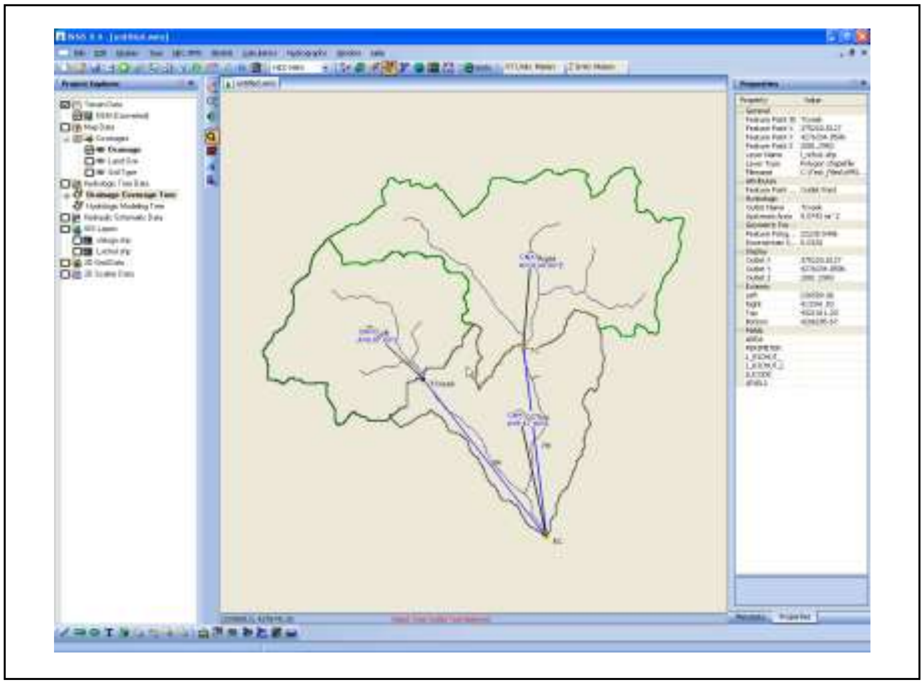
WMS

v. 10.0

WMS 10.0 Tutorial

Watershed Modeling – HEC-HMS Interface

Learn how to set up a basic HEC-HMS model using WMS



Objectives

Build a basic HEC-HMS model from scratch using a DEM, land use, and soil data. Compute the geometric and hydrologic parameters required to run the HEC-HMS model. Divide a single watershed into multiple sub-basins, and define reach and reservoir routing between sub-basins.

Prerequisite Tutorials

- Watershed Modeling – DEM Delineation

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models

Time

- 30-60 minutes

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1 Introduction

WMS includes a graphical interface to HEC-HMS. This tutorial is similar to the HEC-1 tutorial. Geometric attributes such as areas, lengths, and slopes are computed automatically from the digital watershed. Parameters such as loss rates, base flow, unit hydrograph method, and routing data are entered through a series of interactive dialog boxes. Once the parameters needed to define an HMS model have been entered, an input file with the proper format for HMS can be written automatically.

Since only parts of the HMS input file are defined in this chapter, users are encouraged to explore the different available options of each dialog, being sure to select the given method and values before exiting the dialog. Unlike HEC-1, it’s necessary to export the HMS files from WMS and then run the HMS graphical user interface to view the results. In order to do this, have the most recent version of HMS installed.

2 Objectives

Open a file with a watershed delineated from a DEM. Then develop a simple, single basin model using the delineated watershed to derive many of the parameters. Land use and soil shapefiles (downloaded from the Internet) will be used to develop a SCS curve number (CN) value. After establishing the initial HMS model, other variations will be developed, including defining multiple basins with reach routing and including a reservoir with storage routing.

3 Single Basin Analysis

The first simulation will be defined for a single basin. It's necessary to enter the global—or Job Control—parameters, as well as basin and meteorological data.

3.1 Setting up the Job Control

Most of the parameters required for a HEC-HMS model are defined for basins, outlets, and reaches. However, there are some "global" parameters that control the overall simulation and are not specific to any basin or reach in the model. These parameters are defined in the WMS interface using the Job Control dialog.

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Select "hec-1_SingleWatershed.wms" in the *hec-1* directory for this tutorial.
3. Click **Open** to import the project file and close the *Open* dialog. An image will appear in the Main Graphics Window.
4. Toggle off GIS Data in the Project Explorer.
5. **Frame** the project. This will zoom in to the location shown in Figure 1.

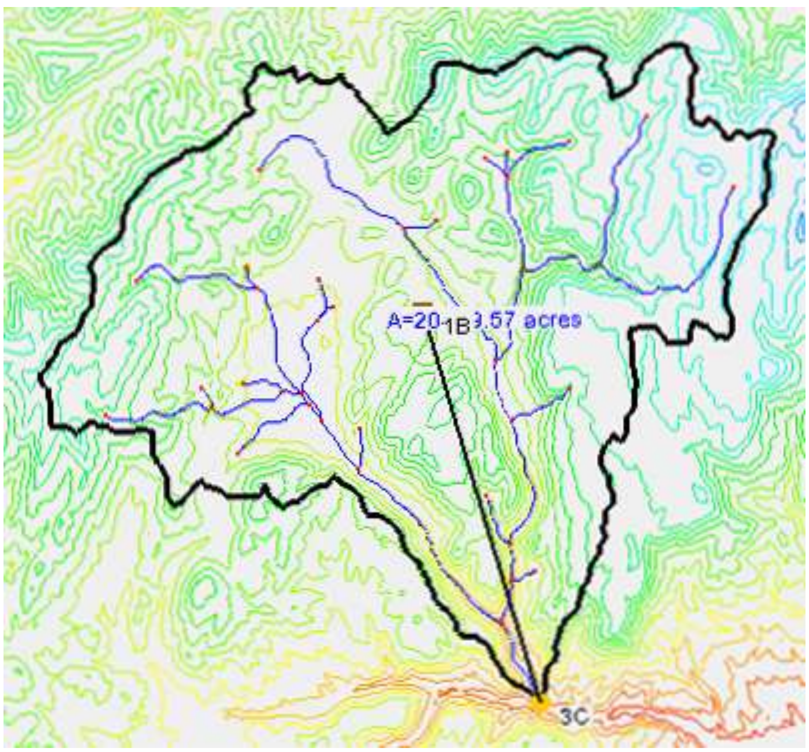


Figure 1 The drainage basin used in this tutorial

6. Switch to the **Hydrologic Modeling** module.
7. Select "HEC-HMS" from the drop-down just above the Graphics Window and next to the module macros.
8. Select *HEC-HMS* | **Job Control…** to bring up the *HMS Job Control* dialog.

