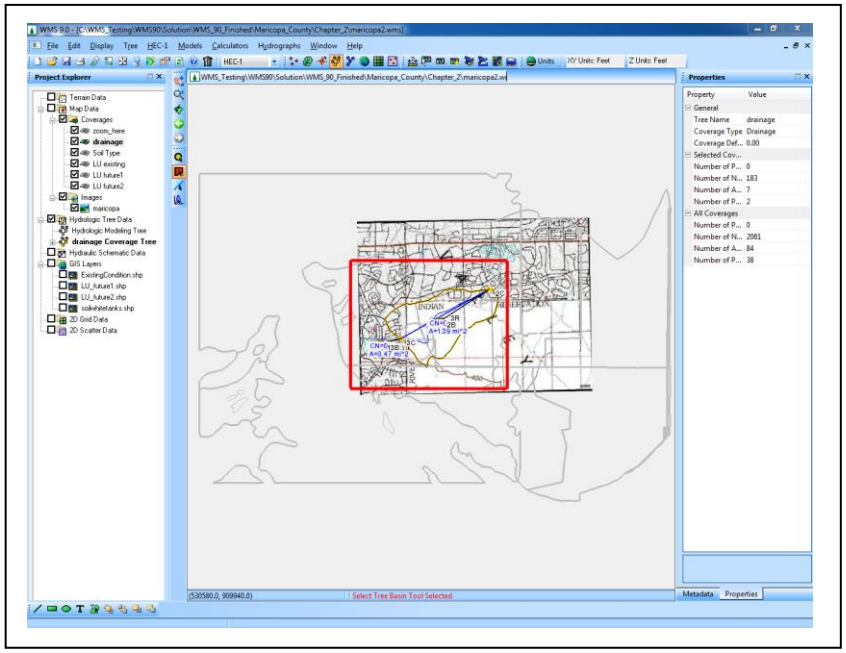
WMS

v. 10.1

WMS 10.1 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 Introduction

This tutorial illustrates the use of a watershed model to predict possible hydrologic reactions based on planned land use developments. It discusses and demonstrates how to define the watershed of interest, build a Maricopa County HEC-1 simulation, run HEC-1 based on existing land use and soil conditions, and run HEC-1 based on proposed conditions.

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.

3 Defining the Watershed

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

3.1 Converting the Shapefile to Feature Polygons

1. Switch to the **GIS** module.
2. Select *Data* | **Add Shapefile Data…** to bring up the *Select shapefile* dialog.
3. Browse to the *MARICOPA\MARICOPA\TUT2* folder and select "basins.shp".
4. Click **Open** to import the shapefile and close the *Select shapefile* dialog.

The shapefile should appear as in Figure 1.

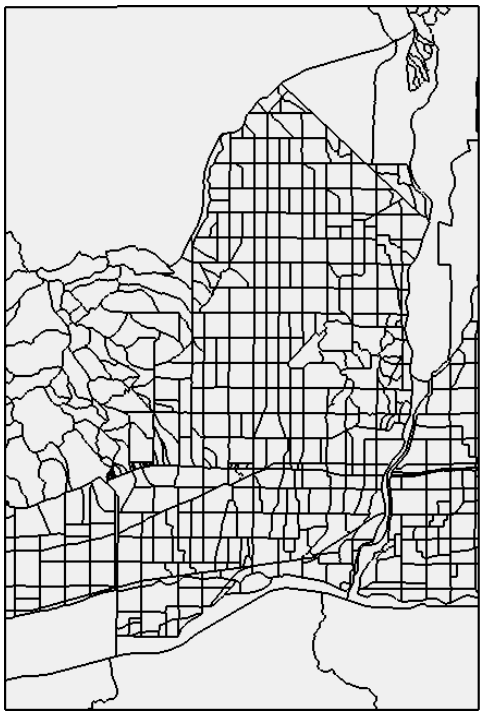

Figure 1 Imported shapefile

5. Select *File* | **Open** to bring up the *Open* dialog.
6. Select "WMS XMDF Project File (*.wms)" from the *Files of type* drop-down.
7. Select "zoom_here.wms" and click **Open** to exit the *Open* dialog and import the project file.

This file identifies the basins used in this tutorial. It also indicates where to zoom in on the project (Figure 2).

8. Using the **Zoom** tool, drag a box around the rectangle as shown in Figure 2.

Next, select two basins before converting the shapefile to feature polygons. When mapping shapefile data to feature objects, only the selected shapes are converted.

