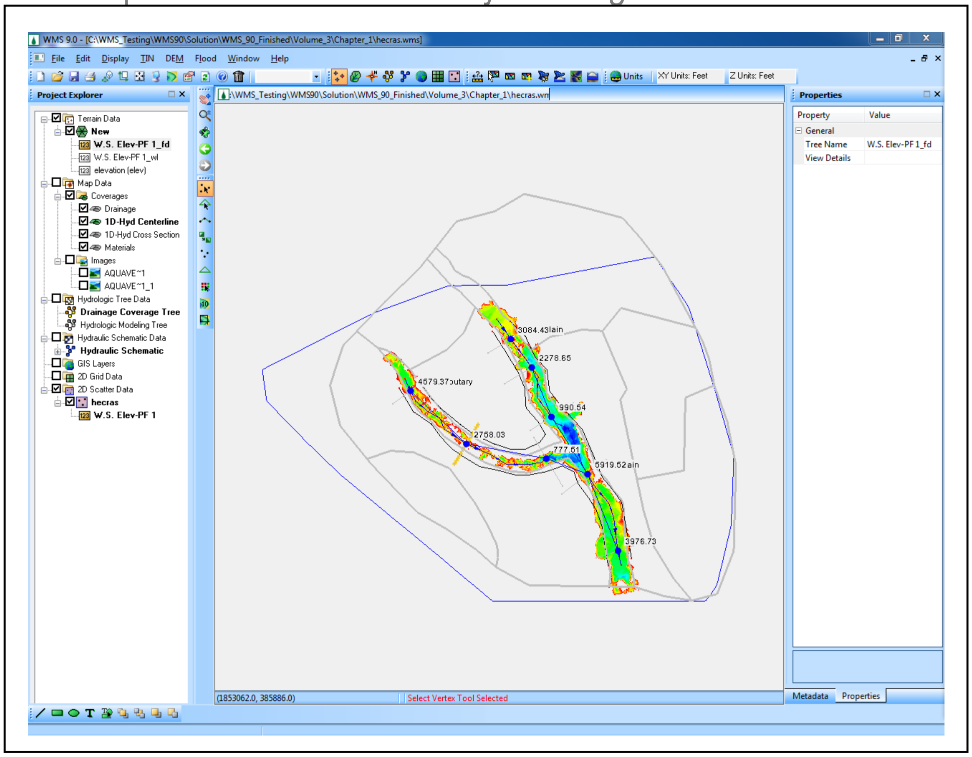
v. 10.1

WMS 10.1 Tutorial

Hydraulics and Floodplain Modeling – HEC-RAS Analysis

Learn how to setup a basic HEC-RAS analysis using WMS



Objectives

Learn how to build cross sections, stream centerlines, and bank lines in a conceptual model format. Cut cross sections from digital elevation data, define Manning's roughness polygons, and assign conceptual model data to an HEC-RAS model. Export and run a HEC-RAS model and read and view the results from the WMS interface.

Prerequisite Tutorials

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

Required Components

- Data
- Drainage
- Map
- River

Time

- 30-60 minutes

1 Introduction

HEC-RAS was developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center. HEC-RAS performs a step backwater curve analysis for either steady state or transient conditions to determine water surface elevations and velocities.

2 Objectives

In this exercise, how to use the WMS River tools to construct a HEC-RAS steady flow model will be covered. This includes the following:

- Building the conceptual model
- Mapping the conceptual data to a hydraulic model representation
- Running the simulation within HEC-RAS
- Viewing results in WMS

3 Preparing the Conceptual Model

The first step to creating an HEC-RAS model is to create a conceptual model which defines the river reaches (layout and attributes), the position of cross sections on those reaches (orientation and station values), bank locations, and material zones. The conceptual model will be used to create a network schematic inside the River module.

Create the conceptual model from a USGS quad map as well as scattered bathymetric (elevation) data in the form of a TIN.

1. Open WMS. If WMS is already open select *File* **| New** then click **No** if prompted to save changes.
2. Select *Display* **| Display Projection** to set the current projection system.

3. In the *Display Projection* dialog, select *Global Projection*, then click the **Set Projection** button.
4. In the *Select Projection* dialog, apply the following settings.
   - *Projection* to “State Plane Coordinate System”
   - *Datum* to “NAD 83”
   - *Planar Units* to “FEET (U.S. SURVEY)”
   - *Zone* to “North Carolina (FIPS 3200)”
5. Select **OK**.
6. Set *Vertical Units* to “U.S. Survey Feet” then click **OK**.
7. Select *File* | **Open** to access the *Open* dialog.
8. Locate the “hecras” folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
9. Select “wmsras.tin” then click **Open**.

If working without access to the internet, skip sections 3.1 and 3.2.

