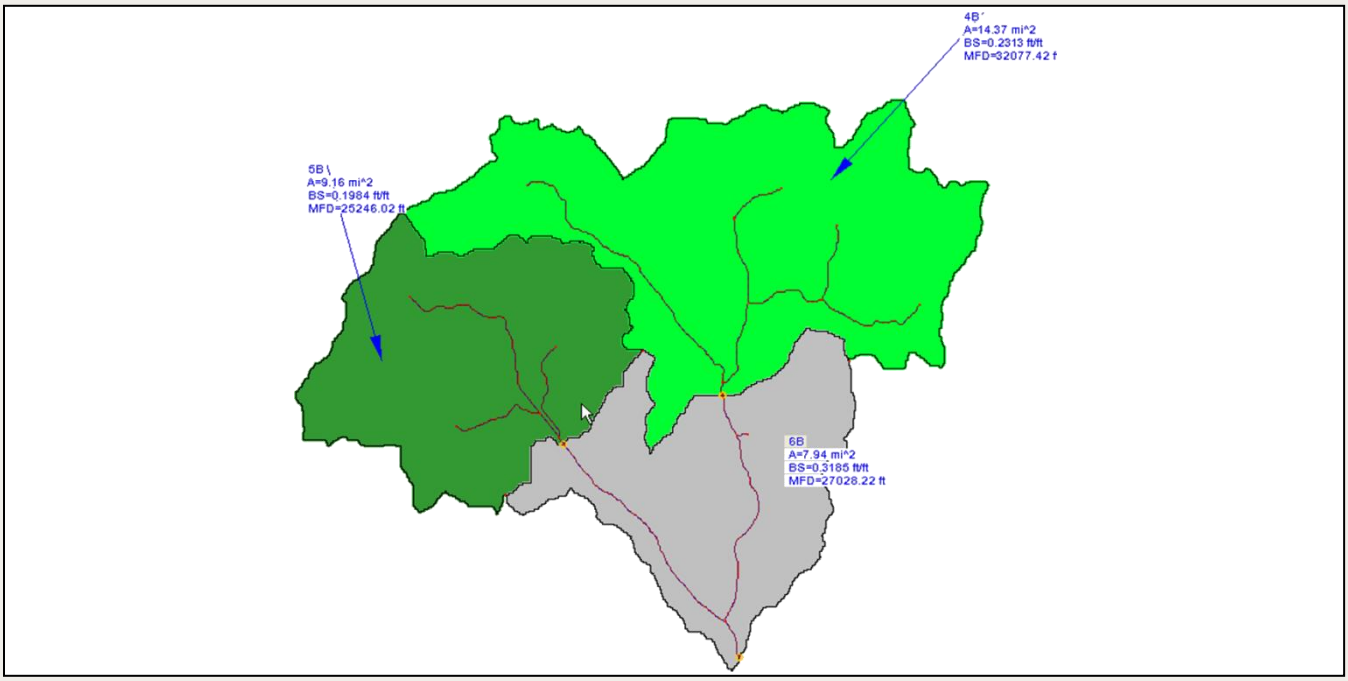
WMS 11.4 Tutorial

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

- Images
- Basic Feature Objects
- 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 the **Ctrl-N** key combination or from the *Menu* bar, select the *File* | **New…** menu item to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click the **Don't Save** button 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. From the *Get Data* bar, 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.

