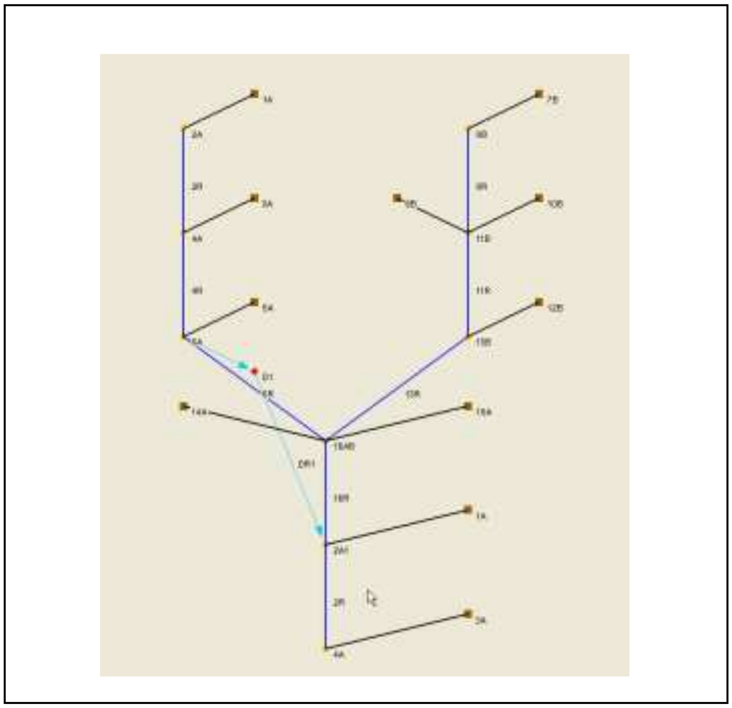
v. 10.0

WMS 10.0 Tutorial

Watershed Modeling – MODRAT Interface – Schematic

Build a MODRAT model by defining a hydrologic schematic



Objectives

This tutorial shows users how to define a basic MODRAT model using the hydrologic schematic tree in WMS. In this tutorial, users build a tree and define MODRAT hydrologic data for sub-basins and hydraulic structures.

Prerequisite Tutorials

- None

Required Components

- Hydrologic Models

Time

- 20-40 minutes

1 Introduction

The Los Angeles County Department of Public Works' Modified Rational (MODRAT) model can be set up and run using the Hydrologic Modeling Module in WMS. This module allows MODRAT simulation of a watershed without requiring GIS or digital terrain data. The tools demonstrated in this exercise are public-domain – there is no charge for using these WMS features.

The following steps will guide users through setting up a topologic tree (schematic) representation of a watershed, entering necessary parameters, and executing a MODRAT simulation.

2 Creating a Topologic Tree (Schematic)

A topologic tree is a simple schematic that shows the connectivity of drainage areas (basins) with outlets (confluence points) and reaches. The schematic can be built in the Hydrologic Modeling module. The following steps will guide users in building a schematic for Palmer Canyon watershed (shown in **Error! Reference source not found.**).