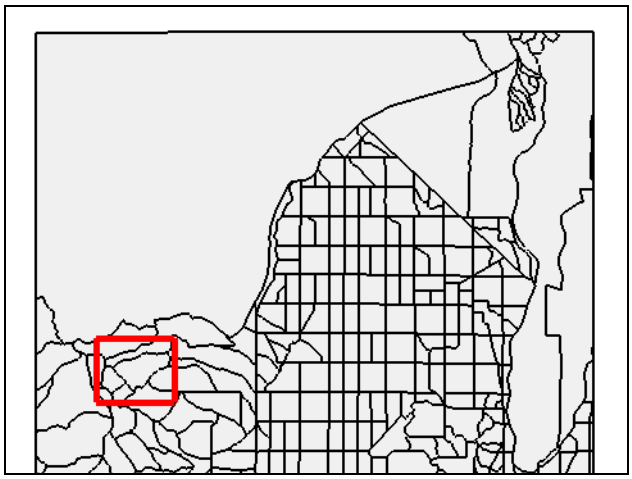

Figure 2 Zoom area

9. Switch to the **GIS** module.
10. Using the **Select shapes** tool while pressing the *Shift* key, select the two polygons shown in Figure 3.

When selected, the polygons will appear outlined in blue.

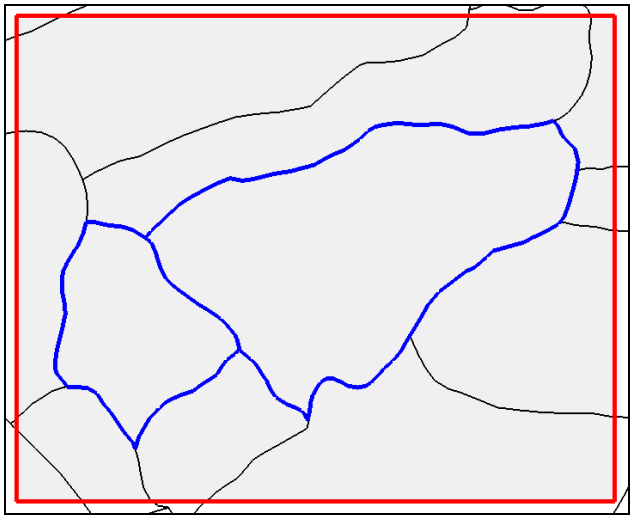

Figure 3 Polygons to select

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. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
14. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.

The feature polygons have now been created so the stream arcs can be created. Before continuing, remove the basins shapefile from the Project Explorer:

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

3.2 Getting a Background Image

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

1. Click **Open** to bring up the *Open* dialog.
2. Select "maricopa.jpg" and click **Open** to exit the *Open* dialog.
3. If asked to create image pyramids, click **Yes**.
4. Switch to the **Map** module.
5. Select the **Create Feature Arc** tool.
6. Select *Feature Objects* | **Attributes…** to bring up the *Feature Arc Type* dialog.
7. In the *Type* section, select *Stream* and click **OK** to close the *Feature Arc Type* dialog.
8. Using Figure 4 as a guide, begin drawing an arc in the rightmost polygon from the location labeled "Start". 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" to end the arc.

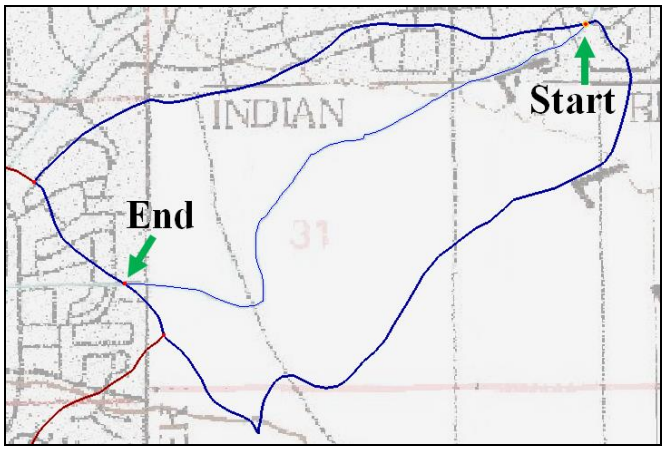

Figure 4 Guide for creating the first stream arc

9. Draw a second stream arc as indicated in Figure 5.

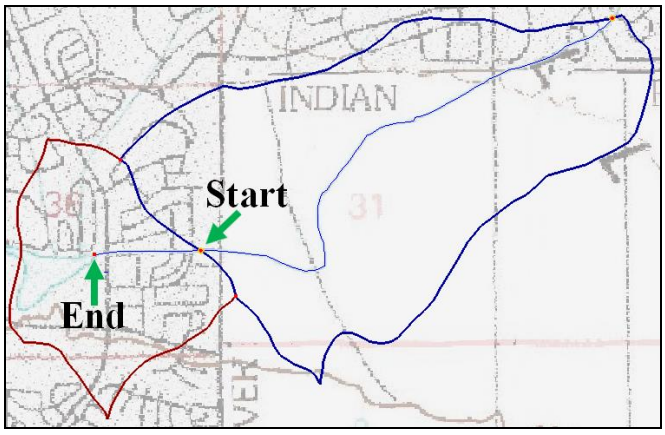

Figure 5 Location of the second stream arc

After creating the stream arcs, define the shared node as an Outlet point:

10. Using the **Select Feature Point** tool, double-click on the node labeled "Start" in Figure 5 to bring up the *Drainage Feature Point Type* dialog.
11. In the *Type* section, select *Drainage outlet* and click **OK** to close the *Drainage Feature Point Type* dialog.

