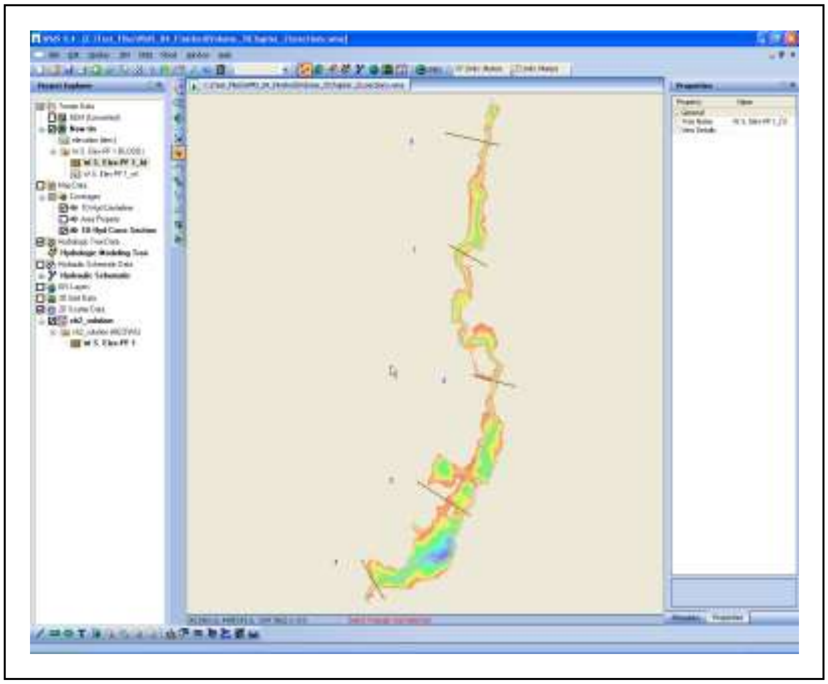
v. 10.0

WMS 10.0 Tutorial

Hydraulics and Floodplain Modeling – Managing HEC-RAS Cross Sections

Modify cross sections in an HEC-RAS model to use surveyed cross section data



Objectives

Build a basic HEC-RAS model from a conceptual schematic of cross sections, river banks, and river centerlines. Extract the cross sections from background elevation data. Then merge surveyed cross sections into extracted cross sections using the cross section database management tools in WMS. Export and run a HEC-RAS model, read the results into WMS, and delineate a floodplain using the HEC-RAS results.

Prerequisite Tutorials

- Hydraulics and Floodplain Modeling – HEC-RAS Analysis

Required Components

- Data
- Drainage
- Map
- River

Time

- 30-60 minutes

1 Introduction

HEC-RAS is a 1-D river model that relies on cross section data along reaches to compute results. Cross sections can be extracted from a TIN in WMS, but the TIN does not always define the channel with enough resolution to get an accurate cross section through the channel. Tools in WMS make it possible to manage cross sections by editing their shape, defining properties, and merging multiple cross sections together. Surveyed channel cross section data can be merged with cross sections extracted from a TIN in order to develop cross sections that accurately depict both the channel and surrounding terrain.

2 Objectives

In this exercise users will learn how to merge cross sections and use the data for input into a HEC-RAS model by:

- Creating a conceptual river model
- Converting a DEM to a TIN for background elevation data
- Extracting cross sections
- Merging cross sections
- Running HEC-RAS

- Delineating the floodplain using HEC-RAS results

3 Creating a Conceptual River Model

A conceptual river model can be created by using GIS data to define the centerline and bank arcs, material properties, and cross section location and geometry. Background images are also useful in creating and viewing this GIS data.

3.1 Open Centerline and Bank Arcs

1. Close all instances of WMS
2. Open WMS
3. Switch to the **Map** module.
4. Select ***File* | *Open***
5. Locate the ***xsecs*** folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
6. Select "river.map" and click **Open**.
7. Select ***Display* | *Display Projection...*** to set the display projection.
8. Select *Global projection* then click *Set Projection*.
9. In the *Select Projection* dialog, set *Projection* to "UTM", *Datum* to "NAD 27", *Horizontal Units* to "Meters", and *Zone* to "12 (114°W - 108°W - Northern Hemisphere)".
10. Select **OK**.
11. Set *Vertical Units* to "U.S. Survey Feet"
12. Select **OK**.
13. Select **Yes** if a message appears telling users that the horizontal and vertical units are inconsistent.

