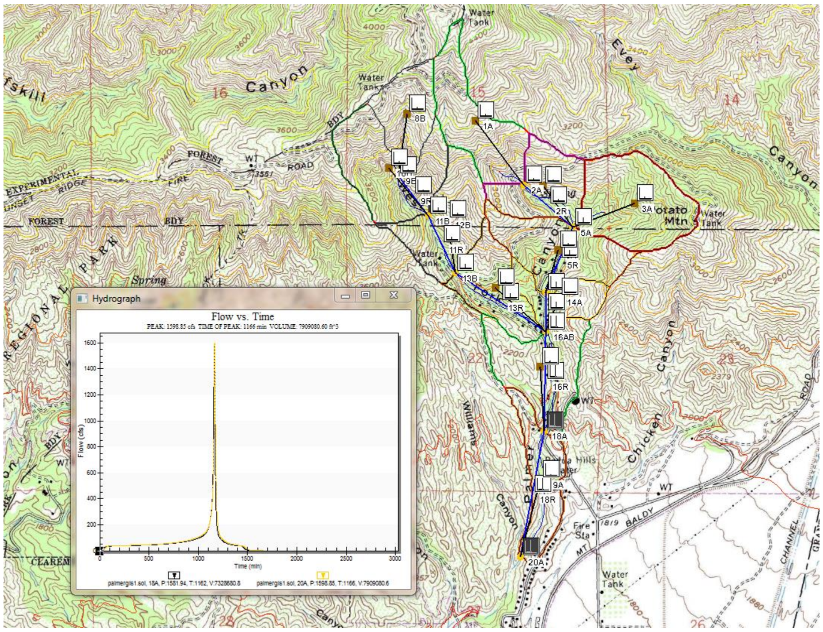
v. 10.1

WMS 10.1 Tutorial

Watershed Modeling – MODRAT Interface (GIS-based)

Delineate a watershed and build a MODRAT model



Objectives

Learn to delineate a watershed from a DEM and derive many of the MODRAT input parameters from the delineated watershed. Learn to use soil and land use GIS data to derive soil number and impervious values. Learn to compute sub-basin time of concentrations from the LACDPW regression equation and rainfall depths using digital rainfall grids. Learn to define reach and reservoir hydrologic routing and run a MODRAT model.

Prerequisite Tutorials

- Watershed Modeling – DEM Delineation

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models

Time

- 30–60 minutes

1 Introduction

WMS has a graphical interface for the Los Angeles County Department of Public Works (LACDPW) Modified Rational (MODRAT) model. Geometric attributes such as areas, lengths, and slopes are computed automatically from the digital watershed. Parameters such as soil numbers, impervious percentages, and routing data are entered through a series of interactive dialog boxes.

Once the parameters needed to define an MODRAT model have been entered, an input file with the proper format for MODRAT can be written automatically. Since only parts of the MODRAT input file are defined in this tutorial, feel free to explore the different available options of each dialog, being sure to select the given method and values before exiting the dialog.

A project containing a delineated watershed will be imported. This tutorial will discuss and demonstrate deriving a simple watershed model from the parameters of the imported project and developing soil number and impervious values from land use and soil shape files.

Time of concentration will be computed using the LACDPW regression equation. Rainfall depths will be computed from digital rainfall grids for Los Angeles County. After establishing the initial MODRAT model, other variations will be developed, including defining reach routing and including a reservoir with storage routing.

2 Getting Started

Starting WMS new at the beginning of each tutorial is recommended. This resets the data, display options, and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **No** to clear all data.

The graphics window of WMS should refresh to show an empty space.

2.1 Importing the Project

Now import a project file with the delineated watershed. The Palmer Canyon watershed was delineated from a 10 meter resolution DEM file.

1. Click **Open** to bring up the *Open* dialog.
2. Select "WMS XMDF Project File (*.wms)" from the *Files of type* drop-down.
3. Browse to the *MODRAT\MODRAT* directory and select "PalmerCyn25_GIS.wms".
4. Click **Open** to import the project and exit the *Open* dialog.
5. If asked to generate image pyramids, click **Yes**.
6. Right-click on " Drainage" and select **Zoom to Layer**.

The Main Graphics Window should appear similar to Figure 1.

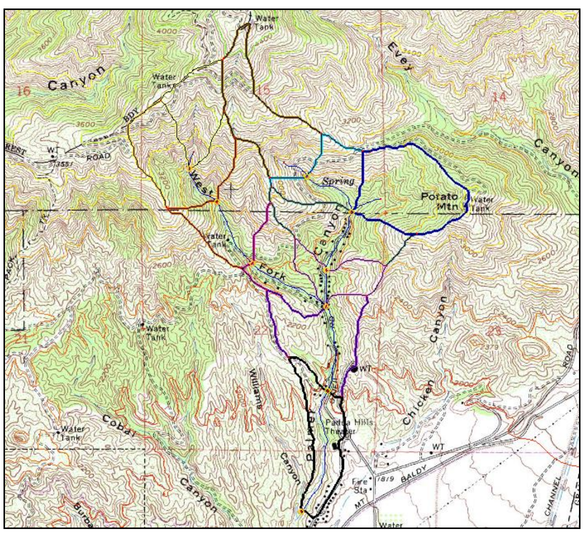


Figure 1 The Palmer Canyon watershed

3 MODRAT Global Setup

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

3.1 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 not specific to any basin or reach in the model that control the overall simulation. These parameters are defined in the WMS interface using the *MODRAT Job Control* dialog.

