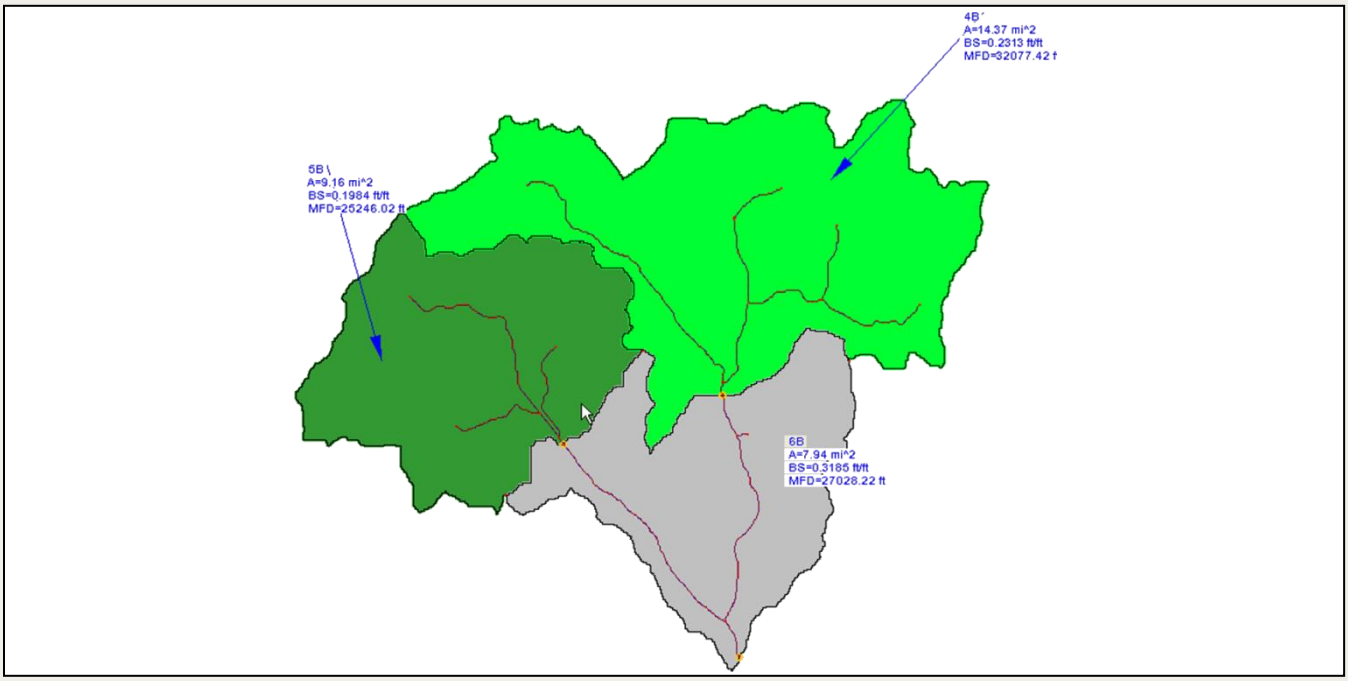
WMS 11.2 Tutorial

DEM Delineation

Learn how to delineate a watershed using the hydrologic modeling wizard



Objectives

Import a digital elevation model, compute flow directions, and delineate a watershed and sub-basins using outlet points.

Prerequisite Tutorials

- Introduction – Images
- Introduction – Basic Feature Objects
- Editing Elevations – DEM Basics

Required Components

- Data
- Drainage
- Map

Time

- 30–60 minutes

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1 Introduction

Watershed delineation from DEMs is straightforward and relatively simple, provided the project area is not entirely flat or completely dominated by man-made structures. The DEM method does not work well if there is no relief in the DEM elevations.

This tutorial discusses and demonstrates:

- DEM delineation using the hydrologic modeling wizard, a step-by-step delineation approach that makes the process even simpler.
- Importing DEM data.
- Computing flow paths and flow accumulations.
- Delineating watersheds from DEMs.
- Delineating sub-basins within a watershed.

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 **Don't Save** to clear all data.

The Graphics Window of WMS should refresh to show an empty space.

3 Setting up a Project with the Hydrologic Modeling Wizard

The *Hydrological Modeling Wizard* is a tool that facilitates setting up hydrologic models.

3.1 Starting the Hydrologic Modeling Wizard

1. Click **Hydrologic Modeling Wizard** to bring up the *Hydrological Modeling Wizard* dialog (Figure 1).

This dialog is dynamic. As an item is selected from the list on the left, the title of the dialog changes and the area to the right of the list has different options available. The items in the list on the left are the various steps used in setting up a hydrologic model. The area to the right shows the options and settings for the selected step.

