

Hydrologic Modeling using HEC-HMS

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Introduction

The objective of this exercise is to create a HEC-HMS model using GIS data for hydrologic modeling of a single event in Cedar Creek Watershed (CCW) in Indiana. Although the data and instructions provided here are for CCW, the process can easily be replicated for any watershed by using a digital elevation model.

Learning Outcomes

- Create a HEC-HMS model using the built-in GIS functions
- Understand different HMS model components
- Parameterization of HMS methods associated with SCS methods and Muskingum Routing
- Add meteorologic information in HMS
- Create a hydrologic simulation for a single event in HMS

Computer Requirements

You must have a computer with windows operating system, and the following programs installed: HEC-HMS version 4.6 or higher

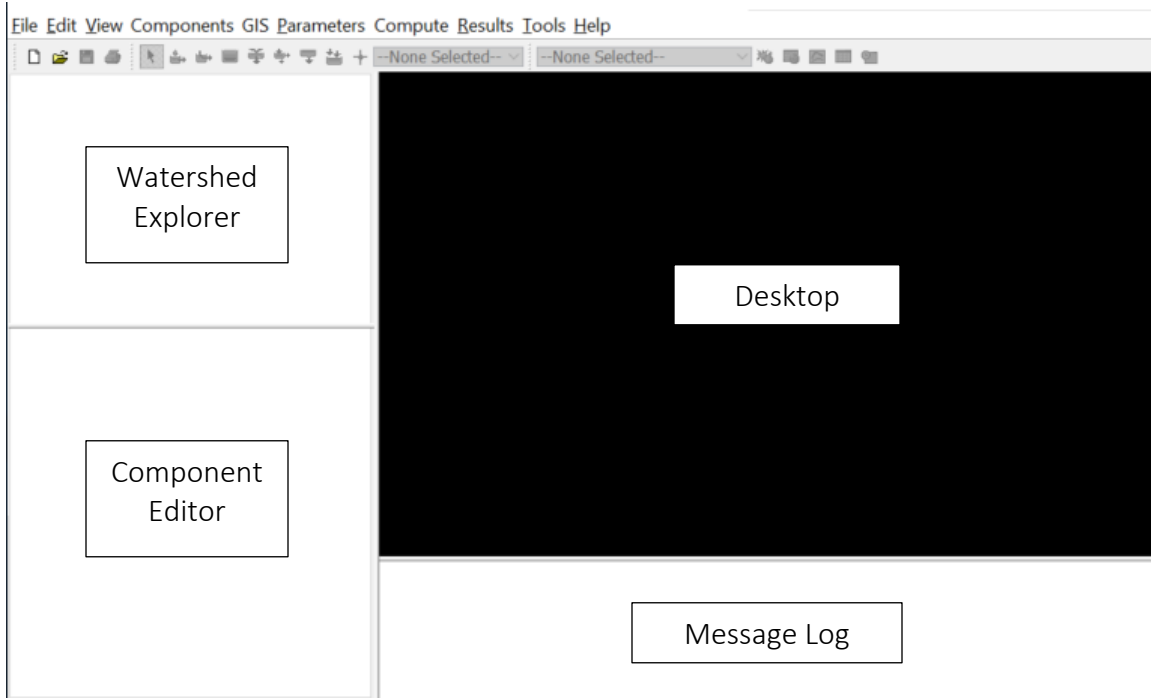
Input Data

The input data needed for this exercise is provided in Module 7 folder on Brightspace. It is also available publicly at: <https://app.box.com/s/khlhuxy49yrebd6mln3i8ef7isxh4r03>. Copy the data and unzip in your working directory. The data includes the following:

- 1) Cedar Creek dem as a GeoTiff (.tif) file
- 2) An Excel File with observed rainfall and streamflow data for a single storm event

Instructions

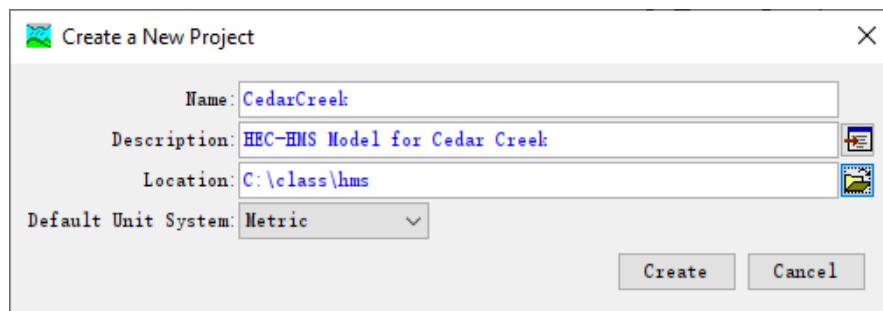
Launch HEC-HMS. Accept the terms and conditions if asked. After a few seconds, the following should appear (desktop color may be different, but that is OK):



Henceforth, this window will be referred to as HEC-HMS Interface. The HEC-HMS interface consists of a menu bar, tool bar, and four panes. These panels are referred to as the Watershed Explorer, the Component Editor, the Message Log and the Desktop. More description on these panes, menus and tools is provided when they are used later in the exercise.

Opening/creating a HEC-HMS project

Click on File→New.. (Ctrl + N). Enter the project name as CedarCreek, provide some basic description (see below) and provide the location of your working folder, use Metric unit system, and push the Create button (use appropriate location based on your folder structure).



HMS Model Components

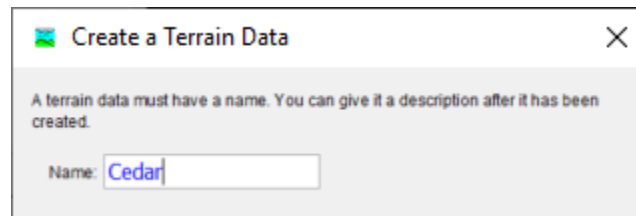
HMS has several four main model components (you can see these by selecting components on the menu bar):

1. Basin model: This stores information relevant to the physical attributes of the model, such as basin areas, river reach connectivity, or reservoir data
2. Meteorologic model: This stores information related to climate/weather. Primarily rainfall data for an event-based simulation
3. Control specifications: This stores information pertinent to the timing of the model such as when a storm occurred and what type of time interval you want to use in the model, etc.
4. Input data (time series, paired data and gridded data): This stores parameters or boundary conditions for basin and meteorologic models.

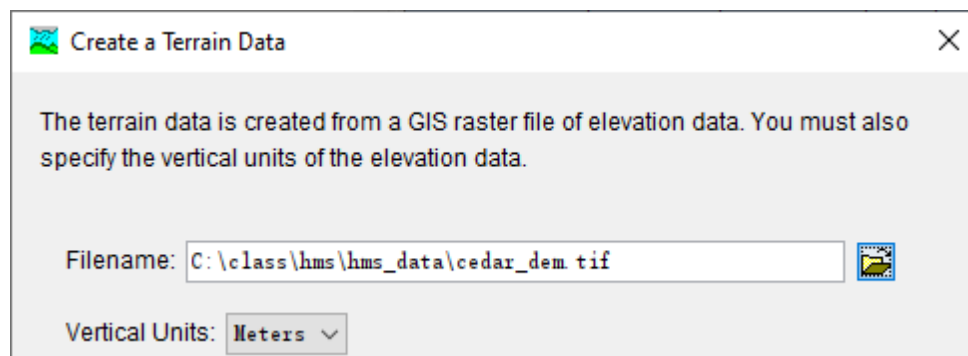
Each of the sections is explored below individually.

Terrain Data Manager

The terrain data manager is used to handle terrain data, i.e., a digital elevation model (DEM), for an area to be included in the model. Once the terrain is imported into HEC-HMS, it can be used to create the basin model. Let's get DEM for Cedar Creek in HEC-HMS. Go to Components → Create Component → Terrain Data. Name the new terrain as Cedar and click Next.



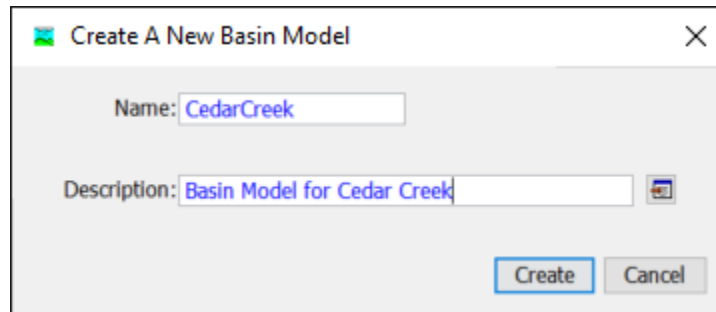
Browse to cedar_dem.tif, choose the appropriate vertical units for elevation (meters in this case), and click Finish.



This will create a Terrain Data Component (folder) in the component editor. If you open this folder (click on the + sign next to the folder), you should see the Cedar terrain (just the name). The DEM will not show up in the window yet! Let's create the basin component.

Basin Model Manager

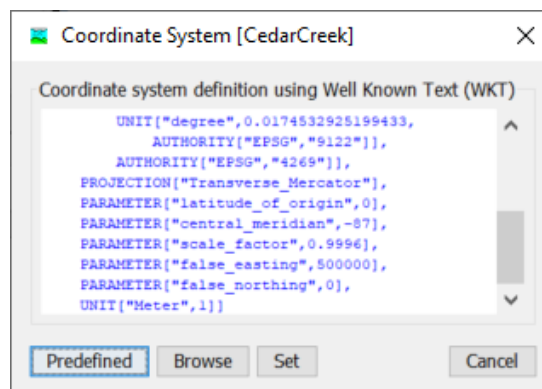
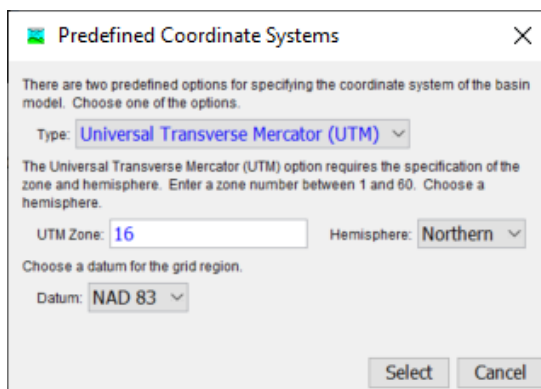
Go to Components → Create Component → Basin Model... Name the basin as CedarCreek, give some description, and push Create.