1. Switch to the **Hydrologic Modeling** module.
2. Turn off " MTBALDY.tif" in the Project Explorer to make the watershed basin easier to see.
3. Select "MODRAT" from the Model drop-down (Figure 2).

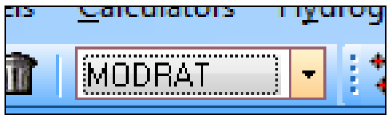


Figure 2 Model drop-down

4. Select *MODRAT* | **Job Control…** to bring up the *MODRAT Job Control* dialog.
5. In the left section, select *MODRAT 2.0*.
6. Select "2" from the *Run time* drop-down.
7. Select "25 year" from the *Storm Frequency* drop-down.
8. In the *Filenames* section, enter "palmergis1" as the *Prefix* and click **Update**.
9. Notice that the *Output files prefix* updated to match.
10. In the *Input* section, enter "palmergis_rain.dat" as the *Rain*.
11. Click **Browse** to the right of *Soil* to bring up the *Open* dialog.
12. Select "sgr_soilx_71.dat" and click **Open** to exit the *Open* dialog.
13. Click **OK** to close the *MODRAT Job Control* dialog.

3.2 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. Using the **Select Basin** tool, select the most upstream basin (Figure 3).

Selecting this basin defines the upstream end of the main line of the watershed.

2. Select *MODRAT* | **Number Tree** to bring up the *MODRAT Renumber* dialog.
3. Click **OK** to close the *MODRAT Renumber* dialog and open the *Select a lateral* dialog.
4. Select "A" from the wide drop-down and click **OK** to close the *Select a lateral* dialog and open another *Select a lateral* dialog.

Since the outlet point upstream from this basin is located on the "A" lateral (this can be determined because the upstream outlet name ends with "A"), the first basin should be assigned to the "A" lateral.

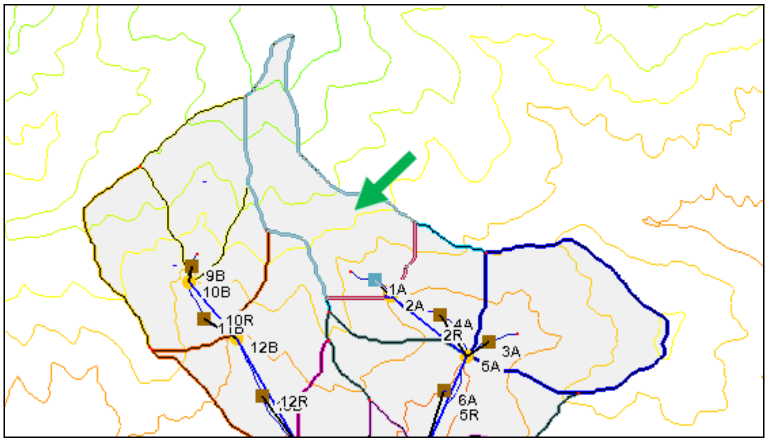


Figure 3 The most upstream basin (indicated by the arrow)

5. Select "B" from the wide drop-down and click **OK** to close the *Select a lateral* dialog.

Since the outlet point upstream from this basin is located on the "B" lateral (determined because the upstream outlet name ends with "B"), this basin should be assigned to the "B" lateral of the watershed.

6. Right-click on " Drainage" in the Project Explorer and select **Zoom To Layer**.
7. Switch to the **Hydrologic Modeling** module.

The renumbering is now complete (Figure 4). Note that the selected basin is now "1A". The main line is met by Line B at the "16AB" confluence (outlet) point. The numbers now indicate the correct order in which the units will be processed by MODRAT.

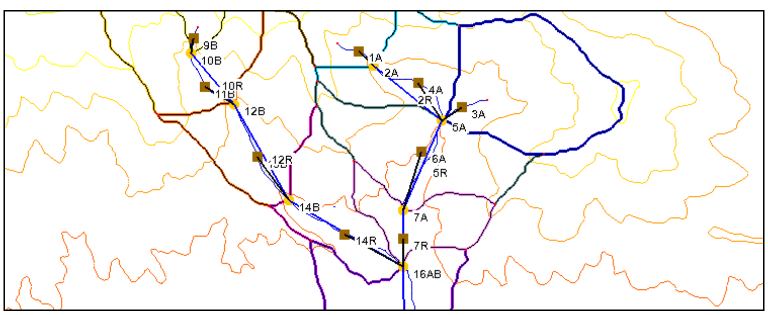


Figure 4 The upper watershed showing renumbering completed

4 MODRAT Basin Data Setup

Each basin in the watershed requires a number of input parameters. Many of these can be computed using tools in WMS.

4.1 Basin Data Parameters

1. Using the **Select basin** tool, double-click on basin "1A" to bring up the *MODRAT Parameters* dialog.

Double-clicking on a basin or outlet icon brings up the parameter editor dialog for the current model (in this case, MODRAT)

2. Notice that the area has been calculated, but all other parameters are empty.
3. Click **OK** to exit the *MODRAT Parameters* dialog.