3.1 Getting a Background Image

Using an Internet connection, load a background image (Aerial photo or a topo map) for the project site. Use any of the Get Data tools in WMS to load images from the internet.

1. Select the **Get Online Maps** tool located in the *Add GIS Data* drop-down menu in the Get Data menu bar. The *Get Online Maps* dialog will appear.
2. Select World Imagery and World Top Map and click **OK**.
3. WMS will load the background image files. It will take a few moments depending upon the internet connection. Once done, an aerial photo and a topo map have been added to the background.

3.2 Create a local copy of the images

The loaded images are read in from a server and sometimes take a long time to zoom and pan around. Create a local copy of the image to expedite such navigations.

1. In the Project Explorer, under the “GIS Data” folder, right-click one of the images and select **Export**. The *Export Image* dialog will appear.

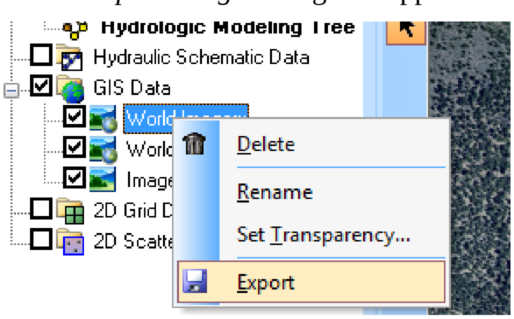


Figure 1 Exporting an image

2. Select **OK** to accept the suggested value of the *resampling ratio*. A resample magnification factor of 1 means that the image will have exactly as many pixels as it is being displayed on the screen. Increase the factor if needing a higher resolution image. Note that it will take a longer time to download.
3. In the *Save As* dialog, assign a name to the downloading image and the location where it will be saved. WMS will download and save the image in the specified location in the local drive. The download progress will be displayed.
4. Once the image has been downloaded, remove the bigger online images (the ones that have a little globe on their icon). To do this, right-click on the online image under the *GIS Data* folder and select **Delete**.
5. Repeat the same process for the other image, but this time set the *Resampling ratio* to "1". This image will download faster.

If able to successfully complete all the steps in sections 3.1 and 3.2, skip section 3.3.

3.3 Open Background Image

If reliable internet access is not available, open an image showing the area of interest for modeling as follows:

1. Select *File* **| Open** to access the *Open* dialog.
2. Open "wmsras.jpg".

3.4 TIN Display Options

The TIN clutters the screen, yet it's necessary to know where it is so as to not create a conceptual model outside the domain of the bathymetric data. To better see the image, turn off the display of TIN triangles, vertices, and contours, and turn on the TIN boundary. To do this:

1. Right-click on the "New" TIN under "Terrain Data" in the Project Explorer and select **Display Options** to open the *Display Options* dialog.
2. On the *TIN* tab, uncheck the *Unlocked vertices* toggle box (it may already be unchecked) and the *Triangles* and the *TIN Contours* toggle boxes.
3. Ensure that the *Boundaries* box is checked.
4. Select **OK**.

3.5 Creating the Coverages

Create a centerline coverage for the reaches and a cross section coverage for the cross sections. These will form the core of the conceptual model.

1. Right-click on the "Coverages" folder within the Project Explorer and choose **New Coverage**.
2. In the *Properties* dialog, change the coverage type to "1D-Hyd Centerline".
3. Select **OK**.
4. Create another new coverage, and set its coverage type to "1D-Hyd Cross Section".
5. Select **OK**.

6. Activate the Centerline coverage by single-clicking on its name in the Project Explorer.

3.6 Creating the Centerline and Bank Arcs

Centerline arcs are used to define the locations and lengths of the study reaches and assign their attributes. Have a centerline following the main channel as well as the tributary on the west. As the flows below the reservoir in the tributary on the East of the Leith Creek are small, disregard that reach in the simulation. To create the centerline arcs:

1. Before creating the feature arcs and to clearly see the reference background images, right-click on the “World Topo Map” image that was just converted and select **Set Transparency…** and set the *image transparency* to “40%” then click **OK** in the *Image Transparency* dialog.
2. Select the **Map** module and select the **Create Feature Arc** tool.
3. Following the pattern in Figure 2, create the centerline of the main channel from upstream to downstream (HEC-RAS views a river in the upstream to downstream direction and it will ultimately help define the left bank and right bank characteristics) by clicking points on the centerline one at a time. Double-click the last point to indicate that it is the end of the centerline.

