HMS-Model Development using GeoHMS

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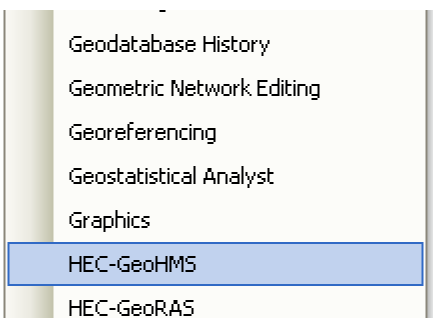
Introduction

This tutorial is designed to expose you to basic functions in HEC-GeoHMS (ArcGIS 10.x version) to create input files for hydrologic modeling with HEC-HMS. It is expected that you are familiar with HEC-HMS and ArcGIS. If you want to get into details of HEC-GeoHMS that are not covered in this tutorial please refer to the HEC-GeoHMS users manual. If you are continuing this exercise as a part of earlier terrain processing using ArcHydro or GeoHMS, you can briefly look over pages 1 and 2, and the actual work will from the bottom of Page 3 (GeoHMS project set-up)

Getting Started

Open ArcMap that you created in the previous lab using Archydro Tools. Save the map document. **Right click** on the menu bar to pop up the context menu showing available tools as shown below.



Check the HEC-GeoHMS menu.

You should now see the HEC-GeoHMS toolbar added to ArcMap as shown below. You can leave it floating or you may dock it in ArcMap.

Note: It is not necessary to load the Spatial Analyst, Utility Network Analyst, or Editor tools because Arc Hydro Tools will automatically use their functionality on as needed basis. These toolbars need to be activated though if you want to use any general functionality that they provide (such as general editing functionality or network tracing). The Spatial Analyst Extension can be activated, by clicking Customize→Extensions…, and checking the box next to Spatial Analyst.

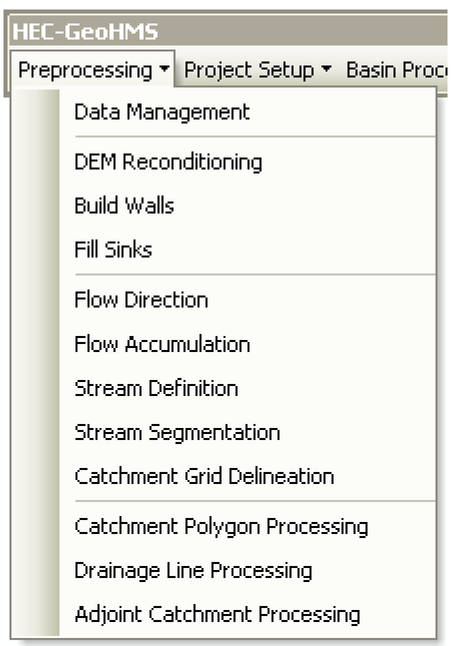
Dataset Setup

All vector data created with GeoHMS will be stored in a new geodatabase that has the same name as the stored project or ArcMap document (unless pointed to an existing geodatabase) and in the same directory where the project has been saved (your working folder). By default, the new raster data are stored in a subdirectory with the same name as the dataset or Data Frame in the ArcMap document (called Layers by default and under the directory where the project is stored). The location of the vector, raster, and time series data can be explicitly specified using the function *ApUtilities→Set Target Locations*.

You can leave the default settings if they are pointing to the same directory where the ArcMap document is saved.

Terrain Preprocessing

Terrain processing involves using the DEM to create a stream network and catchments. The Processing menu (shown below) in HEC-GeoHMS is used for terrain processing. You have already used these tools from the ArcHydro menu in the previous exercise so no need to repeat. Just take a look at the sequence to refresh your memory.



From Terrain Processing using Arc Hydro Tools, you should have the following dataset in your map document.

<u>Raster Data</u>

1. Raw DEM
2. HydroDEM (DEM after reconditioning and filling sinks)
3. Flow Direction Grid
4. Flow Accumulation Grid
5. Stream Grid
6. Stream Link Grid
7. Catchment Grid
8. Slope Grid

Vector Data
1. Catchment Polygons
2. Drainage Line Polygons
3. Adjoint Catchment Polygons

This concludes the terrain processing part. What you have produced is a hydrologic skeleton that can now be used to delineate watersheds or sub-watersheds for any given point on the delineated stream network. The next part of this tutorial involved delineating a watershed to create a HEC-HMS model using HEC-GeoHMS. Save your map document.

HEC-HMS Modeling Development using HEC-GeoHMS

Before you continue, please make sure you have the following datasets in the map document from the previous part.

Rasters
1. Cedar_dem (raw DEM)
2. Fil (filled DEM)
3. Fdr (flow direction grid)
4. Fac (flow accumulation grid)
5. Str (stream network grid)
6. StrLnk (stream link grid) (Note: earlier version of ArcHydro names this grid as Lnk)
7. Cat (catchment grid)
8. WshSlope (slope grid)

Vectors
1. Catchment
2. DrainageLine
3. AdjointCatchment

Save the map document.

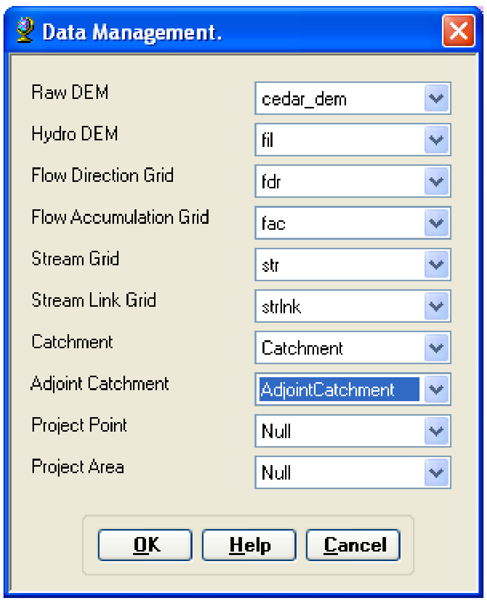
HEC-GeoHMS Project Setup

The HEC-GoeHMS project setup menu has tools for defining the outlet for the watershed, and delineating the watershed for the HEC-HMS project. As multiples HMS basin models can be developed by using the same spatial data, these models are managed by defining two feature classes: *ProjectPoint* and *ProjectArea*. Management of models through ProjectPoint and

ProjectArea let users to see areas for which HMS basin models are already created, and also allow users to re-create models with different stream network thresholds. It is also convenient to delete projects and associated HMS files through ProjectPoint and ProjectArea option.

Dataset Setup

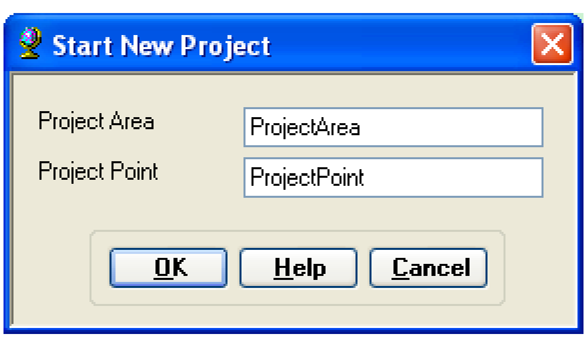
Select *HMS Project Setup→Data Management* on the HEC-GeoHMS Main View toolbar. **Confirm/define** the corresponding map layers in the Data Management window as shown below:



Click *OK*.