Many of the parameters can be computed by WMS using GIS data layers. The following sections will compute the soil type, how impervious it is to flow, and the rainfall depth for each basin.

4.2 Importing a Soil Data Shapefile

1. Right-click on " Coverages" under " Map Data" in the Project Explorer and select **New Coverage** to bring up the *Properties* dialog.
2. Select "Soil Type" from the *Coverage Type* drop-down and click **OK** to close the *Properties* dialog.
3. Switch to the **GIS** module.
4. Select *Data* | **Add Shapefile Data…** to bring up the *Select shapefile* dialog.
5. Browse to the *MODRAT\MODRAT\SoilType* folder and select "soils_2004.shp".
6. Click **Open** to import the soil map for all of Los Angeles County (Figure 5) and exit the *Select shapefile* dialog.

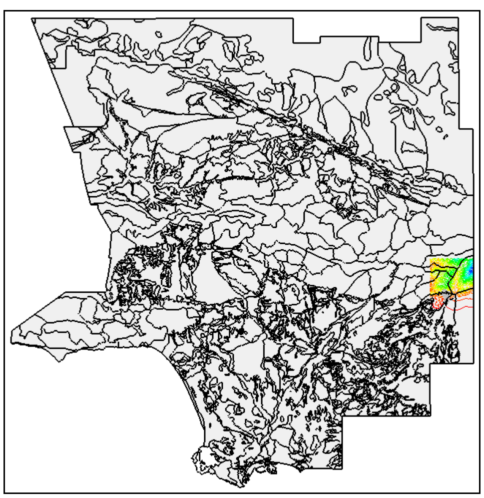


Figure 5 L.A. County soil map

7. Right-click on " Drainage" in the Project Explorer and select **Zoom To Layer**.
8. Select " Soil Type" to make it active.
9. Switch to the **GIS** module.
10. Using the **Select Shapes** tool, drag a selection box (Figure 6) around the watershed extents to select the soil polygons covering the watershed .

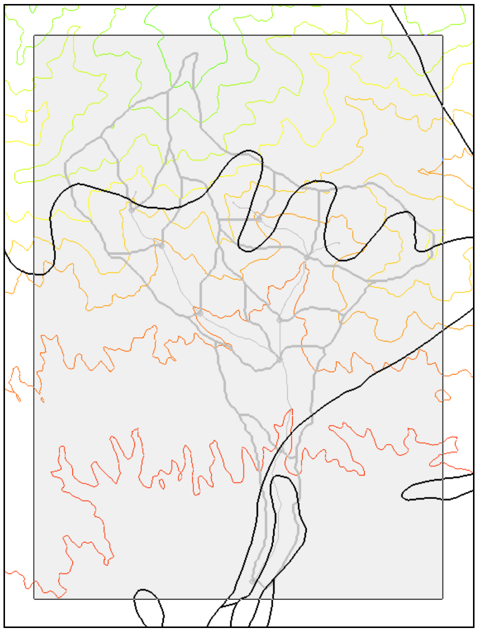


Figure 6 Select the watershed extents

11. Select *Mapping* | **Shapes → Feature Objects** to bring up the G*IS to Feature Objects Wizard* dialog.
12. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
13. In the *Mapping Preview* section, select "LA County soil type" from the drop-down on the *Mapping* row in the *CLASS* column.
14. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
15. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.
16. Turn off " soils_2004.shp" in the Project Explorer.

4.3 Computing and Assigning Soil Numbers

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

1. Select " Drainage" in the Project Explorer to make it active.
2. Switch to the **Hydrologic Modeling** module.
3. Select *MODRAT* | **Map Attributes…** to bring up the *Map MODRAT Attributes* dialog.
4. Select "LA County soil numbers" from the *Computation type* drop-down.
5. Click **OK** to close the *Map MODRAT Attributes* dialog.
6. Using the **Select basin** tool, double-click on basin "1A" to bring up the *MODRAT Parameters* dialog.
7. Notice that the *Soil type* column has been populated on the *1A* row.

8. Click **OK** to exit the *MODRAT Parameters* window.

Feel free to repeat steps 6-8 for any other basin to view the *Soil type* assignment for that basin.

4.4 Percent Impervious Computation

Now load land use data for Los Angeles County and let WMS compute the average percent impervious for each basin.

1. Right-click on " Coverages" under " Map Data" in the Project Explorer and select **New Coverage** to bring up the *Properties* dialog.
2. Select "Land Use" from the *Coverage Type* drop-down and click **OK** to close the *Properties* dialog.
3. Switch to the **GIS** module.
4. Select *Data* | **Add Shapefile Data…** to bring up the *Select shapefile* dialog.
5. Browse to the *MODRAT\MODRAT\LandUse* folder and select "ladpw_landues_2005.shp".
6. Click **Open** to import the shapefile and close the *Select shapefile* dialog.

This loads the land use map for all of Los Angeles County.