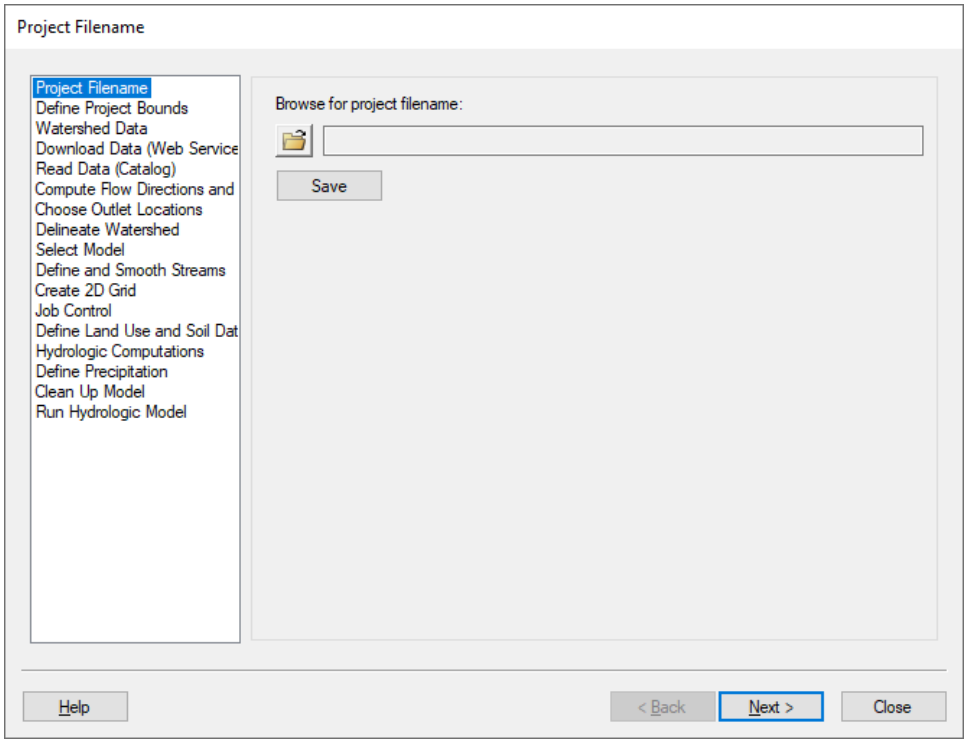

Figure 1: Hydrologic Modeling Wizard dialog

Clicking the **Next >** button 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. From the list on the left, select the “Project Filename” list item.
2. On the right, click the button to bring up the *Select WMS Project File* dialog.
3. Browse to the *\demdelin\demdelin* directory.
4. From the *Save as type* drop-down, select “WMS XMDF Project File (*.wms)”.

5. For the *File name,* enter “DemDelineation.wms”.
6. Click the **Save** button to create the new project and close the *Select WMS Project File* dialog and return to the *Project Filename* dialog.
7. Click the **Save** button (below the  button in the dialog) to save the project filename.
8. Click the **Next >** button 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 the **Define…** button to bring up the *Display Projection* dialog.
2. In the *Horizontal* section, select the *Global Projection* radio button to bring up the *Horizontal Projection* dialog. If the dialog does not automatically open, click the **Set Projection…** button 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 the **OK** button to close the *Horizontal Projection* dialog and return to the *Display Projection* dialog.
7. In the *Vertical* section, from the *Datum* drop-down, select “Local”.
8. From the *Units* drop-down, select “Meters”.
9. Click the **OK** button to close the *Display Projection* dialog and return to the *Define Project Bounds* 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 the **Define…** button to bring up the *Map Locator* dialog.
11. In the Search field, enter “Cove Fort, UT” and press the **Enter** key.
12. If a list of choices is presented, select the *Cove Fort Utah United States* option.
13. Zoom in or out, as necessary, until the *Map Locator* dialog appears similar to Figure 2.
14. Click the **OK** button to close the *Map Locator* dialog and return to the *Define Project Bounds* dialog.

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

15. Click the **Next >** button to go to the “Watershed Data” page of the *Hydrologic Modeling Wizard* dialog.

Figure 2: Project bounds in 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. Under *Select data sources*, turn on *Use web services*.
2. Click the **Next >** button 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 the *Worldwide Elevation Data (Variable Resolution)* checkbox. You may have to scroll down.

