.

Model Calibration

Flow and stage data along the Bassett Creek Main Stem was obtained from continuous monitoring stations at Wisconsin Avenue in Golden Valley and at the Bassett Creek WOMP station in Minneapolis. Model calibration and verification was attempted for three precipitation events: August 2010, April 2011, and August 2011. Precipitation depths and distributions were developed using NEXRAD Doppler precipitation data collected at the KMPX-Minneapolis, Minnesota site.

During the calibration process, it was determined that the model was sensitive to the following parameters: curve number, channel and floodplain Manning's n, and watershed time of concentration. While reasonable adjustments to curve numbers and the watershed time of concentration contributed to model calibration, it was determined that unreasonable values for Manning's n were required to achieve accurate calibration. This is likely due to upstream storage that occurs in depressions, ponds and wetlands that were not included in the model because of the level of detail that is required to incorporate them.

Figures 1 and 2 show the XP-SWMM calibration modeling results and observed data for the August 2010 event at the Wisconsin Avenue and the WOMP station monitoring sites. The modeled stage at the Wisconsin Avenue site shown in Figure 1 indicates that the timing of runoff is appropriate for the Bassett Creek Main Stem. However, the WOMP station results shown in Figure 2 indicate that the second hydrograph peak must be delayed to correspond to observed values. Therefore, in order to more closely match the modeled second hydrograph to the observed data at the WOMP station, it was necessary to increase the Manning's n to unreasonably high values (i.e. Manning's n values of 1.3 in the floodplain instead of more reasonable 0.05-0.07). The same trends were observed for 2011 storm events.

Although calibration can be continued, we recommend that the BCWMC consider adding detail to the model, including additional subwatershed divides and storm sewer data, to better represent upstream storage in depressions, ponds and wetlands. Additional upstream storage will likely delay the runoff rates and shift the Bassett Creek Main Stem hydrograph to more closely match observed values. In addition, the BCWMC may want to consider obtaining flow monitoring data in the North Branch Bassett Creek to better refine modeled runoff from that area of the watershed.

Figure 1 – Calibrated Stage at Wisconsin Avenue, August 2010

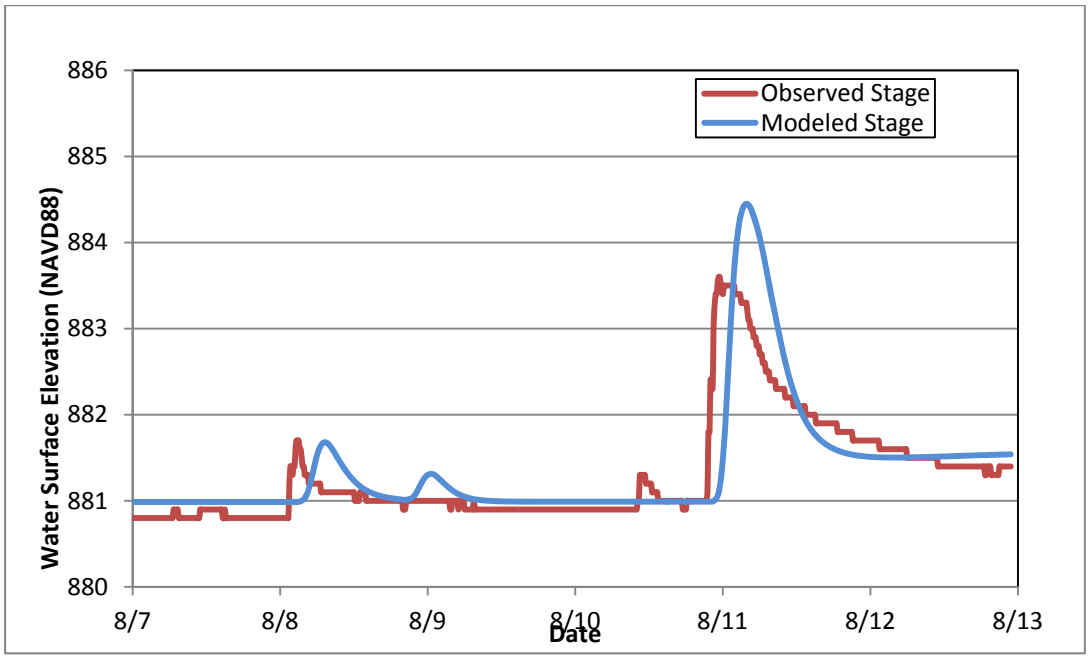
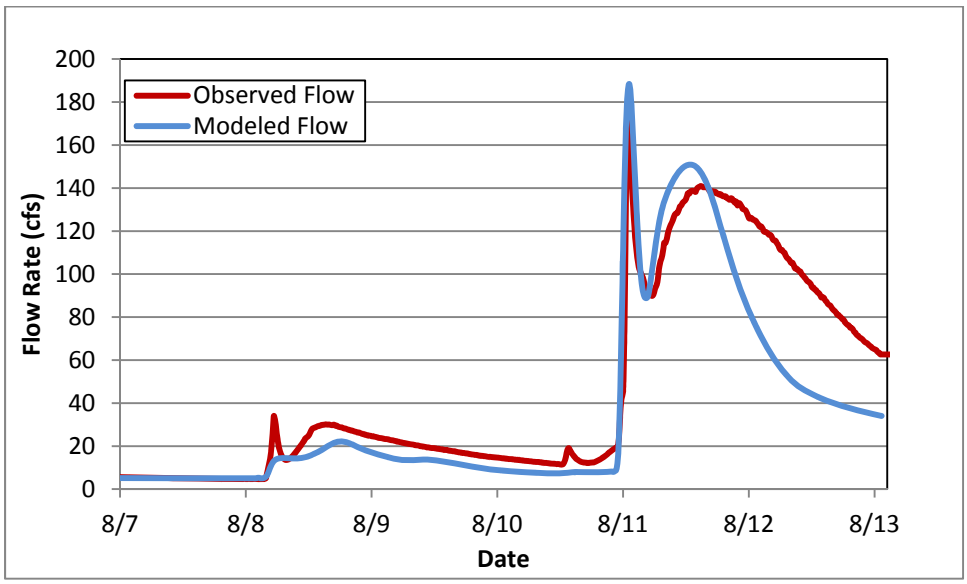


