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Hydrologic Engineering Center

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# **Hydrologic Modeling System HEC-HMS**

## ***Release Notes***

Version 3.1.0  
November 2006



## Introduction

Version 3.0.1 of the Hydrologic Modeling System (HEC-HMS) was completed in April 2006 and released for general use shortly thereafter. Several new simulation features have been added to the program since that time. These include a new reservoir routing method, control gates for reservoir spillways, a new loss and a new baseflow method for the subbasin, two channel loss methods for the reach, and two new methods for the diversion. Other minor enhancements were also added. The development team has also continued careful and systematic testing of the program since the last release. The results of that testing in combination with reports from users has allowed the identification and repair of various problems. Some of these affected simulation results and are described in detail later in this document. Some problems that did not affect results but caused problems in the program interface have been repaired without being specifically documented. The result is this Version 3.1.0 release. It is currently available for the Microsoft Windows® operating system and will soon also be available for the Sun Microsystems Solaris™ operating system.

The program has been designed to be easy to use. However, an understanding of how the program works is critical to producing accurate results. It is suggested that a new user read the *Quick Start Guide* (Version 3.1.0 November 2006). The guide briefly describes the basic features of the program in enough detail to begin using it. The guide also includes a step-by-step tutorial.

## Installation

The installation program and all documentation are available on the HEC website at <http://www.hec.usace.army.mil/>. This new release is installed independently of any previous versions of the program so you will need to remove Version 3.0.1 if you do not want to use it anymore. However, you may keep different versions of the program installed for parallel use or testing if you choose to do so. This new version will automatically open projects developed with any previous version of the program. However, once a project has been opened in Version 3.1.0, it may not be possible to open it with older versions of the program.

The new installation package is designed to be easy to use. It will take you through the steps of selecting a directory for the program files and making other settings. Use the following steps to install the program on the Microsoft Windows® operating system:

1. Download the installation package from the HEC website to a temporary folder on the computer. If the software was provided to you on a CD-ROM or other media, insert it in the appropriate drive.
2. Run the installation program. In Windows Explorer, double-click the icon for the installation program. You must have administrator privileges to run the installer.
3. Follow the on-screen prompts to install the program.

Instructions for installing the program on the Sun Microsystems Solaris™ operating system can be found in Chapter 2 of the User's Manual.

## New Capabilities

The reservoir element can simulate storage and routing affects using the outflow curve or outflow structures methods. A new routing method called specified outflow has been added. This method uses a time-series of releases to specify the outflow from the reservoir. The releases must be specified as a discharge gage in the time-series manager before being used at a reservoir. The outflows specified in the time-series record become the outflow for the reservoir, and then the inflow and the storage curve are used to track the amount of storage. Optional parameters can be used to set up warnings when outflow or storage levels are reached.

Specific structures can be specified for the reservoir element when the outflow structures routing method is used. One of the structure types is the spillway, which can use either the broad crested or ogee method. Control gates have now been added to both spillway methods. Up to 10 gate controls can be used on a spillway. Each gate control specifies either a radial or sluice gate along with the physical properties of the gate. A parameter for the number of identical gates can be used to simplify data entry. In addition to physical properties, each gate has a control method to specify how it operates during a simulation. Currently, the only control is a fixed opening. Future versions of the program will include additional control options.

Specific structures can be specified for the reservoir element when the outflow structures routing method is used. One of the structure types is the outlet, which can use either the orifice or culvert method. A new parameter has been added to the orifice for the number of identical barrels. This is useful when the reservoir has several orifice outlets all with the same cross sectional area, center elevation, and discharge coefficient.

Additional time-series results are now available for reservoirs using the outflow structures routing method. Previously only the composite outflow from the reservoir was available. Now the outflow through each structure in the reservoir can also be viewed. The individual outflow time-series data are available with the other reservoir results on the "Results" tab of the *Watershed Explorer*.

A new loss method using the Smith Parlange procedure has been added to the subbasin element. Smith Parlange is similar to the Green Ampt method but uses a different representation of the wetting front moving down through the soil. All of the parameters can be estimated directly from measured soil properties. Optionally, observed temperature can be used to adjust infiltration for high-temperature environments.

A new baseflow method called nonlinear Boussinesq has been added. It is similar to the recession method except that parameters can be estimated from field measurements such as drainable porosity, effective conductivity, and typical flow length.