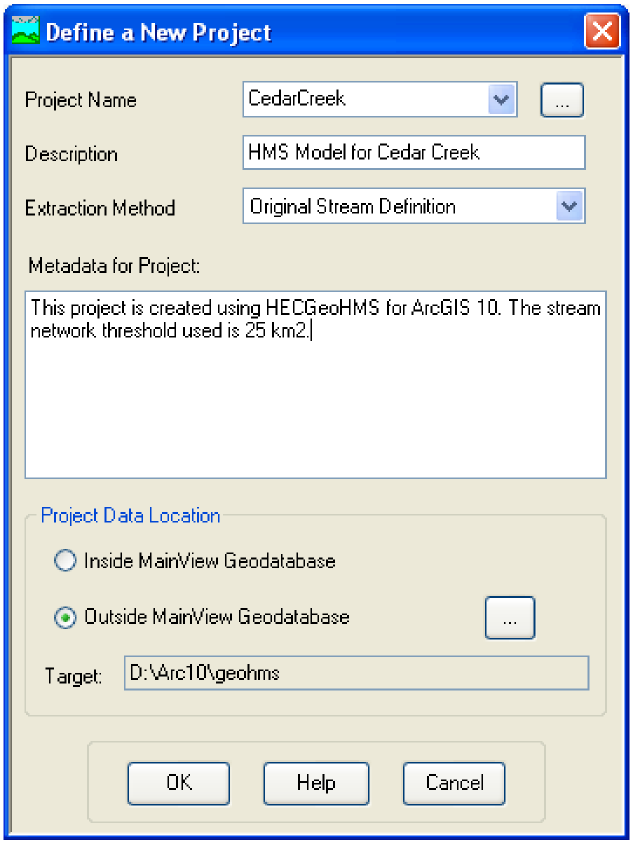
Creating New HMS Project

Click on *Project Setup→Start New Project*. **Confirm** *ProjectArea* for ProjectArea and *ProjectPoint* for ProjectPoint, and click OK.



(**Note:** For some reason, if you get an error message about accuracy/resolution of the data, this has to do with tolerances for x,y,m,z coordinates in your spatial coordinates which you need to fix in ArcCatalog)

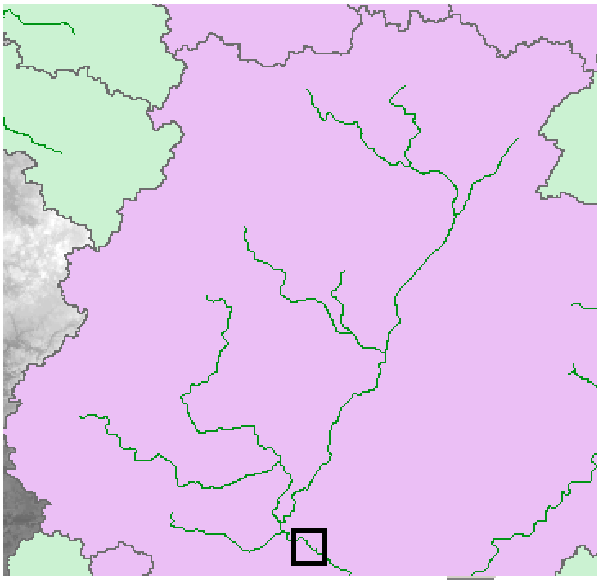
This will create ProjectPoint and ProjectArea feature classes. In the next window, provide the following inputs:



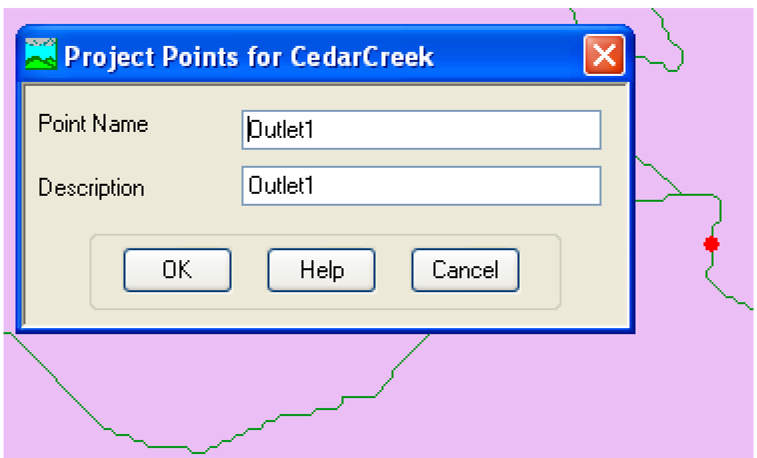
If you click on Extraction Method drop-down menu, you will see another option "A new threshold" which will delineate streams based on this new threshold for the new project. For now **accept** the default original stream definition option. You can write some metadata if you wish, and finally **choose** the outside MainView Geodatabase for Project Data Location, and **browse** to your working directory where *cedar.mxd* is stored. **Click** *OK*.

Click *OK* on the message regarding successful creation of the project. You will see that new feature classes *ProjectArea* and *ProjectPoint* are added to ArcMap's table of contents. These feature classes are added to the same geodatabase *cedar.gdb*.

Next **Zoom-in** to downstream section of the Cedar creek to define the watershed outlet as shown below:

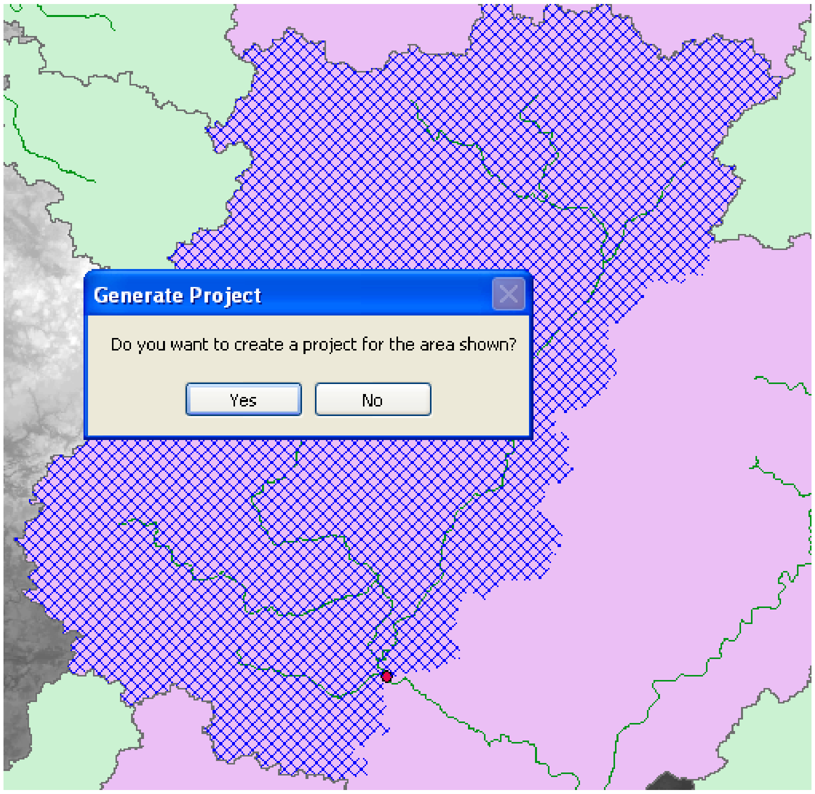


Select the *Add Project Points* tool on the HEC-GeoHMS toolbar, and **click** on the downstream outlet area of the Cedar Creek to define the outlet point as shown below as red dot:



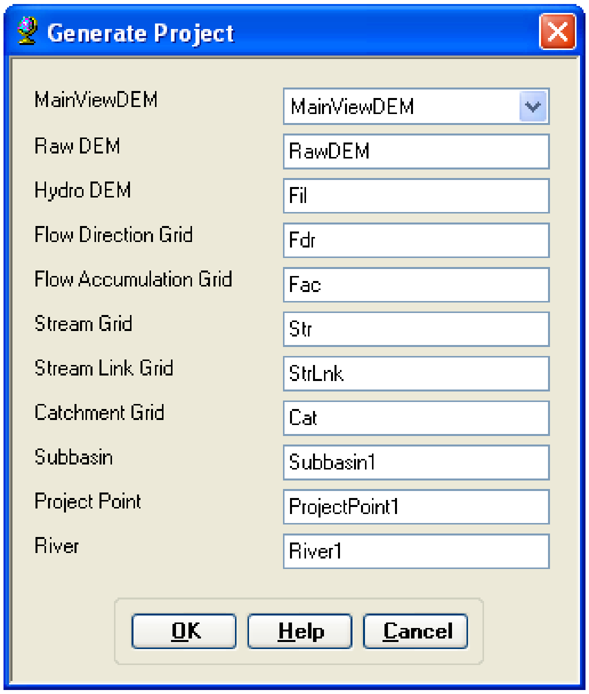
Accept the default Point Name and Description (*Outlet*), and **click** *OK*. This will add a point for the watershed outlet in the *ProjectPoint* feature class. **Save** the map document.

Next, **select** *HMS Project Setup→Generate Project*. This will create a mesh (by delineating watershed for the outlet in Project Point), and display a message box asking if you want to create a project for this hatched area as shown below:



(**Note:** This part could be challenging sometimes. If you face problem in creating Project Area, just delineate a watershed using the point delineation tool  in Arc Hydro for the Project Point feature, and load this watershed polygon into ProjectArea feature class. Make sure the HydroID of ProjectArea is same as ProjectID of ProjectPoint. Also you need to make sure the name and description match with each other)

Click *Yes* on the message box. Next, **confirm** the layer names for the new project (leave default names for Subbasin, Project Point, River and BasinHeader), and **click** *OK*.



This will create a new folder inside your working folder with the name of the project *CedarCreek*, and store all the relevant raster, vector and tabular data inside this folder. The raster data are stored in a sub folder with the project name (CedarCreek) inside *CedarCreek* folder. All vector and tabular data are stored in *CedarCreek.mdb*. You will also notice that a new data frame (*CedarCreek*) is added in ArcMap containing data for cedar creek.

You can also play with the contributing area tool  to find out contributing area at different points along the Cedar creek stream network. With *lnk* grid active, **select** the contributing area tool, and **click** at any point along the stream to know the contributing area.

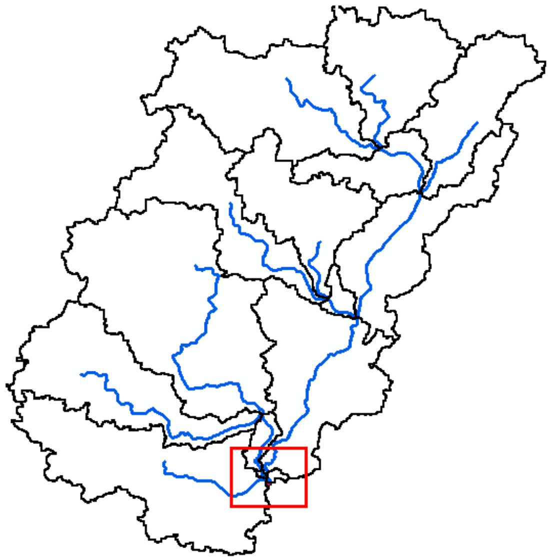
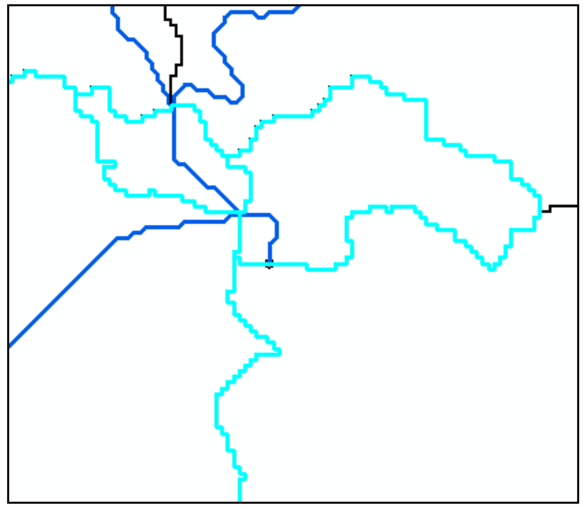
Save the map document.

Basin Processing

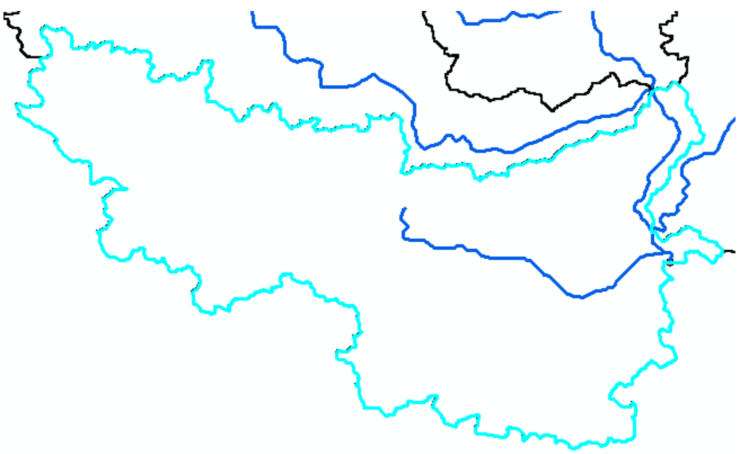
The basin processing menu has features such as revising sub-basin delineations, dividing basins, and merging streams.

Merge Basins

This process merges two or more adjacent basins into one. **Zoom-in** to the area marked in the rectangle below:

Select the three adjacent basins (shown above) using the standard select tool . **Click** on *Basin Processing→ Basin Merge*. You will get a message asking to confirm the merging of selected basins (with basins hatched in background), **click** *Yes*. Similarly merge two more sub-basins as shown below:

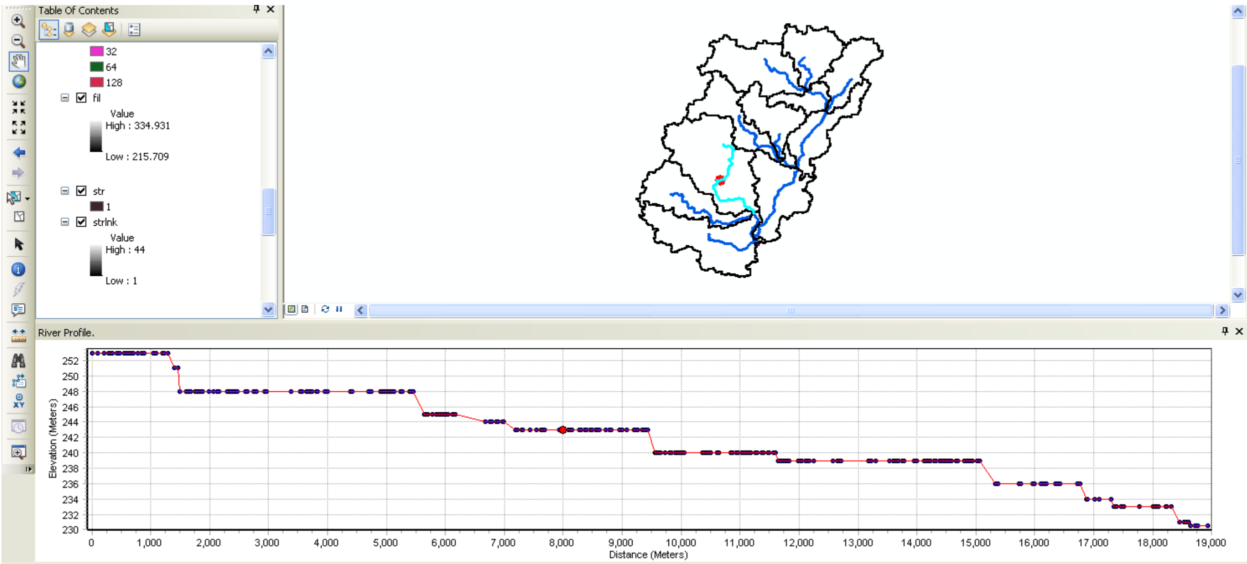


As a result of this merging, we now have 13 sub-basins and 15 river segments in the project. **Save** the map document.