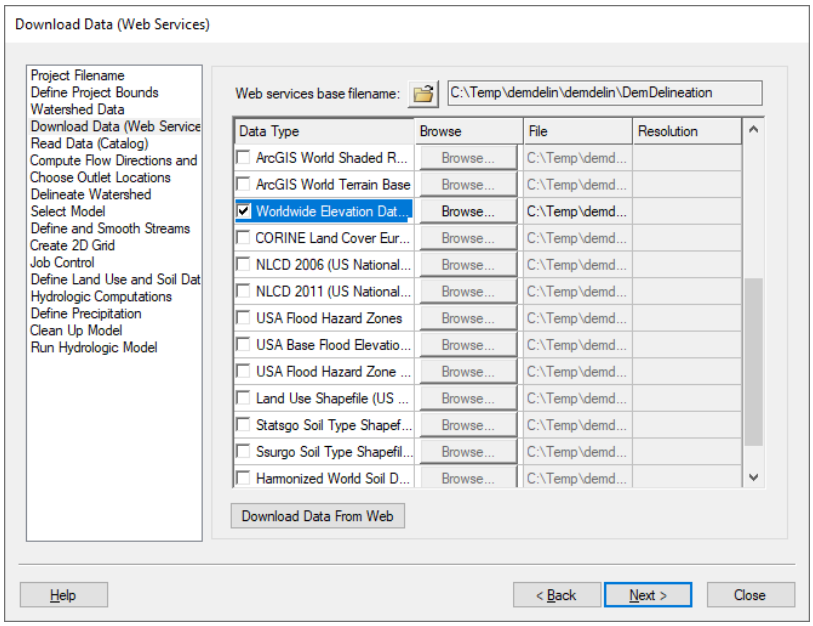

Figure 3: Download Data (Web Services) dialog

4. Turn off all other options in the *Data Type* column.
5. Click the **Download Data From Web** button to bring up the *Zoom level* dialog.
6. From the *Choose a zoom level* drop-down list, select "Zoom level 12 (Resolution = 29.9)"
7. Click the **OK** button to close the *Zoom Level* dialog and return to the *Download Data (Web Services)* 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.

8. In the *Project Explorer,* under the "GIS Data" folder, turn off the "DemDelineation_elev.tif" checkbox.

The DEM will appear similar to Figure 4.

