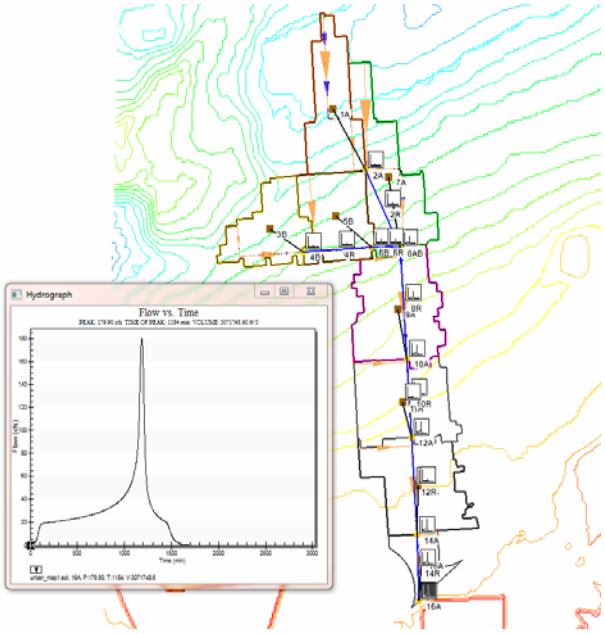
WMS

v. 8.4

WMS 8.4 Tutorial

Watershed Modeling – MODRAT Interface (Map-based)

Build a MODRAT model for an urban watershed using GIS data



Objectives

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

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1 Contents

2 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.

3 Objectives

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

4 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. Switch to the *GIS* module  .
2. Select ***Data | Add Shapefile Data….***
3. Find and open "*urban_poly.shp*" – you will see the basin boundary polygons displayed.

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4. Select ***Data*** **|** ***Add Shapefile Data…***.
5. Find and open "*urban_arc.shp*" – you will see the stream network displayed.
6. Select ***Data*** **|** ***Add Shapefile Data…***.
7. Find and open "*urban_pt.shp*" – you will see the outlet points displayed.

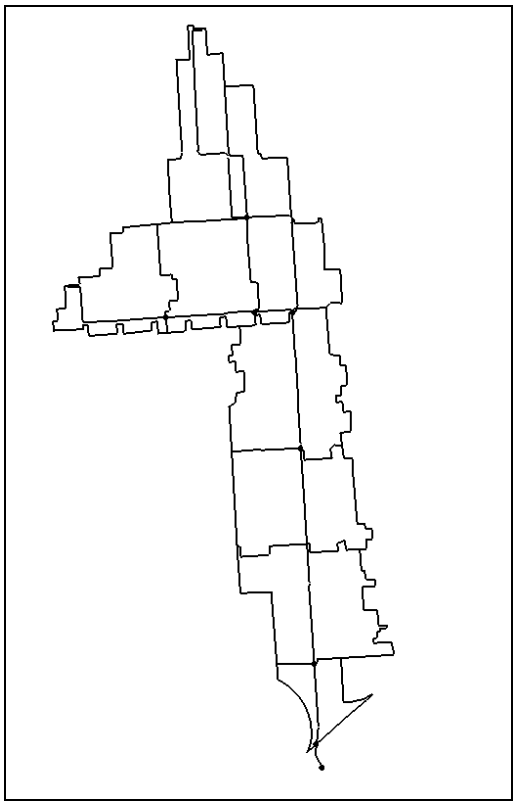

Figure 4-1: Display of watershed data in the GIS Module

4.1 Map GIS Data to Feature Objects

1. Select ***Mapping*** **|** ***Shapes -> Feature Objects.***
2. Select *Yes* at the prompt to use all visible shapes for mapping.
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.

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7. Click *Finish.*

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

8. Toggle off the display of the GIS Layers in the Project Explorer – you will now see the Map Module data more clearly.

5 Watershed Data Cleaning and DEM Matching

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

5.1 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 5-1.

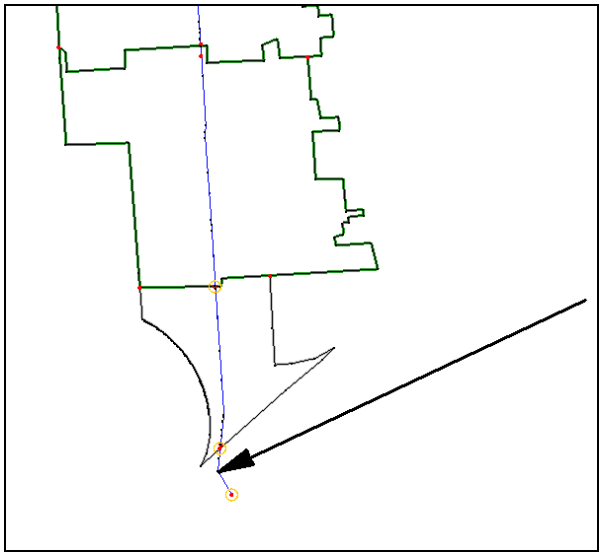

Figure 5-1: Select extra stream arc

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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 5-2.