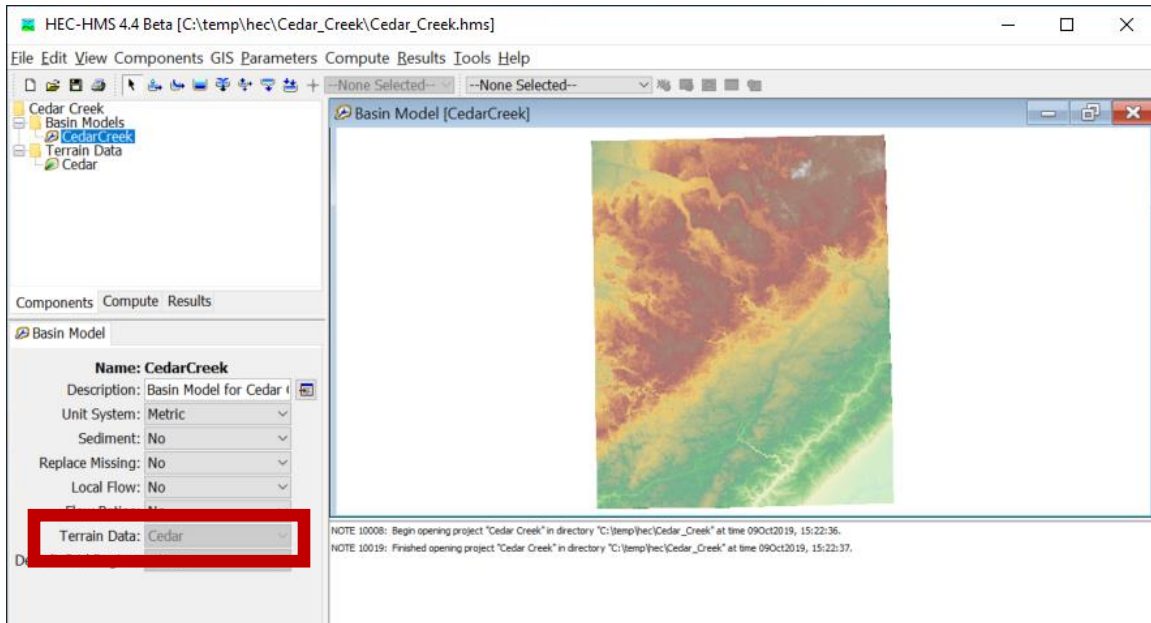
This will create an empty basin model component. Open the basin Models Component and click on CedarCreek to open the empty basin model.

Assigning Coordinate System

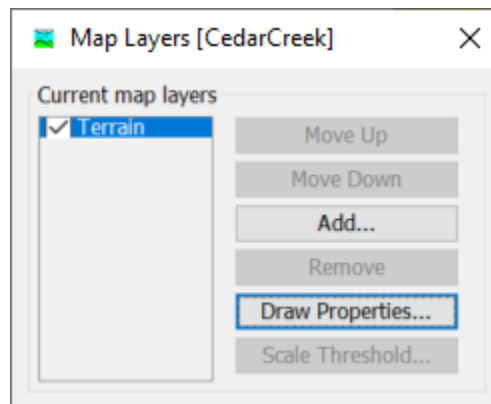
What we have right now is an empty basin model, which we will populate by processing the cedar terrain. To do that, we need to geo-reference the basin model based on our terrain. Go to GIS → Coordinate System. There are two options: Predefined and Browse. If you have a projection file (.prj) for the terrain or any other GIS layer, you can use that through the Browse option. Cedar Creek is in UTM zone 16N so we will just use the Predefined option. Click the predefined button, and select UTM Zone 16 with Datum 1983 (you should use the appropriate datum and UTM zone for other areas). Press Select and then Set as shown below.



Close the Coordinate system window. The terrain data then should show up in the Basin Model window. If not, assign the Cedar terrain to the Basin Model using the Component Editor (Make sure CedarCreek basin model is selected in the Components window).



You can right click on the Basin Model window, and select Map Layers to change the draw properties (symbology) of any layer that is in the basin model.



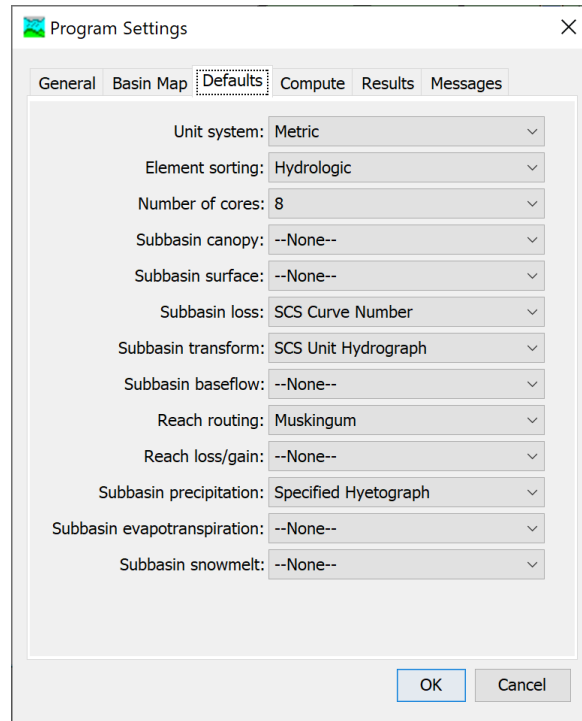
We will not do any changes in this tutorial. You can play with Draw Properties later. The Basin Model is now ready for GIS pre-processing of the DEM.

Terrain or GIS Pre-Processing

Note: Some steps may take longer time than others so be patient!

Select Methods for HEC-HMS simulation: Go to Tools→Program Settings and in the Default tab, pick the methods we are going to use for Subbasin Loss (SCS CN), Subbasin

Transform (SCS Unit Hydrograph), Reach Routing (Muskingum), Subbasin precipitation as Specified Hyetograph, and leave others as none as shown below:

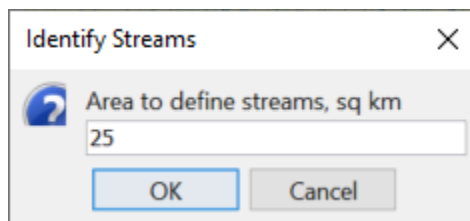



Press OK.

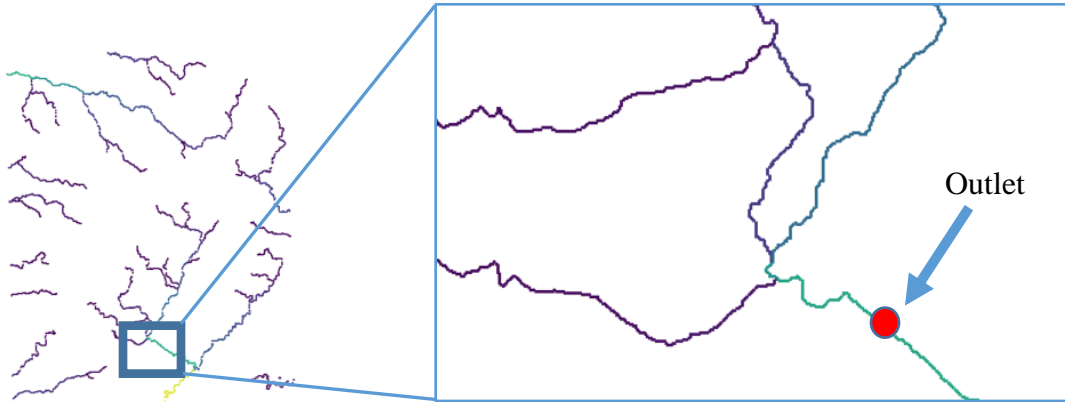
Fill Sinks: Go to GIS→Preprocess Sinks. This will create two layers: a filled DEM and a layer showing sink locations. The resulting layers will be added to the basin model, but these can be turned off by opening the map layers interface (right click on basin model window). For example, the sink locations are not needed so it can be turned off. Right click on Desktop→Map Layers and turn off layers that you do not want as shown.

Flow Direction and Flow Accumulation: Go to GIS→Preprocess Drainage. This will create flow direction and flow accumulation grids, which will be added to the basin model. Again, these layers can be turned off if needed using the map layers interface.

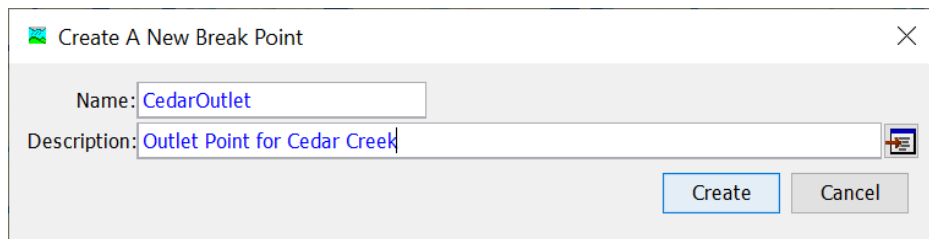
Stream Network Delineation: Go to GIS→Identify streams. Specify the stream area threshold (25 km² in this case) to delineate the streams.