Users without an internet connection should skip sections 3.2 and 3.3.

3.2 Getting a Background Image

Using an Internet connection users can 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 arrow next to the **Add GIS Data** button and select **Get Online Maps** from the drop-down menu; this will open the *Get Online Maps* dialog.
2. Select *World Imagery* and click **OK**.
3. WMS will load the background image file. It will take few moments depending upon the internet connection. Once done, users can see an aerial photo added to the background.

3.3 Create a local copy of the image

The image users just loaded is read in from a server and sometimes it takes a long time to zoom and pan around. Users can create a local copy of the image to expedite such navigations.

1. In the Project Explorer, under the "GIS Data" folder, right click the image that was downloaded and select **Export**.
2. In the *Export Image* dialog, select **OK** to accept the suggested value of resample magnification.
3. In the *Save As* dialog, assign a name to the downloading image and the location where it will be saved. Then click **Save**.
4. Once the image has been downloaded, users can remove the bigger online image (the one that has a little globe on its icon). To do this, right click on the online image under the "GIS Data" folder and select **Delete**.

If users were able to successfully complete all the steps in sections 3.2 and 3.3 they can skip section 3.4.

3.4 Open Background Images

If users do not have reliable internet access, they should open images showing the area users are interested in modeling as follows:

1. Select *File* **| Open** to access the *Open* dialog.
2. In the *Open* dialog, select "jordannarrows.jpg" and "midvale.jpg" and click **Open**.

3.5 Define Centerline and Bank Arcs

1. **Zoom** in close enough around a section of the feature arcs so that users can see three distinct arcs as shown in Figure 1.

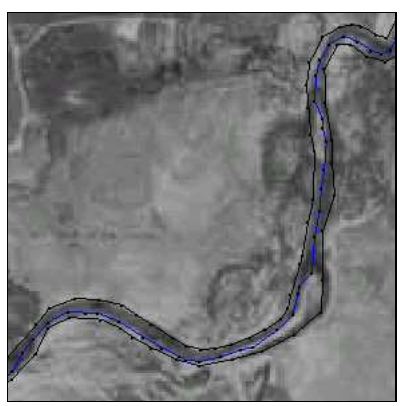


Figure 1 Centerline and bank arcs

The middle arc is the centerline arc that defines the thalweg of the river reach and the outer arcs define the right and left banks.

2. Use the **Select Feature Arc** tool to select the middle arc.

3. Select *Feature Objects* | **Attributes** and choose "Centerline" then select **OK**.
4. In the *River Reach Attributes* dialog, enter "Jordan River" for the *River Name*.
5. Enter "Riverton" in the *Reach Name*.
6. Select **OK**.
7. Use the **Select Feature Arc** tool to select both outer arcs. Press the **SHIFT** key to select both simultaneously.
8. Select *Feature Objects* | **Attributes** and choose "Bank", then select **OK**.

3.6 Create Materials

Materials are defined on an Area Property coverage by digitizing polygons representing different materials using a background image, such as an aerial photograph, or by using land use data from a shapefile or another source. Each different material that is defined will be used later to assign roughness values to the cross sections. In this exercise users will read in a map file containing material data that has already been digitized.

1. Select *File* | **Open** to access the *Open* dialog.
2. Open "materials.map".
3. **Zoom** in around the materials polygons on the "Area Property" coverage.
4. Right-click on the "Area Property" coverage and select **Display Options**.
5. In the *Display Options* dialog, select *Map Data* and toggle *Color Fill Polygons* on.
6. Select **OK**.
7. Select *Edit* | **Materials** to open the *Materials Data* dialog and view the material types associated with each color.
8. Select **Cancel**.

4 Converting a DEM to a TIN

Cross section geometry can be extracted from a TIN in WMS. We will create a TIN by opening a DEM and converting it to a TIN. It is also possible to filter redundant DEM points out of the TIN that users create.