River Profile

(**Note:** we will only look at the functionality of river profile tool, and not split river/basin using this tool.)

The River Profile tool allows displaying the profile of selected river reach(es). If the river slope changes significantly over the reach length, it may be useful to split the river/watershed at such a slope change. **Select** the *River Profile* tool, and **click** on any river segment that you are interested in inspecting. **Confirm** the layers in the next window, and **click** *OK*. This will invoke a dockable window in ArcGIS at the bottom that will display the profile of the selected reach. If you **click** at a point along the profile, a corresponding point showing its location on the river reach will be added to the map display (shown below as red dot).



If you want to split the river segment at the selected point, you can just right click on the point inside the dockable window and split the river. If you want to split the sub-basin at the point displayed in the map, you can use the subbasin divide tool, and click at the point displayed on the map. We will not split any river segments in this exercise.

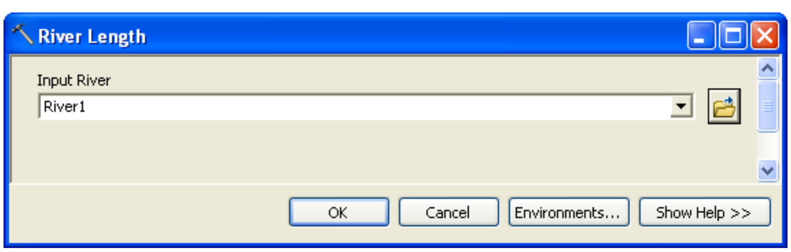
Close the dockable window, and **save** the map document.

Extracting Basin Characteristics

The basin characteristics menu in the HEC-GeoHMS Project View provides tools for extracting physical characteristics of streams and sub-basins into attribute tables.

River Length

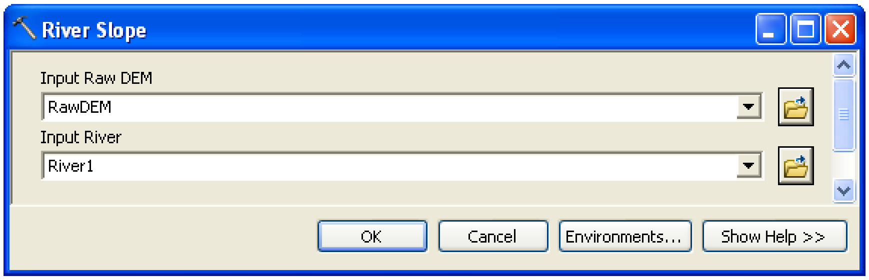
This tool computes the length of river segments and stores them in *RiverLen* field. **Select** *Characteristics→River Length*. **Confirm** the input River name, and **click** *OK*.



You can check the RiverLen field in the input River1 (or whatever name you have for your input river) feature class is populated. **Save** the map document.

River Slope

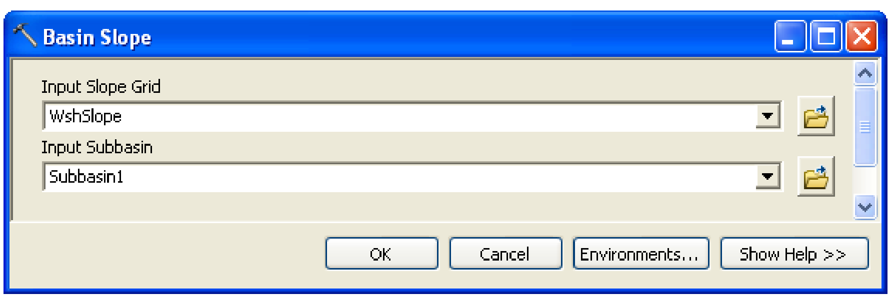
This tool computes the slope of the river segments and stores them in *Slp* field. **Select** *Basin Characteristics*→*River Slope*. **Confirm** inputs for RawDEM and River, and **click** *OK*.



You can check the *Slp* field in the input *River1* (or whatever name you have for your input river) feature class is populated. Fields *ElevUP* and *ElevDS* are also populated during this process. *Slp* = (*ElevUP* – *ElevDS*)/*RiverLen*.

Basin Slope

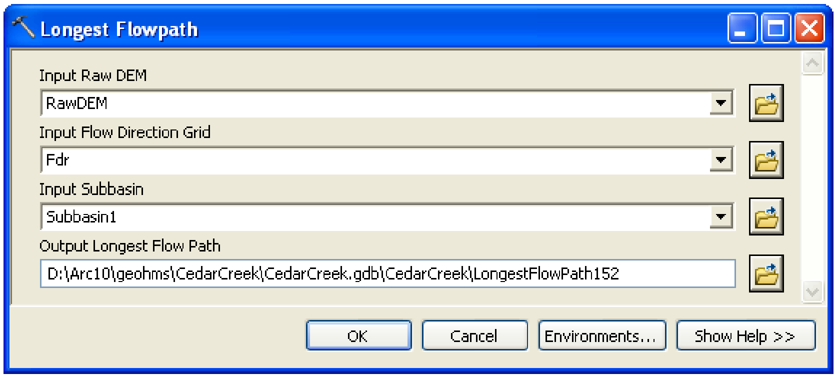
This tool computes average slope for sub-basins using the slope grid and sub-basin polygons. **Add** *wshslope* (percent slope for watershed) grid to the map document. **Select** *Characteristics*→*Basin Slope*. **Confirm** the inputs for Subbasin and Slope Grid , and **click** *OK*.



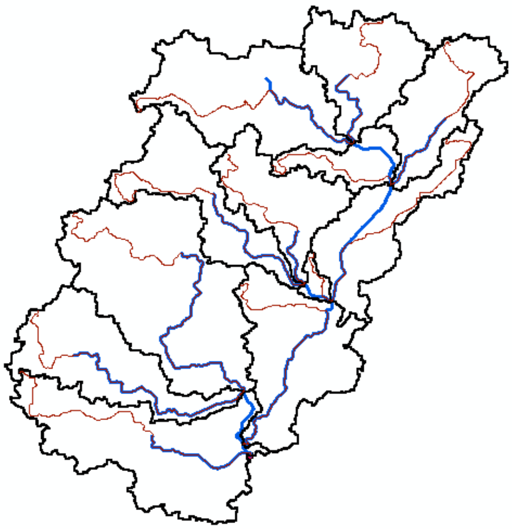
After the computations are complete, the *BasinSlope* field in the input Subbasin feature class is populated.

Longest Flow Path

This will create a feature class with polyline features that will store the longest flow path for each sub-basin. Select *Characteristics*→*Longest Flow Path*. **Confirm** the inputs, and leave the default output name *LongestFlowPath* unchanged. **Click** *OK*.