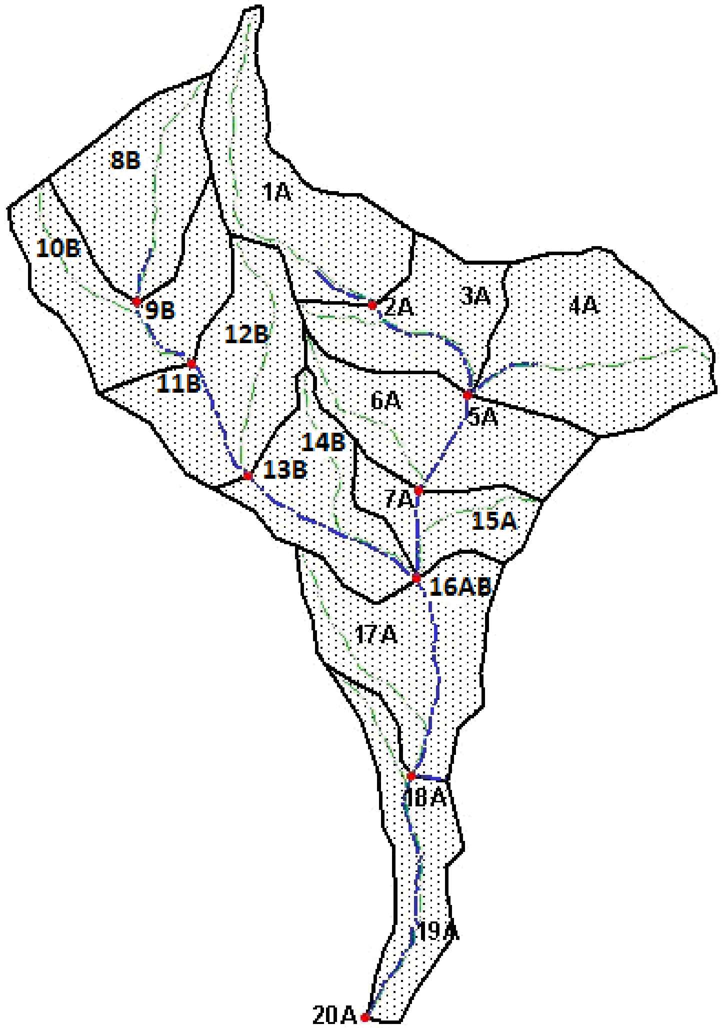


Figure 1 Palmer Canyon watershed

1. Open WMS. If WMS is already open, select *File* | **New**. Then click **No** if asked to save changes.
2. Select the **Hydrologic Modeling** module.
3. Select "MODRAT" in the *Model* drop down list to make MODRAT the active model in WMS.

For the following steps, users can either follow the menu command instructions or press "O" or "B" on the keyboard to create an outlet or basin, respectively (after clicking somewhere in the graphics window to make it active).

4. Select *Tree* | *Add* | **Outlet** -OR- Press the O key – this creates the main watershed outlet.
5. Select *Tree* | *Add* | **Basin** -OR- Press the B key – this attaches a drainage area to the active outlet point.
6. Select *Tree* | *Add* | **Outlet** -OR- Press the O key – this adds a reach and outlet upstream from the active outlet point.

7. Select *Tree* **|** *Add* **| Basin** -OR- Press the B key.
8. Select *Tree* **|** *Add* **| Outlet -**OR**-** Press the O key.
9. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.
10. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key – this attaches a 2nd drainage area to the active outlet point.
11. Select *Tree* **|** *Add* **| Outlet** -OR- Press the O key.
12. Select *Tree* **|** *Add* **| Basin** -OR- Press the B key.
13. Select *Tree* **|** *Add* **| Outlet -**OR- Press the O key.
14. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.
15. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.
16. Select *Tree* **|** *Add* **| Outlet -**OR- Press the O key.
17. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.

Users have completed creating the main line in the Palmer Canyon watershed. Now users will create a tributary line.

18. Click on the yellow circle outlet icon labeled 4C.
19. Select *Tree* **|** *Add* **| Outlet -**OR**-** Press the O key – this creates a 2nd outlet and reach attached to the 4C outlet point.
20. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.
21. Select *Tree* **|** *Add* **| Outlet -**OR**-** Press the O key.
22. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.
23. Select *Tree* **|** *Add* **| Outlet** -OR- Press the O key.
24. Select *Tree* **|** *Add* **| Basin -**OR- Press the B key.

The schematic is now complete. The display should appear as shown in **Error! Reference source not found.**. The connectivity of basins, reaches, and outlets is established and users are ready to begin assigning MODRAT input parameters to the watershed.