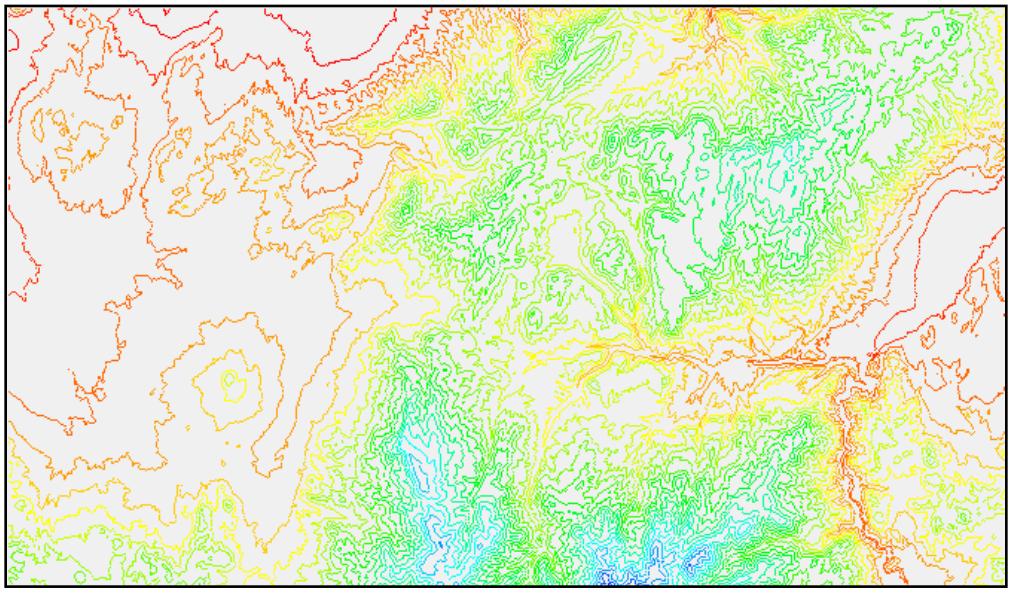

Figure 4: A topographic map with elevation contour lines

9. From the *Get Data* tool bar, click the **Get Online Maps…** tool to bring up the *Get Online Maps* dialog.
10. Hold down the **Ctrl** key and select both *World Imagery* and *USA Topo Map*.
11. Click the **OK** button 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.

12. In the *Download Data (Web Services)* dialog, click the **Next >** button 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. From the *Menu* bar, select the *File* **| Open…** menu item to bring up the *Open* dialog.
2. From the *Files of type* drop-down, select "USGS DEM File (*.dem;*.ddf)".
3. Select "josephpeak.dem", then, while holding down the **Ctrl** key, select "marysvalecanyon.dem", "redridge.dem", and "trailmountain.dem".
4. Click the **Open** button to exit the *Open* dialog.
5. Under the "GIS Data" folder, select all DEM files by holding down **Shift** and selecting the top "josephpeak.dem" and bottom "trailmountain.dem" files.
6. Right-click on any of the selected items and select the *Convert To* | **DEM** context menu item to bring up the *Resample and Export Raster* dialog.
7. Click the **OK** button 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. In the *Hydrologic Modeling Wizard,* click the **Next >** or **<Back** button until the "Compute Flow Directions and Accumulations" page is reached or select it from the list on the left.

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 the "World Imagery" checkbox.

Turning this off will speed up the display.

3. In the *Modules* bar, switch to the **Terrain Data Module**.
4. From the *Macro* bar, click the **Display Options** macro to bring up the *Display Options* dialog.
5. From the list on the left, select the "DEM Data" list item.
6. From the DEM tab on the right, next to *DEM Contours,* click the **Options…** button 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, from the first drop-down, select "Normal Linear".
8. In the *Contour Interval* section, to the right of the *Number of Contours* drop-down, enter "30".
9. Click the **OK** button to close the *DemDelineation_elev Contour Options* dialog.
10. Click the **OK** button to close the *Display Options* window.
11. From the *Menu* bar, select the *DEM* | *Trim* **| Polygon…** menu item to bring up the *Polygon Selection Options* dialog.

12. From the drop-down, select “Enter a polygon interactively”.
13. Click **OK** to close the *Polygon Selection Options* dialog. The cursor becomes selection mode crosshair.
    a. If Section 3.4 was completed, click out the rectangle shown in Figure 5. Double-click to close the rectangle.
    b. If section 3.5 was completed, click out the rectangle shown in Figure 6. Double-click to close the rectangle.

