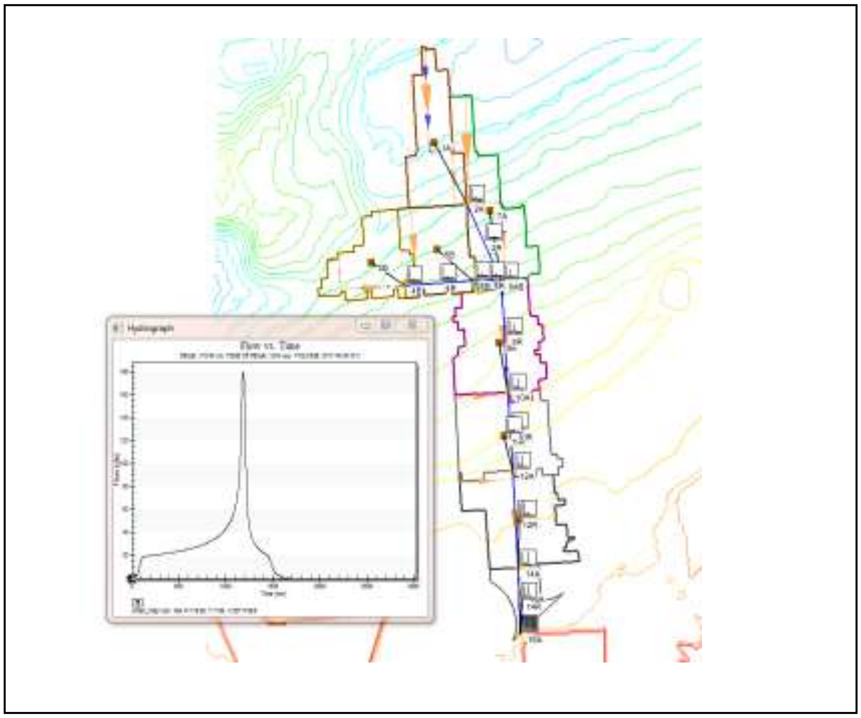
v. 10.0

WMS 10.0 Tutorial

Watershed Modeling – MODRAT Interface (Map-based)

Build a MODRAT model for an urban watershed using GIS data



Objectives

This tutorial shows users how to define a map-based MODRAT model in WMS using pre-delineated watershed boundaries in GIS shapefile format. Users learn how to correlate the imported boundaries with a DEM and to extract information they need to run the MODRAT model.

Prerequisite Tutorials

- Watershed Modeling – Advanced DEM Delineation Techniques

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models

Time

- 30-45 minutes

1 Introduction

The MODRAT interface in WMS is often used to perform modeling on watersheds that have been delineated in other CAD or GIS systems. The basin boundaries and stream networks to be used in the model must be imported into WMS and properly connected so that WMS can create the MODRAT model schematic.

2 Objectives

Users will learn to import watershed data from shapefiles to create a watershed in the Map Module of WMS. Further, users will learn how to correlate this imported data with a DEM of the same area to allow WMS to extract additional information that they will need to run the MODRAT model. Users will complete a MODRAT simulation on the watershed created in the Map Module.

3 Importing Shapefile Data

An urban watershed that has been delineated (by hand) in ArcGIS will be opened into WMS from a series of shapefiles. Three shapefiles are required: 1) basin boundary polygons 2) stream network arcs and 3) outlet points.

1. Open a new WMS window and select the **GIS** module.
2. Select *Data* | **Add Shapefile Data…**
3. In the *Select Shapfile* dialog, locate the "MODRAT" folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
4. Find and open *"*urban_poly.shp*"* –the basin boundary polygons will be displayed.
5. Select *Data* | **Add Shapefile Data…**
6. In the *Select Shapfile* dialog, find and open *"*urban_arc.shp*"* – users will see the stream network displayed.

7. Select *Data* | **Add Shapefile Data…**
8. In the *Select Shapfile* dialog, find and open *"*urban_pt.shp*"* – users will see the outlet points displayed.

