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Comparison of HSPF Outputs Using FTABLES Generated with Field Survey and Digital Data

The Center recently completed a study that examined two different approaches to developing inputs for a widely used watershed-scale water quality model, the Hydrological Simulation Program-FORTRAN (HSPF). The objective of the study was to evaluate what impact the method and level of data detail used to develop cross-section profiles for the model had on average daily flow rates predicted with HSPF. The study compared average daily flow rates predicted by HSPF using field data and digital data to generate cross-section profiles. Findings from this study suggest that cross-sections generated using digital data are a viable option when simulating stream discharge with HSPF and further that if field data are used to generate cross-section profiles, basing the cross-section on fewer observations will not adversely affect simulated discharge predictions.

When using HSPF, the modeler subdivides the stream network into smaller segments, called reaches. Function tables (FTABLES) represent the cross-sectional profiles for each of these reaches. An FTABLE holds multiple rows of data, each representing a different volume of water in the reach and relating that volume to other reach

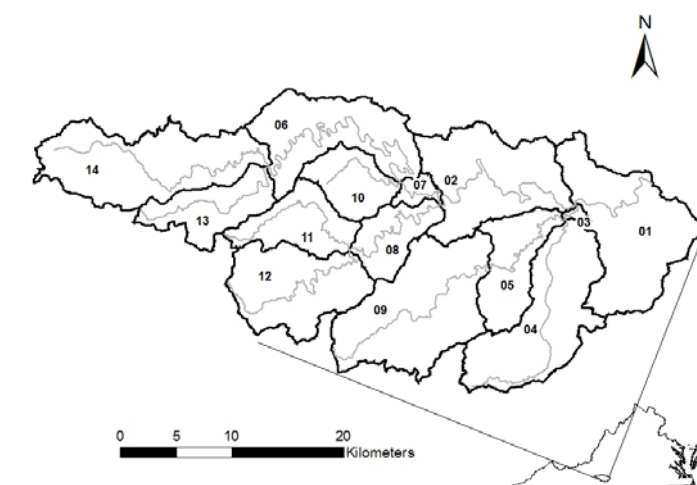


Figure 1: Pigg River watershed location in Virginia showing sub-watershed delineation and stream reaches used in HSPF simulation.

characteristics (typically discharge, stage, and surface area). The model uses the total volume of water in a reach to compute discharge, stage, and surface area by linear interpolation between entries provided in the FTABLE (Bicknell et al., 2000).

When developing FTABLES for use in HSPF, the modeler is presented with two basic options: use some manner of field data (e.g., cross-sectional profile surveys) or digital data (e.g., digital elevation models (DEMs)). The objective of this project was

to determine if the method used to develop FTABLES affected average daily discharge rates simulated by HSPF. Analysis compared simulated discharge rates using 'field-based' FTABLES (those generated using detailed cross-sectional surveys) and 'digital-based' FTABLES (those generated using DEMs and Natural Resource Conservation Service (NRCS) Regional Hydraulic Geometry Curves (NRCS, 2004)). This study looked for differences in average daily flow rates simulated using field-based and digital-based FTABLES.

Five FTABLE scenarios were compared using data collected from the Pigg River watershed located in southern Virginia (Figure 1). Four 'field-based' FTABLE scenarios were developed using from 1 to 4 detailed cross-section surveys collected at predefined intervals along stream reaches. A fifth 'digital-based' scenario was developed using DEMs and NRCS Regional Hydraulic Geometry Curves. The Smirnov k-sample test was used to compare average daily discharge rates simulated with HSPF using the five FTABLE scenarios. No significant difference in simulated stream discharge was found ($p=0.99$) between the five FTABLE scenarios. This result suggests that FTABLES generated using digital data

are a viable option when simulating stream discharge with HSPF, and that if field data are used to generate FTABLES, using fewer cross sections will not adversely affect simulated discharge predictions.