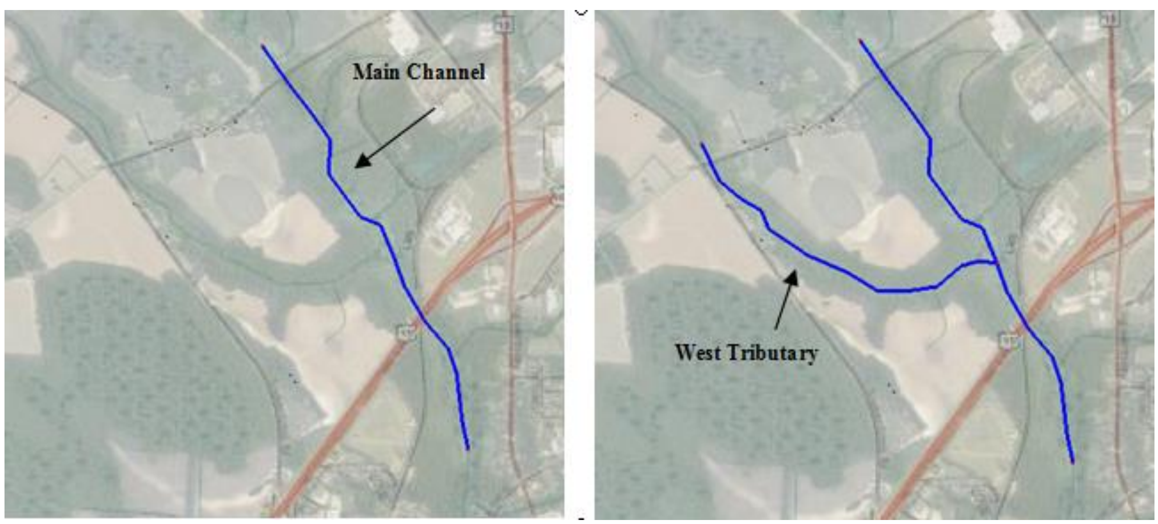


Figure 2 Creating Centerline arcs

4. Create the arc for the west tributary, upstream to downstream, by clicking points on the centerline. Create the last point where the tributary meets the main channel by clicking on the main channel centerline. This splits the centerline of the main channel into two reaches.

This defines the centerline for the model in this simulation. It will consist of two reaches in the main channel (divided by the tributary), and one reach in the west tributary.

Bank arcs are used to define the locations of the banks and the over-bank distances. The next step is to create bank arcs along both sides of each centerline arc. To create the bank arcs:

5. Select the **Create Feature Arc** tool.

6. Create new arcs where the bank locations are estimated to be, based upon contours/colors (roughly follow the green area around the centerline arcs) on the background image. Use Figure 3 as a guide.

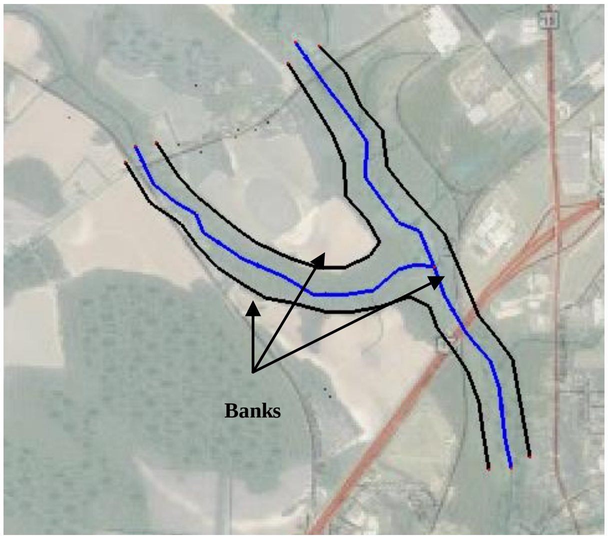


Figure 3 Placement of bank arcs

1. Choose the **Select Feature Arc** tool.
2. Select all of the bank arcs (hold the **SHIFT** key down while selecting in order to multi-select arcs).
3. Select *Feature Objects* **| Attributes**. The *Arc Type* dialog will appear.
4. Change the *Arc Type* to "Bank" then click **OK**.
5. The background images are no longer necessary; uncheck the toggle box next to the "GIS Data" folder in the Project Explorer.

3.7 Naming the Centerline Arcs

Reaches are stream sections where the flow rates and other hydraulic conditions are assumed to be constant. A river can be comprised of one or more reaches, but only one flow path. HEC-RAS has the ability to model multiple rivers (flow paths). To assign names to the rivers and reaches:

1. Double-click the uppermost reach in the main channel.
2. In the *Arc Type* dialog, make sure the type is set to "Centerline" and click **OK**.
3. The *River Reach Attributes* dialog will appear. Enter "Leith Creek" for the *River Name*.
4. Enter "Upper Main" for the *Reach Name*.
5. Select **OK**.
6. Repeat steps 1 to 4 for each reach in the map as shown in Figure 3.

NOTE: For the Lower Main reach, choose Leith Creek from the river name combo box instead of typing it in.