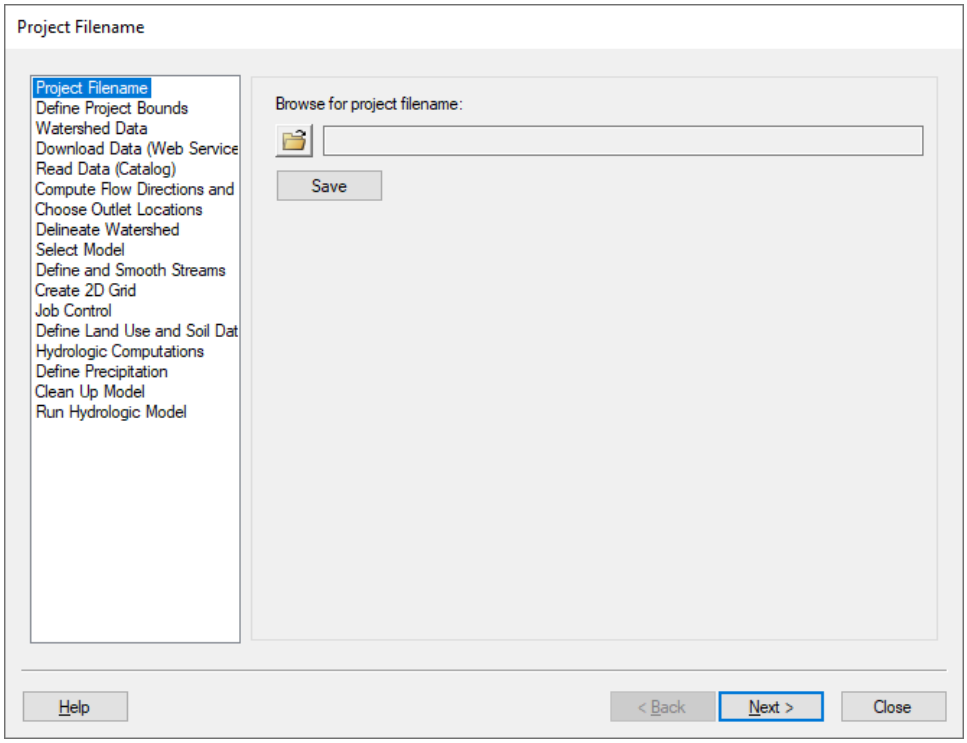

Figure 1 Hydrologic Modeling Wizard dialog

Clicking **Next >** moves through the steps on the left in order, from top to bottom. Move to any step in the wizard at any time by selecting the desired step from the list on the left.

The *Hydrologic Modeling Wizard* window is a non-modal window, meaning it allows interaction with the main menus and Graphics Window while it is open.

3.2 Project Filename

1. Select “Project Filename” from the list on the left.
2. On the right, click the button to bring up the *Select WMS Project File* dialog.
3. Browse to the *demdelin**demdelin*\ directory.
4. Select “WMS XMDF Project File (*.wms)” from the *Save as type* drop-down.
5. Enter “DemDelineation.wms” as the *File name*.

6. Click **Save** to create the new project and close the *Select WMS Project File* dialog.
7. Click **Save** (below the button in the dialog) to save the project filename.
8. Click **Next >** to go to the "Define Project Bounds" page of the *Hydrologic Modeling Wizard* dialog.

The dialog title should change to *Define Project Bounds*.

3.3 Defining Project Bounds

1. On the right, below *Project Projection*, click **Define…** to bring up the *Display Projection* dialog.
2. In the *Horizontal* section, select *Global Projection* to bring up the *Horizontal Projection* dialog. If the dialog does not automatically open, click **Set Projection…** to bring it up.
3. In the tree section of the dialog, expand the "Projected Coordinate Systems" item.
4. Scroll down the list and expand the "UTM" item, then expand the "NAD 1983" item.
5. Select the projection "NAD 1983 UTM Zone 12N".
6. Click **OK** to close the *Horizontal Projection* dialog.
7. In the *Vertical* section, select "Local" from the *Datum* drop-down.
8. Select "Meters" from the *Units* drop-down.
9. Click **OK** to close the *Display Projection* dialog.

Steps 10–14 require an internet connection. If one is not available, please proceed to Section 3.5 to continue the tutorial.

10. Under *Project boundary*, click **Define…** to bring up the *Virtual Earth Map Locator* dialog.
11. Enter "Cove Fort, UT" in the *Place to search for* field and click **Jump to Search Location**.
12. **Zoom** in or out, as necessary, until the *Virtual Earth Map Locator* dialog appears similar to Figure 2.
13. Click **OK** to close the *Virtual Earth Map Locator* dialog.