9. On the *Control Options* tab in the *Control Specifications* section, enter “Clear Creek Tributary” in the *Name* field.
10. In the *Description* field, users can enter their own name.

By default the simulation is set to run for 24 hours starting from today’s date at 15 minute intervals. For this simulation, the settings need to be changed to run it for 25 hours at five minute intervals.

11. Add one hour to the *Ending time* using the small up arrow located just to the right of the field, or by manually changing the hours part of the field.
12. Select “5 Minutes” from the *Time interval* drop-down.
13. On the *Basin Options* tab in the *Basin Model Options* section, enter “Clear Creek Tributary” in the *Name* field.
14. In the *Basin Model Units* section, select the *US customary (English)* radio button (should be the default).

Setting the computation units does not cause any unit conversion to take place. Users are simply telling HEC-1 that they will provide input units in English units (sq. miles for area, inches for rain, feet/miles for length) and expect results of computation to be in English units (cfs). If users specify Metric then they must ensure that input units are metric (sq. kilometers, mm for rain, meters/kilometers for length) and results will be in metric (cms).

15. On the *Meteorological Options* tab in the *Meteorological Model Options* section, enter “Clear Creek Tributary” in the *Name* field.
16. Click **OK** to close the *HMS Job Control* dialog.

Note that HEC-HMS includes advanced options for long term simulation and local inflows at junctions, but these will not be explored in this model.

3.2 Setting up the Meteorological Data

In HEC-1, precipitation is handled as a Basin Data attribute. HEC-HMS instead defines precipitation separately in the Meteorological Data. This is because of the ability of HEC-HMS to model long term simulations that require additional information and often a lot more input.

1. Select *HEC-HMS* | **Meteorological Parameters…** to bring up the *HMS Meteorological Model* dialog.
2. Select “SCS Hypothetical Storm” from the *Precipitation Method* drop-down.
3. Select “Type II” from the *Storm Selection* drop-down.
4. Enter “1.8” as the *Storm Depth*.
5. Click **OK** to close the *HMS Meteorological Model* dialog.

3.3 Setting up the Basin Data Parameters

In the first simulation, treat the entire watershed as a single basin.

1. Select the **Select Basin** tool.

2. Double-click on the brown basin icon labeled "1B" to bring up the *HMS Properties* dialog. The icon may be obscured by another label (Figure 2).

Double-clicking on a basin or outlet icon always brings up the parameter editor dialog for the current model (in this case HEC-HMS). Notice that the area has been calculated (in this case in sq. miles because users are performing calculations in English units).

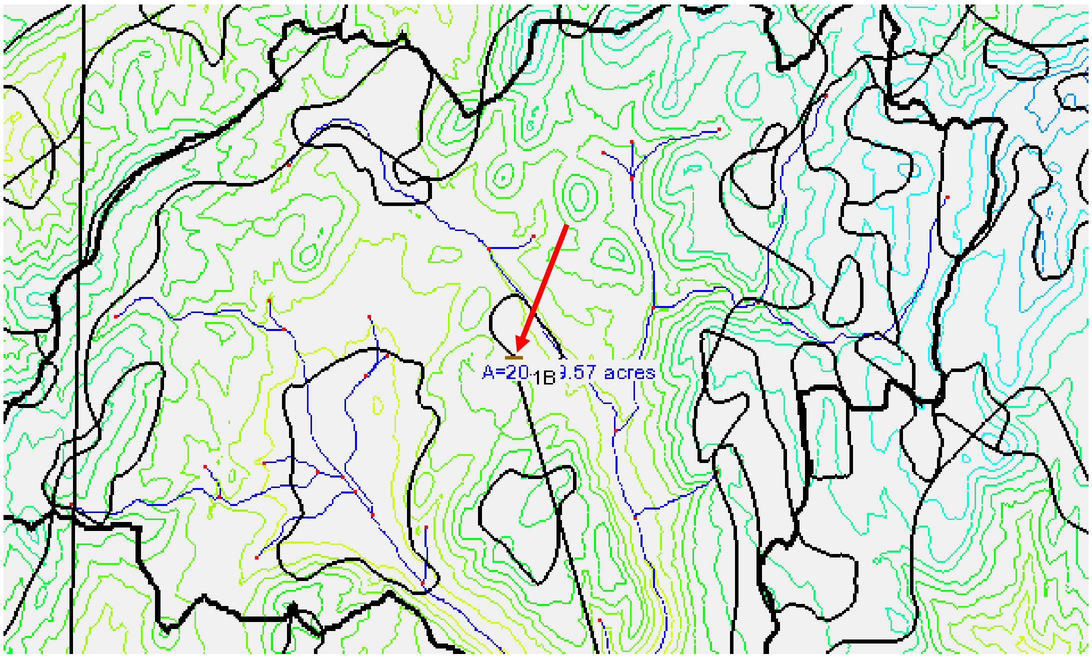


Figure 2 Brown basin icon 1B is behind the label, with the top just visible

1. In the *Display options* section, toggle on *Loss Rate Method* in the *Display* column. A new column will appear in the *Properties* section.
2. Toggle *SCS Curve Number* in the *Show* column. Several new columns will appear in the *Properties* section.
3. Scroll down and toggle on *Transform* in the *Display* column. Several new columns will appear in the *Properties* section.
4. Toggle on *SCS* in the *Show* column. Two new columns will appear in the *Properties* section.
5. In the *Properties* section, click the "1B" in the *Name* column to highlight it.
6. Enter "CCTrib" and press the *Tab* key twice to move to the *Description* field.
7. Enter "Main Branch" in the description.
8. Enter "70.0" in the *SCS Curve No.* column. Users will compute a curve number (CN) value from actual land use and soil files later.

For the SCS CN method, initial losses are estimated as 20% of the maximum storage value computed from the CN when the initial loss is zero. To override this computation, enter a value other than zero. For now, assume there is no impervious area.

9. Scroll to the right and click the **Compute…** button in the *Basin Data* column to bring up the *Basin Time Computation* dialog.
10. Select "Compute Lag Time" from the *Computation type* drop-down.

11. Select “SCS Method” from the *Method* drop-down.
12. Click **OK** to update the computed lag time and close the *Basin Time Computation* dialog.
13. Click **OK** to close the *HMS Properties* dialog. The brown basin icon formerly named “1B” is now named “CCTrib”.

Users now have all of the parameters set to run a single basin analysis.

