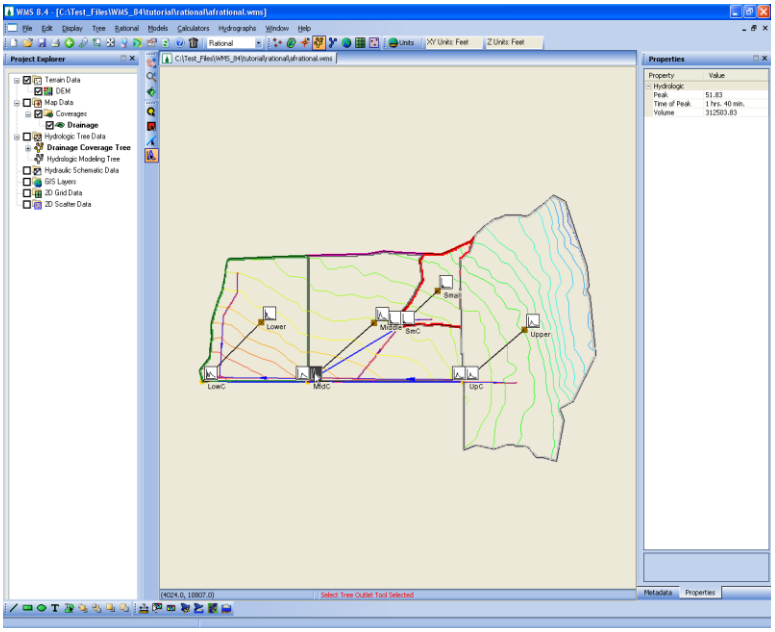
WMS

v. 9.1

WMS 9.1 Tutorial

Watershed Modeling – Rational Method Interface

Learn how to model urban areas using WMS' rational method interface



Objectives

This tutorial demonstrates how to model urban areas using the Rational method, one of the simplest and best known methods used in urban hydrology. You learn how to compute rainfall intensity, compute hydrographs, and how to combine and route hydrographs using the traditional method and by summing hydrographs.

Prerequisite Tutorials

- Watershed Modeling – DEM Delineation
- Watershed Modeling – Advanced DEM Delineation Techniques (Optional)

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models

Time

- 15-45 minutes

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1 Contents

2 Introduction

The Rational Method is one of the simplest and best known methods routinely applied in urban hydrology. Peak flows are computed from the simple equation:

$$Q = kCiA$$

where:

Q - Peak flow

k - Conversion factor

C - Runoff coefficient

i - Rainfall intensity

A - Area

In this exercise you will learn how to solve problems using a digital terrain model and the Rational Method.

3 Reading in Terrain Data

1. Close all instances of WMS
2. Open WMS
3. Select ***File* | *Open***
4. Locate the ***rational*** folder in your tutorial files. If you have used default installation settings in WMS, the tutorial files will be located in ***\My documents\WMS 9.1\Tutorials\.***
5. Find and open *"afrational.wms"*
6. Switch to the *Drainage* module
7. Select ***DEM* | *Compute Basin Data***

8. The Model units should be feet. For Parameter units set the Basin Areas to *Acres* and Distances to *Feet*.
9. Select *OK*
10. Select ***Display | Display Options***
11. In the *Drainage Data* tab click the *All off* button
12. Select *OK*

4 Running a Rational Method Simulation

The areas computed with the DEM can now be used in setting up a Rational Method simulation of the urban development. Each of the outlet points represents an inlet to a storm drain.

1. Switch to the *Hydrologic Modeling* module
2. Set the Model combo box at the top of the screen to *Rational*
3. Double-click the basin icon for the basin labeled *"*Upper*"* in Figure 4-1

The Rational Method dialog should appear. The parameters shown in the dialog correspond to the basin that was selected.