3.3 Computing the Basin Data

The watershed construction has been completed. Next, compute the basin parameters that will be used by HEC-1.

1. Select *Feature Objects* | **Compute Basin Data…** to bring up the Units dialog.
2. In the *Model units* section, click **Current Projection...** to bring up the *Display Projection* dialog.
3. In the *Horizontal* section, click **Set Protection…** to bring up the *Select Projections* dialog.
4. Select ("Feet (U.S. Survey)" from the *Planar Units* drop-down and click **OK** to close the *Select Projection* dialog.
5. In the *Vertical* section, select "Feet (U.S. Survey)" from the *Units* drop-down and click **OK** to close the *Display Projection* dialog.
6. In the *Parameter* units section, select "Square miles" from the *Basin Areas* drop-down.
7. Select "Feet" from the *Distances* drop-down and click **OK** to close the *Units* dialog.

Each basin should now have the area in square miles showing (Figure 6).

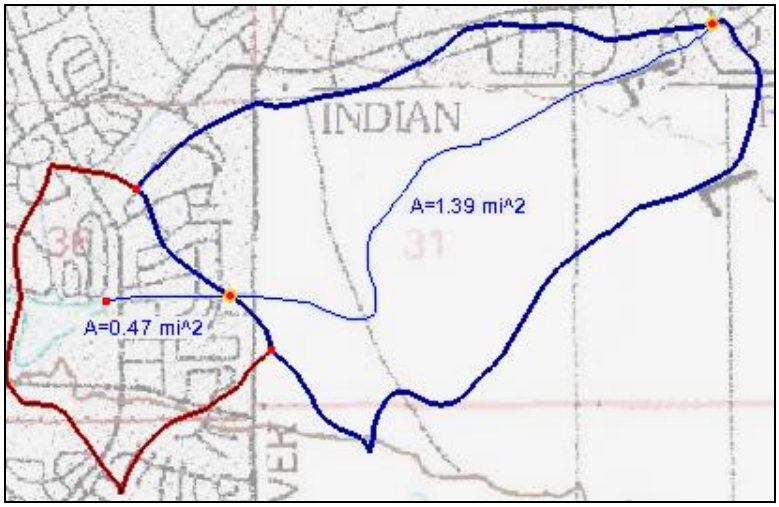

Figure 6 The area of each basin

4 Building the HEC-1 Model

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

4.1 Initializing Rainfall Data

1. Switch to the **Hydrologic Modeling** module.
2. Select "HEC-1" from the Model drop-down (Figure 7).

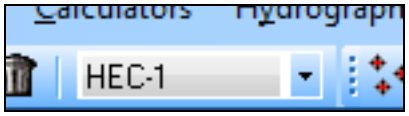

Figure 7 The Model drop-down

3. Select *HEC-1* | **Job Control…** to bring up the *HEC-1 Job Control* dialog.
4. Click **Initialize Maricopa County Precipitation Data** to bring up the *Maricopa County Precipitation Data Initialization* dialog.
5. Select *Basin Average (PB/PC)* and select "6 hour" from the drop-down.
6. Click **Browse** to bring up the *Open* dialog.

This allows a rainfall grid to be selected and imported to use for computing precipitation.

7. Select "noaa50y6h" and click **Open** to exit the *Open* dialog and open the *Compute Rainfall* dialog.
8. Click **OK** to accept the default cell size and close the *Compute Rainfall* dialog.
9. Click OK to close the *Maricopa County Precipitation Data Initialization* dialog.
10. Click **OK** to close the *HEC-1 Job Control* dialog.

4.2 Defining Unit Hydrograph Method

1. Using the **Select basin** tool, double-click on the left basin icon to bring up the *Edit HEC-1 Parameters* dialog.
2. In the *Basin HEC-1 Cards* section, click **Unit Hydrograph Method…** to bring up the *HEC-1 Unit Hydrograph Methods* dialog.
3. Click **Compute Parameters-Basin Data** to bring up the *Basin Time Computation* dialog.
4. Select "Compute Lag Time" from the *Computation type* drop-down.
5. Select "Tulsa Rural Method" from the *Method* drop-down.
6. In the *Variables* section, select the line "*S Maximum flow distance slope"* and enter "2000.0" as the *Variable value*.
7. Select the line the line "*S Maximum flow distance slope"* once again to update its value.
8. Click **OK** to close the *Basin Time Computation* dialog.

