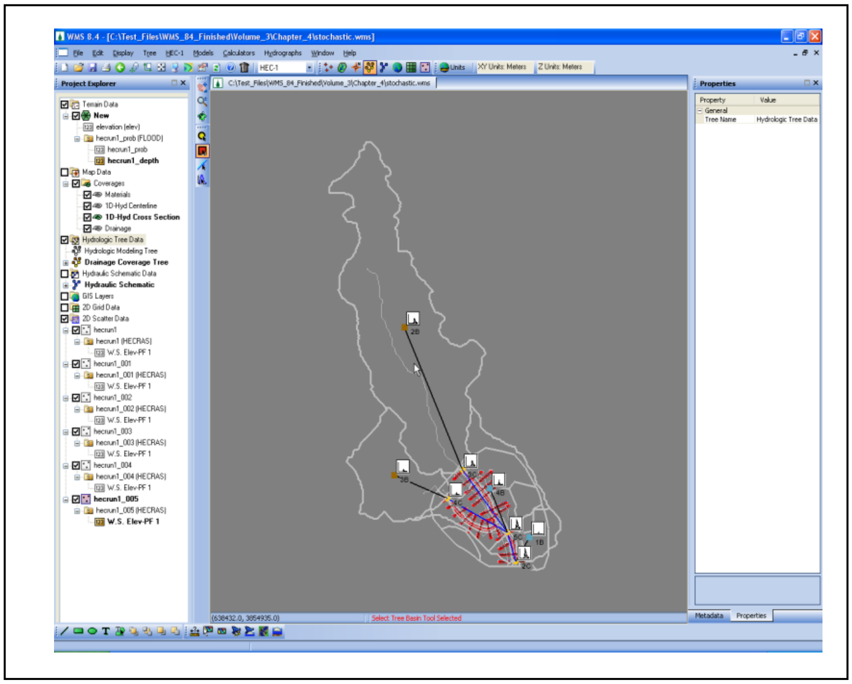
WMS

v. 10.1

*WMS 10.1 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 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. This tutorial demonstrates 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. Specify a range of values to be used in the stochastic model.

# 2 Objectives

This exercise shows the basics of setting up a stochastic model that will run the HEC-1, HEC-RAS, and Floodplain Delineation models simultaneously. It cover how to:

- 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. Use the stochastic modeling features of WMS to create a probabilistic map of floodplain boundaries. 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. WMS 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, 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 a HEC-RAS project file is imported 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, 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.

Now assign key values to the parameters that they wish to randomly vary during the Stochastic run. Key values are negative integers assigned 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. If needed, 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, only HEC-1 parameters have assigned key values, 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.

Choose either a Monte Carlo or Latin Hypercube approach to generating values for the stochastic model. Use the Monte Carlo approach for this exercise. When using the Monte Carlo method, specify the number of simulations to run. With the Latin Hypercube approach, instead of specifying a number of simulations, 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 there are three variables, with three segments each, then a Latin Hypercube model will run 27 times. Aalso 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*.

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 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 using the Stochastic Model to run Floodplain Delineation over and over again, 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. Click **Close** when done viewing the results.

Progress for the simulations will be displayed in the Stochastic dialog. The values selected for the CN and precipitation are shown 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, notice 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. It showed the basics of setting up a stochastic model that will run the HEC-1, HEC-RAS, and Floodplain Delineation models simultaneously. This objective reviewed how to:

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