4.1 Open a DEM

1. Switch to the **Terrain Data** module.
2. Select *File* | **Open** to access the *Open* dialog.
3. Open "91606647.hdr" in the "91696647" folder.
4. Select **OK** in the *Improting NED GRIDFLOAT File* dialog.
5. Select **Yes** to change projection. This will open the *Reproject Object* dialog.

6. In the *Object Projection* section toggle on *Global Projection* and click **Set Projection** button. This will open the *Select Projection* dialog.
7. Ensure “Geographic (Latitude/Longitude)”, and “NAD 83” are selected in the *Projection* and *Datum* drop down boxes.
8. Select **OK**.
9. Set *Vertical units* to “Meters”.
10. In the *Project Projection* section toggle *Set* on.
11. Click **Set Projection**.
12. The *Select Projection* dialog will reappear. Set *Projection* to “UTM”, *Datum* to “NAD 27”, *Planar Units* to “METERS”, and *Zone* to “12 (114°W - 108°W – Northern Hemisphere)”.
13. Select **OK**.
14. Set the V*ertical units* to “Meters”.
15. Select **OK**.

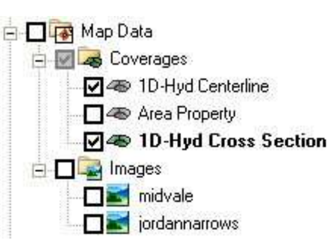
4.2 Convert to a TIN

1. Select *DEM* **|** *Conversion* **|** *DEM → TIN* **| Filtered**.
2. In the *DEM Conversion Options* dialog, select **OK**.
3. Right-click on “New Tin” under “Terrain Data” in the Project Explorer and select **Display Options** to open the *Display Options* dialog.
4. On the *TIN Data* tab, toggle *Triangles* off and *Boundaries* on.
5. Select **OK**.
6. Hide the DEM under the “Terrain Data” by toggling its check box off.

5 Extracting Cross Sections

It is very easy to extract cross section geometry from a TIN in WMS. This is done by creating arcs that represent the plan view of the cross sections on a 1D-Hyd Cross Section coverage.

1. Switch to the **Map** module.
2. Select *File* **| Open** to access the *Open* dialog.
3. Open “xsections.map” in the “xsecs” folder.

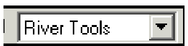


4. Hide the materials polygons by toggling “Area Property” coverage in the Project Explorer off.
5. Hide the background image by toggling it off.
6. Zoom in around the cross section arcs labeled 0 – 4.
7. Select the **Contour Options** icon, located at the top of the window.

8. The *elevation (elev) Contour Options* dialog will appear. For the *Contour Interval*, select the “Specified Interval” and enter a value of “10.0”.
9. Select **OK**.

The cross section arcs are approximately as wide as the floodplain might be. They end where there is a sharp break in slope and the terrain gets relatively steep. Wider cross section arcs are generally not necessary for a HEC-RAS analysis.

10. Make sure the “1D-Hyd Cross Section” coverage is active in the Project Explorer.
11. In the *Model* drop-down list at the top of the screen select “River Tools”.



12. Select *River Tools* **| Extract Cross Section**.
13. In the *Extract Cross Sections* dialog, select **OK**.
14. In the *Save* dialog, enter “xsec” for the name of the new cross section database where all of the cross sections will be stored, then click **Save**.
15. When prompted to extract cross sections from the DEM or the TIN, select the *TIN* option.

6 Merging Cross Sections

Any two cross sections can easily be merged in WMS. We will create a new cross section database that stores surveyed channel cross section data and merge it with the cross sections that users just extracted from the TIN. Merging cross sections will create more accurate cross section geometry data. Cross sections are merged by aligning both cross sections using reference points such as the thalweg or bank locations and then inserting points from one cross section into the other.

6.1 Open Channel Cross Section Data

1. Select *File* **| Edit File**.
2. In the *Open* dialog, open “channel.txt”.
3. Select **OK** to open with Notepad or choose any other text editor or spreadsheet.
4. Leave “channel.txt” open for later use.

