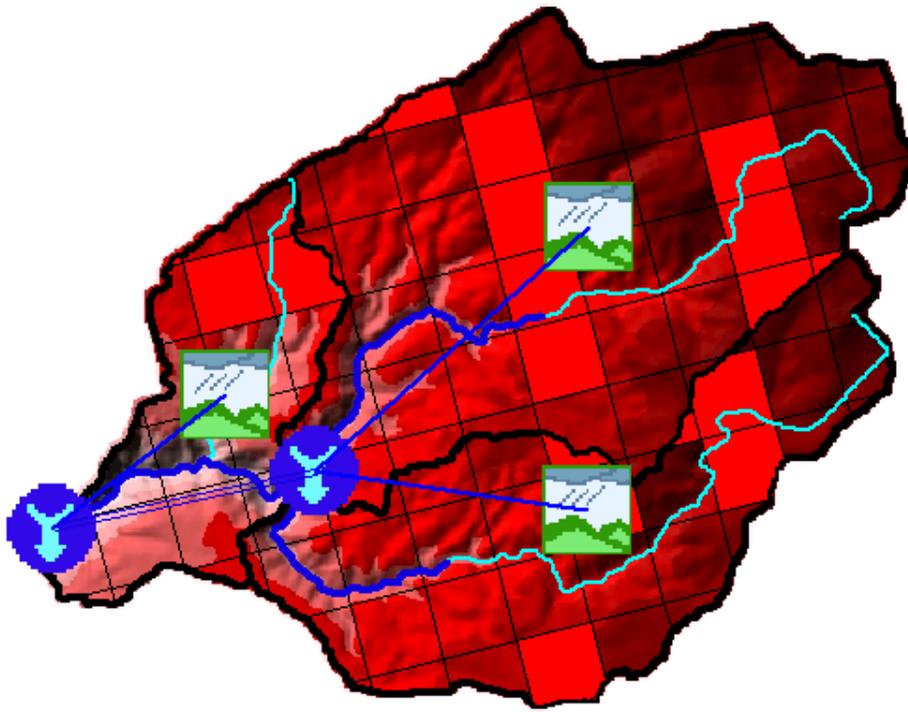**US Army Corps
of Engineers**
Hydrologic Engineering Center

HEC-GeoHMS
Geospatial Hydrologic Modeling Extension

User's Manual

Version 4.2
May 2009

CPD-77

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14. ABSTRACT
The Hydrologic Engineering Center's Geospatial Hydrologic Modeling, HEC-GeoHMS public domain extension to ESRI ArcGIS software (ArcGIS 9.2/9.3, Spatial Analyst). HEC-GeoHMS is a geospatial hydrology toolkit for engineers and hydrologists. The user can visualize spatial information, document watershed characteristics, perform spatial analysis, delineate subbasins and streams, construct inputs to hydrologic models, and assist with report preparation. Through the use of HEC-GeoHMS a user can easily and efficiently create hydrologic inputs that can be used directly with the Hydrologic Engineering Center's Hydrologic Modeling System, HEC-HMS software.

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HEC-GeoHMS
Geospatial Hydrologic Modeling Extension

User's Manual

Version 4.2
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CPD-77

Geospatial Hydrologic Modeling Extension, HEC-GeoHMS
Software Distribution and Availability Statement

The HEC-GeoHMS executable code and documentation are public domain software that was developed under a Cooperative Research and Development Agreement by the Hydrologic Engineering Center (HEC) and the Environmental Systems Research Institute, Inc. (ESRI) and using USACE Research and Development funding. The software and documentation were developed with United States Federal Government resources and is therefore in the public domain. This software can be downloaded for free from our internet site (www.hec.usace.army.mil). HEC cannot provide technical support for this software to non-Corps users; however, we will respond to all documented instances of program errors. Documented errors are bugs in the software due to programming mistakes, not model problems due to user-entered data.

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Foreword

Developments in Geographic Information System (GIS) tools for hydrologic and hydraulic modeling at the Hydrologic Engineering Center (HEC) resulted from many years of interest in geospatial data usage. The earliest work was in the mid 1970's when HEC developed software based on the concepts developed in the Harvard University's School of Landscape Architecture, Honey Hill Project. That early work culminated with the development of the Spatial Analysis Methodology (HEC-SAM), which included a grid-cell data bank and analysis software for hydrologic and flood damage calculations. That early work had the same concepts as those of today, but the limitations in the computer hardware, GIS software, and data availability made widespread engineering applications difficult.

The current development builds on those early experiences and takes the technology to several practical engineering products including the Hydrologic Engineering Center's Geospatial Hydrologic Modeling (HEC-GeoHMS) extension. HEC resurrected its earlier efforts by reviewing current GIS capabilities in association with Professor David Maidment from the University of Texas. HEC and Dr. Maidment formulated a watershed data structure that would link GIS and hydrologic models. From that time, the definition and content of the GIS and hydrologic data structures evolved into a hydrologic GIS preprocessor, PrePro. Taking advantage of the wealth of terrain and geographic data readily available over the Internet and from government agencies, PrePro delineates streams and watersheds and builds the hydrologic model structure for HEC-HMS. PrePro was the predecessor to HEC-GeoHMS.

The development of PrePro at the University of Texas was partially supported by HEC via the Corps' Civil Works R&D program. The effort also received substantial support from the Texas Department of Transportation as well as support from other national and international agencies. Dr. Maidment, Dr. Olivera, and others at the Center for Research in Water Resources provided valuable assistance for the development of HEC-GeoHMS.

HEC-GeoHMS Version 1.0 was developed to use readily available digital geospatial information to construct hydrologic models more expediently than using manual methods. Also, development of basic watershed information will aid the user in estimating hydrologic parameters. After gaining adequate experience with using GIS-generated parameters, users can take steps to streamline the process of hydrologic parameter estimation.

The Wisconsin Department of Natural Resources (WDNR) and Environmental System Research Institute's, Inc. (ESRI) contributed greatly to the development of HEC-GeoHMS Version 1.1. WDNR developed completed HMS models using the hydrologic parameters and topographic parameters for regional regression analysis provided b HEC-GeoHMS Version 1. With this version, users were able to extract more watershed characteristics from digital elevation models (DEM) and GIS data for developing hydrologic parameters. Users

were also able to work with DEMs in a number of coordinate systems and projections. This version introduced tools to recondition the DEMs by imposing a known stream network onto the terrain grid. HEC-GeoHMS Version 1.1 also expanded its scope to develop meteorologic models and control specifications for an HEC-HMS model. HEC-GeoHMS Version 1.1 was the terminal release of the software using ESRI's ArcView 3.x platform.

HEC-GeoHMS Version 4.2 is the result of continued development by HEC and ESRI to modernize the features and functionality of HEC-GeoHMS Version 1.1 (for ArcView 3.x) to the ArcGIS 9.3 platform (ArcView license). This work was accomplished through a Cooperative Research and Development Agreement (CRADA) between HEC and ESRI and using USACE Research and Development funding.

Acknowledgements

HEC-GeoHMS has benefited from many years of research and program development. From an institutional perspective, the University of Texas at Austin has contributed important research, development, and demonstration of concepts. Having that basis for the technology, HEC and Environmental Systems Research Institute, Inc. (ESRI) contributed extensive software development and documentation through a Cooperative Research and Development Agreement (CRADA) to engineer technology into commercial software.

At HEC, James Doan, Matthew Fleming, Bill Scharffenberg, Cameron Ackerman, Jay Pak, Gary Brunner, and Jeff Harris are members of the HEC-GeoHMS development team. From ESRI, Dr. Dean Djokic, Dr. Zichuan Ye, Mr. Sreeresh Sreedhar, and Christine Dartiguenave contributed valuable software insight, development, and programming in conjunction with HEC. This manual was written by James Doan and Matthew Fleming. HEC software implementation is under the guidance of Christopher N. Dunn, Director, Hydrologic Engineering Center

C H A P T E R   1

Introduction

In recent years, advances in Geographic Information Systems (GIS) have opened many opportunities for enhancing hydrologic modeling of watershed systems. With an openness to share spatial information via the internet from government agencies, commercial vendors, and private companies, coupled with powerful spatial algorithms, the integration of GIS with hydrologic modeling holds the promise of a cost-effective alternative for studying watersheds. The ability to perform spatial analysis for the development of lumped and distributed hydrologic parameters not only saves time and effort, but also improves accuracy over traditional methods. In addition, hydrologic modeling has evolved to consider radar rainfall and advanced techniques for modeling the watershed on a grid level. Rainfall and infiltration can be computed cell by cell providing greater detail than traditional basin average methods. These advanced modeling techniques have become feasible because the time-consuming data manipulations can now be generated efficiently using spatial operations in a GIS. For example, the ability to perform spatial overlays of information to compute basin average or grid-based parameters is crucial for computing hydrologic parameters.

HEC-GeoHMS has been developed as a geospatial hydrology toolkit for engineers and hydrologists with limited GIS experience. The program allows users to visualize spatial information, document watershed characteristics, perform spatial analysis, delineate subbasins and streams, construct inputs to hydrologic models, and assist with report preparation. Working with HEC-GeoHMS through its interfaces, menus, tools, buttons, and context-sensitive online help allows the user to expediently create hydrologic inputs that can be used directly with the Hydrologic Engineering Center's Hydrologic Modeling System, HEC-HMS.

Chapter 1 discusses the intended use of HEC-GeoHMS and provides an overview of this manual. Below is an outline of Chapter 1.

Contents

- Technical Capabilities
- Program Features
- Intended Application of HEC-GeoHMS
- User's Manual Overview

Technical Capabilities

Hydrologic modeling has evolved to represent the subbasin in more detail than the traditional approach where hydrologic parameters are averaged over large basins. With the availability of radar rainfall and spatial data, hydrologic modeling using smaller subbasin areas or a grid system has introduced a more detailed representation of the basin. HEC-GeoHMS has been designed to meet the needs of both modeling approaches.

HEC-GeoHMS creates background map files, basin model files, meteorologic model files, and a grid cell parameter file which can be used by HEC-HMS to develop a hydrologic model. The basin model file contains hydrologic elements and their hydrologic connectivity. The basin model file includes subbasin areas and other hydrologic parameters that could be estimated using geospatial data. To assist with estimating hydrologic parameters, HEC-GeoHMS can generate tables containing physical characteristics of streams and watersheds. The grid cell parameter file is required in order to use the ModClark transform method, grid-based precipitation (like radar rainfall), or gridded loss methods.

New features in HEC-GeoHMS Version 4.2 allow the user to analyze DEM's in a number of coordinate systems and projections, including Albers-Equal Area, Universal Transverse Mercator (UTM), Transverse Mercator, Lambert, and the State Plane Coordinate System. An added capability allows users to use a more sophisticated "burning in" technique to impose the stream network onto the terrain. This is accomplished as a gradual step-wise process to better reproduce stream networks and watershed boundaries. With regards to hydrologic parameter estimation, HEC-GeoHMS contains tools to assist the user in estimating initial values of some hydrologic parameters.

Program Features

HEC-GeoHMS 4.2 is a public-domain extension for ArcGIS 9.2/9.3 (ArcView® license) and the Spatial Analyst extension. ArcView GIS and its Spatial Analyst extension are available from the Environmental Systems Research Institute, Inc. (ESRI). The following program features illustrate functionality and ease of use for HEC-GeoHMS.

Data Management

HEC-GeoHMS performs a number of administrative tasks that help the user manage GIS data derived from the program. The data management feature tracks GIS data layers and their names. Prior to performing a particular operation, the data manager will offer the appropriate data inputs for operation, and prompt the user for confirmation. Other times, the data management feature manages the locations of various projects and also performs error checking and detection.

Terrain Preprocessing

HEC-GeoHMS allows users to perform terrain preprocessing in either a step-by-step fashion or batch mode. In the step-by-step process, the user often has the opportunity to examine the outputs and make corrections to the dataset, as appropriate. Batch processing will allow terrain preprocessing to be performed unattended.

Basin Processing

The emphasis of the subbasin delineation, processing, and manipulation capability is on flexibility, ease of use, and user interactivity. As the user subdivides a basin or merges many smaller subbasins together, the results of the operation are displayed immediately for the user's confirmation. The ability to perform subbasin processing interactively is powerful, because the results are presented quickly for the user to make a modeling decision instead of having to reprocess the data. For example, the user can obtain a stream profile and look for significant grade breaks. If a subbasin subdivision at a grade break is desired, the user, using the delineation tool, just clicks on the stream at the grade break. Other tools allow the user to delineate subbasins in a batch mode by supplying a dataset containing point locations of desired outlets.

Hydrologic Parameter Estimation

Users can now compute the Curve Number and other loss rate parameters based on various soil and land use databases. The curve number can represent an average value for a subbasin or an individual cell for a grid-based subbasin. In addition, watershed and channel characteristics together with a spreadsheet template are linked to HEC-GeoHMS to assist the user with estimation of initial values of time of concentration. Also, basin and channel characteristics can be used to calculate CN Lag and simple prismatic Muskingum-Cunge routing parameters.

HMS Model Support

HEC-GeoHMS produces a number of hydrologic inputs that are used directly in HEC-HMS. In addition, the program supports the estimation of hydrologic parameters by providing tables of physical characteristics for streams and subbasins. While working with HEC-GeoHMS, the user can toggle HEC-GeoHMS on/off in order to bring in other ArcGIS extension programs to perform spatial operations and develop additional parameters for populating the hydrologic model.

Intended Application of HEC-GeoHMS

HEC-GeoHMS is intended to process watershed data after the initial compilation and preparation of terrain data is completed. The assembly of GIS data can be performed using standard GIS software packages that support ARC Grid format. Even though this user's manual provides some guidance and discussions on the proper approach for assembling data, HEC-GeoHMS is not intended as a tool for data assembly. When assembling data, it is important to understand how to use GIS software to put data of different types and formats into a common coordinate system. A few examples of required data include digital elevation models (DEM), digital stream alignments, and stream gage locations.

When the data assembly is complete, HEC-GeoHMS processes the terrain and spatial information to generate a number of hydrologic inputs. It is intended that these hydrologic inputs provide the user with an initial HEC-HMS model. The user can estimate hydrologic parameters from stream and subbasin characteristics, gaged precipitation, and stream flow data. In addition, the user has full control in HEC-HMS to modify the hydrologic elements and their connectivity to more accurately represent field conditions.

User's Manual Overview

This manual provides detailed instructions for using HEC-GeoHMS to develop hydrologic inputs for HEC-HMS. The manual is organized as follows:

Chapter 1 - Introduction

Chapter 2 - Instructions for Installing HEC-GeoHMS and Getting Started

Chapter 3 - Overview of the Major Steps in using HEC-GeoHMS

Chapter 4 - Data Collection

Chapter 5 - Issues Related to Data Assembly

Chapter 6 - Terrain Preprocessing

Chapter 7 - Setting up a Detailed HEC-GeoHMS Project

Chapter 8 - Basin Processing

Chapter 9 - Physical Characteristics Extracted for Streams and Subbasins

Chapter 10 - Hydrologic Parameter Estimation

Chapter 11 – Creation of Input Files for HMS

Chapter 12 - Description of Utility Tools

Chapter 13 - Example Application of HEC-GeoHMS

Appendix A - References

Appendix B - Map File Format

Appendix C - Grid-Cell Parameter File Format

Appendix D - Grids in HEC-DSS, HRAP, and SHG Grid Systems

C H A P T E R   2

HEC-GeoHMS Installation

This chapter discusses the hardware and software requirements and installation procedures for HEC-GeoHMS. Prior to installing this software, Microsoft .NET framework should be installed first and then ArcView GIS version 9.2 or version 9.3 and the Spatial Analyst extension should be installed using their installation guides. Below is an outline of Chapter 2.

Contents

- Hardware and Software Requirements
- Installation of HEC-GeoHMS
- Loading HEC-GeoHMS

Hardware and Software Requirements

The minimum hardware and software requirement for using HEC-GeoHMS are similar to those of ArcView GIS. However, when working with GIS, it is important to take into account the size of the datasets as well as the complexity of the analysis when determining adequate computer resources. Even though the program will still work on a slower machine, the user will often experience long computing times. To assure that performance is not being compromised, the following hardware recommendations should be considered with the idea that more computer resources, in terms of central processing unit (CPU) speed, memory, and hard drive space, could improve program performance.

Recommended Hardware Specifications

The recommended hardware specifications are as follows:

CPU Speed: 1.6 GHz recommended or higher

Memory/RAM: 1 GB minimum, 2 GB recommended or higher

Hard Drive Space: Hard drive space available should be at least twenty times the size of the terrain data. For example, if the terrain data takes up 50 MB, then the available hard drive space should be about 1 GB. In many cases, having ample hard drive space available will improve performance because the spatial operations often generate many temporary intermediate files and repeatedly perform file caching.

Required Software Specifications

There are two installation packages for HEC-GeoHMS version 4.2. One version is for ArcGIS 9.2 and the other is for ArcGIS 9.3. Run the HEC-GeoHMS version 4.2.92 installation package if ArcGIS 9.2 is installed on your computer and run the HEC-GeoHMS version 4.2.93 installation package if ArcGIS 9.3 is installed on your computer. The required hardware specifications are as follows:

Operating System: Windows XP

Pre-installed software for HEC-GeoHMS version 4.2.92:
                          Microsoft .NET Framework Version 2
                          ArcView GIS 9.2
                          Spatial Analyst

Pre-installed software for HEC-GeoHMS version 4.2.93:
                          Microsoft .NET Framework Version 2
                          ArcView GIS 9.3
                          Spatial Analyst

Installation of HEC-GeoHMS

A number of software programs are required to run HEC-GeoHMS. These include Arc Hydro Tools, the Water Utilities Application Framework, and the XML Data Exchange Tools. These will be automatically installed when HEC-GeoHMS is installed. You should make sure to properly uninstall old versions of the software (HEC-GeoHMS, Water Utility Applications Framework, XML Data Exchange, and Arc Hydro Tools) prior to installing a new version. Removal of software previously installed is performed through the Windows Control Panel using the Add or Remove Programs dialog. This will ensure that all files are unregistered and deleted properly.

The recommended procedure for uninstalling older versions is as follows:

1. Close all ArcGIS applications (ArcMap, ArcCatalog, ArcToolbox).

2. Open the Add or Remove Programs dialog and remove the following: Arc Hydro Tools, HEC-GeoHMS, Water Utilities Application Framework, HEC-GeoDozer, and XML Data Exchange Tools. Which components are uninstalled depends on the applications you have installed. If you look in the ESRI installation directory (usually C:\Program Files\ESRI\WaterUtils) you will see some of the installed applications.

3. After removing the applications, check each of the directories in the application installation directories shown in step 2. If any of the bin directories contain a dll, first unregister the dll and then delete the file.

4. Delete ALL directories that contained the old applications.

5. Recommended – run a registry cleaning application to ensure there are no "hanging" components left.

The recommended procedure for installing HEC-GeoHMS 4.2 is as follows:

1. Insert the HEC-GeoHMS CD into your CD drive (or download the software from our web page: www.hec.usace.army.mil).

2. The setup program should run automatically if installing from a CD. When downloading from the web page you will need to save the setup file in a temporary directory and then execute the "GeoHMS4.2.92_Setup.exe" or "GeoHMS4.2.93_Setup.exe" file to run the setup program.

3. If the setup program does not automatically run from the CD, use the windows explorer to start the setup program on the CD.

4. Follow the setup instructions on the screen.

The HEC-GeoHMS version 4.2 installation packages will automatically install the Water Utilities Application Framework, XML Data Exchange Tools, Arc Hydro Tools, and HEC-GeoHMS version 4.2. By default, the Water Utilities Application Framework, XML Data Exchange Tools, and Arc Hydro Tools will be installed to the C:\Program Files\ESRI\WaterUtils directory. HEC-GeoHMS will be installed to the C:\Program Files\HEC\HEC-GeoHMS directory.