9. Select *Given unit hydrograph (UI)* and click **Maricopa County S-Graph** to bring up the *S-Graph Options* dialog.
10. In the *S-Graph types* section, select "Phoenix Valley" from the drop-down and click **OK** to close the *S-Graph Options* dialog and open the *XY Series Editor* dialog.
11. Click **OK** to exit the *XY Series Editor* dialog.
12. Click **OK** to exit the *HEC-1 Unit Hydrograph Methods* dialog.
13. Click **Next Hydrograph Station** → button twice to select the basin on the right.

Note that the basin number in the *HEC-1 File Output* section (listed to the right of "KK" in the text field) matches the basin number for the basin on the right.

14. Repeat steps 2-12 above to define the unit hydrograph for this basin, using "2400.0" as the *Variable value* for *S Max flow distance slope* in steps 6-7.

4.3 Defining Routing Method

1. Click ← **Previous Hydrograph Station** to select the outlet located between the two basins.
2. In the *Routing HEC-I Cards* section, click **Routing Data…** to bring up the *HEC-1 Routing Data* dialog.
3. Select "Muskingum (RM)" from the *Routing Type* drop-down.
4. Click **Compute NSTPS** to bring up the *Compute NSTPS* dialog.
5. Select *From Channel Velocity Estimate* and enter "6.0" as the *Channel velocity estimate*.
6. Click **OK** to close the *Computer NSTPS* dialog.
7. Click **OK** to exit the *HEC-1 Routing Data* dialog.
8. Click **Done** to exit the *Edit HEC-1 Parameters* dialog.

4.4 Importing the Land Use Coverages

The last parameter needing to be defined before running HEC-1 is the Green-Ampt losses. To have WMS compute losses, 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. Using the **Select Drawing Objects** tool, select the rectangle surrounding the two basins and press *Delete*.
3. Right-click on "Coverages" in the Project Explorer and select **New Coverage** to bring up the *Properties* dialog.
4. Select "Soil Type" from the *Coverage type* drop-down.

Notice that the *Coverage name* is automatically changed to "Soil Type".

5. Click **OK** to close the *Properties* dialog.

6. Repeat steps 3-5, selecting "Land Use" as the *Coverage type* and entering "LU existing" as the *Coverage name*.
7. Repeat steps 3-5, selecting "Land Use" as the *Coverage type* and entering "LU future 1" as the *Coverage name*.
8. Repeat steps 3-5, selecting "Land Use" as the *Coverage type* and entering "LU future 2" as the *Coverage name*.
9. Select "LU existing" make it active.
10. Switch to the **GIS** module.
11. Select *Data* | **Add Shapefile Data** to bring up the *Select shapefile* dialog.
12. Select "ExistingCondition.shp" and click **Open** to import the shapefile and exit the *Open* dialog.
13. Select *Mapping* | **Shapes → Feature Objects** to bring up the *GIS to Feature Objects Wizard* dialog.
14. Click **Yes** when asked to use all shapes.
15. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
16. On the *Mapping* row in the *LDUSE_LID* column, select "Land use" from the drop-down.
17. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
18. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.

The Graphic Window should appear similar to Figure 8.

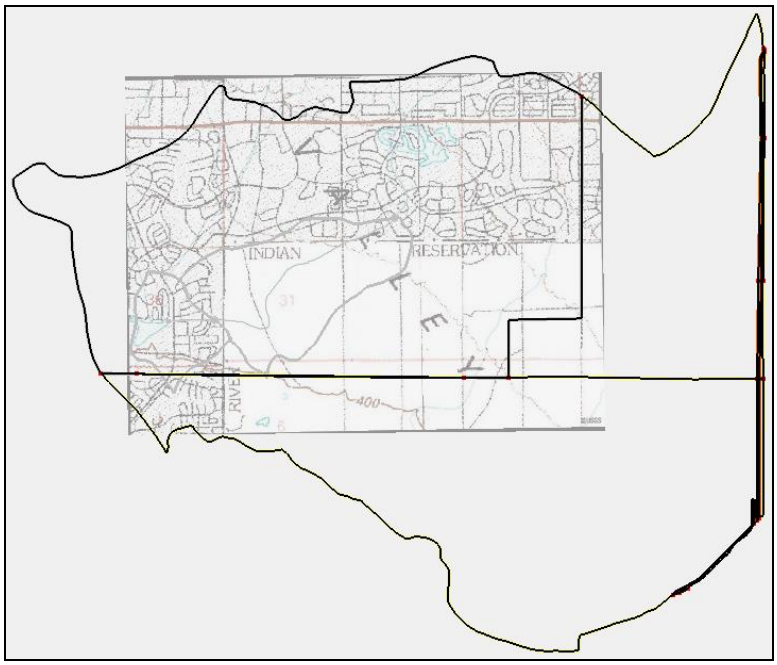

Figure 8 Imported existing conditions land use shapefile

Now import the first future land use shapefile.