6.2 Create a New Cross Section Database

1. In WMS, select *River Tools* **| Manage Cross Sections**.
2. In the *Manage Cross Sections* dialog, choose the **New Cross Section Database** button.
3. Enter “channelxsec.idx” for the *File name*.
4. Select **Save**.

6.3 Define Channel Cross Sections in the Database

The current cross section database should be "channelxsec.idx" (the one that users just created).

1. Click on the **Edit Cross Section Database** button to open the *CsDb Management* window.
2. Click the **New** button to add a cross section to the database.
3. Select the **Edit** button to edit the cross section. This will open the *Cross-Section Attributes* dialog.
4. Click the **Add** button. In the *Add Points* dialog, enter "7" to add seven points to the cross section.
5. Select **OK**.
6. Make sure *XY* is toggled off.
7. Copy and paste the cross section data for Channel Section 1 from "channel.txt" (opened in Notepad) into the Cross-Section Attributes Geom Edit tab as shown in Figure 2. Make sure to paste the data into the first row.

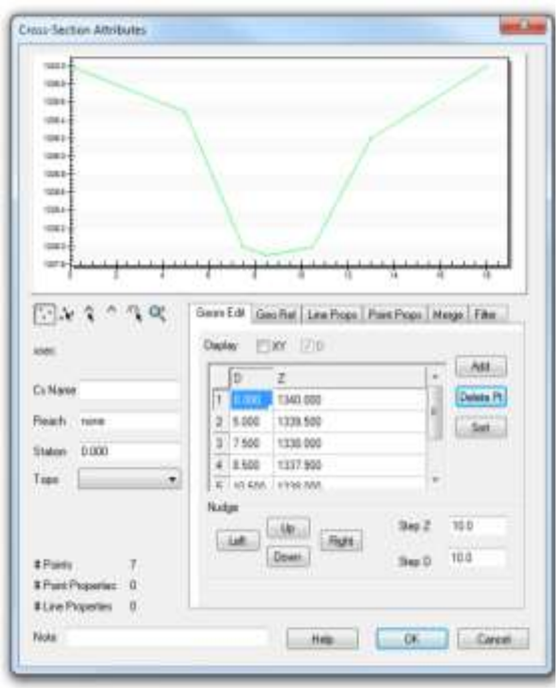


Figure 2 Adding cross section geometry data to the database

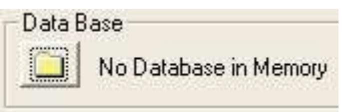
8. Select the *Point Props* tab.
9. Click the *Auto Mark* button to automatically define thalweg and right/left bank points. These reference points will be used to align cross sections for merging.
10. Select **OK**.
11. Repeat steps 2-10 to add the 4 remaining channel cross sections in *channel.txt* to the cross section database.
12. Click the **Save** button.

13. Select **OK**.
14. Select **OK**.
15. Close the text file “channel.txt” in Notepad.
16. Select **No** if asked to save changes.

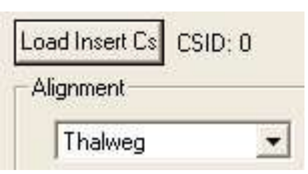
6.4 Align Channel Cross Sections with Extracted Cross Sections

This will allow users to view all of the extracted cross sections and assign the highlighted geometry to this cross section arc.

1. Use the **Select Feature Arc** tool to select the cross section arc at the top of the screen labeled “0”.
2. Select *Feature Objects* **| Attributes**.
3. In the *River Cross Section Attributes* dialog, select **Assign Cross Section**.
4. The *Assign Cross Section Profile* dialog will appear. Click the **Edit** button.
5. The *Cross-Section Attributes* dialog will reappear. Select the *Line Props* tab to view the material properties (roughness values) that will be applied to each cross section. These can be edited if necessary.
6. Select the *Merge* tab.
7. Select the **Load Insert Cs** button.
8. Click on the Data Base **Browse** button.



9. From the *Open* dialog, open “channelxsec.idx”.
10. Make sure that the csid number that is highlighted for the channel cross section matches the csid number of the extracted cross section that users are editing (these numbers also match the number labels displayed next to each cross section arc on the screen).
11. Select **OK**.