The boundary coordinates should appear below the *Project boundary* **Define…** button.

14. Click **Next >** to go to the "Watershed Data" page of the *Hydrologic Modeling Wizard* dialog.

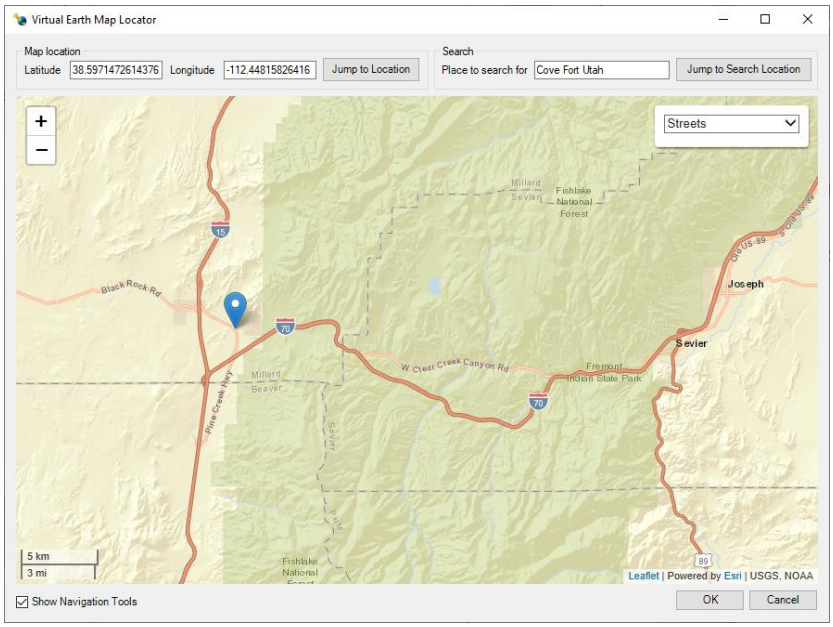

Figure 2 Project bounds in Virtual Earth Map Locator dialog

3.4 Importing Watershed Data using Web Services

This section requires an internet connection. If one is not available, please proceed to Section 3.5 to continue the tutorial.

1. Turn on *Use web services* under *Select data sources*.
2. Click **Next >** to go to the "Download Data (Web Services)" page of the *Hydrologic Modeling Wizard* dialog (Figure 3).
3. In the *Data Type* column, turn on *Worldwide Elevation Data (Variable Resolution)*.

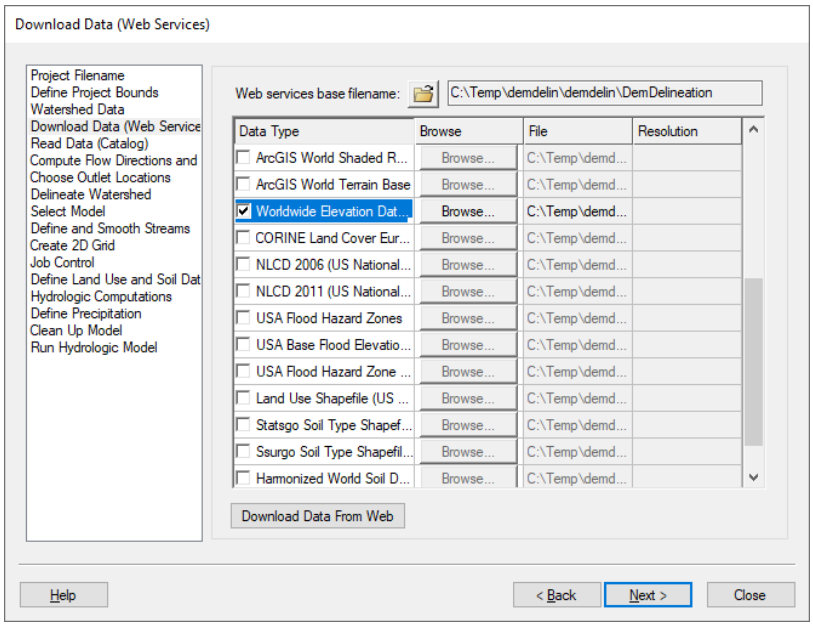

Figure 3 Download Data (Web Services) dialog

4. Turn off all other options in the *Data Type* column.
5. Click **Download Data From Web** to bring up the *Zoom level* dialog.
6. Select "Zoom level 12 (Resolution = 29.9)" from the drop-down list and click **OK** to close the *Zoom Level* dialog.

WMS will proceed to download the requested data for the project area that was specified. The file will appear in the GIS module and in the Terrain Data module.