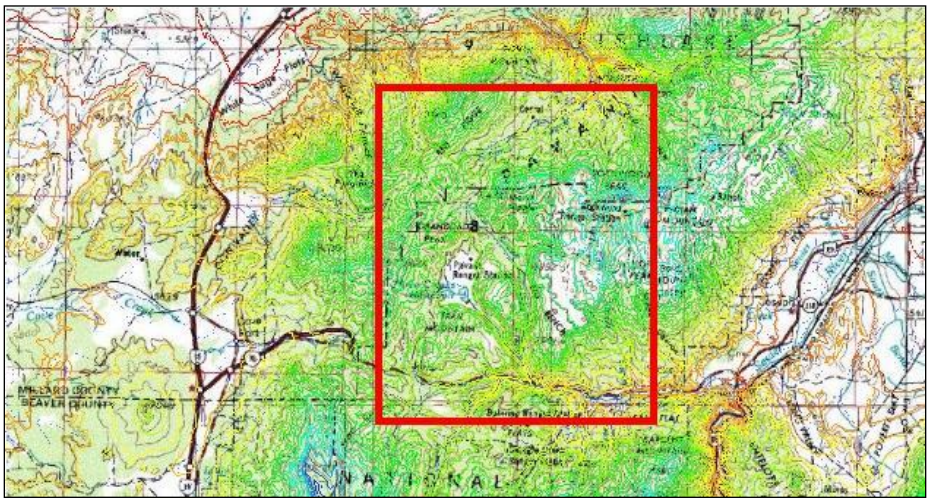

Figure 5: DEM trim area if online maps are used

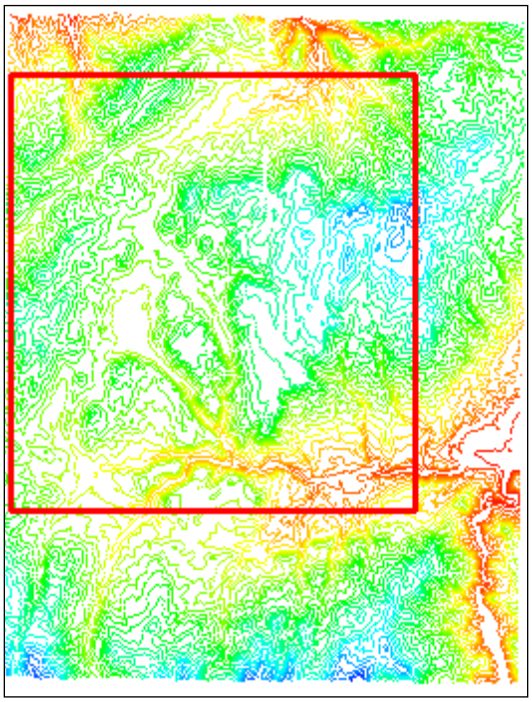

Figure 6: DEM trim area if local map files are used

14. In the *Project Explorer*, turn off all images in the “ GIS Data” folder with the checkbox.

15. From the *Macro* bar, click the **Frame** macro to zoom to the extents of 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. From the *Macro* bar, click the **Display Options** macro to bring up the *Display Options* dialog.
2. From the list on the left, select "DEM Data".
3. On the *DEM* tab on the right, turn on the *No Data Cells* checkbox.
4. Click the **OK** button to close the *Display Options* dialog.
5. Right-click on the " DemDelineation_elev (Trimmed)" data and select the **Fill** context menu item.

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

6. From the *Menu* bar, select *Display* **| Display Options…** to bring up the *Display Options* dialog.
7. From the list on the left, select "DEM Data".
8. On the *DEM* tab on the right, turn off the *No Data Cells* checkbox.
9. Click the **OK** button to close the *Display Options* dialog.

4 Watershed Delineation using the Hydrologic Modeling Wizard

The Hydrologic Modeling Wizard can delineate watersheds using the TOPAZ program.

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 the dialog was closed, click on the **Hydrologic Modeling Wizard** button, to reopen it.
2. From the list on the left, select the "Compute Flow Directions and Accumulations (TOPAZ)" item.
3. On the right, select the *Write TOPAZ files to a temp directory* radio button.
4. From the *Compute sub-basin areas in* drop-down, select "Square Miles".
5. From the *Compute distances in* drop-down, select "Feet".
6. Click the **Compute TOPAZ** button to bring up the *Model Wrapper* dialog and allow the tool to run to completion.

7. When TOPAZ finishes, turn on the *Read solution on exit* checkbox and click the **Close** button to exit the *Model Wrapper* dialog.

The display in the main WMS *Graphics Window* should update.

8. In the *Compute Flow Directions and Accumulations* dialog, for the *Min flow accumulation threshold*, enter “2.0” (mi^2).
9. Click the **Apply to Display** button.