Specify Outlet: To specify the outlet, zoom to the Cedar Creek outlet (shown below), and use the Break Point Creation Tool () to create the outlet (break) point at the location shown below.

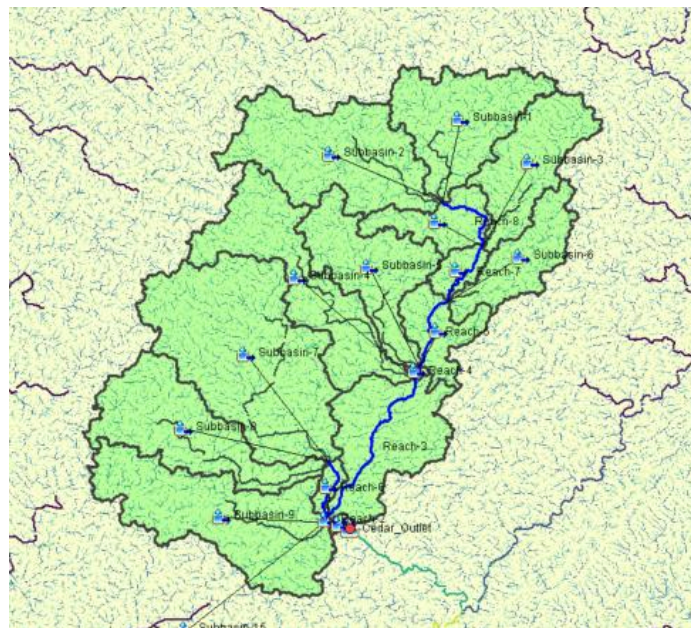
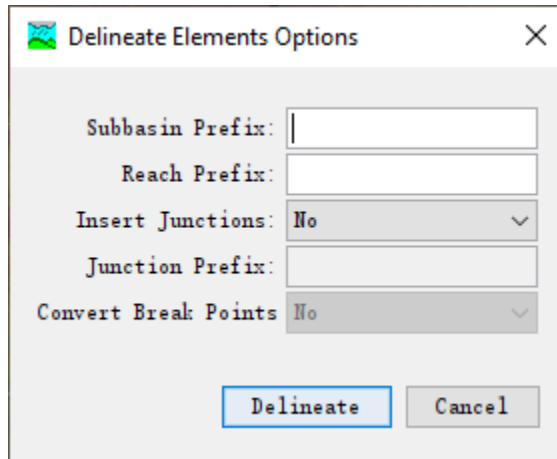


Name the outlet as CedarOutlet (do not include space between words), provide some description or leave it blank, and push Create.



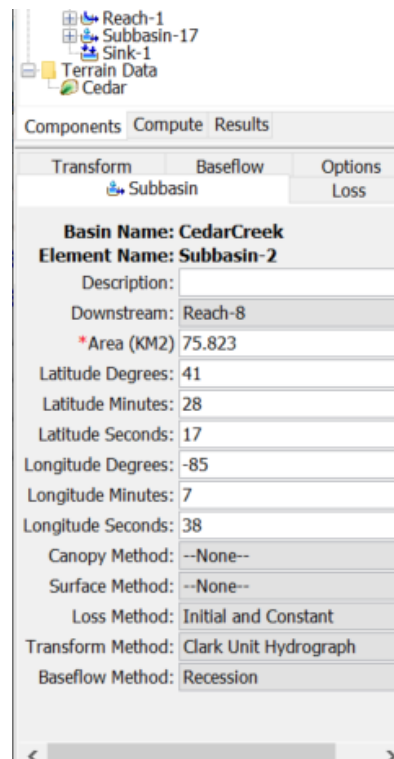
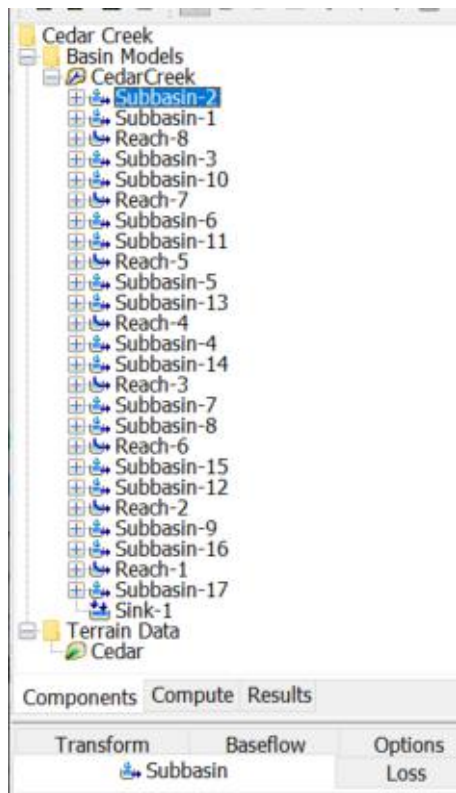
A break point named CedarOutlet will be added to the basin model.

Delineate Watershed Boundary and Sub-basins: Go to GIS→Delineate Elements. A prompt that allows you to set some delineation options will appear. These include options for how HMS will automatically name elements, whether or not to create junctions automatically, or whether to convert break points to elements. Leave all options as default in the popped-out window of Delineate Elements Options and click on Delineate. This will generate Sub-basins and Reaches as shown below.



Merging Sub-basins

You can see the details of the Cedar Creek Basin model in the Watershed Explorer. The basin model primarily has two types of elements: sub-basin and reach. A sub-basin represents an area or spatial computational unit to convert rainfall to runoff. A reach represents a linear (river) unit to transport the water downstream towards the outlet. If you expand any sub-basin or reach, you will see the methods and parameters associated with it in the Component editor window. Note: Your numbers for sub-basins and other parameters may be different, but that is OK.



Although we are using only the sub-basin and reach element in this model, other elements are also available in HEC-HMS. These are briefly described below



Subbasin – Used for rainfall-runoff computation on a watershed.



Reach – Used to convey (route) streamflow downstream in the basin model.



Reservoir – Used to model the detention and attenuation of a hydrograph caused by a reservoir or detention pond.



Junction – Used to combine flows from upstream reaches and sub-basins.



Diversion – Used to model abstraction of flow from the main channel.

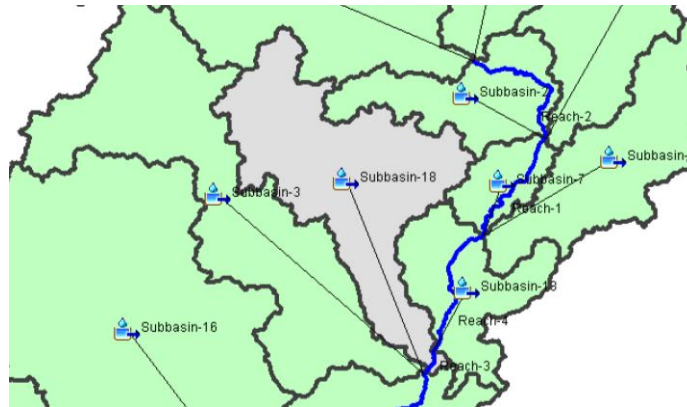


Source – Used to introduce flow into the basin model (from a stream crossing the boundary of the modeled region). Source has no inflow.



Sink – Used to represent the outlet of the physical watershed. Sink has no outflow.

You will notice that some sub-basins are very small (less than 5 km² area). If you want, these can be merged using the GIS functions in HEC-HMS. To merge two adjacent sub-basins, select these sub-basins (using the select arrow button). Select one sub-basin first and then using the **shift button**, select the other sub-basin that you want to merge with. After selections, go to GIS→Merge Elements. The Merge Elements tool in GIS is only enabled if **the two selected sub-basins are adjacent to each other and share a common junction or meet at a common point**. If the Merge Elements tool is not enabled, then the selected sub-basins cannot be merged. If more than two sub-basins need to be merged into a single element, first merge two elements, and repeat the process. The figure below shows two adjacent subbasins that are selected (in gray) and can be merged.



Extracting and Assigning CN values for sub-basins

For each **sub-basin**, you will see the Description (blank in this case), the name of the immediate downstream element, area, centroidal location (lat/long), and five different methods: Canopy, Surface, Loss, Transform and Baseflow.

Remember the sub-basin element is used to convert rainfall to runoff. So, the information on methods used to compute loss rates, hydrograph transformation and baseflow is required for each sub-basin element.

1. The canopy method represents the presence of plants in the sub-basin. This information is used to compute the interception of rainfall and evapotranspiration by the plants. Selecting a canopy method is necessary for continuous simulation, but is optional for a single event. This is set as “None” so we will not use canopy method in this exercise.
2. The surface method represents the surface depressions where water may accumulate after rainfall. After rainfall, some water may get captured in these surface depressions and will slowly infiltrate into the ground without contributing to direct runoff. Similar to canopy method, selecting a surface method is important for continuous simulation, but is optional for single events. This is also set as “None” so we will not use a surface method in the exercise.

3. The loss method represents the amount of water lost to the ground due to infiltration. HEC-HMS has many methods to compute infiltration losses. Some of these are specifically meant for continuous simulation, while some for event simulation. In this exercise, we will use the most commonly used SCS Curve number method to compute losses and get excess rainfall from the total rainfall. Click on the drop-down menu to see other choices. You will need some hydrology background or training to recognize all the names/methods.
4. The *Transform method* represents the transformation of excess rainfall (total rainfall minus the losses) to direct runoff. Again, click on the drop-down menu to view your options. In this exercise, we will use the *SCS* technique (dimensionless unit hydrograph in Chapter 7 of Chow Maidment Mays Hydrology book).
5. The baseflow method represents the sub-surface processes and computes the contribution of water flowing within the sub-surface into the stream. HEC-HMS adds the direct runoff and baseflow to compute the total streamflow. In this exercise, we will not include baseflow in the simulation.