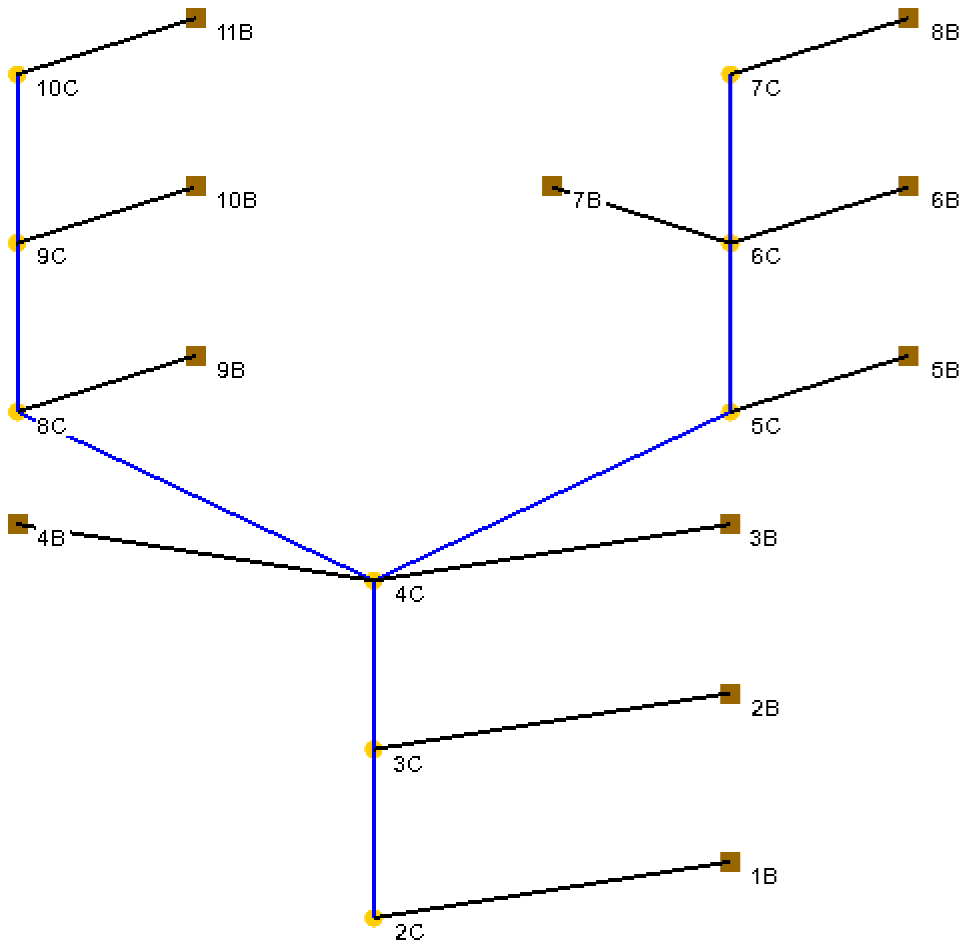


Figure 2 Schematic for Palmer Canyon watershed

3 MODRAT Job Control

The Job Control window for MODRAT allows users to specify input and output filenames, simulation duration, and storm frequency.

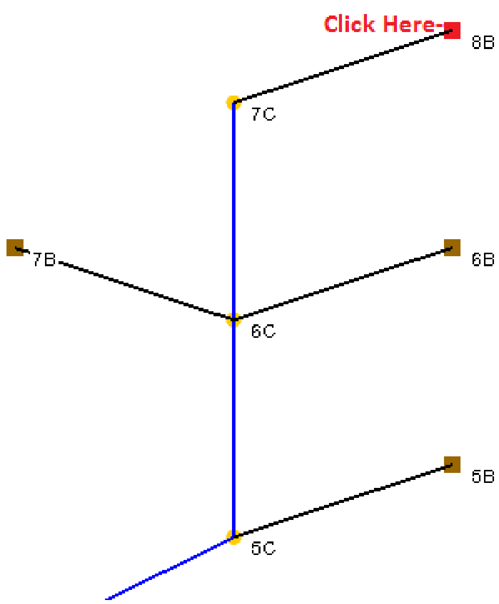
1. Select *MODRAT* **| Job Control.**
2. The *MODRAT Job Control* dialog will appear. Choose *MODRAT 2.0* at the top of the dialog.
3. Select “2” in the *Run time* drop down list.
4. Select “25 year” in the *Frequency* drop down list.
5. Enter “palmer1” in the Prefix box, and then select **Update**. Note that the default prefix for output files is now updated.
6. Enter “palmer_rain.dat” in the Rain file box. WMS will write the rainfall input data to this filename.