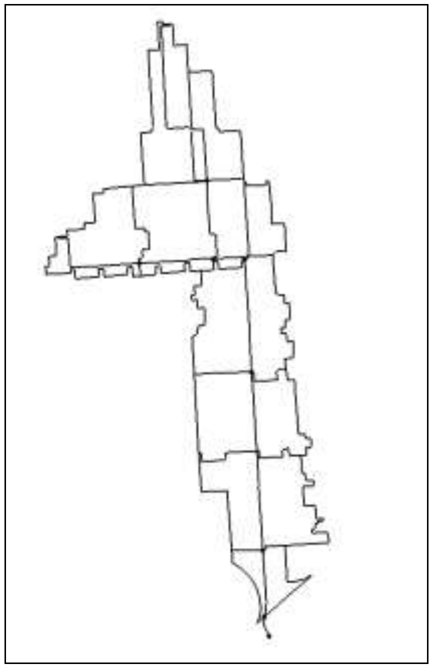


Figure 1 Display of watershed data in the GIS module

3.1 Map GIS Data to Feature Objects

1. Select *Mapping* | **Shapes → Feature Objects**.
2. Select **Yes** when the prompt to use all visible shapes for mapping appear.
3. The *GIS to Feature Objects Wizard* will appear – click **Next** to start the wizard.
4. The next screen will show Point Attribute Mapping – the data fields from the point shapefile that will be transferred to feature objects. Click **Next** to accept default mapping.
5. The next screen will show Arc Attribute Mapping – the data fields from the arc shapefile that will be transferred to feature objects. Click **Next** to accept default mapping.
6. The next screen will show Polygon Attribute Mapping – the data fields from the polygon shapefile that will be transferred to feature objects. Click **Next** to accept default mapping.
7. Click **Finish**.

The data has been transferred to the Drainage Coverage of the Map Module now and is ready for users to review to make sure it is properly connected/attributed for MODRAT modeling.

8. Toggle off the display of the "GIS Data" layers in the Project Explorer – users will now see the Map Module data more clearly.

4 Watershed Data Cleaning and DEM Matching

The watershed data users now have in the Drainage coverage is mostly correct, but there are a few errors to be fixed. Users will match the DEM for this watershed to the Drainage layer so that WMS can extract slopes for their watershed analysis.

4.1 Cleaning Streams

The stream network must be inspected to ensure all directions are correct and outlets are snapped to basin boundaries when using data from a shapefile. In this watershed, there is an extra stream segment at the bottom of the watershed and an outlet that is not snapped and set properly.

1. Switch to the **Map** module.
2. Note that the steam network displayed is shown in blue and there is an outlet point shown at the lower end of the streams. This indicates that the attributes for the stream arc are properly set. **Zoom** in and **Pan** to verify that the arrows show flow direction from the top to the bottom of the watershed.
3. Choose the **Select Feature Arc** tool.
4. Select the stream arc that extends out of the watershed as shown in Figure 2.

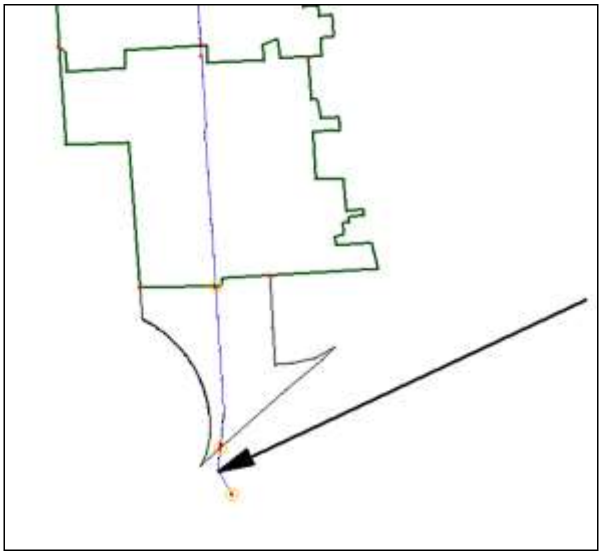


Figure 2 Select extra stream arc

5. Press the **Delete** key.
6. Click **OK** to confirm deletion of the arc.
7. Click on the **Frame** macro.
8. Use the **Zoom** tool to zoom to the area shown in Figure 3.

