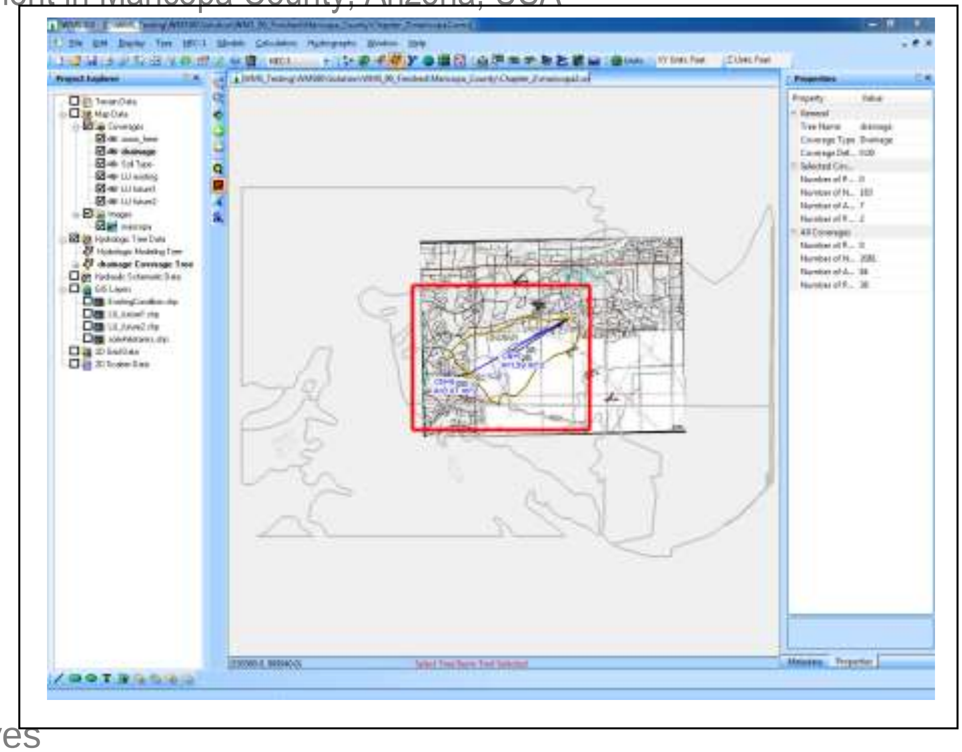
v. 10.0

WMS 10.0 Tutorial

Watershed Modeling – Maricopa County: Master Plan – Creating a Predictive HEC-1 Model

Build a watershed model to predict hydrologic reactions based on land use development in Maricopa County, Arizona, USA



Objectives

Define an urban watershed for an area of interest in Maricopa County. Build an HEC-1 simulation and run this simulation based on both existing and proposed land use conditions to determine the impact of land use changes on the watershed hydrograph.

Prerequisite Tutorials

- Watershed Modeling – HEC-1 Interface
- Watershed Modeling – Advanced DEM Delineation Techniques

Required Components

- Data
- Drainage
- Map
- Hydrology

Time

- 30-60 minutes

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1 Objectives

This exercise illustrates the use of a watershed model to predict possible hydrologic reactions based on planned land use developments. The following sections will show users how to use WMS to:

1. Define the watershed of interest
2. Build a Maricopa County HEC-1 simulation
3. Run HEC-1 based on existing land use and soil conditions
4. Run HEC-1 based on proposed conditions

2 Defining the Watershed

To create the basins to be used in HEC-1 simulations, users will use a shapefile containing pre-delineated sub basins for the Maricopa County. Also, users will manually create drainage outlets and feature stream arcs for the basins of interest. Finally, users will use WMS to compute the hydrologic parameters for their watershed basins.