7. Hide "DemDelineation_elev.tif" under the "GIS Data" folder.

The DEM will appear similar to Figure 4.

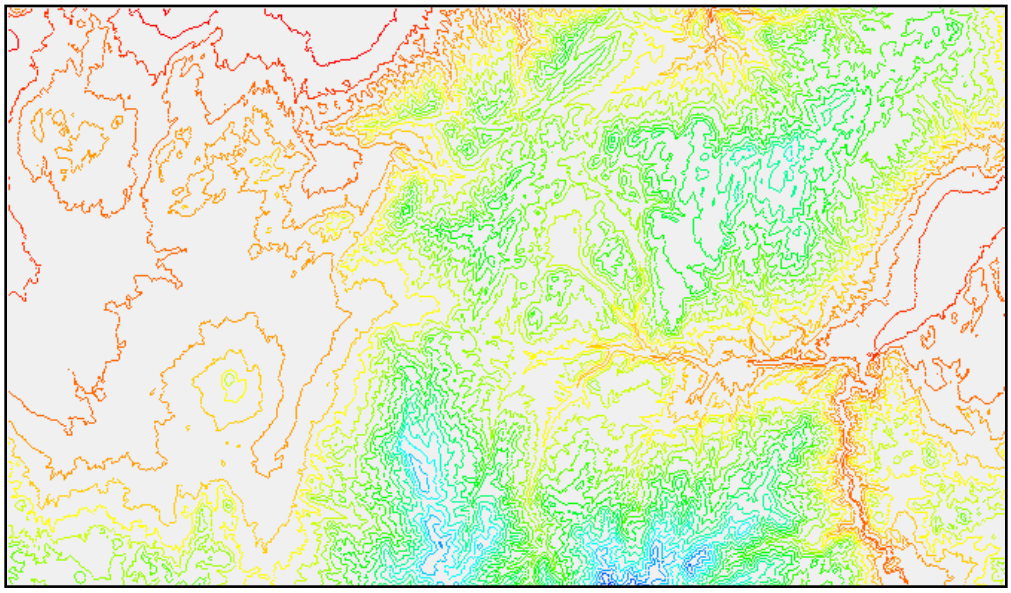

Figure 4 A topographic map with elevation contour lines

8. In the main WMS window, click **Get Online Maps…** to bring up the *Get Online Maps* dialog.
9. Hold down the *Ctrl* key and select both *World Imagery* and *USA Topo Map*.
10. Click **OK** to close the *Get Online Maps* dialog and import the two online maps.

Once the image files have been downloaded from Web Services, WMS automatically opens the files into the WMS project.

11. In the *Hydrologic Modeling Wizard* dialog, click **Next >** to go to the "Compute Flow Directions and Accumulations" page.

If the online maps imported correctly, skip to Section 3.6.

3.5 Importing Watershed Data via Local Files

Note: This section should only be completed if the online maps were unable to be imported in Section 3.4.

To import a set of four 30-meter DEMs from the 1:24000 series, complete the following steps:

1. Select *File* **| Open…** to bring up the *Open* dialog.
2. Select "USGS DEM File (*.dem;*.ddf)" from the *Files of type* drop-down.

3. Select “josephpeak.dem” then, while holding down the Ctrl key, select “marysvalecanyon.dem”, “redridge.dem”, and “trailmountain.dem”.
4. Click **Open** to exit the *Open* dialog.
5. Under the “ GIS Data” folder, select “ josephpeak.dem”, “ marysvalecanyon.dem”, “ redridge.dem”, and “ trailmountain.dem” by holding down *Shift* and selecting “ josephpeak.dem” and “ trailmountain.dem”.
6. Right-click on any of the selected items and select *Convert To* | **DEM** to bring up the *Resample and Export Raster* dialog.
7. Click **OK** to accept the defaults and close the *Resample and Export Raster* dialog.

Thinning the resolution of the DEMs will reduce the density of elevation points so that the DEM data will be processed faster. The resolution of points in the 30-meter DEMs is too dense for the purposes of this tutorial, so no accuracy will be lost by thinning.

8. Click **Next >** enough times to go to the “Compute Flow Directions and Accumulations” page of the *Hydrologic Modeling Wizard* dialog.

3.6 Trimming the DEM

Trimming the DEM so that it encompasses the extents of the project area reduces the computational time required for watershed delineation.

1. Move the Hydrologic Modeling Wizard dialog to the side so the main WMS window is completely visible. This dialog will be used again in Section 4.
2. In the Project Explorer, turn off “ World Imagery”.

Turning this off will speed up the display.