7. Enter *"C:\Program Files\WMS90\modrat\lasoilx.dat"* in the Soil file box. WMS will read the soil data from this file – this is the soil file appropriate for the San Gabriel River watershed where Palmer Canyon is located.
8. Select **OK**.

4 Schematic Tree Numbering

The MODRAT model requires that a watershed model be numbered sequentially in operational order from upstream to downstream. The order in which hydrologic units are processed depends on model numbering. WMS will help users automatically number the tree.

1. Click on the sub-basin (brown square) labeled 8B (most upstream on the right branch) to select it. This indicates to WMS the upstream end of the main line of the watershed.
2. Select *MODRAT* | **Number Tree**.
3. In the *MODRAT Renumber* dialog, select **OK** to start numbering with location/lateral of 1A.
4. The *Select a lateral* dialog will appear. As the numbering process proceeds users will be prompted to "Select a lateral" for each of the basins at a confluence. Notice that WMS zooms into the outlet point labeled 14AB and its surrounding outlet points – Assign basin 4B to the "B" lateral of the watershed and select **OK**.



5. Assign basin 3B to the "A" lateral of the watershed and select **OK**.
6. Click on the **Frame** macro.

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

Save the WMS project at this point.

7. Select *File* | **Save As…**.
8. In the *Save As* dialog, enter "PalmerCyn25.wms" as the *File name* and click **Save**.

WMS will save the 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 Edit MODRAT Input Parameters

Input parameters for each basin and reach must be defined for the watershed. The following sections will guide users through entering required data for basins and reaches. Users will also set output preferences for each hydrologic unit.

5.1 Editing Basin Data

Each basin (drainage area) must have data associated with it to be successfully simulated by MODRAT.

1. Select *MODRAT* **| Edit Parameters**. The *MODRAT Parameters* window will appear.
2. Select "All" in the *Show* drop down list.
3. Find the basin labeled 1A on the spreadsheet.
4. Enter a value of "67.74" for *Area*.
5. Enter a value of "8.56" for *Time of Concentration (Tc)*.
6. Enter a value of "81" for *Soil type*.
7. Enter a value of "1.00" for *% Impervious*.
8. Enter a value of "10.25" for *Rainfall depth*.
9. In the *Temporal distribution* column click on the **Define…** button in the All row (colored yellow) of the spreadsheet. This will bring up an *XY Series Editor* window where users will specify the rainfall temporal distribution (time vs. cumulative rainfall percentage).

Rather than type in values, users will load the default LACDPW 4th Day Design Storm distribution from a file.

1. Select the **Import** button.
2. In the *Open File* dialog, find and open the file named "LACDPWStorm-4thday.xys".

The LACDPW curve will appear in the spreadsheet/plot window.

3. Select **OK** to assign this curve to all basins.
4. In the All row (colored yellow) of the spreadsheet Choose "Hydrograph (*.HYF) and WMS plot file (*.SOL)" in the *Hydrograph Output* column.