Notice how the display of flow accumulations cells changes in the main WMS *Graphics Window*.

10. For the Min flow accumulation threshold, enter “0.5” (mi^2).
11. Click the **Apply to Display** button.
12. For the Min flow accumulation threshold, enter “1.0” (mi^2.
13. Click the **Apply to Display** button.

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

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

4.2 Choosing Outlet Locations

1. In the *Graphics Window*, using the **Zoom** static tool, zoom in to the area similar to the one shown in Figure 7.

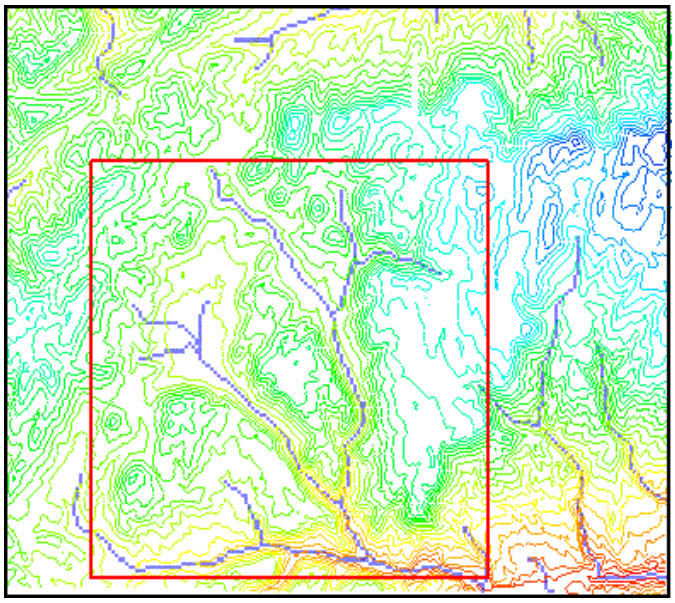

Figure 7: DEM zoom area

2. In the *Choose Outlet Location* page of the *Hydrologic Modeling Wizard* dialog, click the **Create outlet point** button.
3. In the Graphics Window, place the outlet location just upstream of the stream junction by clicking on the location shown in Figure 8.

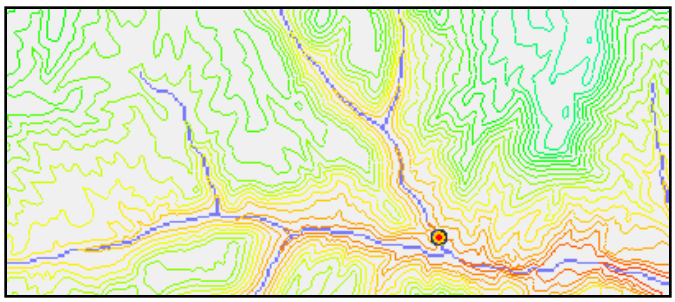

Figure 8: Drainage outlet location

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

4.3 Delineating Watershed

On the *Delineate Watershed* page of the *Hydrologic Modeling Wizard* dialog.

1. For the *Stream threshold value,* enter “1.0” (mi^2).
2. Click the **Delineate Watershed** button.

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).

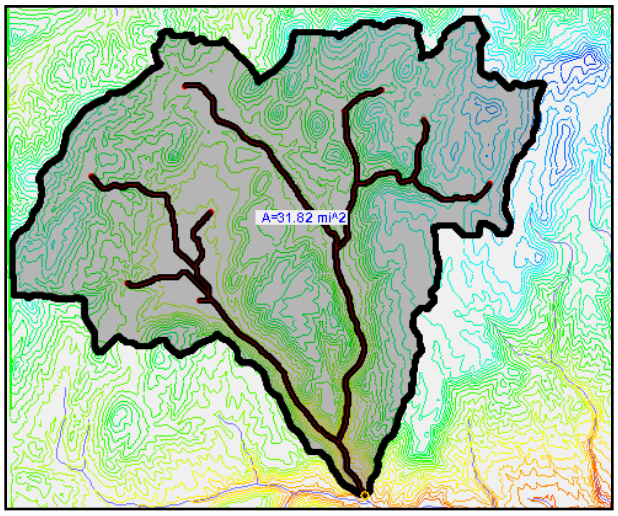

Figure 9: Delineated watershed basin showing streams

4.4 Creating Sub-basins

Create a sub-basin within a watershed basin.