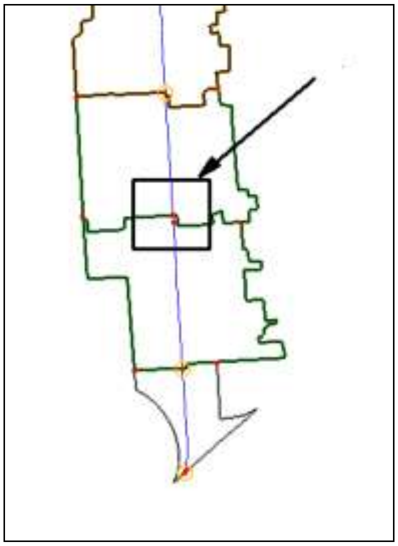


Figure 3 Zoom area

9. Select the **Select Feature Point/Node** tool.
10. Click on the node shown in Figure 4 below to select it.

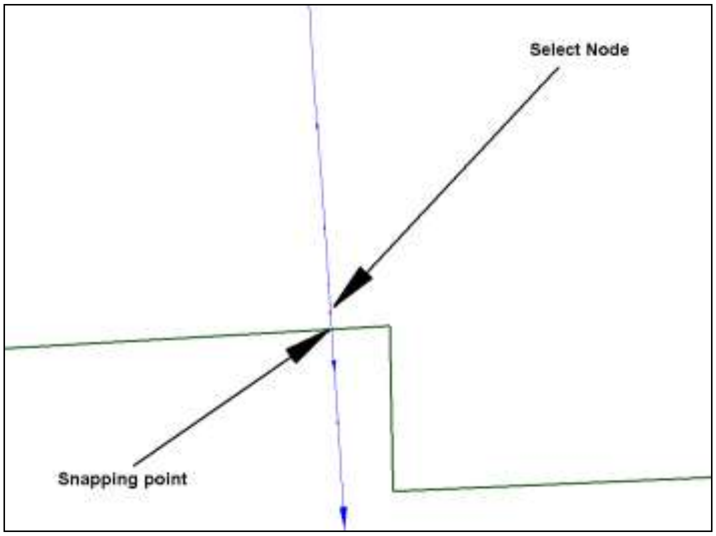


Figure 4 Node snapping

11. Select *Feature Objects* **| Clean…**
12. The *Clean Options* dialog will appear. Ensure that *Snap selected nodes* is checked and all other options are unchecked.
13. Click **OK**.
14. Note that "Select a snapping point…" is shown in the Help message in the lower left corner of WMS.
15. Click on the Snapping point indicated in Figure 4 – there is a vertex located on the boundary polygon at that point and WMS will snap to it.
16. Double-click on the node that is now located at the intersection of the stream arc and the basin boundary.
17. In the *Drainage Feature Point Type* dialog, choose *Drainage outlet* and click **OK**.

18. Click on the **Frame** macro.

Users have now cleaned the errors in the GIS data. The extra stream arc is gone and all outlet points are now correctly snapped to basin boundaries. Users will now read in the DEM for this area and correlate the watershed data to it.

4.2 Matching DEM Data

The DEM for this watershed area will allow WMS to calculate slopes in the watershed. Users will open it and assign it to match the watershed data.

1. Select *File* | **Open…** .
2. In the *Open* dialog, find and open *"*torrance_clipped.asc*"*.
3. Select **OK** in the *Importing ArcInfo Grid* window that appears and shows the DEM bounding coordinates.
4. Switch to the **Drainage** module.
5. Select *DEM* | **Polygon Basin IDs → DEM**.
6. Select *DEM* | **Compute Basin Data**.
7. Click on the **Current Projection…** button in the *Units* dialog.
8. The *Display Projection* dialog will appear. Select the *Global projection* option then click **Set Projection**.
9. In the *Select Projection* dialog, set the *Projection* to "State Plane Coordinate System", *Zone* to "California Zone 5 (FIPS 405)", *Datum* to "NAD83", and *Planar Units* to "FEET (U.S. Survey)".
10. Select **OK** to save changes and close the *Select Projection* dialog.
11. Set the *Vertical Projection* to "Local" and *Units* to "U.S. Survey Feet".
12. Click **OK**.
13. Set *Basin Areas* to "Acres" and ensure that *Distances* is set to "Feet".
14. Click **OK** in the *Units* dialog.
15. Click **OK** in any warning messages that appear.
16. The basin areas should now be displayed. To make the display clearer choose *Display* | **Display Options…** to open the *Display Options* dialog.
17. On the *DEM Data* tab, toggle all items except *DEM Contours* off.
18. On the *Drainage Data* tab, toggle off *Basin Areas*.
19. Click **OK**.