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

5. Use the table below to input values for the basins shown:

Basin Name	Area	Tc	Soil	% Imp.	Rainfall	Output
3A	47.71	6.61	88	1.0	9.91	HYF/SOL
4A	82.87	7.15	88	1.0	9.96	HYF/SOL
6A	62.50	6.48	88	1.0	9.64	HYF/SOL
8A	57.69	6.12	81	1.0	10.05	HYF/SOL
9B	60.77	7.12	88	1.0	9.80	HYF/SOL

11B	65.61	7.12	88	1.0	9.76	HYF/SOL
13B	48.91	8.17	88	1.0	9.41	HYF/SOL
15B	31.47	5.74	88	1.0	9.42	HYF/SOL
17A	69.26	10.52	88	1.0	8.95	HYF/SOL
19A	46.02	13.22	11	8.35	8.32	HYF/SOL

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

The basin parameters for all drainage areas should now be entered for the simulation. Now is a good time to save the work users have done so far.

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

Users will now continue to work on editing parameters for the simulation.

5.2 Editing Reach Parameters

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. Click on the outlet labeled 2A on the schematic.
2. Select *MODRAT* **| Edit Parameters**. The *MODRAT Parameters* window will appear.
3. Find the outlet labeled 2A and enter a value of “1606.96” for *Length*.
4. Enter a value of “0.2553” for *Slope*.
5. Verify that “Variable” is selected as the *Routing Type*.
6. Verify that “0.014” is entered for *Manning’s n* (default value).
7. Choose “Hydrograph (*.HYF) and WMS plot file (*.SOL)” in the *Hydrograph Output* column.

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

8. Select “All” in the *Show* drop down list.
9. Use the table below to input values:

Reach Name	Length	Slope	Routing Type	n	Output
5A	1172.57	0.0851	Valley	-	HYF/SOL
7A	955.29	0.1026	Valley	-	HYF/SOL
10B	967.88	0.2877	Variable	0.014	HYF/SOL
12B	1395.38	0.2710	Variable	0.014	HYF/SOL
14B	2151.68	0.0798	Valley	-	HYF/SOL
16AB	2247.75	0.091	Valley	-	HYF/SOL
18A	2835.86	0.0737	Valley	-	HYF/SOL
20A	0.00	0.00	Variable	0.014	HYF/SOL

10. When users are finished entering the parameters choose **OK** on 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.

11. Select *File* **| Save** .

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, WMS will perform a model check. Follow the steps below:

1. Select *MODRAT* **| Check Simulation**.
2. The *MODRAT Model Check* will appear. Review the model check report noting that there are 2 possible errors in the MODRAT model.
3. Note that the possible errors are reports for outlet 20A - this is the watershed outlet; therefore, there is no reach downstream that users need to define.
4. Click **Done** to exit the *MODRAT Model Check*.

The model checker is a simple way to verify that users have not left out any needed data. 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:

5. Select *MODRAT* **| Run Simulation**.
6. The *MODRAT Run Options* dialog will appear. Review the input file; it should be named “Palmer1.lac”.
7. Ensure that the *Save file before run* toggle is checked.
8. Ensure that the Prefix for output files box contains “Palmer1”.
9. Click **OK** to start the simulation.

A window will appear and report the progress of the MODRAT simulation.

10. Select **Close** once MODRAT finishes running (users 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.

11. Double-click on the hydrograph icon next to outlet 20A.
12. Review the hydrograph plot that appears in a new plot window. Note that peak flow, time to peak, and volume are reported in the title and legend of the plot.
13. Hold the **SHIFT** key and double-click on the hydrograph icon next to outlet 16AB.
14. Review the new plot that appears with both hydrographs plotted on the same axes.
15. Close all plot windows by clicking on the X in the upper right corner of each window.
16. Select *File* **| Edit File**.
17. In the *Open* dialog, find and open the file named “Palmer1.out”.

18. Click **OK** to open the file with Notepad, if prompted.
19. Review the text summary output of the simulation.
20. 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 that were not included in this simple model. The following sections will present 2 of those options: detention basins and diversions.