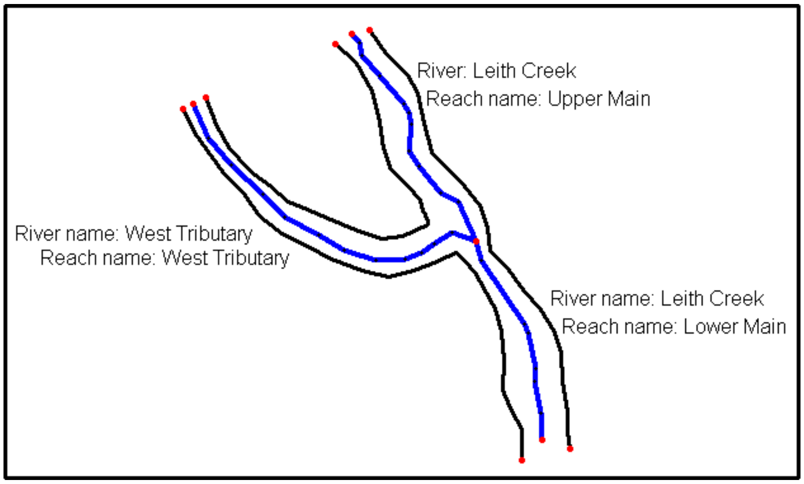


Figure 4 River and Reach names

3.8 Creating Land Use / Materials Coverage

One of the properties HEC-RAS uses is roughness values. Designate materials to different areas of the model. Later assign each material a roughness value. The material zones are stored in WMS as an Area Property coverage. To load the materials data:

1. Select *File* | **Open** to access the *Open* dialog.
2. Open the file “Materials.map”.
3. Select *Edit* | **Materials** to open the *Materials Data* dialog.
4. Click the **New** button 5 times in order to create 5 new material types.
5. Rename the materials as shown below in Figure 5. Chose the colors and patterns for each heading if desired.

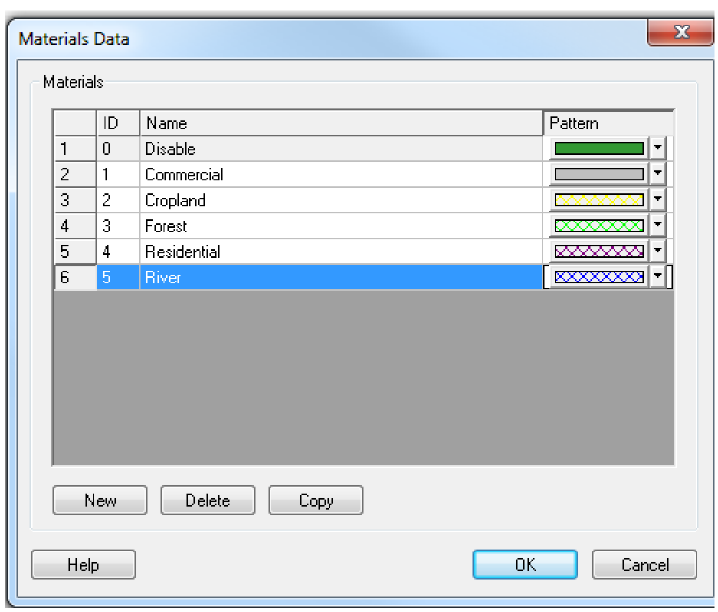


Figure 5 Materials Data headings

6. Select **OK** to close the *Materials Data* dialog.

7. Make sure the newly created area property coverage, “Materials”, is active in the Project Explorer.
8. Right-click on the “Materials” coverage and choose **Properties**.
9. In the *Properties* dialog, change the *Coverage type* to “Area Property” and enter “Materials” as the *coverage name*.
10. Select **OK**.

Now having defined all the materials, assign a material type to each polygon in the Materials coverage.

11. Select the **Select Feature Polygon** tool.
12. Double-click on the polygon that defines the river area (see Figure 6).
13. The *Land Poly Atts* dialog will appear. Set the polygon type to *Material* and choose “River” from the drop-down list.
14. Select **OK**.
15. Using Figure 6 as a guide, define material types for the remaining polygons (remember it is also possible to double-click on a polygon to bring up the attributes dialog).