3. Switch to the **Terrain Data** module.
4. Click **Display Options** to bring up the *Display Options* dialog.
5. Select “DEM Data” from the list on the left.
6. Click **Options…** next to *DEM Contours* to bring up the *DemDelineation_elev Contour Options* dialog (if section 3.5 was completed, this will have a different dialog name).
7. In the *Contour Method* section, select “Normal Linear” from the first drop-down.
8. In the *Contour Interval* section, enter “30” to the right of the drop-down.
9. Click **OK** to close the *DemDelineation_elev Contour Options* dialog.
10. Click **OK** to close the *Display Options* window.
11. Select *DEM* | *Trim* **| Polygon…** to bring up the *Polygon Selection Options* dialog.
12. Select “Enter a polygon interactively” from the drop-down.
13. Click **OK** to close the *Polygon Selection Options* dialog.
14. If Section 3.4 was completed, click out the rectangle shown in Figure 5. Double-click to close the rectangle.
15. If section 3.5 was completed, click out the rectangle shown in Figure 6. Double-click to close the rectangle.

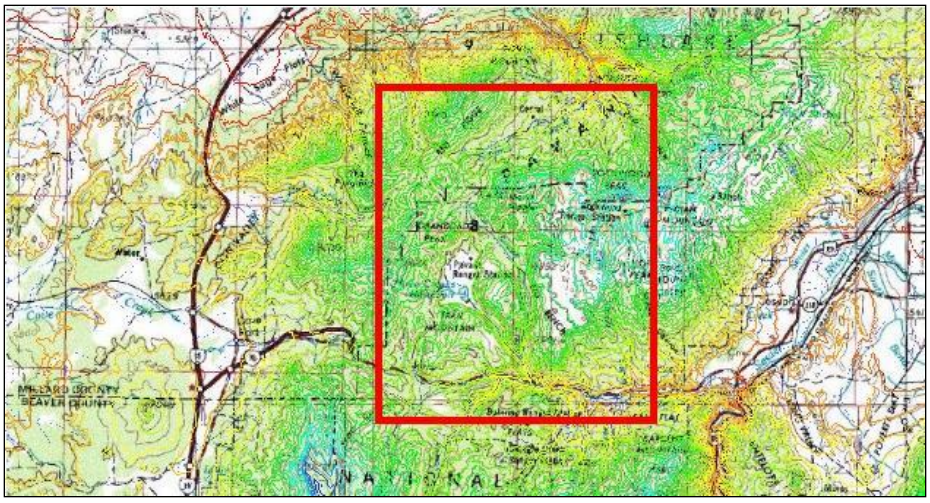

Figure 5 DEM trim area for if online maps used

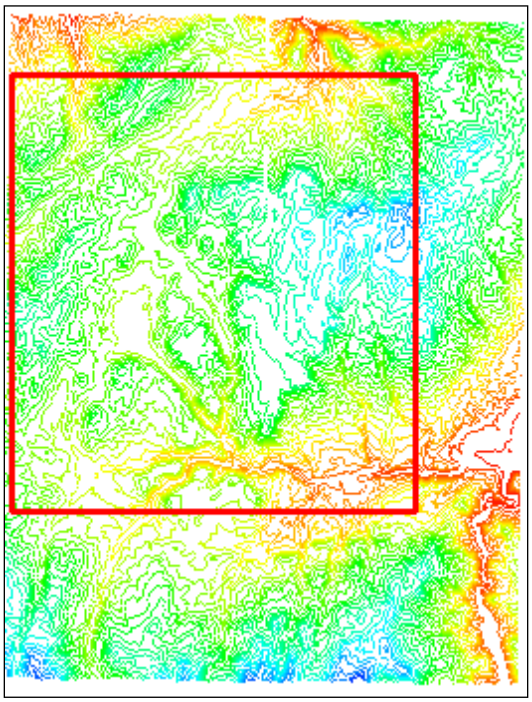

Figure 6 DEM trim area if local map files used

16. Turn off all images in the "GIS Data" folder in the Project Explorer.
17. **Frame** the project.

3.7 DEM Fill Command

The DEM **Fill** command fills gaps in DEM data by interpolating missing data values using inverse distance weighting of the neighboring eight cells. This functionality is useful when tiling multiple DEM files in WMS, particularly if a thinning factor is applied when the DEMs are imported. It is not necessary to use this command on seamless DEMs obtained from the WMS web services (NED). If Section 3.4 was completed successfully, then skip to Section 4.

1. Click **Display Options** to bring up the *Display Options* dialog.
2. Select “DEM Data” from the list on the left.
3. On the *DEM* tab, turn on *No Data Cells*.
4. Click **OK** to close the *Display Options* dialog.
5. Right-click on “ … (Trimmed)” and select **Fill**.