Figure 2 – Calibrated Flow at the WOMP Station, August 2010



Model Results

Table 1 compares the water surface elevations from the XP-SWMM model to those presented in the September 2004 BCWMC Watershed Management Plan (Table 5-3 Bassett Creek Flood Profiles 2009 Amendment) and to those recorded in the Hennepin County Preliminary Flood Insurance Study (FIS). Table 1 shows several changes and significant differences in the water surface elevations between the XP-SWMM model, the BCWMC plan and the FIS. The changes were expected and are principally the result of updated bridge and culvert geometry due to construction of several new crossings. To a lesser degree, the changes in stage are caused by changes in watershed divides as determined from storm sewer data received from the cities, since the original HEC-1 and HEC-2 models were created.

The hydraulic inputs as modeled (cross-sections, channel and lake storage areas, culverts and bridges) accurately represent Plymouth Creek, the North Branch of Bassett Creek and the Bassett Creek Main Stem. However since the model has not been fully calibrated, we suggest that the hydrologic parameters (curve numbers and time of concentrations) be more accurately defined after further refinement of the model. As the model currently exists, it will be a useful tool for the cities and BCWMC to evaluate relative changes in flow rate (i.e. – existing flow rates versus proposed flow rates) as runoff enters the creek or through the creek. However we do not recommend that the BCWMC adopt the predicted 100-year flow rates and water surface elevations from the model until calibration can be finalized.

At this time we recommend that the BCWMC maintain ownership of the model and update the model as needed or as refined data becomes available. If the BCWMC elects to provide the model to cities for their own use, we recommend that all formal model changes be managed by the BCWMC to ensure consistency and prevent version control complications.

Recommendations for Future Use

As noted in this memorandum, we recommend the BCWMC consider the following:

1. The current XP-SWMM model may be used to compare relative changes in flow rate (i.e. – existing vs. proposed conditions runoff rates), but should not be used for determining absolute flow rates or water surface elevations until further refinements and calibration is completed.

2. We recommend the BCWMC consider adding detail to the model, including additional subwatershed divides and storm sewer data, to better represent upstream storage in depressions, ponds and wetlands and to refine the calibration parameters to allow the model to be used to establish flood elevations in the creek.
3. We recommend the BCWMC consider obtaining flow monitoring data in the North Branch Bassett Creek to better refine modeled runoff from that area of the watershed.
4. We recommend the BCWMC consider modeling the updated Atlas 14 precipitation depths for the 100-year storm event prior to adopting new 100-year flood elevations.
5. If model refinements can be completed in a timely manner, the BCWMC should consider requesting FEMA to modify its draft floodplain maps to reflect the water surface elevations calculated by the XP-SWMM model.