7. Right-click on " Drainage" and select **Zoom To Layer**.
8. Select " Land Use" to make it active.
9. Switch to the **GIS** module.
10. Using the **Select Shapes** tool, drag a selection box around the watershed extents to select the land use polygons covering the watershed.
11. Select *Mapping* | **Shapes → Feature Objects** to bring up the *GIS to Feature Objects Wizard* dialog.
12. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
13. Scroll to the right and select "Percent Impervious" from the drop-down in the *IMPERV* column on the *Mapping* row.
14. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
15. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.
16. Turn off " adpw_landuse_2005.shp" in the Project Explorer.

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

17. Select " Drainage" in the Project Explorer to make it active.
18. Switch to the **Hydrologic Modeling** module.
19. Select *MODRAT* | **Map Attributes…** to bring up the *Map MODRAT Attributes* dialog.

20. Select "LA County land use" from the *Computation type* drop-down and click **OK** to close the *Map MODRAT Attributes* dialog.
21. Once the computation is finished, use the **Select basin** tool to double-click on any sub-basin icon to bring up the *MODRAT Parameters* dialog and view the value in the *Impervious %* column.
22. Click **Cancel** to exit the *MODRAT Parameters* window when done.

4.5 Rainfall Depth and Distribution Assignment

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

1. Switch to the **Drainage** module.
2. Click **Open** to bring up the *Open* dialog.
3. Select "Rainfall Depth Grid (*.*)" from the *Files of type* drop-down.
4. Browse to the *MODRAT\MODRAT* folder and select "lac25yr24hr.asc".
5. Click **Open** to exit the *Open* dialog and import the rainfall depth file.

Notice the new " Rain Fall" entry under the " Grid" folder under the " Map Data" folder in the Project Explorer.

6. Right-click on " Drainage" and select **Zoom To Layer**.
7. Switch to the **Hydrologic Modeling** module.

The Graphics Window should appear similar to Figure 7.

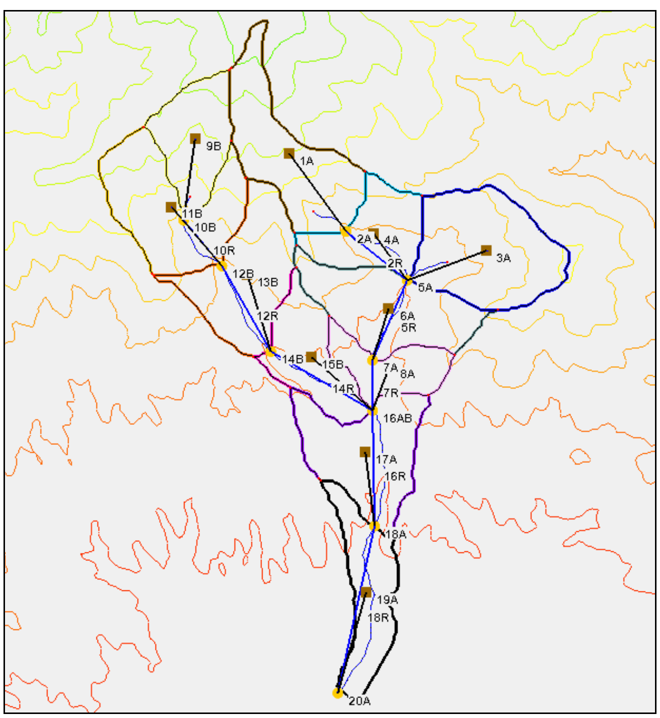


Figure 7 After importing the rainfall depth grid

8. Select *Calculators* | **Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
9. In the *Computation* section, select "Rainfall Depth" and click **OK** to close the *Compute GIS Attributes* dialog.
10. Using the **Select Basin** tool, double-click on basin "1A" to bring up the *MODRAT Parameters* dialog.
11. Select "All" from the *Show* drop-down.
12. In the *Temporal distribution* column in the *All* row, click **Define…** to bring up the *XY Series Editor* dialog.

This dialog allows the rainfall temporal distribution (time vs. cumulative rainfall percentage) to be specified.

13. Click **Import…** to bring up the *Open File* dialog.
14. Select "LACDPWStorm-4thday.xys" and click **Open** to import the file and exit the *Open File* dialog.

The *Selected Curve* drop-down should have "LACDPWStorm-4thday" selected, and the rainfall mass curve is displayed (Figure 8).

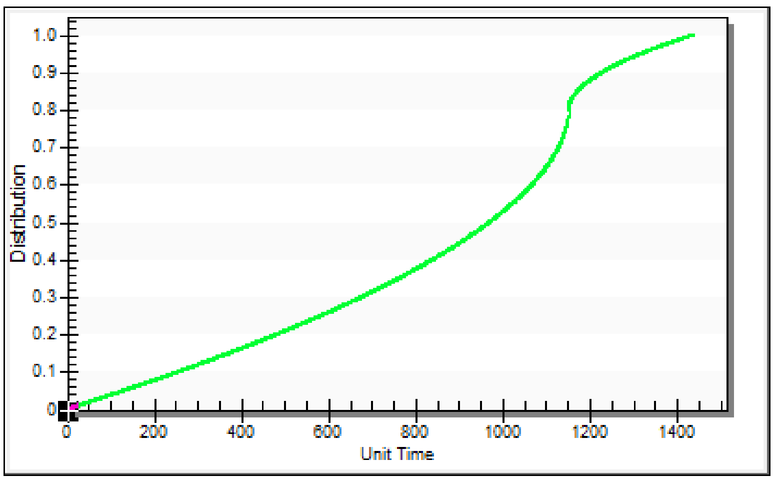


Figure 8   LACDPW storm distribution curve

15. Click **OK** to close the *XY Series Editor* dialog.
16. Click **OK** to close the *MODRAT Parameters* dialog.

This process assigned a rainfall depth to each basin and also assigned the LACDPW storm distribution curve to all basins. Next, clean up the display of the model by turning off several layers now that they have been used and are not needed:

17. Turn off " Soil Type", " Land Use", and " Rain Fall" in the Project Explorer.

4.6 Time of Concentration

The final parameter needed for each basin in the model is the Time of Concentration (Tc). WMS has the LACDPW T_C equation method built in and linked to GIS data capabilities. Do the following to compute T_C for all basins.

1. Switch to the **Drainage** module.
2. Select *DEM* | **Compute Basin Data** to bring up the *Units* dialog.
3. Click **Drain Data Compute Opts...** to bring up the *Drainage Data Computation Options* dialog.
4. At the bottom of the dialog, turn on *Create Tc Coverage*.
5. Click **OK** to close the *Drainage Data Computation Options* dialog.
6. Click **OK** to close the *Units* dialog.

Note that the basin data is recomputed and the basin area is displayed. There is also a new " Time Computation" coverage containing the longest flow path of each basin.

7. Click **Display Options** to open the *Display Options* dialog.
8. Select "Drainage Data" from the list on the left.
9. On the *Drainage Data* tab, turn off *Basin Areas*.
10. Click **OK** to close the *Display Options* dialog.
11. Select " Drainage" to make it active.
12. Switch to the **Hydrologic Modeling** module.
13. Select *MODRAT* | **Compute Tc…** to bring up the *Step 1 of 2* page of the *Compute MODRAT Time of Concentration Wizard* dialog.
14. In the *LACDPW TC Equation – check required input parameters* section, notice that a check of required input for T_C computations has been performed.
15. Click **Next** to go to the *Step 2 of 2* page of the *Compute MODRAT Time of Concentration Wizard* dialog.
16. In the *Time of concentration results* section, review the values in the *TC (min)* column for each basin, then click **Done** to close the *Compute MODRAT Time of Concentration Wizard* dialog.

Review the T_C by using the **Select basin** tool to double-click on the desired basin to bring up the *MODRAT Parameters* dialog. Review any basin this way.

The input parameters for all basins have now been entered for the simulation. Now save this data to the working project file.

17. **Save** the project.
18. Click **No** if asked to save image files in the project directory.

5 MODRAT Reach and Outlet Data Setup

Each reach must have data associated with it to be successfully simulated by MODRAT. The *MODRAT Parameters* dialog allows editing of parameters for that point, and the channel downstream from that point to the next.

1. Using the **Select outlet** tool, double-click outlet "2A" to bring up the *MODRAT Parameters* dialog.

Notice that *Length (ft)* and *Slope (ft/ft)* have been computed already.

2. In the *Routing type* column, select "Mountain" from the drop-down

Notice that the *Manning's n* field becomes inactive.

3. Scroll to the right to the *Hydrograph output* column and select "Hydrograph (*.hyf) and WMS plot file (*.sol)" from the drop-down.

The input for one of the reaches in the Palmer Canyon watershed has now been completed. Now define data for all the reaches in a similar fashion:

4. Select "All" from the *Show* drop-down to make all outlets visible in the spreadsheet.
5. Use the table below to enter the values for the remaining outlets:

Name	Routing type	Manning's n	Hydrograph Output
2A	Mountain		HYF/SOL
5A	Valley		HYF/SOL
7A	Valley		HYF/SOL
10B	Mountain		HYF/SOL
12B	Mountain		HYF/SOL
14B	Valley		HYF/SOL
16AB	Valley		HYF/SOL
18A	Valley		HYF/SOL
20A	Variable	0.014	HYF/SOL

6. When finished entering the parameters, click OK to close theMODRAT Parameters dialog.

The input parameters for all reaches should now be entered for the simulation. Note that outlet "20A", the most downstream outlet, does not need a length or slope defined since it is at the downstream end of the watershed.

7. Save the project.
8. Click **No** if asked to save image files to the project directory.

6 Running a MODRAT 2.0 Simulation

All the data required to run a simulation is now ready. To make sure there are no omissions in the data, perform a model check.

1. Select *MODRAT* | **Check Simulation…** to bring up the *MODRAT Model Check* dialog.
2. Review the model check report, noting that there are two possible errors in the MODRAT model.

Because outlet "20A" is the watershed outlet, no reach downstream needs to be defined.

3. Click **Done** to exit the *MODRAT Model Check* dialog.

The model checker is a simple way to verify that all required data has been included. It does not verify that the model is correct, but that all the data needed to run the simulation is in place.