1. On the *Delineate Watershed* page of the *Hydrologic Modeling Wizard* dialog, select the “Choose Outlet Locations” item from the list on the left (or click the **< Back** button) to return to the “Choose Outlet Locations” page.
2. Using the **Zoom** static tool, zoom in to the area shown in Figure 10.

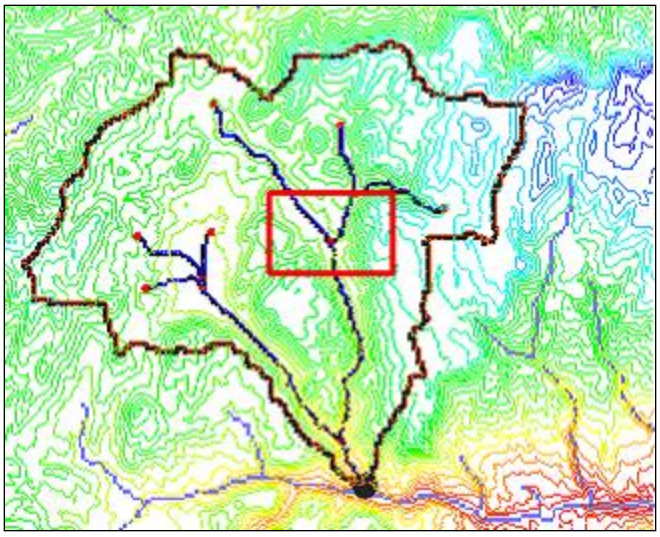

Figure 10: Zoom in to this area on the right

3. In the *Choose Outlet Location* dialog, click the **Create outlet point** button.
4. Create an outlet location 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* dialog to make them more visible.

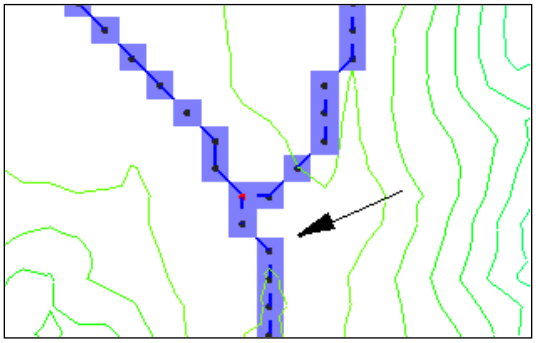

Figure 11: New outlet location

5. From the *Macro* bar, click the **Frame** macro to zoom to the extents of the project.
6. Using the **Zoom** static tool, zoom in to the branch shown in Figure 12.

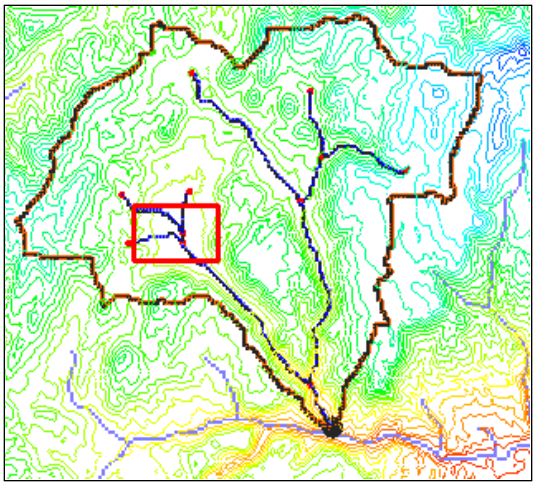

Figure 12: Zoom in to this area on the left

7. On the *Choose Outlet Location* page of the *Hydrologic Modeling Wizard* dialog, click the **Create outlet point** button.
8. Create an outlet location 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.

