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Hydrologic Engineering Center

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# **Hydrologic Modeling System HEC-HMS**

## ***Release Notes***

Version 4.0  
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## Hydrologic Modeling System HEC-HMS, Release Notes

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## Introduction

Version 3.5 of the Hydrologic Modeling System (HEC-HMS) was completed in August 2010 and released for general use shortly thereafter. The basin model has been enhanced with zones to facilitate data entry for large watershed models, and calibration aids that provide a dynamic, visual calibration process. A new simulation component designed for producing flow forecasts has also been added to the program. With this version, the program also adds major new simulation components for surface erosion, sediment transport, and nutrient water quality. 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 have 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 4.0 release. It is currently available for the Microsoft Windows® operating system, the Oracle Solaris™ operating system, and also the Linux® 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 4.0 May 2013). 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 3.5 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 4.0, 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 Oracle Solaris™ operating system and the Linux® operating system can be found in Chapter 2 of the User's Manual.

## **New Capabilities**

A number of new capabilities have been added to the program. Complete descriptions are given below.

### **Basin Map**

The hydrologic elements in a basin model have always been displayed using icons. Reach elements have been represented with a straight line from the upstream point of the reach to the downstream point of the reach. Subbasin elements have been represented with an icon usually located at the centroid of the subbasin. Reservoir elements have been represented with an icon most often located at the outlet of the reservoir. A static background map can be added to the basin model to provide additional visual cues to the location of subbasin outlines and reach channels. There is now an option to represent the elements with a higher level of spatial precision. A subbasin can be represented with a polygon that shows the subbasin outline. A reach can be represented with a polyline that shows the reach channel. A reservoir can be represented with a polygon that shows the lake outline. The spatial data must be stored in the Shape File format, and coordinated with the basin model. You can find more information in the User's Manual on page 110.

### **Basin Model Zones**

Basin model zones are designed to facilitate stream flow forecasting. One or more zone configurations can be created in a basin model. Each zone configuration includes one or more zones, and each subbasin is assigned to one of the zones. Zone configurations have some use in the basin model where they can be used in the global editors and global summary table. The primary use for zone configurations is in the new forecast alternative where they facilitate parameter adjustments to the subbasins in each zone. You can find more information in the User's Manual on page 128.

### **Calibration Aids**

Calibration aids are associated with computation points and designed to improve the manual calibration process. Any element in a basin model can be designated a computation point by using the Computation Point Manager. The Manager also allows you to select parameters upstream of each selected computation point and set the calibration range for each parameter. The parameter properties are used to create a custom editor with a slider bar for each parameter. Custom graphs can also be configured at each computation point with time-series results selected from the upstream elements. The current simulation run is automatically recomputed after each adjustment of a slider bar and the result graphs show the updated results. You can find more information in the User's Manual on page 139.

### **Shortwave Radiation**

Shortwave radiation in the context of hydrology refers to energy from the sun that arrives at the land surface. Shortwave radiation is usually the dominate energy source for evapotranspiration and snowmelt. A shortwave radiation method has been added to the meteorologic model, with several available methods for representing the energy flux. This new component will allow for better representation of solar radiation in present modeling components and

components planned for the future. You can find more information in the User's Manual on page 238.

### **Specified Evapotranspiration**

The specified evapotranspiration method within the meteorologic model provides a new option for setting the potential evapotranspiration rate for subbasin canopy and loss rate components. The values for use in the method may be specified manually or computed by an external model. The data values are stored in a time-series gage, and one gage may be selected for each subbasin. You can find more information in the User's Manual on page 259.

### **Forecast Alternatives**

A new compute component has been created to join the current simulation run, optimization trial, and depth-area analysis. The new forecast alternative includes features specifically designed to streamline the process of producing a flow forecast. Each forecast alternative is composed of a basin model and meteorologic model along with a start time, forecast time, and end time. The alternative works by starting from the parameter data in the basin model, and then allowing the user to specify adjustments to those parameters. The adjustments are specified with the help of a zone configuration, which reduces the tediousness of setting adjustments separately for each element. You can find more information in the User's Manual on page 323.