A new feature class storing longest flow path for each sub-basin is created as shown below.

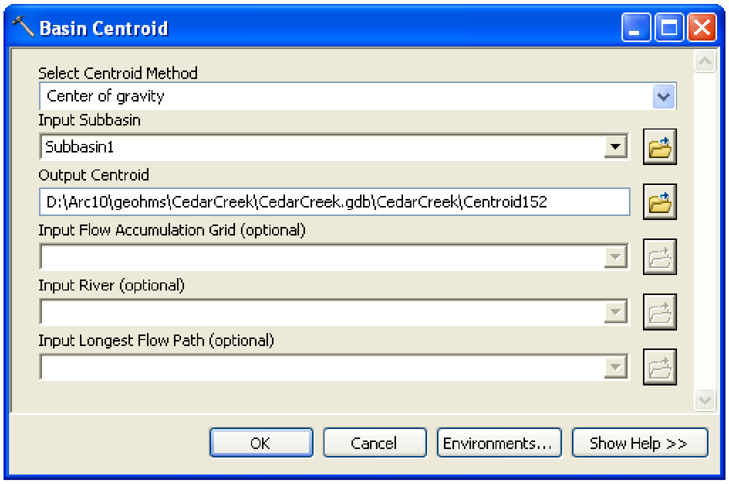


Open the attribute table of Longest Flow Path, and examine its attributes. **Close** the attribute table, and **save** the map document.

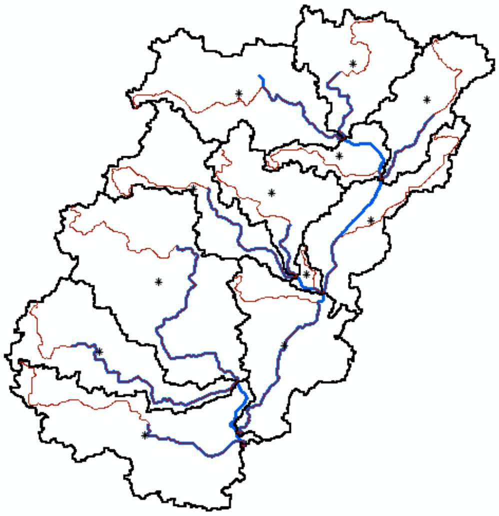
Basin Centroid

This will create a *Centroid* point feature class to store the centroid of each sub-basin. Select *Characteristics*→*Basin Centroid.* **Choose** the default *Center of Gravity Method*, input Subbasin, leave the default name for Centroid. Click OK.

(Note: Center of Gravity Method computes the centroid as the center of gravity of the sub basin if it is located within the sub basin. If the Center of Gravity is outside, it is snapped to the closest boundary. Longest Flow Path Method computes the centroid as the midpoint of the longest flow path within the sub basin. The quality of the results by the two methods is a function of the shape of the sub basin and should be evaluated after they are generated.)



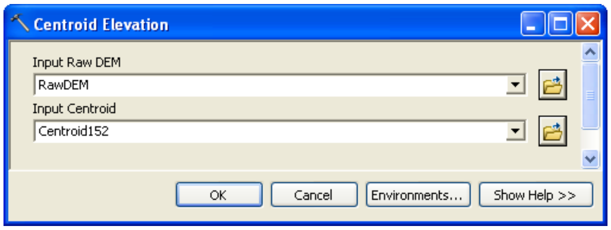
A point feature class showing centroid for each sub-basin is added to the map document.



As centroid locations look reasonable, we will accept the center of gravity method results, and proceed. **Save** the map document.

Basin Centroid Elevation

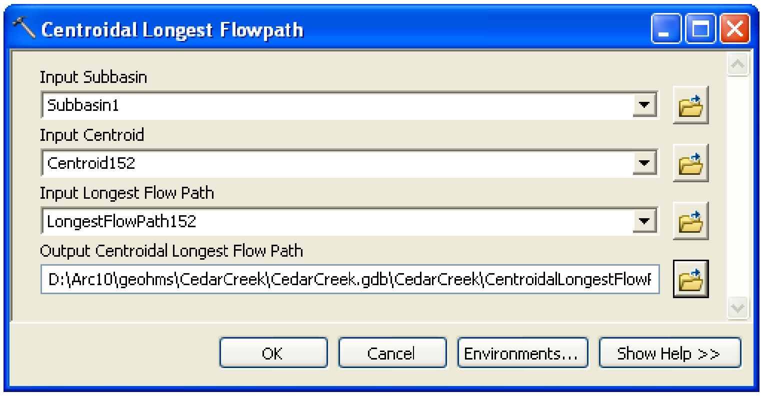
This will compute the elevation for each centroid point using the underlying DEM. **Select** *Characteristics→Centroid Elevation*. **Confirm** the input DEM and centroid feature class, and **click** *OK*.



After the computations are complete, **open** the attribute table of Centroid to examine the Elevation field.

Centroidal Longest Flow Path

Select *Characteristics→Centroidal Longest Flow Path*. **Confirm** the inputs, and leave the default name for output Centroidal Longest Flow Path, and **Click** *OK*.



This creates a new polyline feature class showing the flowpath for each centroid point along longest flow path. **Save** the map document.

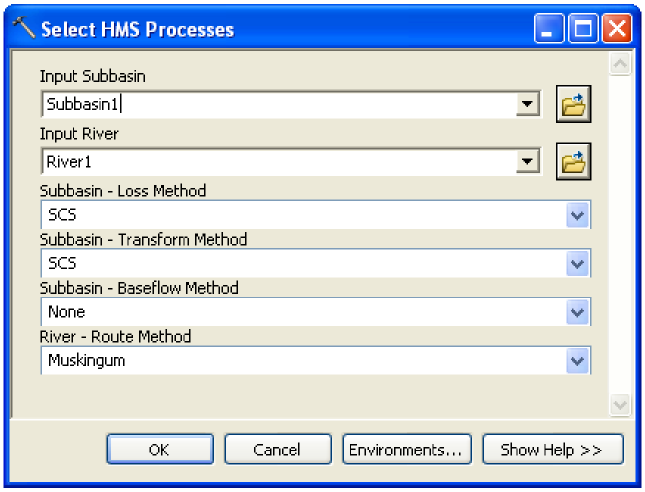
HMS Inputs/Parameters

The parameters menu in HEC-GeoHMS provides tools to estimate and assign a number of watershed and stream parameters for use in HMS. These parameters include SCS curve number, time of concentration, channel routing coefficients, etc.

Select HMS Processes

You can specify the methods that HMS should use for transform (rainfall to runoff) and routing (channel routing) using this function. Of course, this can be modified and/or assigned inside HMS.

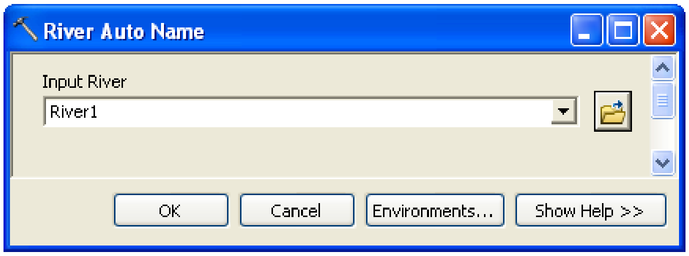
Select *Parameters→Select HMS Processes*. **Confirm** input feature classes for Subbasin and River, and **click** *OK*. Choose *SCS* for Loss Method (getting excess rainfall from total rainfall), *SCS* for Transform Method (for converting excess rainfall to direct runoff), *None* for Baseflow Type, and *Muskingum* for Route Method (channel routing). **Click** *OK*.