1. Select "LU future 1" in the Project Explorer make it active.
2. Turn off "ExistingCondition.shp" in the Project Explorer.
3. Switch to the **GIS** module.
4. Select *Data* | **Add Shapefile Data** to bring up the *Select shapefile* dialog.
5. Select "LU_future1.shp" and click **Open** to import the shapefile and exit the *Select shapefile* dialog.
6. Using the **Select shapes** tool, draw a selection box around the extents of the watershed area for the two basins (the thin-walled box in Figure 9).

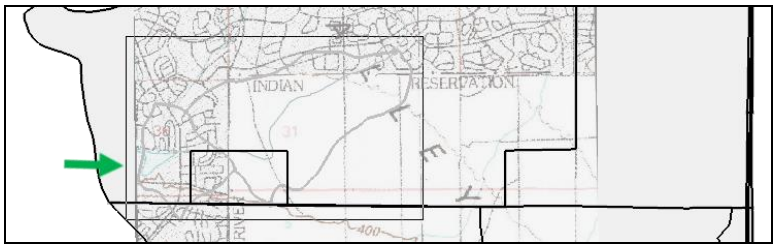

Figure 9 Select the area encompassing the watershed

By drawing a selection box around the extents of the watershed area, all land use polygons that overlap the watershed are selected (Figure 10).

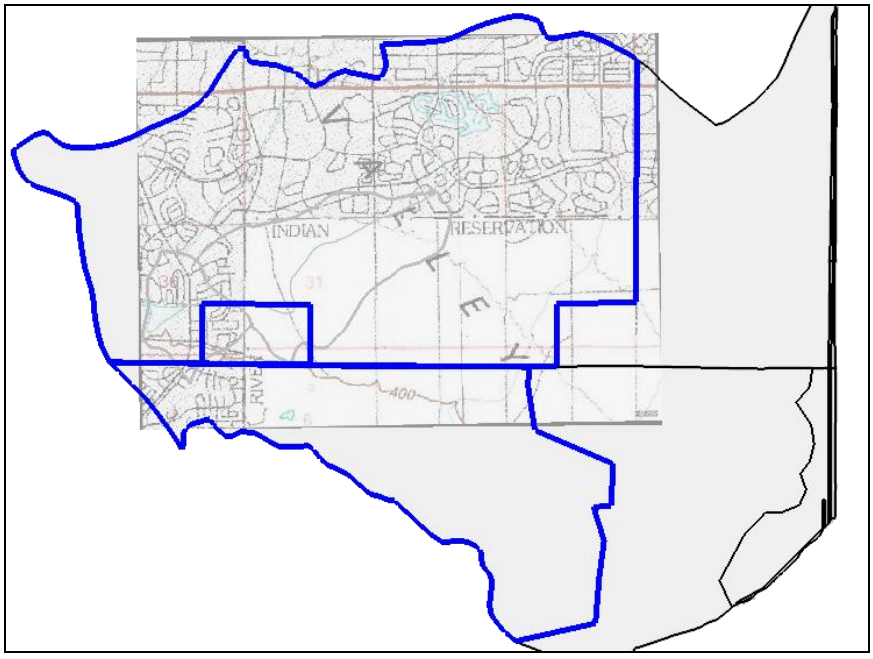

Figure 10 Three land use polygons selected which overlap the watershed

7. Select *Mapping* | **Shapes → Feature Objects** to bring up the *GIS to Feature Objects Wizard* dialog.
8. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
9. Notice the drop-down on the *Mapping* row in the *LU_CODE* column automatically selected "Land use".

10. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
11. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.
12. Turn off "LU_future1.shp" in the Project Explorer.

Next, import the second future land use shapefile.

1. Select "LU future 2" to make it active.
2. Switch to the **GIS** module.
3. Select *Data* | **Add Shapefile Data** to bring up the *Select shapefile* dialog.
4. Select "LU_future2.shp" and click **Open** to exit the *Select shapefiles* dialog.
5. Using the **Select Shapes** tool, draw a selection box around the two basins (Figure 11).