Loading HEC-GeoHMS

Once HEC-GeoHMS is installed, it can be loaded within an ArcMap document. Select the **Tools→Customize** menu option. In the list of toolbars that appears, scroll down and select **ArcHydro Tools 9**, **HEC-GeoHMS Main View 9**, and **HEC-GeoHMS Project View 9** as shown in Figure 2-1.
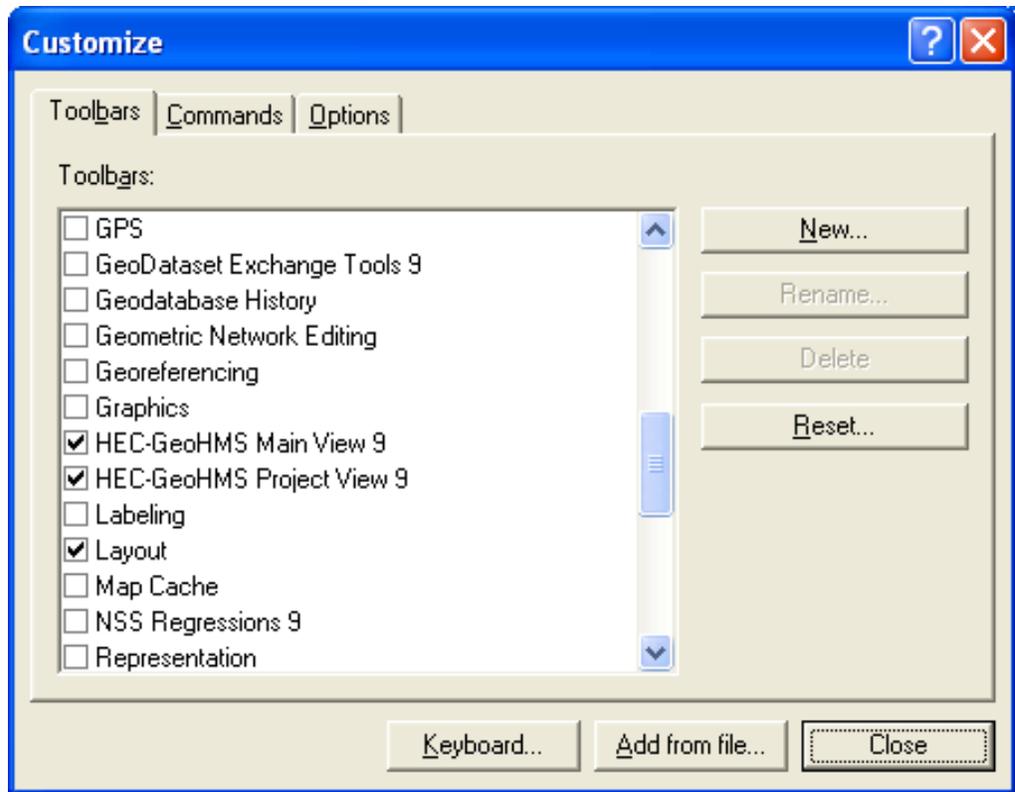
Figure 2-1. Load the Arc Hydro and HEC-GeoHMS Toolbars.

The user can load the Spatial Analyst extension by selecting the **Tools →
Extension** menu item. When properly installed and loaded, the **ArcHydro
Tools**, **HEC-GeoHMS** *MainView* and *Project View* toolbars are shown in
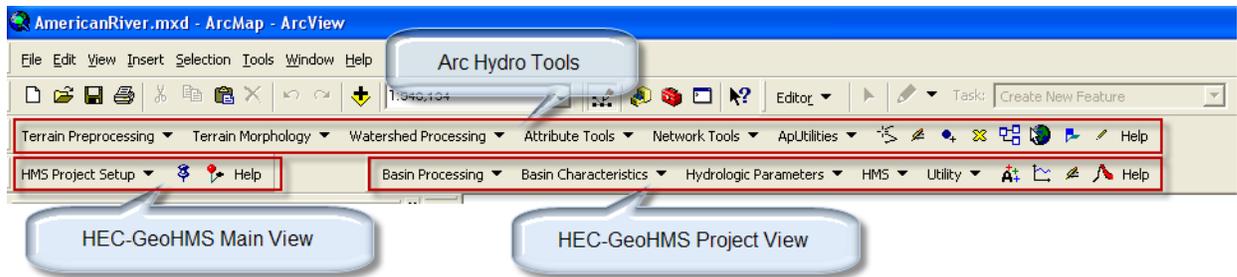Figure 2-2.

Figure 2-2. Arc Hydro and HEC-GeoHMS Toolbars Loaded within ArcMap**.**

C H A P T E R   3

Working with HEC-GeoHMS – An Overview

HEC-GeoHMS is a set of ArcGIS tools specifically designed to process geospatial data and create input files for the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). It includes integrated data management and a graphical user interface (GUI). Through the GUI, which consists of menus, tools, and buttons, the user can analyze the terrain information, delineate subbasins and streams, and prepare hydrologic inputs.

The relationship between GIS, HEC-GeoHMS, and HEC-HMS is illustrated in Figure 3-1, with the vertical dashed line separating the roles of GIS and watershed hydrology. HEC-GeoHMS provides the connection for translating GIS spatial information into model files for HEC-HMS. The GIS capability is used for data formatting, processing, and coordinate transformation. The end result of the GIS processing is a spatial hydrology database that consists of the digital elevation model (DEM), soil types, land use information, rainfall, etc.
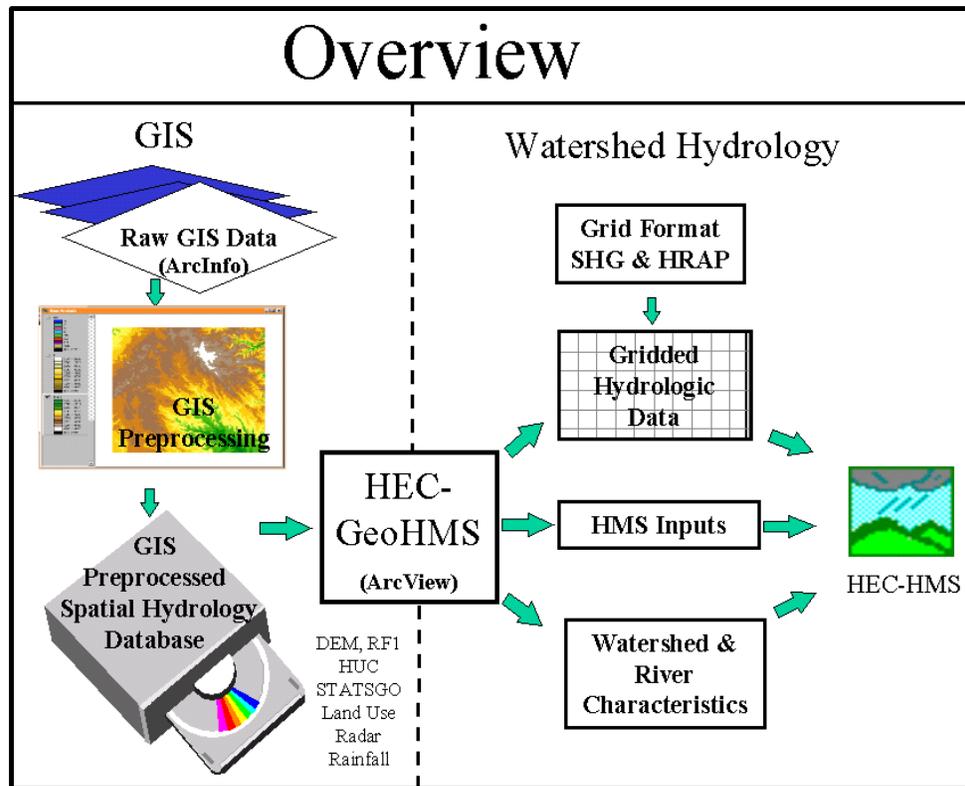
Figure 3-1. Overview of GIS and Hydrology Programs.

Currently, HEC-GeoHMS operates on the DEM to derive subbasin delineation and to prepare a number of hydrologic inputs. HEC-HMS accepts these hydrologic inputs as a starting point for hydrologic modeling. The following steps describe the major steps in starting a project and taking it through the HEC-GeoHMS process.

Contents

- Data Collection
- Data Assembly
- Terrain Preprocessing
- Hydrologic Processing
- Basin Processing
- Stream and Watershed Characteristics
- Hydrologic Parameters
- HMS Model Files

Data Collection

With the volume of spatial data available, it is important to identify the data that will meet project needs. Spatial data comes in many formats, resolutions, intended uses, quality, and prices. Prior to collecting data, the project specifications should be thoroughly reviewed for any recommendations. When a project does not specify a particular dataset, review the project's goals and objectives to help define acceptable data in terms of data storage, resolution, and accuracy. In addition, economic factors should be considered to determine the cost effectiveness in collecting and assembling the data or purchasing the data from a vendor. Whether the data are collected or purchased, metadata must also be acquired to provide necessary documentation. Data collection is discussed in greater detail in Chapter 4.

Data Assembly

Data assembly often requires efforts of an experienced GIS user. Because GIS data have many forms and formats, users often need to convert the data into a common format and then into a common coordinate system. For example, data describing the terrain should be in ESRI's ARC Grid format while vector data, such as stream alignments and stream flow gage locations, should be in the shapefile format. By having a common coordinate system, these datasets can be overlaid and spatial operations can be performed. A list of coordinate systems compatible with HEC-GeoHMS is contained in Chapter 5. Often times, datasets are provided in rectangular portions. When assembling data, especially terrain, special efforts are required to ensure that data are continuous along the edges. Terrain data assembly is discussed in Chapter 5.

Terrain Preprocessing

Using the terrain data as input, terrain preprocessing is a series of steps to derive the drainage network. The steps consist of computing the flow direction, flow accumulation, stream definition, and watershed delineation. These steps can be done step by step or in a batch manner. Once these datasets are developed, they are used in later steps for subbasin and stream delineation. It is important to recognize that the watershed and stream delineation in the terrain preprocessing steps is preliminary. In the next step - basin processing, the user has the capability to delineate and edit basins in accordance with project specifications. Terrain preprocessing is performed using the Arc Hydro Tools toolbar as shown in Figure 3-2. The Arc Hydro toolbar was designed for a wide range of use; therefore, only a few tools are applicable for a HEC-GeoHMS project.
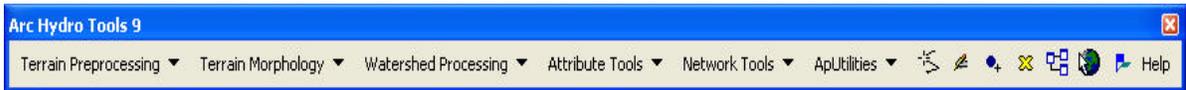
Figure 3-2. Arc Hydro Tools Toolbar.

Table 3-1 shows menu options required for a HEC-GeoHMS project. These functionalities will be discussed in greater detail in Chapter 6. Detailed documentation of all Arc Hydro Tools can be downloaded from ESRI's ftp site, ftp://ftp.esri.com/ArcHydro/Doc/.

The HEC-GeoHMS *Main View* toolbar, as shown in Figure 3-3 is generally responsible for setting up the spatial database for the hydrologic study area.

Table 3-2 and Table 3-3 describe menu options and toolbar buttons on the HEC-GeoHMS *Main View* toolbar.

Figure 3-3. HEC-GeoHMS Main View 9 Toolbar.

Table 3-1. Arc Hydro Tools Menu Options.

Menus	Descriptions
	The Arc Hydro Tools **Terrain Preprocessing** menu is used to process and analyze the terrain. It has the capability of processing the terrain in a step by step process. It also has data management capability for tracking datasets as they are derived.
	The **ApUtilities** menu contains miscellaneous tools dealing with assigning roles for datasets and managing XML ID configurations. Most users should not use this menu except Set Target Locations, which useful for specifying project pathnames after moving a project.
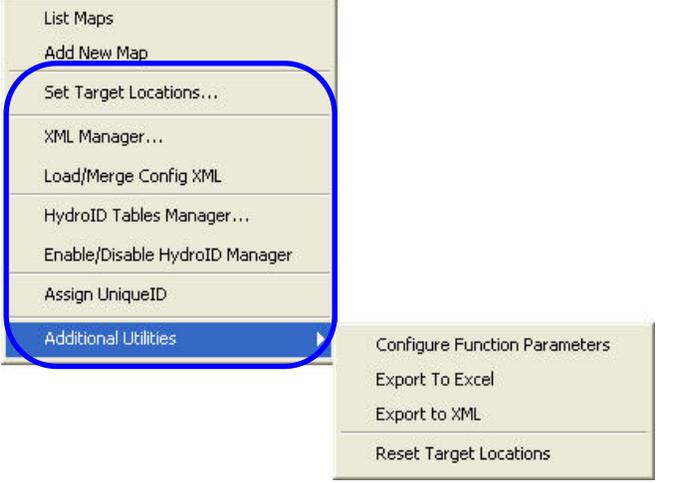
Table 3-2. HEC-GeoHMS Main View Menu Options**.**

Menus	Descriptions
	After the terrain has been preprocessed, the **HMS Project Setup** menu is used to extract the terrain information for the project area. The extracted information will be placed in a separate data frame, referred to as the project data frame.

Table 3-3. HEC-GeoHMS Main View Toolbar Buttons.

Buttons	Names	Descriptions
	Add Project Points	Add point for the watershed outlet location. Terrain data will be extracted for project watershed.
	Identify Contributing Area	Identify the drainage area at a point.
Help	Help	Access context sensitive help on any tool or menu.

Hydrologic Processing

Hydrologic processing is performed with the HEC-GeoHMS *Project View* toolbar, which is generally responsible for hydrologic model construction and setup. The *Project View* toolbar is shown in Figure 3-4. Menu options and toolbar buttons are described in Table 3-4 and Table 3-5. Typically, the user proceeds from left to right when using this toolbar to generate HEC-HMS input files.
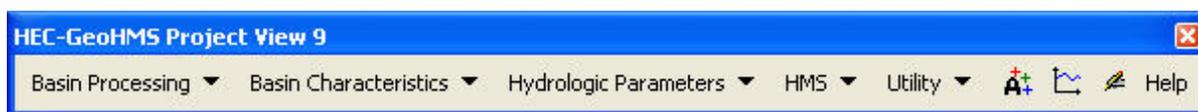
Figure 3-4. HEC-GeoHMS Project View Toolbar.

Basin Processing

In this step, the user is provided with a variety of interactive and batch-mode tools to delineate subbasins. In the interactive mode, the tools allow the user to see the delineation results, assess outcomes, and accept or deny the resulting delineation. When the user performs interactive basin processing, the program will prompt the user to confirm the results. In the batch mode, the user can supply the outlet locations and the program will delineate subbasins at those locations, but without interaction to view and revise.

Stream and Watershed Characteristics

When the stream and subbasin delineation has been finalized, the user can extract physical characteristics. Physical characteristics for a stream include the length, upstream and downstream elevations, and slope. This information is extracted from the terrain data and stored in attribute tables. Similarly, physical characteristics for a subbasin, such as longest flow lengths, centroidal flow lengths, and slopes, are extracted from terrain data and stored in the attribute table. These physical characteristic could be exported and used externally to estimate hydrologic parameters.

Table 3-4. HEC-GeoHMS Project View Menus.

Menus	Descriptions
Data Management Basin Merge River Merge Split Basin at Confluences Import Batch Points Delineate Batch Points	The **Basin Processing** menu provides the user with interactive and batch processing capabilities to modify existing subbasins and delineate new subbasins. There are also several tools available for subdividing basins and preparing batch points for delineation.
Data Management River Length River Slope Basin Slope Longest Flow Path Basin Centroid Centroid Elevation Centroidal Flow Path	The **Basis Characteristics** menu computes the physical characteristics for both the streams and subbasins based on the terrain data. The stream characteristics will be stored in the stream's attribute table. Similarly, the basin characteristics will be stored in the subbasin's attribute table.
Data Management Select HMS Processes River Auto Name Basin Auto Name Grid Cell Processing Subbasin Parameters from Raster Subbasin Parameters from Features Muskingum-Cunge and Kinematic Wave Parameters TR55 Flow Path Segments TR55 Flow Segment Parameters TR55 Export Tt Parameters to Excel CN Lag Method	The **Hydrologic Parameters** menu provides the user with tools to estimate hydrologic parameters and to develop a grid-based representation of the watershed.

Menus		Descriptions
Data Management Map to HMS Units Check Data HMS Schematic Toggle HMS Legend ▶ Add Coordinates Prepare Data for Model Export Background Map File Grid Cell Parameter File Basin File Generate ASCII Grids Generate DSS from ASCII Grid Meteorologic Model ▶ HMS Project Setup Import HMS File		The **HMS** menu performs a number of tasks related to the creation of HEC-HMS input files.
Generate CN Grid Features to Rasters Gage Thiessen Polygon Add Latitude Longitude		The **Utility** menu contains tools for estimating hydrologic parameters.

Table 3-5. HEC-GeoHMS Project View Toolbar Buttons.

Buttons	Names	Descriptions
🅰	Subbasin Divide	Subdivide existing subbasin at user-specified point.
〰	River Profile	View the stream profile with elevation based on the terrain data.
✐	Interactive Flow Path	Interactively trace the flow path downstream of a user-specified point (for visualization purposes).
Help	Help	Access context sensitive help on any tool or menu.

Hydrologic Parameters

In addition to extracting physical characteristics, the user has the option to estimate initial values of various hydrologic parameters. Hydrologic parameters, such as the curve number, can be extracted as basin average and grid-based quantities from soil and land use databases. Other hydrologic parameters, such as time of concentration, are computed from various datasets that include terrain and precipitation data.

HEC-HMS Model Files

HEC-GeoHMS produces a number of files that can be used directly by HEC-HMS. These files include background map files, the basin model file, the meteorologic model file, and a project file. When the HEC-GeoHMS generated files are brought into an HEC-HMS project, the user has a partially completed HEC-HMS model. To complete the model, hydrologic parameters need to be estimated and entered into the basin model using editors provided within HEC-HMS. In addition, the user can add or remove hydrologic elements and their connectivity to reflect difficult modeling areas. Finally, the user needs to develop a meteorologic model to represent the precipitation and a control specifications to define the simulation time window. When these three model components are completed, the user can compute a simulation run and calibrate the hydrologic model.

C H A P T E R   4

Data Collection

The purpose of this chapter is to illustrate some of the ways spatial datasets are used in hydrology. By understanding how the datasets are utilized, the user can focus adequate time, effort, and attention on the appropriate dataset. When collecting data, the user can assess the quality of the data and its metadata to insure that they meet project specifications. This chapter also provides a list of data types, descriptions, and possible sources as a starting point for collecting data. Below is an outline of Chapter 4.

Contents

- Data Usage
- Data Types, Descriptions, and Sources

Data Usage

Spatial data are collected and used in a variety of ways. Understanding how data are used provides many important guidelines in data collection. When the data are intended as input in the program, they should be collected with attention given to accuracy, resolution, validity of data source, and quality of documentation. Oftentimes when the best available data are not adequate, the appropriate course of action will be to develop data that meets project specifications instead of putting efforts in correcting "bad" data. Terrain data is critical because HEC-GeoHMS uses it to determine drainage paths and physical characteristics. Other data often serve many useful roles, such as reference information, documentation, and visualization.

Reference data depicting known stream alignments, stream flow gage locations, and drainage boundaries are very helpful for comparing and validating the GIS delineated streams and subbasins. GIS data can be collected and used with existing spatial data to document field conditions. For example, photographs of drainage structures, as shown in Figure 4-1, and other field conditions can be photographed and geographically located to more effectively document these facilities and show their spatial relationships. GIS data can be used to visualize multiple datasets. For example, aerial images can be overlaid with subbasin boundaries to see land use patterns and variability.
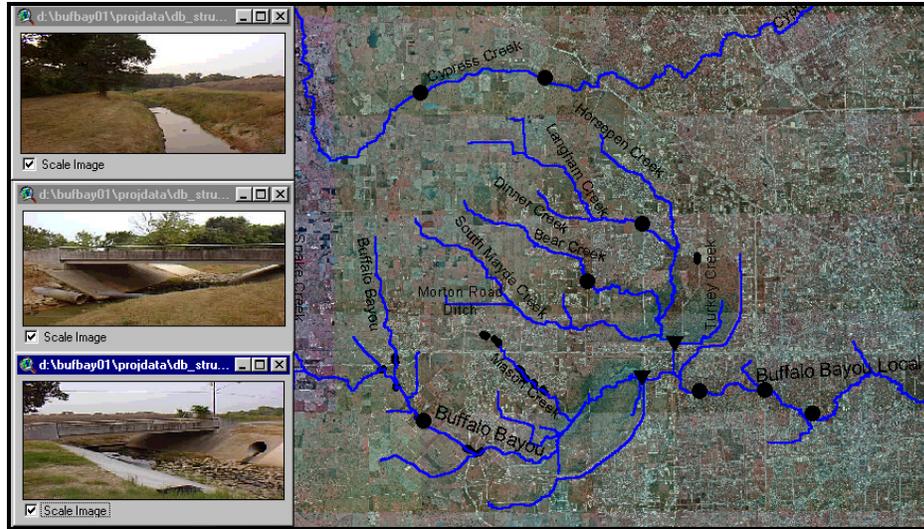
Figure 4-1. Field Documentation with Photographs.

Data Types, Descriptions, and Sources

The amount of GIS data available through government institutions and data vendors has grown greatly over the years. Some of these data are available for free while others are provided for a fee. Table 4-1 provides a starting point for collecting and searching for GIS data. The list provides brief descriptions of the data used in hydrology and their sources. Additional information on the datasets can generally be found at the respective institution's web site. Although terrain data is the minimum data requirement to run HEC-GeoHMS, the other datasets contains important information for constructing the hydrologic model. Finally, metadata must also be collected for documentation. At a minimum, the metadata should include the data source and projections information.