Further study is currently underway to determine the effect of FTABLE generation methods on HSPF predictions of bacteria concentrations. This follow-up study will compare minimum and maximum predicted flow rates as well as minimum, average, and maximum predicted bacteria concentrations using each of the FTABLE generation methods from the original study. The research will be completed this summer.

References:

- Bicknell, B. R., J. C. Imhoff, J. L. Kittle, Jr., T. H. Jobs, and A. S. Donigian, Jr. 2000. Hydrological Simulation Program-FORTRAN User's Manual for Release 12. Aqua Terra Consultants, Mountain View, CA.
- NRCS. 2004. Natural Resource Conservation Service National Water Management Center. Regional Hydraulic Geometry Curves. Available at <http://wmc.ar.nrcs.usda.gov/technical/HHSWR/Geomorphic/index.html>. Accessed on May 9, 2005.

TMDL Implementation-Characteristics of Successful Projects

This past May, the Center for TMDL and Watershed Studies completed a project entitled "TMDL Implementation-Characteristics of Successful Projects," funded by the U.S. Environmental Protection Agency (EPA). The goal of this project was to review TMDLs that have been or are being implemented and to identify factors that contribute to successful implementation. This was accomplished by reviewing seventeen on-going implementation efforts across the country and their associated TMDLs and implementation plans. Case studies of these watersheds were developed to identify the characteristics and approaches that facilitate implementation and water quality improvement.

The most common characteristics of successful watershed improvements in this study were (in order): adequate funding; government agency interest and involvement; stakeholder meetings during TMDL development; stakeholder interest and involvement;

the presence of a TMDL where the pollutant and needed reductions were systematically assessed and quantified; targeted implementation; staged implementation; and increasing awareness and/or educational activities. Each of these characteristics was possessed by more than half of the surveyed watersheds. The primary characteristics that hindered implementation success were lack of data and lack of funding.

Several watersheds contained particularly unique beneficial features. In Segment 15 of the South Platte River in Colorado, the 'Metro District,' a permitted discharger, funded many of the implementation efforts, conducted water quality studies, and produced watershed plans. In Swan Lake, Alaska, the local municipality embraced water quality improvement efforts with the establishment of lake clean-up days, which engaged many stakeholders in active clean-up of debris in watershed. In Nine Eagles Lake, Iowa, the department of natural re-

sources and the department of forestry worked together to reduce sources of sediment in the watershed. A watershed group in James River, Missouri, was the main force behind extensive nonpoint source BMP installation, despite a TMDL that focused primarily on the dominant point source polluter in the watershed. In Truckee River, Nevada, the river has been delisted for the pollutant for which a detailed, modeling-based TMDL was completed (nitrogen), while it is still listed for the pollutants for which a less-detailed 'bare bones' TMDL (term used by the Nevada Division of Environmental Protection) was developed.

Many lessons were learned from this project, the primary one being that one size implementation plan does not fit all watersheds. Further, stakeholder involvement is crucial along with a focused, relevant, achievable watershed plan. For more information on the project and the individual case studies please look at the final project report available at our website at <http://www.tmdl.bse.vt.edu/research/>.

Recent Center Meetings and Presentations

Opequon TMDL Implementation Plan Final Public Meeting. Review of the Opequon Creek TMDL Implementation Plan. May 10, 2006. Winchester, Va.

Big Otter TMDL Implementation Plan Agricultural Working Group Meeting. Best Management Practice Implementation Water Quality Modeling Updates and Overview of Livestock Fencing Best Management Practice Quantity and Estimation Procedures. March 14, 2006. Bedford, Va.

Big Otter TMDL Implementation Plan Residential/Government Working Group Meeting. Best Management Practice Implementation Water Quality Modeling Updates. March 14, 2006. Bedford, Va.

Presentation of Characterization of Successful Implementation project, TMDL Implementation, Lessons Learned. 2006 AWRA Summer Specialty Conference on Adaptive Management of Water Resources, June 26, 2006.