The watershed is now ready for modeling. The basin areas have been computed and stream lengths/slopes have been computed.

This is a good place to save the project to the hard drive before continuing. Save this data to a WMS project file:

20. Select *File* | **Save As…** .
21. In the *Save As* dialog, enter *"*Urban_map.wms" as the *File name* and click **Save**.

WMS will save this project to a set of WMS Project files. The *.wms file is an index file and contains other information that instructs WMS to load all the files associated with the project when users open their project at a later time.

5 MODRAT Global Setup

The MODRAT analysis setup requires users to enter Job Control data, Basin data for each subarea, reach data for each channel, and elevation-storage-discharge relationships for each storage facility. The following sections will guide users in entering data and using GIS data layers to acquire input data for MODRAT.

5.1 Job Control

Most of the parameters required for a MODRAT model are defined for basins, outlets, and reaches. However, there are a few "global" parameters that control the overall simulation. These parameters are not specific to any basin or reach in the model. These parameters are defined in the WMS interface using the Job Control dialog.

1. Switch to the **Hydrologic Modeling** module.
2. Select "MODRAT" from the drop down list of models found in the Models Window – a MODRAT menu item will appear in the Menu Bar.
3. Select *MODRAT* **| Job Control…**
4. Choose *MODRAT 2.0* at the top of the *MODRAT Job Control* dialog.
5. Select "2" in the *Run time* drop down list.
6. Select "25 year" in the *Frequency* drop down list.
7. Enter "urban_map1" in the *Prefix* box, then click **Update**. Note that the default prefix for output files is now updated.
8. Enter "urban_rain1.dat" in the *Rain* file box.
9. Enter "\MODRAT\lasoilx_100.dat" in the *Soil* file box.
10. Select **OK**.

5.2 Tree Numbering

Each basin or reach is assigned a default name when it is created by WMS. However, these must be named and numbered in sequential order from upstream to downstream using a MODRAT naming convention so that MODRAT analyzes the model in the proper order.

1. Select the **Select Basin** tool.
2. Click on the brown square sub-basin icon at the northernmost sub-basin in the watershed.
3. Select *MODRAT* **| Number Tree…**
4. Select **OK** to start numbering with location/lateral of 1A.
5. As the numbering process proceeds users will be prompted to "Select a lateral" for each of the basins at a confluence. Notice that WMS first zooms into the basin labeled 4B and its surrounding outlet points. Since the outlet points upstream from basin 4B could be located on either the "A" or "B" lateral (users can determine the

lateral because the upstream outlets end with both "A" and "B"), users can assign either lateral. Select the default "A" lateral and select **OK**.

6. Right-click on the “Drainage” coverage in the Project Explorer and select **Zoom To Layer**.

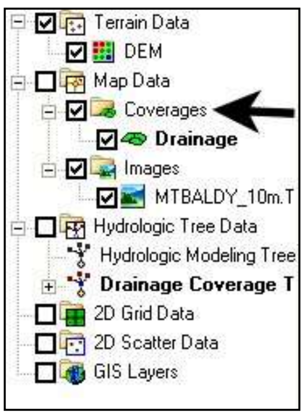
The numbering is now complete. Note that the basin selected when the numbering started is now labeled 1A. The main line is met by Line B at the confluence (outlet) point labeled 8AB. The numbers indicate the order in which the units will be processed by MODRAT.

6 MODRAT Basin Data Setup

Each basin in the watershed requires a number of input parameters. Many of the parameters can be computed by WMS using GIS data layers. The following sections will compute Soil Number, % Impervious, and Rainfall Depth for each basin.

6.1 Soil Number Computation

Users will load soil data for Los Angeles County and let WMS compute the dominant soil type for each basin.