Table 1. Comparison of BCWMC, FIS, and XP-SWMM flood elevations (US = upstream side; DS = downstream side)

Location	BCWMC Plan Flood Elev. (ft)	FIS Flood Elev. (ft)	XP-SWMM Model Flood Elev. (ft)
Bassett Creek Main Stem			
Old Penn Ave Bridge (DS)	814.7	814.9	----*
Old Penn Ave Bridge (US)	815.0	815.0	----*
BN RR Bridge	815.1	815.0	813.6
MN&S RR Bridge (DS)	816.2	815.5	817.2
MN&S RR Bridge (US)	816.0	816.0	817.4
Fruen Mill Dam (DS)	816.3	817.0	817.9
Fruen Mill Dam (US)	818.0	818.0	818.5
Glenwood Ave	820.1	820.5	821.0
Hwy 55 (DS)	821.5	821.0	822.8
Hwy 55 (US)	826.0	826.0	824.6
Golf Cart Bridge	826.0	826.0	824.6
MN&S RR Bridge	826.0	826.0	824.7
Plymouth Ave Bridge	826.0	826.0	825.1
Wirth Parkway (DS)	826.0	826.0	825.2
Wirth Parkway (US) Bridge	826.3	826.2	825.2
Confluence w/ Sweeney Lake Branch	827.0	827.0	826.5
Golden Valley Road (DS)	827.2	827.0	827.8
Golden Valley Road (US)	830.0	830.0	831.5
Dresden Lane (DS)	830.3	830.0	832.3
Dresden Lane (US)	831.4	831.0	832.5
Bassett Creek Drive	832.0	832.0	833.0
Bassett Creek Drive	832.7	833.0	834.7
Noble Lane (DS)	839.5	839.5	838.6
Highway 100 (DS)	843.2	843.0	844.2
Hwy 100 (US)	849.0	849.0	----*
DS Confluence N. Branch	849.0	849.0	----*
Westbrook Road (DS)	857.1	857.0	858.0
Westbrook Road (US)	858.1	858.0	858.5
Duluth Street (DS)	861.3	861.3	860.8
Duluth Street (US)	861.8	861.8	861.1

Table 1. Comparison of BCWMC, FIS, and XP-SWMM flood elevations (US = upstream side; DS = downstream side)

Location	BCWMC Plan Flood Elev. (ft)	FIS Flood Elev. (ft)	XP-SWMM Model Flood Elev. (ft)
Bassett Creek Main Stem			
St. Croix Avenue (DS)	863.0	863.0	863.5
St. Croix Avenue (US)	864.1	864.0	863.9
MN&S RR (DS)	869.5	869.0	869.5
MN&S RR (US)	869.5	869.2	870.1
Douglas Drive (DS)	870.2	870.0	870.3
Douglas Drive (US)	871.0	871.0	870.9
Florida Avenue (DS)	871.6	871.8	871.6
Florida Avenue (US)	872.3	872.0	872.1
Hampshire Ave (DS)	872.5	872.8	872.5
Hampshire Ave (US)	873.0	873.0	872.8
GV Country Club (DS)	874.4	875.0	875.3
GV Country Club (US)	878.4	876.0	880.3
Pennsylvania Avenue (DS)	879.3	879.0	880.8
Pennsylvania Avenue(US)	880.5	880.0	881.6
C&NW RR (DS)	881.7	882.0	883.4
C&NW RR (US)	882.9	883.0	884.6
Winnetka Ave (DS)	883.3	883.5	885.1
Winnetka Ave (US)	883.5	883.6	885.6
Wisconsin Ave (DS)	884.7	885.0	886.3
Wisconsin Ave (US)	888.0	887.0	888.4
Golden Valley Road (DS)	888.0	888.0	888.4
Golden Valley Road (US)	888.0	888.0	888.4
Westbound Hwy 55 (DS)	888.0	888.0	888.5
Eastbound Hwy 55 (US)	888.1	888.0	888.5
Boone Ave (DS)	888.2	888.0	888.5
Boone Ave (US)	888.3	888.0	888.5
Hwy 169 (DS)	888.4	888.5	888.6
Hwy 169 (US)	888.5	888.7	888.6
Hwy 55 Ramp (DS)	888.5	889.0	888.6
Hwy 55 Ramp (US)	888.5	889.0	888.6

Table 1. Comparison of BCWMC, FIS, and XP-SWMM flood elevations (US = upstream side; DS = downstream side)