To execute the MODRAT simulation, do the following:

4. Select *MODRAT* | **Run Simulation…** to bring up the *MODRAT Run Options* dialog.
5. The *Input File* should be named "palmergis1.lac" (scroll to the right in the path field to verify the file name is correct).
6. Turn on *Save file before run* and click **OK** to close the *MODRAT Run Options* dialog and open the *Model Wrapper* dialog.
7. Once MODRAT finishes, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog and import the solutions.

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

8. Using the **Select hydrograph** tool, double-click on the hydrograph icon next to outlet "20A" to bring up the *Hydrograph* dialog (Figure 9).
9. Once done reviewing the hydrograph plot click the in the top right corner to close the *Hydrograph* dialog.

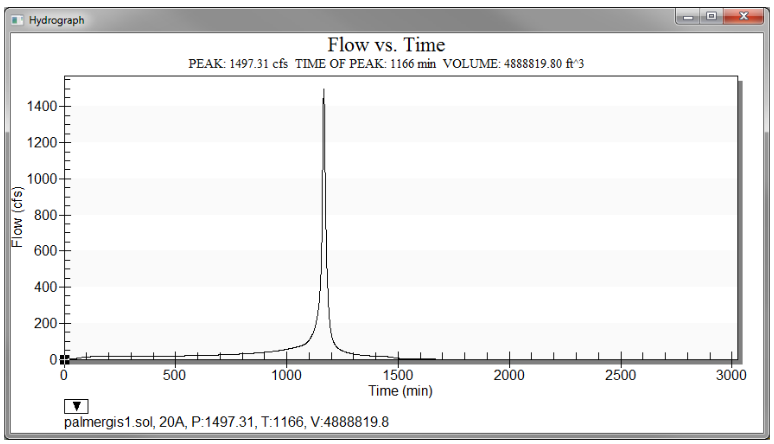


Figure 9 Solution hydrograph for MODRAT simulation

10. Select *File* | **Edit File…** to bring up the *Open* dialog.
11. Select "palmergis1.out" and click **Open** to exit the *Open* dialog and bring up the *View Data File* dialog. If the *Never ask this again* option was previously turned on, this dialog will not appear. If this is the case, skip to step 15.
12. Select the desired text editor from the *Open with* drop-down and click **OK** to close the *View Data File* dialog and open "palmergis1.out" in the selected text editor.
13. Once done reviewing the output, close the text editor by clicking the in the top right corner and return to WMS.

The simulation with MODRAT has now been successfully completed. There are many other options in the MODRAT model that were not included in this simple model.

7 Burned Watershed Simulation

This section show how to quickly create a burned watershed simulation from a regular MODRAT watershed model, and then change some Job Control options and soil number data using the automated tools in WMS:

1. Select *MODRAT* **| Job Control…** to bring up the *MODRAT Job Control* dialog.
2. Enter "palmergis_burn" as the *Prefix* and click **Update**.
3. In the *Input* section, verify that "sgr_soilx_71.dat" is the file name in the *Soil* field (scroll to the right in the field, if necessary).
4. Click **OK** to close the *MODRAT Job Control* dialog.

The soil file designated in the *MODRAT Job Control* dialog must contain soil data for burned conditions in order for the simulation work correctly. The "sgr_soilx_71.dat" file contains regular soil data for typical Los Angeles County soil numbers (2-180) and for burned soil numbers (202-380).

Now update all the soil numbers in the watershed to reflect burned conditions.

5. Select *MODRAT* **| Create Burned Simulation…** to bring up the *Generate Burned Simulation* dialog.
6. Enter "200" as the *Burned soils increment* (this is the default).

This is the increment to be added to normal soils to get the corresponding burned soil.

7. Enter "15.0" as the *% impervious limit*.

Basins with higher impervious values will not be affected by the burn.

8. Click **OK** to close the *Generate Burned Simulation* dialog.
9. Using the **Select basin** tool, double-click on any sub-basin icon to bring up the *MODRAT Parameters* window and view the new *Soil type* number assigned.

Notice that the *Soil type* value has changed from the previous value.

10. Click **OK** to exit the *MODRAT Parameters* window.
11. Select *MODRAT* **| Run Simulation…** to bring up the *MODRAT Run Options* dialog.
12. Click **Browse** to bring up the *Select MODRAT Input File Name* dialog.
13. Enter "palmergis_burn.lac" as the *File name* and click **Save** to close the *Select MODRAT Input File Name* dialog.
14. Turn on *Save file before run* and click **OK** to close the *MODRAT Run Options* dialog, open the *Model Wrapper* dialog, and start the simulation.
15. When MODRAT finishes, turn on *Read solution on exit* and click **Close** to close the *Model Wrapper* dialog and import the solutions.

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

16. Using the **Select hydrograph** tool, double-click on the hydrograph icon next to outlet "20A" to bring up the *Hydrograph* dialog.

The plot contains the original hydrograph (from the previous run) and the new hydrograph from the burned simulation (read in from the new SOL file). It should look similar to Figure 10.