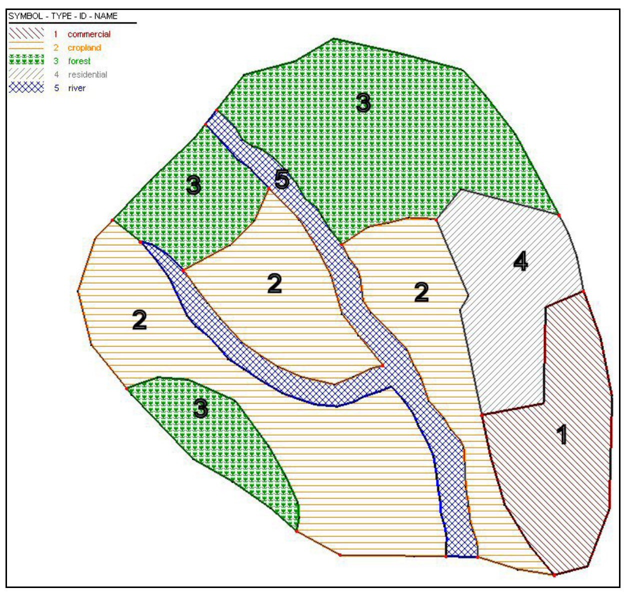


Figure 6 Materials used in HEC-RAS Simulation

3.9 Creating the Cross Sections

HEC-RAS associates most of its model data with cross sections and generates solutions or output at the cross sections. Therefore, cross sections are the most important part of the map. HEC-RAS requires at least two cross sections on each reach. To create the cross sections:

1. Set the current coverage to 1D-Hyd Cross Section by single-clicking on it in the Project Explorer.
2. Select the **Create Feature Arc** tool.

3. Create at least two cross sections on each reach by clicking a point on one side of the reach then double-clicking a point on the other side of the reach as shown in Figure 7.

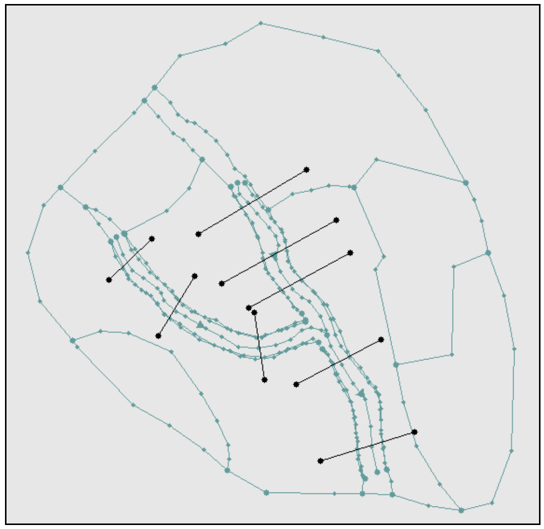


Figure 7   Cross section coverage

3.10 Extracting Cross Sections

In the cross section coverage, all arcs are cross section arcs. Their position and orientation define the location of the cross sections in the system, but as of yet, they do not have any data assigned. Assign elevation data, materials, and point property locations to the cross sections. This information will be extracted from the TIN, the area property coverage, and the centerline coverage. To extract this data:

1. Select *River Tools* | **Extract Cross Section**. The *Extract Cross Sections* dialog will appear.

WMS will extract an elevation point at every triangle edge along the cross section arc. The default extraction settings are to use the centerline coverage to generate point properties and the area property coverage to define material zones.

2. Select **OK**.
3. When WMS prompts for a file name and location for saving the cross section database in the *Save* dialog, enter the name “xsecs” and select **Save**.

Each cross section arc now stores a link to a cross section database record which contains xyz data, materials properties, bank locations, and thalweg locations. To view and edit the information at a cross section:

4. Choose the **Select Feature Arc**  tool.
5. Double-click on any cross section. This brings up the *River Cross Section Attributes* dialog.
6. Ensure that the reach name is assigned correctly.
7. Click on the **Assign Cross Section** button. This brings up the *Assign Cross Section Profile* dialog, which is used to view the current cross section shape and select a different cross section from a cross section database if desired.

8. Click on the **Edit** button. This brings up the *Cross-Section Attributes* dialog. This dialog can be used to view and/or edit the cross section
9. Click on the *Line Props* tab to view the materials that are assigned to the cross section.
10. Click on the *Point Props* tab to view the locations of the left bank, right bank, and thalweg.
11. Select **Cancel** until all the dialogs are closed

For this exercise use the cross sections as extracted from the TIN, but for a project it is often necessary to edit a cross section, or merge surveyed cross sections and perform other editing procedures. This is the topic of a separate chapter and therefore is not covered in detail here.

4 Creating the Network Schematic

WMS interacts with HEC-RAS using a HEC-GeoRAS geometry file. This file contains the cross sectional data used by HEC-RAS in addition to three dimensional georeferencing data. To create this geometry file, the conceptual model must be converted to a network schematic diagram in the River module. To convert the conceptual model to a network schematic:

1. Set the current coverage to 1D-Hyd Centerline by clicking on it in the Project Explorer.
2. Select *River Tools* **| Map → 1D Schematic**.

The screen should appear similar to Figure 8.

