MINNESOTA POLLUTION CONTROL AGENCY

Middle Minnesota River HSPF Summary

4/27/17

The hydrologic model HSPF (Hydrological Simulation Program – FORTRAN) was used to support decision-making for potential sediment and nutrient reduction strategies in the Middle Minnesota River basin (or Minnesota-Mankato). This document describes the development of the Middle Minnesota HSPF as well as some of the modeled data output. For information regarding these models or for any data/reports relating to them, please contact Dr. Charles Regan (chuck.regan@state.mn.us) at the Minnesota Pollution Control Agency (MPCA).

HSPF Development

HSPF models allow for advanced hydrologic simulation of a basin through multiple sources of spatial and temporal observed data. The model was developed and continues to be supported by the EPA and has been consistently used in peer-reviewed watershed studies. More on HSPF can be found at http://www.pca.state.mn.us/index.php/view-document.html?gid=21398. The engineering firm TetraTech completed the most recent version of the Middle Minnesota model in 2016 while RESPEC Engineering developed the previous model. The Middle Minnesota watershed was modeled jointly with several other watersheds within the greater Minnesota River basin. All data from this model is part of the public domain.

Subwatershed Delineation and Land Segment Development

The watershed model is separated into subwatersheds based on hydrography data (from GIS analysis) and could be adjusted based on specific stream concerns (such as impairments). Pervious and impervious land segments within each subwatershed divide the subwatersheds into distinct sections based on land use, soil properties, type of tillage, manure application, and other factors. For example, cropland land segments are divided into two soil groups – HSG A/B and HSG B/C – along with either conservation or conventional tillage. This data was compiled from multiple federal, state, and local organizations and government entities. Land cover data for land segments originated from the National Land Cover Database of 2001 and 2006.

Calibration - Hydrology

Fifteen flow calibration gages data were used for hydrologic calibration from the Minnesota Department of Natural Resources, the USGS, and the MPCA. The modeled period was between 1995 and 2012. Calibration involves first determining annual water balance, then modifying for seasonal changes in hydrology, ensuring high and low flow volumes are accurate, and finally modifying hydrograph to storm flows. Snow and snowmelt are also factored into the model based on meteorological inputs. Calibration of water balance from land segments and soil groups examines precipitation, runoff (surface and subsurface), potential and total evapotranspiration, and deep groundwater loss/recharge.

Calibration – Water Quality

Multiple constituents of water quality were modeled, including biochemical oxygen demand, dissolved oxygen, sediment, temperature, as well as nitrogen and phosphorus (and many of their constituent species). Water quality calibration is more challenging because fewer data points exist (compared to flow data) and there is greater uncertainty in data collection (for example because of the timing of samples). Thirty-two sites across the Middle Minnesota were used for water quality calibration, with available data ranging from four samples over the modeled period to more than 1,000 samples. Observed water quality and flow data from 27 point sources, such as waste water treatment facilities or industrial discharges (based on NPDES permits), were also incorporated into the model. For small point source facilities, nitrogen species were often unavailable and had to be estimated.

Sediment

Sediment loads are divided into sand, silt, and clay for the HSPF simulation. The recent model version for the Middle Minnesota was recalibrated for greater accuracy in sediment simulation. Specifically, sediment source assessment was recalibrated to align with radiometric data and greater representation of bluff sediment. Calibration included parametrization of land sediment loading sources, delivery rates to streams, and in-stream scour and deposition rates. Eight sediment calibration sites with at least 100 samples were available for the Middle Minnesota, ranging in data from March 1996 to September 2012. These larger sample populations were a priority of the sediment recalibration.

Dissolved Oxygen, Biochemical Oxygen Demand, and Nutrients

Parameterization of water quality constituents was designed to account for land-use, soils, geology, and land management practices. Parameters were not adjusted purely to ensure simulated data matched observed data, but rather to accurately demonstrate observed watershed properties. Nitrate and ammonia atmospheric deposition was also included from the National Atmospheric Deposition Program and the Environmental Protection Agency. Nutrient loads for Individual Sewage Treatment Systems (ISTS) were also factored into the model via GIS analysis as a function of land area.