12. Choose “Thalweg” for *Alignment* to align the thalweg (specified as a point property) of the channel cross section with the thalweg of the extracted cross section.
13. Enter a value for Step Z (try “5”) and use the *Down* button to move the channel cross section vertically.
14. Reduce the Step Z value to “1” and use the *Up* button to position the cross section.
15. Keep reducing the Step Z value and using the *Up* and *Down* buttons until the cross sections are aligned correctly.
16. Enter a value for Step D and use the *Left* and *Right* buttons if users need to move the channel cross section horizontally.

17. Select “Insert All” from the *Merge* drop-down list.
18. Click **Apply** to insert the channel cross section and permanently change the extracted cross section data.

19. Select **OK** and notice the updated extracted cross section geometry.
20. Select **OK**.
21. Select **OK**.
22. Repeat this process (steps 1-21) for all of the cross section arcs.

A profile of the surveyed cross section geometry will appear in the upper left corner of the profile view of the extracted cross section geometry as shown in Figure 3.

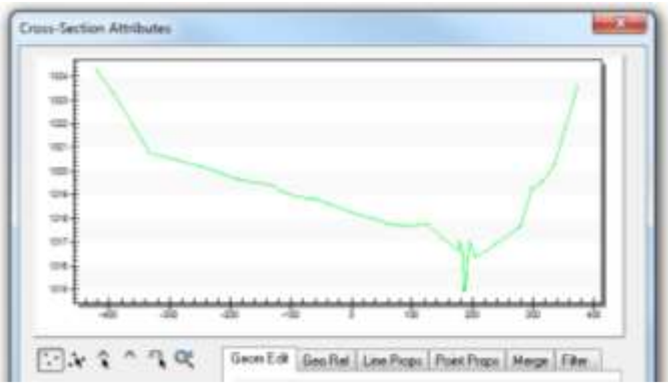


Figure 3 Merging cross sections

Merge cross sections using the Alignment tools shown in Figure 4. Users can align cross sections using reference points (point properties) that are defined on both cross sections such as left end, left bank, thalweg, right bank, and right end. Enter a value for the Offset and the cross section will be offset that distance from the alignment point. Specify a distance for Step Z and use the Up and Down buttons to move the inserted cross section vertically. Do the same for Step D using the Left and Right buttons to move the cross section horizontally. The horizontal and vertical scales on the plots are useful for determining the distances to enter. (Remember that the scales are not equal and so the vertical distances are magnified).

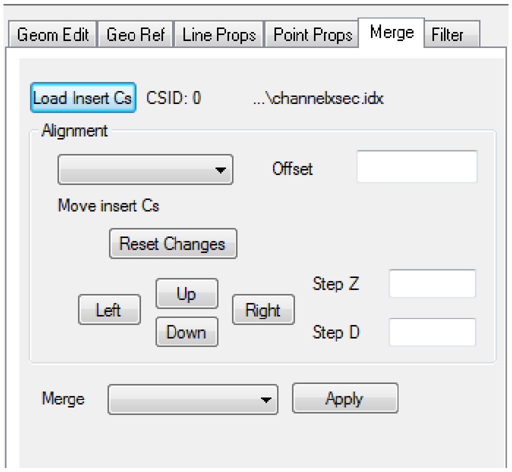


Figure 4 Alignment tools

The **Zoom** tool is useful for viewing the alignment of the cross sections close-up once users have the channel cross section located in the general area where it will be inserted.

7 Running HEC-RAS

A schematic will be created using the GIS data defined in WMS and exported to HEC-RAS. Post-processing options are also available in WMS after running an HEC-RAS simulation.

7.1 Creating a Schematic and Defining Roughness Values

1. Make the "1D-Hyd Centerline" the active coverage in the Project Explorer.
2. Select *River Tools* | **Map** → **1D Schematic**.
3. Switch to the **River**  module.
4. Select *HEC-RAS* | **Material Properties**. The *Hecras Material Properties* dialgo will appear.
5. Enter roughness values for Agriculture, Brushland, Bare, River, and Urban as shown in Figure 5.