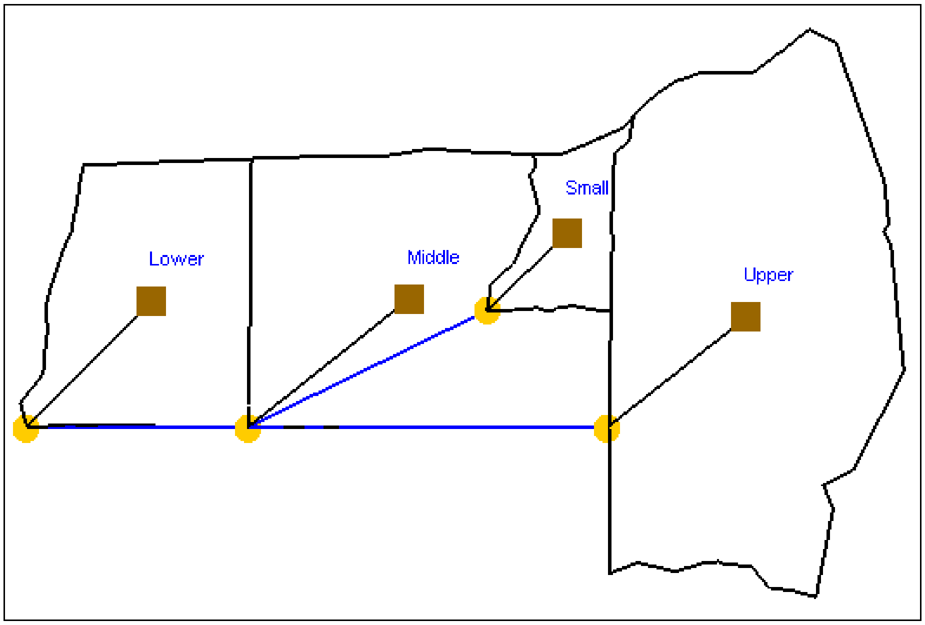

Figure 4-1: Basins

4.1 Runoff Coefficients and Time of Concentration

The runoff coefficient, C, is used to account for losses between rainfall and runoff. The more developed a catchment is, the higher the C value it will have.

1. For Runoff Coefficient (C) enter a value of **0.20**
2. For Time of concentration (Tc) enter a value of **22**

3. Select *OK*
4. Double click on the basin labeled “Small” in Figure 4-1
5. Enter a value of **0.35** for C
6. Enter a value of **6** for Time of Concentration
7. Select *OK*
8. Repeat this process for the other two basins, using the table below to fill in values for C and t_c

Basin Name	Runoff Coefficient C	Time of Concentration t_c
Upper	0.20	22
Small	0.35	06
Middle	0.40	18
Lower	0.40	11

9. When you are finished entering the parameters select *OK* to close the Rational Method dialog

A runoff coefficient coverage could be used to automatically map C values and basin data, or a time computation coverage could be employed to determine Tc values, but they can also be computed/estimated separately and entered as demonstrated here.

4.2 Rainfall Intensity (i) and Basin Peak Flows

As part of the WMS interface to the Rational Method, you can compute IDF curves using either HYDRO-35, NOAA, or user defined data. For this exercise we will use HYDRO-35 data and a recurrence interval of 10 years.

1. Double-click the icon for the “Upper” catchment
2. In the Compute I – IDF Curves row click on the *Compute…* button
3. Make sure the *HYDRO-35 Data (Eastern US)* option is selected
4. Click on the *Define Storm Data…* button
5. Enter the following values to define IDF curves using HYDRO-35

Time (min)	Depth (in)
2 yr. 5 min.	0.47
2 yr. 15 min.	0.97
2 yr. 60 min	1.72
100 yr. 5 min.	0.81
100 yr. 15 min.	1.75
100 yr. 60 min.	3.60

6. Select the *OK* button after correctly entering the rainfall values

The IDF curves for the 2, 5, 10, 25, 50, and 100 year recurrence intervals will be drawn, and values listed for selected times given in the windows on the right of the IDF Computation dialog.