Table 4-1. Data Types, Descriptions, and Sources.

Digital Elevation Model (DEM)
DEMs are typically generated from USGS maps and are available for multiple resolutions. DEM data can be gathered from the USGS National Elevation Dataset (NED) program. Other sources like Light Detection And Ranging (LIDAR) and Interferometric Synthetic Aperture Radar (IFSAR) can also be used. A DEM at a 30-by-30-meter resolution is generally used for modeling the terrain because of its widespread availability. Source: http://ned.usgs.gov/www.usgs.gov
Hydrologic Unit Code (HUC)
The HUC contains the major watershed boundaries as published by the USGS. The HUC shows watershed boundaries at 4 levels of detail ranging from local to regional drainage area. Source http://www.epa.gov/waterscience/ftp/basins/gis_data/huc/

http://nhd.usgs.gov/

Digital Line Graph (DLG)

In addition to a line representation of transportation data, such as streets and railroads, DLGs include water features, such as stream networks and irrigation ditches. DLGs are maintained by the United States Geological Survey (USGS).

Source
http://nhd.usgs.gov/

Stream Networks

Stream networks are maintained by the Environmental Protection Agency (EPA). Many versions of stream networks are available as the River Reach File (RF1), the River Reach File (RF3), and the National Hydrography Dataset (NHD).

Source
www.epa.com
http://nhd.usgs.gov

Streamflow Gage Data

Although stream flow gage data are natively non-spatial, the latitude and longitude coordinates of the gage are provided most of time. The stream flow gage locations can be converted into a GIS dataset by using the coordinate information. The majority of stream flow gages are maintained by the USGS, state governments, and flood control districts.

Source
www.usgs.gov

Digital Orthophoto Quarter Quads (DOQQ)

Digital aerial photos are available at various resolutions and can be used as a background base map.

Source
Various governmental authorities and commercial vendors.

Drainage Facilities Photographs

Photographs can be taken of key drainage structures. The photographs often include the areas looking upstream and downstream of the structures as well as the faces of the structures.

Source
Field observations conducted by the modelers.

Street Data

Street level data that is provided by the US Census Bureau often needs format conversion before it can be accessed though GIS software. A number of data vendors have performed the format conversion as well as other value-added improvements.

Source
United States Census Bureau and commercial vendors.

Soil Types Data
The Soil Surveys Geographic Database (SSURGO) contains soil data at the county level and the State Soil Geographic Database (STATSGO) contains soil data at the state level.   Source http://soils.usda.gov/survey/geography/
Land Use/Land Cover
The USGS Land Use Land Cover (LULC) provides good coverage but may be dated. State GIS websites can also be a source of land use data. Source http://edc.usgs.gov

C H A P T E R   5

Data Assembly

The assembly of GIS datasets often requires conversion of file formats and coordinate systems, as well as geographical referencing of non-spatial datasets. In addition to file formatting, data assembly often requires a number of map related transformations to ensure that vector and raster data are in proper alignment and map distortions are minimized. All data layers should have the same datum, projection, and common coordinate system in order to perform spatial analysis.

When data are assembled with GIS software, the user should be aware of the distinctions between various spatial operations. For example, when the user joins various sized terrain tiles into a continuous terrain model, the ArcInfo grid "merge" and/or "mosaic" commands produce different results. The "merge" command will overwrite overlapping areas along the edges with the data that is merged last. However, the "mosaic" command will perform smoothing of data values along the overlapping areas. Recognizing the different approaches for combining terrain is crucial to prevent abrupt changes in elevation along the edges of terrain tiles that could affect drainage path determination. Other data assembly issues include combining various datasets of different resolution, filling data gaps as shown in Figure 5-1, and data re-sampling techniques. Below is an outline of Chapter 5.

Contents

- Terrain Data Assembly
- Data Issues
- Hydrologic Coordinate System Specifications
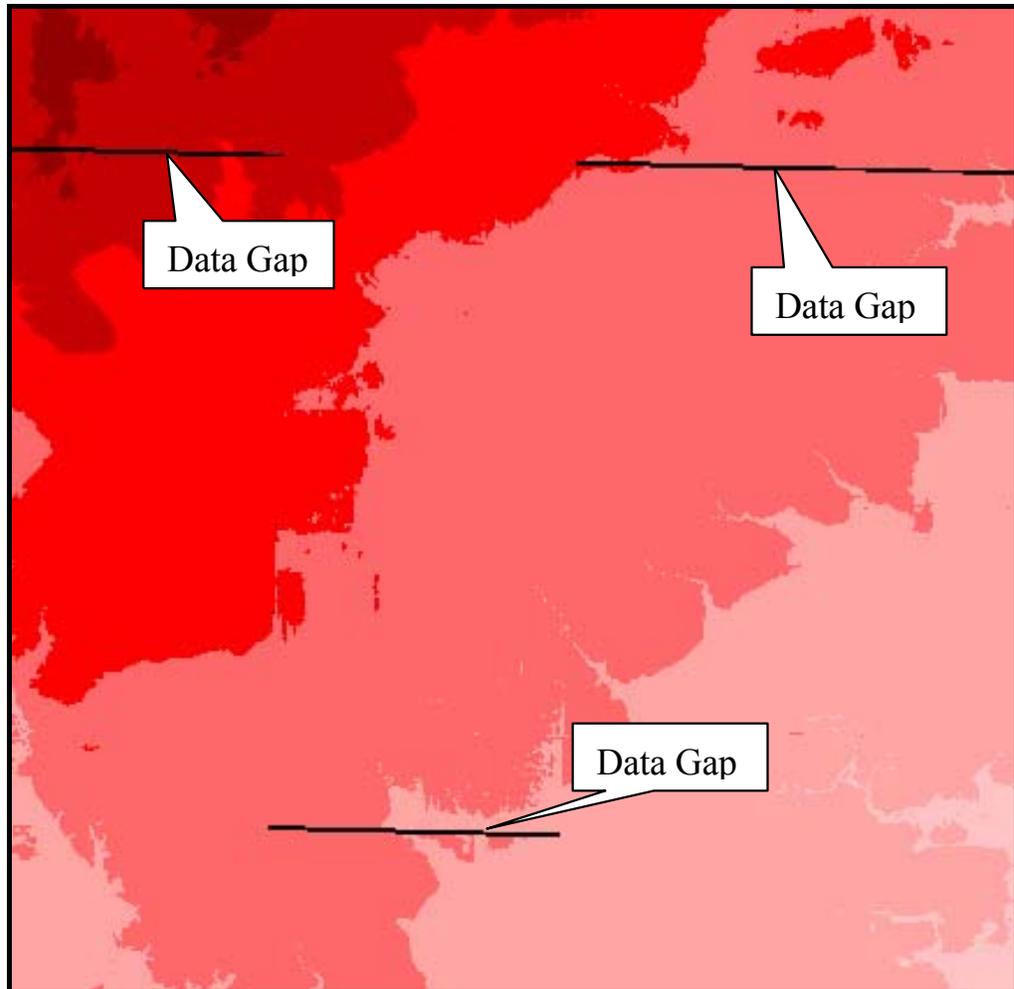
Figure 5-1. DEM Model with Data Gaps.

Terrain Data Assembly

The growth and availability of seamless terrain data in recent years has provided users with better quality data and minimized the need to manually assemble terrain datasets from small tiles of data. Also, the seamless data has been edge-matched and contains the same coordinate system, datum, and units. However, in some cases where manual assembly of terrain data is required, the user should be aware of many important issues related to the data age, units, coordinate system, datum, etc. Ultimately, the quality of the results depends heavily on the terrain data. Traditionally, continuous terrain data was assembled manually from joining tiles of terrain information as shown in Figure 5-2. Then, data gaps were filled in with interpolated elevation values from neighboring grid cells to make a continuous DEM model as shown in Figure 5-3. However, when terrain data were assembled in this manner, they often contained errors and areas that were problematic for computing drainage patterns from a hydrologic standpoint. Often, terrain data undergoes extensive editing to correct problematic areas. Automated routines are available to fill

depressions in the DEM. The "depressionless" DEM may still not have streams located properly when compared to other map and photo resources. Extensive editing is usually required to create a hydrologically corrected or conditioned DEM. The availability of seamless DEM data from the USGS has dramatically saved time and effort in building quality terrain data; however, there are still many issues surrounding terrain data assembly as discussed below.

Waller NW	Magnolia West	Magnolia East	Oklahoma	Tamina	Outlaw Pond	Splendora	Plum Grove
Waller	Hockley	Rose Hill	Tomball	Spring	Maedan	Moonshine Hill	Huffman
Hockley Mound	Warren Lake	Cypress	Satsuma	Aldine	Humble	Harmaston	Crosby
Brookshire	Katy	Addicks	Hedwig Village	Houston Heights	Settegast	Jacinto City	Highlands
Fulshear	Richmond Northeast	Clodine	Alief	Bellaire	Park Place	Pasadena	La Porte
Orchard	Richmond	Sugar Land	Missouri City	Almeda	Pearland	Friends-wood	League City

Figure 5-2. DEM Tile Quad Names.
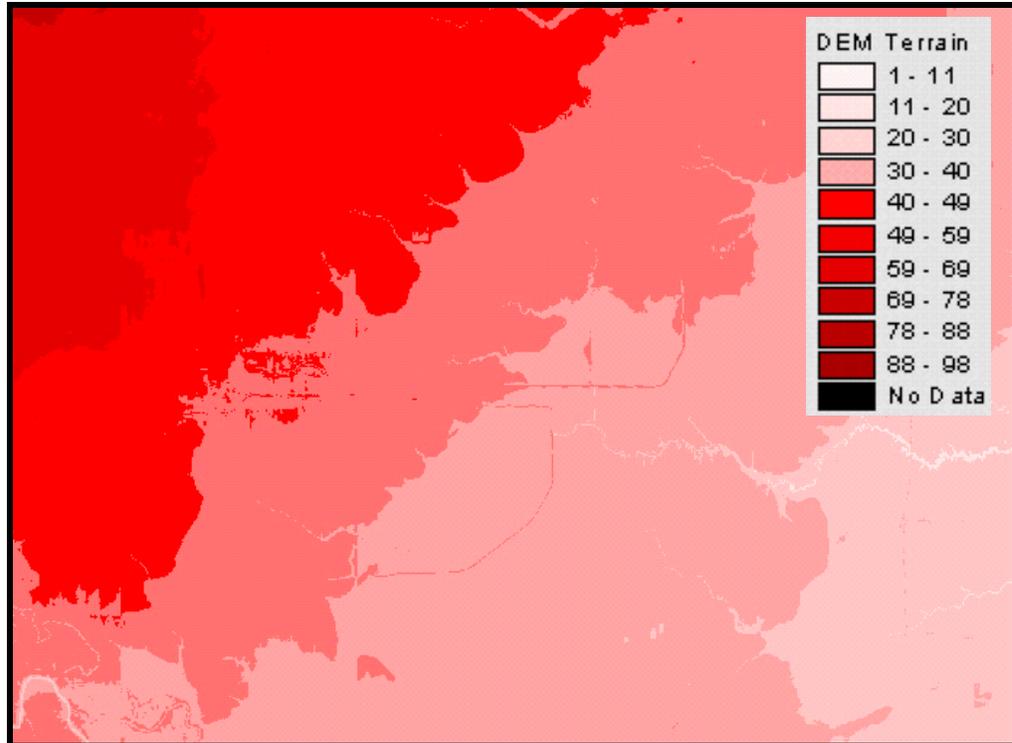
Figure 5-3. Continuous DEM.

Hydrologically Corrected Terrain Model

The preparation of "hydrologically corrected" terrain data often requires much iteration through drainage path computations. To represent the movement of water through the watershed, the "hydrologically corrected" DEM must have the proper accuracy and resolution to capture details of the stream network. The problems often arise when the watershed has low relief and the resolution is not fine enough to delineate the stream network.

The DEM contains elevation averages at regular intervals that may not accurately represent stream locations and watershed boundaries. For example, stream and watershed delineation sometimes does not coincide with published data sources, like those from the EPA (RF1 and RF3). A "hydrologically corrected" terrain model must represent accurate stream patterns across the DEM. Many factors, such as cell resolution, accuracy, and topographic relief deserve careful consideration because they often affect the quality of the terrain model. In theory, combining GIS datasets of different resolutions is generally not recommended because of the difficulty in assessing the accuracy and the precision of the resulting dataset. In practice, however, combining datasets of various resolutions is necessary due to lack of uniform data and data coverage.

Depressionless Terrain Model

In contrast to the effort required for the "hydrologically corrected" DEM, the "depressionless" DEM is simply constructed using automated algorithms to fill

in the sinks or depressions in the assembled DEM. In a depressionless DEM, water moves across the terrain model towards the edge. A depressionless DEM does not address closed basins or substantial non-contributing areas. Because of the complexity and effort required for constructing a hydrologically corrected terrain model, a depressionless terrain model often serves as a simpler substitute in the analysis. For study regions with moderate to high topographic relief, the depressionless terrain model may be adequate for the analysis. For low-relief regions, however, the depressionless terrain model often needs additional work to adequately represent the terrain. For example, a watershed with flat terrain often requires editing to force proper drainage.

Until better data quality and editing techniques are available, users may struggle with terrain data assembly. It is important to identify the issues with the data so that the user can understand and fix the problems.

Data Issues

Table 5-1 contains a number of issues that might be encountered when assembling terrain data and possible solutions to those problems.

Table 5-1. Data Issues.

Data Issues	Descriptions and Potential Solutions
1. Low-relief terrain	With low-relief terrain, it is often difficult to delineate reliable drainage paths from relative average elevations. Finer resolution terrain data should be considered for the flat region if it is available. However, finer resolution data has its tradeoffs with increased storage and longer computation times. Other possible approaches include imposing the published stream alignment onto the terrain.
2. Man-made structures	Man-made structures like dams often alter the flow direction because the water surface prevents the mapping of the reservoir bottom. In addition, when the terrain data is filled, the terrain is represented as a flat surface behind the dam. A potential way to deal with this situation would be to put an artificial notch at the dam and carve a stream onto the terrain.
3. Missing elevation data	Missing elevation data often exist along the edges and can be filled with interpolated values from neighboring elevations. Bad elevation data due to re-sampling effects and other causes can be fixed with spot elevation editing on a cell by cell basis or by region.
4. Subsidence and impacts	The ground surface may subside due to overdraft of groundwater. Recognizing when the terrain data were developed, the terrain data should be checked for subsidence.
5. Subsurface flow	Volcanic soils, limestone formations, and canals/tunnels lead to drainage patterns that the terrain cannot reproduce. These difficult features must be handled in HEC-GeoHMS by delineating the subbasin downstream of the feature to avoid the problem areas or by

	modifying the terrain to impose the correct drainage patterns.

Hydrologic Coordinate System Specifications

Transforming spatial data into a common coordinate system ensures proper alignment of various datasets for spatial analysis. Coordinate system transformation often leads to map distortions of direction, distance, shape, and area. From a hydrologic perspective, where the terrain and precipitation are important, a suitable coordinate system should preserve area. One possible coordinate system is the Albers Equal Area projection, which preserves area. This coordinate system is defined in Table 5-2.

The user is allowed to analyze terrain data in a number of coordinate systems and projections, including Albers-Equal Area, Universal Transverse Mercator (UTM), Transverse Mercator, Lambert, and the State Plane Coordinate System. The user should always verify the terrain data has been projected into a compatible projection before using HEC-GeoHMS.

Table 5-2. Standard Hydrologic Grid Coordinate System.

Projection:	Albers Equal-Area
Spheroid:	GRS80
Datum:	North American Datum, 1983 (NAD83)
Central Meridian:	96 degrees 0 minutes 0 seconds West
Latitude of Origin:	23 degrees 0 minutes 0 seconds North
1st Standard Parallel:	29 degrees 30 minutes 0 seconds North
2nd Standard Parallel:	45 degrees 30 minutes 0 seconds North
False Easting:	0.0
False Northing:	0.0
Units:	Meters

C H A P T E R   6

Terrain Preprocessing

Terrain preprocessing marks the first step in developing an HEC-GeoHMS project. In this step, a terrain model is used as an input to derive eight additional datasets that collectively describe the drainage pattern of the watershed and allows for stream and subbasin delineation. The first five datasets are grid layers that represent the flow direction, flow accumulation, stream definition, stream segmentation, and watershed delineation. The next two datasets are vector layers of the watersheds and streams. The last dataset, the aggregated watersheds, is used primarily to improve the performance in watershed delineation. Terrain preprocessing is performed using the **Arc Hydro Tools** Toolbar. Detailed documentation for Arc Hydro can be downloaded from ESRI ftp site, ftp://ftp.esri.com/ArcHydro/Doc/.

The terrain data is processed and analyzed using the 8-pour point approach to determine flow paths. Terrain analysis is computer intensive and some steps may require several hours, depending on the amount of data and computer resources. After terrain preprocessing is completed, the resulting datasets serve as a spatial database for the study. With the information centralized in the spatial database, pertinent datasets can be extracted for subsequent work to build the hydrologic models. Preliminary watershed and stream delineation provides results that can be verified with published information to detect possible errors in the terrain data. If errors are detected, the DEM should be edited. Arc Hydro contains a number of tools for modifying the terrain data. When the DEM has been revised to better represent field conditions, it should be processed again to update the spatial database.

This chapter will discuss terrain preprocessing features and functionality. Below is an outline of Chapter 6.

Contents

- Features and Functionality
- Data Management
- Terrain Reconditioning
- Terrain Preprocessing

Features and Functionality

The HEC-GeoHMS and Arc Hydro extensions add features and functionality to the standard ArcMap menus. The HEC-GeoHMS and Arc Hydro toolbars are shown in Figure 6-1. All terrain prepossessing tools are contained in the **Arc Hydro Tools** toolbar. A number of capabilities related to terrain processing are under the **Terrain Preprocessing** menu. Once terrain processing is complete, the data can be extracted to support hydrologic model creation via the **HMS Model Setup** menu on the **HEC-GeoHMS Main View** toolbar.

Figure 6-1. ArcMap Project with Arc Hydro Tools and HEC-GeoHMS Toolbars Highlighted.

Data Management

Data that are introduced or derived by Arc Hydro and HEC-GeoHMS extensions are managed through role association. For example, when the DEM is added to the ArcMap document, HEC-GeoHMS will associate it with "RawDEM", which is the original DEM. When the Fill tool is used, the program will automatically offer the RawDEM as default for creating a depressionless DEM. Aside from associating datasets with their intended roles as they are created, data management allows the user the ability to bring in other datasets and assign a role to them. For example, if the user has developed the flow direction and accumulation grid in another program, they can bring these data in as layers and assign their roles. This is a good way to keep track of data as they are generated. Figure 6-2 shows the data management of layers on the left-hand side and the assigned layers on the right-hand side. The "Null" entry for the assigned layer indicates that the appropriate layer has not been created and assigned. When the appropriate layers are created, their names replace the "Null" entry. Arc Hydro was created as a general hydrology tool. Therefore, a number of the datasets created by Arc Hydro are not applicable to an HEC-GeoHMS project. Only those datasets required for an HEC-GeoHMS project are highlighted in Figure 6-2.
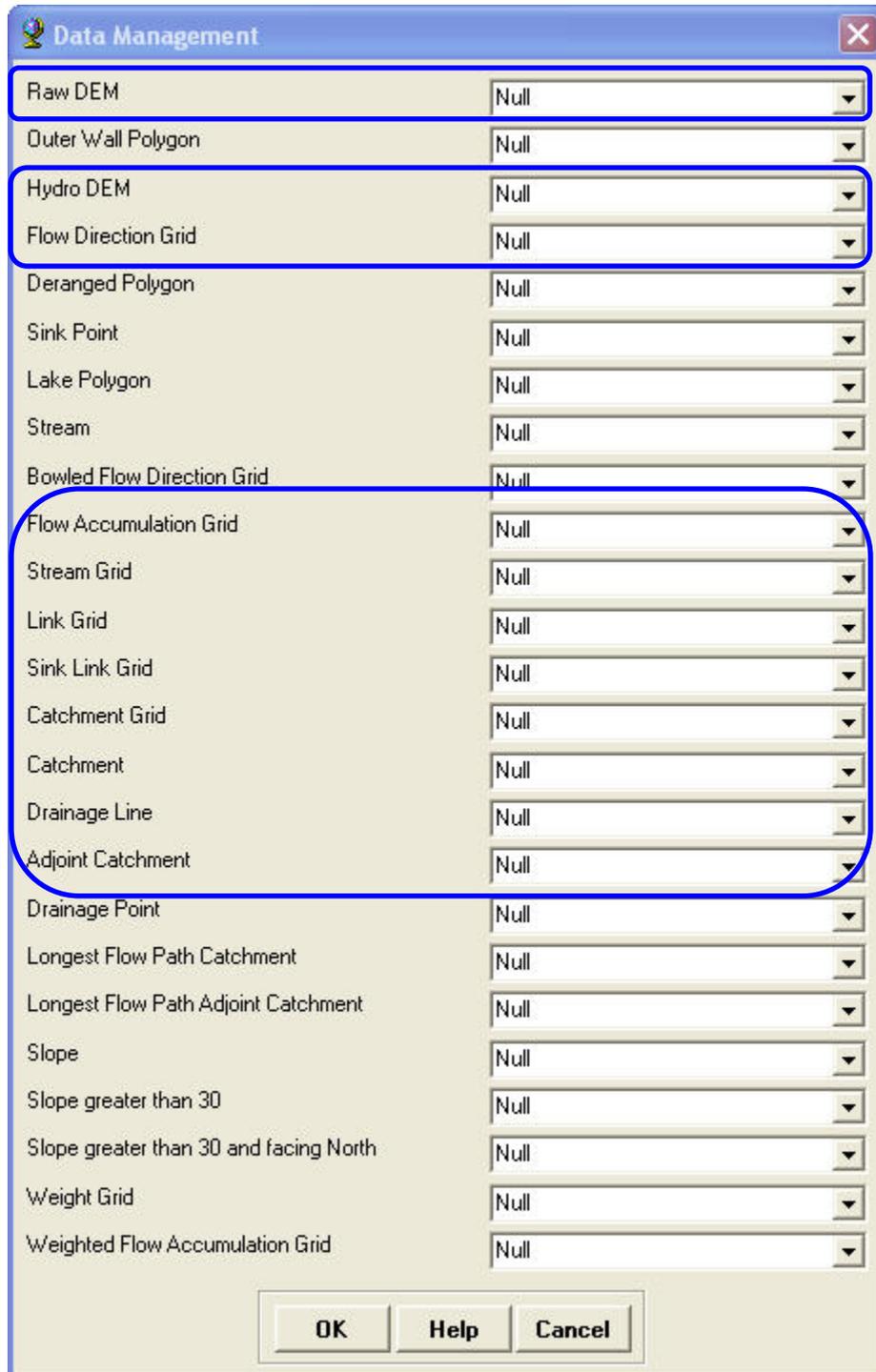
Figure 6-2. Data Management Window.