3.4 Running HEC-HMS

Whenever users run an HEC-HMS simulation, they must save the information created in WMS to HEC-HMS files and then load it as a project in HEC-HMS. This tutorial is not a comprehensive review of HEC-HMS but should give users an idea of how to open a project created by WMS, run an analysis and view some basic results.

1. Select *HEC-HMS* | **Save HMS File…** to bring up the *Save HMS File* dialog.
2. Enter “CCTribNew.hms” in the *File name* field.

Use only alphanumeric characters in the file name, and do not use any characters with diacritics (i.e., umlaut, accent, circumflex). HEC-HMS will not process the files correctly if special characters are in the file name.

3. Select “HMS File (*.hms)” from the *Save as type* drop-down.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

Now users will start HEC-HMS on the computer.

5. Locate and launch “HEC-HMS.exe” on the computer being used.
6. Once in HEC-HMS, select *File* **| Open…** to bring up the *Open an Existing Project* dialog.
7. If needed, click the **Browse** button to bring up the *Select Project File* dialog.
8. Browse to the location where the HMS project from WMS was just saved (by default this will be in the *hec-1* directory of the tutorial files) and select the “CCTrib-new.hms” project file.
9. Click **Select** to open the file and close the *Select Project File* dialog.
10. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select “HMS Basin Files” from the drop-down and click **OK** to close the *Open File Format* dialog.
11. From the HEC-HMS Project Explorer, expand the “Basin Models”, “Meteorologic Models”, and “Control Specifications” folders.
12. Expand the “Clear Creek Tributary” basin model and then select it. The HEC-HMS Project Explorer should appear similar to Figure 3.

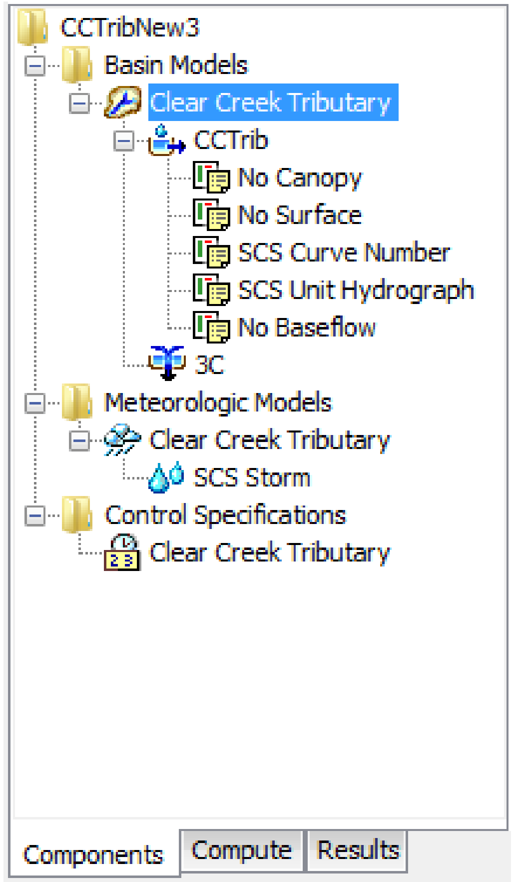
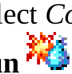


Figure 3 HEC-HMS Project Explorer

To create the simulation, do the following in HEC-HMS:

1. Select *Compute* **|** *Create Compute* | **Simulation Run…** to bring up the *Create Simulation Run [Step 1 of 4]* dialog.
2. Enter “CCTrib 1” in the *Name* field, then click **Next >** to close the *Create Simulation Run [Step 1 of 4]* dialog and open the *Create Simulation Run [Step 2 of 4]* dialog.
3. Select “Clear Creek Tributary” from the list of simulations and click **Next >** to close the *Create Simulation Run [Step 2 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
4. Select “Clear Creek Tributary” from the list of meteorological models and click **Next >** to close the *Create Simulation Run [Step 3 of 4]* dialog and open the *Create Simulation Run [Step 4 of 4]* dialog.
5. Select “Clear Creek Tributary” from the list of control specifications and click **Finish** to close the *Create Simulation Run [Step 4 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
6. Select *Compute* | **Compute Run [CCTrib 1]**, or click the **Compute Current Run**  macro. A progress dialog will appear.
7. When finished computing, click **Close** to close the dialog.

8. Select the "CCTrib" basin under the "Clear Creek Tributary" basin model from the HEC-HMS Project Explorer.
9. Select *Results* | **Global Summary Table** and explore.
10. Select *Results* | **Element Graph** and explore.
11. Select *Results* | **Element Summary Table** and explore.
12. Select *Results* | **Element Time-Series Table** and explore.

Users now have a completed HEC-HMS simulation for a single basin and the resulting hydrograph for the CCTrib sub-basin element should look something like the one shown in Figure 4.

