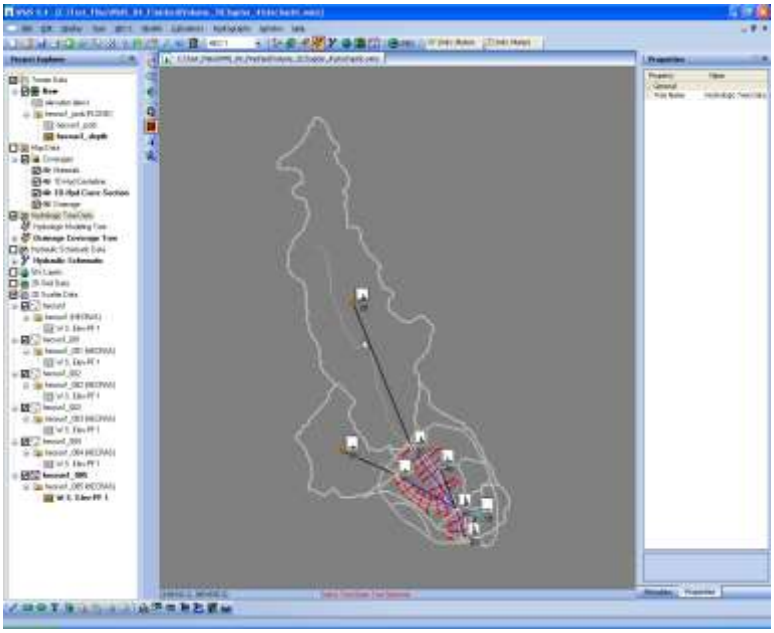
WMS

v. 10.0

WMS 10.0 Tutorial

Hydraulics and Floodplain Modeling – Stochastic Modeling Using HEC-1 and HEC-RAS

Learn how to setup and run a Monte-Carlo style risk analysis using the HEC-1 and HEC-RAS models



Objectives

This tutorial shows users how to setup and run a risk analysis that determines the probably of flooding at each point in a floodplain for a certain recurrence interval. This is called stochastic modeling, and users learn how to identify and set minimum, maximum, and mean values for hydrologic and hydraulic model parameters and then to run a sequence of models and floodplain delineations to determine flood risks in a flood study area.

Prerequisite Tutorials

- Watershed Modeling – HEC-1 Interface
- Hydraulics and Floodplain Modeling – HEC-RAS Analysis
- Hydraulics and Floodplain Modeling – Floodplain Delineation

Required Components

- Data
- Drainage
- Hydrology
- Hydrologic Models
- Map
- River

Time

- 20-40 minutes

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1 Introduction

This exercise demonstrates how to run a stochastic model within WMS. Since a certain degree of uncertainty usually exists in the selection of input parameters, running a stochastic model helps to explore multiple model solutions for differing input values. Users can specify a range of values to be used in the stochastic model.

2 Objectives

In this exercise, users will learn the basics of setting up a stochastic model that will run the HEC-1, HEC-RAS, and Floodplain Delineation models simultaneously. Users will:

- Assign key values to parameters
- Define the Stochastic Model characteristics
- Run the Model
- View the solution means and probabilities

3 Opening the HEC-1 and HEC-RAS Models

Working HEC-1 and HEC-RAS models have been previously prepared for use in this exercise. Users will use the stochastic modeling features of WMS to create a probabilistic map of floodplain boundaries. Users may choose to review the development of these models in their separate exercises.

There is generally a high degree of uncertainty associated with hydrologic modeling parameters such as the SCS Curve Number and rainfall depth. Using WMS users can vary these parameters stochastically in order to analyze a more complete parameter space and then use the results to reflect the known uncertainty in a floodplain delineation. The stochastic simulation will run a specified number of simulations using randomly generated values of basin curve numbers and basin precipitation for each simulation. Results from the HEC-1 run are then passed to a developed HEC-RAS simulation, and finally the results from HEC-RAS are used to compute a series of flood plain boundaries from which a probability of flooding, based on model parameter uncertainty can be computed.

1. Open WMS. If WMS is already open, select *File* | **New** then click **No** if asked to save changes.
2. Select *File* | **Open**  to access the *Open* dialog.

3. Locate the "stochastic" folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
4. Open "run1.wms".

This file is a WMS project file that references all of the prepared input data for the HEC-1 and HEC-RAS models. Each simulation has been previously tested to ensure that they can be run successfully.

3.1 Preparing the HEC-RAS Model

To begin, users will zoom in on the HEC-RAS model domain.