You can **open** the attribute table of subbasin feature class to see that the subbasin methods are added to *LossMet*, *TransMet*, and *BaseMet* fields, respectively. The Muskingum method is added to *RouteMet* field in the River feature class. You can treat these methods as tentative which can be changed in HMS model. **Save** the map document.

River Auto Name

This function assigns names to river segments. **Select** *Parameters→River Auto Name*. **Confirm** the input feature class for River, and **click** *OK*.



The *Name* field in the input River feature class is populated with names that have "R###" format, where "R" stands for river/reach "###" is an integer.

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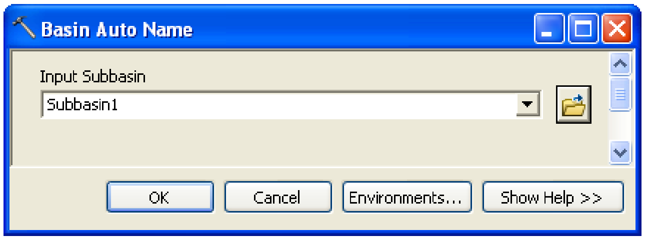
Basin Auto Name

This function assigns names to sub-basins. **Select** *Parameters→Basin Auto Name*. **Confirm** the input feature class for sub-basin, and **click** *OK*.

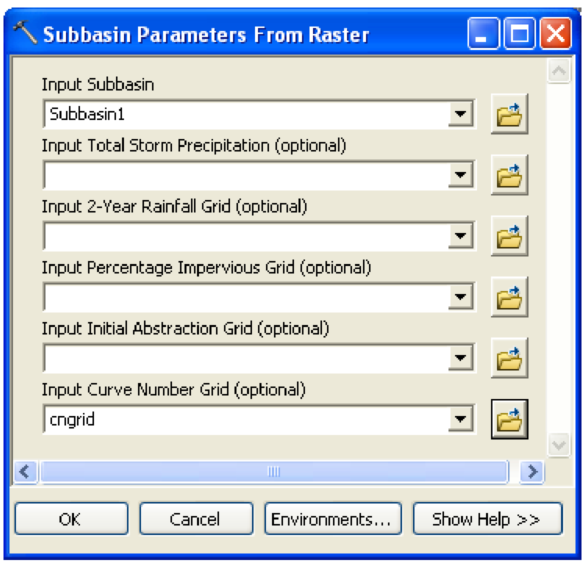


Like river names, the *Name* field in the input Subbasin feature class is populated with names that have "W###" format, where "W" stands for watershed, and "###" is an integer. **Save** the map document.

Sub-basin Parameters

Depending on the method (HMS process) you intend to use for your HMS model, each sub-basin must have parameters such as SCS curve number for SCS method and initial loss constant, etc. These parameters are assigned using Subbasin Parameters option. This function overlays subbasins over grids and compute average value for each basin. We will explore only those parameters that do not require additional datasets or information.

Add *cngrid* (curve number grid) from Layers folder to the map document. **Select** *Parameters→Subbasin Parameters from Raster*. You will get a window in which you will have to select the rasters that you want to use for extracting parameters. In this case, we will only extract the CN number for each basin from a curve number grid. Accordingly, select the cngrid for the Input Curve Number Grid, and and Click OK.



After the computations are complete, you can **open** the attribute table for subbasin, and see that a field named *BasinCN* is populated with average curve number for each sub-basin. **Close** the attribute table, and **save** the map document.

(**Note:** We will skip parameters associated with computing rainfall as these numbers should come from detailed analysis of the watershed. However, if you are interested, you can explore these functions if you have all the necessary data for their execution.)

SCS Curve Number is extracted using a grid, but parameters can also be extracted by using a feature class and its intersection with subbasins by using the Subbasin Parameters from Features option, but this option is not described in this exercise.

CN Lag Method

The function computes basin lag in hours (weighted time of concentration or time from the center of mass of excess rainfall hyetograph to the peak of runoff hydrograph) using the NRCS National Engineering Handbook (1972) curve number method. **Select** *Hydrologic Parameters→CN Lag Method*. This function populates the *BasinLag* field in the subbasin feature class with numbers that represent basin lag time in hours. **Save** the map document.

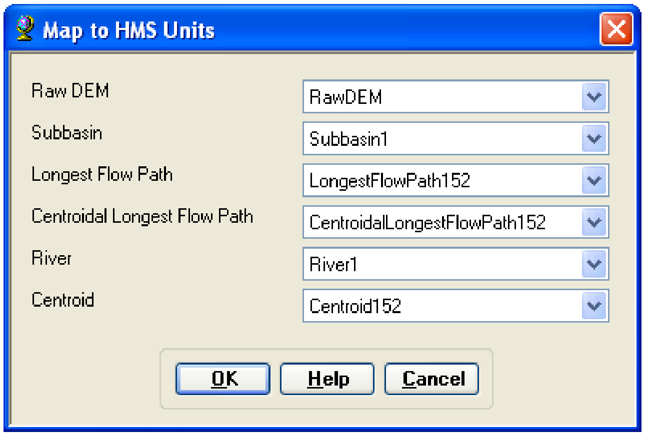
Take a look at attribute tables of River and Subbasin feature class to see what fields are populated, and what they mean in hydrologic modeling.

HMS

The HMS menu has tools for creating input files for HEC-HMS.

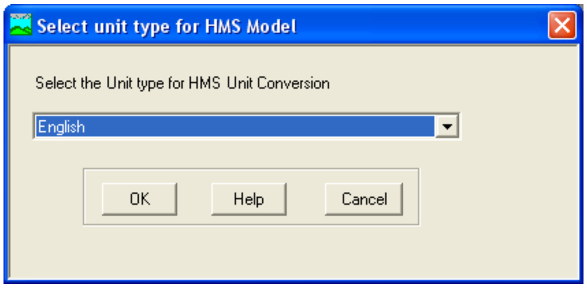
Map to HMS Units

This tool is used to convert units. **Click** on *HMS→Map to HMS Units*. **Confirm** the input files, and **click** *OK*.



(**Note:** Due to some unknown reasons, if you get an error message at this point saying field cannot be added to a layer, save the map document, exit ArcMap and open the document, and try again)

In the next window, **choose** *English* units (default) from the drop-down menu, and **click** *OK*.

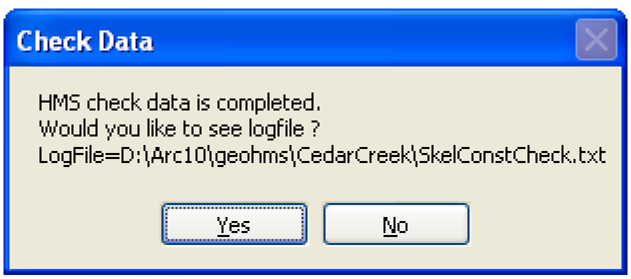


After this process is complete, you will see new fields in both River and Subbasin feature classes that will have fields ending with "_HMS" to indicate these fields store attributes in the specified HMS units (English in this case). All fields that store lengths and areas will have corresponding "_HMS" fields as a result of this conversion.

Check Data

This tool will verify all the input datasets. **Select** *HMS→Check Data*. **Confirm** the input datasets to be checked, and **click** *OK*.

You should get a message after the data check saying the check data is completed successfully as shown below.



You can also look at the log file and make sure there are no errors in the data by scrolling to the bottom of the log file as shown below.