21. Clear the results by selecting *Hydrographs* **| Delete All**.

7 Adding a Diversion (Flow Split)

The flow in a line of a MODRAT model can be split using a diversion in WMS. The diverted flow can be routed and returned to a downstream location in the model, if desired. To split flow at one location in the model, do the following:

1. Select the outlet named 14B by clicking on the yellow circle.
2. Select *Tree* **|** *Add* **| Diversion.**

WMS will insert the diversion.

3. Click on the outlet named 20A.
4. Select *Tree* **| Retrieve Diversion**.

Note that the diversion arrow returns to the outlet named 20A. Since users have added a diversion in their model, they should now renumber the model to include this new diversion in the numbering scheme. Follow these steps to renumber the model:

5. Click on the sub-basin labeled 1A (most upstream on the right branch) to select it. This indicates to WMS the upstream end of the main line of the watershed.
6. Select *MODRAT* **| Number Tree**.
7. In the *MODRAT Renumber* dialog, select **OK** to start numbering with location/lateral of 1A.
8. The *Select a lateral* prompt will appear. Assign basin 15B to the "B" lateral of the watershed and select **OK**.
9. Assign basin 8A to the "A" lateral of the watershed and select **OK**.
10. Click on the **Frame** macro.

Now that the location and return have been defined, users will need to instruct MODRAT how to split the flow and route it in the diversion channel.

11. Double-click the outlet named 14BC – the *MODRAT Parameters* window will appear.
12. Turn on the *Relief Drains* display option if it is not already on.
13. Set the *Relief drain type* box to “Drain Capacity”.
14. Enter “250.0” in the *Flow rate* box – this is the maximum flow allowed in the main channel above which flow will be diverted.

15. Click **OK** to exit the window.
16. Double-click the diversion icon named 15C – the *MODRAT Parameters* window will appear.
17. Enter "5000.0" in the *Length* box.
18. Enter "0.05" in the *Slope* box.
19. Choose "Circular pipe" in the *Routing type* box.
20. Enter "0.014" in the *Manning's n* box.
21. Enter "3.0" (ft) in *Size* column (diameter).
22. Choose Hydrograph "(*.HYF) and WMS plot file (*.SOL)" in the *Input/Output Options*.
23. Click **OK** to exit the window.

The diversion is now complete. To re-run the simulation and see the effects of the split, do the following:

24. Select *MODRAT* **| Run Simulation**.
25. In the *MODRAT Run Optins* dialog, click the **browse** button next to the Input File.
26. In the *Select MODRAT Input File Name* dialog, enter the name "Palmer2.lac", then click **Save**.
27. Ensure that the *Save file before run* toggle is checked.
28. Enter "Palmer2" in the Prefix for output files box.
29. 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:

30. Select **Close** once MODRAT finishes running (users 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.

31. Double-click on the hydrograph icon next to outlet 14BC.
32. Note that the hydrograph peak is cut off at 250.0 cfs.
33. Double-click on the hydrograph icon next to diversion 15C.
34. Review the hydrograph in the relief drain channel.
35. Close all plot windows by clicking on the X in the upper right corner of each window.
36. Clear the results by selecting *Hydrographs* **| Delete All**.

8 Adding a Detention Basin

Users can place a detention basin at any outlet point and route incoming flow through that structure with MODRAT. In this model, users will define a detention basin at the watershed outlet (mouth of Palmer Canyon).

1. Double-click the outlet named 21AC – the *MODRAT Parameters* window will appear.
2. Turn on the *Reservoir Routing* display option.
3. Click the *Reservoir routing* toggle.
4. Click the **Define** button under the *Reservoir* column.
5. The *Detention Basin Hydrograph Routing* dialog will appear with a blank Elevation-Storage Capacity-Discharge window. Click the **Define** button in the upper left.

Users will now define a hypothetical detention basin from approximate geometric parameters. WMS can compute a storage capacity curve for a rectangular basin. Users could also enter a pre-computed storage capacity curve.