Interior “no data” cells will disappear as elevations at those locations are interpolated using the surrounding cells.

6. Select *Display* **| Display Options…** to bring up the *Display Options* dialog.
7. Select “DEM Data” from the list on the left.
8. On the *DEM* tab, turn off *No Data Cells* and click **OK** to close the *Display Options* dialog.

4 Watershed Delineation using the Hydrologic Modeling Wizard

4.1 Computing Flow Directions and Accumulations

WMS computes flow directions and flow accumulations to create streams on the DEM using a program called TOPAZ.

1. Switch back to the *Hydrologic Modeling Wizard* dialog. If it was closed, click **Hydrologic Modeling Wizard** to open it and select “Compute Flow Directions and Accumulations (TOPAZ)” from the list on the left.
2. On the right, select *Write TOPAZ files to a temp directory*.
3. Select “Square Miles” from the *Compute sub-basin areas in* drop-down.
4. Select “Feet” from the *Compute distances in* drop-down.
5. Click **Compute TOPAZ** to bring up the *Model Wrapper* dialog.
6. When TOPAZ finishes, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.

The display in the main WMS window should update.

7. Enter “2.0” (mi^2) as the *Min flow accumulation threshold*.
8. Click **Apply to Display**.

Notice how the display of flow accumulations cells changes in the main WMS window.

9. Enter “0.5” (mi^2) as the *Min flow accumulation threshold*.
10. Click **Apply to Display**.
11. Enter “1.0” (mi^2) as the *Min flow accumulation threshold*.
12. Click **Apply to Display**.

With each of the above adjustments, notice the changes in the lengths of the various streams in the main WMS window.

13. Click **Next >** to go to the “Choose Outlet Locations” page of the *Hydrologic Modeling Wizard* dialog.

4.2 Choosing Outlet Locations

1. In the main WMS window, **Zoom** in to the area similar to the one shown in Figure 7.

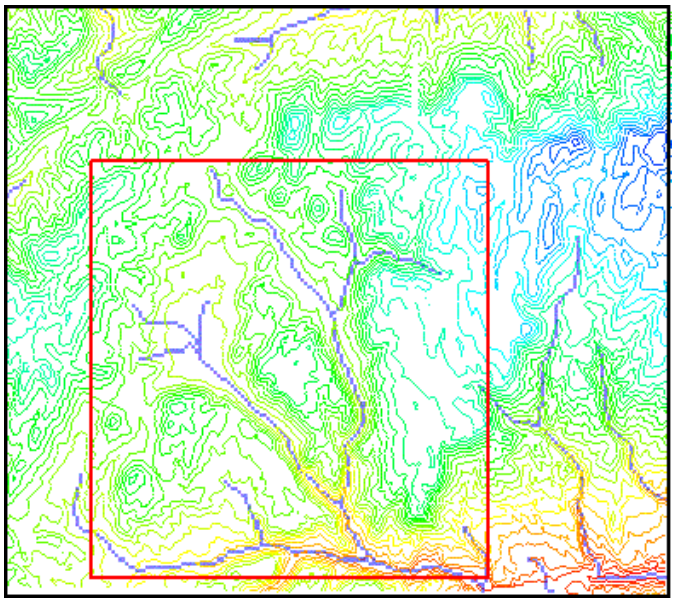

Figure 7 DEM zoom area

2. In the *Hydrologic Modeling Wizard* dialog, click the **Create outlet point** button.
3. In the main WMS window, place the outlet just upstream of the stream junction by clicking on the location shown in Figure 8.

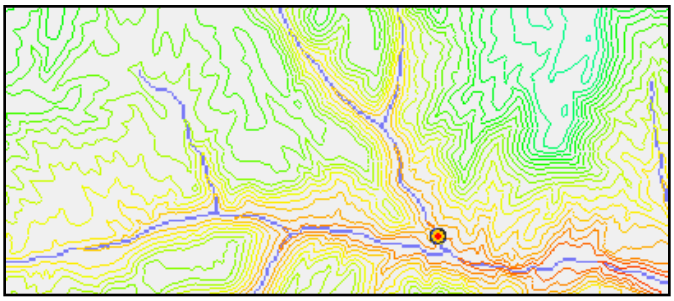

Figure 8 Drainage outlet location

4. Click **Next >** to go to the "Delineate Watershed" page of the *Hydrologic Modeling Wizard* dialog.

4.3 Delineating Watershed

1. Enter "1.0" (mi^2) as the *Stream threshold value*.
2. Click **Delineate Watershed**.

WMS now digitizes stream arcs using the DEM streams (DEM cells with flow accumulations greater than the stream threshold value), defines the basin boundary, and computes geometric parameters for the basin including basin area, average basin slope, mean basin elevation, and maximum flow distance (Figure 9).