1. Hide all basins and outlets by un-checking the box next to the "Hydrologic Tree Data" folder in the Project Explorer.
2. Hide the coverage named "Drainage" by un-checking its visibility box in the Project Explorer.
3. Select the **Frame** macro.
4. Activate the "1D-Hyd Centerline" coverage by single-clicking on its name in the Project Explorer.
5. Select "River Tools" from the model list at the top of the screen.
6. Select *River Tools* | **Map → 1D Schematic**. This step initializes the HEC-RAS river scheme in preparation for reading in the HEC-RAS solution.
7. Switch to the **River** module.
8. Select *HEC-RAS* | **Read Solution**.
9. From the *Open* dialog, open "hecrun1.prj".

When users read in a HEC-RAS project file in which the water surface profiles have been calculated, a scatter point is placed at the thalweg location of each cross section. Each scatter point contains the value of the water surface elevation at that point in the river reach. To create additional scatter points for interpolation purposes, users need to interpolate more scatter points along both the center-line and cross section arcs.

10. Make sure the "1D-Hyd-Centerline" coverage is active in the Project Explorer.
11. Select *River Tools* | **Interpolate Water Surface Elevations**.
12. In the *Interpolate Stages* dialog, set the *Create a data point* field to "At a specified spacing".
13. Enter "60" for the *Data point spacing*.
14. Select **OK**.
15. Activate the "1D-Hyd Cross Section" coverage from the Project Explorer.
16. Select *River Tools* | **Interpolate Water Surface Elevations**.
17. Select **OK** in the *Interpolate Stages* dialog.

This same data point spacing (60) will be used to interpolate each HEC-RAS solution along the reach and the cross sections when running the stochastic simulations.

3.2 Preparing the HEC-1 Model

1. Show the "Drainage" coverage by checking its box in the Project Explorer.
2. Show the contents of the "Hydrologic Tree Data" folder by toggling on its check box.
3. Select the **Frame** macro.

Users will now assign key values to the parameters that they wish to randomly vary during the Stochastic run. Key values are negative integers that users assign to a parameter in lieu of the actual value. By entering a negative value for precipitation, for example, WMS replaces the precipitation value with a feasible precipitation value at run time. This precipitation value changes for each new run. Each generated value is based on a normal distribution, and can be controlled by specifying minimum and maximum allowable values.

4. Select the "Hydrologic Tree Data" folder in the Project Explorer.
5. Choose the **Select Basin** tool.
6. Multi-select the basins labeled 2B and 3B by holding the **SHIFT** key while single-clicking on each basin icon.
7. Select *HEC-1* | **Edit Parameters**.
8. Select the **Precipitation** button in the *Edit HEC-1 Parameters* dialog.
9. The *HEC-1 Precipitation* dialog will appear. Enter a value of "-1" in the *Average precipitation* field.
10. Select **OK**.
11. Select the **Loss Method** button.
12. In the *HEC-1 Loss Methods* dialog, enter a value of "-2" in the *CRVNBR* field.
13. Select **OK**.
14. Select **Done**.
15. Multi-select the basins labeled 4B and 1B. Users may need to hide the "River Hydraulic Schematic" in the *River Data display options* in order to see the basin icons.
16. Use the method shown in the previous steps 7-14 to assign an *Average precipitation* value of "-1" and a *CRVNBR* value of "-3" to these basins.

4 Running the Stochastic Model

For this exercise, users have assigned key values only to HEC-1 parameters, namely precipitation and Curve Number. However, WMS also allows key values to be assigned to Manning's n values for the HEC-RAS model, and Search Radius for the Floodplain Delineation model.

4.1 Setting up the Model

1. Select *HEC-1* | **Stochastic Modeling**. The *Stochastic Run Parameters* dialog will appear.

Users can choose either a Monte Carlo or Latin Hypercube approach to generating values for the stochastic model. Users will use the Monte Carlo approach for this exercise. When

using the Monte Carlo method, users must specify the number of simulations that they want to run. With the Latin Hypercube approach, instead of specifying a number of simulations, users enter a number of segments for each variable. The total number of simulations for a Latin hypercube run is equal to the product of the number of segments for each variable. If users have 3 variables, with 3 segments each, then a Latin Hypercube model will run 27 times. Users also specify maximum, minimum, and starting values for each stochastic variable.

2. Select the *Monte Carlo* option for the *Simulation type*.
3. Enter "5" for the *Number of simulations*.

Users only specify five simulations for this exercise in the interest of time. Remember, though, that statistical studies indicate that in order for the generated values to resemble a normal distribution, one should run at least 30 simulations.