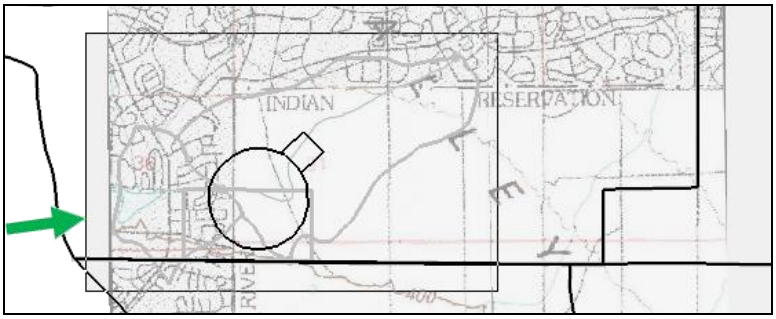

Figure 11 Selection box for second future land use

6. Select *Mapping* | **Shapes → Feature Objects** to bring up the *GIS to Feature Objects Wizard* dialog.
7. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
8. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
9. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.
10. Turn off "LU_future2.shp" in the Project Explorer.

4.5 Importing the Soil Type Coverage

1. Turn on "Soil Type" to make it active.
2. Switch to the **GIS** module.
3. Select *Data* | **Add Shapefile Data** to bring up the *Select shapefile* dialog.
4. Select "soilwhitetanks.shp" and click **Open** to exit the *Select shapefile* dialog.
5. Using the **Select Shapes** tool, draw a selection box around the two basins (Figure 12).
6. Select *Mapping* | **Shapes → Feature Objects** to bring up the *GIS to Feature Objects Wizard* dialog.

7. Click **Next** to go to the *Step 1 of 2* page of the *GIS to Feature Objects Wizard* dialog.
8. On the *Mapping* row in the *SLTYP_LID* column, select "SCS soil type" from the drop-down.
9. Click **Next** to go to the *Step 2 of 2* page of the *GIS to Feature Objects Wizard* dialog.
10. Click **Finish** to close the *GIS to Feature Objects Wizard* dialog.
11. Turn off "soilwhitetanks.shp" in the Project Explorer.

Figure 12 Selecting soil types overlapping the watershed

4.6 Computing Losses

1. Switch to the **Hydrologic Modeling** module.
2. Select *Calculators* | **Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
3. In the *Computation* section, select "Green-Ampt parameters" from the drop-down.
4. In the *Mapping* section, select *Land use mapp*ing.
5. Click **Import** to bring up the *Open* dialog.
6. Select "landusemagtable.txt" and click **Open** to import the file and exit the *Open* dialog.
7. Select *Soil type mapping* and click **Import** to bring up the *Open* dialog.
8. Click **OK** if warned that any previous tables will be replaced.
9. Select "soiltable.txt" and click **Open** to import the file and exit the *Open* dialog.
10. In the section below the *Computation* section, select "LU Existing" from the *Land use coverage name* drop-down.
11. Click **OK** to close the *Compute GIS Attributes* dialog.

The losses for the existing land use conditions have now been computed. When computing runoff values for future scenarios, simply recompute losses using the *Compute GIS Attributes* dialog.

The Graphics Window should appear similar to Figure 13.

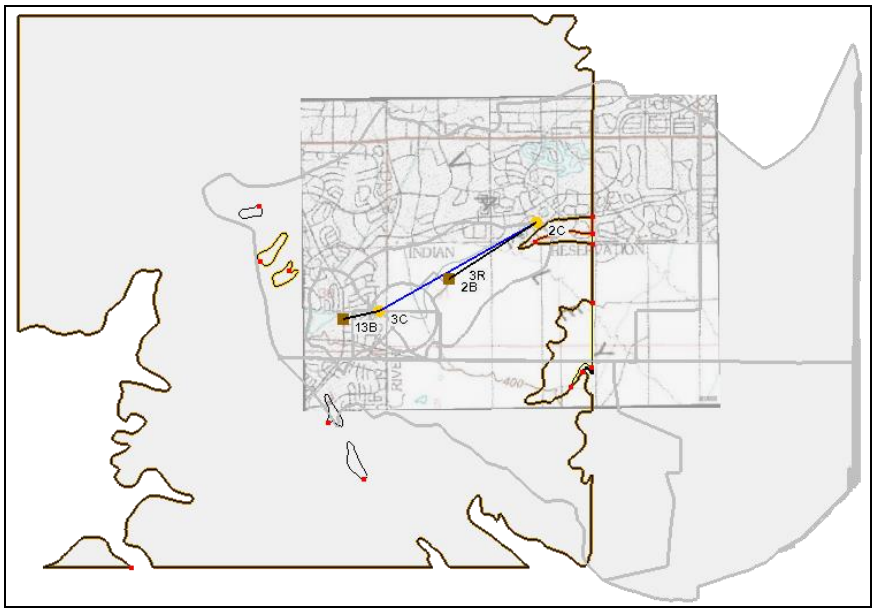

Figure 13 After computing losses

5 Running HEC-1

5.1 Existing Conditions

1. Select *HEC-1* | **Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
2. Click **Browse** to bring up the *Select HEC-1 Input File* dialog.
3. Enter "Mp_existing.hc1" as the *File name* and click **Save** to close the *Select HEC-1 Input File* dialog.
4. Turn on *Save file before run* and click **OK** to close the *HEC-1 Run Options* dialog and bring up the *Model Wrapper* dialog.
5. When HEC-1 finishes, turn on *Read solution on exit* and click **Close** to import the solutions and close the *Model Wrapper* dialog.
6. Using the **Select hydrograph** tool, double-click on the hydrograph at the top right (the most downstream outlet) to bring up the *Hydrograph* dialog.
7. The hydrograph shows that for the existing land use conditions, the peak runoff for a 50 year, 6 hour storm is approximately 1160 cfs (Figure 14).
8. When done reviewing the hydrograph, click the in the top right corner to close the *Hydrograph* dialog.