1. Right-click on the “Coverages” folder in the “Map Data” section of the Project Explorer.
2. Choose **New Coverage** in the pop-up menu.
3. Select “Soil Type” as the *Coverage Type* in the *Properties* window.
4. Select **OK**.
5. Switch to the **GIS** module.
6. Select *Data* **| Add Shapefile Data…**
7. In the *Select shapefile* dialog, open *“*soils_2004.shp*”* – the soil map for all of L.A. County will be loaded.
8. Right-click on the “Drainage” coverage in the Project Explorer and select **Zoom To Layer**.
9. Select the “Soil Type” coverage.
10. Switch back to the **GIS** module.
11. Choose the **Select Shapes** tool.
12. Drag a selection box around the watershed extents – the soil polygons covering the watershed will be selected.
13. Select *Mapping* **| Shapes → Feature Objects**.
14. In the *GIS to Feature Objects Wizard*, select **Next**.
15. Make sure the *CLASS* field is mapped to the “LA County soil type” attribute.
16. Select **Next**.
17. Select **Finish**.
18. Hide the “soils_2004.shp” file by toggling off its check box in the Project Explorer.

Now that the soil data is loaded, do the following to compute and assign the soil numbers to MODRAT.

19. Select the "Drainage" coverage in the Project Explorer to designate it as the active coverage.
20. Switch to the **Hydrologic Modeling** module.
21. Select *MODRAT* | **Map Attributes…**
22. In the *Map MODRAT Attributes* dialog, select "LA County soil numbers" as the *Computation type*.
23. Select **OK**.
24. Once the computation is finished, double-click on any brown basin icon to bring up the *MODRAT Parameters* dialog and view the Soil type assigned.
25. Click **OK** to exit the *MODRAT Parameters* dialog.

6.2 % Impervious Computation

Users will now load land use data for Los Angeles County and let WMS compute the average % impervious for each basin.

1. Right-click on the "Coverages" folder in the "Map Data" section of the Project Explorer.
2. Choose **New Coverage** in the pop-up menu.
3. Select "Land Use" as the *Coverage Type* in the *Properties* dialog.
4. Select **OK**.
5. Switch to the **GIS** module.
6. Select *Data* | **Add Shapefile Data…**
7. In the *Select shapefile* dialog, open *"*ladpw_landuse_2005.shp*"* – the land use map for all of L.A. County will be loaded.
8. Right-click on the "Drainage" coverage in the Project Explorer and select **Zoom To Layer**.
9. Select the "Land Use" coverage.
10. Switch back to the **GIS** module.
11. Choose the **Select Shapes** tool.
12. Drag a selection box around the watershed extents – the land use polygons covering the watershed will be selected.
13. Select *Mapping* | **Shapes** → **Feature Objects**.
14. In the *GIS to Feature Objects Wizard*, select **Next**.
15. Make sure the *IMPERV* field is mapped to the "Percent impervious" attribute. Scroll to the right to view this field.
16. Select **Next**.
17. Select **Finish**.

18. Hide the "ladpw_landuse_2005.shp" file by toggling off its check box in the Project Explorer.

Now that the land use data is loaded, do the following to compute and assign the % impervious to MODRAT.

19. Select the "Drainage" coverage in the Project Explorer to designate it as the active coverage.
20. Switch to the **Hydrologic Modeling** module.
21. Select *MODRAT* **| Map Attributes…**
22. In the *Map MODRAT Attributes* dialog, select "LA County land use" as the *Computation type*.
23. Select **OK**.
24. Once the computation is finished, double-click on any brown basin icon to bring up the *MODRAT Parameters* dialog and view the % Impervious assigned.
25. Click **OK** to exit the *MODRAT Parameters* dialog.

6.3 Rainfall Depth & Distribution Assignment

Users will now load a rainfall depth grid for the 25-year storm frequency for Los Angeles County and let WMS compute the average rainfall depth for each basin. Then users will assign a rainfall mass curve to the model to provide the temporal distribution of the storm depth.

1. Switch to the **Drainage** module.
2. Select *File* **| Open…** .
3. The *Open* dialog will appear. Change the File Type filter to "Rainfall Depth Grid (*.*)".
4. Open the file named *"*lac25yr24hr.asc*"* – the rainfall grid will be opened and displayed.
5. Right-click on the "Drainage" coverage in the Project Explorer and select **Zoom To Layer**.
6. Switch to the **Hydrologic Modeling** module.
7. Select *Calculators* **| Compute GIS Attributes…**
8. In the *Compute GIS Attributes* dialog, select "Rainfall Depth" as the *Computation*.
9. Select **OK**.
10. Double-click on the basin labeled 1A to bring up the *MODRAT Parameters* window and view the Rainfall Depth assigned.
11. Choose *Show*: "All" in the upper right corner of the dialog.
12. In the Temporal distribution column click on the **Define…** button in the All row (colored yellow) of the spreadsheet. This will bring up a window where users will specify the rainfall temporal distribution (time vs. cumulative rainfall percentage).
13. Select the **Import** button in the *XY Series Editor*.
14. From the *Open File* dialog, open the file named "LACDPWStorm-4thday.xys".