Terrain Reconditioning

Many users in the past have used the simple "burning in" techniques to force a stream network on the DEM. This simple "burning in" technique allows the user to abruptly lower only the stream cell elevation by a fixed amount. Similar to the simple "burning in" technique, the new **Terrain Reconditioning** method, located on the **Arc Hydro Tools** toolbar allows the user to lower the elevation of the stream cell and also provides an option to gradually lower the neighboring cells along the stream. This method creates a gradual transition from the overbank to the stream. This method can be used to eliminate the undesirable side effect of fictitious islands near the stream centerline that parallel the stream as shown in Figure 6-3.

The **DEM Reconditioning** tool modifies the terrain by lowering grid cells along line features. This function requires two inputs, a grid and a line layer, which must be present in the data frame to be accessible from the dropdown menu. The function outputs a reconditioned grid. Both input data layers should be in the same projection.
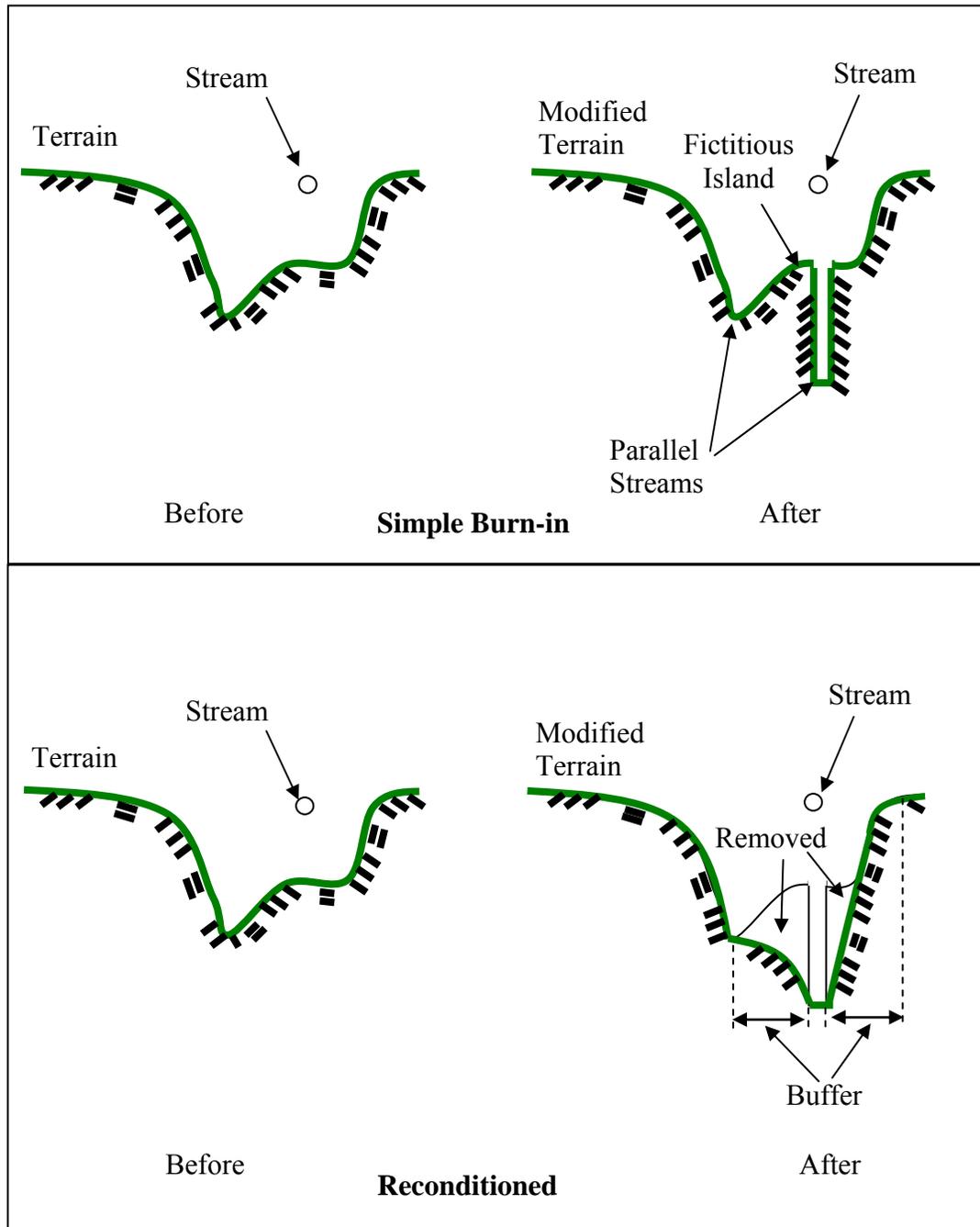
Figure 6-3. Cross-Section View of Burning-In Techniques.

Open the DEM reconditioning tool by selecting the **Terrain Preprocessing→DEM Manipulation→DEM Reconditioning** menu option. After opening the tool, the user needs to select the raw DEM, the stream layer ("AGREE Stream") which could be a published stream network, and the output DEM ("AGREE DEM"). Then the user must set three reconditioning parameters as shown in Figure 6-4.
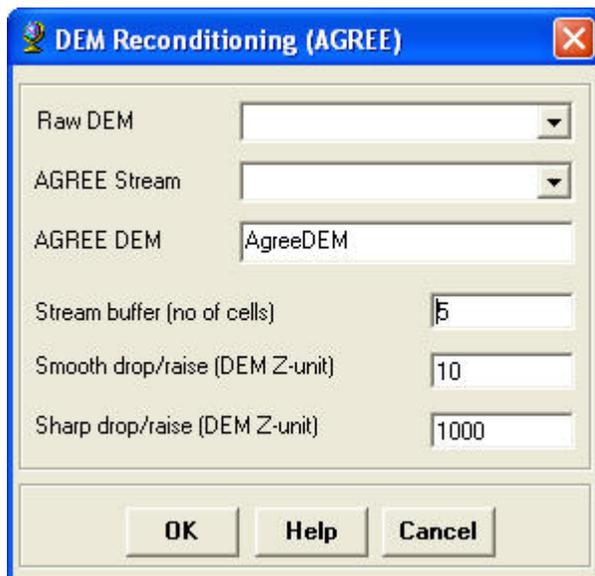
Figure 6-4. DEM Reconditioning Tool.

- Stream buffer (number of cells) – this is the number of cells around the vector line theme for which the smoothing will occur.

- Smooth drop/raise (DEM Z-unit) – this is the amount (in vertical units) that the river will be dropped if the number is positive or the fence will be extruded if the number is negative. This value will be used to interpolate the DEM into the buffered area between the boundary of the buffer and the dropped/raised vector feature.

- Sharp drop/raise (DEM Z-unit) – this is the additional amount (in vertical units) that the river will be dropped if the number is positive, or the fence will be extruded if the number is negative. This amount of additional burning/fencing will be on top of the smooth buffer interpolation.

The original AGREE method was developed with Arc/Info by Ferdi Hellweger at the University of Texas at Austin in 1997. For a full reference to the procedure refer to the web link: http://www.ce.utexas.edu/prof/maidment/GISHYDRO/ferdi/research/agree/agree.html.

Another useful tool for editing the terrain data is the **Build Walls** tool. Published subbasin delineations or those from past studies can be used to build walls in the terrain. This will ensure that subbasin delineations from the terrain data are the same as existing datasets. Select the **Terrain**

Preprocessing→**DEM Manipulation**→**Build Walls** menu option. The ***Build Walls*** editor is shown in Figure 6-5. The user must define the input DEM and a polygon layer of subbasin boundaries. Both outer wall and inner wall polygon layers can be defined, but only one is required. The outer wall polygon layer represents the boundary of the entire drainage basin and the inner wall polygon layer represents subbasins within the drainage basin. The breach line layer is used to represent the stream network. The program will lower the cell walls in which the breach lines overlay allowing water to flow out of the subbasin. The inner wall height is used to raise grid cells in the terrain data layer that overlay boundaries in the inner wall layer. The outer wall height will automatically be double the inner wall height. The inner wall buffer and breach line buffer are the number of cells around these layers that will be raised or lowered.
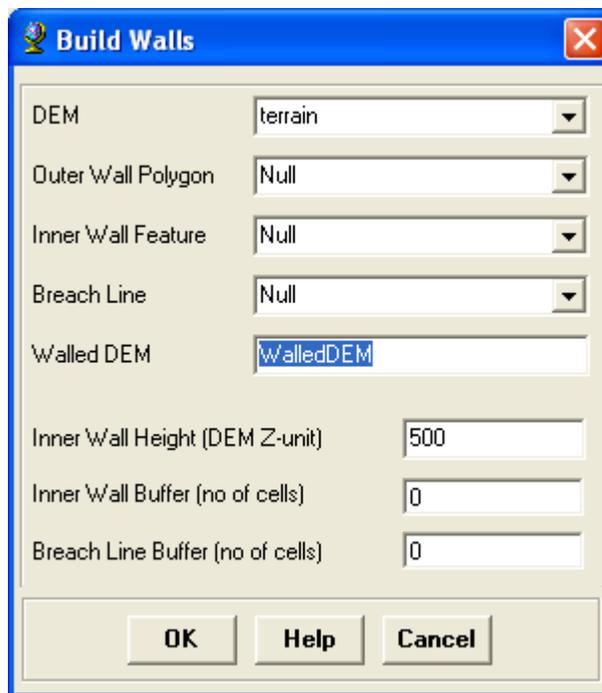
Figure 6-5. Build Walls Tool.

For best results, users will often need to make multiple passes through this burning/fencing process. After the reconditioned DEM is obtained, users should use the **Fill Sinks** tool to remove potential sinks generated from the reconditioning process.

Terrain Preprocessing

By applying the GIS algorithms discussed below, the terrain can be processed in a step-by-step process where datasets are derived after each operation. Greater control over the results is possible because the user verifies the results and makes decisions before proceeding. For example, prior to performing the stream definition, it is good practice to use the Identify Contributing Area tool

and check the contributing area at several locations. This information on the area can help pick a threshold for adequate stream definition.

GIS Approach

GIS approaches toward hydrologic analysis require a terrain model that is hydrologically corrected. A hydrologically corrected DEM is one in which all depressions have been filled. The GIS analyzes the depressionless terrain data by applying the 8-point pour model, where water flows across the landscape from cell to cell based on the direction of the greatest elevation gradient. Steps in the analysis include filling depressions or pits, calculating flow direction and flow accumulation, delineating streams with an accumulation threshold, defining streams, segmenting streams, delineating watersheds, processing watershed polygons, processing streams, and aggregating watersheds.

Depressionless DEM

The depressionless DEM is created by filling the depressions or pits by increasing the elevation of the pit cells to the level of the surrounding terrain. The pits are often considered as errors in the DEM due to re-sampling and interpolating the grid. For example, in a group of three-by-three cells, if the center cell has the lowest elevation compared to its eight neighboring cells, then the center cell's elevation will be increased equaling the next lowest cell. Filling the depressions allows water to flow across the landscape. This assumption is generally valid when a large storm event fills up the small depressions and any incremental amount of water that flows into the depression will displace the same amount of water from the depression.

The steps to fill depressions are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing →
  DEM Manipulation → Fill Sinks**.

- The *Fill Sinks* editor is shown in Figure 6-6. The user must specify the input DEM (also referred to as the unfilled DEM).

- A "Deranged Polygon" is used to define areas that will not be filled. A deranged polygon should not be defined when creating a HEC-GeoHMS project.

- The filled DEM is referred to as the "Hydro DEM". The default name is "Fil", which can be overwritten by the user.

- When creating a HEC-GeoHMS project, the "Use IsSink Field" and "Fill Threshold (DEM Z-unit)" option should not be selected. Make sure "Fill All" is selected.

- Press **OK**.
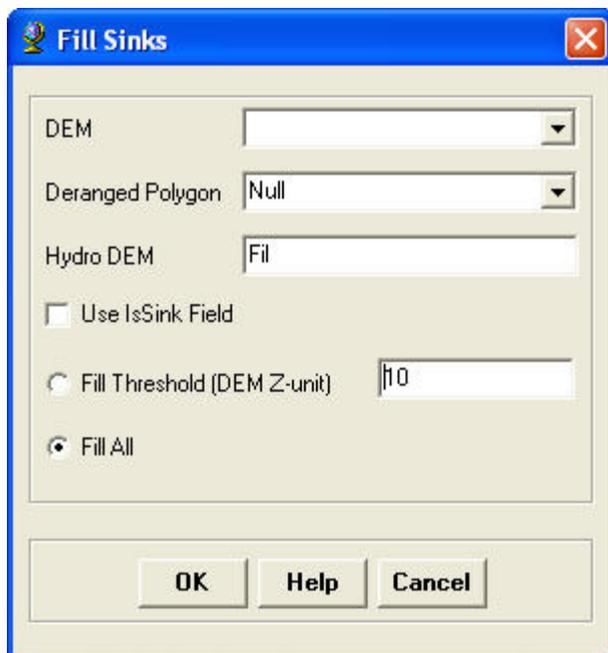
Figure 6-6. Fill Sinks.

The hydrologically corrected DEM is used as the starting point for delineating subbasins and river reaches. With the step-by-step approach, each step begins with the program offering a list of inputs that will be used to produce the output grid or vector layer. If the step-by-step procedure is performed in a sequential order, the program will automatically offer the correct data input for processing. In a few instances, when certain steps are repeated or performed out of order, it would be important to verify that the appropriate datasets are used.

Flow Direction. This step defines the direction of the steepest descent for each terrain cell. Similar to a compass, the eight-point pour algorithm specifies the following eight possible directions:

<table>
<tr><td>

1 = east, 2= southeast,

4 = south, 8 = southwest,

16= west, 32=northwest,

64 = north, 128=northeast.

</td><td>

</td></tr>
</table>
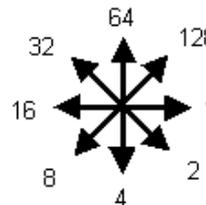
The steps to compute flow directions are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing →
  Flow Direction**. The *Flow Direction* editor is shown in Figure 6-7.

- Confirm that the input of the "Hydro DEM" is the hydrologically
  corrected DEM (filled DEM).
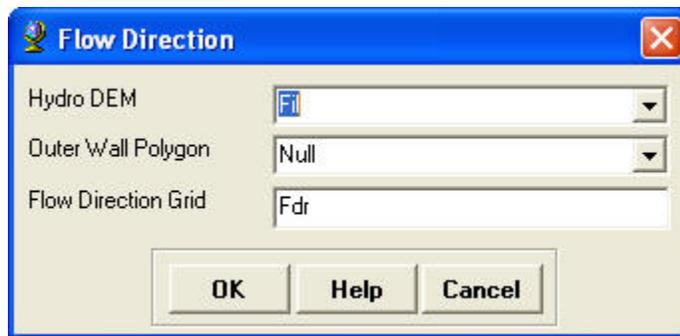
Figure 6-7. Flow Direction Editor.

- If you used the Build Walls tool to fence in an external wall then use the same outer wall polygon as before. Otherwise, leave this input set to "Null".

- The name of the output flow direction grid is defined in the "Flow Direction Grid" field. "Fdr" is the default name that can be overwritten by the user.

- Press **OK**.

The result of the Flow Direction operation is shown in Figure 6-8.
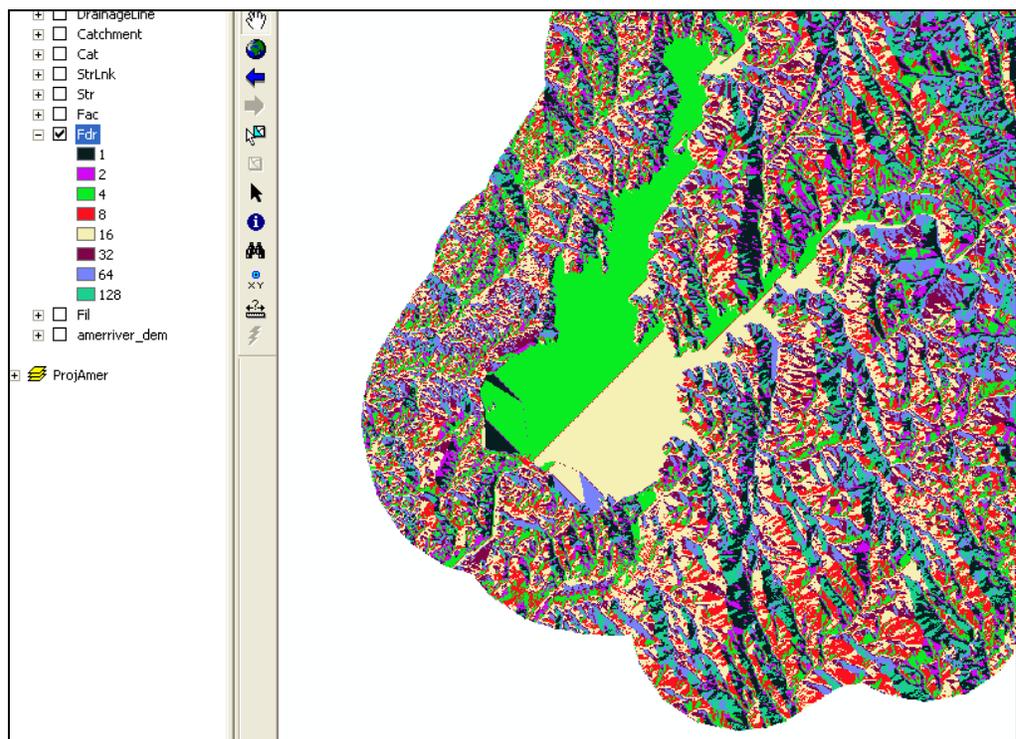
Figure 6-8. Flow Direction Result.

Flow Accumulation. This step determines the number of upstream cells draining to a given cell. Upstream drainage area at a given cell can be calculated by multiplying the flow accumulation value by the grid cell area.

The steps to compute flow accumulation are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing →
  Flow Accumulation**. The *Flow Accumulation* editor is shown in Figure
  6-9.

Figure 6-9. Flow Accumulation Editor.

- Select the "Flow Direction Grid".

- The name of the output flow accumulation grid is defined in the "Flow
  Accumulation Grid" field. "Fac" is the default name that can be
  overwritten by the user.

- Press **OK**.