Calibration Results

The calibration process for HSPF modeling is the “weight of evidence” method, meaning that calibration involves a combination of statistical analysis, visual comparisons, and compatibility with existing scientific information. In general, the model was well calibrated for hydrology and water quality based on qualitative comparisons and quantitative analyses such as correlation coefficient and coefficient of determination metrics. For example, the Middle Minnesota sediment calibration points have a median error load range of -0.5% to 1.8%. Generally, the model was calibrated to balance main-stem flow and loads to upstream reaches. The model is determined to be suitable for all MPCA business needs. *Figure 1* shows an example of hydrologic calibration for the Watonwan. *Figure 2* displays the sediment source assessment for the Watonwan. Additional calibration figures are available upon request.

While the MPCA and TetraTech have confidence in the model calibration, TetraTech provided certain model criteria that could be improved. This includes more accurate precipitation data, which could be achieved by “gridded” precipitation analysis. Additional data for stream hydraulics, tile data, and bluff areas would also help calibration. Furthermore, a more detailed manure application survey would present more accurate simulation of nutrient runoff loading rates.

Figure 1: Flow-duration curve of simulated streamflow (blue) and observed streamflow (red) near the outlet of the Watonwan River. (Figure produced by RESPEC.)

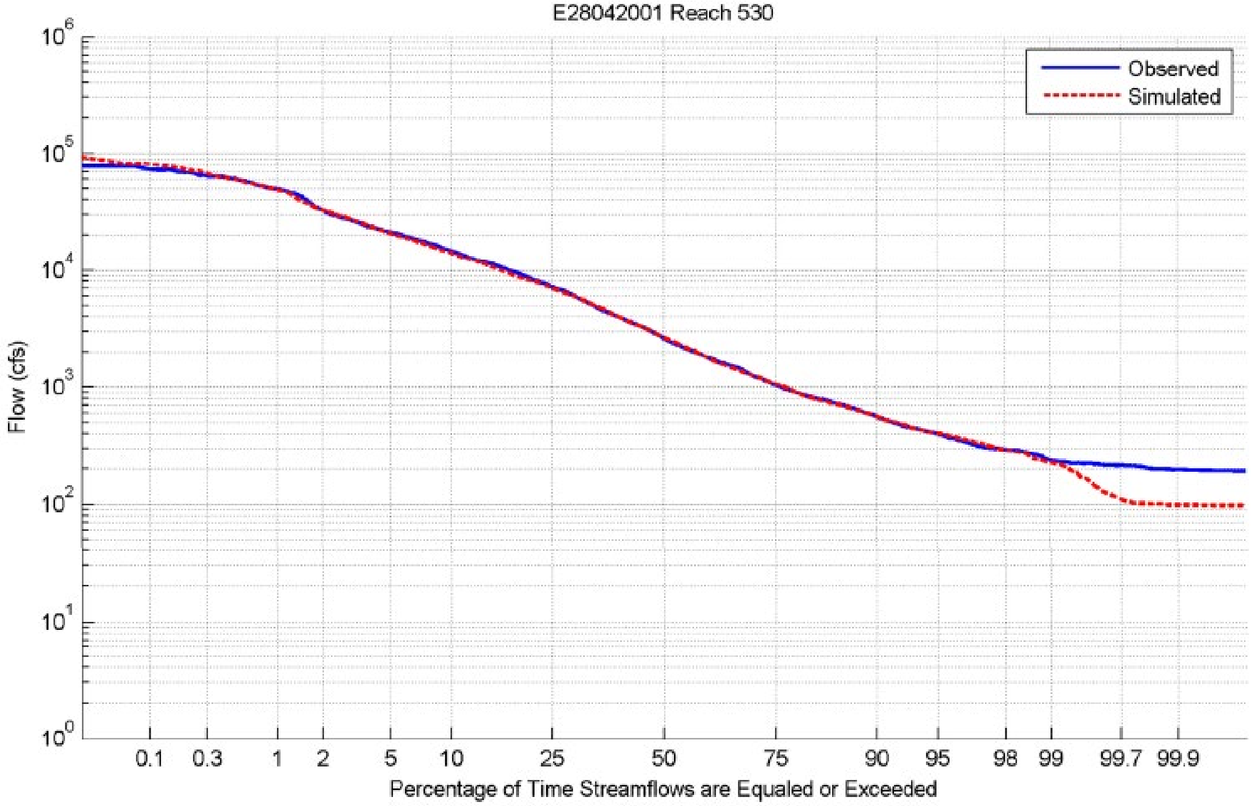

Figure 2: Sediment source assessment for the Watonwan watershed. (Figure produced by TetraTech.)