All of the seven element types in the basin model can optionally compute stage by using an elevation-discharge (rating) curve. The user must specify the curve in the paired data manager before it can be used at an element. The curve is used by first computing outflow from the element, then computing stage from the rating curve. The routing reach can now compute stage from the simulated flow depth if the modified Puls or Muskingum-Cunge routing methods are used. The modified Puls method computes stage using an invert elevation and an elevation-discharge curve. The Muskingum-Cunge method computes stage using an

invert elevation and the internally computed flow depth. The additional results are shown under the reach element on the "Results" tab of the *Watershed Explorer*.

Reach elements take inflow and compute outflow using a routing method. A variety of routing methods are available for different circumstances and data requirements. A loss/gain method has been added to the reach to account for losses or additions during the routing process. Initially two methods are provided that can only account for losses, but future methods will also be able to account for gaining streams. The constant loss/gain method allows a fixed flow rate to be subtracted from the routed flow; the remaining flow is multiplied by a ratio. The flow rate, ratio, or both can be used to control the properties of the channel loss. The percolation method only applies to the modified Puls and Muskingum-Cunge methods. It computes the submerged area in plan view and then multiplies by a percolation rate. Both methods use an optimization algorithm to solve for the routed flow, accounting for losses removed along the reach length.

The diversion element in previous versions computed diverted flow using an inflow-diversion function specified by the user. The function specifies the amount of flow to divert as the inflow to the element changes. Two new methods are now available. The lateral weir method uses the broad-crested spillway assumptions to compute diverted flow based on the properties of the weir and the flow depth at the element. The pump station method uses a head-discharge pump to similarly compute the diverted flow. Both new methods use an optimization algorithm to solve for the diverted flow, recognizing that removing flow from the diversion element reduces the flow depth at the diversion.

The gridded soil moisture accounting loss method computes infiltration separately for each grid cell in a subbasin. Previous versions provided only the subbasin excess precipitation, as compared to the soil moisture accounting loss method which provided 16 different time-series of various results. Subbasin-average results are now similarly provided for the gridded soil moisture accounting loss method. The results are computed as the area-weighted average results for the grid cells in the subbasin.

The "Results" tab of the *Watershed Explorer* shows the time-series that are available for each hydrologic element. One or more results can be selected for preview and then opened in a graph or time-series table. It is now possible to add additional results to a graph or time-series table that is already open. To do so, place the mouse over the result you wish to add. Hold the mouse button and drag the mouse until it is over the graph or table, then release the mouse button. The graph or time-series table will redraw with the additional result shown along with the previous results.

Additional results are now available for a depth-area analysis. Previously the results were limited to a summary table showing the peak flow at each analysis point. The results for each element above an analysis point are now available from the "Results" tab on the *Watershed Explorer*. The results available at each element are the same as for elements in a simulation run. You will find a folder for each analysis point under the analysis name. Within each analysis point folder you will find the elements upstream of that point, with their individual summary tables and time-series results. Depth-area analysis results can be mixed with simulation run and optimization trial results in preview graphs, graphs, and time-series tables.

## Changes in Operation

Previous versions of the program allowed up to 30 characters for named components. For example, basin models, hydrologic elements, simulation runs, and other components could all have a name up to 30 characters long. It was found that this could cause a problem with storing and retrieving some types of simulation results. It was necessary to reduce the number of allowed characters to 28 in order for the results system to work correctly. Existing data sets with names longer than 28 characters will have their names automatically truncated. This will cause problems if two hydrologic elements have exactly the same name except for the final two characters. Data files will need to be updated manually in those very rare cases.

The program continuously tracks changes to the project components along with the date each simulation was last computed. This information is used to determine if results need to be computed before graphs, summary tables, and time-series tables can be viewed. Previous versions of the program always computed all components when a simulation run was computed, even if only one or two elements had data changes. Beginning with this version, only the components that have changed, along with any downstream components, will be processed during a compute. This will reduce the amount of time required to perform a compute, especially in large models. You may force all components to be recomputed by holding the *control* key when beginning a compute. For example, hold the *control* key when clicking the compute button on the toolbar to force all elements to be computed during a simulation run.

Some simulations require large amounts of computer memory. For example, a basin model with 25 subbasins using continuous simulation for a multi-decade time window could require more than 1 GB of memory to complete successfully. A new memory management option has been added in the program settings to allow large simulations to complete when less memory is available. Using the option will cause the simulation to proceed slower since data is retrieved from the hard disk instead of caching it in memory. However, using the memory option will allow very large simulations to complete in as little as 256 MB of memory. The option is called "Optimize for minimum memory usage" and can be found in the program settings. You may contact the Hydrologic Engineering Center for assistance estimating memory requirements or configuring the program to use large memory allocations.