2.1 Converting the Shapefile to Feature Polygons

1. Open WMS. If WMS is already open, select *File* | **New**, then select **No** if asked to save changes.
2. Switch to the **GIS** module.
3. Select *Data* | **Add Shapefile Data.**
4. In the *Select shapefile* dialog, locate the "Maricopa\tut2" folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com**.**
5. Select "basins.shp" and click **Open**.
6. Select *File* | **Open** .
7. In the *Open* dialog, locate and open "zoom_here.wms". This file identifies the basins used in this exercise.

8. Select the **Zoom** tool.
9. Drag a box approximately around the rectangle shown in Figure 1.

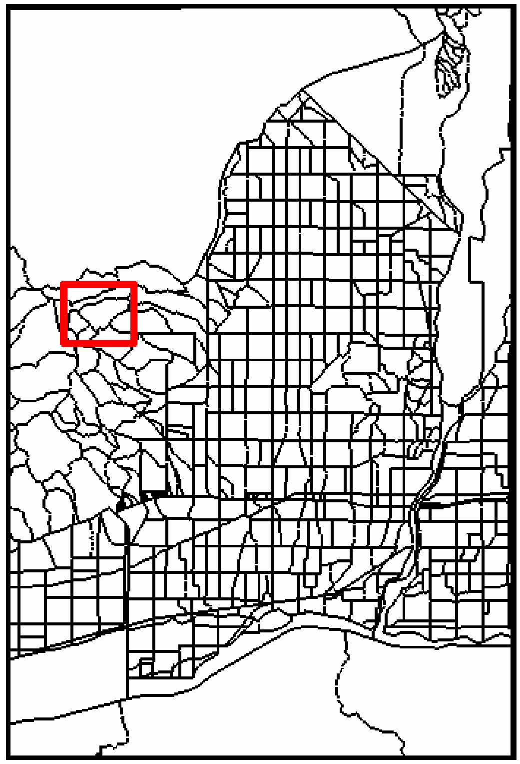

Figure 1 Zoom area

Users will select two basins before converting the shapefile to feature polygons (when mapping shapefile data to feature objects, only the selected shapes are converted).

10. Choose the **Select Shapes** tool.
11. Multi-select the two polygons shown in Figure 2 by holding the *SHIFT* key while selecting each polygon. When selected, the polygons will appear outlined in blue.

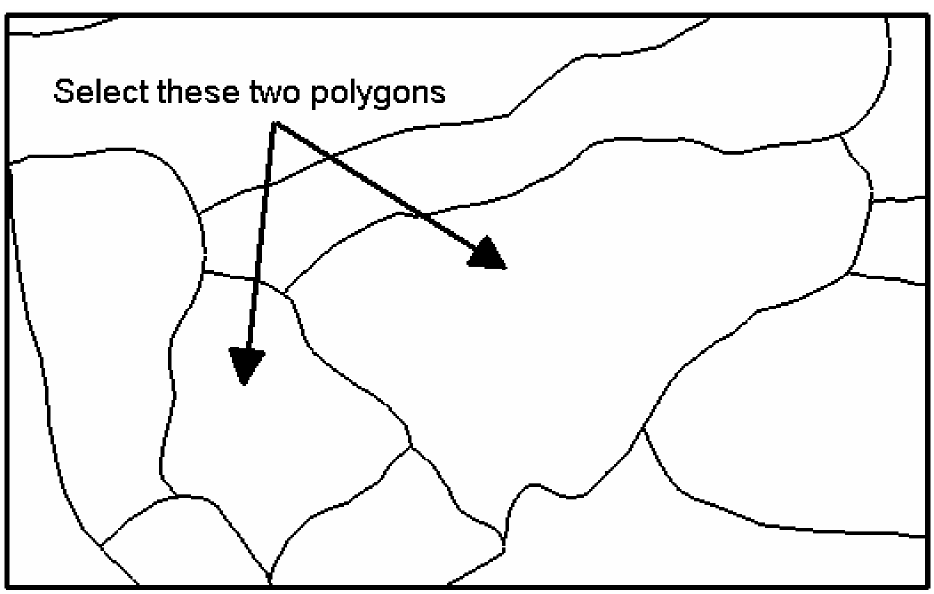

Figure 2 Polygons to select

12. Select *Mapping* **| Shapes → Feature Objects**.
13. The *GIS to Feature Objects Wizard* will appear. Select **Next**.
14. Select **Next**.
15. Select **Finish**.