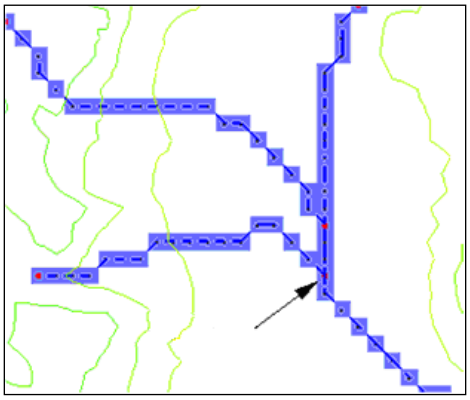

Figure 13: Create an outlet just below the stream junction

9. From the *Macro* bar, click the **Frame** macro to zoom to the extents of the project.
10. On the *Choose Outlet Location* page of the *Hydrologic Modeling Wizard* dialog, click the **Next >** button to go to the "Delineate Watershed" page of the *Hydrologic Modeling Wizard* dialog.
11. Click the **Delineate Watershed** button.
12. When asked to delete all existing feature data, click the **OK** button.

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 the **Close** button to close the *Hydrologic Modeling Wizard* dialog.

4.5 Saving the WMS Project File

1. From the *Menu* bar, select the *File* | **Save As…** menu item to open a *Save As* dialog.
2. Enter “DemDelineation_full.wms” for the *File name.*
3. Click the **Save** button.
4. If prompted to save image files in the project directory, click the **No** button.

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. In the *Module* bar, switch to the **Drainage Module** .
2. Using the **Flow path** tool from the *Dynamic* tool bar, 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. From the *Menu* bar, select *Display* | *Toolbars* | **Map Tools** to show the *Map Tools* tool bar.
4. Using the **Select Feature Polygon** tool from the *Map Tools* tool bar, select any one of the drainage basin polygons.
5. From the *Menu* bar, select the *DEM* | **Draw Flow Patterns** menu item.

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

6. Click the **Display Options** macro to bring up the *Display Options* dialog.
7. From the list on the left, select the “Drainage Data” item.
8. On the *Drainage Data* tab on the right, in the lower section, turn on the *Flow Patterns* checkbox.
9. Click the **OK** button to close the *Display Options* dialog.

In the *Graphics Window,* 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.

10. Click the **Display Options** macro to bring up the *Display Options* dialog.
11. From the list on the left, select the “Drainage Data” item.
12. In the lower section, turn off *Flow Patterns,* and continue to the next section of the tutorial.

5.2 Basin Labels

1. In the *Display Options* dialog, on the Drainage Data tab, turn on the *Basin Names*, *Basin Slopes*, and *Max Flow Distance* checkboxes.
2. Click the **OK** button 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 from the *Dynamic* tool bar, 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. From the *Modules* bar, switch to the **Terrain Data Module** to make it active.
2. Click the **Display Options** macro to bring up the *Display Options* dialog.
3. From the list on the left, select “DEM Data”.
4. Turn off the *Flow Accumulation*, *Color Fill Drainage Basins*, *Fill Basin Boundary Only,* and *DEM Contours* checkboxes.
5. Click the **OK** button 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. In the *Project Explorer,* right-click on the “ Drainage” map data coverage and select the **Zoom To Layer** context menu item.
2. Right-click on “ Drainage” and select the **Display Options…** context menu item to bring up the *Display Options* dialog.
3. From the list on the left, select “Map Data”.
4. In the *Map* tab, in the spreadsheet, turn on the *Color Fill Polygons* checkbox.
5. Click the **OK** button 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.