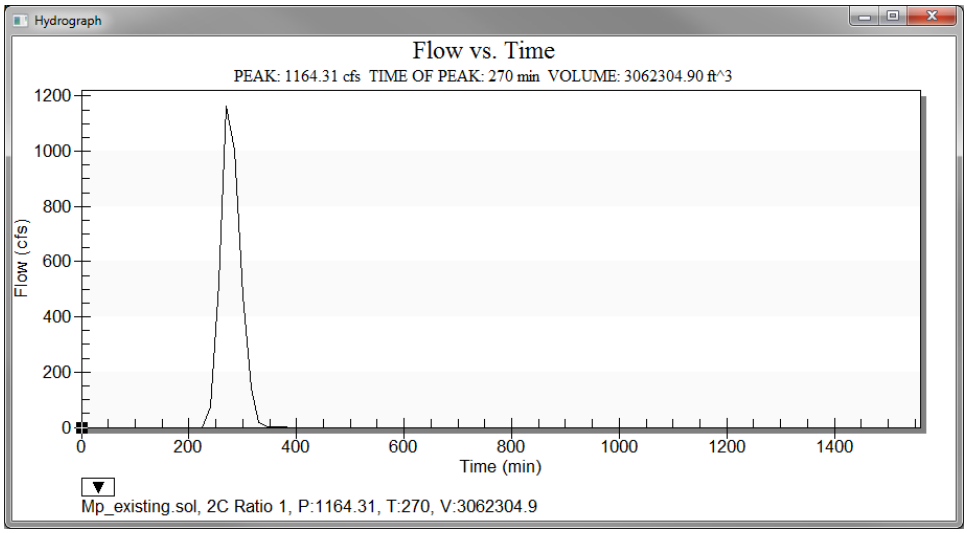

Figure 14 Hydrograph for existing conditions

5.2 Future 1 Conditions

1. Select *Calculators* | **Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
2. In the *Computation* section, select "Green-Ampt parameters" from the drop-down.
3. In the section below the *Computation* section, select "LU future 1" from the *Land use coverage name* drop-down.
4. Click **OK** to close the *Compute GIS Attributes* dialog..
5. Select *HEC-1* | **Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
6. Click **Browse** to bring up the *Select HEC-1 Input File* dialog.
7. Enter "MP_future1.hc1" as the *File name* and click **Save** to close the *Select HEC-1 Input File* dialog.
8. Turn on *Save file before run* and click **OK** close the *HEC-1 Run Options* dialog and bring up the *Model Wrapper* dialog.
9. Once HEC-1 finishes, turn on *Read solution on exit* and click **Close** to import the solutions and close the *Model Wrapper* dialog.
9. Using the **Select hydrograph** tool, double-click on the hydrograph at the top right (the most downstream outlet) to bring up the *Hydrograph* dialog (Figure 15).
10. In the upper left-hand corner of the *Hydrograph* dialog, note that the peak runoff has increased to about 1360 cfs.

This new hydrograph is superimposed over the previous one. Next, zoom in on a portion of the hydrographs or maximize the *Hydrograph* dialog to enlarge the graphs.

- Drag a box around the peaks of the hydrographs.

- Right-click anywhere within the *Hydrograph* dialog and select **Maximize Plot**.
- To view the entire plot, right-click anywhere within the *Hydrograph* dialog and select **Frame Plot**.

11. Once done, press the *Esc* key to restore the *Hydrograph* dialog to its original size.
12. When done reviewing the hydrographs, click the in the top right corner to close the *Hydrograph* dialog.