Presentation detailing the Center's activities and accomplishments at the 5th Natural Resource Extension Professionals Conference at Park City, Utah (May 2006).



Summary of 2005 and 2006 Center TMDLs

The Center for TMDL and Watershed Studies at Virginia Tech (the Center) continues to develop TMDLs for the state of Virginia. In 2005 and 2006, the Center developed TMDLs for four project areas with bacteria and/or general aquatic life use (benthic) impairments.

A bacteria TMDL was completed for the North River watershed, which is located in the Shenandoah Valley of Virginia within parts of Rockingham and Augusta Counties, encompassing the cities of Harrisonburg and Staunton. The Shenandoah Valley has a higher agricultural use than the rest of the Commonwealth, with many poultry and dairy operations. Water quality samples collected at three stations in the North River watershed during the 2004 assessment period violated the instantaneous water quality standard for bacteria 29, 33, and 37% of the time. The HSPF model was used to model hydrology and water quality. The hydrology component of the model was calibrated to one flow gage located midway through the model; the water quality portion of the model was calibrated to three monitoring stations located throughout the watershed. The HSPF model was then used to generate allocation scenarios for North River. The North River TMDL presented a unique problem in that 76% of its drainage area included 17 watersheds with previously developed TMDLs. In fact, output from the calibrated HSPF model predicted that an estimated 91% of the *E. coli* in the mean daily *E. coli* concentration at the watershed outlet currently comes from areas covered by a previously developed TMDL. These TMDLs were completed by several contractors to meet two different standards (due to a historical change in the standard), and used several different methods. Thus, using the existing modeling data added challenges to the process. In addition to the bacteria TMDL, a stressor analysis was completed for North River to change its impairment category. Analysis of the available data showed that, in similar fashion to the bacteria TMDL, most of the benthic stressors were coming from watersheds for which benthic TMDLs had already been completed. We put together a document that supported the reclassification of North River from category 5A, impaired and

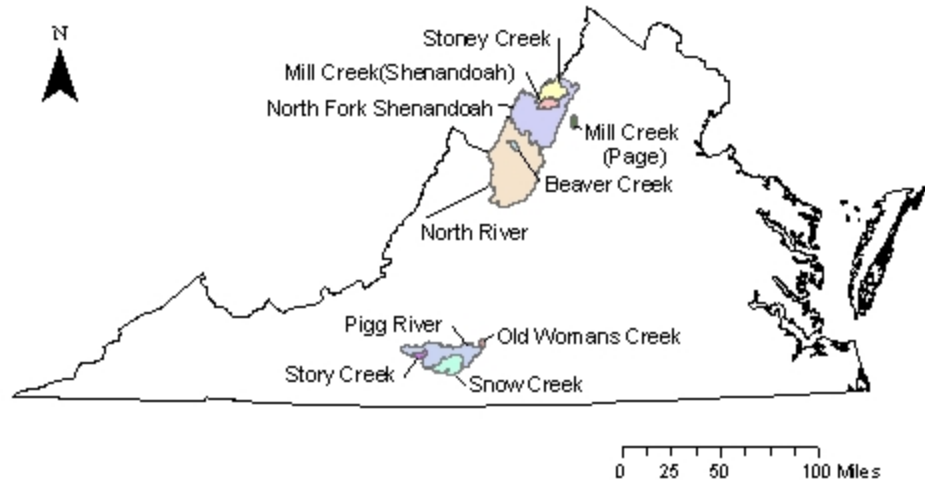


Figure 1: Location of each TMDL

requiring a TMDL, to category 4A, impaired but not needing a TMDL because a TMDL to address the pollution is already in place.