The result of the Flow Accumulation operation is the "Fac" grid, as shown in
Figure 6-10.
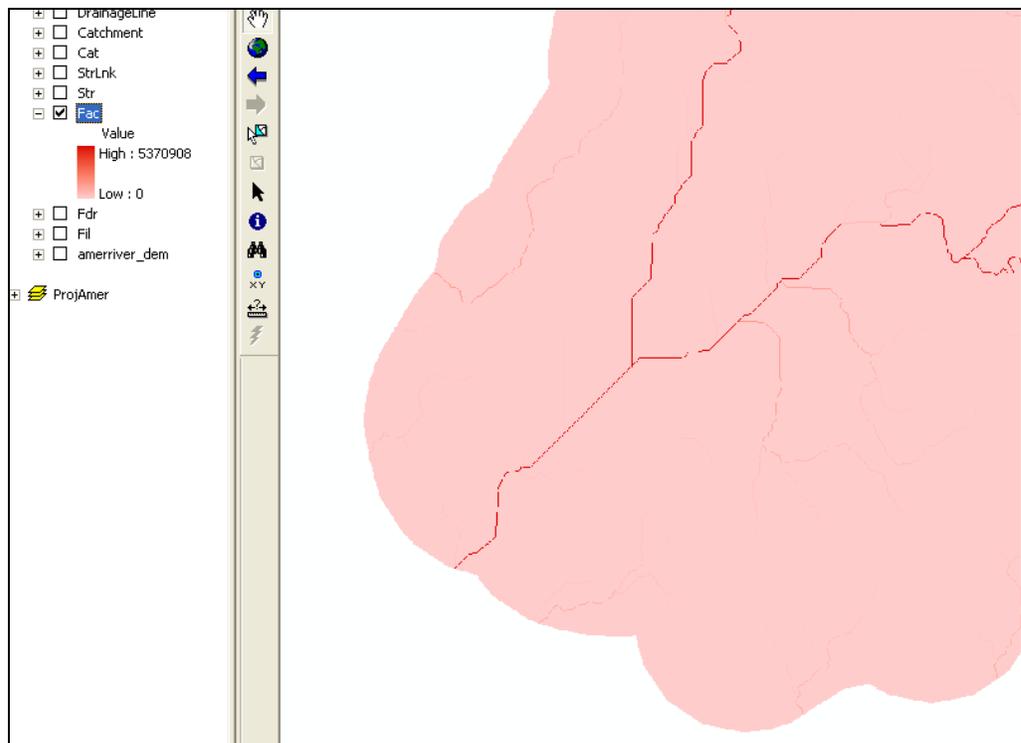
Figure 6-10. Flow Accumulation Result.

Stream Definition. This step classifies all cells with a flow accumulation greater than the user-defined threshold as cells belonging to the stream network. Typically, cells with high flow accumulation, greater than a user-defined threshold value, are considered part of a stream network. The user-specified threshold may be specified as an area in distance units squared, e.g., square miles, or as a number of cells. The flow accumulation for a particular cell must exceed the user-defined threshold for a stream to be initiated. The default is one percent (1%) of the largest drainage area in the entire DEM. The smaller the threshold chosen, the greater the number of subbasins delineated in a following step.

The steps to compute stream definition are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing** → **Stream Definition**. The ***Stream Definition*** editor is shown in Figure 6-11.

Figure 6-11. Stream Definition Editor.

- Make sure the "Flow Accumulation Grid" is selected.

- The name of the output stream grid is defined in the "Stream Grid" input field. "Str" is the default name that can be overwritten by the user.

- Press **OK**.

- Enter the stream threshold as "Number of cells" or "Area" as shown in Figure 6-12.

- Press **OK**.
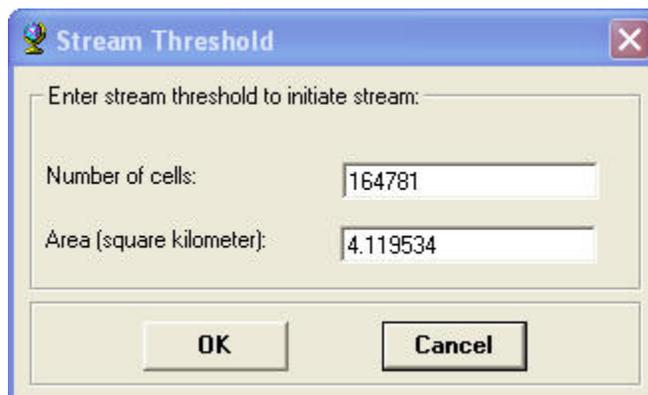
Figure 6-12. Stream Threshold Definition.

The result of the Stream Definition operation is the "Str" grid as shown in Figure 6-13.
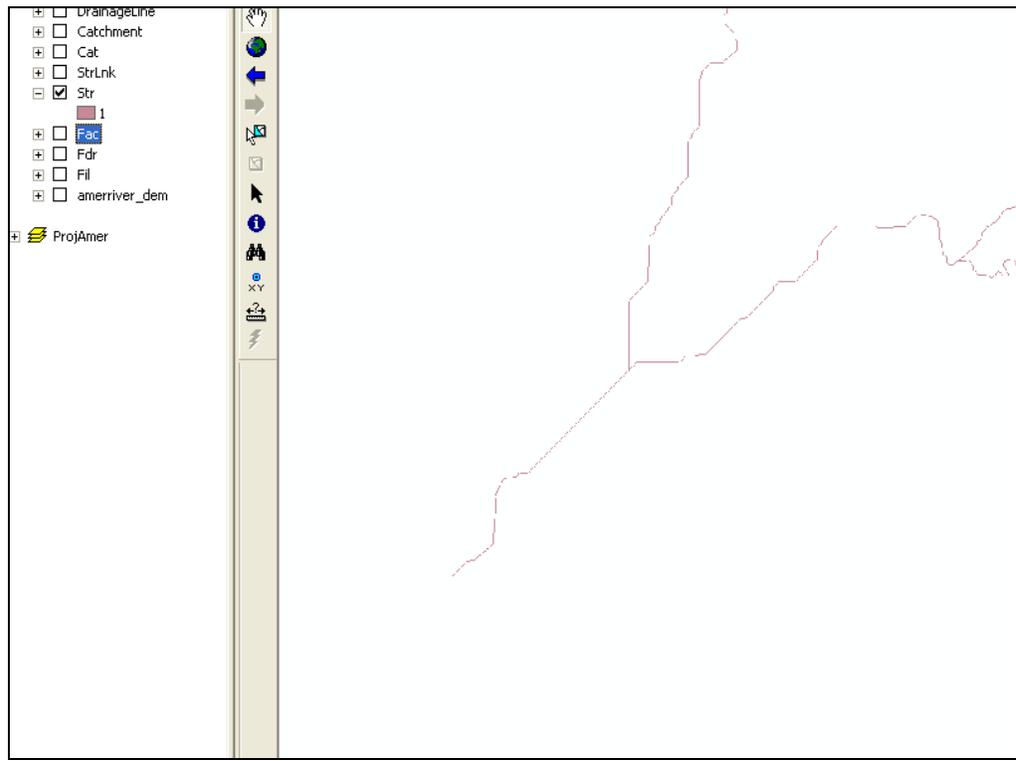
Figure 6-13. Stream Definition Result.

Stream Segmentation. This step divides the stream into segments. Stream segments, or links, are the sections of a stream that connect two successive junctions, a junction and an outlet, or a junction and the drainage divide.

The steps to compute stream segments are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing →Stream Segmentation**. The ***Stream Segmentation*** editor is shown in Figure 6-14.
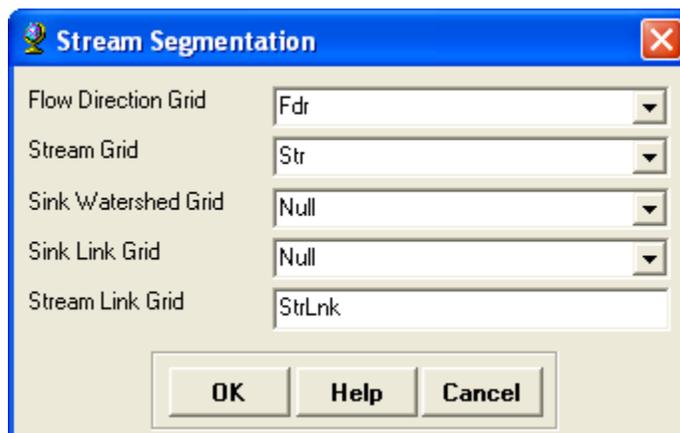
Figure 6-14. Stream Segmentation Editor.

- Select the "Flow Direction Grid" and the "Stream Grid".

- Do not specify a "Sink Watershed Grid" and a "Sink Link Grid". These are not needed for an HEC-GeoHMS project.

- Enter a name for the "Stream Link Grid". "StrLnk" is the default name that can be overwritten by the user.

- Press **OK**.

The stream segmentation operation results in many stream segments as shown in Figure 6-15.
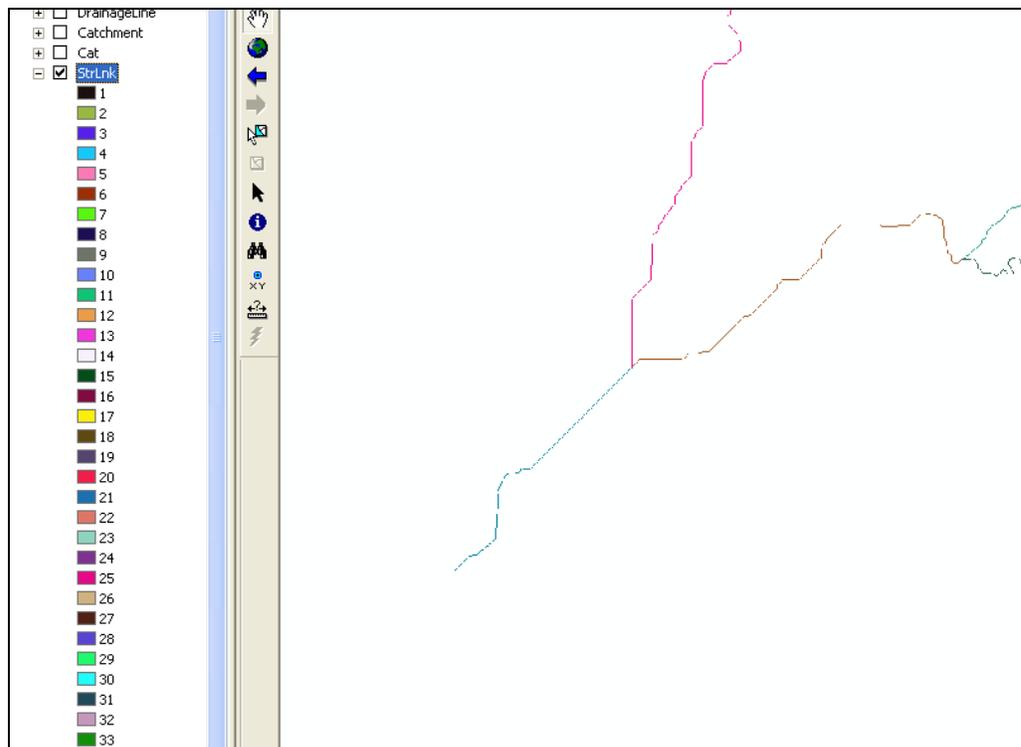
Figure 6-15. Stream Segmentation Operation Result.

Catchment Grid Delineation. This step delineates a subbasin for every stream segment.

The steps to delineate watersheds are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing →
  Catchment Grid Delineation**. The *Catchment Grid Delineation* editor is shown in Figure 6-16.

- Select the "Flow Direction Grid" and the "Stream Link Grid".

- Enter a name for the "Catchment Grid" in the input field. "Cat" is the default name that can be overwritten by the user.

- Press **OK**.
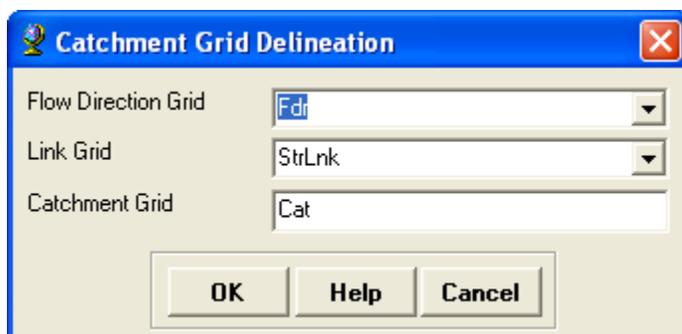
Figure 6-16. Catchment Delineation Editor.

The watershed delineation operation results in many subbasins as shown in Figure 6-17.
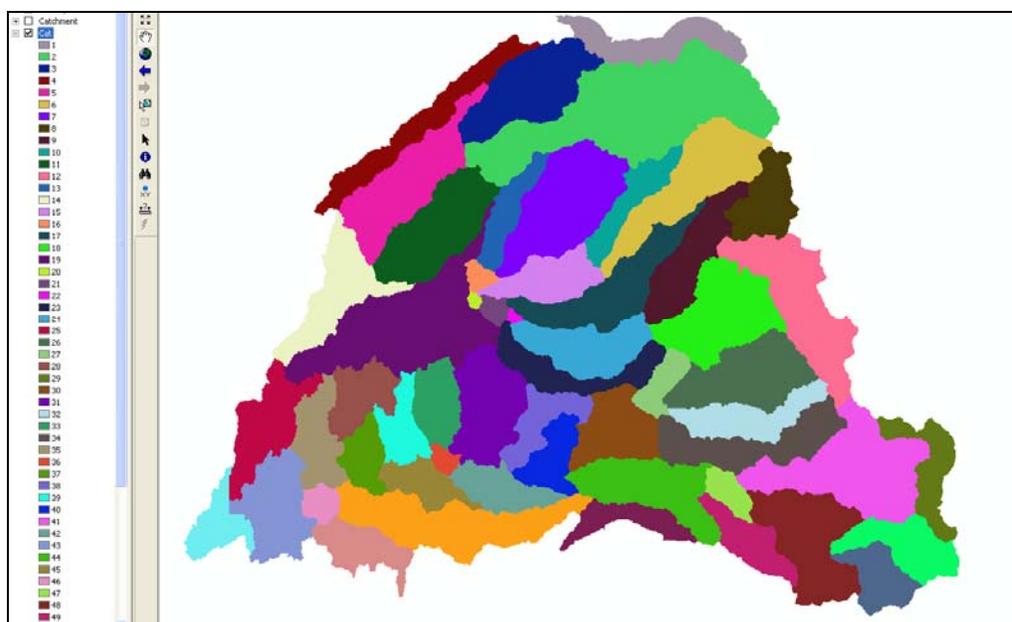
Figure 6-17. Catchment Delineation Result.

Catchment Polygon Processing. This step creates a vector layer of subbasins using the catchment grid computed in the previous step.

The steps to create a polygon subbasin layer are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing → Catchment Polygon Processing**. The *Catchment Polygon Processing* editor is shown in Figure 6-18.

- Select the "Catchment Grid".

- Enter a name for the polygon subbasin layer in the "Catchment" input field. "Catchment" is the default name that can be overwritten by the user.

- Press **OK**.
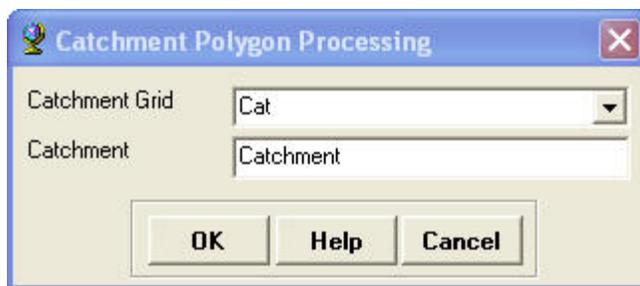
Figure 6-18. Catchment Polygon Processing Editor.

The catchment polygon processing operation creates a polygon subbasin layer as shown in Figure 6-19.
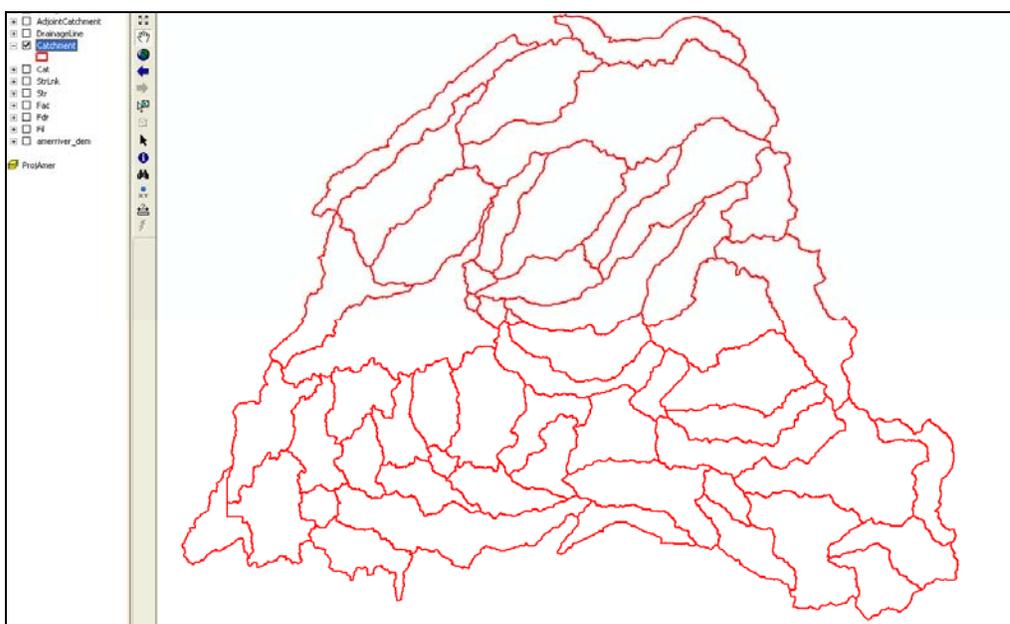
Figure 6-19. Catchment Polygon Processing Result.

Drainage Line Processing. This step creates a vector stream coverage.

The steps to vectorize stream segments are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing → Drainage Line Processing**. The ***Drainage Line Processing*** editor is shown in Figure 6-20.
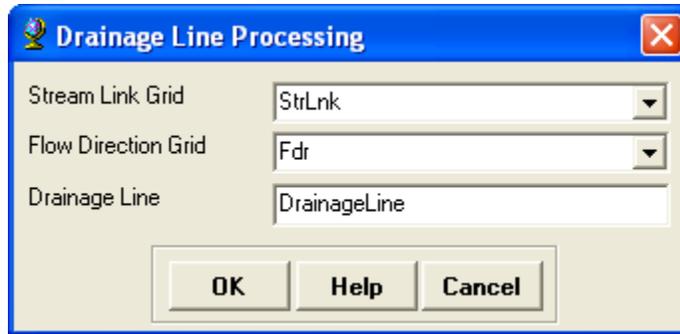
Figure 6-20. Drainage Line Processing Operation.

- Select the "Stream Link Grid" and the "Flow Direction Grid".

- Enter a name for the drainage line layer. "DrainageLine" is the default name that can be overwritten by the user.

- Press **OK**.

The stream layer is shown in Figure 6-21.
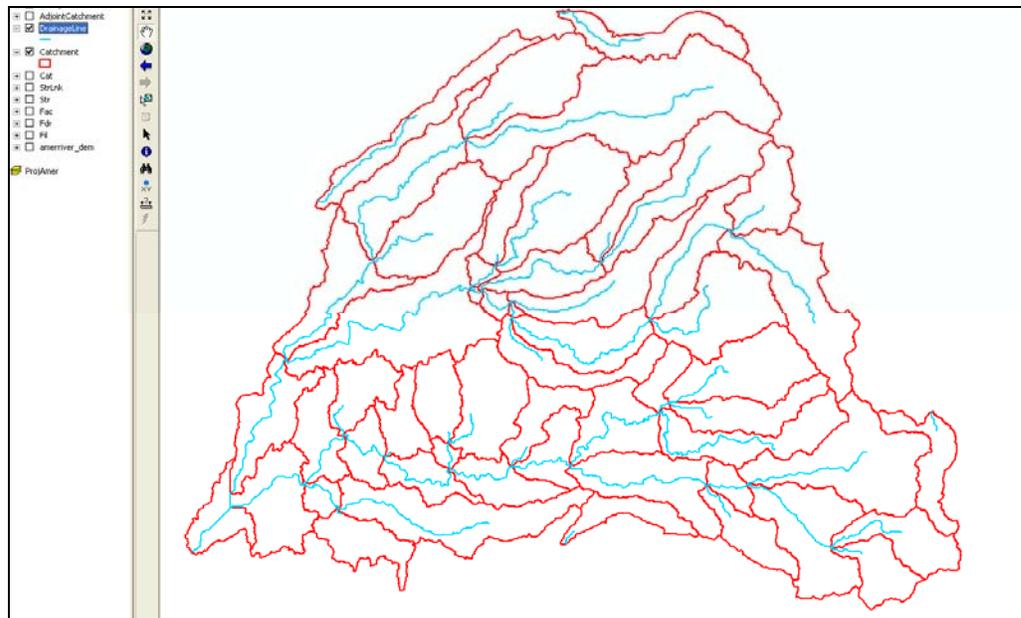
Figure 6-21. Drainage Line Processing Result.