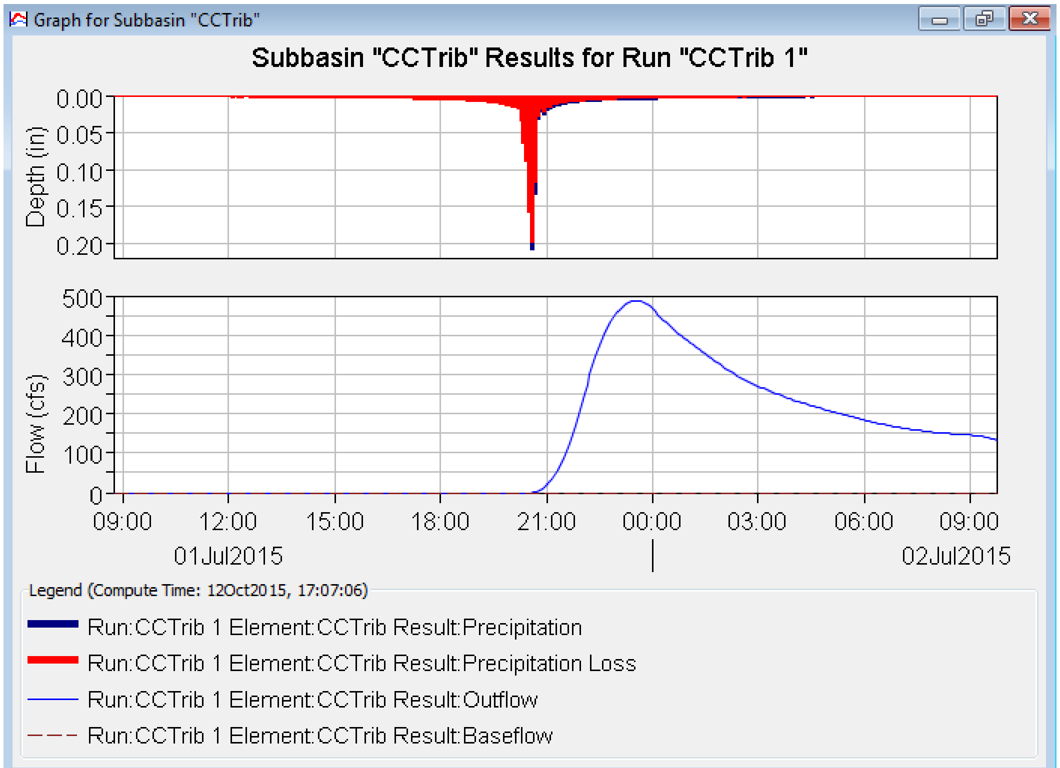


Figure 4 Solution hydrograph for HEC-HMS simulation

13. Users may continue to explore the HEC-HMS input parameters passed from WMS and computed results or any other options
14. When finished close the Global and Element summary tables and graph windows and exit HEC-HMS by selecting *File* **| Exit**
15. Select **Yes** when prompted to save the project.

4 Computing the CN Using Land Use and Soils Data

In the initial simulation, users estimated a CN, but with access to the internet it is simple to compute a composite CN based on digital land use and soils files. This was demonstrated in more detail in the *Advanced Feature Objects* tutorial, but users will go through the steps here as a review.

4.1 Computing a Composite CN

At the beginning of this tutorial, users loaded digital land use and soils files for the purpose of calculating a CN. In addition to this data, table must be defined that relates CN values for each of the four different hydrologic soil groups (A, B, C, D) for each land use. For this exercise, import an existing file and compute the CN numbers.

To do this:

1. Toggle on the "Land Use" and "Soil Type" coverages in the Project Explorer. It is not necessary to have the Land Use and Soil Type coverages displayed for the computations to work, they can provide useful information.
2. Select the "Drainage" coverage to make it active.
3. Select the **Hydrologic Modeling** module.
4. Select *Calculators* **| Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
5. Click the **Import** button.
6. A notification dialog will appear stating the new table will overwrite the current table. Click **OK** to close the notification dialog and open the *Open* dialog.
7. Select "scsland.tbl" and click **Open** to import the table and close the *Open* dialog.
8. Click **OK** to compute the CN from the land use and soils layers and close the *Compute GIS Attributes* dialog.
9. A *View Data File* dialog may appear asking which program to use to view the "cn_report.txt" file. Select a text editor from the *Open With* drop-down, or click the **Find Other…** button to find one not listed in the drop-down.
10. Click **OK** to close the *View Data File* dialog and open the "cn_report.txt" file in the selected text editor.

Notice the computed CN displayed in the Runoff Curve Number Report and above the area label in the WMS graphics window.

11. Close the Runoff Curve Number Report when done reviewing it and return to WMS.

4.2 Running HEC-HMS

Next, run another simulation to compare the results with the modified CN value.

1. Right click on "Drainage Coverage Tree" in the Project Explorer and select **Save HMS File…** to bring up the *Save HSM File* dialog.
2. Enter "CCTribCN.hms" in the *File name* field.
3. Select "HMS File (*.hms)" from the *Save as type* drop-down.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

HEC-HMS will be used to do additional calculations:

1. Locate and launch "HEC-HMS.exe" on the computer being used.

2. Once in HEC-HMS, select *File* **| Open…** to bring up the *Open an Existing Project* dialog.
3. If needed, click the **Browse** button to bring up the *Select Project File* dialog.
4. Browse to the location where the HMS project from WMS was just saved (by default this will be in the *hec-1* directory of the tutorial files) and select the "CCTribCN.hms" project file.
5. Click **Select** to open the file and close the *Select Project File* dialog.
6. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select "HMS Basin Files" from the drop-down and click **OK** to close the *Open File Format* dialog.
7. From the HEC-HMS Project Explorer, expand the "Basin Models", "Meteorologic Models", and "Control Specifications" folders.
8. Expand the "Clear Creek Tributary" basin model and then select it.

To create the simulation, do the following in HEC-HMS:

1. Select *Compute* **|** *Create Compute* | **Simulation Run…** to bring up the *Create Simulation Run [Step 1 of 4]* dialog.
2. Enter "CCTribCN 1" in the *Name* field, then click **Next >** to close the *Create Simulation Run [Step 1 of 4]* dialog and open the *Create Simulation Run [Step 2 of 4]* dialog.
3. Select "Clear Creek Tributary" from the list of simulations and click **Next >** to close the *Create Simulation Run [Step 2 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
4. Select "Clear Creek Tributary" from the list of meteorological models and click **Next >** to close the *Create Simulation Run [Step 3 of 4]* dialog and open the *Create Simulation Run [Step 4 of 4]* dialog.
5. Select "Clear Creek Tributary" from the list of control specifications and click **Finish** to close the *Create Simulation Run [Step 4 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
6. Select *Compute* | **Compute Run [CCTribCN 1]**, or click the **Compute Current Run**  macro. A progress dialog will appear.
7. When finished computing, click **Close** to close the progress dialog.
8. Select the "CCTrib" basin under the "Clear Creek Tributary" basin model from the HEC-HMS Project Explorer.
9. Select *Results* | **Global Summary Table** and explore.
10. Select *Results* | **Element Graph** and explore.
11. Select *Results* | **Element Summary Table** and explore.
12. Select *Results* | **Element Time-Series Table** and explore.

Users may continue to explore the HEC-HMS input parameters passed from WMS and computed results or any other options.

13. When finished close the Global and Element summary tables and graph windows and exit HEC-HMS by selecting *File* | **Exit**
14. Select **Yes** when prompted to save the project.

5 Adding Sub-basins and Routing

Now to subdivide the watershed into two upper basins and one lower basin and define routing for the reaches that connect the upper basins to the watershed outlet.

5.1 Delineating the Sub-basin

1. **Zoom** in to the area shown in Figure 5.