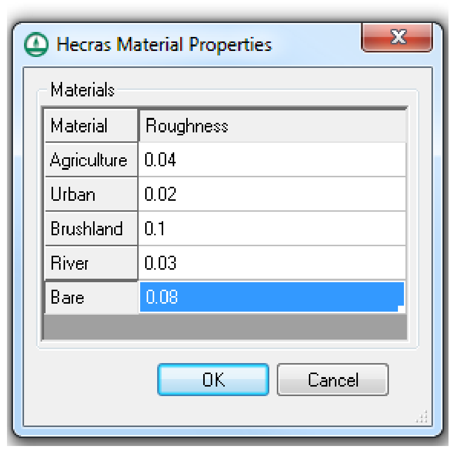


Figure 5 Materials roughness values

6. Select **OK**.
7. Select *HEC-RAS* | **Model Control**. The *HEC-RAS Model Control* dialog will appear.

8. Select "Materials" under *Roughness* for use in generating roughness values.
9. Select **OK**.

7.2 Running HEC-RAS

1. Select *HEC-RAS* | **Export GIS File**.
2. The *Enter a filename to save an HEC-RAS project file* dialog will open. Enter "hecras.prj" and **Save**.
3. Select **Yes** if asked to replace existing file.

This will start HEC-RAS with the geometry file exported from WMS already loaded. The window will be titled *HEC-RAS 4.1.0*.

4. Select *Options* | **Unit system (US Customary/SI)** in the HEC-RAS window.
5. In the *HEC-RAS* dialog, select *System International (Metric System).*
6. Select **OK**.
7. Select **Yes** to set the project units to SI (metric).
8. Select *Edit* | **Geometric Data**. The *Geometric Data – WMS Project Geometry* window will appear.
9. The display should look similar to that shown in Figure 6 (If users do not have the most recent version of HEC-RAS they may receive a plot extents error message. This can be corrected by selecting *View* | **Set Schematic Plot Extents** and selecting the **Set to Computed Extents** button).