7. From the text window in the upper right hand part of the dialog, click on the line of data for the 10-yr recurrence interval as shown in Figure 4-2

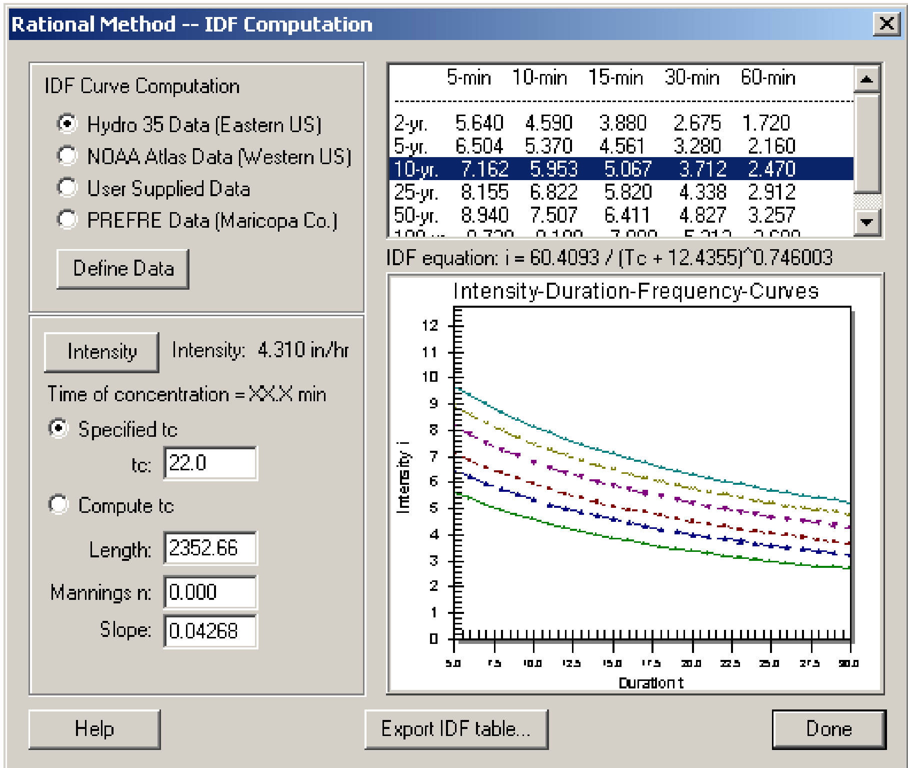

Figure 4-2: IDF Computation Dialog with 10-yr Recurrence Interval Selected

The rainfall intensity is determined using the selected interval according to the value for time of concentration, which was previously entered.

8. Compute i by clicking on the *Compute Intensity* button
9. Select the *Done* button. The value of i computed using the Rational Method – IDF Computation dialog is automatically entered for the Rainfall Intensity (I).

Note that the input for this basin is complete and a value for runoff Q is computed and displayed in the Flowrate (Q) row.

10. Select *OK*

The HYDRO-35 data only needs to be entered once (unless different data is to be used for different basins), so the rainfall intensity for the remaining basins can be defined using the following steps:

11. Double click on the basin icon for “Small”
12. In the Compute I – IDF Curves row select the *Compute…* button
13. Verify that the line of text for the 10-yr recurrence interval is highlighted
14. Click on the *Compute Intensity* button
15. Select *Done*
16. Select *OK*
17. Repeat these steps for the “Middle” and “Lower” basins

4.3 Basin Hydrographs

As the data entry for each basin is completed, a peak flow (Q) is computed and listed in the Flowrate (Q) row. The Rational Method equation does not produce a hydrograph. However, one of several unit-dimensionless hydrographs can be used to distribute the peak flow through time to create a runoff hydrograph.

1. Double-click the basin labeled "Upper" in Figure 4-1
2. In the Compute Hydrographs row click on the *Compute…* button
3. For the Hydrograph computation method choose *Rational method hydrograph*
4. Select *Done* to compute the hydrograph
5. Select *OK* on the Rational Method dialog
6. Double-click on the small hydrograph box that appears to the upper right of the basin icon to open up a plot window of the hydrograph

You should see the hydrograph displayed in a plot window as shown in Figure 4-3.