6. In the *Storage Capacity Input* window, select the *Known Geometry* option.
7. Enter “500” feet for *Length*.
8. Enter “500” feet for *Width*.
9. Enter a *Depth* of “20” feet.
10. Enter a *Side slope* of “1”.
11. Leave the *Base elevation* at “0.0” (It will be assumed on-grade at the outlet location).
12. Select **OK**.

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

13. Select the **Define Outflow Discharges…** button in the *Detention Basin Analysis* dialog.
14. The *Elevation Discharge Input* dialog will appear. Select the **Add Riser** button.
15. Set the *Opening Shape Type* to “Circular”.
16. Set the *Diameter* to “4.90” feet.
17. Set the *Height above Base Elev to Bottom of Opening* to “1.0” foot.
18. Select the **Add Weir** button.
19. Set the *Weir length* to “50.0” feet.
20. Set the *Height above Base Elev* to “17.0” feet.
21. Select **OK**.
22. Select **OK** in the *Detention Basin Analysis* window.

23. Note the curves are now plotted in the *Detention Basin Hydrograph Routing* window, shown in **Error! Reference source not found.**.

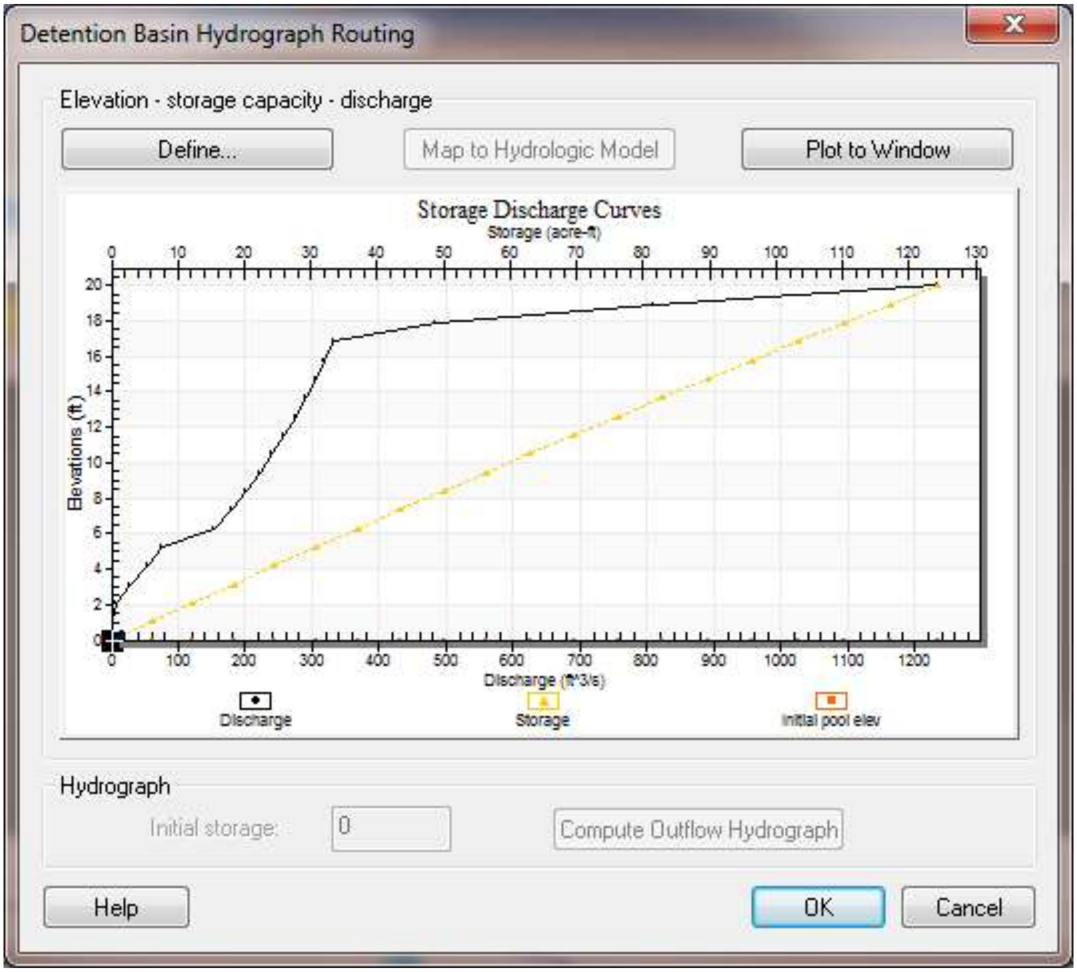


Figure 3 Reservoir Storage-Elevation-Discharge

24. Click **OK**.
25. Click **OK** to exit the *MODRAT Parameters* window.

Users have now defined a detention facility that has an outlet pipe 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. To re-run the simulation and see the effects, do the following:

26. Select *MODRAT* **| Run Simulation**.
27. In the *MODRAT Run Options* dialog, click the button next to the Input File.
28. In the *Select MODRAT Input File Name* dialog enter the name "Palmer3.lac". Then click **Save**.
29. Ensure that the *Save file before run* toggle is checked.
30. Enter "Palmer3" in the Prefix for output files box.
31. Click **OK** to start the simulation.

A window will appear and report the progress of the MODRAT simulation.

32. Select **Close** once MODRAT finishes running (users 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.

33. Note that there are two hydrograph icons near 21A. Click on one, then hold the SHIFT key and double-click on the other. When selecting multiple hydrographs, users can also view all the selected hydrographs in a single plot by selecting the ***Display* | *Open Hydrograph Plot*** command.
34. Both hydrographs will be plotted in a new window. Note the effects of the detention basin on the incoming hydrograph.