### **Erosion and Sediment Transport**

It is now possible to evaluate erosion and sediment transport within the watershed. Subbasin elements optionally have an erosion method, with choices for agricultural and urban environments. Reach elements include erosion and settling of sediment, with transport of the mass that exceeds the transport capacity. Reservoir elements include settling of sediment and transport of the mass that remains suspended in the water column. Sediment features are also found in the source and diversion elements. The comprehensive approach permits evaluation of erosion and sediment effects throughout the watershed. The results of the analysis can also be used as upstream and lateral inflow boundary conditions to an HEC-RAS model in order to evaluate complex hydraulic and sedimentation problems. You can find more information in the User's Manual on page 363.

### **Nutrient Water Quality**

It is now possible to perform simple evaluations of nutrient water quality within the channel network. Nitrogen and phosphorus constituents are evaluated along with dissolved oxygen, biological oxygen demand (BOD) and algae. The reach and reservoir elements include detailed representation of the physical and chemical kinetics of the reactions, plus transport of the constituents suspended in the water column. The other elements have basic capability to introduce the boundary conditions and move the constituents between reaches and reservoirs. You can find more information in the User's Manual on page 391.

## Changes in Operation

A number of existing capabilities in the program have changed. Complete descriptions are given below.

### Frequency Precipitation

The primary parameter data in the frequency precipitation method is the depth-duration data. Previous program versions used the same depth-duration data for all subbasins. There is now an option to have separate depth-duration data for each subbasin. When this option is used, default data may be entered for all subbasins, and then overridden at one or more subbasins where a different depth-duration relationship is needed.

### Optimization Trial

Previously the optimization trial was based on a simulation run. The trial is now based directly on a basin model and meteorologic model. The start time and end time of the trial are specified as part of the trial properties.

### Temperature Index Snowmelt

The wet melt rain limit parameter is used to determine when to apply the wet melt rate to the snowpack. The precipitation rate must exceed the wet melt rain limit before the wet melt rate will be applied. The wet melt rain limit is specified with units of mm/day or in/day, depending on the unit system. It was found that during a simulation the value of the wet melt rain limit was used as if it were specified in mm/hr or in/hr. The effect of this error was that a physically reasonable estimate of the wet melt rain limit would result in no wet melt time periods during the simulation. The interpretation of the units of the parameter has been corrected in the internal simulation calculations.

Previously there was no check performed on the ATI-coldrate function. Consequently if no paired data table were selected, then the simulation would proceed without warning and a default value of the coldrate would be used. The default value was significantly different than the values found to prevail in most watersheds. The default value resulted in a significantly colder snowpack which caused a major delay in the onset of snowpack melting once the temperature rose above freezing. The ATI-coldrate function is now checked when all the other parameters in the temperature index snowmelt method are checked, and a warning message is issued when no function is selected. The default value for use when no ATI-coldrate function is specified is typical of many watersheds.

### Priestley Taylor Evapotranspiration

Previously the radiation input for the Priestley Taylor method was specified as a time-series gage. The gridded version of the method specified the radiation with a grid selection. In both cases the specification included the net radiation across all wavelengths including shortwave and longwave. The Priestley Taylor method now uses the radiation computed by the shortwave radiation method in the meteorologic model. A shortwave radiation method should be selected and configured to provide the net radiation required by the Priestley Taylor approach; the best choice at present is the "specified pyranograph" method with a defined time-series of net radiation.

## **Global Editors**

Previously the global editors could be used only for viewing and editing data in the subbasin and reach basin model elements. The global editors can now be printed. This allows a quick method for documenting the parameter values used in subbasin and reach elements.

## **File Names**

Previously it was not possible to use file names that included a dash character. This restriction applied to HEC-DSS files and map files. This restriction is no longer necessary and the restriction has been relaxed. It is now possible to use files where the file name includes a dash character.