A **reach** element represents a river or stream and has two methods: routing and loss/gain. A routing method accounts for the storage effects as the water is traveling downstream through the reach; whereas the loss/gain method accounts for water exchange/interaction between the stream and the sub-surface. In this exercise, we will use the Muskingum routing method for all reaches and no loss/gain method.

For all sub-basins make sure the following is selected: Canopy: None, Surface: None, Loss: SCS Curve Number, Transform: SCS Unit Hydrograph and Baseflow: None.

Longitude Degrees: -65
Longitude Minutes: 7
Longitude Seconds: 38
Canopy Method: --None--
Surface Method: --None--
Loss Method: SCS Curve Number
Transform Method: SCS Unit Hydrograph
Baseflow Method: --None--

Similarly, for all reaches, the routing is already set to Muskingum and Loss/Gain to None.

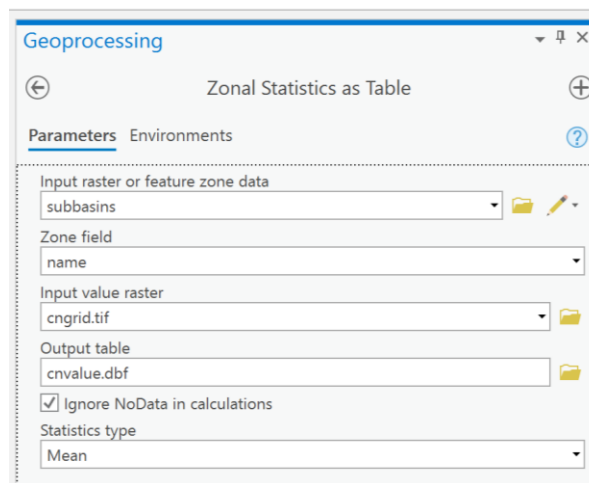
Basin Name: CedarCreek
Element Name: Reach-2
Description: [empty]
Downstream: Reach-1
Routing Method: Muskingum
Loss/Gain Method: --None--

Parameters

Once the methods are specified, the next step is to assign parameters to the Loss, Transform and Routing methods. Select any basin element in the Watershed Explorer and then you will see the methods in the Component Editor. You will also see three Tabs for Loss, Transform and Options. If you select any other method for Canopy, Surface or Baseflow, a new tab will be added to this list. Each tab lets us specify the parameter associated with this method. Select the Loss Tab and you will see empty boxes for Initial Abstraction, CN and Impervious (%). For all sub-basins, we will use an initial abstraction of zero and Impervious (%) as zero.

Steps for Assigning CN Values for Sub-Basins

- 1) Export the sub-basin elements from HEC-HMS to a shape file by using GIS→Export Layers. Use Sub-basins to export in the next step and save it as *subbasins.shp*
- 2) Open a new ArcGIS project and save it as *hms_cn* in your working folder
- 3) Add *subbasins.shp* and *cngrid.tif* layers to the ArcGIS project/map
- 4) Use the “Zonal Statistics as Table” tool from ArcGIS geoprocessing tools to assign mean CN value to each sub-basins. Store the output from this tool as a standalone table named *cnvalue.dbf* . Use the Name of each sub-basin to store the mean CN value in the output table as shown below.



- 5) Save your ArcGIS project. Open the *cnvalue.dbf* table in excel. Copy and paste the mean value of CN for each sub-basin into HEC-HMS parameters table for sub-basins loss method as shown below. Make sure values get copied for the right sub-basins! The easiest way is to sort the sub-basins by name in both Excel and in HMS and copy/paste CN values as shown below.

| | A | B | C | D | E |
|----|-------------|-----------|--------|-----------|-------|
| 1 | name | ZONE_CODE | COUNT | AREA | MEAN |
| 2 | Subbasin-1 | 1 | 45114 | 40602600 | 82.09 |
| 3 | Subbasin-11 | 8 | 45957 | 41361300 | 82.68 |
| 4 | Subbasin-12 | 9 | 17251 | 15525900 | 81.36 |
| 5 | Subbasin-13 | 10 | 22244 | 20019600 | 80.26 |
| 6 | Subbasin-14 | 11 | 56790 | 51111000 | 81.79 |
| 7 | Subbasin-16 | 12 | 131940 | 118746000 | 79.79 |
| 8 | Subbasin-18 | 13 | 55053 | 49547700 | 81.01 |
| 9 | Subbasin-2 | 2 | 24149 | 21734100 | 81.91 |
| 10 | Subbasin-3 | 3 | 71799 | 64619100 | 79.68 |
| 11 | Subbasin-4 | 4 | 67838 | 61054200 | 80.19 |
| 12 | Subbasin-5 | 5 | 80998 | 72898200 | 79.38 |
| 13 | Subbasin-6 | 6 | 80148 | 72133200 | 80.91 |
| 14 | Subbasin-7 | 7 | 9845 | 8860500 | 79.49 |
| 15 | Subbasin-9 | 14 | 7280 | 6552000 | 75.86 |

| Subbasin | Initial Abstraction (MM) | Curve Number | Impervious (%) |
|-------------|--------------------------|--------------|----------------|
| Subbasin-1 | 0 | 82.091 | 0.0 |
| Subbasin-11 | 0 | 82.678 | 0.0 |
| Subbasin-12 | 0 | 81.361 | 0.0 |
| Subbasin-13 | 0 | 80.257 | 0.0 |
| Subbasin-14 | 0 | 81.787 | 0.0 |
| Subbasin-16 | 0 | 79.792 | 0.0 |
| Subbasin-18 | 0 | 81.011 | 0.0 |
| Subbasin-2 | 0 | 81.915 | 0.0 |
| Subbasin-3 | 0 | 79.681 | 0.0 |
| Subbasin-4 | 0 | 80.185 | 0.0 |
| Subbasin-5 | 0 | 79.379 | 0.0 |
| Subbasin-6 | 0 | 80.912 | 0.0 |
| Subbasin-7 | 0 | 79.487 | 0.0 |
| Subbasin-9 | 0 | 75.856 | 0.0 |

Assigning Lag times for sub-basins

Lag Time (L) can be computed by multiplying time of concentration (T_c) by 0.6. T_c can be computed by using the following expression:

$$T_c = \frac{l^{0.8}(S + 1)^{0.7}}{1140Y^{0.5}}$$

Where:

T_c = time of concentration in hours

l = flow length of the longest flowpath in ft

Y = average watershed land slope, %

S = maximum potential retention in inches = (1000/CN) – 10

CN = SCS Curve Number (0 < CN < 99)

CN value was computed in the previous unit for each sub-basin, which can be used to get S in the above expression. The flow length (l) and average slope (Y) can be obtained from the sub-basins characteristics table in HEC-HMS. Go to Parameters → Sub-basin Characteristics to see the characteristic table.

| Subbasin | Longest Flowpath Length (KM) | Longest Flowpath Slope | Centroidal Flowpath Length (KM) | Centroidal Flowpath Slope | 10-85 Flowpath Length (KM) | 10-85 Flowpath Slope | Basin Slope |
|-------------|------------------------------|------------------------|---------------------------------|---------------------------|----------------------------|----------------------|-------------|
| Subbasin-1 | 21.18836 | 0.00113 | 10.24256 | 0.00129 | 15.89127 | 0.00084 | 0.02664 |
| Subbasin-11 | 16.30473 | 0.00210 | 7.48841 | 0.00078 | 12.22855 | 0.00077 | 0.02161 |
| Subbasin-12 | 15.26271 | 0.00099 | 6.90388 | 0.00050 | 11.44703 | 0.00062 | 0.01560 |
| Subbasin-13 | 8.77220 | 0.00141 | 3.11478 | 0.00187 | 6.57915 | 0.00100 | 0.01482 |
| Subbasin-14 | 15.27708 | 0.00170 | 8.35628 | 0.00077 | 11.45781 | 0.00128 | 0.02243 |
| Subbasin-16 | 33.87255 | 0.00196 | 20.97035 | 0.00124 | 25.40441 | 0.00171 | 0.02540 |
| Subbasin-18 | 21.53326 | 0.00201 | 10.69238 | 0.00138 | 16.14994 | 0.00146 | 0.02487 |
| Subbasin-2 | 13.71175 | 0.00169 | 4.70301 | 0.00180 | 10.28381 | 0.00167 | 0.02384 |
| Subbasin-3 | 29.49571 | 0.00200 | 15.46205 | 0.00125 | 22.12179 | 0.00163 | 0.03299 |
| Subbasin-4 | 25.67984 | 0.00207 | 15.25808 | 0.00110 | 19.25988 | 0.00101 | 0.02952 |
| Subbasin-5 | 24.90711 | 0.00150 | 8.21463 | 0.00090 | 18.68034 | 0.00113 | 0.02370 |
| Subbasin-6 | 23.04447 | 0.00195 | 11.96447 | 0.00115 | 17.28335 | 0.00159 | 0.03717 |
| Subbasin-7 | 6.93882 | 0.00209 | 3.10963 | 0.00080 | 5.20411 | 0.00161 | 0.01966 |
| Subbasin-9 | 8.41220 | 0.00210 | 4.74331 | 0.00065 | 6.30915 | 0.00071 | 0.04002 |

All this information can be used to get the lag time in minutes by setting up a table in MS Excel. Open an empty Excel file and save it by giving an appropriate name.