Watershed Aggregation. This step aggregates the upstream subbasins at every stream confluence. This is a required step and is performed to improve computational performance for interactively delineating subbasins and to enhance data extraction when defining a HEC-GeoHMS project. This step does not have any hydrologic significance.

The steps to aggregate watersheds are shown below.

- From the **Arc Hydro Tools** toolbar, select **Terrain Preprocessing →
  Adjoint Catchment Processing**. The *Adjoint Catchment Processing*
  editor is shown in Figure 6-22.
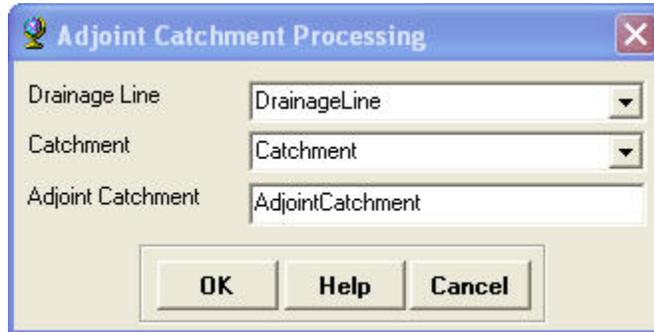
Figure 6-22. Adjoint Catchment Editor.

- Select the "Drainage Line" and "Catchment" layers.

- Enter a name for the adjoint catchment layer. "AdjointCatchment" is the
  default name that can be overwritten by the user.

- Press **OK**.

C H A P T E R   7

HMS Project Setup

The **HMS Project Setup** menu on the **HEC-GeoHMS Main View toolbar** is responsible for extracting data that will be used to develop the necessary information to create an HEC-HMS project. The approach for extraction involves specifying a control point at the downstream outlet. This location represents the downstream boundary for the HEC-HMS project. After defining the downstream outlet, HEC-GeoHMS will extract data from the datasets created using the terrain preprocessing tools for the drainage area upstream of the outlet. Then HEC-GeoHMS can be used to refine the subbasin and stream delineations, extract physical characteristics of subbasins and streams, estimate model parameters, and prepare input files for HEC-HMS. Multiple project outlets can be defined in the same project; these projects are managed through two feature classes: project points and project area. The management of these projects allows re-creation of a study area with different thresholds and allows the user to delete unneeded projects and related files easily and conveniently.

Start New Project

To define a new project name and create a directory to contain extracted data and related files, go to the HMS Project Setup menu located on the **HEC-GeoHMS Main View** toolbar. The user should already be zoomed into the area where the outlet will be defined before selecting these menu options.

- Select **HMS Project Setup → Start New Project**.

- Accept the default names "ProjectArea" and "Project Points" or enter a new name for these layers. The project area layer is used to show the upstream drainage area for the outlet point and the project point layer shows the location of the outlet point.

- The ***Define a New Project*** editor will open as shown in Figure 7-1.

- Enter the project name and description.

- Select the method of generating the project. Select "Original Stream Definition" from the dropdown menu as shown in Figure 7-1.

Another option for the threshold is "A new threshold", which allows the user to specify a new threshold for the project. As mentioned before, the threshold is used to classify all flow accumulation cells with a flow accumulation greater than the user-defined threshold as cells belonging to the stream network.
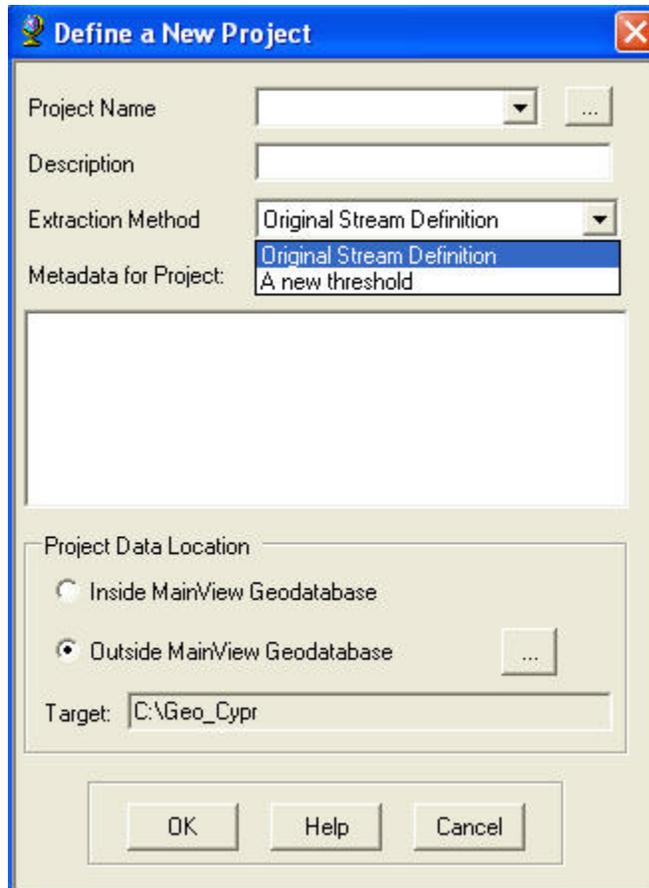
Figure 7-1. Define a New Project Editor.

Typically, cells with high flow accumulation, greater than a user-defined threshold value, are considered part of a stream network. The user-specified threshold may be specified as an area in distance units squared, e.g., square miles, or as a number of cells. The flow accumulation for a particular cell must exceed the user-defined threshold for a stream to be initiated. The smaller the threshold, the greater the number of subbasins.

- Choose a location to store all datasets. Initially, the program will clip all datasets created from the terrain preprocessing steps and store them in the project data directory. Additional datasets created by HEC-GeoHMS tools will be stored in this directory as well.

- Press **OK**.

A message window will open, as shown in Figure 7-2, that lets the user know the directory where the project data will be saved. In addition, the message window lists two additional steps that must be followed in order to generate the project. The steps must immediately follow or the new project will not be generated. Therefore, the user should already be zoomed into the area where the outlet will be defined before the ***Define a New Project*** editor is opened.
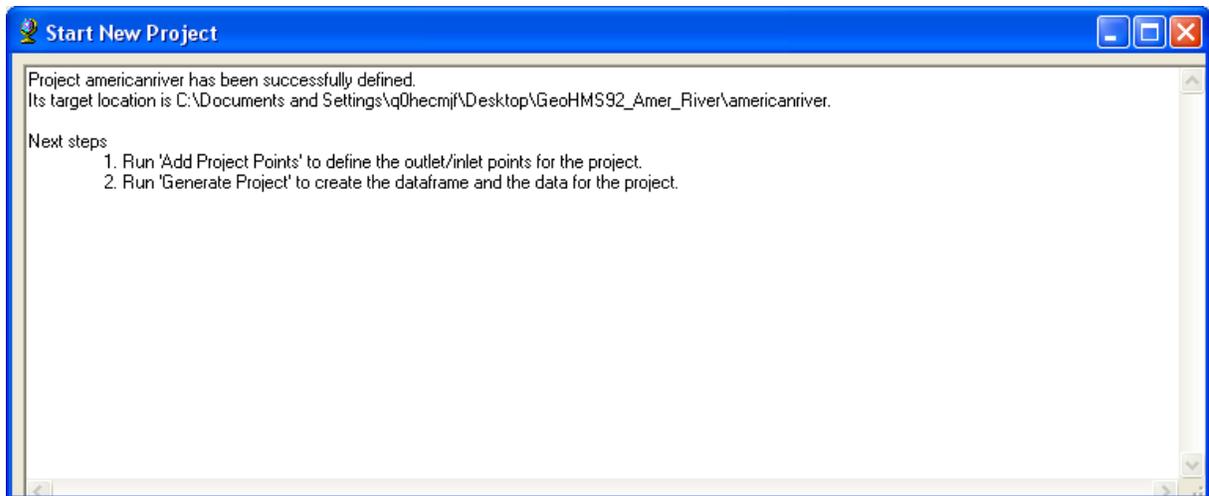
Figure 7-2. Steps for Creating a New Project.

- Select the ⚕ (**Add Project Points**) tool.
- Specify the outlet point for the project area as shown in Figure 7-3.
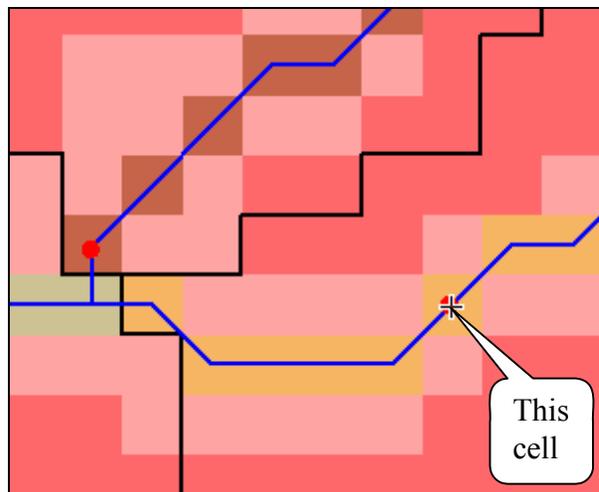
Figure 7-3. Specify Outlet Location.

- Select **HMS Project Setup → Generate Project**.

- The first time the **Generate Project** option is selected, a data management editor will open letting the user verify the correct datasets are associated to the required project layers. Click the **OK** button after checking the data.

- The map will automatically zoom to the area upstream of the outlet point and the drainage area will be shaded. The *Generate Project* editor will open asking if the user wants to create a project for the shaded area. Press the **Yes** button.

- The *New Project Layer Names* editor will open as shown in Figure 7-4. The user can accept the default names or overwrite them with customized names.

A new data frame will be created and the name will be set to the project name. All the terrain preprocessing data for the project area will be extracted and imported into the new data frame. Additional projects can be generated from the original set of preprocessed data. As illustrated Figure 7-5, the user can generate multiple projects from the original set of preprocessed data. The benefit of this setup is that it allows the user to preserve the original data and work on multiple projects.
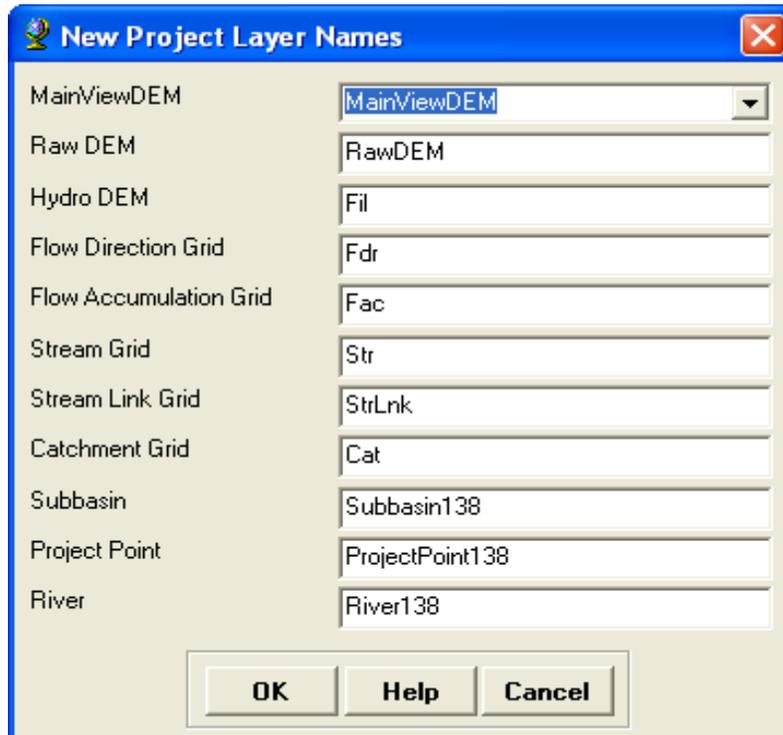
Figure 7-4. Editor for Naming Datasets Created for the New Project.
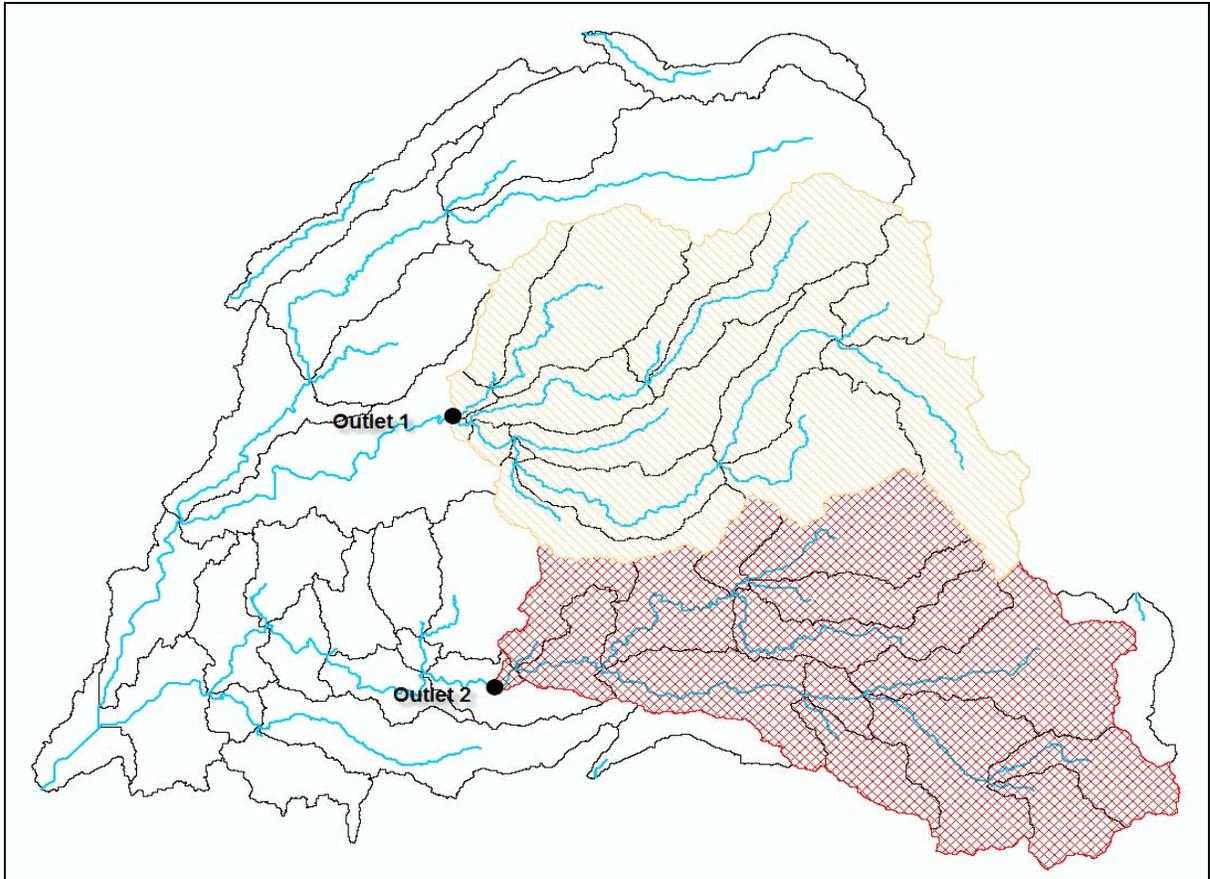
Figure 7-5. Main View with Two Projects.

CHAPTER 8

Basin Processing

After the terrain preprocessing is completed and a new project has been created, the **Basin Processing** menu on the **HEC-GeoHMS Project View** toolbar can be used to revise the subbasin delineations. Customized subbasin and routing reach delineations should include points where information is needed, i.e., stream flow gage locations, flood damage centers, environmental concerns, and hydrologic and hydraulic controls. The tools described in this chapter will allow the user to interactively combine or subdivide subbasins as well as to delineate subbasins to a set of points.
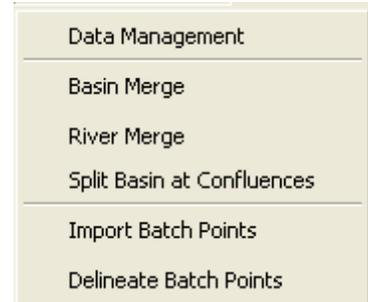
This chapter will discuss the tools for subbasin delineation that are available from the **Basin Processing** menu. Below is an outline of Chapter 8.

Contents

- Basin Merge
- Basin Subdivision
- River Merge
- River Profile
- Split Basins at Confluences
- Batch Subbasin Delineation

Basin Merge

Under the **Basin Processing** menu, the **Basin Merge** menu item merges multiple subbasins together into one subbasin. This tool works interactively by presenting the result of the operation and giving the user options to accept or cancel the operation. Below are rules and a list of steps for using the merge tool.

Rules!

- The subbasins must share a common confluence or

- The subbasins must be adjacent in an upstream and downstream manner.

- More than two subbasins are permitted.

Steps

- Make the subbasin layer active.

- Use the **select** tool ⬚ and select the two subbasins as shown in Figure 8-1.
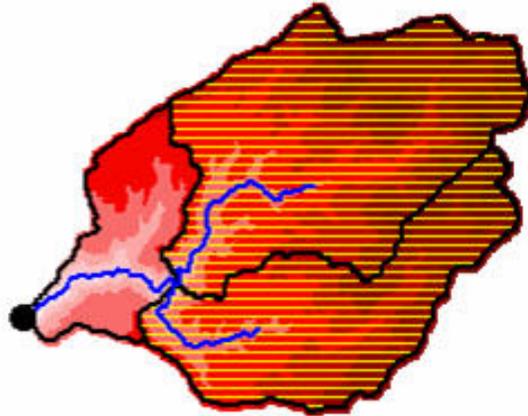
Figure 8-1. Merge Selected Subbasins.

- Select **Basin Processing → Basin Merge**.

- The result of the merged subbasin is displayed with a prompt for confirmation of the results. Press **Yes** to accept the resulting merged subbasin or **No** to cancel the merge operation.

The result of the merged basin is shown in Figure 8-2.
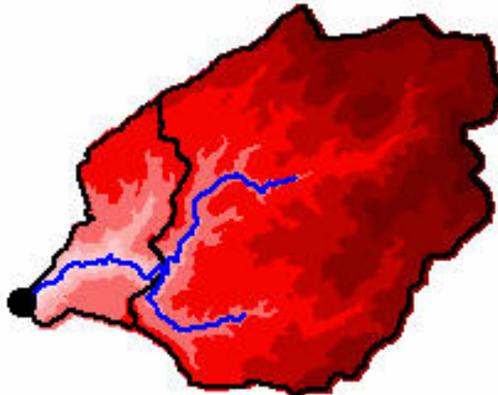
Figure 8-2. Basin Merge Result.

Basin Subdivision

A basin can be subdivided with the **Subbasin Divide**, [icon], tool. The tool tip can be viewed by placing the pointer tool [icon] over the **Subbasin Divide** [icon] tool. A subbasin can be subdivided on the existing or non-existing stream network.

Method 1: Basin Subdivision on Existing Stream

An existing basin can be subdivided into two basins on an existing stream.

- Zoom in to the area of interest as shown in Figure 8-3. Make the stream grid (default name is "Str") layer visible. The "Str" grid layer represents the grid cells that compose the visible stream network. The existing streams are shown as blue lines in the river layer.
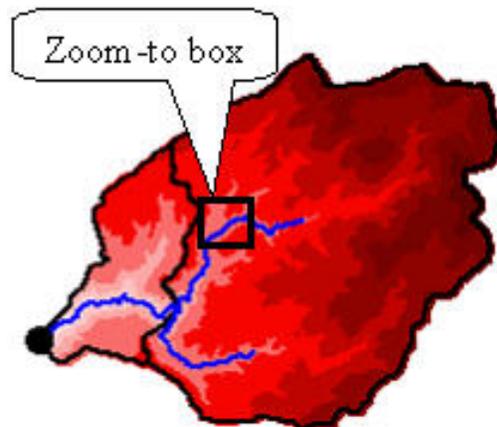
Figure 8-3. Zoom in Prior to Basin Subdivision.

- Select the **Subbasin Divide** [icon] tool.
- Click on the cell of interest as shown in Figure 8-4.
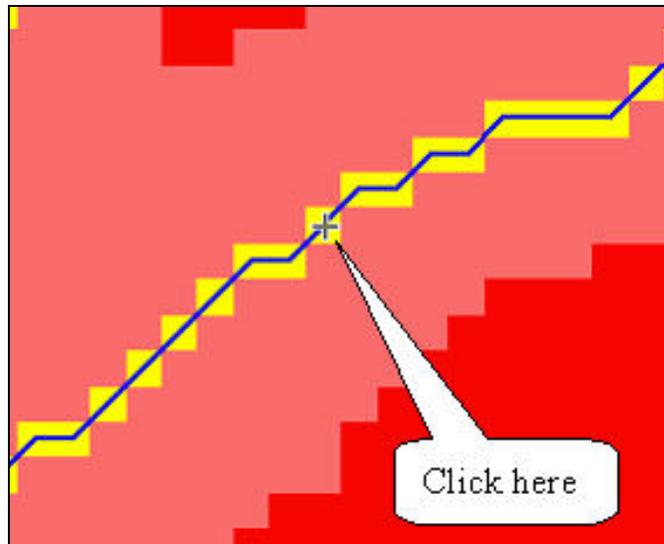
Figure 8-4. Click on the Cell to Subdivide Basin.