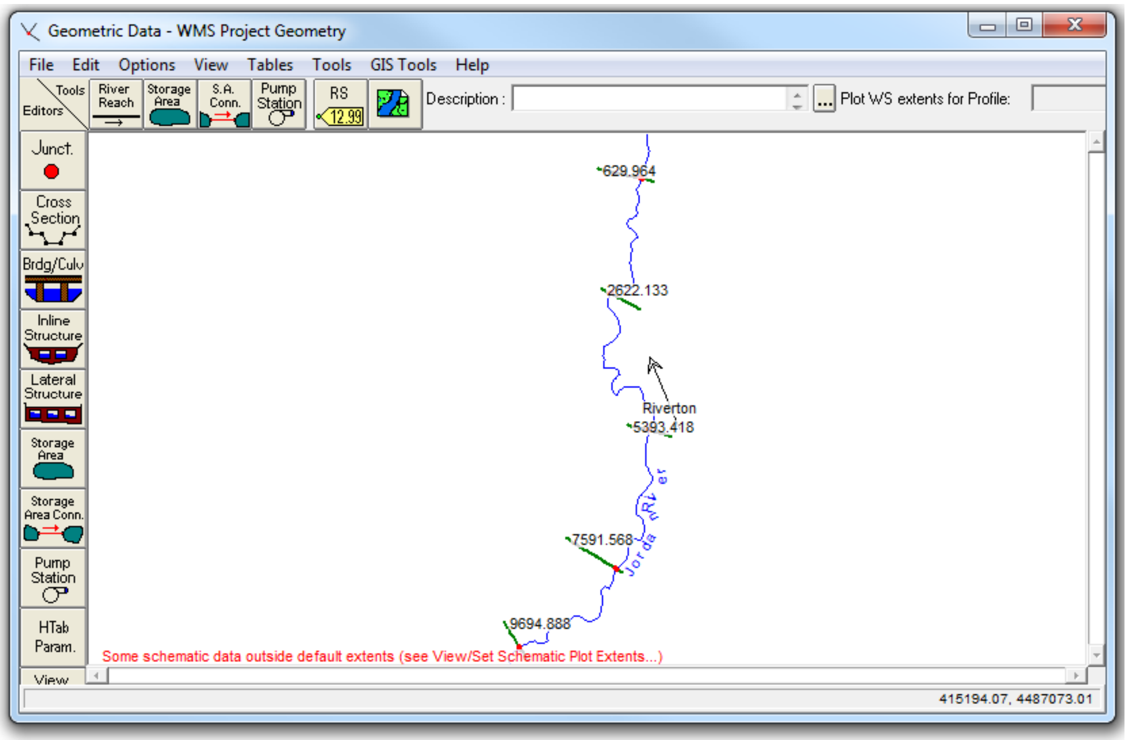


Figure 6 Geometric data imported from WMS

10. Select *File* | **Exit Geometry Data Editor** on the Geometric Data window.
11. Select *Edit* | **Steady Flow Data**. The *Steady Flow Data – WMS Project Flow* dialog will appear.

12. Enter “80” m^3/s for PF 1 (profile flow rate).
13. Click the **Reach Boundary Conditions** button. The *Steady Flow Boundary Conditions* dialog will open.
14. Click the **Normal Depth** button to enter the Downstream boundary condition.
15. Enter “0.003” for the downstream slope.
16. Select **OK**.
17. Highlight the *Upstream* boundary condition and click on the **Normal Depth** button.

18. Enter “0.0015” for the upstream slope.
19. Select **OK**.
20. Select **OK**.
21. Click the **Apply Data** button.
22. Select *File* **| Exit Flow Data Editor** on the *Steady Flow Data* window.
23. Select *Run* **| Steady Flow Analysis**. The *Steady Flow Analysis* dialog will appear.
24. Change the *Flow Regime* to “Mixed”.
25. Click on the **Compute** button.
26. Select **Close** to exit the *HEC-RAS Finished Computations*.
27. Select *File* **| Exit** on the *Steady Flow Analysis* window.
28. Select *File* **| Save Project** on the main *HEC-RAS* window.
29. Close the *HEC-RAS 4.1.0* window.

7.3 Post-processing

1. In WMS select *HEC-RAS* **| Read Solution**.
2. Use the **Select River Reach** tool to select the river reach icon displayed on the schematic.
3. Select *HEC-RAS* | **Plot Solution** to view the profile plot generated by HEC-RAS for the river reach. This will open a *Profile Plot* window.
4. Use the **Select Cross Section** tool to select one of the cross section icons displayed on the schematic.
5. Select *HEC-RAS* **| Plot Solution** to view the cross section profile plot generated by HEC-RAS in a *Cross Section* window. Click the red X to exit when done viewing results.

8 Floodplain Delineation

HEC-RAS computes a water surface elevation at each cross section. We will interpolate the HEC-RAS results along the cross section and centerline feature arcs in order to improve the floodplain delineation. WMS intersects the water surface elevation data with the background elevation TIN in order to delineate the floodplain.

8.1 Interpolating HEC-RAS Results

1. Select *Display* **| Display Options** to open the *Display Options* dialog.
2. On the *River Data* tab, toggle *River Hydraulic Schematic* off.
3. Select **OK**.
4. Make the “1D-Hyd Cross Section” coverage active in the Project Explorer.

5. Make sure that none of the cross section arcs are selected by clicking somewhere else on the screen.
6. Select *River Tools* **| Interpolate Water Surface Elevations**.
7. The *Interpolate Stages* dialog will appear. Choose *Create a data point* “At a specified spacing”.
8. Enter “100” for the *Data point spacing*.
9. Select **OK**.
10. Make the “1D-Hyd Centerline” coverage active in the Project Explorer.
11. Select *River Tools* **| Interpolate Water Surface Elevations**. The *Interpolate Stages* dialog will reappear.
12. Select **OK**.