The feature polygons have now been created and users are ready to create the stream arcs. Before continuing, users will remove the basins shapefile from the Project Explorer:

16. Right-click "basins.shp" in the Project Explorer and select **Delete**.

2.2 Getting a Background Image

To aid users in drawing the stream arcs, users will import a background map depicting some of the geographic features within the watershed.

1. Select *File* **| Open**.
2. In the *Open* dialog, locate and open "maricopa.jpg". Select **Yes** if prompted to create pyramids.
3. Switch to the **Map** module.
4. Select the **Create Feature Arc** tool.
5. Select *Feature Objects* **| Attributes**.
6. In the *Feature Arc Type* dialog, change the *Arc type* to *Stream*.
7. Select **OK**.
8. Using Figure 3 as a guide, begin drawing an arc from the location labeled "Start Here." Click along the outline of the stream shown on the topo map so that the arc represents the stream's geometry. Double-click at the location labeled "End Here" to end the arc.

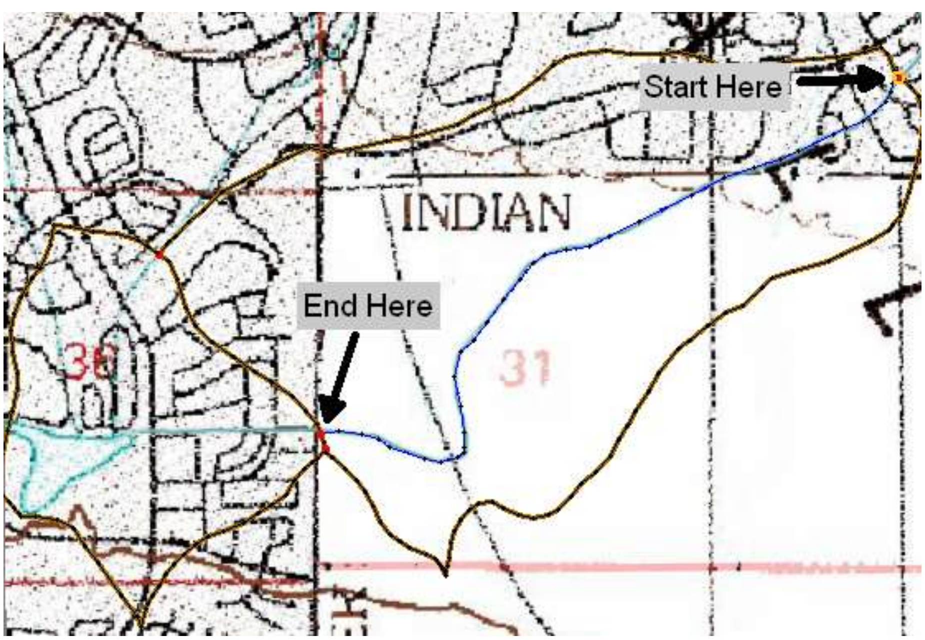

Figure 3   Guide for creating the first stream arc

9. Draw a second stream arc as indicated in Figure 4.

Figure 4 Location of the second stream arc

Having created the stream arcs, users will define their shared node as an Outlet point:

10. Select the **Select Feature Point** tool.
11. Double-click on the node labeled "Start Here" in Figure 4.
12. Change the *Point type* to *Drainage outlet*.
13. Select **OK**.

2.3 Compute the Basin Data

Users have completed the watershed construction and are ready to compute the basin parameters that will be used by HEC-1.