4. Choose "HEC-1" from the *Selected model* list box.
5. Toggle on the *Define stochastic model* check box.
6. Under the *Filename parameters* section, select the Base filename **Browse** button.
7. The *Select the stochastic run base filename* dialog will open. Browse to the folder in which the HEC-RAS project file ("hecrun1.prj") is located and enter "hecrun1" as the *File name*.
8. Select **Save**.
9. Select the **Add variable** button 3 times to add 3 variables to the table if three variables are not already shown.
10. Refer to Figure 1 and enter the values shown for each stochastic variable

	Used	Name	Key	Type	Sta...	Min ...	Ma...	Stand...	Distribution	Log
1	☑	HEC1_1	-1	Precipitat...	6.0	3.0	9.0	2.5	Normal	☐
2	☑	HEC1_2	-2	Curve Nu...	68.0	62.0	72.0	4.0	Normal	☐
3	☑	HEC1_3	-3	Curve Nu...	76.0	70.0	80.0	4.0	Normal	☐

Figure 1 Values for the Stochastic Variables table

Now, users will turn on stochastic modeling for the HEC-RAS and Floodplain models:

11. Change the *Selected model* list box to "HEC-RAS".
12. Toggle on the *Define stochastic model* check box.
13. Select the Base filename **Browse** button and browse to the same path as "hecrun1.prj".
14. Enter "hecrun1" as the *File name* and select **Save**.
15. Change the *Selected model* list box to "Floodplain".
16. Toggle on the *Define stochastic model* check box.
17. Select the Base filename button and **browse** to the same path as "hecrun1.prj".
18. Enter "hecrun1" as the *File name* and select **Save**.
19. Select **OK** to exit the *Stochastic Run Parameters* dialog.
20. Select *File* | **Save** to save the changes.

4.2 Running the Model

The last step in setting up the stochastic simulation is linking the output hydrographs (in this case it is a steady state simulation and so only the peak flow is used) from the HEC-1 model to the HEC-RAS input boundary condition for the appropriate rivers and reaches.

1. Select *HEC-1* | **Run Stochastic Model**.
2. In the *Model Steering* dialog, choose "2B Basin Hydrograph" from the *Select a hydrograph* combo box.
3. Choose "Leith River" from the *Select a river* combo box.
4. Choose "Upper Branch" from the *Select a reach* combo box.
5. Choose "2648.529" from the *Select a cross section* list box.
6. Select the **Assign Peak Flow BC** button
7. Repeat the previous steps to link the hydrographs and cross sections shown in Table 1:

Table 1 Assigning additional hydrographs to cross sections

Hydrograph	River	Reach	Cross section
3B	Left Fork	Branch	1703.086
5C	Leith River	Lower Branch	759.138
2C	Leith River	Lower Branch	72.889

Before users use the Stochastic Model to run Floodplain Delineation over and over again, they need to change some of the delineation options. To set these options:

8. Select the **Floodplain Delineation Options** button to open the *Floodplain Delineation* dialog.
9. Change the *Max search radius* to "1500".
10. Make sure the *Quadrants* check box is toggled on.
11. Enter "3" for the *Number of stages in a quadrant*.
12. Select **OK**.
13. Select **OK** to run the Stochastic simulations. A new *Stochastic HEC-1* window will open where the results will be displayed. Users can click **Close** when they are done viewing the results.

Progress for the simulations will be displayed in the Stochastic dialog. Users will be able to see the values selected for the CN and precipitation for each run as well as the diagnostic information for the models. It is possible to abort prematurely by selecting the **Abort** button.

5 Viewing the Results

All solutions (HEC-1 hydrographs, HEC-RAS river stages, and Floodplain delineations) are read into WMS. Furthermore, at the completion of the stochastic run, WMS computes a dataset containing the probabilities that flooding will occur at various locations within the original TIN. This is computed by assigning to each vertex in the TIN whether it was flooded or not. At the completion of all runs contours showing 0-100 percent probability of flooding can be viewed. 100% probability would mean that flooding occurred for the entire

model, 50% probability would be flooding for half of the simulations, etc. To view the results:

1. Select **Close** to exit the *Stochastic HEC-1* wrapper.
2. Switch to the **Terrain Data** module.
3. Right-click on "New" under "Terrain Data" in the Project Explorer and select **Display Options** to open the *Display Options* dialog.
4. Select *TIN Data* and toggle on the *TIN Contours* check box.
5. Select **OK**.
6. Select the dataset named "hecrun1_prob" in the "Terrain Data" folder of the Project Explorer.

By contouring this dataset, users see the probabilities of the floodplain arriving at different locations.

7. Now, select the dataset named "hecrun1_depth".

This dataset contains the average depths from all of the stochastic simulations.

6 Conclusion

This exercise demonstrates how to run a stochastic model within WMS. Users should have learned the basics of setting up a stochastic model that will run the HEC-1, HEC-RAS, and Floodplain Delineation models simultaneously. As a part of this objective, users should have learned how to:

- Assign key values to parameters
- Define the Stochastic Model characteristics
- Run the Model
- View the solution means and probabilities