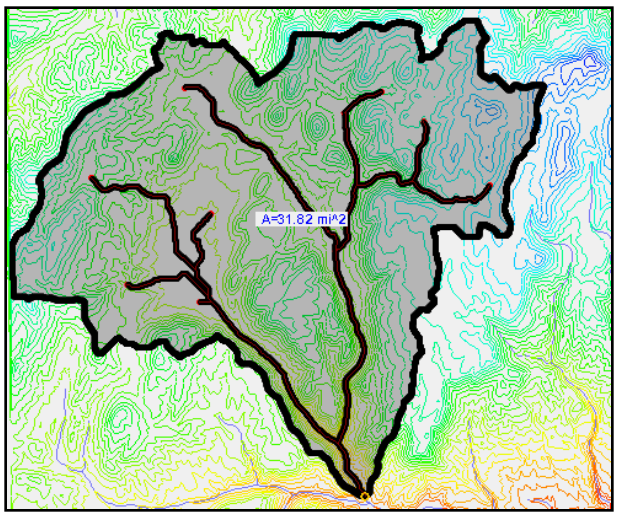

Figure 9 Delineated watershed basin showing streams

4.4 Creating Sub-basins

1. In the *Hydrologic Modeling Wizard* dialog, select "Choose Outlet Locations" (or click **< Back)** to return to the "Choose Outlet Locations" page.
2. **Zoom** in to the area shown in Figure 10.

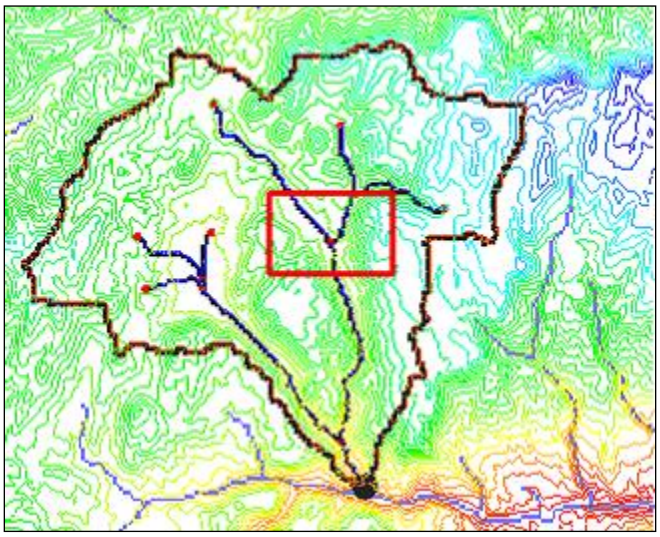

Figure 10 Zoom in to this area on the right

3. In the *Hydrologic Modeling Wizard* dialog, click **Create outlet point**.
4. Create an outlet two vertices below the stream junction (Figure 11).

Note that the stream junction might appear slightly different from Figure 11. Also, consider adjusting the vertices in the Display Options to make them more visible.

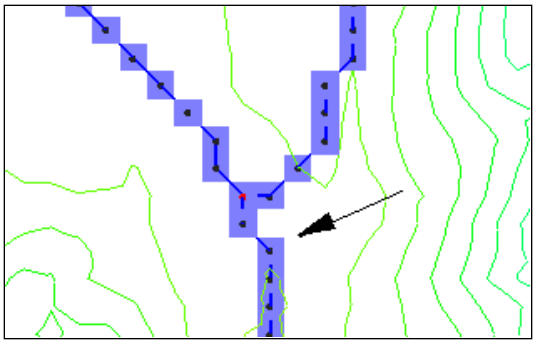

Figure 11 New outlet location

5. **Frame** the project.
6. **Zoom** in to the branch shown in Figure 12.

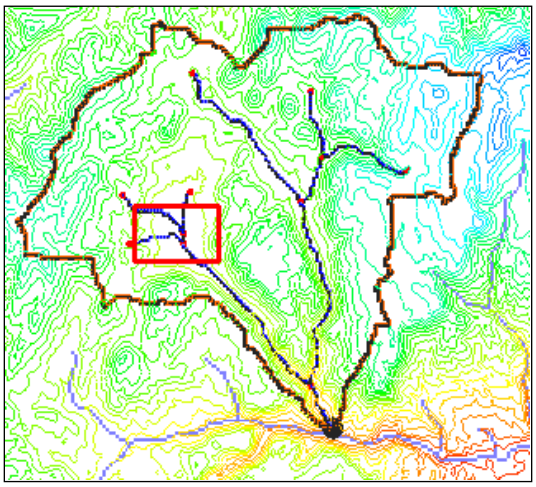

Figure 12 Zoom in to this area on the left

7. Click **Create outlet point** in the *Hydrologic Modeling Wizard* dialog.
8. Create an outlet just below the stream junction of the most downstream branch visible (junction show in Figure 13). Again note that what displays in the Graphics Window may not exactly match Figure 13.