15. The Selected Curve in the *XY Series Editor* should now read “LACDPWStorm-4thday” and the rainfall mass curve displayed.
16. Select **OK**.
17. Select **OK**.

The process above has assigned a rainfall depth to each basin and also assigned the LACDPW storm distribution curve to all basins. By selecting the curve for one basin, WMS will assign it to all basins if the working model is a MODRAT model. This is a shortcut built into the MODRAT interface.

Clean up the display of the model by turning off several layers now that they have been used and are not needed:

18. Hide the “Soil Type Map Coverage” file by toggling off its check box in the Project Explorer.
19. Hide the “Land Use Map Coverage” file by toggling off its check box in the Project Explorer.
20. Hide the “Rain Fall Grid” file by toggling off its check box in the Project Explorer.

6.4 Time of Concentration

The final parameter needed for each basin in the model is the Time of Concentration. Users will specify the longest flow path in each basin and then let WMS compute the T_c using the LACDPW regression equation. Do the following to compute T_c for all basins:

1. Right-click on the “Coverages” folder in the “Map Data” section of the Project Explorer.
2. Choose **New Coverage** in the pop-up menu.
3. Select “Time Computation” as the *Coverage Type* in the *Properties* window.
4. Select **OK**.
5. Select *Display* **| Display Options…** to open the *Display Options* dialog.
6. On the *Drainage Data* tab, make sure *Basin Areas* is toggled off.
7. Select **OK**.
8. Select the **Create Feature Arc** tool.
9. Digitize the longest flow paths as shown in the figure below by clicking near the outlet in each basin, clicking along the path shown, and double-clicking at the upstream end to complete the arc. **Do not cross any basin boundary with these flow path arcs – each is a separate arc contained within each basin.**