- 1) Copy the sub-basins name column from HEC-HMS and paste it in the Excel file.
- 2) Copy the CN values from the dbf file and paste next to the sub-basins name column (make sure the names correspond correctly so each sub-basin gets the correct value).
- 3) Copy the Longest Flowpath Length (KM) column from HEC-HMS characteristics table and paste it in the Excel file next to the CN column (again make sure the names and values match).
- 4) Copy the Basin Slope column from HEC-HMS characteristics table and paste it in Excel next to the longest flowpath column.
- 5) Create columns to compute S from CN values, length in (ft), and slope as % (Y).
- 6) Create a column to compute and store Tc values in hour by using the above expression.
- 7) Create a column to compute Lag or lag time in minutes by using Tc.

Save your Excel file. Copy and paste the lag time values in HEC-HMS by going to Parameters→Transform→SCS Unit Hydrograph. Make sure the names and values correspond correctly between Excel and HEC-HMS. The figures below show the Excel columns and the HMS parameter table for SCS Unit Hydrograph method.

| name | CN | L (km) | Slope | L (ft) | Y (%) | S | Tc | Lag (hr) | Lag(min) |
|-------------|-------|--------|---------|----------|-------|------|-------|----------|----------|
| Subbasin-1 | 82.09 | 21.19 | 0.02664 | 69515.62 | 2.66 | 2.18 | 9.03 | 5.42 | 325.20 |
| Subbasin-11 | 82.68 | 16.30 | 0.02161 | 53493.21 | 2.16 | 2.10 | 7.98 | 4.79 | 287.20 |
| Subbasin-12 | 81.36 | 15.26 | 0.0156 | 50074.51 | 1.56 | 2.29 | 9.30 | 5.58 | 334.69 |
| Subbasin-13 | 80.26 | 8.77 | 0.01482 | 28780.18 | 1.48 | 2.46 | 6.34 | 3.81 | 228.35 |
| Subbasin-14 | 81.79 | 15.28 | 0.02243 | 50121.66 | 2.24 | 2.23 | 7.65 | 4.59 | 275.52 |
| Subbasin-16 | 79.79 | 33.87 | 0.0254 | 111130.4 | 2.54 | 2.53 | 14.49 | 8.69 | 521.57 |
| Subbasin-18 | 81.01 | 21.53 | 0.02487 | 70647.18 | 2.49 | 2.34 | 9.81 | 5.88 | 353.04 |
| Subbasin-2 | 81.91 | 13.71 | 0.02384 | 44986.06 | 2.38 | 2.21 | 6.78 | 4.07 | 244.09 |
| Subbasin-3 | 79.68 | 29.50 | 0.03299 | 96770.71 | 3.30 | 2.55 | 11.42 | 6.85 | 411.12 |
| Subbasin-4 | 80.19 | 25.68 | 0.02952 | 84251.45 | 2.95 | 2.47 | 10.64 | 6.38 | 382.94 |
| Subbasin-5 | 79.38 | 24.91 | 0.0237 | 81716.24 | 2.37 | 2.60 | 11.88 | 7.13 | 427.66 |
| Subbasin-6 | 80.91 | 23.04 | 0.03717 | 75605.22 | 3.72 | 2.36 | 8.50 | 5.10 | 305.84 |
| Subbasin-7 | 79.49 | 6.94 | 0.01966 | 22765.16 | 1.97 | 2.58 | 4.68 | 2.81 | 168.34 |
| Subbasin-9 | 75.86 | 8.41 | 0.04002 | 27599.08 | 4.00 | 3.18 | 4.26 | 2.56 | 153.47 |

SCS Transform(CedarCreek)

Show Elements: All Elements Sorting: Hydrologic

| Subbasin | Graph Type | Lag Time (MIN) |
|-------------|------------|----------------|
| Subbasin-6 | Standard | 325.1984612 |
| Subbasin-1 | Standard | 287.1990496 |
| Subbasin-11 | Standard | 334.6934068 |
| Subbasin-2 | Standard | 228.3460739 |
| Subbasin-12 | Standard | 275.5208098 |
| Subbasin-7 | Standard | 521.5687899 |
| Subbasin-13 | Standard | 353.0422481 |
| Subbasin-3 | Standard | 244.0922671 |
| Subbasin-18 | Standard | 411.1169488 |
| Subbasin-16 | Standard | 382.9408035 |
| Subbasin-4 | Standard | 427.6591895 |
| Subbasin-14 | Standard | 305.8416575 |
| Subbasin-5 | Standard | 168.3443113 |
| Subbasin-9 | Standard | 153.4652305 |

Compute: All Elements Apply Close

Assigning Muskingum Parameters

Click on any reach (e.g., R8 in this case), and you will see that the Muskingum Routing method needs two key parameters: K and X. Routing is described in chapters 8-10 in the Chow Maidment and Mays Hydrology book. The Muskingum parameter K is the travel time of a flood wave passing through a reach, X is a measure of the degree of storage (X = 0 means a level-pool reservoir or maximum storage, X = 0.5 means a pure transmission reach in which there are no storage effects, and X ranges between 0 and 0.5). A reach can be divided into a number of sub-reaches if necessary to keep the computations numerically stable. Click on the Routing tab to see the Muskingum parameters for this reach. You will notice that both Muskingum K and X are blank. We can either specify these parameters for individual reach like we did for all sub-basins, or we can specify these parameters for all reaches by using another interface. Because we will use same Muskingum K and X for all reaches, it is better to use a simpler method than specifying these values for each reach.

In the main menu, Select *Parameters* → *Routing* → *Muskingum*. Click on the Show Elements menu to see All Elements, and then manually enter 0.5 for Muskingum K and 0.25 for Muskingum X, and click *Apply*.

Muskingum Routing (CedarCreek)

Show Elements: All Elements Sorting: Hydrologic

| Reach | Initial Type | Initial Discharge (M3/S) | Muskingum K (HR) | Muskingum X | Number of Subreaches |
|---------|--------------------|--------------------------|------------------|-------------|----------------------|
| Reach-8 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-7 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-1 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-5 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-4 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-3 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-6 | Discharge = Inflow | | 0.5 | 0.25 | 1 |
| Reach-2 | Discharge = Inflow | | 0.5 | 0.25 | 1 |

Compute: All Elements Apply Close

Similar to editing or entering parameters for reaches, you can look at the parameters for all sub-basin elements by first selecting a sub-basin element, and then going to Parameters in the menu bar and selecting a method.

Save your project. You are doing great!

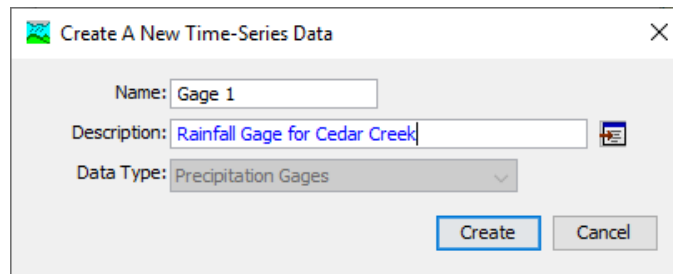
Creating a Meteorologic Model

A basin model provides the physical skeleton on a watershed including its properties such as areas of sub-basins, the methods used to transform rainfall to runoff, and the overall connectivity for water movement to reach the outlet. The main driver for this hydrologic system is the water which is provided in the form of rainfall input. All types of rainfall inputs in HEC-HMS are provided using a meteorologic model.

Using Gauged Rainfall (Time Series Component)

This is done by specifying a time series of rainfall at a Rainfall gauge, and associating this gauge with each individual sub-basin or all sub-basins. We will use only one rainfall gauge for the Cedar Creek Watershed.

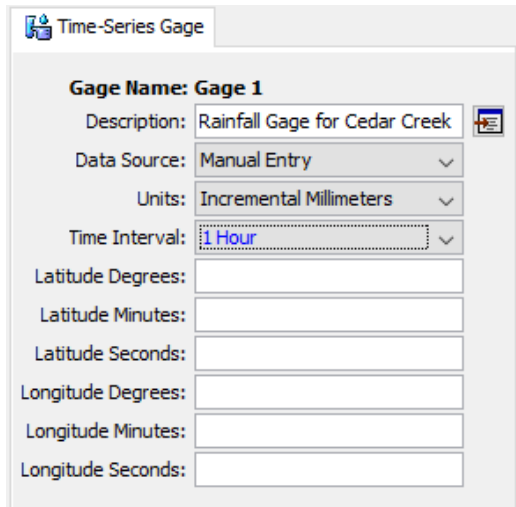
Click on Components→Time Series Data Manager, and create a new Precipitation Gauge called Gage 1.



Close the Time-Series Data Manager.

Next, in the Watershed Explorer, expand the Time Series folder to provide data for the newly created (Gage 1) rain gauge. We will use an observed event in Cedar Creek to populate the information for the rain gauge. The details (rainfall and runoff) for this event are available in the *cedar_observed.xlsx* Excel file provided to you with the input data on Brightspace.

Based on the information in the excel file, populate the information for the precipitation gauge. Click on Gage in watershed explorer to see the information in the component editor. Check the time interval of each rainfall observation and the depth of rainfall observed during this time interval. Make sure you use the correct units. As we are using only one gage, its specific location information (lat/long) does not matter so that information is left blank.