Location	BCWMC Plan Flood Elev. (ft)	FIS Flood Elev. (ft)	XP-SWMM Model Flood Elev. (ft)
Bassett Creek Main Stem			
Hwy 55 Eastbound (DS)	888.5	889.0	888.6
Hwy 55 Eastbound (US)	888.5	889.0	888.6
Hwy 55 Westbound (DS)	888.5	889.0	888.6
Hwy 55 Westbound (US)	888.8	889.0	888.6
Hwy 169 ramp to W 55 (DS)	888.8	889.0	888.6
Hwy 169 ramp to W 55 (US)	888.8	889.0	888.6
Hwy 55 N Frontage Rd (DS)	889.0	889.0	888.6
Hwy 55 N Frontage Rd (US)	889.0	889.0	888.6
10^{th} Ave (DS)	889.0	889.0	888.8
10^{th} Ave (US)	889.0	889.0	888.8
C&NW RR Bridge (DS)	889.0	889.0	888.9
C&NW RR Bridge (US)	889.4	889.5	888.9
South Shore Drive (DS)	889.4	889.5	889.1
South Shore Drive (US)	890.3	890.0	889.7
Medicine Lake Weir (DS)	890.3	890.0	889.7
North Branch Bassett Creek			
Hwy 100 Control (US)	849.0	849.0	----*
Confluence w/Main Stem	849.0	849.0	----*
29th Avenue (DS)	849.0	849.0	----*
29th Avenue (US)	849.5	850.0	----*
32nd Avenue (DS)	849.6	850.0	848.4
32nd Avenue (US)	854.0	854.0	854.2
Brunswick Avenue (DS)	854.7	855.0	854.4
Brunswick Avenue (US)	855.9	856.0	855.3
34th Culvert (DS)	862.8	863.0	863.3
34th Culvert (US)	866.1	866.0	865.4
Douglas Drive (DS)	870.0	870.0	----*
Douglas Drive (US)	870.1	871.0	----*
Edgewood Emb (DS)	870.7	871.0	868.0
Edgewood Emb (US)	878.2	878.0	876.8

Table 1. Comparison of BCWMC, FIS, and XP-SWMM flood elevations (US = upstream side; DS = downstream side)

Location	BCWMC Plan Flood Elev. (ft)	FIS Flood Elev. (ft)	XP-SWMM Model Flood Elev. (ft)
North Branch Bassett Creek			
Georgia Avenue (DS)	878.2	878.0	877.3
Georgia Avenue (US)	878.4	878.0	877.4
36th & Hampshire (DS)	878.4	878.0	877.4
36th & Hampshire (US)	879.0	879.0	877.6
Inlet of 42" CMP	888.0	886.0	885.0
Boone Ave. (US)	889.5	889.0	888.8
Northwood Lake	889.5	889.0	888.8
TH 169 (DS)	889.5	889.0	890.0
TH 169(US)	890.5	-----	892.0
Rockford Road (US)	898.5	-----	901.5
Plymouth Creek			
Medicine Lake	890.3	890.0	889.7
West Medicine Lake Drive (DS)	890.3	892.5	891.4
West Medicine Lake Drive (US)	891.5	893.0	894.6
26th Avenue N. (DS)	925.0	925.0	925.6
26th Avenue N. (US)	925.5	930.0	927.1
28th Avenue N. Dike (DS)	928.0	930.0	930.3
28th Avenue N. Dike (US)	930.8	930.0	930.5
County Road 61 (DS)	930.8	930.0	930.6
County Road 61 (US)	931.2	930.0	931.6
Xenium Lane (DS)	931.2	930.0	932.4
Xenium Lane (US)	931.5	931.0	932.9
I-494 (DS)	935.0	936.0	936.1
I-494 (US)	938.5	936.0	939.0
Fernbrook Lane (DS)	947.0	946.0	946.0
Fernbrook Lane (US)	948.0	951.0	946.1
Central Park Pond Outlet Structure (DS)	949.0	952.5	950.0
Central Park Pond Outlet Structure (US)	953.0	952.5	954.9
37th Avenue	956.0	953.0	954.9
County Road 9(3-72” RCPA)	959.0	953.0	958.3

Table 1. Comparison of BCWMC, FIS, and XP-SWMM flood elevations (US = upstream side; DS = downstream side)

Location	BCWMC Plan Flood Elev. (ft)	FIS Flood Elev. (ft)	XP-SWMM Model Flood Elev. (ft)
Plymouth Creek			
Vicksburg Lane (DS)	961.0	960.0	963.0
Vicksburg Lane (US)	962.0	962.0	963.0

*XP-SWMM modeling results are being reviewed at these locations.