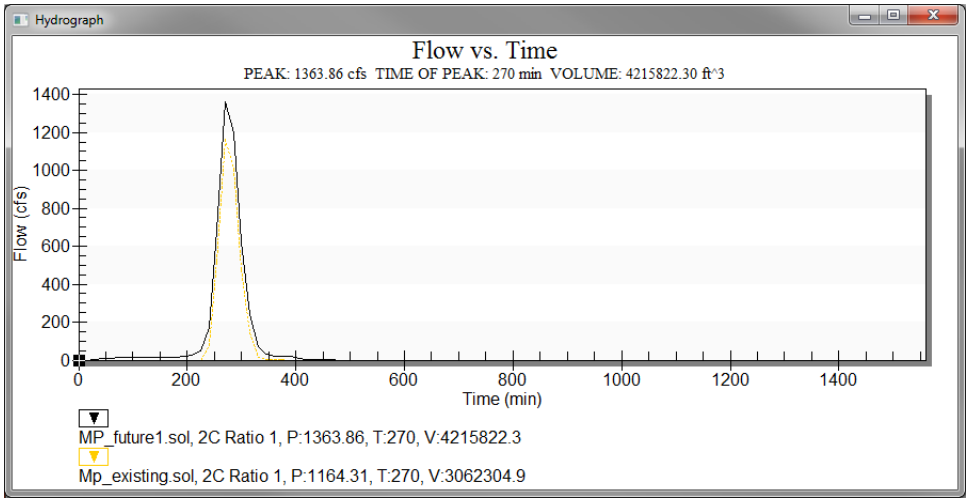

Figure 15 Hydrograph for future 1 conditions

5.3 Future 2 Conditions

1. Select *Calculators* | **Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog,
2. In the *Computation* section, select "Green-Ampt parameters" from the drop-down.
3. In the section below the *Computation* section, select "LU future 2" from the *Land use coverage name* drop-down.
4. Click **OK** to close the *Compute GIS Attributes* dialog.
5. Select *HEC-1* | **Run Simulation…** to bring up the *HEC-1 Run Options* dialog.
6. Click **Browse** to bring up the *Select HEC-1 Input File* dialog.
7. Enter "MP_future2.hc1" as the *File name* and click **Save** to close the *Select HEC-1 Input File* dialog.
8. Turn on *Save file before run* and click **OK** close the *HEC-1 Run Options* dialog and bring up the *Model Wrapper* dialog.
9. When HEC-1 is finished, turn on *Read solution on exit* and click **Close** to import the solutions and close the *Model Wrapper* dialog.
10. Using the **Select hydrograph** tool, double-click on the hydrograph at the top right (the most downstream outlet) to bring up the *Hydrograph* dialog (Figure).

11. Notice that the peak runoff for "LU future 2" (about 1360cfs) is slightly higher than that for "LU future 1".

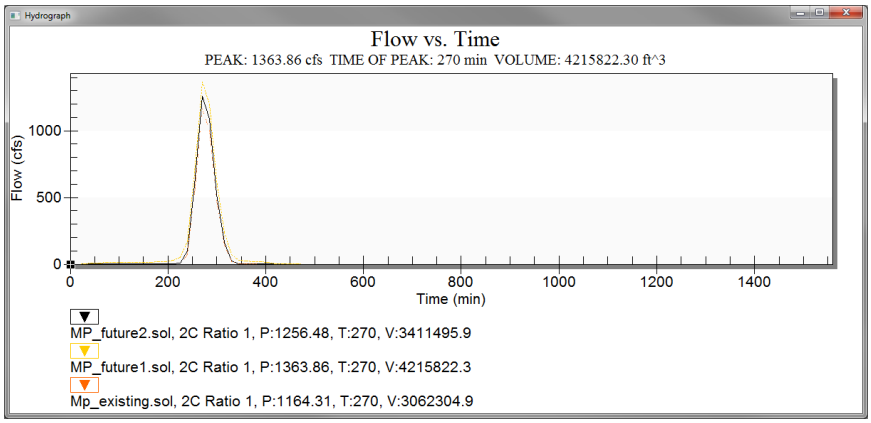

Figure 16 Hydrograph for future 2 conditions

The results in the *Hydrograph* dialog can be exported as tabular data.

12. Right-click within the *Hydrograph* dialog and select **Export/Print…** to bring up the *Exporting Flow vs. Time* dialog.
13. In the *Export* section, select *Text / Data*.
14. In the *Export Destination* section, select *File* and click **Browse** to bring up the *Save As* dialog.
15. Enter "LU_future2-export.dat" as the *File name* and click **Save** to close the *Save As* dialog.
16. Click **Export…** to close the *Exporting Flow vs. Time* dialog and bring up the *Export… Flow vs. Time* dialog.
17. Click **Export** to accept the defaults and close the *Export… Flow vs. Time* dialog.

The exported data can 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. If HEC-1 terminates unsuccessfully, reviewing the OUT file can reveal possible errors and warnings.

6 Conclusion

This concludes the "Watershed Modeling – Maricopa Predictive HEC-1 Model" tutorial. The HEC-1 model for storm drain modeling was discussed and demonstrated, along with the following key topics:

- Defining the watershed of interest
- Building a Maricopa County HEC-1 simulation
- Running HEC-1 based on existing land use and soil conditions
- Running HEC-1 based on proposed (or future) conditions