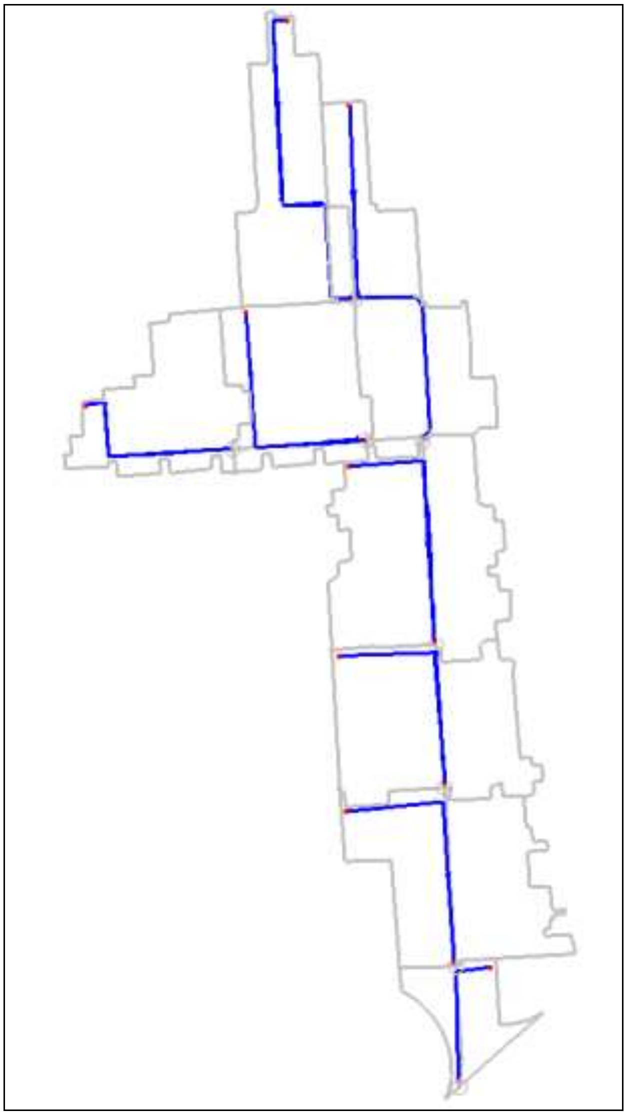


Figure 5 Watershed Tc arcs

10. Click on the "Drainage" coverage in the Project Explorer to make it the active coverage.
11. Switch to the **Hydrologic Modeling** module.
12. Select *MODRAT* **| Compute Tc…**
13. The *Compute MODRAT Time of Concentration Wizard* will appear. Note that a check of required input for T_c computations has been performed. Click **Next** in the Compute MODRAT T_c Wizard.
14. Review the T_c computed for each basin.
15. Select **Done**.
16. Once the computation is finished, double-click on any brown sub-basin icon to bring up the *MODRAT Parameters* dialog and view the Tc assigned.
17. Select **OK** to exit the *MODRAT Parameters* dialog.

The input parameters for all basins should now be entered for the simulation. Save this data to the working project file.

18. Select *File* | **Save** .

WMS will overwrite the previous files with the updated data users have entered.

7 MODRAT Reach/Outlet Data Setup

Each reach must have data associated with it to be successfully simulated by MODRAT. Reaches are selected in WMS by clicking on an outlet (confluence) point. The parameters for that point and the channel downstream from that point to the next can be edited.

1. Double-click the outlet labeled 2A at the upper end of the main channel – this will load the parameters for that reach into the *MODRAT Parameters* window for review/editing.
2. Note that *Length* and *Slope* have been computed and are entered in the *MODRAT Parameters* window.
3. Select "Street" under *Routing type*, then enter "40" ft for *Size* and "6" for *Curb height*.
4. Choose "Hydrograph (*.HYF) and WMS plot file (*.SOL)" in the *Input/Output Options*.

Users have now completed the input for one of the reaches in the watershed. Users will need to define data for all reaches in a similar fashion:

5. Repeat the steps for all reaches, using the table below to fill in values. To view the full table select *Show*: "All".

Reach Name	n	Channel	Var1	Output
5B	0.014	Street	30' – 6"	HYF/SOL
7B	0.014	Street	30' – 6"	HYF/SOL
8AB	0.014	Street	40' – 6"	HYF/SOL
10A	0.014	Street	40' – 6"	HYF/SOL
12A	0.014	Street	64' – 6"	HYF/SOL
14A	0.014	Street	64' – 6"	HYF/SOL
16A	-	Variable	-	HYF/SOL

6. When users are finished entering the parameters choose **OK** in the *MODRAT Parameters* dialog.

The input parameters for all reaches should now be entered for the simulation. Save this data to the working project file.

7. Select *File* | **Save** .

WMS will overwrite the previous files with the updated data users have entered.

8 Running a MODRAT Simulation

All the data required to run a simulation is now ready.

1. Select *MODRAT* | **Run Simulation…**
2. Review the *Input File*. It should be named *"*urban_map1.lac*"*.
3. Ensure that the *Save file before run* toggle is checked.

4. Ensure that the *Prefix* for output files box contains “urban_map1”.
5. Click **OK** to start the simulation.

A window will appear and report the progress of the MODRAT simulation. At the end of the simulation, do the following to return to WMS and view the results of the simulation:

6. Verify that “End of MODRAT” is displayed in the model run window.
7. Select **Close** once MODRAT finishes running (wait a few seconds to a minute or so).

The resulting hydrographs will be read in and a small hydrograph plot will appear next to each basin and outlet.

8. Double-click on the hydrograph icon next to outlet labeled 16A.
9. Review the hydrograph plot that appears in a new plot window.
10. Close the plot window by clicking on the X in the upper right corner.
11. Select *File* **| Edit File…**
12. In the *Open* dialog, find and open the file named “urban_map1.out”.
13. Confirm opening the file with Notepad, if prompted.
14. Review the text summary output of the simulation.
15. Close the file by clicking on the X in the upper right corner of the Notepad window.

Users have successfully completed a simulation with MODRAT. There are many other options in the MODRAT model that were not included in this simple model.

9 Conclusion

In this exercise, users have learned to import watershed data from shapefiles in order to create a watershed in the Map Module of WMS. Users should also have learned to correlate imported data with a DEM of the same area, and how to complete a MODRAT simulation on a watershed created in the Map Module.