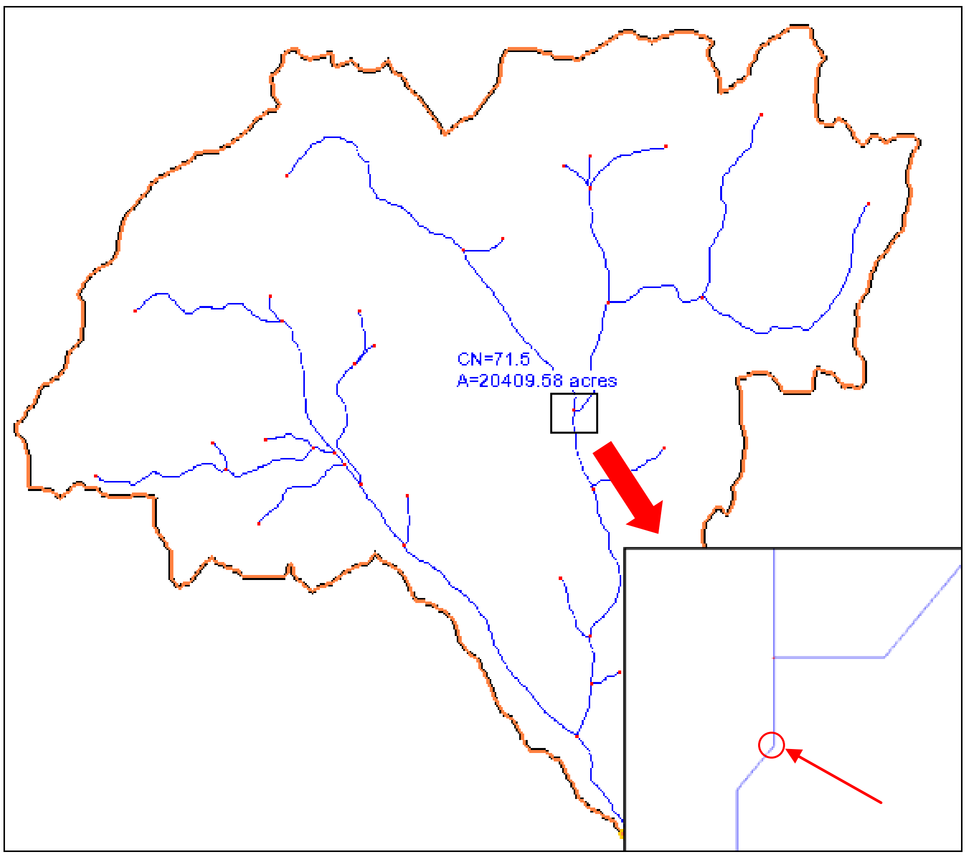


Figure 5 Zoom area, with enlarged view at bottom right

2. Right-click on “Drainage” in the Project Explorer and select **Display Options…** to bring up the *Display Options* dialog.
3. Select “Map Data” from the list on the left.
4. On the *Map* tab below the *Coverage type* drop-down, toggle on *Vertices*
5. Click **OK** to close the *Display Options* dialog.
6. Select the **Drainage Module** macro.

7. Using the **Select Feature Vertex** tool, select the vertex just below the main branching point (see inset in Figure 5).
8. Select *DEM* | **Node ↔ Outlet**. This creates an outlet point just below the branch in order to have a single upstream basin. To create a separate basin for each upstream branch, define the branching node as an outlet.
9. **Frame** the project.
10. **Zoom** in to the area shown in Figure 6.

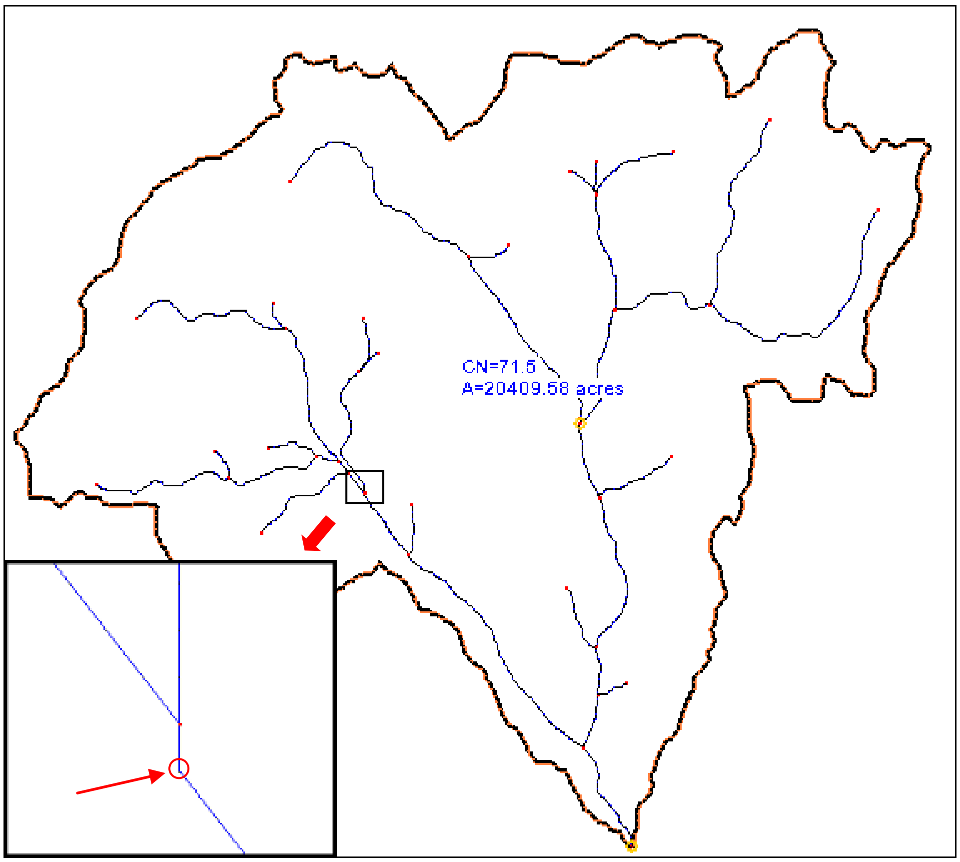


Figure 6 Zoom area, with enlarged view at bottom left

11. Using the **Select Feature Vertex** tool, select the vertex just below the main branching point (see inset in Figure 6).
12. Select *DEM* | **Node ↔ Outlet** to create the outlet point.
13. Frame the project.
14. Select *DEM* | **Delineate Basins Wizard** to bring up the *Stream Feature Arc Options* dialog.
15. If a notification dialog appears stating that all existing feature data on this drainage coverage will be deleted and recreated, click **OK** to continue.
16. Click **OK** to accept the defaults, close the *Stream Feature Arc Options* dialog, and open the *Units* dialog.

17. Click **OK** to accept the defaults and close the *Units* dialog. The drainage basin should now be divided into three sub-basins (Figure).