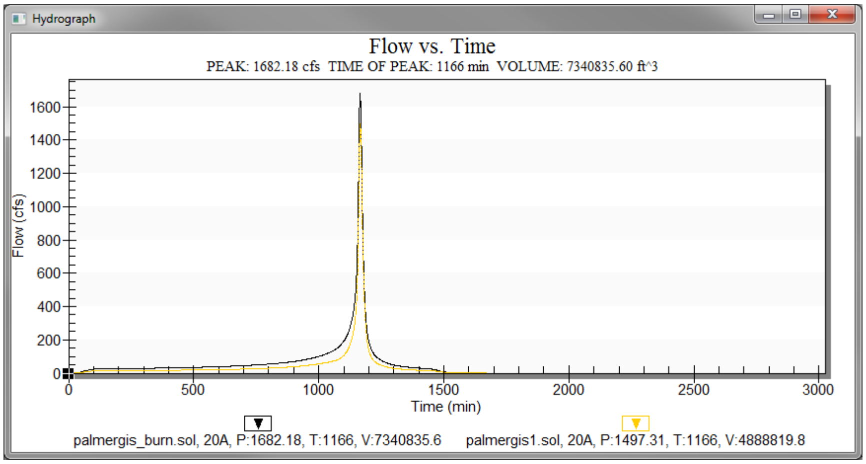


Figure 10 Burned and original hydrographs

17. When done reviewing the hydrograph plots, click the at the top right of the *Hydrograph* dialog to close it.
18. Clear the results by selecting *Hydrographs* **| Delete All**.
19. **Save** the project.
20. If asked to save images to the project directory, click **No**.

8 Debris Production

WMS has a tool for computing the amount of debris produced as part of the runoff from mountainous and burned drainage basins. The following sections demonstrate how to compute debris production, account for debris control structures, and generate reports detailing the calculations.

8.1 DPA Zones

The debris production calculator in WMS requires GIS data that defines debris production area (DPA) zones. Drainage basin polygons are overlaid with the DPA zone polygons in order to determine debris production rates, which are applied to the area contributing to any outlet point of interest.

1. Right-click on the “ Coverages” folder in the “ Map Data” section of the Project Explorer and select **New Coverage** to bring up the *Properties* dialog.
2. Select “MODRAT DPA Zone” from the *Coverage Type* drop-down and click **OK** to close the *Properties* dialog.
3. Switch to the **GIS** module.
4. Select *Data* **| Add Shapefile Data…** to bring up the *Select shapefile* dialog.

5. Browse to the *MODRAT\MODRAT\DPAZones* folder and select "dpazones.shp".
6. Click **Open** to import the shapefile and close the *Select shapefile* dialog.

This contains the Debris Production Area (DPA) zones for all of Los Angeles County (Figure 11).

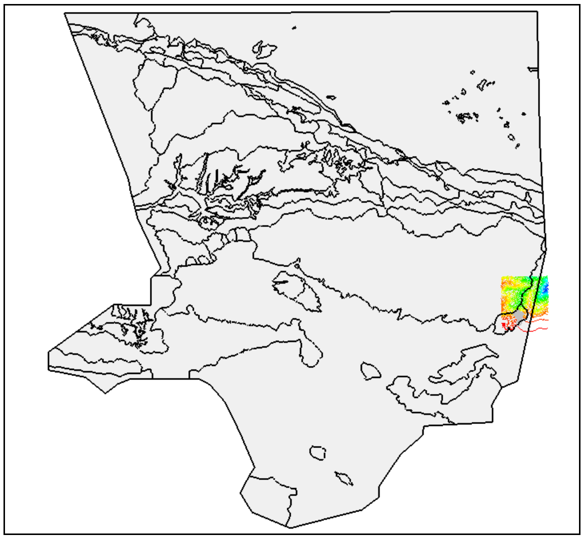


Figure 11 DPA Zones in the imported shapefile

7. Right-click on " Drainage" in the Project Explorer and select **Zoom To Layer**.
8. Select " MODRAT DPA Zone" to make it active.
9. Switch back to the **GIS** module.
10. Using the **Select shapes** tool, drag a selection box around the watershed extents (Figure 12).

This selects the DPA zone polygons covering the watershed.

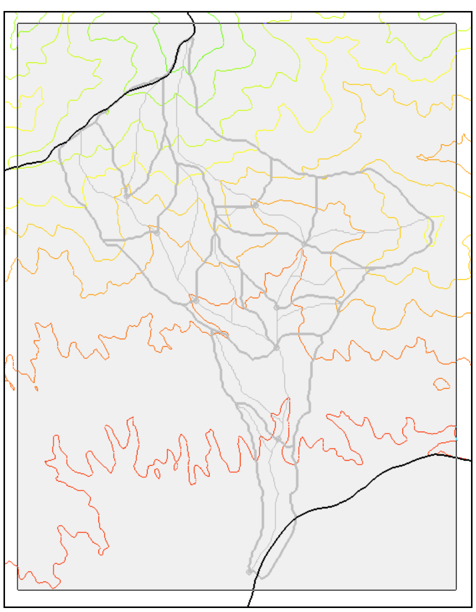


Figure 12 Selecting the watershed extents

11. Select *Mapping* | **Shapes** → **Feature Objects** to bring up the *GIS to Feature Objects Wizard* dialog.
12. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
13. Select "DPA Zone" from the drop-down in the *DPA_ZONES* column.
14. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
15. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.
16. Turn off " dpazones.shp" in the Project Explorer.
17. Switch to the **Hydrologic Modeling** module.
18. Select *MODRAT* | **Debris Production\Bulking…** to bring up the *Debris Production* dialog.
19. On the *Basin data* tab, click **Compute GIS Data…** to bring up the *Compute GIS Attributes* dialog.
20. In the second section, select "MODRAT DPA Zone" from the *Soil type coverage name* drop-down.
21. Select "Land Use" from the *Land use coverage name* drop-down.
22. Click **OK** to close the *Compute GIS Attributes* dialog.