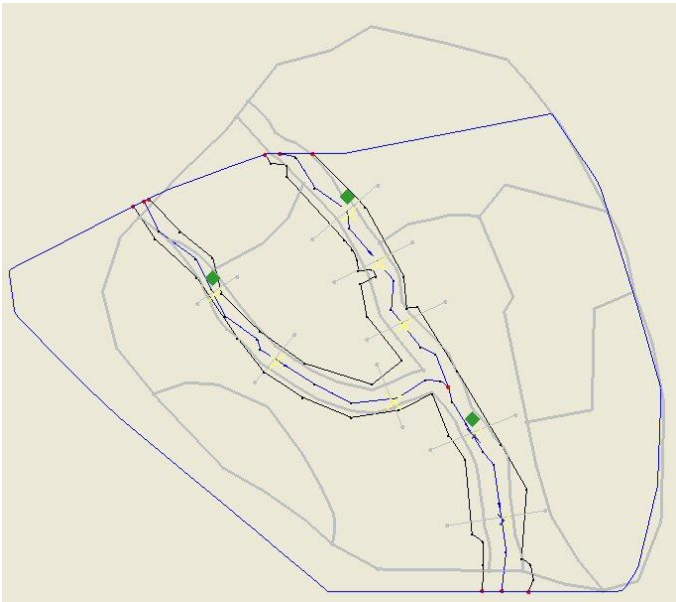


Figure 8 Schematic diagram

Now WMS includes two separate representations of the data. The first is created as a conceptual model, which is stored as a series of coverages. The second is a numeric model stored as a schematic of cross sections organized into reaches. Modifications to the network schematic that can be used by HEC-RAS can be made directly in the River module, or indirectly by editing the conceptual model in the Map module and mapping to a new network schematic.

HEC-RAS needs Manning's roughness values for the materials found in the cross section database. The roughness values are stored as part of the 1D model in the River module. To specify the roughness values for the each of the materials:

3. Switch to the **River** module.
4. Select *HEC-RAS* | **Material Properties**. The *Hecras Material Properties* dialog will appear.
5. Enter the roughness values for each material as shown in Figure 9.

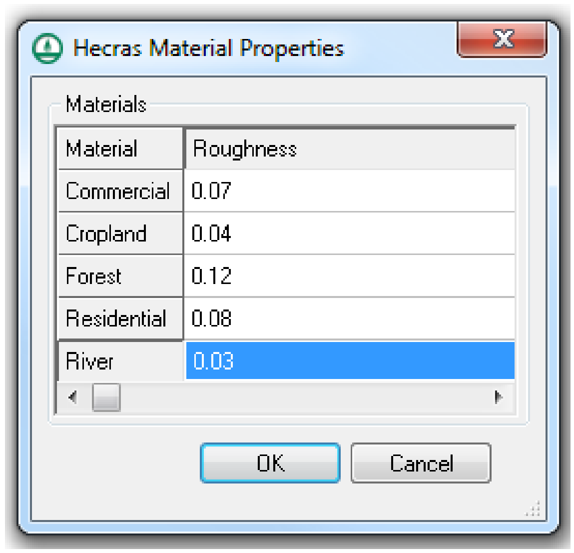


Figure 9 HEC-RAS Material Properties dialog

6. Select **OK**.

Now tell HEC-RAS which set of line properties in the database should be used as material types. To do this:

7. Select *HEC-RAS* | **Model Control** to open the *HEC-RAS Model Control* dialog.
8. Select "Materials". This is the line property name that stores the roughness values for the cross section database.
9. Select **OK**.

5 Creating the HEC-RAS Project File

Now that the model has been set up, create the HEC-RAS project file. To create this file:

1. Select *HEC-RAS* | **Export GIS File**.
2. In the *Enter a filename to save an HEC-RAS project file* dialog, name the file "hecras.prj" and select **Save**.
3. Select **Yes** to overwrite existing files, if prompted.

After saving out the HEC-RAS project file, WMS automatically opens the HEC-RAS application and loads the project.

6 Using HEC-RAS

Within HEC-RAS, setup and run the simulation and then export the results for post-processing in WMS. The setup will include entering junction lengths, specifying flow values, and assigning river boundary conditions.

1. Select *Edit* | **Geometric Data**.

The screen should appear similar to Figure 10.