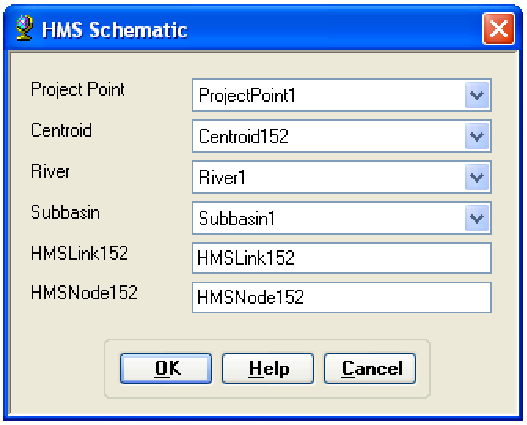
```
CHECKING SUMMARY
****************

Unique names           - no problems.
River containment      - no problems.
Center containment     - no problems.
River connectivity     - no problems.
VIP relevance          - no problems.
```

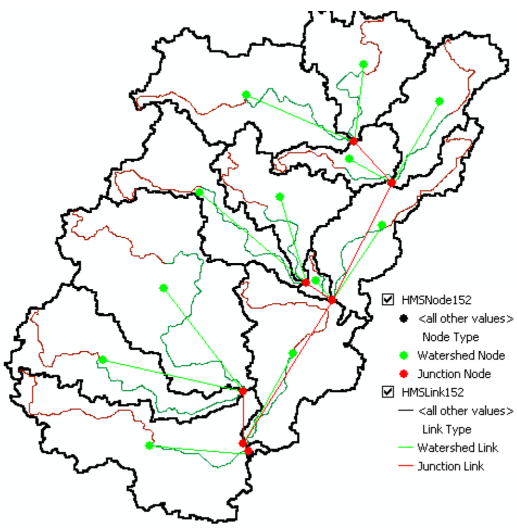
If you get problems in any of the above four categories (names, containment, connectivity and relevance), you can look at the log file to identify the problem, and fix it by yourself. This version of HecGeoHMS apparently gives error with river connectivity even if the rivers are well connected. Therefore, check the data carefully, and if you think everything is OK, ignore the errors (if you get any for connectivity) and proceed.

HMS Schematic

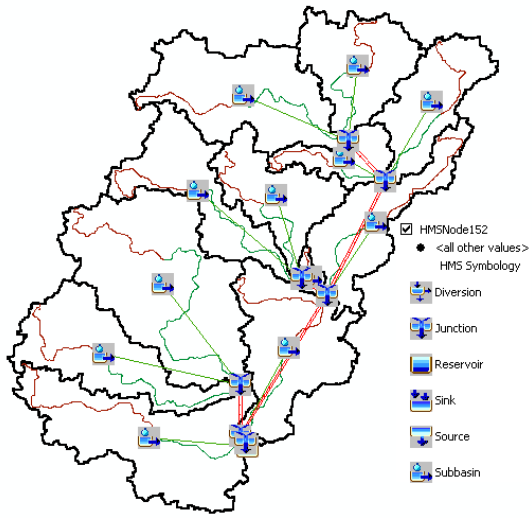
This tool creates a GIS representation of the hydrologic system using a schematic network with basin elements (nodes/links or junctions/edges) and their connectivity. **Select** *HMS→HMS Schematic*. **Confirm** the inputs, and **click** *OK*.



Two new feature classes *HMS Link* and *HMSNode* will be added to the map document.



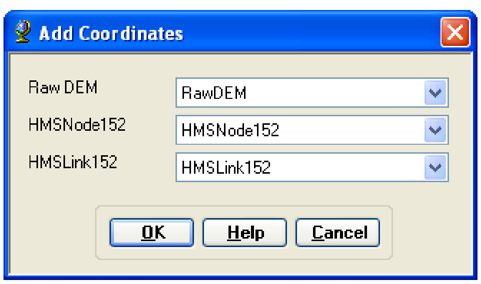
After the schematic is created, you can get a feel of how this model will look like in HEC-HMS by toggling/switching between regular and HMS legend. **Select** *HMS→Toggle HMS Legend→HMS Legend*



You can keep whatever legend you like. **Save** the map document.

Add Coordinates

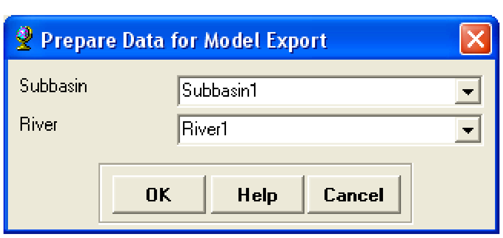
This tool attaches geographic coordinates to features in *HMSLink* and *HMSNode* feature classes. This is useful for exporting the schematic to other models or programs without losing the geospatial information. **Select** *HMS→Add Coordinates*. **Confirm** the input files, and **click** *OK*.



The geographic coordinates including the "z" coordinate for nodes are stored as attributes (CanvasX, CanvasY, and Elevation) in *HMSLink* and *HMSNode* feature classes.

Prepare Data for Model Export

Select *HMS→Prepare Data for Model Export*. **Confirm** the input Subbasin and River files, and **click** *OK*.



This function allows preparing subbasin and river features for export.

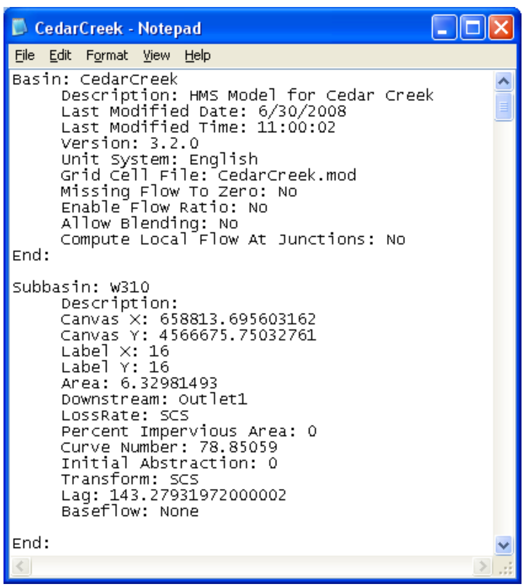
Background Shape File

Select *HMS→Background Shape File*. This function captures the geographic information (x,y) of the subbasin boundaries and stream alignments in a text file that can be read and displayed within HMS. Two shapefiles: one for river and one for sub-basin are created in the project folder. **Click** *OK* on the process completion message box.

Basin Model

Select *HMS→Basin Model File*. This function will export the information on hydrologic elements (nodes and links), their connectivity and related geographic information to a text file with .basin extension. The output file *CedarCreek.basin* (project name with .basin extension) is created in the project folder. **Click** *OK* on the process completion message box.

You can also open the .basin file using Notepad and examine its contents.




```
Basin: CedarCreek
     Description: HMS Model for Cedar Creek
     Last Modified Date: 6/30/2008
     Last Modified Time: 11:00:02
     Version: 3.2.0
     Unit System: English
     Grid Cell File: CedarCreek.mod
     Missing Flow To Zero: No
     Enable Flow Ratio: No
     Allow Blending: No
     Compute Local Flow At Junctions: No
End:

Subbasin: W310
     Description:
     Canvas X: 658813.695603162
     Canvas Y: 4566675.75032761
     Label X: 16
     Label Y: 16
     Area: 6.32981493
     Downstream: Outlet1
     LossRate: SCS
     Percent Impervious Area: 0
     Curve Number: 78.85059
     Initial Abstraction: 0
     Transform: SCS
     Lag: 143.27931972000002
     Baseflow: None

End:
```

Meteorologic Model

We do not have any meteorologic data (temperature, rainfall etc) at this point. We will only create an empty file that we can populate inside HMS. **Select** *HMS→Met Model File→Specified Hyetograph*. The output file *CedarCreek.met* (project name with .met extension) is created in the project folder. **Click** *OK* on the process completion message box.