1. Select *Feature Objects* **| Compute Basin Data**.
2. In the *Units* dialog, click the **Current Projection...** button.
3. In the *Display Projection* dialog, change both the *Horizontal* and *Vertical Units* to "U.S. Survey Feet".
4. Select **OK**.
5. Verify that the Parameter Units are "Square miles" for *Basin Areas* and "Feet" for *Distances*.
6. Select **OK**.

3 Building the HEC-1 Model

Having computed parameters such as basin area, slope, and length, users will proceed to set up a HEC-1 simulation.

3.1 Initialize Rainfall Data

1. Switch to the **Hydrologic Modeling** module.
2. Select "HEC-1" from the model drop-down box at the top of the screen, to the left of the modules.
3. Select *HEC-1* **| Job Control**.
4. In the *HEC-1 Job Control* dialog, click the **Initialize Maricopa County Precipitation Data** button.
5. In the *Maricopa County Precipitation Data Initialization* dialog, choose the *Basin Average* method and change the duration to "6 hour".
6. Click on the **Browse** button to select a rainfall grid to read in and use to compute precipitation.
7. In the *Open* dialog, locate and open "noaa50y6h".
8. Select **OK** to leave the default and close the *Compute Rainfall* dialog.
9. Select **OK** twice more to return to the WMS window.

3.2 Define Unit Hydrograph Method

1. Double-click on the left basin icon.
2. The *Edit HEC-1 Parameters* dialog will open. Click the **Unit Hydrograph Method** button.
3. In the *HEC-1 Unit Hydrograph Methods* dialog, click the **Compute Parameters-Basin Data** button.
4. In the *Basin Time Computation* dialog, set the *Computation type* to "Compute Lag Time".
5. Select "Tulsa Rural Method" from the *Method* drop-down box.
6. Highlight the line containing *S Maximum flow distance slope* from the Variable list by clicking on it.
7. Enter "2000" in the *Variable value* field.
8. Highlight the line containing the variable *S* once again to update its value.
9. Select **OK**.
10. Back in the *HEC-1 Unit Hydrograph Methods* dialog, choose the *Given unit hydrograph (UI)* option.
11. Select the **Maricopa County S-Graph** button.
12. In the *S-Graph Options* dialog, choose "Phoenix Valley" as the *S-Graph type* and select **OK**.
13. The *XY Series Editor* will appear. Select **OK** to exit.
14. Select **OK** to exit the *HEC-1 Unit Hydrograph Methods* dialog.
15. Click the **Next Hydrograph Station** → button twice to edit the basin on the right.
16. Repeat steps 2 thru 14 above to define the unit hydrograph for this basin. In this case, however, enter "2400" for the variable *S Max flow distance slope*.

3.3 Define Routing Method

1. Click the ← **Previous Hydrograph Station** button to select the outlet located between the two basins.
2. Click the **Routing Data** button.
3. In the *HEC-1 Routing Data* dialog, choose the “Muskingum (RM)” option under *Routing Type*.
4. Click the **Compute NSTPS** button.
5. In the *Compute NSTPS* dialog, choose the *From Channel Velocity Estimate* option.
6. Enter “6” for the *Channel velocity estimate* and select **OK**.
7. Select **OK** to exit the *HEC-1 Routing Data* dialog.
8. Select **Done** to exit the *Edit HEC-1 Parameters* dialog.

3.4 Import the Soil Type and Land Use Coverages

The last parameter users need to define before running HEC-1 is the Green-Ampt losses. To have WMS compute losses, users will create one soil-type coverage and three land-use coverages (one representing existing land-use conditions and two representing future land-use scenarios).