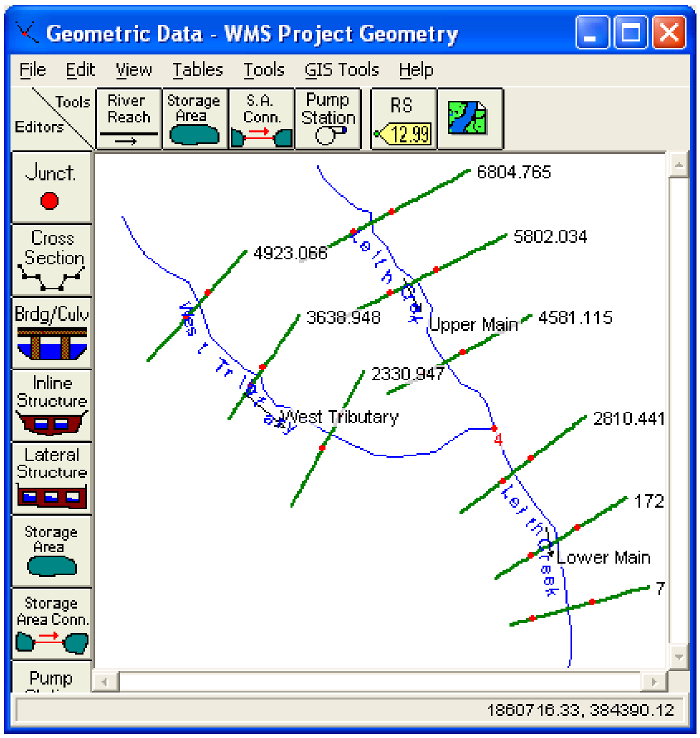


Figure 10 Geometric Editor in HEC-RAS

In the case that an excessive number of points are extracted from the cross section arcs, HEC-RAS has a tool that will filter points that are too close together to run an analysis. Since there are many data editing tools available within HEC-RAS in addition to the filtering tool, simply be aware of such tools and browse the HEC-RAS user's manual for more information if needed.

Enter junction lengths in the *Geometric Data Editor*.

2. Click on the node (junction) that joins the West Tributary and Upper Main reaches.
3. Select *Edit Junction* from the pop-up menu.

The Junction Length value should be entered as the distance stretching across the junction between adjacent cross sections. Measure these lengths with the Measure tool in WMS.

4. Activate the WMS window.
5. Switch to the **Map** module.
6. Choose the **Measure** tool.
7. As shown in the example in figure below, trace the distance along the centerline arc between the most downstream cross section arc on the West Tributary reach and the

most upstream cross section arc on the Lower Main reach. Note the length for future use.

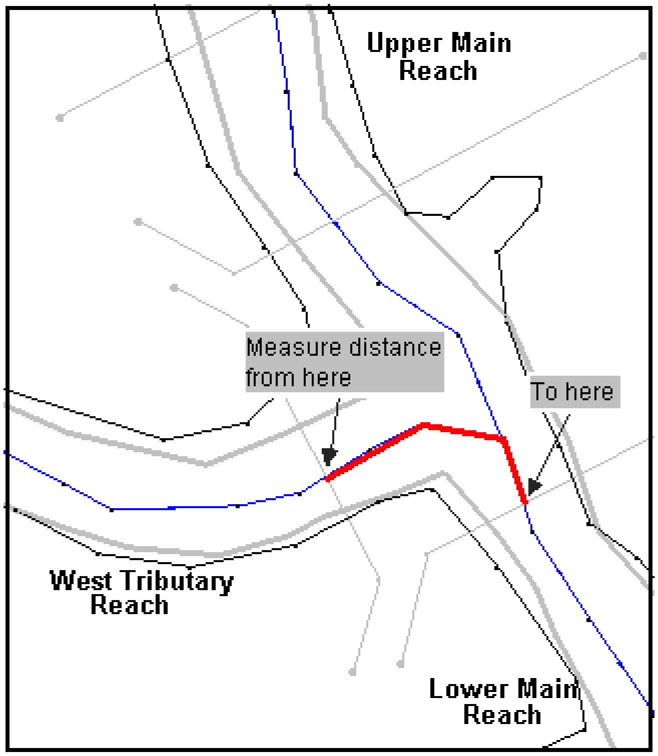


Figure 11 Measuring Junction Lengths

8. Revert back to the HEC-RAS Junction Data dialog
9. Enter the measured length in the Junction Length field corresponding to the "To: West Tributary – West Tributary" line
10. Repeat these steps to measure and enter the Junction Length between the most downstream cross section arc on the Upper Main reach and the most upstream cross section arc on the Lower Main reach
11. Once finished entering both lengths, select **OK**
12. Select *File* **| Exit Geometry Data Editor**

The next step is to define the flow and boundary conditions for the reaches. To define this information:

13. Select *Edit* **| Steady Flow Data**
14. For Profile 1 (PF 1), enter 4000 for Upper Main; enter 5000 for Lower Main; enter 1000 for West Tributary
15. Click on the **Reach Boundary Conditions** button

For the analysis, have HEC-RAS compute normal depths at the boundaries of the model. To do this:

16. For each of the blank boxes in the spreadsheet, select the box and click on the **Normal Depth** button. In the dialog that appears, enter the following values for the slopes of each reach: 0.003 for the upper reach, 0.001 for the lower reach, and 0.005 for the tributary.