Time-Series Gage

Gage Name: Gage 1

Description: Rainfall Gage for Cedar Creek

Data Source: Manual Entry

Units: Incremental Millimeters

Time Interval: 1 Hour

Latitude Degrees:

Latitude Minutes:

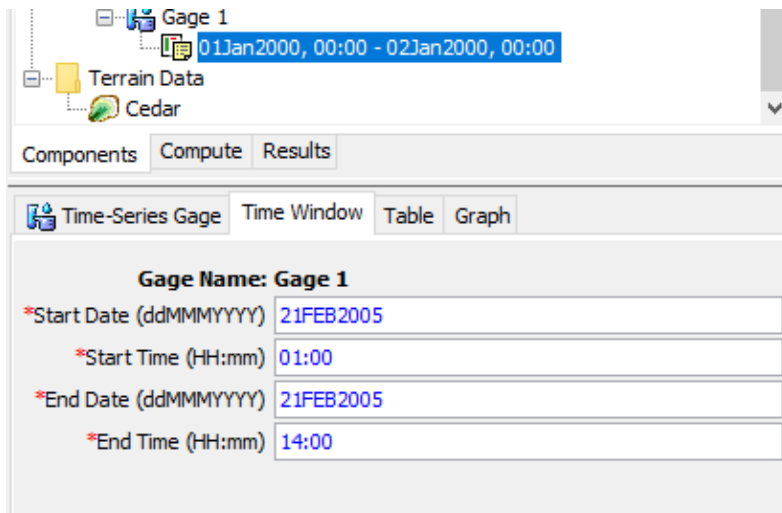
Latitude Seconds:

Longitude Degrees:

Longitude Minutes:

Longitude Seconds:

Next, click on the time information below Gage 1 and enter the start and end date/time of the rainfall event based on the Excel file. **The format of how you enter the data and time is critical.**



Gage 1
01Jan2000, 00:00 - 02Jan2000, 00:00

Terrain Data
Cedar

Components Compute Results

Time-Series Gage Time Window Table Graph

Gage Name: Gage 1

*Start Date (ddMMMYYYY) 21FEB2005

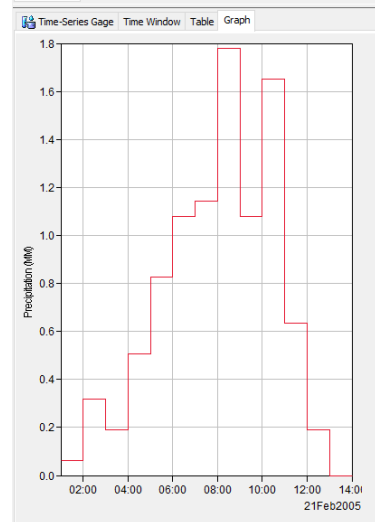
*Start Time (HH:mm) 01:00

*End Date (ddMMMYYYY) 21FEB2005

*End Time (HH:mm) 14:00

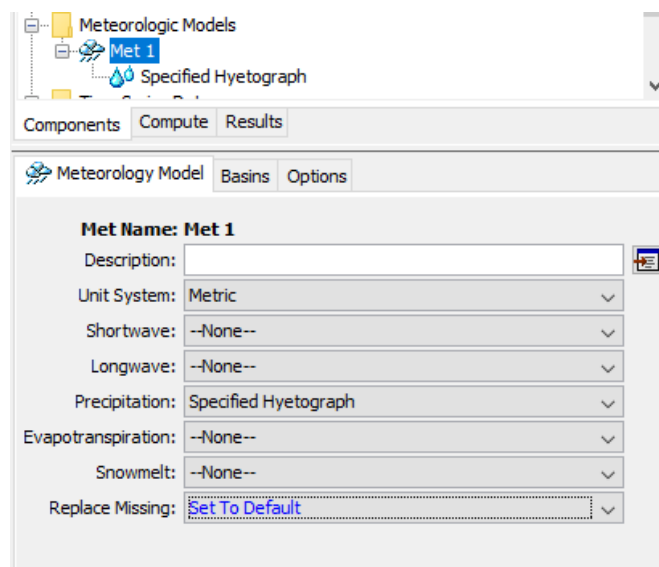
Once you enter the data/time information in the Time Window tab, exact number of rows to enter the precipitation depth will be created in the Table tab. Populate the Table (copy/paste from Excel as shown below. First row is disabled so start with second row).

| Time (ddMMYYYY, HH:mm) | Precipitation (MM) |
|------------------------|--------------------|
| 21Feb2005, 01:00 | |
| 21Feb2005, 02:00 | 0.0635 |
| 21Feb2005, 03:00 | 0.3175 |
| 21Feb2005, 04:00 | 0.1905 |
| 21Feb2005, 05:00 | 0.508 |
| 21Feb2005, 06:00 | 0.8255 |
| 21Feb2005, 07:00 | 1.0795 |
| 21Feb2005, 08:00 | 1.143 |
| 21Feb2005, 09:00 | 1.778 |
| 21Feb2005, 10:00 | 1.0795 |
| 21Feb2005, 11:00 | 1.651 |
| 21Feb2005, 12:00 | 0.635 |
| 21Feb2005, 13:00 | 0.1905 |
| 21Feb2005, 14:00 | 0 |

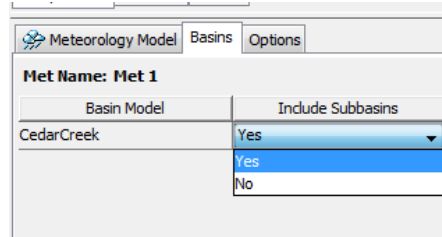


Once you have defined a rainfall gage, this gage can be associated with one or all sub-basins by using the Meteorologic Model.

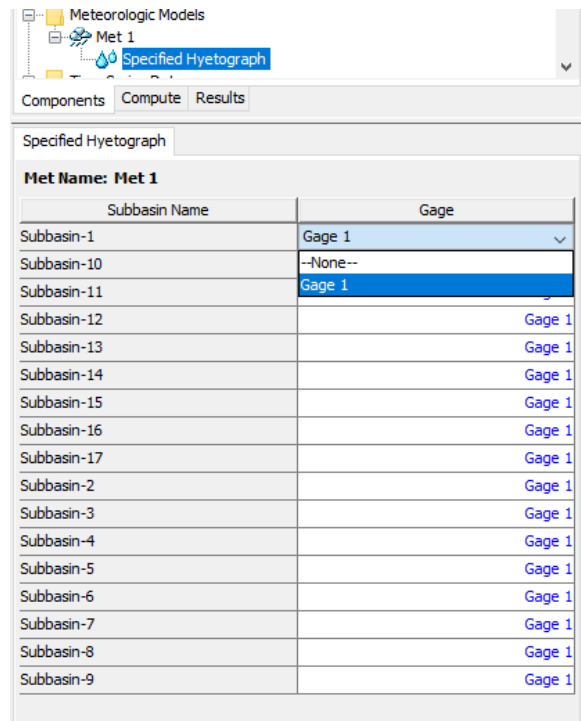
On the main menu, click on Components → Meteorologic Model Manager and create a new Meteorologic model called Met 1. You will see that a Meteorologic Model will be added to the components window. Expand the Meteorologic Model folder, and expand Met 1. In its properties window, select precipitation as Specified Hyetograph and then the “Abort Compute” to “Set To Default” for replace missing as shown below. What this will do is run the model even if some rainfall values are missing instead of aborting the program.



Next for the Basins option, select Yes to Include Sub basins as shown below.



Then in the Watershed Explorer, select Specified Hyetograph under Met 1 and associate the rainfall gage with all sub-basins as shown below.



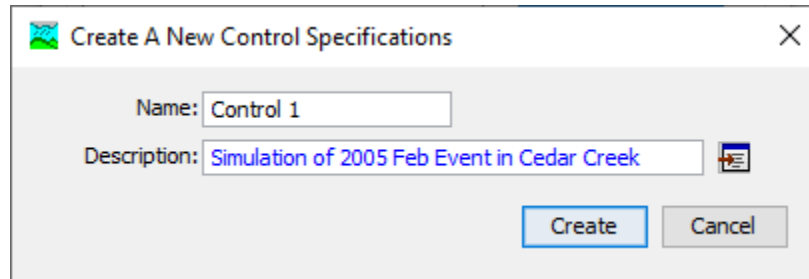
After the meteorologic data are provided, the model is ready for simulation. One final step before executing the model is to specify the time step information and the duration of the simulation. This is done by using the Control Specifications Manager.

Save your project. You are doing extremely well!!

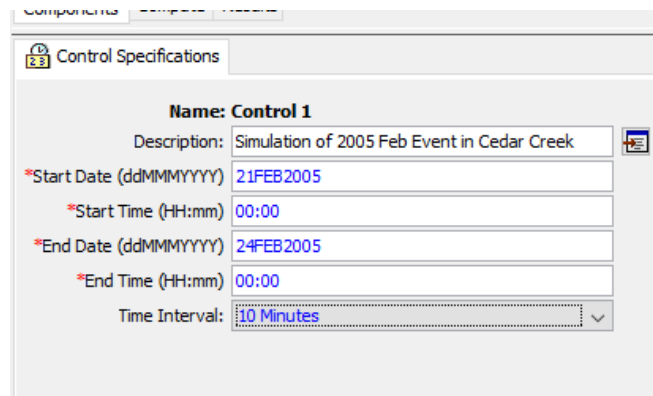
Creating a Control Specification File and Simulation Run

Defining the Control Specifications (*this is specific to gaged rainfall information. Control Specification file must be changed appropriately for other inputs including Frequency Storm*)

The final task in the model setup involves establishing the model's time limits. **Select Components**→*Control Specifications Manager*. **Select New** in the control specifications manager and **type** the following information:



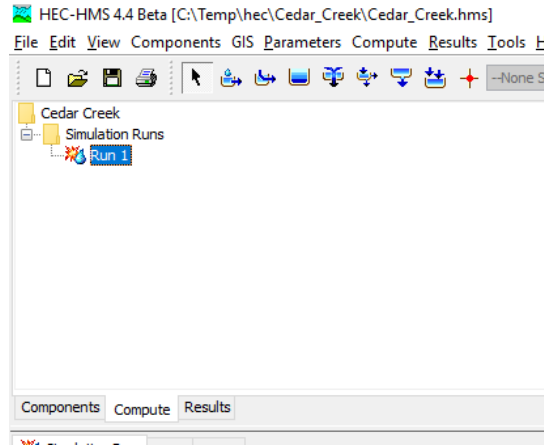
Click Create and **close** the control specifications manager. This will add a Control Specifications folder in the Watershed Explorer. To see the control specifications file, **expand** the folder, and select Control 1. This will prompt the control specifications tab in the component editor. **Specify** the duration of the simulation in date and time, and also the time interval of the calculations as shown below. Again, this information is based on the excel file.