1. Switch to the **Map** module.
2. Choose the **Select Drawing Objects** tool at the bottom of screen.
3. Select the rectangle surrounding the two basins and press **DELETE**.
4. Right-click on the “Coverages” folder in the Project Explorer and select **New Coverage**.
5. Change the *Coverage type* to “Soil Type” (notice that the *Coverage name* is automatically changed to “Soil Type”).
6. Select **OK**.
7. Create another new coverage and change its *type* to “Land Use”.
8. Set the coverage name as “LU existing”, by typing this into the *Coverage name* field.
9. Select **OK**.
10. Create two more “Land Use” type coverages and name *them* “LU future 1” and “LU future 2”, respectively.
11. Select the “LU existing” coverage in the Project Explorer to activate it.
12. Switch to the **GIS** module.
13. Select *Data* | **Add Shapefile Data**.
14. In the *Select shapefile* dialog, locate and open “ExistingCondition.shp”.
15. Select *Mapping* **| Shapes → Feature Objects**.
16. Select **Yes** when asked to use all shapes.
17. In the *GIS to Feature Objects Wizard*, select **Next**.

18. Find the column labeled *LDUSE_LID* and change its Mapping field to “Land use”.
19. Select **Next**.
20. Select **Finish**.
21. Select “LU future 1” in the Project Explorer to activate it.
22. Hide “ExistingCondition.shp” by un-checking its box in the Project Explorer.
23. Switch to the **GIS** module.
24. Select *Data* **| Add Shapefile Data**.
25. In the *Select shapefile* dialog, open “LU_future1.shp”.
26. Choose the **Select Shapes** tool.
27. Draw a selection box around the two basins (the extents of the watershed area).

By drawing a selection box around the extents of their watershed area, users select all land use polygons that overlap their watershed.

28. Select *Mapping* | **Shapes → Feature Objects**.
29. The *GIS to Feature Objects Wizard* will reappear. Select **Next**.
30. Notice that in this case, the *LU_CODE* field was automatically mapped to the “Land use” attribute. Select **Next**.
31. Select **Finish**.
32. Activate the “LU future 2” coverage in the Project Explorer.
33. Hide “LU_future1.shp” by un-checking its box in the Project Explorer.
34. Switch to the **GIS** module.
35. Select *Data* **| Add Shapefile Data**.
36. In the *Select shapefile* dialog, open “LU_future2.shp”.
37. Choose the **Select Shapes** tool.
38. Draw a selection box around the two basins (the extents of the watershed area).
39. Select *Mapping* | **Shapes → Feature Objects**.
40. In the *GIS to Feature Objects Wizard*, consecutively select **Next**, **Next**, and **Finish**.
41. Activate the “Soil Type” coverage in the Project Explorer by clicking on it.
42. Hide “LU_future2.shp” by un-checking its box in the Project Explorer.
43. Switch to the **GIS** module.
44. Select *Data* **| Add Shapefile Data**.
45. In the *Select shapefile* dialog, open “soilwhitetanks.shp”.
46. Choose the **Select Shapes** tool.
47. Draw a selection box around the two basins (the extents of the watershed area).
48. Select *Mapping* **| Shapes → Feature Objects**.
49. In the *GIS to Feature Objects Wizard*, select **Next**.

50. Find the column labeled *SLTYP_LID* and change its Mapping field to “SCS soil type”.
51. Select **Next**.
52. Select **Finish**.
53. Hide “soilwhitetanks.shp” by un-checking its box in the Project Explorer.

3.5 Computing Losses

1. Switch to the **Hydrologic Modeling** module.
2. Select *Calculators* **| Compute GIS Attributes**.
3. The *Compute GIS Attributes* dialog will appear. Change the *Computation* field to “Green-Ampt parameters”.
4. Select the *Land use mapp*ing option at the bottom.
5. Click the **Import** button.
6. The *Open* dialog will appear. Open “landusemagtable.tbl”.
7. Select the *Soil type mapping* option.
8. Click the **Import** button.
9. Select **OK** if a warning that any previous tables will be replaced appears.
10. The *Open* dialog will reappear. Open “soiltable.tbl”.
11. Set the land use coverage name field to “LU Existing”.
12. Select **OK**.

Users have computed the losses for the existing land use conditions. Later, when users want to compute runoff values for the future scenarios, users will simply re-compute losses in the Compute GIS Attributes calculator.

