Texas A & M University and U.S. Bureau of Reclamation

Hydrologic Modeling Inventory
Model Description Form
July 18, 2007

Name of Model:
Hydrological Simulation Program FORTRAN (HSPF)

Model Type:
Continuous simulation watershed model. HSPF simulates hydrologic and water quality processes in natural and man-made water systems.

Model Objective(s):
HSPF is a process-based watershed model for quantifying runoff and addressing water quality impairments associated with combined point and nonpoint sources. HSPF simulates nonpoint source runoff and pollutant loadings for a watershed and performs flow and water quality routing in stream reaches. HSPF can be used to estimate nonpoint source loads from various land uses as well as fate and transport processes in streams and lakes.

Agency and Office:
Joint sponsorship of both the U.S. Environmental Protection Agency and the U.S. Geological Survey

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Model Structure or Mathematical Basis:
HSPF contains hundreds of process algorithms developed from theory, laboratory experiments, and empirical relations from instrumented watersheds. The model consists of a set of modules arranged in an organized structure, which permit the continuous simulation of a comprehensive range of hydrologic and water quality processes. HSPF's design incorporates a hierarchy of program subroutines, each of which performs a major task during the program's execution. The subroutines are grouped into different levels of operations in a hierarchical structure. The importance of this program structure lies in its modular design. This allows for the addition and/or replacement of individual modules and allows HSPF to be easily adapted for special applications designed by the user.

Model Parameters:
Successful application of HSPF requires modelers to evaluate parameters for selected

process-based algorithms. A complete description of the model parameters is included in the user's manual.

Spatial Scale Employed in the Model:
HSPF has been applied to watersheds ranging in size from the Chesapeake Bay, with roughly 62,000 square miles of tributary area, down to a few acres.

Temporal Scale Employed in the Model:
HSPF can simulate any period from a few minutes to hundreds of years. Typically the model is run for a time span ranging from 10-20 years, on an hourly time step.

Input Data Requirements:
HSPF is designed so that it can be applied to most watersheds using existing meteorologic and hydrologic data; soils and topographic information; and land use, drainage, and system (physical and man-made) characteristics. Typical input time-series records include precipitation, potential evapotranspiration (and other meteorologic data), waste discharges, and calibration data such as streamflow and constituent concentrations. Physical measurements and related parameters are required to describe the land area, channels, and reservoirs.

Computer Requirements:
Since the underlying code is written almost entirely in ANSI standard Fortran, implementation on a variety of computers and Fortran compilers is possible. HSPF is commonly run on Windows and Unix/Linux operating systems.

Model Output:
HSPF uses such information as the time history of rainfall, temperature, evaporation, and parameters related to land use patterns, soil characteristics, and agricultural practices to simulate the processes that occur in a watershed. The initial result of an HSPF simulation is a time history of the quantity and quality of water transported over the land surface and through various soil zones down to the groundwater aquifers. Runoff flow rate, sediment loads, nutrients, pesticides, toxic chemicals, and other quality constituent concentrations can be predicted. The model uses these results and stream channel information to simulate instream processes. From this HSPF produces a time history of water quantity and quality at any point in the watershed.

Parameter Estimation / Model Calibration:
An interactive version of HSPF, known as the Expert System for Calibration of HSPF, or HSPEXP, was developed by the USGS in the early 1990's (http://water.usgs.gov/software/hspexp.html). This program provides the user with expert advice for HSPF hydrology calibration, suggesting which parameters should be changed up or down to improve the calibration based on computed error statistics.

HSPFParm, a database of HSPF parameter values from applications across North America, is available as a source of model parameter values that can provide a starting point for developing new watershed applications. HSPFParm is available from http://www.epa.gov/waterscience/ftp/basins/HSPFParm/.

The parameter optimization program PEST may be accessed to assist in the estimation of HSPF parameters. PEST is a very powerful and complex tool that can be effective in model parameter estimation and calibration when the user has detailed knowledge of both HSPF and PEST. However, users should be aware that physically unrealistic parameter values can be produced by PEST if parameter ranges are not properly constrained for local conditions. See http://www.epa.gov/ceampubl/tools/pest/ for more details.

Model Testing and Verification:
The integrity of HSPF is assured by careful attention to version control and model maintenance. Software maintenance of HSPF, almost all of which has been performed by AQUA TERRA Consultants, have included maintaining a list of software errors, correcting errors, implementing enhancements, adapting the code to new computer environments (hardware and operating system), testing, and providing new versions to EPA and USGS for distribution to users. At the same time a continual flow of academic contributions have assured that HSPF maintained a strong scientific basis.

Model Sensitivity:
Model sensitivity for HSPF needs to be assessed for each model application because parameter sensitivity is a function of local watershed, i.e. climatic, edaphic, topographic, vegetation, etc. conditions. The primary forcing functions of precipitation and evapotranspiration are key input timeseries in most all applications, but for watersheds in northern climates with significant snowfall will also be sensitive to other climate variables such as air temperature and solar radiation. Water quality sensitivity is dependent on the specific model options selected by the user, in addition to driving hydrology and sediment simulation along with local pollutant sources represented in the model application. All of these issues re-enforce the need to perform sensitivity analyses for each model application, a truism for essentially all watershed models.

Model Reliability:
HSPF is commonly recognized as the most complete and defensible process-based watershed model for quantifying runoff and addressing water quality impairments associated with combined point and nonpoint sources. Since its initial development nearly twenty years ago, the HSPF model has been applied throughout North America and numerous countries and climatic regimes around the world; it enjoys the joint sponsorship of both the U.S. Environmental Protection Agency and the U.S. Geological Survey, and continues to undergo refinement and enhancement of its component simulation capabilities along with user support and code maintenance activities.

Model Application / Case Studies:
There have been many hundreds of applications of HSPF all over the world. To encourage the informed use of HSPF, AQUA TERRA Consultants collects, and periodically updates, an HSPF bibliography that includes useful references related to both model development and applications. See http://www.aquaterra.com/hspfbib.html for the current HSPF bibliography.

Documentation:

Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr., T.H. Jobes, and A.S. Donigian, Jr. 2005. Hydrological Simulation Program - Fortran (HSPF). User's Manual for Release 12.2. U.S. EPA National Exposure Research Laboratory, Athens, GA, in cooperation with U.S. Geological Survey, Water Resources Division, Reston, VA.

Other Comments:

HSPF is currently released as a core watershed model of the BASINS environmental analysis system, developed by the U.S. Environmental Protection Agency's (EPA's) Office of Water. See http://www.epa.gov/waterscience/basins/ for more details on BASINS.

AQUA TERRA Consultants provides workshops to support the use of HSPF through BASINS. See http://www.epa.gov/waterscience/basins/training.htm for information about upcoming BASINS/HSPF workshops. In addition, a BASINS/HSPF Bibliography of related reports and journal articles is maintained and available on the AQUA TERRA Consultants web site, http://www.aquaterra.com/.