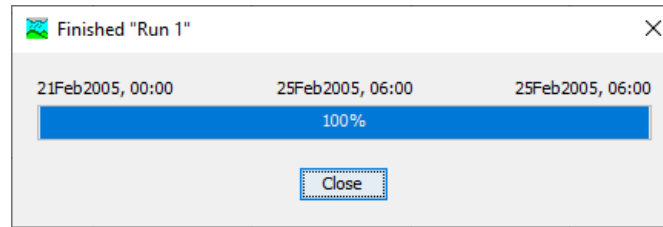
In this case, the duration (start/end date) is based on the Excel file for the streamflow. The rainfall is for a time step of one hour, and we are picking 10 minutes to **keep it shorter than 1 hour**.

Executing the HMS Model

Finally, you have finished providing all the data involved in creating the Cedar Creek HEC-HMS model. The last step is to run the model. Select *Compute*→*Create Simulation Run*. Accept the default name for the run (Run 1), click *Next* to complete all the steps and finally Click *Finish* to complete the run. Now to run the model, select the Compute tab in the Watershed Explorer and select Run 1 as shown below.



Next, in the top menu, select *Compute* → *Select Run* → *Run 1*, and then go to *Compute* → *Compute Run [Run 1]* to see the following window (alternatively you can click the compute run tool  in the tool bar):




Click *Close*. You will see a log in the message log as program executes the model. If there are errors in the model, you will see them in red color. For this model, there are no errors.

If you reached this stage and did not get any errors, pat yourself in the back! You are a rock star!! If you got errors, there is still hope. Please go back and fix the errors and become a rock star!

If you want to make runs with alternative model files, you can do so by first creating/importing new model files (basin, Meteorologic and control specifications), creating a new run (say Run 2) by going to *Compute* → *Create simulation run* and selecting the new files while creating Run 2. Although the model used in this exercise has one dataset each for basin, meteorology and control specifications, HMS is slick in that it allows the user to have multiple data sets available to include conveniently in different runs.

Viewing HEC-HMS Results

HEC-HMS allows you to view results in tabular or graphical form. To view a global results table, **select** *Results* → *Global Summary Table* (alternatively you can click the Global Summary tool  in the tool bar). You will get a window like the one shown below which summarizes the peak discharge and time, the total volume of storm runoff and the drainage area from which it came.

Global Summary Results for Run "Run 1"

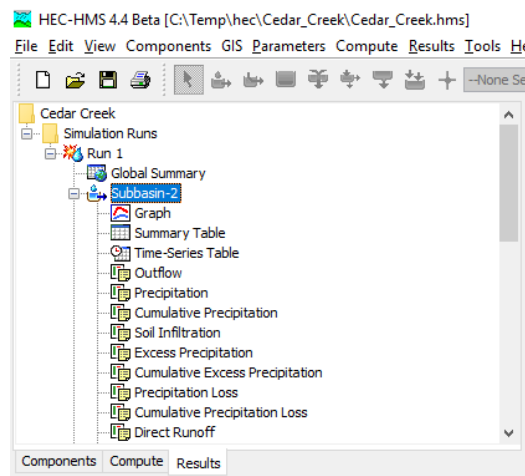
Project: Cedar Creek Simulation Run: Run 1

Start of Run: 21Feb2005, 00:00 Basin Model: CedarCreek
 End of Run: 25Feb2005, 06:00 Meteorologic Model: Met 1
 Compute Time: 15Oct2019, 14:27:07 Control Specifications: Control 1

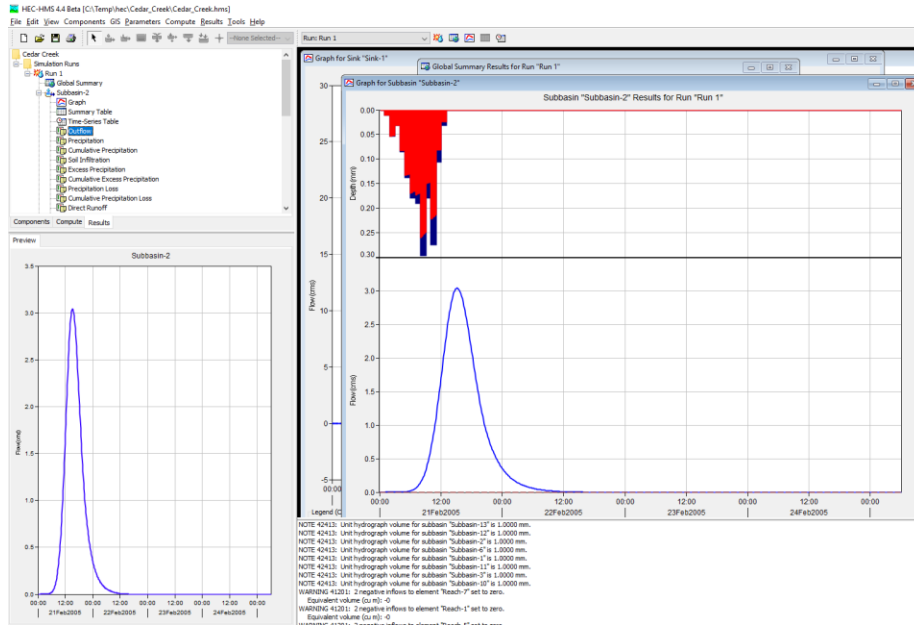
Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Hydrologic

| Hydrologic Element | Drainage Area (KM2) | Peak Discharge (M3/S) | Time of Peak | Volume (MM) |
|--------------------|---------------------|-----------------------|------------------|-------------|
| Subbasin-2 | 75.823 | 3.0 | 21Feb2005, 15:10 | 1.23 |
| Subbasin-1 | 54.741 | 2.8 | 21Feb2005, 14:40 | 1.48 |
| Reach-8 | 130.564 | 5.8 | 21Feb2005, 15:20 | 1.33 |
| Subbasin-3 | 43.148 | 2.0 | 21Feb2005, 14:50 | 1.35 |
| Subbasin-10 | 21.734 | 1.2 | 21Feb2005, 14:00 | 1.40 |
| Reach-7 | 195.446 | 8.8 | 21Feb2005, 15:30 | 1.34 |
| Subbasin-6 | 31.503 | 1.6 | 21Feb2005, 14:30 | 1.38 |
| Subbasin-11 | 8.8605 | 0.7 | 21Feb2005, 12:00 | 1.38 |
| Reach-1 | 697.7632 | 26.8 | 21Feb2005, 17:20 | 1.38 |
| Reach-5 | 235.8095 | 10.3 | 21Feb2005, 15:50 | 1.35 |
| Subbasin-5 | 48.672 | 2.6 | 21Feb2005, 14:20 | 1.45 |
| Subbasin-13 | 21.442 | 1.4 | 21Feb2005, 12:40 | 1.38 |
| Reach-4 | 305.9235 | 13.2 | 21Feb2005, 15:40 | 1.37 |
| Subbasin-4 | 65.769 | 2.3 | 21Feb2005, 16:20 | 1.27 |
| Subbasin-14 | 0.8757 | 0.1 | 21Feb2005, 12:20 | 1.26 |


Additionally, you may view results for each element within the model. There are several options to do this, and each option provides output in different ways. One option is to use the watershed explorer and component editor tab. To view results, you select the Results tab in the watershed explorer, expand the Simulation Runs folder, and expand Run 1. To see results for any element, expand that element as below:

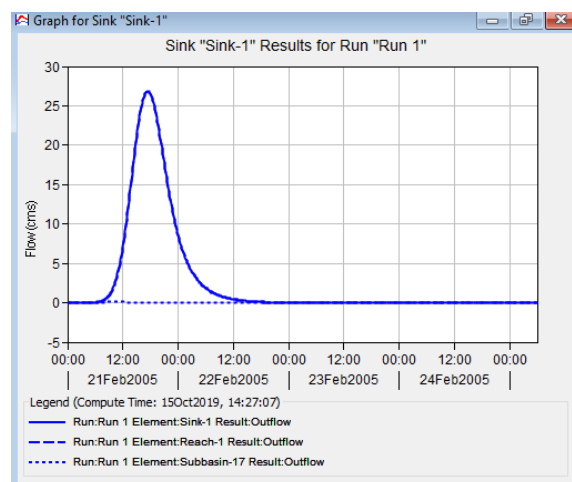


To see the outflow from any sub-basin, you can select outflow and see the outflow hydrograph in the component editor as shown below (remember the blue curve is the hydrograph and the red/blue inverted columns on top is the rainfall):



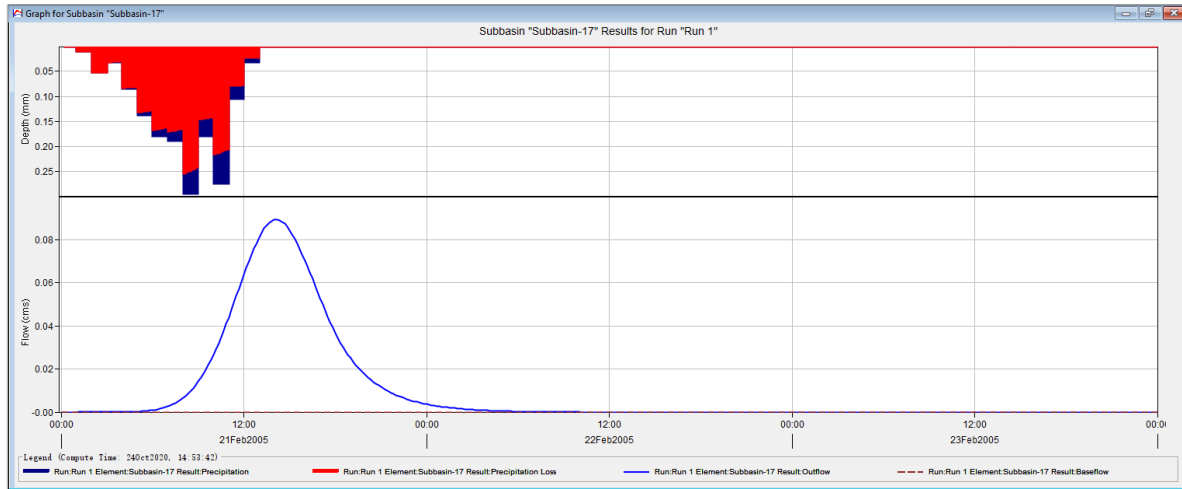
Similarly, you can look at other graphs in the component editor by selecting the variable in the watershed explorer. You can select a reach element and see the attenuation in the inflow and outflow hydrograph by selecting the combined inflow and outflow option in the watershed explorer. Each element also has a **summary** option that gives the results from the global summary table (a single row of the table) for that particular element.


