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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),
Maryland Department of the Environment (MDE), and the
U.S. Environmental Protection Agency Chesapeake Bay Program Office (CBP)

Progress Report July 1–September 30, 2001

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Project Description

Problem. The National Water-Quality Assessment (NAWQA) Program, Potomac River Basin study unit (1992-95), has 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 has responsibility 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 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 three months the following tasks were completed by the USGS.

1. Development of the model reach and watershed segmentation.

2. Compilation of stream discharge data.

3. Compilation of stream cross-section data throughout the basin.

Model Segmentation
In general, model segmentation consists of several tasks. For the Potomac Watershed Model (PWM), as well as the CBWM, sources (e.g., fertilizer application) will be distributed over counties, precipitation will be distributed to either watersheds or counties broken by major topographic features, and edge-of-stream loads will be calculated for watershed-county segments and delivered to individual stream reaches.

During the reporting period (July 1, 2001 through September 30, 2001), emphasis was on developing the stream reach network and associated watersheds or drainage areas. These areas (intersected with counties) will constitute the model land segments for delivery of edge-of-stream loads to stream reaches. The reach network was based on USEPA RF1 and the USGS Chesapeake Bay SPARROW model (Preston and Brakebill, 1999). Reaches with average annual discharge less than 100 ft^3/s (according to RF1) were not used, in order to reduce the total number of stream reaches to a manageable number). (A number of exceptions to this rule were made, for streams with load data or that were being monitored under MDE's TMDL program.) Reaches were split at USGS stream gaging stations that had at least 8 years of record for the period 1985-2000. This produced the final reach network for simulation. Watersheds representing land areas draining to each reach were then delineated based on analysis of DEM (Digital Elevation Model) data (Figure 1).

Compilation of stream discharge data
Both hourly (unit value) and mean daily stream discharge data were compiled for over 70 gages within the Potomac River basin (and over 230 in the entire Chesapeake Bay Watershed). These data were pulled from USGS ADAPS databases maintained in each Water Resources Division District office to populate new SQL Server databases.

Compilation of stream cross-section data
In order to route water and chemicals through individual stream reaches, HSPF uses simple convex routing that requires designation of the relations among stream cross-sectional area, depth, velocity and reach volume. These relations are provided in the form of F-tables that require (where available) measurements of stream cross-sections, velocities, and depths. This information is available for all sites gaged by the USGS in hard copy files. During the reporting period, the process of compiling this information was begun.

Plans for Next Quarter

1. Complete watershed-county segmentation work, including QA/QC, for the entire modeled domain (Chesapeake Bay Watershed and the remainder of the state of Virginia).

2. Compile all available precipitation data for the time period 1984-2001, and for the entire modeled region including a 25-km buffer outside of the modeled region.

3. Conduct weather-type analysis of existing precipitation data for stratification; perform x-y-z regression of stratified data to develop spatial interpolation relations for the entire modeled region.

4. Continue data compilation for F-tables; begin process of extrapolating existing information to ungaged reaches.

5. Explore use of PEST software for parameter estimation.

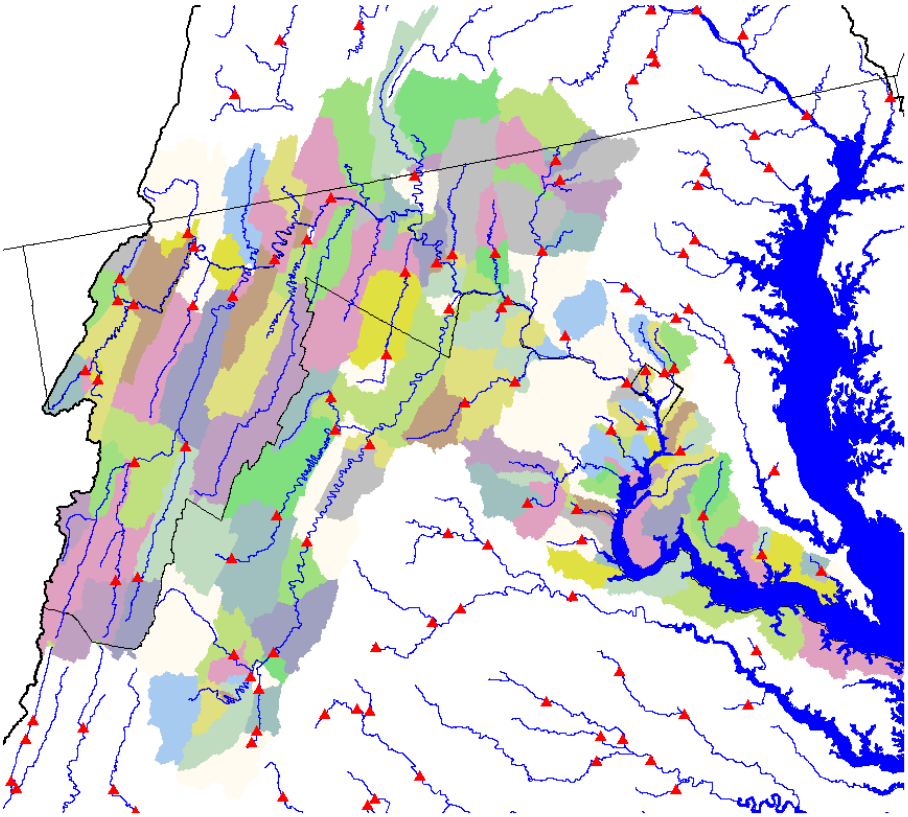

Figure 1 Model reach and watershed segmentation (without county breaks) for the Potomac River Basin.

References

Preston, S.D., and Brakebill, J.W., 1999, Application of spatially referenced regression modeling for the evaluation of total nitrogen loading in the Chesapeake Bay Watershed: U.S. Geological Survey Water-Resources Investigations Report 99-4054.