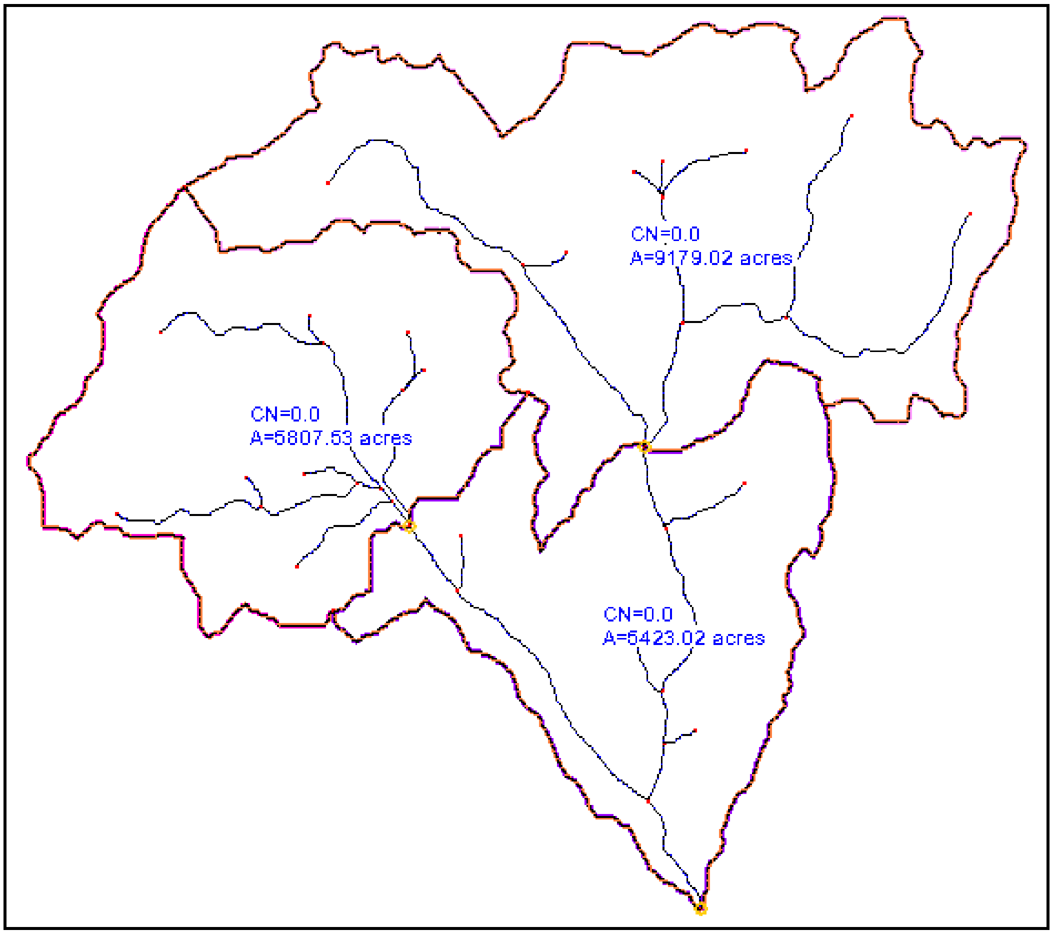


Figure 7 The three sub-basins after delineation

5.2 Updating the Basin Parameters

It's necessary to recompute the CN values and define precipitation and lag time for the basins.

1. Select the **Hydrologic Modeling** module.
2. Select *Calculators* **| Compute GIS Attributes…** to bring up the *Compute GIS Attributes* dialog.
3. Select **OK** to accept the defaults and close the *Compute GIS Attributes* dialog. The CN values will be updated for all basins. In this case, all three are very similar because there is one dominant soil polygon that covers the entire watershed.
4. A *View Data File* dialog may appear asking which program to use to view the "cn_report.txt" file. Select a text editor from the *Open With* drop-down, or click the **Find Other…** button to find one not listed in the drop-down. Toggle on *Remember this setting* to prevent WMS from asking every time.

5. Click **OK** to close the *View Data File* dialog and open the “cn_report.txt” file in the selected text editor.

Notice the computed CN displayed in the Runoff Curve Number Report and above the area label in the WMS graphics window.

1. Close the Runoff Curve Number Report when done reviewing it and return to WMS.
2. Using the **Select Basin** tool, double-click on the upper right brown basin icon (labeled “8B”) to bring up the *HMS Properties* dialog
3. Select “All” from the *Show* drop-down.
4. In the *Display options* section, toggle on *Loss Rate Method* in the *Display* column and *SCS Curve Number* in the *Show* column.
5. Toggle on *Transform* in the *Display* column and *SCS* in the *Show* column.
6. In the *Properties* section in the *Name* column, change “8B” to “Right”.
7. Change “9B” to “Left”.
8. Change “10B” to “CCTrib”.
9. Click the **Define…** button in the Basin Data column of the “10B” row to bring up the Basin Time Computation dialog.
10. Select “Compute Lag Time” from the *Computation* type drop-down.
11. Select “SCS Method” from the *Method* drop-down.
12. Click **OK** to close the *Basin Time Computation* dialog.
13. Repeat steps 14-17 for the “9B” and “8B” rows.
14. Click **OK** to close the *HMS Properties* dialog.

There is now a computed lag time for each basin (each about 1 hour). Because the CN values have been computed automatically, they do not need to be changed here.

5.3 Setting up the Routing Parameters

If HEC-HMS were run right now, the hydrographs from the upper basins would be combined with the lower basin hydrograph at the watershed outlet without any lag or attenuation because the routing parameters are not yet set. A routing method needs to be defined now to instruct HEC-HMS to compute lag and attenuation on the upper basin hydrographs before adding them to the lower hydrograph.

Routing for a reach is always defined at the upstream outlet of the reach in WMS.

1. Using the **Select Outlet** tool, double-click on the upper right basin outlet (labeled “9C”) to bring up the *HMS Properties* dialog.
2. Select “Reaches” from the *Type* drop-down.
3. Select “Selected” from the *Show* drop-down.
4. In the *Display options* section, toggle on *Method* in the *Display* column and *Muskingum Cunge Std* in the *Show* column.

5. In the *Properties* section, select "Muskingum Cunge" from the *Routing Method* drop-down.
6. Scroll to the right and enter "5.0" in the *Bottom Width/Diameter (ft)* column.
7. Enter "1.0" in the *Side Slope (xH:1V)* column.
8. Enter "0.05" in the *Mannings n* column. This is fairly rough, giving an exaggerated routing effects for this purposes of this exercise.
9. Select **OK** to close the *HMS Properties* dialog.
10. Using the **Select Outlet** tool, double-click on the upper left basin outlet (labeled "10C") to bring up the *HMS Properties* dialog.
11. Select "Reaches" from the *Type* drop-down.
12. In the *Properties* section, select "Muskingum Cunge" from the *Routing Method* drop-down.
13. Scroll to the right and enter "5.0" in the *Bottom Width/Diameter (ft)* column.
14. Enter "1.0" in the *Side Slope (xH:1V)* column.
15. Enter "0.05" in the *Mannings n* column.
16. Select **OK** to close the *HMS Properties* dialog. The project will appear similar to Figure.