35. Close all plot windows by clicking on the X in the upper right corner of each plot window.
36. Clear the results by selecting *Hydrographs* **| Delete All**.

9 Running MODRAT 1.0 - Optional

To run the older version of MODRAT (MODRAT 1.0 which uses the 4 day storm approach instead of a continuous simulation approach) users simply need to change the rainfall input for their model. Users must change some Job Control items and edit the precipitation input for the basins in the model.

1. Select *MODRAT* | **Job Control**.
2. The *MODRAT Job Control* dialog will appear. Choose MODRAT at the top of the dialog and ensure that the *Time Period* is set to ”Days:4”.
3. Select **OK**.
4. Select *MODRAT* | **Edit Parameters**. The *MODRAT Parameters* window will apear.
5. Set the *Type* (upper right of the dialog) to “Basins”.
6. Set the *Show* option (upper right of the dialog) to “All”.
7. In the *Temporal distribution* column click on the **Define…** button in the All row (colored yellow) of the spreadsheet.
8. The *XY Series Editor* will appear. Click on the **Import** button.
9. In the *Open* dialog, find and open the file named “LACDPWStorm1500min.xys”.

The LACDPW1500min curve will appear in the spreadsheet/plot window.

10. Select **OK** to assign this curve to all basins.

Note that the rainfall depths entered do not need to be changed since users ran a 4th day simulation with MODRAT 2.0. These depths correspond to a 24 hour design storm and are appropriate with the 1500 min. curve used with MODRAT 1.0.

11. Select **OK** to close the *MODRAT Parameters* dialog.
12. Select *MODRAT* | **Run Simulation**.

13. In the *MODRAT Run Options* dialog, click the button next to the Input File.
14. In the *Select MODRAT Input File Name* dialog enter the name "Palmer4.lac". Then click **Save**.
15. Ensure that the *Save file before run* toggle is checked.
16. Enter "Palmer4" in the Prefix for output files box.
17. Click **OK** to start the simulation.

A window will appear and report the progress of the MODRAT simulation.

18. Select **Close** once MODRAT finishes running (users 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. Review hydrographs as needed.

10 Conclusion

In this exercise users have learned some of the options available for using the MODRAT model in WMS. Users will want to continue experimenting with the different options so that users can become familiar with all the capabilities in WMS for doing MODRAT simulations.