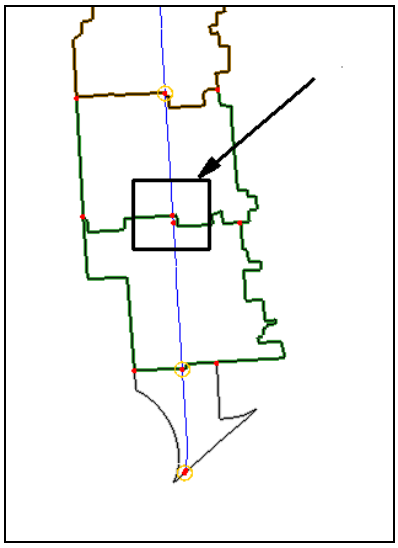

Figure 5-2: Zoom to specified area

9. Select the *Select Feature Point/Node* tool .
10. Click on the node shown in Figure 5-3 below to select it.

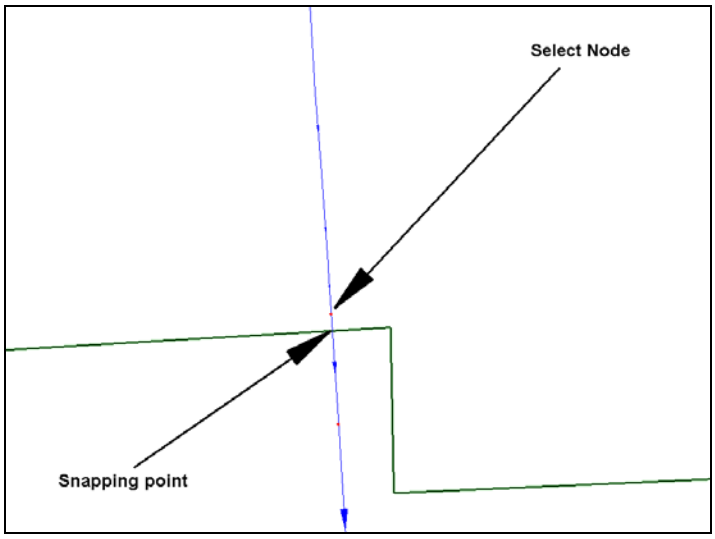

Figure 5-3: Node snapping

11. Select ***Feature Objects | Clean….***
12. Ensure that *Snap selected nodes* is check and all other options are unchecked.
13. Click *OK*.

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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 5-3 – 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. Choose *Drainage outlet* and click *OK.*
18. Click on the *Frame* macro .

You 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. You will now read in the DEM for this area and correlate the watershed data to it.

5.2 Matching DEM Data

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

1. Select ***File* | *Open…*** .
2. 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 Coordinates…* button in the Units dialog.
8. Select the ***Global projection*** option and set the Horizontal System to *State Plane Coordinate System, California Zone 5 (FIPS 405), NAD83, FEET (U.S. Survey).* Select OK to save changes and close the Select Projection dialog.
9. Set the Vertical System to Projection: *Local* and Units: *U.S. Survey Feet*.
10. Click *OK.*
11. Set Basin Areas to *Acres* and ensure that Distances is set to *Feet.*
12. Click *OK* in the Units dialog.
13. Click *OK* in any warning messages that appear.
14. The basin areas should now be displayed. To make the display clearer choose ***Display* | *Display Options…*** .
15. On the *DEM Data* tab, toggle OFF all items except *DEM Contours.*
16. On the *Drainage Data tab*, toggle OFF *Basin Areas.*
17. Click *OK.*

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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 your project to the hard drive before continuing. Save this data to a WMS project file:

18. Select ***File | Save As…*** .
19. Enter "*Urban_map.wms*" and click *Save.*

WMS will save your 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 you open your project at a later time.

6 MODRAT Global Setup

The MODRAT analysis setup requires you 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 you in entering data and using GIS data layers to acquire input data for MODRAT.