Another way of looking at results is by **using the tools on the tool bar**, which basically show individual results or plots that you see in the Results tab. To use these tools, you need to select the element by using the component tab in the watershed explorer. For example, select *Outlet* in the watershed explorer, and click on the view graph tool  to get the following graph:



The dashed line hydrographs are the inflow data from the sub-basins immediately upstream of the outlet which is added to the routed flow in the channel to produce the total outflow

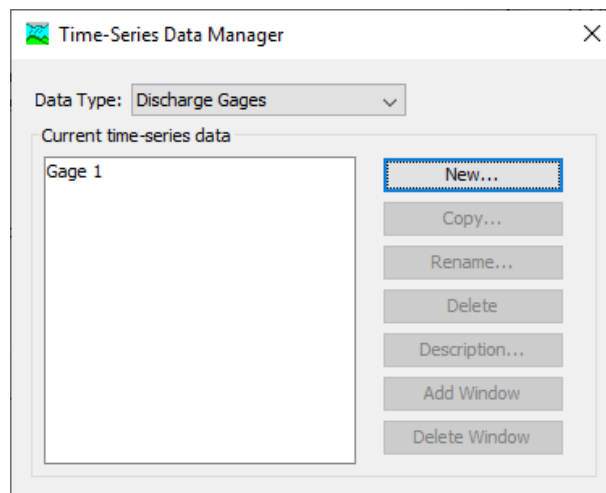
curve. If you click on a sub-basin just upstream of the outlet, you see the rainfall at the top and the runoff at the bottom as shown below:



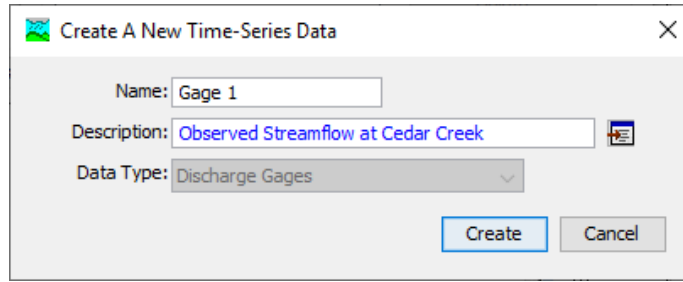
Unlike a single graph in the component editor, you get to see all graphs (input precipitation, outflow hydrograph, baseflow, precipitation losses) in a single window using this option. You can also see the results in tabular form by using the view time series table tool  in the toolbar. These functions are also accessed through the Results menu on the menu bar.

Comparison of Model Output with Observed Flow Data

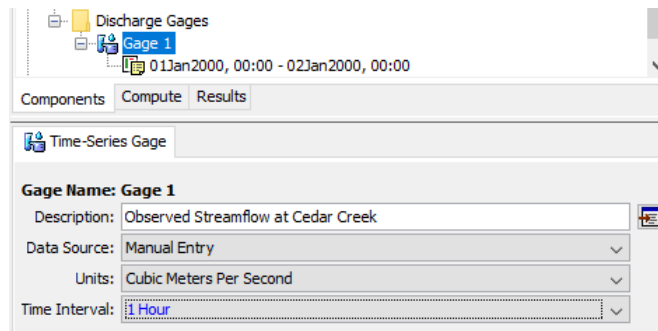
Similar to entering information for a rain gauge, information on observed streamflow can also be entered for a stream gauge, and linked to the watershed outlet. This helps in comparing the model output with observations, and can also be used for model calibration. Select Components→Time Series Data Manger, and select **Discharge Gages** as shown below, and select New..



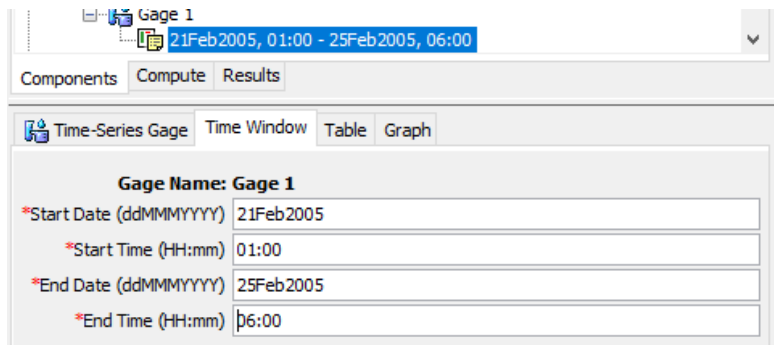
Accept the default name (Gage 1), enter some description for the gauge, and select Create.



Once the gage is created, expand the Time Series folder in Project Explorer, Select the discharge gage, and enter all the needed information for the discharge gage by using the data (runoff or outflow sheet) from the Excel file as shown below.



Next, select the time window and enter the following information.

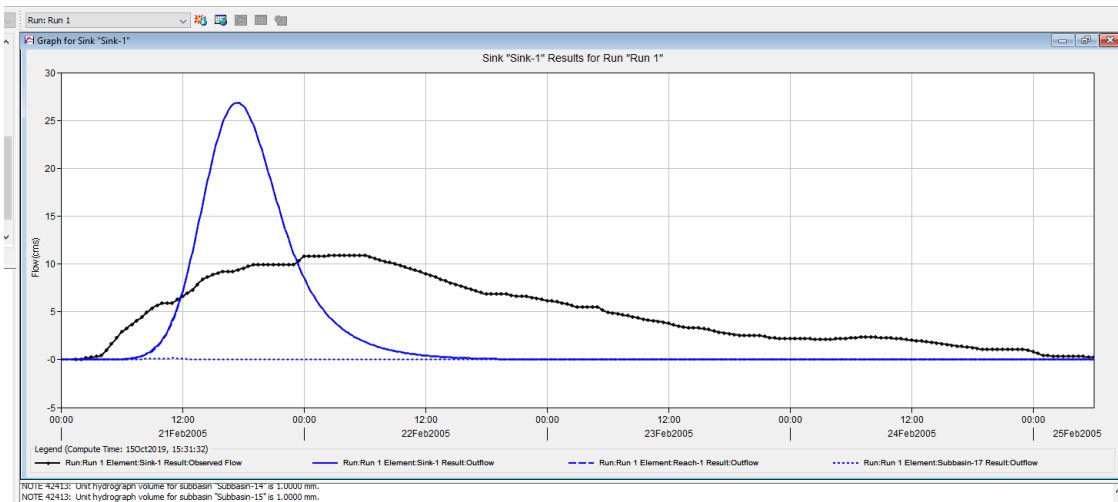


| Time (ddMMYYYY, HH:mm) | Discharge (M3/S) |
|------------------------|------------------|
| 21Feb2005, 01:00 | 0 |
| 21Feb2005, 02:00 | 0.056642 |
| 21Feb2005, 03:00 | 0.2605532 |
| 21Feb2005, 04:00 | 0.4078224 |
| 21Feb2005, 05:00 | 1.6312896 |
| 21Feb2005, 06:00 | 2.9000704 |
| 21Feb2005, 07:00 | 3.6704016 |
| 21Feb2005, 08:00 | 4.4633896 |
| 21Feb2005, 09:00 | 5.3696616 |
| 21Feb2005, 10:00 | 5.9360816 |
| 21Feb2005, 11:00 | 5.9360816 |
| 21Feb2005, 12:00 | 6.6157856 |
| 21Feb2005, 13:00 | 7.2954896 |
| 21Feb2005, 14:00 | 8.4283296 |
| 21Feb2005, 15:00 | 8.8814656 |
| 21Feb2005, 16:00 | 9.2213176 |
| 21Feb2005, 17:00 | 9.2213176 |
| 21Feb2005, 18:00 | 9.5611696 |
| 21Feb2005, 19:00 | 9.9010216 |
| 21Feb2005, 20:00 | 9.9010216 |

After entering the flow information for Gage 1, select the Sink element, and link it with Gage 1 by going to Options in the component editor as shown below.

Basin Name: CedarCreek
 Element Name: Sink-1
 Observed Flow: --None--
 Observed Stage: --None--
 Elev-Discharge: Gage 1
 Ref Flow (M3/S):
 Ref Label:

Run the simulation again, and look at the discharge at the Sink/outlet. You will notice that (shown below) the observed flow peak is much smaller and occurs little later than the simulated flow.



OK, you are done for now! Later you will learn how perform sensitivity analysis and calibrate the model!