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Development of a Calibrated Watershed Model, Potomac River Basin

A Cooperative Project between the U.S. Geological Survey (USGS),
the Interstate Commission on the Potomac River Basin (ICPRB),
the Maryland Department of the Environment (MDE), and the
U.S. Environmental Protection Agency Chesapeake Bay Program Office (CBP)

Progress Report April 1–June 30, 2002

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Project Description

Problem. Work performed by the National Water-Quality Assessment (NAWQA) Program Potomac River Basin study unit (1992-95) indicated that elevated concentrations of nutrients in surface and ground water in the basin often result from human activities such as manure and fertilizer application. A watershed model of the basin is needed to assess the effects of point and nonpoint nutrient and sediment sources on water quality in the Potomac River and its tributaries.

Objectives. The USGS is responsible for the following objectives: 1) compile necessary data for simulation of Potomac watershed processes, using the Hydrologic Simulation Program-FORTRAN (HSPF); 2) create necessary control files for HSPF simulation of the Potomac River Basin, following the framework developed by CBP for Phase 5 of the Chesapeake Bay Watershed Model (CBWM); 3) develop and implement innovative calibration procedures to improve HSPF model calibration; 4) calibrate an HSPF model for the Potomac River Basin; and 5) prepare reports on calibration and analysis of model results.

Benefits and relevance. The calibrated Potomac Watershed Model will allow resource managers to simulate the effects of land-use changes and best management practices on water quality and evaluate alternative approaches for correcting existing water-quality and water-quantity problems within the Potomac River Basin. The proposed study also meets several goals of the USGS Water Resources Division (WRD).

Approach and methods. The proposed study will involve the following tasks: 1) compilation of existing input data, development of model segmentation and network, processing of time-series data, and compilation of ancillary data and observational data for model calibration; 2) development of a model calibration strategy through implementation of existing software for general inversion and calibration of multi-parameter hydrological models; 3) calibration of hydrological and water-quality model (sediment and nutrients); 4) analysis of model results, including consideration of specific study questions; and 5) dissemination of calibrated model and preparation of final reports analyzing the model results.

USGS will be responsible for development and calibration of the Potomac Watershed Model. CBP will be responsible for parallel development of the CBWM (Phase 5); the Potomac Watershed Model developed by USGS will be one major basin nested within the CBWM. ICPRB will be responsible for all aspects of outreach and inter-agency coordination, and prepare reports for MDE on model aspects relevant to Total Maximum Daily Loads (TMDL) needs.

Timeline and personnel. The project will run from July 1, 2001 through June 30, 2004. The primary product from the project will be a calibrated model of the Potomac River Basin for hydrology, suspended sediment, and nutrients. The completed model will be delivered to ICPRB by October 1, 2003. Intermediate provisional data sets and model results will be disseminated as completed. Progress will be reported by the USGS quarterly; final reports describing the model development and analysis and documenting calibration methods and calibrated parameters will also be prepared by the USGS. Project personnel include a project chief and one other modeler, as well as part-time GIS and database support.

Progress During Reporting Period

During the past 3 months, the following tasks were completed by the USGS:

1. Watershed segmentation line work and codification of stream segments were completed for the entire Chesapeake Bay Region.

2. Daily discharge data from USGS stream gages located within the Chesapeake Bay watershed was used to produce the binary time series files (WDM- HSPF format).

3. Generation of time series with hourly precipitation and binary files with meteorological data for the Patuxent watershed was completed.

Watershed segmentation line work, and codification of stream segments
Quality control was completed for the line work of the watershed (reach) segmentation. The Maryland and Virginia State watershed line work was used for all cases except in circumstances in which the state watershed boundary was not near the monitoring site; for these particular cases, DEMs were used for the delineation. Downstream ID (DSID) has been attributed to all reaches, and those draining directly to the bay have a DSID of ZERO. Additional attributes such as the mean discharge of the reach was being added to the watershed ID.

The codification of stream segments was developed based on several considerations. The location of the stream with respect to a major or minor basin was definitive in the final codification since the code should allow the user to easily identify the location of the reach segment. The codification scheme is shown in Figure 1, and the major and minor basins are identified in Table 1 for streams within the Chesapeake Bay Watershed and Table 2 for streams outside the Chesapeake Bay Watershed.

catcode
First Digit = Major Basin
Second Digit = Minor Basin
Third Digit = Round(log10(cfs flow) * 3 - 5)
4-7 digits = uniqid
8-11 digits = downstream id

Figure 1. Codification scheme for reaches within the Chesapeake Bay Regional Watershed Model.

Generation of time series with hourly precipitation
Completion of the initial precipitation model development (*xyz*-MLR analysis) of weather-type stratified data to develop spatial interpolation relations for the entire modeled region was achieved, and the estimation of daily and hourly precipitation for the time period 1984-2001 on a 5-km grid was completed. The software developed by Lauren Hay of the USGS National Research Program in Denver, for the spatial and temporal distribution of daily and hourly precipitation, was installed in the USGS network in the Baltimore office and USGS staff has already tested the software. Binary files with time series for individual precipitation-county segments in the Patuxent watershed were produced. The Patuxent watershed is used as the test case for the new structure in the modeling approach.

Daily discharge data from the USGS
Records of daily discharge data were obtained from the USGS database for gages located within the Chesapeake Bay Watershed, to produce the binary files (HSPF- format). This information is necessary when using the parameter estimator (PEST) for the calibration of the hydrology.

Table 1. Major and minor basins used in the codification of stream reaches for streams within the Chesapeake Bay Watershed. First letter is the major basin ID while the second letter is the minor basin ID.

SU - Susquehanna Upper, above confluence with West Branch
SW - Susquehanna, West Branch
SJ - Susquehanna, Juniata River branch
SL - Susquehanna below West Branch confluence not including Juniata.
PU - Potomac upper, above confluence with Shenandoah
PS - Shenandoah River
PM - Monocacy and Potomac below Shenandoah, above Chain Bridge
PL - Potomac Lower, Below Chain Bridge
JU - James Upper, above Richmond site
JL - James Lower, below Richmond site
JA - Appomatox River
JB - James below Richmond site
YP - Pamunkey
YM - Mattaponi
YO – York
RU - Rappahannock, upper
RL - Rappahannock, lower
XU - Patuxent above Bowie
XL - Patuxent below Bowie
WL - Western shore, lower
WM - western shore, middle (Patapsco, Back)
WU - Western shore, upper
EU - Eastern shore, upper
EL - Eastern shore, lower
EM - Eastern shore, middle (Choptank)

Table 2. Major and minor basins used in the codification of stream reaches for streams outside the Chesapeake Bay Watershed.

YO - Youghiogheny (Maryland west of CB)
DE - Delmarva, east of CB
TU - Tennessee upper
BS - Big Sandy
NR - New River
OD - Roanoke, Dan River
OR - Roanoke River
MN - Meherin, Nottoway

Plans for Next Quarter

1. Continue collection of cross-sectional information for the generation of F-TABLES. Develop preliminary regressions to estimate cross section parameters in ungaged basins.

2. Review the Directory Structure for the Phase 5 Chesapeake Bay Watershed model; create files and debug External Transfer Module (ETM) and other scripts as necessary to initiate a Patuxent watershed simulation.

3. Update software for the parameter estimator PEST (Utility TSPROC).