## **Non-Level Dam Top**

The non-level dam top option can be used to represent the flow of water over the top of the dam. The physical properties of the dam top are represented with an eight-point cross section and a weir coefficient. It was found that a simulation would proceed even if the water surface elevation was above all elevations in the cross section. When this occurred, it was assumed that "vertical walls" existed at the first and last station in the cross section. Furthermore, no warning message was issued when the water surface elevation exceeded the cross section. These assumptions could lead to significant error in the overflow calculations, depending on the actual shape of the dam top. A new test has been added to verify that the water surface elevation is below the first and last stations in the cross section. An error message is issued when this condition occurs and the simulation stops. The user should carefully evaluate the cross section used for the non-level dam top to verify that the top of the dam is properly represented up to and slightly above the maximum water surface elevation during a simulation.

## **Gage Weights Precipitation**

The gage weights precipitation method includes an optional index precipitation that can be used to adjust for regional trends. When used, the index is specified for each gage and also for each subbasin. It was found that the index adjustment was being applied during the temporal distribution of the total precipitation depth for each subbasin. The index would be more appropriately applied at an earlier stage in the precipitation calculations when calculating the precipitation depth for each subbasin. The optional index processing has been moved to the calculation of the depth for each subbasin.

## **Problems Repaired**

It was found that the frequency storm precipitation method did not compute accurate results if the storm area was left blank. This error was only present in Version 3.4 and Version 3.5. The documentation states that when the storm area is left blank, a separate storm is applied to each subbasin with an area equal to the drainage area of the subbasin. Unfortunately, all subbasins were receiving the same precipitation based on the drainage area of the last subbasin in the basin model. This problem is now repaired. However, leaving the storm area blank is not advised and should be done with extreme care. In general the storm area should always equal the drainage area at the point in the watershed where results will be evaluated.

The kinematic wave transform method may include either one or two runoff planes. When two runoff planes are used, the percentage of the subbasin assigned to each plane must be specified. Previously, the two percentages were checked to verify they summed to 100. The verification is now performed in full accuracy without truncating decimal digits.

Previously, in some circumstances the changes in kinematic wave transform parameter values were not recognized. This could potentially lead to a failure to recompute results for the subbasin. Changes in the kinematic wave transform parameters are now fully recognized, and a recompute is performed when necessary.

In certain rare cases, it was possible that a simulation could not proceed because the output HEC-DSS file did not exist and could not be created. In general this was caused by attempting to create the output HEC-DSS file in a directory where the program user did not have appropriate operating system privileges. The simulation will now terminate with an error if the output HEC-DSS file does not exist and cannot be created because of privilege issues.

The reservoir element includes the optional observed pool elevation. Previously, processing the observed data would lead to an error if computed pool elevation was not available for the reservoir. The computed pool elevation is now verified before attempting to process the observed pool elevation.

A custom output HEC-DSS file may be specified for a simulation run. If a project was copied, the simulation runs in the copy would store results to the original project directory. Custom output HEC-DSS files are now updated correctly when a project is copied.

The subbasin element includes both incremental, and optionally, cumulative precipitation time-series in the simulation results. Previously the cumulative precipitation time-series was stored with the wrong time data; the values were shifted by one time interval. Cumulative precipitation is used only for display purposes and simulation results remained accurate. The cumulative precipitation data is now shown with the correct time data.

Each basin model element may use an optional rating curve to compute stage from the computed flow time-series. This curve is not extrapolated in order to reduce the error that is associated with blindly extending a rating curve. Previously the error message issued when the flow exceeded the rating curve was difficult to understand. The error message has now been clarified and uses a simple description indicating either underflow or overflow.

Time-series gages such as precipitation or discharge gages include parameter units, unit system, data type, etc. Previously when these gages connected to external HEC-DSS files, these properties were not updated if the data in the external file was changed. Now the external files are checked automatically and properties updated when necessary.

The user hyetograph precipitation method can be used to specify a precipitation gage for each subbasin. The gage data may be stored in an external HEC-DSS file. The data in the file is now checked at the beginning of a simulation to determine if any aspect of the data has changed since the simulation was last computed. The precipitation data is only processed for the simulation if there has been a change since the last compute. The same approach is used where ever time-series data is used, including in other precipitation methods, snowmelt methods, and evapotranspiration methods.