6.1 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 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 *"C:\Program Files\WMS84\tutorial\MODRAT\lasoilx_100.dat"* in the Soil file box.
10. Select *OK.*

6.2 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.

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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 you 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 (you can determine the lateral because the upstream outlets end with both "A" and "B"), you 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***.

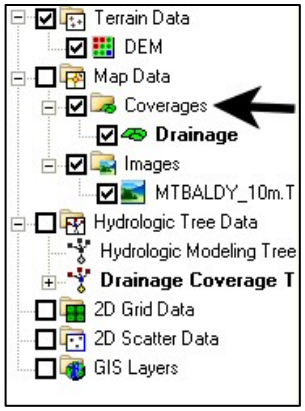
The numbering is now complete. Note that the basin selected when the numbering started is now labeled 1A. The main line is met by Line B at the confluence (outlet) point labeled 8AB. The numbers indicate the order in which the units will be processed by MODRAT.

7 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.

7.1 Soil Number Computation

You 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. 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 .

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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. 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. 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.

7.2 % Impervious Computation

You 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. 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.

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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. Select *Next.*
15. Make sure the IMPERV field is mapped to the *Percent impervious* attribute.
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. 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.

7.3 Rainfall Depth & Distribution Assignment

You 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 you 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. 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.

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7. Select ***Calculators | Compute GIS Attributes….***
8. 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 you will specify the rainfall temporal distribution (time vs. cumulative rainfall percentage).
13. Select the *Import* button in the XY Series Editor.
14. 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 your 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.

7.4 Time of Concentration

The final parameter needed for each basin in the model is the Time of Concentration. You 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…***  .

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6. On the *Drainage Data* tab, toggle OFF *Basin Areas.*
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.**

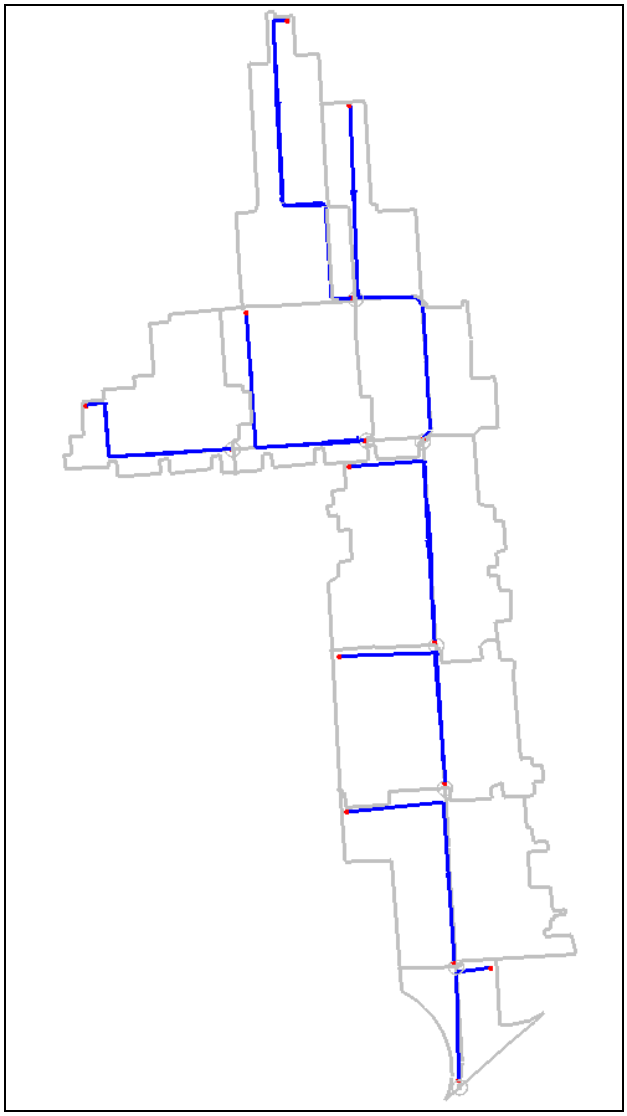

Figure 7-1: Watershed Tc arcs

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….***

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13. 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 your working project file.

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

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

8 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, Size = 40 ft, Curb height = 6 in as the Routing type.
4. Choose *Hydrograph (*.HYF) and WMS plot file (*.SOL)* in the Input/Output Options.

You have now completed the input for one of the reaches in the watershed. You 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.

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 you are finished entering the parameters choose *OK* in the MODRAT Parameters dialog.

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

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

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

9 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 (you may have to 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. Find and open the file named "*urban_map1.out*".
13. Confirm that you want to open 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.

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

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