A sediment TMDL was completed for Mill Creek (Shenandoah County) to address a benthic impairment. The stressor analysis identified sediment as the most probable stressor, and the dominant sediment sources as trampled stream banks from livestock with stream access and associated bare riparian areas. Supplemental biological monitoring also identified the Crooked Run tributary as being impaired. Because of the proximity of the Crooked Run confluence with Mill Creek and the downstream station listed for the benthic impairment, sediment sources in Crooked Run appear to be the major contributor to the relatively minor Mill Creek impairment. In anticipation of the need for a TMDL to address a probable benthic impairment on Crooked Run, a sediment TMDL for Crooked Run was included in the Appendix of the Mill Creek TMDL. A concurrent bacteria TMDL for Mill Creek requires an increased level of livestock exclusion from streams that will directly affect the sediment loads from channel erosion in Mill Creek. A coordinated effort to restore the riparian vegetation in

conjunction with livestock exclusion from targeted stream sections should be a major step in remedying the benthic impairment in the Mill Creek watershed.

The previous examples provide a representation of the TMDLs the Center completed within Virginia over the last two years. A unique feature of this two-year cycle was the completion of three large-basin TMDLs: North River (described above), North Fork of the Shenandoah River, and Pigg River. Each of these included impaired tributary watersheds. We hope the inclusion of larger basins within a single TMDL in this fashion will allow for easier implementation of the TMDLs down the road. In addition to the TMDLs described earlier, the Center completed bacterial TMDLs for the North Fork of the Shenandoah River, including Stony Creek and Mill Creek; Beaver Creek, a tributary to North River; Pigg River, including Story Creek and Snow Creek; Old Womans Creek; and Mill Creek in Page County. Final reports can be obtained at the Virginia DEQ website at http://gisweb.deq.virginia.gov/tmdlapp/tmdl_draft_reports.cfm.

Recent Center Publications

Benham, B.L., M.K. Laird, B.B. Ross, D.H. Vaughan, and D.R. Peek. 2006. Surface quality impacts of conservation tillage practices on burley tobacco production systems in southwest Virginia. *Water, Air, and Soil Pollut.* (accepted).

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Benham, B.L. 2006. The Center for TMDL and Watershed Studies: creating resources and tools for watershed management. *J. of Extension.* (accepted).

Benham, B.L., K.M. Brannan, G.R. Yagow, R.W. Zeckoski, T.A. Dillaha, S. Mostaghimi, and J.W. Wynn. 2005. Development of bacteria and benthic TMDLs: a case study, Linville Creek, Virginia. *J. Environ. Qual.* 34:1860-1872.

Benham, B.L., J.H. Cunningham, K.M. Brannan, S. Mostaghimi, T.A. Dillaha, J. Pease and E.P. Smith. 2005. Development of survey-like assessment tools to assess agricultural best Management practice performance potential. *J. Soil and Water Conserv.* 60(5): 251-259.

Mishra, A., B.L. Benham, and S. Mostaghimi. 2006. Sediment and nutrient transport from agricultural lands fertilized with animal manures. *Water Air Soil Pollut.* (accepted).

Staley, N.A., T. Bright, R.W. Zeckoski, B.L. Benham, K.M. Brannan. 2006. Comparison of HSPF outputs using FTABLES generated with field survey and digital data. *J. Amer. Water Res. Assoc.* (in press).

Wagner, R., T. Dillaha, and G. Yagow. 2006. An Assessment of the Reference Watershed Approach for TMDLs with Biological Impairments. *J. Water, Air, and Soil Pollution* (accepted).

Yagow, G., B. Wilson, P. Srivastava, and C. Obropta. 2006. Application of biological indicators in TMDL assessment and implementation. Transactions ASAE, s1004 TMDL Collection, accepted.

Zeckoski, R.W., B.L. Benham, S.B. Shah, M.L. Wolfe, K.M. Brannan, M. Al-Smadi, T.A. Dillaha, S. Mostaghimi, and C.D. Heatwole. 2005. BSLC: a tool for bacteria source characterization for watershed management. *Applied Eng. Agric.* 21(5): 879-889.



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The Center's mission is to conduct interdisciplinary research, teaching, and outreach to improve the integrity of the Nation's waters and watersheds by advancing the science, tools, and expertise available for developing, evaluating, and implementing watershed planning and management processes.