17. Select **OK**
18. Click the **Apply Data** button
19. Select *File* **| Exit Flow Data Editor**

Now run the steady flow analysis. First set an option to set flow distribution locations so that velocity profiles will be computed. To set this option and perform the analysis:

20. Select *Run* **| Steady Flow Analysis**
21. Select *Options* **| Flow Distribution Locations**
22. Change the Global subsections to 3 in each of the three fields (LOB, Channel, and ROB)
23. Select **OK**
24. Click the **Compute** button. This runs the 1D analysis
25. Close the *Steady Flow Analysis* dialog
26. Exit out of the HEC-RAS program and save information, if prompted.

7 Post-Processing

Now that HEC-RAS has computed water surface elevations, read the solution into WMS. The water surface elevations are read in as 2D Scatter Points and can be used to perform a floodplain delineation. To read the solution:

1. In WMS, switch to the *River* module
2. Select *HEC-RAS* **| Read Solution**

Notice that a new scatter point file has been read into WMS. These points contain the water surface elevations computed by HEC-RAS. Since seven cross sections were used in the model, there are only seven scatter points with which to perform the floodplain delineation. WMS has a tool that interpolates scatter points along centerline and cross section arcs which achieves more accurate floodplain delineation.

3. Select the 1D-Hyd Centerline coverage from the Project Explorer
4. Select *River Tools* **| Interpolate Water Surface Elevations**

Note that *hecras* is selected as the Scatter dataset. In this case, it is the only scatter dataset available. But if there were multiple datasets, specify which one to use for the interpolation.

5. Choose *At a specified spacing* for the Create a data point option
6. Enter 60 for the spacing
7. Select **OK**
8. Select the 1D-Hyd Cross Section coverage from the Project Explorer
9. Select *River Tools* **| Interpolate Water Surface Elevations**
10. Select **OK**
11. Switch to the *Terrain Data* module
12. Select *Flood* **| Delineate**
13. Toggle on the *Search radius* check box and enter 1000 for the radius

14. Toggle on the *Quadrants* check box
15. Enter 4 for the number of stages in a quadrant
16. Select **OK**
17. WMS now computes two new datasets corresponding to floodplain depths and water surface elevations (river bed elevation and flood depth)
18. Select the dataset named *W.S. Elev-PF 1 (FLOOD)*
19. Select *Display* **| Display Options**
20. Choose *TIN Data*
21. Toggle on *TIN Contours* and choose the **Options** button
22. Choose "Color fill" under *Contour Method*
23. Under Data Range, select *Specify a Range*
24. Deselect *Fill below* and *Fill above*
25. Select **OK** twice to exit both dialogs

These color-filled contours, shown in Figure 7-1, represent the varying water surface elevations in the computed floodplain. For more information and practice on floodplain delineation, see the third chapter of this volume, entitled *Floodplain Delineation*. A second HEC-RAS exercise where surveyed cross sections are used can be found in the next chapter.

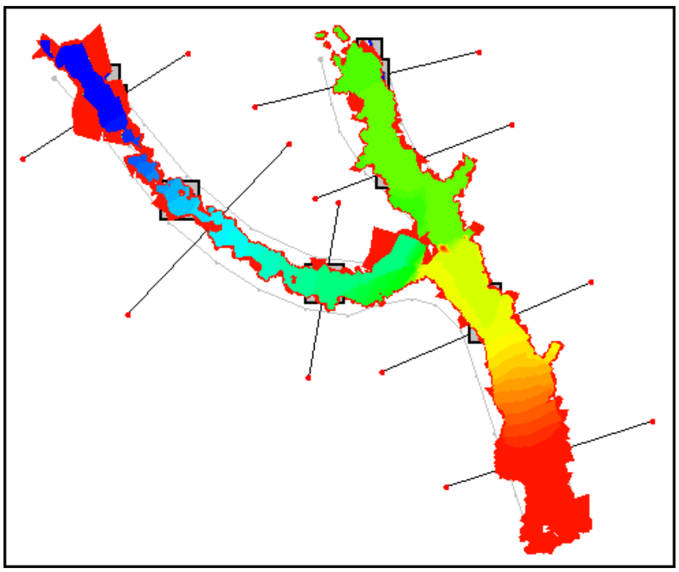


Figure 7-1: Resulting TIN from the Floodplain Delineation

8 Conclusion

This concludes this WMS Hydraulics and Floodplain Modeling tutorial. This exercise showed how to use WMS River to construct a HEC-RAS steady flow model. As part of this process, the following was show:

- Build a conceptual model

- Map the conceptual data to a hydraulic model representation
- Run the simulation within HEC-RAS
- View the results in WMS