4 Run HEC-1 for Existing Conditions

1. Select *HEC-1* **| Run Simulation**.
2. The *HEC-1 Run Options* dialog will appear. Click the **browse** button next to the Input File.
3. For the file name enter *“*Mp_existing*”* and click **Save** (this specifies the file name but does not actually save it).
4. Verify that the *Save file before run* option is toggled on.
5. Select **OK**.
6. The *Model Wrapper* dialog will appear. Select **Close** when the HEC-1 simulation finishes.
7. Double-click on the most downstream hydrograph icon (farthest to the right).
8. The hydrograph shows that for the existing land use conditions, the peak runoff for a 50 year, 6 hour storm is approximately 1260 cfs.
9. Close the hydrograph plot window.

5 Run HEC-1 for the Proposed Conditions

1. Select *Calculators* **| Compute GIS Attributes**.
2. The *Compute GIS Attributes* dialog will appear. Change the *Computation* field to "Green-Ampt parameters".
3. Change the land use coverage name to "LU future 1".
4. Select **OK**.
5. Select *HEC-1* **| Run Simulation**.
6. The *HEC-1 Run Options* dialog will appear. Click the **browse** button next to the Input File.
7. For the file name enter *"*MP_future1*"* and click **Save** (this specifies the file name but does not actually save it).
8. Verify that the *Save file before run* option is toggled on.
9. Select **OK** to run HEC-1.
10. Select **Close** in the *Model Wrapper* dialog when the HEC-1 simulation finishes.
11. Double-click on the most downstream hydrograph icon.
12. In the upper left-hand corner of the Plot Window, note that the peak runoff has increased to 1440 cfs. This new hydrograph is superimposed over the previous one. Users can zoom in on a portion of the hydrographs and/or maximize the Plot Window to enlarge the graph(s).
13. Drag a box around the peaks of the hydrographs.
14. Right-click anywhere within the Plot window and select **Maximize Plot**.
15. Press the **ESC** key to return the Plot window to its original size.
16. To view the entire hydrographs once more, right-click anywhere within the Plot Window and select **Frame Plot**.
17. Close the plot window.
18. Select *Calculators* **| Compute GIS Attributes**.
19. The *Compute GIS Attributes* dialog will appear. Change the *Computation* field to "Green-Ampt parameters".
20. Change the land use coverage name to "LU future 2".
21. Select **OK**.
22. Select *HEC-1* **| Run Simulation**.
23. The *HEC-1 Run Options* dialog will appear. Click the **browse** button next to the Input File.
24. For the file name enter *"*MP_future2*"* and click **Save** (this specifies the file name but does not actually save it).
25. Verify that the *Save file before run* option is toggled on.
26. Select **OK** to run HEC-1.
27. Select **Close** when the HEC-1 simulation finishes.

28. Double-click on the most downstream hydrograph icon.
29. Notice that the peak runoff for LU future 2 (1460cfs) is slightly higher than for LU future 1. The results users are viewing in the plot window can be exported as tabular data.
30. Right-click within the Plot window and select **Export/Print**.
31. A new dialog called *Exporting Flow vs. Time* will appear. Change the *Export type* to *Text / Data*.
32. Change the *Export destination* to *File*.
33. Click the **Browse** button.
34. In the *Save As* dialog, specify a path and filename and click **Save**.
35. Click the **Export** button.
36. In the *Export…Flow vs. Time* dialog, leave the options at the default settings and click the **Export** button.

The exported data can now be opened in a spreadsheet editor for further manipulation. Another effective way to view HEC-1 results is to browse the HEC-1 output file (*.out), which can be viewed with any text editor. Also, if HEC-1 had not terminated successfully, then checking the (*.out) file might reveal possible errors and/or warnings.

6 Conclusion

In this exercise, users were taught to use the HEC-1 model for storm drain modeling. In particular a user should have learned to:

1. Define the watershed of interest
2. Build a Maricopa County HEC-1 simulation
3. Run HEC-1 based on existing land use and soil conditions
4. Run HEC-1 based on proposed conditions