Total debris produced is reported for each outlet shown in the spreadsheet by summing the debris produced within each DPA zone for all undeveloped drainage areas that contribute runoff to the outlet.

8.2 Debris Control Structures

Adequate or undersized debris control structures can be defined at any outlet point and included in debris production calculations for all downstream outlets.

1. Switch to the *Debris production* tab.
2. In the *5A* column on the *Control structures* row, click **View…** to bring up the *Control Structures* dialog.

All of the outlets located upstream of outlet "5A" are listed in this dialog.

3. In the *Location* column, turn on *2A*.
4. Select "Adequate" from the *Size* drop-down.
5. Click **OK** to close the *Control Structures* dialog.

Notice that the debris calculations are automatically updated. An adequately sized control structure will remove all debris produced upstream of the location of the control structure from the results reported at all downstream locations.

6. In the *5A* column on the *Control structures* row, click **View…** to bring up the *Control Structures* dialog.
7. Select "Undersized" from the *Size* drop-down.
8. Enter "10000.00" as the *Capacity*.

9. Select “(yd^3)” from the *Units* drop-down.
10. Click **OK** to close the *Control Structures* dialog.

Values now show up in the Excess controlled debris row of the spreadsheet and are included in the total debris reported for all outlets downstream of the control structure.

11. In the *5A* column on the *Control structures* row, click **View…** to bring up the *Control Structures* dialog.
12. Select “(%)” from the *Units* drop-down.
13. Enter “0.5” as the *Capacity* (only decimal percentages are valid).
14. Click **OK** to close the *Control Structures* dialog.

In this case, 50% of the debris produced upstream of the control structure is contained and the other 50% of the debris in included in the total debris reported for all outlets downstream of the control structure.

8.3 Reports

It is important to understand the difference between using report nodes and exporting a report that details the debris production computations.

1. Click **All On** next to *Report*.

This marks all of the outlets displayed in the spreadsheet as report nodes. Report node locations are saved with the WMS project file and are used to indicate which outlets are of interest within a specific project.

2. Click **All Off** next to *Report*.
3. On the *Outlet* row, turn on *5A*.

This marks outlet “5A” as a report node.

4. Select “Report nodes” from the *Show* drop-down.

Now only the data for outlet 5A is shown in the spreadsheet. There is also an option for showing outlets selected in the graphics window.

5. Click **Export…** to bring up the *Select LA County debris production filename* dialog.
6. Click **Save** to close the *Select LA County debris production filename* dialog and save the report using the default location and file name.
7. Click **OK** to close the *Debris Production* dialog.
8. Select *File* **| Edit File…** to bring up the *Open* dialog.
9. Select “ladebris.txt” and click **Open** to exit the *Open* dialog and bring up the *View Data File* dialog. If the *Never ask this again* option was previously turned on, this dialog will not appear. If that is the case, skip to step 11.
10. Select the desired text editor from the *Open with* drop-down and click **OK** to close the *View Data File* dialog and open “ladebris.txt” in the desired text editor.

Reports will include both summary and detailed data for all outlets that appear in the spreadsheet when exported. In this case, only data for outlet “5A” is included in the report because that was the only data shown in the spreadsheet at the time that the report was exported.

11. Once finished reviewing the data, click the  in the top right corner to close the text editor window and return to WMS.

9 Bulking Flows

Burned flow rates are bulked in order to account for the debris and sediment in the runoff flow rate. Bulking factors are determined using DPA zones. The Bulked Flow calculator operates in the same fashion as the Debris Production calculator, including accounting for the effects of debris control structures. Burned flow values can be directly entered into the spreadsheet or read from a MODRAT solution.

1. Select *MODRAT* **| Debris Production/Bulking…** to bring up the *Debris Production* dialog.
2. Switch to the *Bulked flow* tab.
3. Select "All" from the *Show* drop-down.
4. Click **Get Burned Flows From MODRAT Solution…** to bring up the *Open* dialog.
5. Select "palmergis_burn.out" and click **Open** to exit the *Open* dialog.

The bulked flow values in the spreadsheet are automatically updated. If desired, click on the *Control structures* **View…** button in column *5A* of the spreadsheet to experiment with combining debris control structures with flow bulking.

6. Click **OK** to close the *Debris Production* dialog.

10 Conclusion

This concludes the "Watershed Modeling – MODRAT Interface (GIS-based)" tutorial. The following key concepts were discussed and demonstrated:

- Entering job control parameters
- Defining basin parameters from GIS data
- Defining routing parameters
- Saving MODRAT input files
- Reading hydrograph results
- Creating a burned simulation
- Debris production and flow bulking
- Comparing results from two runs