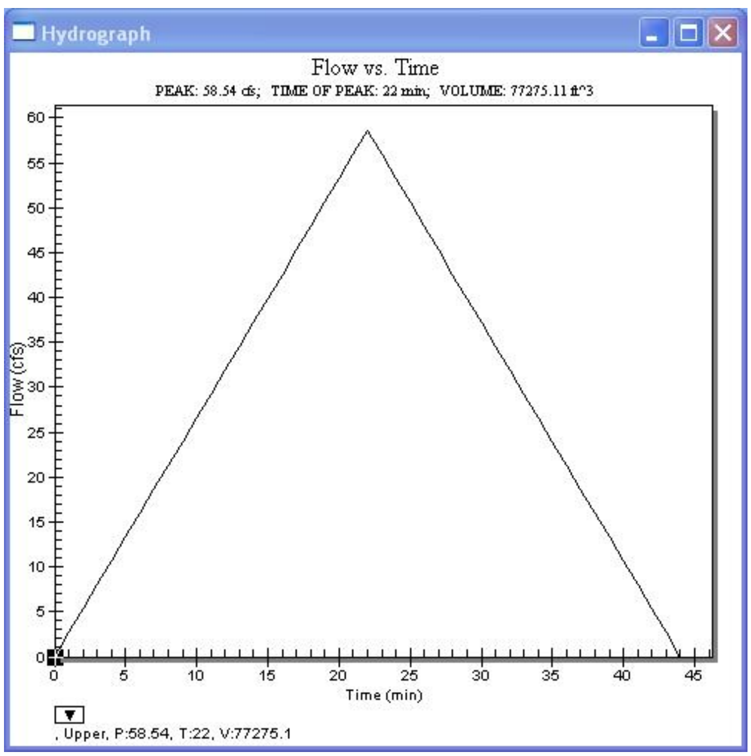

Figure 4-3: Rational Method Hydrograph for the Upper Basin

7. When you are finished viewing the hydrograph close the plot window by selecting the X in the upper right corner of the window

4.4 Outlet Peak Flows and Hydrographs (Traditional Method)

At outlet points WMS uses data from all upstream basins to calculate composite rational method parameters, which can be used to compute peak flows and generate hydrographs. The area is the cumulative upstream area, and the runoff coefficient is determined as an area weighted value from the upstream basins. The time of concentration at an outlet point is defined as the longest flow time from contributing upstream basins (times of concentration) combined with any lag (travel) times from channels. With the time of concentration at the outlet defined you will need to determine the appropriate rainfall intensity. In order for WMS to compute peak flows and hydrographs at outlets you will need to define the travel time between outlet points and the rainfall intensity for the total time of concentration at each outlet.

1. Select the *Select Outlet* tool 
2. Double-click on "UpC", which is the outlet icon of the "Upper" basin as shown in Figure 4-1 (be sure to select the circular outlet icon and not the square basin icon)

You will note in the Outlet portion of the Rational Method dialog that information upstream from this outlet has been aggregated (in this case though there is just one basin upstream). The longest flow time is listed for the time of concentration, a cumulative area, and a weighted C value.

3. In the Outlet column and Compute I – IDF Curves row click on the *Compute…* button
4. Make sure that the 10-yr line of text is highlighted
5. Click on the *Compute Intensity* button
6. Select *Done*

Notice that a composite peak flow is computed and displayed in the Flowrate (Q) row for the outlet.

7. For Routing Lag Time (Tl) enter a value of **5** minutes

This is the time that is takes for water to travel in the channel from outlet "UpC" down to oulet "MidC" and will be used for total time of concentration calculations at downstream outlet points.

8. Select *OK*
9. Double-click the outlet icon names "SmC", which is the outlet of the "Small" basin
10. In the Outlet column and Compute I – IDF Curves row click on the *Compute…* button
11. Verify that the 10-yr line of text is highlighted
12. Click on the *Compute Intensity* button
13. Select *Done*
14. For Routing Lag Time (Tl) enter a value of **3** minutes
15. Select *OK*
16. Double-click on the next downstream outlet named "MidC"

Note that for this outlet the upstream areas are summed, the C values weighted, and the longest travel path is determined based on the upstream basin Tc's and travel times between outlets.