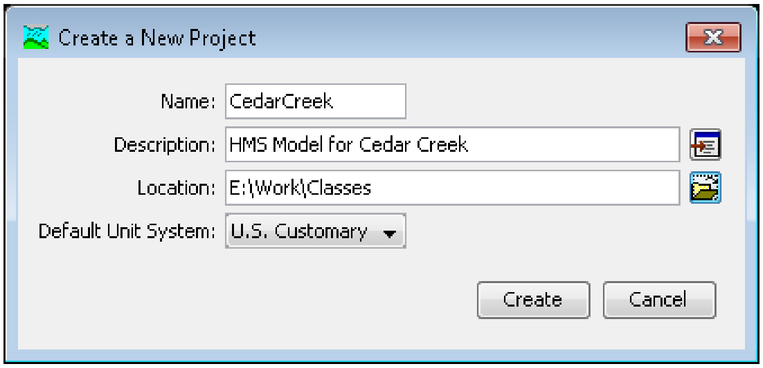
You can also open the .met file using Notepad and examine its contents.

Save the map document. You have successfully created a HEC-HMS project for Cedar Creek. Congratulations! In the following part, you will open this project in HEC-HMS.

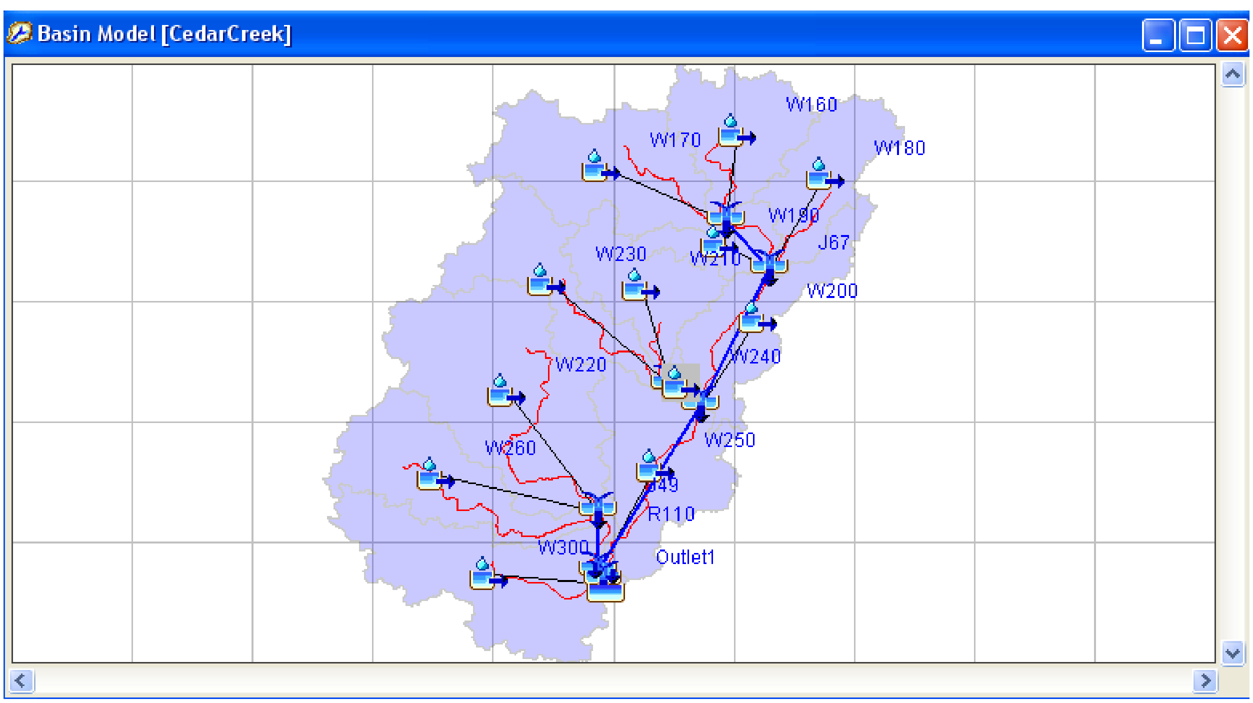
Opening the HMS Model

This section briefly explains how to interface or open the project files created by GeoHMS using HMS.

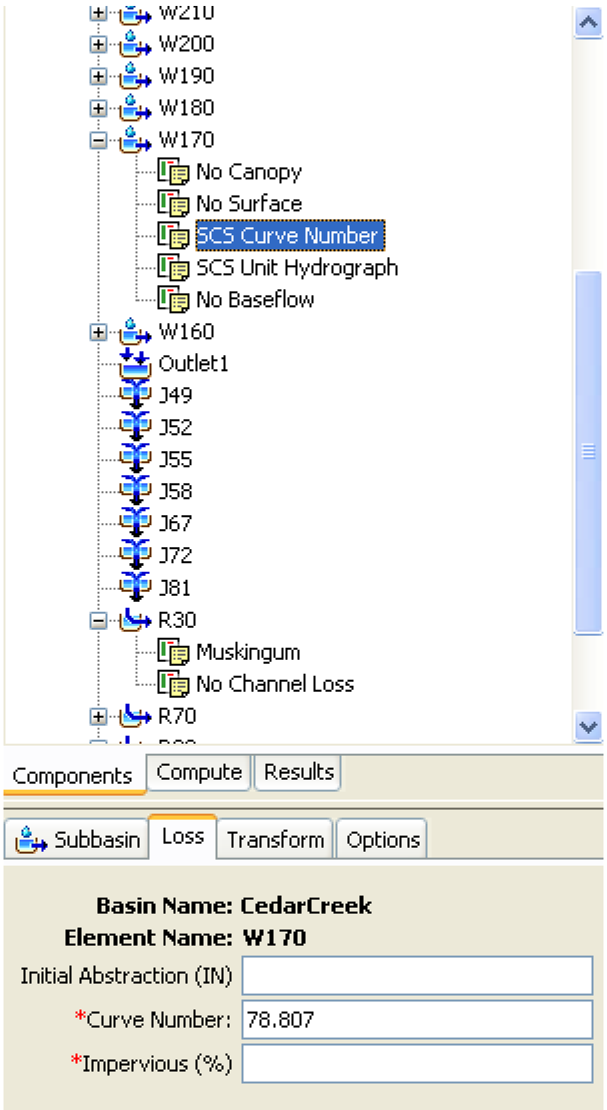
Open *HEC-HMS*, and **select** *File→New*. Create a new project called CedarCreek using US Customary unit in your working directory.



Next, go to File→ Import→Basin Model, and browse to the .basin file and add it to the project. Save the project. You will see the basin folder in the left window, click on the + sign to open the folder and click on the basin to see the Cedar Creek basin. Click on View→Background Map, and then add the river and basin shapefiles to see the watershed as shown below.
basin along with its sub-basins, streams, links and junctions as shown below.



If you expand the CedarCreek basin in watershed explorer, you will see the list of junctions, reaches and subbasins. You can click on any reach and see its associated methods. For example, when you **click** on a Reach (R##), you will see that *Muskingum* routing method is associated with it. Similarly, if you **click** on a Watershed (W##), you will see *SCS Curve Number* (for abstractions) and *SCS Unit Hydrograph* (for runoff calculations) are associated with it. Again, if you **click** on *SCS Curve Number*, you will see corresponding parameters in the *Component Window* as shown below. All this information, which is now independent of GIS, is extracted from attributes that we created in HEC-GeoHMS.



Manipulating data in HMS, populating the Meteorologic file, and running the model is beyond the scope of this tutorial, and will be covered in other tutorial. **Save** your HMS project.

OK, you are done for now!!