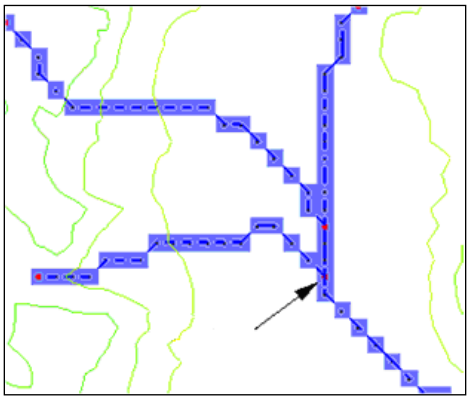

Figure 13 Create an outlet just below the stream junction

9. **Frame** the project.

10. Click **Next >** to go to the "Delineate Watershed" page of the *Hydrologic Modeling Wizard* dialog.
11. Click **Delineate Watershed**.
12. Click **OK** when asked to delete all existing feature data.

A complete hydrologic model will not be completed in this tutorial. Therefore, the rest of the steps in the *Hydrologic Modeling Wizard* dialog do not need to be completed.

13. Click **Close** to close the *Hydrologic Modeling Wizard* dialog.

4.5 Saving the WMS Project File

1. **Save** the project to open a *Save As* dialog.
2. Enter "DemDelineation_full.wms" for the *File name* and click **Save**.
3. Click **No** if prompted to save image files in the project directory.

5 Delineation Display Options

WMS has several options for displaying DEMs and the results of basin delineation from a DEM. This section will explore a few of these options.

5.1 Displaying Flow Paths

1. Switch to the **Drainage** module.
2. Using the **Flow Path** tool, click anywhere on the DEM.

WMS will use the DEM flow directions to trace the entire flow path. The flow paths will disappear as soon as another tool is selected.

3. Select *Display* **|** *Toolbars* **| Map Tools** to show the Map Tools toolbar.
4. Using the **Select Feature Polygon** tool, select any one of the drainage basin polygons.
5. Select *DEM* **| Draw Flow Patterns**.

Flow paths for each of the DEM cells within the selected drainage basin polygon are displayed until another tool is selected.

6. Click **Display Options** to bring up the *Display Options* dialog.
7. Select "Drainage Data" from the list on the left.
8. In the lower section, turn on *Flow Patterns* and click **OK** to close the *Display Options* dialog.

Flow paths for each of the DEM cells in the selected drainage basin are displayed. Notice that the flow paths are always displayed, even when another tool is selected.

9. Click **Display Options** to bring up the *Display Options* dialog.
10. Select "Drainage Data" from the list on the left.
11. In the lower section, turn off *Flow Patterns* and continue to the next section of the tutorial.

5.2 Basin Labels

1. Turn on *Basin Names*, *Basin Slopes*, and *Max Flow Distance*.
2. Click **OK** to close the *Display Options* dialog.

The basin labels displaying the area, slope, and other data can be moved to more convenient locations if desired.

3. Using the **Move basin label** tool, click on a more desirable location for the basin labels within any of the three basins.
4. To display the label outside a basin, click and drag from any point within a basin to the desired location in order to display the basin label with an arrow.

5.3 Display Options

When finished using the elevation data, turn off the DEM contours and extra streams displays if desired.

1. Switch to the **Terrain Data** module to make it active
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select “DEM Data” from the list on the left.
4. Turn off *Flow Accumulation*, *Color Fill Drainage Basins*, *Fill Basin Boundary Only,* and *DEM Contours*.
5. Click **OK** to close the *Display Options* dialog.

5.4 Color Fill Basins

WMS also allows each basin to be filled with a different color. This is useful when the background image does not need to be showing.

1. Right-click on “ Drainage” and select **Zoom To Layer**.
2. Right-click on “ Drainage” and select **Display Options…** to bring up the *Display Options* dialog.
3. Select “Map Data” from the list on the left.
4. Turn on *Color Fill Polygons* and click **OK** to close the *Display Options* dialog.

6 Conclusion

This concludes the “DEM Delineation” tutorial. The following key topics were discussed and demonstrated:

- Importing DEM Data
- Computing flow paths and flow accumulations
- Delineating watersheds from DEMs
- Delineating sub-basins within a watershed

Feel free to work through any of this tutorial using copies of other data. Be sure to save a project file for future reference.