17. In the Outlet column and Compute I – IDF Curves row click on the *Compute…* button
18. Make sure that the 10-yr line of text is highlighted
19. Click on the *Compute Intensity* button
20. Select *Done*
21. For Routing Lag Time (Tl) enter a value of **4** minutes
22. Select *OK*

The last or bottom-most outlet does not need to have a Routing lag time defined since the hydrograph accumulations will occur at this point, but you will still need to define the rainfall intensity.

23. Double-click on the bottom-most outlet point, "LowC"
24. In the Outlet column and Compute I – IDF Curves row click on the *Compute…* button
25. Verify that the 10-yr line of text is highlighted
26. Click on the *Compute Intensity* button
27. Select *Done*
28. In the Outlet column and Compute Hydrographs row click on the *Compute…* button
29. Select the *Traditional method* option
30. For Hydrograph computation method choose *Rational Method hydrograph*
31. Select *Done*
32. Select *OK* in the Rational Method dialog
33. Double-click on the hydrograph icon for the most downstream outlet
34. Close the hydrograph plot window when you are done viewing by selecting the X in the upper right corner of the window

4.5 Combine Hydrographs by Summing

Besides the traditional method of computing peak flows and hydrographs for multiple sub-basins within a watershed, WMS will also allow you to lag hydrographs computed for basins and add them using the principle of superposition at outlets in order to produce downstream peak flows and hydrographs.

1. Double-click on the downstream-most outlet point named "LowC"
2. In the Outlet column and Compute Hydrographs row click on the *Compute…* button
3. Select the *Route by summing* option
4. For the Hydrograph computation method choose the *Rational method hydrograph* option
5. Select *Done*

6. Select *OK*
7. Double-click the hydrograph icon for the bottom-most outlet

You can now see the difference between these two methods as both hydrographs are plotted in the window.

8. Close the hydrograph plot window when you are done viewing by selecting the X in the upper right corner of the window

5 Adding a Detention Basin

If you compute runoff using the route by summing method then you can route hydrographs through detention basin structures defined at any of the outlet locations.

1. Double-click the outlet named “MidC”, which is the outlet for the “Middle” catchment in Figure 4-1
2. In the Outlet column and Define Reservoir row click on the *Define…* button
3. Click the *Define…* button in the Detention Basin Hydrograph Routing dialog
4. Click on the *Define Storage…* button

You will now define a hypothetical detention basin for the “Small” catchment from approximate geometric parameters. WMS can compute a storage capacity curve for any rectangular basin. You could also enter a pre-computed storage capacity curve or use the elevation data to calculate the storage capacity data.

5. Choose the *Known Geometry* option
6. For Length enter **150** feet
7. For Width enter **200** feet
8. Enter a Depth of **30** feet
9. Enter a Side slope of **2**
10. Leave the Base elevation at **0.0** (it will be assumed on-grade at the outlet location)
11. Select *OK*

You will now define a standpipe and spillway (weir) for outlet structures and WMS will compute the elevation-discharge relationship automatically. In addition to standpipes and weirs you can define low-level outlets, or you can enter a pre-computed elevation-discharge relationship.

12. Click on the *Define Discharges…* button
13. Click on the *Add Standpipe* button
14. Set the Pipe diameter to **4** feet
15. Set the Standpipe elevation to **7** feet
16. Click on the *Add Weir* button

17. Set the Weir length to **20** feet
18. Set the Weir elevation to **25** feet
19. Select *OK* four times to return to the main WMS graphics window

You have now defined a detention facility that has a standpipe and a spillway for control structures. The incoming hydrograph to this outlet point will be routed through the detention facility before being routed downstream and combined with the hydrographs of other basins.

20. Select ***Hydrographs | Delete All***
21. Double-click on the downstream-most outlet point named "LowC"
22. In the Outlet column and Compute Hydrographs row click on the *Compute…* button
23. Select the *Route by summing* option
24. For Hydrograph computation method choose *Universal hydrograph method*
25. Select *Done*
26. Select *OK*
27. Double-click on the hydrograph icon for the outlet named "MidC" to view the incoming and routed hydrographs

6 Conclusion

In this exercise you have learned some of the options available for using the Rational method in WMS. You will want to continue experimenting with the different options so that you can become familiar with all the capabilities in WMS for doing Rational method simulations.