Changes in project components are continuously tracked in combination with the last time a simulation was computed. This information is used to determine if results should be available or if a particular component needs to be recomputed. However, this mechanism does not check to see if results can actually be retrieved from the project DSS file. This saves much time and only causes problems if results have been manually deleted from the DSS file. If you routinely make manual modifications to the DSS file, you should turn on the new "Verify data existence during results availability check" option in the program settings. This option slows down data visualization, but makes sure that results are recomputed if they have been deleted from the DSS file.

Previous versions of the program only allowed a project name to be used once. If two different versions of a project were stored in different directories, they could not be easily accessed since they had the same name. This restriction has been relaxed. Multiple projects with the same name can now be used as long as they are stored in different directories.

## Problems Repaired

Specific structures can be specified for the reservoir element when the outflow structures routing method is used. One of the structure types is the spillway, which can use either the broad crested or ogee method. The ogee method represents a spillway curved approximately in the shape of a letter "S". The exact shape of the curve is designed based on the so-called design head. This is simply the effective flow depth over the spillway crest at the design discharge. Adjustments are made in the discharge coefficients when the flow depth is not equal to the design head. Previously the program made an abrupt change in how the coefficients were calculated, using the criteria of effective head equal to 1.3 times the design head. For flows below the criteria, coefficients were calculated using experimental data. For flows above the criteria, coefficients were calculated using the normal depth assumption. This led to discontinuities in spillway flow that were not realistic. The procedure has been changed to remove the criteria and always calculate coefficients based on experimental results. This leads to smooth changes in the discharge over the spillway as flow increases.

The kinematic wave routing method uses an explicit step solution algorithm. This mathematical approach represents the reach with a collection of equally spaced nodes. The underlying differential equations are solved at the nodes to simulate the movement of flow through the reach. The solution requires the initial flow at each node and the inflow at the upstream node for each time step of the simulation. Testing discovered that the inflow at the upstream node was not being used correctly, resulting in errors of up to 5% in the routed peak flow. This problem has been repaired.

The monthly average evapotranspiration method in the meteorologic model allows the specification of a uniform rate for each month. Every time interval within the month has the same rate. A problem was found with the last time interval in a month. For only the last interval, the rate for the following month was incorrectly used. The problem has been fixed so that every time interval in a month uses the correct rate.

A problem was fixed with the liquid water calculation in the temperature index snowmelt method. The liquid water capacity serves as a threshold for the arrival of melted snow at the soil surface. The amount of liquid water the snowpack can hold is controlled indirectly by specifying the liquid water capacity as a percentage of snow water equivalent (SWE). For each time step, the amount of SWE is multiplied by the specified percentage to determine the capacity of the snowpack to hold liquid water. The calculated amount of liquid water must accumulate before melted snow can begin reaching the soil surface. The problem occurred when the amount of SWE was decreasing as the snowpack melted. In this case, the amount of liquid water that can be held in the snowpack is also decreasing in time. When the liquid water capacity decreases, any water in excess of the new, lower capacity should leave the snowpack as liquid water at the soil surface. This was not happening; instead the liquid water was returned to the snowpack as SWE. This has now been corrected.

The soil moisture accounting loss method includes a soil layer that is divided into an upper (gravity) zone and a lower (tension) zone. Actual evapotranspiration is calculated differently when the current soil storage is within the upper zone as compared to the lower zone. A problem was found where the actual evapotranspiration was not calculated correctly during consecutive time steps of the soil storage being in the lower zone and no precipitation occurring. The actual evapotranspiration was accumulating instead of incrementing from one

time interval to the next. The reported evapotranspiration from the soil layer is now correct under all conditions.

The Green and Ampt loss method uses a time to ponding for computing the length of time necessary for precipitation to sufficiently saturate the soil so that surface runoff begins. While computing the time to ponding for uniform precipitation is straight forward, complex rainfall patterns greatly complicate the calculations. In some cases, surface ponding may occur under a steady supply of precipitation, but if the precipitation rate decreases the ponding condition cannot be maintained. An error was found and fixed that affected infiltration calculations only in the time interval when the ponding condition was lost; all other calculations were found to be correct.

The piping dam break option in the reservoir element represents a break using a small rectangular opening in the dam face that grows. Flow through the opening is assumed to be well-represented as pressure flow. However, if the submergence on the piping opening is not sufficient for pressure flow to prevail, then it automatically converts to a free surface break similar to the overtop break option. A simulation run would fail to compute successfully if the conversion from pressure flow to free surface flow happened during the very last time interval in the development duration. The simulation run would complete successfully if the conversion happened earlier in the development duration. Corrections to the conversion calculations have been made so that it happens successfully no matter when the conversion happens in the development duration.