- A few seconds later, the map zooms out and the subdivided basins are highlighted. The *Project Points* editor opens prompting the user to name the new subbasin outlet. Accept the default name for the new basin outlet or overwrite it in the text box.

- Press **OK** to make the delineation permanent.

The result of the operation is shown in Figure 8-5.
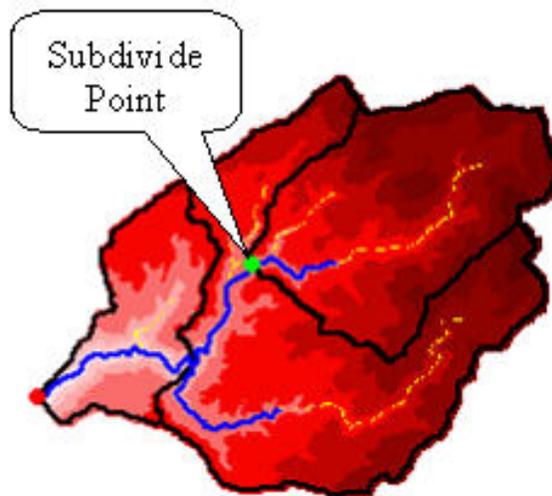
Figure 8-5. Basin Subdivision Result.

Method 2: Basin Subdivision without Existing Stream

When an existing stream does not extend upstream far enough, the user can use the same **Subbasin Divide** tool to delineate a new subbasin. In this case, the

flow accumulation grid can be use to see the detailed stream network. For example, in Figure 8-6, the blue line (if document is in color) is the river layer. The river layer is positioned on top of the flow accumulation grid. The detailed stream is visible in the flow accumulation grid. In this grid, the value is determined by the number of upstream cells that flow into a particular cell. A value of zero is indicative of a grid cell located on the subbasin divide. Figure 8-6 show the stream network extends past the river layer. You can modify the legend to see more detail in the flow accumulation grid if needed. When subdividing a basin at a point that is not on the existing stream, the program will trace a new stream segment downstream from the specified point to the existing stream.

- Zoom in to the area of interest and make the flow accumulation layer visible.

- With the **Subbasin Divide** tool selected, click on a grid cell in the flow accumulation grid that is part of the detailed stream network.

- Accept the default name for the outlet or overwrite it in the text box and press **OK**.
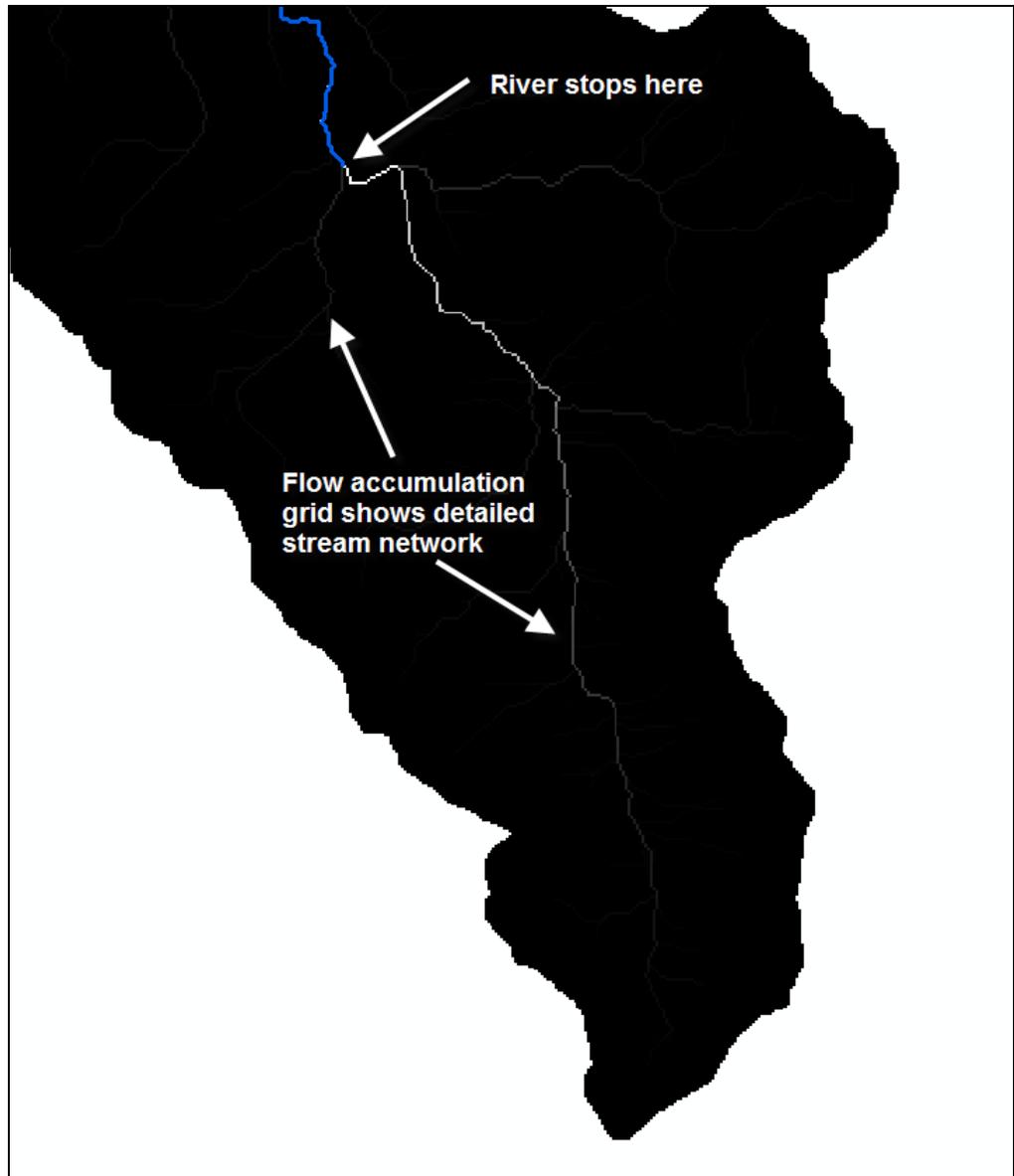
Figure 8-6. Flow Accumulation Grid Shows Detailed Stream Network.

River Merge

When subbasin merges and subdivisions are performed, stream segments are often created. As an example, the result of merging two subbasins into one subbasin can result in multiple river segments. When creating an HEC-HMS project, these two segments will be treated as separate routing reaches. If the user intends to model routing with multiple reaches, the user will need to develop routing parameters for both reaches. However, if the user intends to model the routing with a single reach, then the user will need to merge both stream segments.

Steps

- Make the river layer active.

- Select the two stream segments with the ⬚ **Select** tool.

- Select **Basin Processing → River Merge**.

- Confirm the merge by pressing the **Yes** button. The selected stream segments become one segment.

River Profile

The river profile tool provides information on slopes and grade breaks that can be useful for selecting delineation points. The river profile is created by extracting elevation values from the terrain model along the stream line. Creating the river profile can be performed using the **River Profile** ⬚ tool.

Steps

- Make the river layer active.

- Select the ⬚ **Profile** tool.

- Confirm the correct data layers are associated to the required datasets in the *River Profile* editor as shown in Figure 8-7.

Figure 8-7. River Profile Editor.

- Click on a stream segment (river layer) in the map to open a profile like the one shown in Figure 8-8.
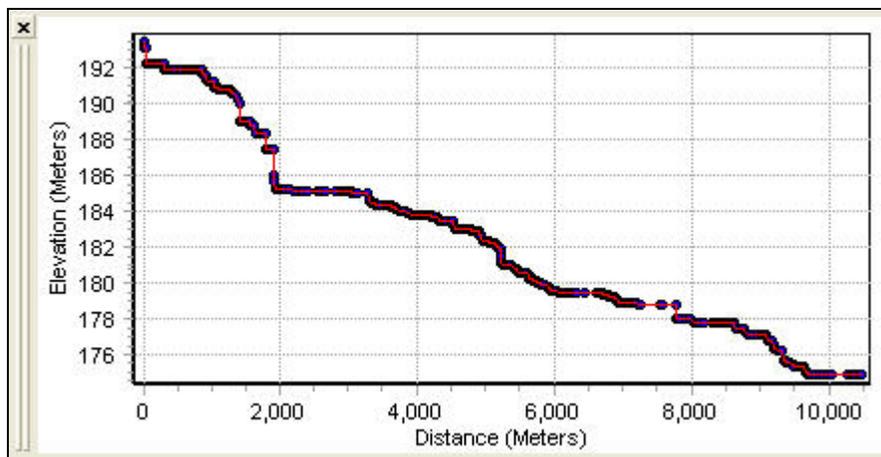
Figure 8-8. River Profile.

Split Basins at Confluences

The **Split Basins at Confluences** tool allows the user to subdivide a subbasin at all confluence. For the situation shown in Figure 8-9, this tool should be used instead of the interactive **Subbasin Divide** tool.
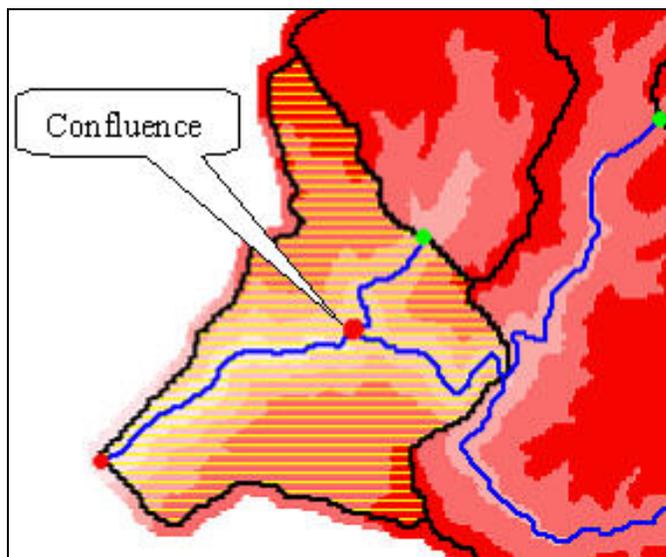
Figure 8-9. Subdivide Basin at Confluence.

Rules!

- Only one basin can be selected.
- This tool can be used in a basin having multiple confluences.

Steps

- Activate the subbasin layer.

- Select the subbasin containing the confluence with the [icon] **Select** tool as shown in Figure 8-9.

- Select **Basin Processing → Split Basin at Confluences**.

- Confirm the split subbasins by pressing the **Yes** button.

The operation created three subbasins as shown in Figure 8-10. One subbasin is created for each stream segment.
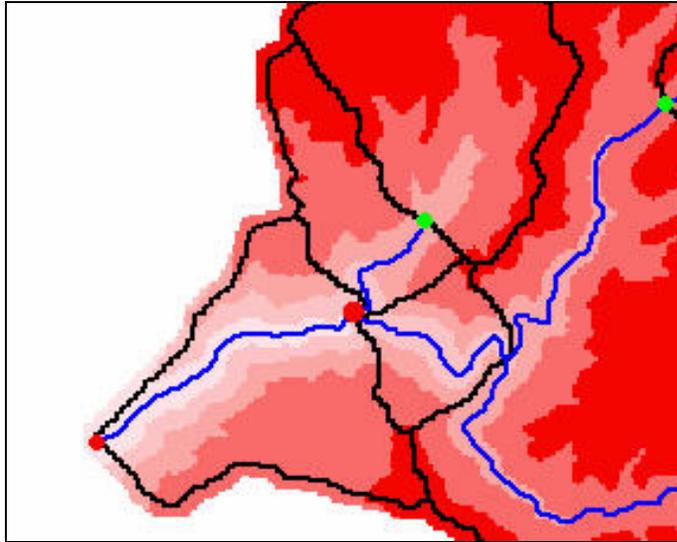
Figure 8-10. Subbasins Subdivided at Confluence.

Batch Subbasin Delineation

Subbasin delineation may also be accomplished through batch processing; this requires a point layer be created that contains the desired outlet locations. It is important to recognize that the batch subbasin delineation operates on the existing delineation by further delineating with the new outlet points. There are two methods for creating the batch point layer.

Method 1: Batch Point Tool

Use the [icon] **Batch Point Generation** tool from the **Arc Hydro Tools** toolbar to place points on the map. This tool will automatically create a batch point layer. To use this tool effectively, turn on the flow accumulation grid, zoom in until grid cells in the stream network are visible, and place the point within a stream grid cell.

Rules!

- The delineation points should be located on the stream network.

Steps

- Click on the ⊠ **Batch Point Generation** tool. Then click in the map to add a batch point. An editor opens letting the user define the name of the batch point layer the first time this tool is used to create a batch point. Click the **OK** button.

- In the ***Batch Point Generation*** editor enter a name and description for the batch point as shown in Figure 8-11. The "BatchDone" and "SnapOn"options can be used to turn on (select 1) or off (select 0) batch processing and stream snapping for that point. The "Type" should be set to "Outlet".
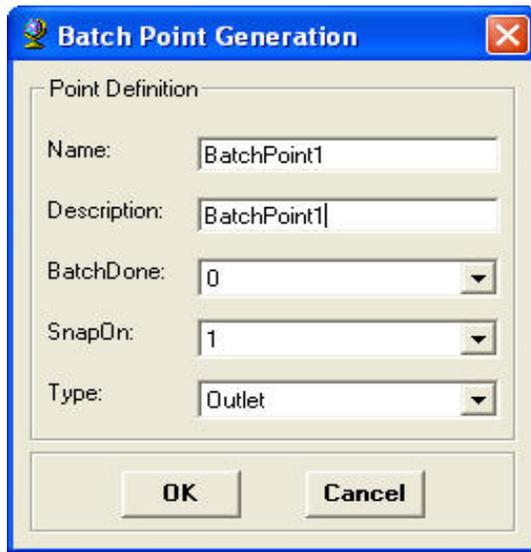
Figure 8-11. Batch Point Generation Editor.

The batch point layer contains the essential fields shown in Figure 8-12. These fields provide instructions and information for the program to perform batch subbasin delineation. The field headings and values are discussed in Table 8-1.

Shape *	OID *	Name	Descript	BatchDone	SnapOn	SrcType
Point	1	BatchPoint1	BatchPoint1	0	1	0

Figure 8-12. Batch Point Attribute Table.

Table 8-1. Batch Point Fields, Descriptions, and Values.

Field Headings	Descriptions	Possible Values
Shape	Standard requirement for noting the feature type (point, line, polygon).	Point
OID	Standard identifier for tracking the number of points generated.	Integer
Name	The name of the outlet location (can be edited by the user).	Text
Descript	The description of the outlet location (can be edited by the user).	Text
BatchDone	An indicator if batch processing has been performed for the points.	"0" indicates that batch processing has not been performed. "1" indicates that batch processing has been performed. "-1" indicates that batch processing has been performed unsuccessfully.
SnapOn	A flag that can be set to enable snapping of the user-specified point to the stream.	"1" enables snapping. "0" disables snapping.

- To process the batch points in the batch point layer, select **Basin Processing → Delineate Batch Points**.

Method 2: Import Batch Points

This method is useful when the user already has an existing point layer containing points of interest, stream flow gage locations, and/or previous hydrologic model outlet locations. The user can import the existing point features into the batch point layer.

Steps

- Select points from an existing point layer using the 🔲 **Select** tool. The points must be selected in order for them to be imported.

- Select the **Basin Processing → Import Batch Points** menu option.

- Enter a name for the "Batch Point" layer and press **OK**.

- To process the batch points in the batch point layer, select **Basin Processing → Delineate Batch Points**.

C H A P T E R   9

Stream and Subbasin Characteristics

HEC-GeoHMS computes several topographic characteristics of streams and subbasins that can be used for estimating hydrologic parameters. The user should compare and verify the physical characteristics with published information prior to estimating the hydrologic parameters. The stream and subbasin physical characteristics are stored in attribute tables, which can be exported for use with a spreadsheet and other programs.

This chapter will discuss the tools for extracting topographic characteristics of streams and subbasins. These tools are available from the **Basin Characteristics** menu on the **HEC-GeoHMS Project View** toolbar. A list of the physical characteristics extracted for the streams and subbasins are summarized in Table 9-1. These characteristics are saved to the attribute tables of the stream and subbasin layers. Below is an outline of Chapter 9.

| Data Management |
| River Length |
| River Slope |
| Basin Slope |
| Longest Flow Path |
| Basin Centroid |
| Centroid Elevation Update |
| Centroidal Flow Path |

Contents

- River Length
- River Slope
- Basin Slope
- Longest Flow Path
- Basin Centroid
- Centroid Elevation
- Centroidal Flow Path

Table 9-1. Physical Characteristics.

Data Layer	Physical Characteristics	Attribute Table Heading
Stream Layer	Length	RivLen
	Upstream elevation	ElevUP
	Downstream elevation	ElevDS
	Slope	Slp
Subbasin Layer	Area	Area
Centroid Layer	Centroid location	
	Centroid elevation	Elevation
Longest Flow Path Layer	Location of the longest flow path	
	Longest flow length	LongestFL
	Upstream elevation	ElevUS
	Downstream elevation	ElevDS
	Slope between endpoints	Slp
Centroidal Flow Path Layer	Location of the Centroidal flow Path	
	Centroidal Length	CentroidalFL

River Length

This step computes the river length for selected or all routing reaches in the river layer. A field named "RivLen" is added to the attribute table and populated with values.

Steps

- Select **Basin Characteristics → River Length**.

- Make sure the river layer is selected in the ***River Length Computation*** editor as shown in Figure 9-1.

- Press **OK**.

Figure 9-1. River Length Computation Editor.

The units of "RivLen" are taken from the units of the DEM.

River Slope

This step extracts the upstream and downstream elevation of a river reach and computes the slope. The upstream and downstream elevation and slope are

added to the river layer's attribute table with the column headings: "ElevUP", "ElevDS", and "Slp".

Steps

- Select **Basin Characteristics → River Slope**.

- Make sure the raw DEM and river layer are selected in the *River Slope Computation* editor as shown in Figure 9-2.

- Press **OK**.

Figure 9-2. River Slope Computation Editor.

- If the vertical units for the DEM are not specified in the spatial reference information, the program will assume that the vertical units are the same as the horizontal units as shown Figure 9-3. Press **OK**.
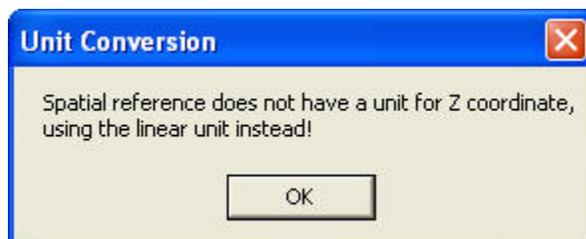
Figure 9-3. DEM's Vertical Units.

Basin Slope

This function computes the average basin slope in the watershed. If computed, this will be used for the computation of the CN Lag time parameter (found under the **Hydrologic Parameters** menu). The **Basin Slope** tool operates on a selected set of subbasins in the subbasin layer. If no subbasin has been selected, the function processes all the subbasins. The basin slope is determined by averaging values from a slope grid for each subbasin. The slope grid can be created using the **Terrain Preprocessing → Slope** tool on the **Arc Hydro Tools** toolbar or the **Spatial Analyst → Surface Analysis → Slope** tool on the **Spatial Analyst** toolbar.

Steps

- Make sure a slope grid is available in the data frame.

- Select **Basin Characteristics → Basin Slope**.

- Select the subbasin layer and slope grid in the ***Basin Slope*** editor as shown in Figure 9-4.

- Press **OK**.
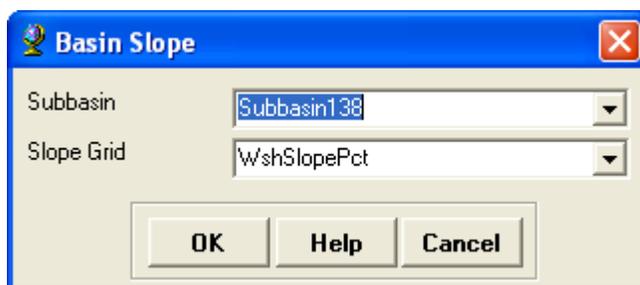
Figure 9-4. Basin Slope Editor.

The subbasin layer's attribute table will contain a column named "BasinSlope" that will be populated with the average slope computed using the selected slope grid.