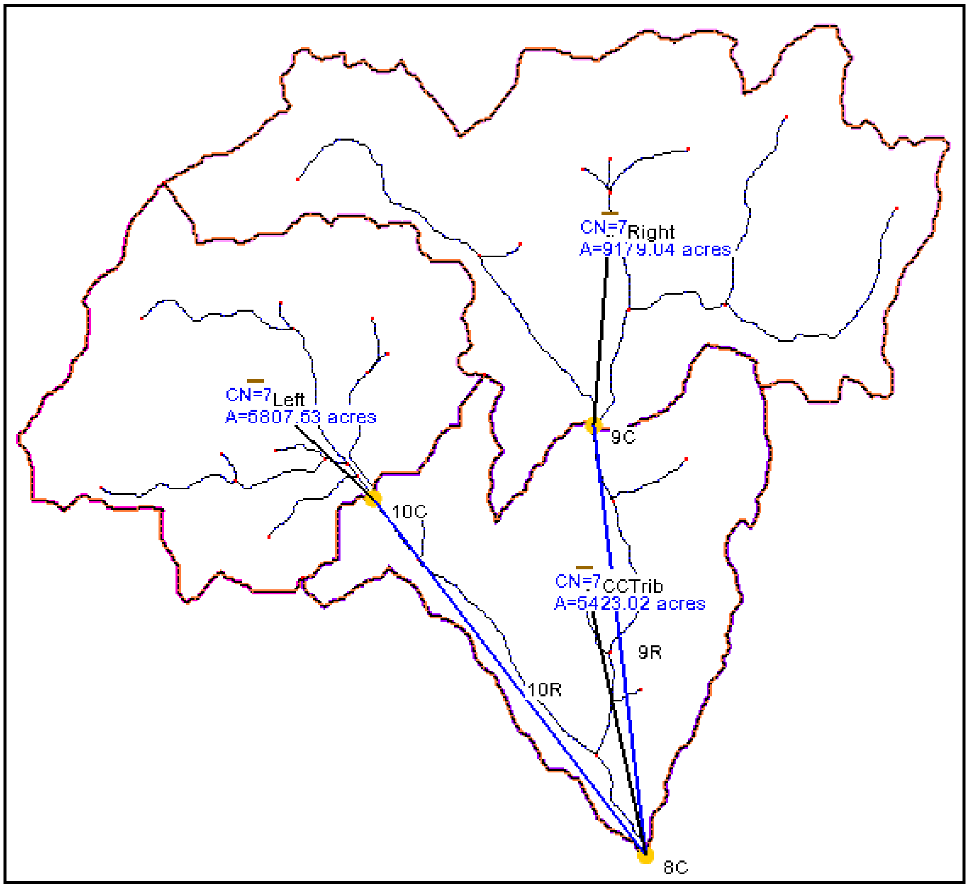


Figure 8 Three sub-basins after upper basins' output defined

5.4 Running HEC-HMS

Everything is now defined to run a three basin HEC-HMS analysis that includes routing the upper basins through the reaches connecting them to the watershed outlet.

1. Right click on “Drainage Coverage Tree” in the Project Explorer and select **Save HMS File…** to bring up the *Save HSM File* dialog.
2. Enter “CCTribRoute.hms” in the *File name* field.
3. Select “HMS File (*.hms)” from the *Save as type* drop-down.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

HEC-HMS will be used to do additional calculations:

5. Locate and launch “HEC-HMS.exe” on the computer being used.
6. Once in HEC-HMS, select *File* **| Open…** to bring up the *Open an Existing Project* dialog.
7. If needed, click the **Browse** button to bring up the *Select Project File* dialog.
8. Browse to the location where the HMS project from WMS was just saved (by default this will be in the *hec-1* directory of the tutorial files) and select the “CCTribRoute.hms” project file.
9. Click **Select** to open the file and close the *Select Project File* dialog.
10. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select “HMS Basin Files” from the drop-down and click **OK** to close the *Open File Format* dialog.
11. From the HEC-HMS Project Explorer, expand the “Basin Models”, “Meteorologic Models”, and “Control Specifications” folders.
12. Expand the “Clear Creek Tributary” basin model and then select it.

To create the simulation, do the following in HEC-HMS:

1. Select *Compute* **|** *Create Compute* | **Simulation Run…** to bring up the *Create Simulation Run [Step 1 of 4]* dialog.
2. Enter “CCTribRoute 1” in the *Name* field, then click **Next >** to close the *Create Simulation Run [Step 1 of 4]* dialog and open the *Create Simulation Run [Step 2 of 4]* dialog.
3. Select “Clear Creek Tributary” from the list of simulations and click **Next >** to close the *Create Simulation Run [Step 2 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
4. Select “Clear Creek Tributary” from the list of meteorological models and click **Next >** to close the *Create Simulation Run [Step 3 of 4]* dialog and open the *Create Simulation Run [Step 4 of 4]* dialog.
5. Select “Clear Creek Tributary” from the list of control specifications and click **Finish** to close the *Create Simulation Run [Step 4 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
6. Select *Compute* | **Compute Run [CCTribRoute 1]**, or click the **Compute Current Run**  macro. A progress dialog will appear.

7. When finished computing, click **Close** to close the progress dialog.
8. Select the any of the basins under the “Clear Creek Tributary” basin model from the HEC-HMS Project Explorer.
9. Select *Results* | **Global Summary Table** and explore.
10. Select *Results* | **Element Graph** and explore.
11. Select *Results* | **Element Summary Table** and explore.
12. Select *Results* | **Element Time-Series Table** and explore.

Users may continue to explore the HEC-HMS input parameters passed from WMS and computed results or any other options.

13. When finished close the Global and Element summary tables and graph windows and exit HEC-HMS by selecting ***File* | *Exit***
14. Select **Yes** when prompted to save the project.

6 Modeling a Reservoir in HEC-HMS

A small reservoir exists at the outlet of the upper left basin. It has a storage capacity of 1000 ac-ft at the spillway level and 1540 ac-ft at the dam crest.

6.1 Defining a Reservoir in Combination with Routing

One of the routing methods available in HEC-HMS is storage routing, which can be used to define reservoir routing. In this case, Muskingum-Cunge routing is already being used to move the hydrograph through the reach connecting the upper left basin to the watershed outlet. The outlet must be defined as a reservoir in order to route the hydrograph through the reservoir before routing it downstream.