A basin model element can be renamed directly in the Watershed Explorer by clicking in the display tree. The new name was not verified as unique. This could lead to a case where two elements in the display tree appeared to have the same name. The rename process now verifies the uniqueness of the name as part of performing the rename operation.

The results from a depth-area analysis would be unavailable under certain rare conditions. Results are now available appropriately, based on the date the depth-area analysis was last computed and the date the parameter data was last changed.

Meteorologic model results could be incorrect under some rare circumstances when the save states option was used in a simulation run. Results were always correct when the save states option was not used. Results are now always correct even if using the save states option.

The weir coefficient for broad-crested spillways and level dam tops does in fact have units even though they were not shown in the interface. The coefficients were converted correctly when switching between unit systems, and used correctly in simulations. The units are now displayed in the interface.

The reservoir element did not initialize correctly if the outflow structures routing method was used, the additional release component was used, and the initial condition was a specified storage, discharge, or pool elevation. The initialization happened correctly if a different initial condition was used, or the additional release component was not used. The reservoir now initializes correctly under all of these conditions.

The reservoir element may include a pump. If the on or off elevation of the pump was exactly equal to the lowest or highest elevation in the storage curve, then the simulation would abort with a parameter error. The method for checking the validity of the on and off elevation of the pump has been improved so that the simulation will only abort if the specified elevations are truly outside the range of the storage curve.

Observed flow data may be optionally added at any basin model element. If the observed data was missing for every single time interval of a simulation, then opening the summary table would result in an error. The observed flow data is now checked, and the error is handled in a way that permits the summary table to be viewed but without the observed data included in the summary.

Some output results could be corrupted while copying a project, if the project were copied immediately after completing a simulation. The copy operation has been improved so that the results do not become corrupted.

The total storm depth is optional for a time-series gage used in the user specified hyetograph precipitation method, the gage weights method, or the inverse distance method. The index precipitation is option in the gage weights precipitation method or the inverse distance method. A value of zero could be entered for these optional parameters even though this had the effect of eliminating the precipitation. It is now required that these option parameters have a value of at least 1 millimeter.

The method for checking the validity of temperature data in the snowmelt methods was incomplete. In some rare cases it was possible for the data to be invalid and yet the simulation would proceed and produce erroneous results. A

comprehensive check is now performed to prevent use of invalid temperature data.

Some precipitation data could be lost when opening a project created with Version 2.1.3 or earlier. The optional index precipitation values would be lost when converting the old project data to Version 3.5 format. The old data is now converted correctly.

The optional precipitation ratio in the simulation run was ignored if the gridded precipitation method was selected. The precipitation ratio was applied for all other precipitation methods. The ratio now works correctly with all precipitation methods including gridded precipitation.

The results from a basin model using the ModClark transform could be unpredictable, if the basin model was used in two separate simulation runs with different time intervals. The results would always be correct if a simulation was computed first. The results are now always correct no matter what time interval is selected or when a simulation run is computed.

There could be problems in a subbasin if the linear reservoir baseflow method was selected, and the basin model was copied and used immediately in a new simulation run. Any problems would correct themselves automatically if the project were closed and reopened.

## Documentation

The *Hydrologic Modeling System HEC-HMS: Quick Start Guide* (Version 4.0 February 2013) 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 4.0 May 2013) 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 3.5 release. The updates are generally confined to Chapter 7 in select locations describing the subbasin element capabilities.

The *Hydrologic Modeling System HEC-HMS: Validation Guide* (Version 4.0 May 2013) contains information on the procedures used to certify the software for release. The manual describes the tests that have been established and the procedures used for determining the correct result for each test. An accompanying data kit includes all of the project data necessary to replicate the tests performed at HEC prior to certifying a new release for distribution.

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* (March 2008) also continues to accurately describe how to apply the program to various engineering problems. The guide is undergoing revision to add guidance on how to use new features of the program and will be released when completed.

## 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, continuous simulation, sediment transport, or water quality. Special guidance is also available for the development of models for flow forecasting. Extended support for large or complex projects can be arranged under a separate reimbursable project agreement.

Support cannot be provided to users outside the Corps of Engineers. Several companies and organizations offer varying levels of support, some through a 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 can be located through internet searches.

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:

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