8.2 Delineating the Floodplain

1. Switch to the **Terrain Data**  module.
2. Select *Flood* **| Delineate**.
3. In the *Floodplain Delineation* dialog, enter “500” for *Max search radius*.
4. Enter “2” for *Number of stages in a quadrant*.
5. Select **OK**.
6. Select the flood depth dataset, “W.S. Elev-PF 1_fd”, from the “Terrain Data” folder of the Project Explorer.
7. Select *Display* **| Contour Options** . The *W.S. Elev-PF 1_fd Contour Options* dialog will open.
8. For *Contour Interval* select the “Number of Contours” option and enter “25”.
9. For *Contour Method* select “Color fill” and adjust the Transparency to 55%.
10. Under Data Range, select *Specify a range*.

Notice that the values of the default range are much smaller than the actual elevation of the TIN. This is because these values are the flood depth.

11. Deselect the *Fill below* and *Fill above* checkboxes.
12. Select **OK**.

Two data sets were created by delineating the floodplain. “W.S. Elev-PF 1_fd” contains flood depth values and “W.S. Elev-PF 1_wl” contains water surface elevations.

13. Select “W.S. Elev-PF 1_wl” from the Project Explorer and experiment with viewing the results, similar to the flood depth. Users may also want to experiment with adjusting the transparency and turn the background image on as shown in Figure 7. When specifying the range, notice that the default values are actual TIN elevations.

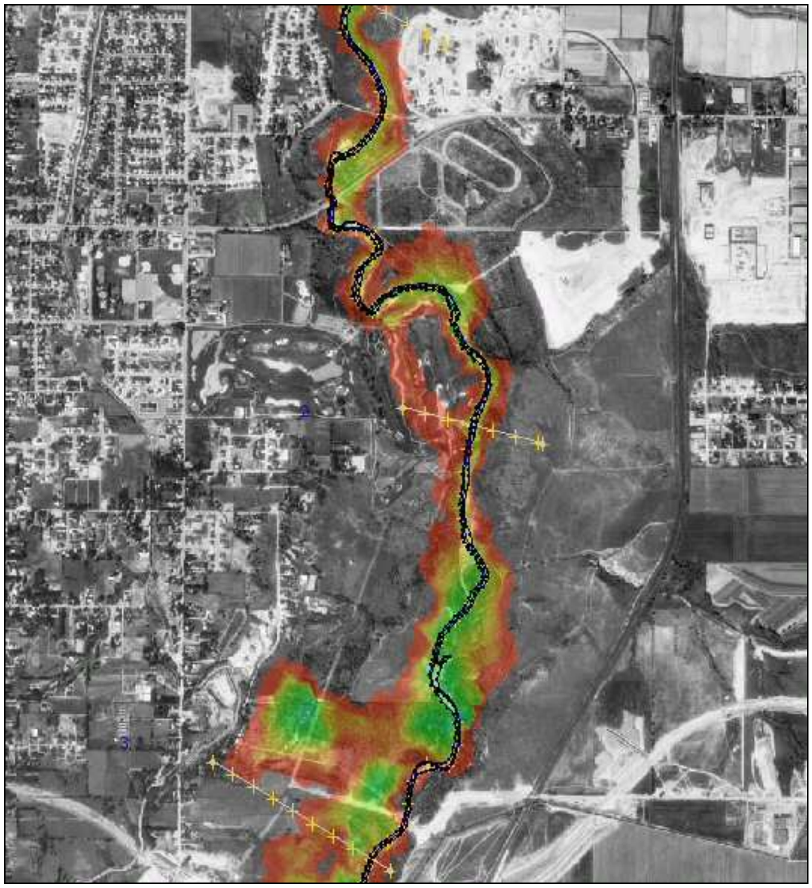


Figure 7 Flood depth map

It is important to remember that the HEC-RAS results came from merged cross sections, but the floodplain is delineated on the original TIN that does not include the surveyed channel cross section data. The water surface elevations of the flood are the same, but the flood depths in the channels, where cross sections were merged, may be deeper than shown.

9 Conclusion

In this exercise, users main goal was to learn to merge cross sections and use the data for input into a HEC-RAS model. In particular users should have learned how to:

- Create a conceptual river model
- Converta DEM to a TIN for background elevation data
- Extract cross sections
- Merge cross sections
- Run HEC-RAS
- Delineate the floodplain using HEC-RAS results