15. Using the **Select Outlet**  tool, select the outlet of the upper left basin (labeled “10C”).
16. Right-click on the outlet and select *Add* **| Reservoir**. The icon will change color and become a triangle.

6.2 Setting up the Reservoir Routing Parameters

In order to define reservoir routing with HEC-HMS, elevation vs. storage (storage capacity curve) and elevation vs. discharge rating curves must be defined. Values can be entered directly or computed based on hydraulic structures. In this exercise, values will be entered directly, using the same elevation values for both curves.

In this case, there should be no outflow until the elevation in the reservoir reaches the spillway. Since HEC-HMS linearly interpolates between consecutive points on the elevation-discharge and elevation-volume curves, two points on the curves at almost the same elevation (6821.99 ft and 6822 ft) will be entered. The first will have no outflow and the second will have the discharge over the spillway (640 cfs) as defined for the dam.

The initial conditions of the reservoir need to be entered to define the reservoir routing. The initial condition can be defined as an elevation, a discharge, or a volume. For this example, the initial condition is set to an elevation four feet below the top of the spillway (the spillway corresponds to elevation 6822).

1. Using the **Select Outlet** tool, double-click on the reservoir outlet point to bring up the *HMS Properties* dialog.
2. In the *Properties* section, change “10C” to “Tcreek” in the *Name* column.
3. On the *Tcreek* row, select “Elevation-Storage-Discharge” from the *Method* drop-down.
4. Select “Elevation (ft)” from the *Initial* drop-down.
5. Enter “6818” in the *Initial Value* column.
6. Click the **Define…** button in the *Elevation-Storage* column to bring up the *XY Series Editor* dialog.
7. Click the **New** button.
8. Enter “Elevation-Storage” in the *Curve Name* field.
9. In the *Elevation(ft)* column, enter the following in the first seven rows:
   - “6803.0”
   - “6808.0”
   - “6813.0”
   - “6818.0”
   - “6821.99”
   - “6822.0”
   - “6825.0”
10. In the *Storage (ac-ft)* column, enter the following in the first seven rows:
    - “0.0”
    - “200.0”
    - “410.0”
    - “650.0”
    - “999.99”
    - “1000.0”
    - “1540.0”
11. Click **OK** to close the *XY Series Editor* dialog.
12. Click the **Define…** button in the *Storage-Discharge* column to bring up the *XY Series Editor* dialog.
13. Click the **New** button.
14. Enter “Storage-Discharge” in the *Curve Name* field.
15. In the *Volume (ac-ft)* column, enter the following in the first seven rows:

- “0.0”
- “200.0”
- “410.0”
- “650.0”
- “999.99”
- “1000.0”
- “1540.0”

16. In the *Discharge (cfs)* column, enter the following in the first seven rows:
    - “0.0”
    - “0.0”
    - “0.0”
    - “0.0”
    - “639.99”. There is no outflow until the water level reaches the spillway.
    - “640.0”
    - “7000.0”
17. Click **OK** to close the *XY Series Editor* dialog.
18. Click **OK** to close the *HMS Properties* dialog.

6.3 Running HEC-HMS

Everything is now defined to run a three-basin HEC-HMS analysis that includes routing the upper basins through the reaches connecting them to the watershed outlet.

1. Right click on “Drainage Coverage Tree” in the Project Explorer and select **Save HMS File…** to bring up the *Save HSM File* dialog.
2. Enter “CCTribReservoir.hms” in the *File name* field.
3. Select “HMS File (*.hms)” from the *Save as type* drop-down.
4. Click **Save** to save the HMS file and close the *Save HMS File* dialog.

HEC-HMS will be used to do additional calculations:

1. Locate and launch “HEC-HMS.exe” on the computer being used.
2. Once in HEC-HMS, select *File* **| Open…** to bring up the *Open an Existing Project* dialog.
3. If needed, click the **Browse** button to bring up the *Select Project File* dialog.
4. Select the “CCTribReservoir” project file.
5. Click **Select** to open the file and close the *Select Project File* dialog.
6. The *Open File Format* dialog may appear. If so, in the *Open file as* section, select “HMS Basin Files” from the drop-down and click **OK** to close the *Open File Format* dialog.

7. From the HEC-HMS Project Explorer, expand the “Basin Models”, “Meteorologic Models”, “Control Specifications”, and “Paired Data” folders.
8. Expand the “Clear Creek Tributary” basin model and then select it.

To create the simulation, do the following in HEC-HMS:

9. Select *Compute* **|** *Create Compute* | **Simulation Run…** to bring up the *Create Simulation Run [Step 1 of 4]* dialog.
10. Enter “CCTribReservoir 1” in the *Name* field, then click **Next >** to close the *Create Simulation Run [Step 1 of 4]* dialog and open the *Create Simulation Run [Step 2 of 4]* dialog.
11. Select “Clear Creek Tributary” from the list of simulations and click **Next >** to close the *Create Simulation Run [Step 2 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
12. Select “Clear Creek Tributary” from the list of meteorological models and click **Next >** to close the *Create Simulation Run [Step 3 of 4]* dialog and open the *Create Simulation Run [Step 4 of 4]* dialog.
13. Select “Clear Creek Tributary” from the list of control specifications and click **Finish** to close the *Create Simulation Run [Step 4 of 4]* dialog and open the *Create Simulation Run [Step 3 of 4]* dialog.
14. Select *Compute* | **Compute Run** [**CCTribReservoir 1**]. A progress dialog will appear.
15. When finished computing, click **Close** to close the progress dialog.
16. Select the any of the basins under the “Clear Creek Tributary” basin model from the HEC-HMS Project Explorer.
17. Select *Results* | **Global Summary Table** and explore.
18. Select *Results* | **Element Graph** and explore.
19. Select *Results* | **Element Summary Table** and explore.
20. Select *Results* | **Element Time-Series Table** and explore.

Users may continue to explore the HEC-HMS input parameters passed from WMS and computed results or any other options.

21. When finished close the Global and Element summary tables and graph windows and exit HEC-HMS by selecting ***File* | *Exit***
22. Select **Yes** when prompted to save the project.

7 Conclusion

This concludes the exercise defining HEC-HMS files and displaying hydrographs. The concepts learned include entering job control parameters, defining basin parameters such as loss rates, precipitation, and hydrograph methodology, a watershed analysis, defining routing parameters, routing a hydrograph through a reservoir, and saving and running HEC-HMS simulations.