## Future Plans

Land surface erosion and channel sediment transport is under development. Initially two simple methods will be provided for simulating land surface erosion as part of subbasin calculations. Eventually more complex methods will be added to the subbasin. A simplified channel transport capability will be added to reach elements. It will handle erosion and deposition within the channel in addition to transport down the channel, all in a simplified approach appropriate for hydrologic simulation. It is not anticipated to include a movable bed.

Several features will be added to the reservoir element. A method for simulating evaporation from the pool will be added. Percolation from the bottom of the pool will be provided along with percolation through the dam. The percolation from the dam will consider both the tailwater and pool surface elevation to determine the direction of water movement. Finally, two new spillway methods will be added: a user-specified elevation-discharge curve, and a specified release using a discharge gage.

New statistical summaries will be developed that are better suited to analyzing continuous simulation results. Currently all summary statistics are for the entire simulation time window. For example, peak flow and total discharge volume are computed for the entire simulation time window. The new summaries will provide peak flow volumes over durations ranging from 1 hour to 90 days. Summaries will also be developed for evaluating the flow statistics in relation to a flow target, permitting measurement of performance compared to environmental requirements. Finally, summaries will be added for evaluating model performance on a monthly basis.

The optimization capabilities for parameter estimation will be expanded. A search method is under investigation that will be better able to find optimal



parameter estimates in difficult circumstances. Also, new objective functions will be added that are better suited to calibrating continuous simulation methods.

Several features for the basin map are already under development. A stream alignment will be added for specifying the location and stationing of streams. Using it will be optional, but it will facilitate laying out reach elements and integrating with other HEC software. Tools will also be added for controlling the drawing properties of background maps. Also, display of gridded input (such as precipitation) and gridded parameters (such as SCS curve numbers) will be added to the map. Finally tools will be added to make it easier to organize large basin models, both for entering data and reviewing output results.

Results visualization will also be improved. Drawing properties for graphs will be customizable. Access to the line styles, background patterns, axis scales, titles, and other components of a graph will all be customizable.

## Documentation

The *Hydrologic Modeling System HEC-HMS: Quick Start Guide* (Version 3.1.0 November 2006) provides a brief description of the program for new users. It describes the different parts of the interface and the basic steps necessary to obtain simulation results. A tutorial takes the user through the creation of a new project and shows how to obtain results. The guide has been updated to reflect changes in the interface.

The *Hydrologic Modeling System HEC-HMS: User's Manual* (Version 3.1.0 November 2006) contains extensive information on installing and using the program. Details on the use of each of the features and capabilities in the program are included. The manual has been updated with information describing new features added to the program for this Version 3.1.0 release. Most of the updates are confined to Chapter 6 on basin models.

The *Hydrologic Modeling System HEC-HMS: Technical Reference Manual* (March 2000) continues to accurately describe the mathematical models included in the program. New simulation capabilities have been added to the program and are not included in the manual. The manual is currently undergoing a major revision to expand documentation of existing mathematical models and fully describe the newly added models.

The *Hydrologic Modeling System HEC-HMS: Applications Guide* (December 2002) also continues to accurately describe how to apply the program to various engineering problems. However, the guide is undergoing revision to add guidance on how to use new features of the program to more efficiently solve problems.

## Support Policy

Technical support for program users within the Corps of Engineers is provided through an annual subscription service. Subscribing offices can expect full support from HEC staff in the routine application of the program. Users are strongly urged to consult with HEC staff on the technical feasibility of using the program before beginning a project with unique requirements such as grid cell hydrology, snow melt, or continuous simulation. Extended support for large or complex projects can be arranged under a separate reimbursable project agreement.

Support can not be provided to users outside the Corps of Engineers. Domestic and foreign vendors are available that provide fee-for-service support similar to the support provided to subscribing Corps offices. Such service agreements are between the user and the vendor and do not include HEC staff. Vendors do contact HEC on behalf of their users when unusual problems or errors are encountered. A list of vendors can be found at <http://www.hec.usace.army.mil/>.

Reporting of suspected program errors is unrestricted and we will reply to all correspondence concerning such errors. We are continuously working to improve the program and possible bugs should always be reported. Reports should include a written description of the steps that lead to the problem and the effects that result from it. If we cannot reproduce the reported problem, we may ask you to send a copy of your project.

Request support or report program errors through the following channels:

- Call 530.756.1104, 7:30 am to 4:30 pm PT Monday through Friday.
- Fax 530.756.8250 any time.
- Write to U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, 609 Second Street, Davis, CA 95616 USA.
- Send email to [hec.hms@usace.army.mil](mailto:hec.hms@usace.army.mil) on the internet.
- Visit our web site at <http://www.hec.usace.army.mil>.