Longest Flow Path

The **Longest Flow Path** tool computes a number of physical characteristics: the longest flow length, upstream elevation, downstream elevation, and slope between the endpoints. These characteristics are stored in the longest flow path layer.

Steps

- Select **Basin Characteristics → Longest Flow Path**.

- The ***Longest Flow Path Computation*** editor is shown in Figure 9-5. Select the raw DEM, flow direction grid, and the subbasin layer. Then enter a name for the longest flow path layer or accept the default name.

- Press **OK**.

- If the vertical units for the DEM are not specified in the spatial reference information, the program will assume that the vertical units are the same as the horizontal units as shown Figure 9-3. Press **OK**.
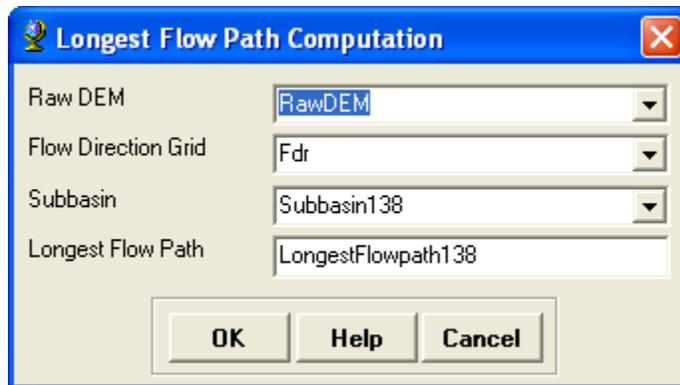
Figure 9-5. Longest Flow Path Computation Editor.

When finished, the longest flow path layer is added to the data frame. This layer's attribute table contains the following fields:

- DrainID: HydroID of the associated subbasin.

- LengthDown: Length from the beginning of the longest flow path feature to the subbasin outlet.

- LongestFL: Length of the longest flow path.

- Slp: Slope of the longest flow path.

- ElevUP: Elevation at the upstream end of the longest flow path in map units.

- ElevDS: Elevation at the downstream end of the longest flow path in map units.

Basin Centroid

The Basin Centroid tool will identify the centroid of each subbasin. The function will operate on the selected set of subbasins or all subbasins. The basin centroid location can be estimated in four ways. Three methods may be used to define the centroid, each one using a different algorithm and thus providing a different result. The quality of the results is a function of the shape of the subbasin and should be evaluated after they are generated. The fourth method is user-specified, where the user moves the centroid to the desired location after it is created. Sometimes, the centroid is located on the subbasin boundary and therefore should be move or a different method should be used.

Steps

- Select **Basin Characteristics → Basin Centroid**

- Select the basin centroid method as shown in Figure 9-6. Press **OK**.
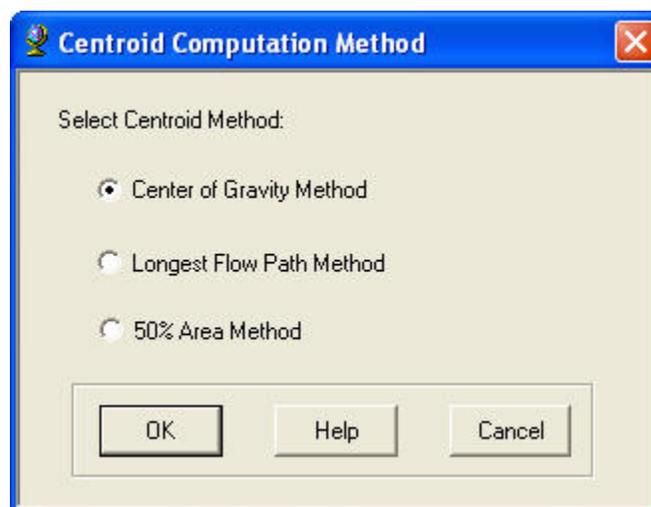
Figure 9-6. Basin Centroid Methods.

Method 1: Center of Gravity Method

The **Center of Gravity** method computes the centroid as the center of gravity of the subbasin. If the center of gravity is outside the subbasin, it is snapped to the closest boundary.

- Select **Center of Gravity Method**. Press **OK**.

- Make sure the subbasin layer is selected and enter a name for the centroid layer in the *Basin Centroid Computation* editor as shown in Figure 9-7.

- Press **OK**.

Figure 9-7. Basin Centroid Computation Editor.

The result is a new point layer that shows subbasin centroids.

Method 2: Longest Flow Path Method

The **Longest Flow Path** method computes the centroid as the midpoint of the longest flow path within the subbasin.

- Select **Longest Flow Path Method**. Press **OK**.

- Make sure the subbasin and longest flow path layers are selected and enter a name for the centroid layer in the *Basin Centroid Computation* editor as shown in Figure 9-8.

- Press **OK**.

Figure 9-8. Basin Centroid Computation Editor.

The result is a new point layer that shows subbasin centroids.

Method 3: 50% Area Method

The **50% Area** method computes the centroid as the point having a contributing area equal to 50% of the area of the subbasin.

- Select **50% Area Method**. Press **OK**.

- Make sure the flow accumulation grid, subbasin, and river layers are selected and enter a name for the centroid layer in the ***Basin Centroid Computation*** editor as shown in Figure 9-9.

- Press **OK**.

Figure 9-9. Basin Centroid Computation Editor.

The result is a new point layer that shows subbasin centroids.

Method 4: User-Specified Centroid Location

When the three previous methods do not produce satisfactory estimates of the centroid, the user can manually edit the centroid layer to move the centroid to a more suitable location.

- Select **Editor → Starting Editing** on the **Editor** toolbar.
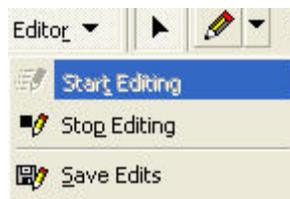
- Select the geodatabase containing the centroid layer as shown in Figure 9-10. Press **OK**.
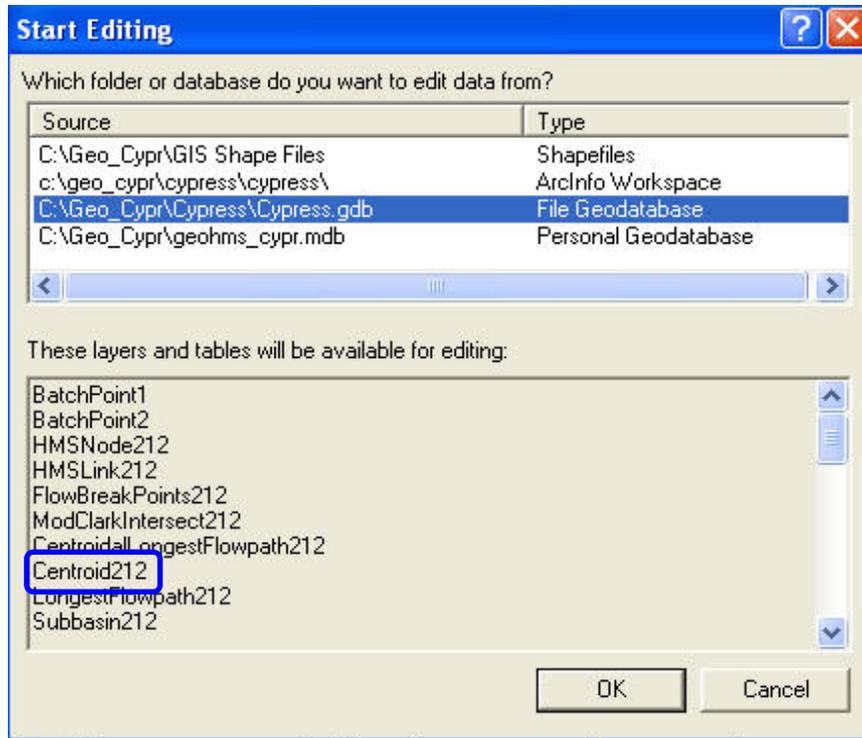
Figure 9-10. Select Geodatabase Containing the Centroid Layer.

- Select the **Edit** tool on the **Editor** toolbar. Then select the centroid to be moved. Make sure that only the centroid point is selected and not other layers in the map. You can set the centroid layer to the only selectable layer to prevent unintentionally selecting features in other layers. You can do this by selecting the **Selection** tab at the bottom of the table of contents and then uncheck all layers but the centroid layer**.**
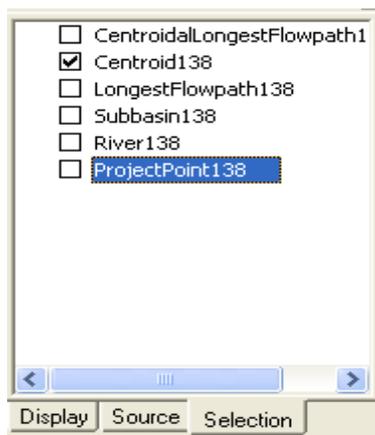
- The pointer turns into a double arrow when a centroid is selected.
- Click and drag the centroid to another location as shown in Figure 9-11.

Figure 9-11. User-Specified Centroid Location.

- To stop editing and save the changes, select **Editor → Stop Editing**.

Centroid Elevation

This operation computes the elevation for each centroid point using a DEM. The elevations are stored in the centroid layer's attribute table.

Steps

- Select **Basin Characteristics → Centroid Elevation**.
- Select the raw DEM and centroid layers in the *Centroid Elevation Computation* editor as shown in Figure 9-12.
- Press **OK**.
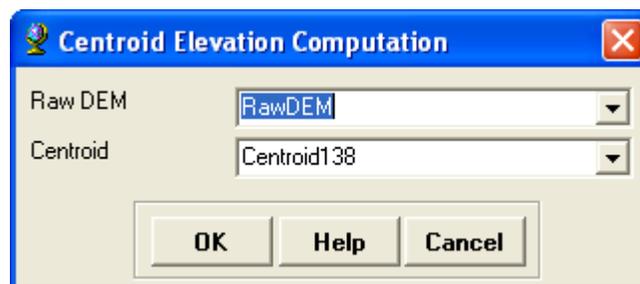
Figure 9-12. Centroid Elevation Computation Editor.

- If the vertical units for the DEM are not specified in the spatial reference information, the program will assume that the vertical units are the same as the horizontal units as shown Figure 9-3. Press **OK**.

When finished, the "Elevation" field in the centroid layer's attribute table will be populated.

Centroidal Flow Path

This operation computes the centroidal flow path by projecting the centroid onto the longest flow path. The centroidal flow path is measured from the projected point on the longest flow path to the subbasin outlet as shown in Figure 9-13.
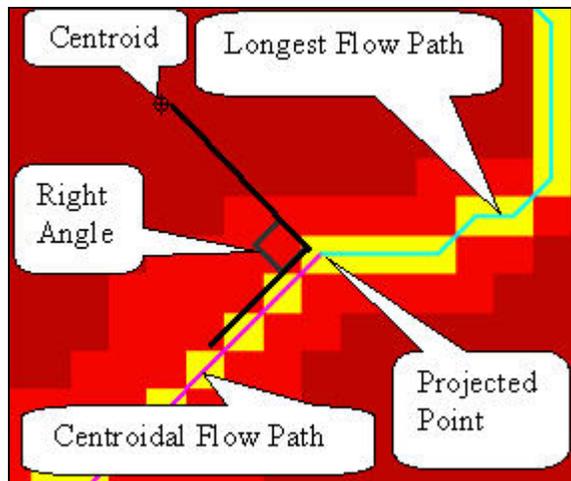
Figure 9-13. Centroidal Flow Path.

Steps

- Select **Basin Characteristics → Centroidal Flow Path**.

- Select the subbasin, centroid, and longest flow path layers in the ***Centroidal Longest Flow Path Computation*** editor as shown in Figure 9-14. Then enter a name or accept the default name for the centroidal longest flow path layer.

- Press **OK**.

The result of the centroidal flow path operation is a centroidal flow path layer. The attribute table contains a field named "CentroidalFL" that is populated with the length of the centroidal flow path line.
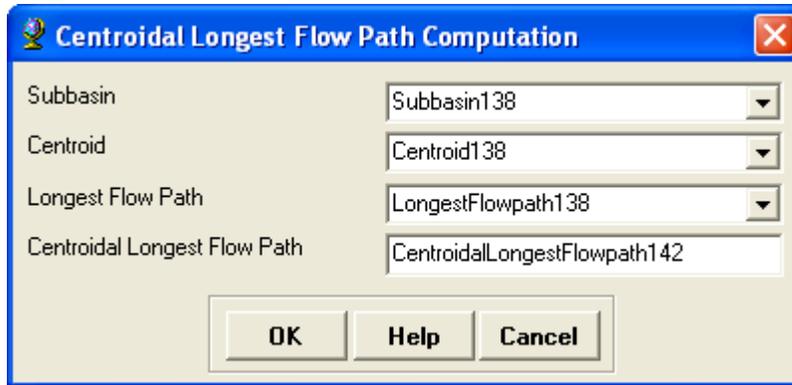
Figure 9-14. Centroidal Longest Flow Path Computation Editor.

C H A P T E R   1 0

Hydrologic Parameter Estimation

After the physical characteristics of streams and subbasins have been extracted, users have the option to estimate a number of hydrologic parameters. Parameters can be estimated as subbasin average and grid-based values using soil and land use databases. Other hydrologic parameters, such as time of concentration and Muskingum-Cunge routing parameters can be obtained from the terrain, surveyed data, and precipitation data.

The program can assist in estimating the curve number, loss rates for the initial and constant and deficit and constant loss methods, Muskingun-Cunge and kinematic wave routing parameters, subbasin time of concentration, and subbasin lag time. Tools on the **Hydrologic Parameters** menu will populate the attribute tables for the subbasin and river layers. This information will be contained in the HEC-HMS model file generated by HEC-GeoHMS, thus saving the user time when parameterizing the model. The user should compare and verify these estimated hydrologic parameters against published information. Parameter values computed using GIS data sources should be treated as initial estimates. Calibration and validation of the HEC-HMS model should be used to refine model parameters.

Data Management
Select HMS Processes
River Auto Name
Basin Auto Name
Grid Cell Processing
Subbasin Parameters from Raster
Subbasin Parameters from Features
Muskingum-Cunge and Kinematic Wave Parameters
TR55 Flow Path Segments
TR55 Flow Segment Parameters
TR55 Export Tt Parameters to Excel
CN Lag Method

This chapter will discuss the tools for estimating hydrologic parameters that are available from the **Hydrologic Parameters** menu. Below is an outline of Chapter 10.

Contents

- Select HMS Processes
- River Auto Name
- Basin Auto Name
- Grid Cell Processing
- Subbasin Parameters from Raster

- Subbasin Parameters from Features
- Muskingum-Cunge and Kinematic Wave Parameters
- Time of Concentration
- CN Lag Method

Select HMS Processes

This tool allows the users to select the HEC-HMS modeling methods that will be used in the study. This information is saved in attribute tables for the subbasin and river layers and will be included in the HEC-HMS project files created by HEC-GeoHMS.

Steps

- Go to **Hydrologic Parameters → Select HMS Processes**.

- Verify that the subbasin and river layers are selected.

- From the dropdown menus, the user can select Loss, Transform, and Baseflow methods for the subbasins and a Route method for the river reaches as shown in Figure 10-1.
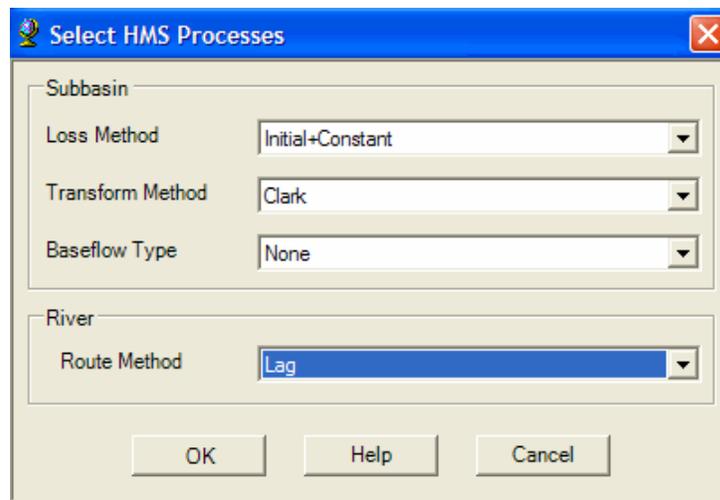
Figure 10-1. Select HMS Processes.

River Auto Name

This process names reaches in sequence from upstream to downstream. The naming convention combines the letter "R" and a number. For example, the upstream reach starts with R500 and then R490, R480, R470, etc. are the reach names proceeding downstream. The intent of this tool is to quickly name the reaches. The user should change the default names to a more descriptive name.

Steps

- Select **Hydrologic Parameters → River Auto Name**.

- Confirm that the river layer is selected and press **OK**.

The river auto name operation creates a "Name" column in the river layer's attribute table as shown in Figure 10-2.

Figure 10-2. River Auto Name Result.

The following steps can be used to edit the names in the attribute table.

- From the **Editor** toolbar, select **Editor → Start Editing**.

- Select the appropriate geodatabase containing the river layer.

- Open the river layer's attribute table.

- Select a field in the "Name" column and revise it.

- When finished, select **Editor → Stop Editing**.

- The user is prompted to save the edits.

Basin Auto Name

This process names the subbasins in sequence from upstream to downstream. The naming convention combines the letter "W" and a number. For example, the upstream subbasin starts with W500 and then W490, W480, W470, etc. are the subbasin names proceeding downstream. The intent of this tool is to quickly name subbasins. The user should change the default names to a more descriptive name.

Steps

- Select **Hydrologic Parameters → Basin Auto Name**.

- Confirm the subbasin layer is selected and press **OK**.

The basin auto name operation creates a "Name" column in the subbasin layer's attribute table as shown in Figure 10-3.
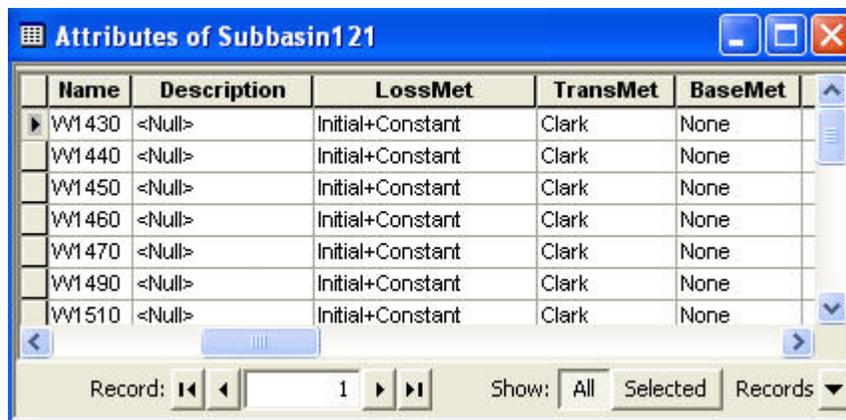
Figure 10-3. Subbasin Auto Name Result.

Grid Cell Processing

The **Grid Cell Processing** tool should only be used if the user plans on using gridded precipitation, like RADAR rainfall, and gridded loss methods. This tool is not necessary if using precipitation gage data or hypothetical storms. The grid cell processing tool creates a grid-based representation of the basin. This tool should be used after the user has revised the subbasin names.

This tool creates a grid cell polygon layer, which divides the project area into grid cells. The grid is intersected with the subbasin layer to determine grid cell locations and areas within each subbasin. HEC-GeoHMS supports two pre-defined grid geometries: the Standard Hydrologic Grid (SHG) and the Hydrologic Rainfall Analysis Project (HRAP). Radar rainfall data from the National Weather Service is reported in the HRAP grid format; however, tools available from HEC can convert the radar data to the SHG format. More details on the selection of a grid format are available in Appendix D.

The grid cell processing tool creates a number of new layers. A new polygon layer showing the grid intersected with the subbasin polygons will be added to the project data frame. In addition, the grid cell processing tool will create a new data frame and populate it with three layers. All three layers are projected to the SHG or HRAP coordinate system. The layers include a polygon layer of the grid, polygon layer of the subbasin boundaries, and polygon layer of the intersection between the grid and subbasin boundaries.

As mentioned, the grid cell processing tool will create a new polygon layer showing the grid intersected with the subbasin polygons and add it to the project data frame. This grid cell polygon layer contains the following fields:

- Cell_Area: Grid cell area chosen by the user.

- Cell_ID: Unique identifier for each grid cell polygon.

- Name: Name of the subbasin the cell is located within.

- Cell_X: x coordinate of the cell.

- Cell_Y: y coordinate of the cell.

- Mod_Area: Area of each polygon in square kilometers

- FlowLength: Average distance in kilometers of all the DEM cells in the grid polygon to the subbasin's outlet.

Steps

- Select **Hydrologic Parameters → Grid Cell Processing**. The *Grid Cell Processing* editor is shown in Figure 10-4.
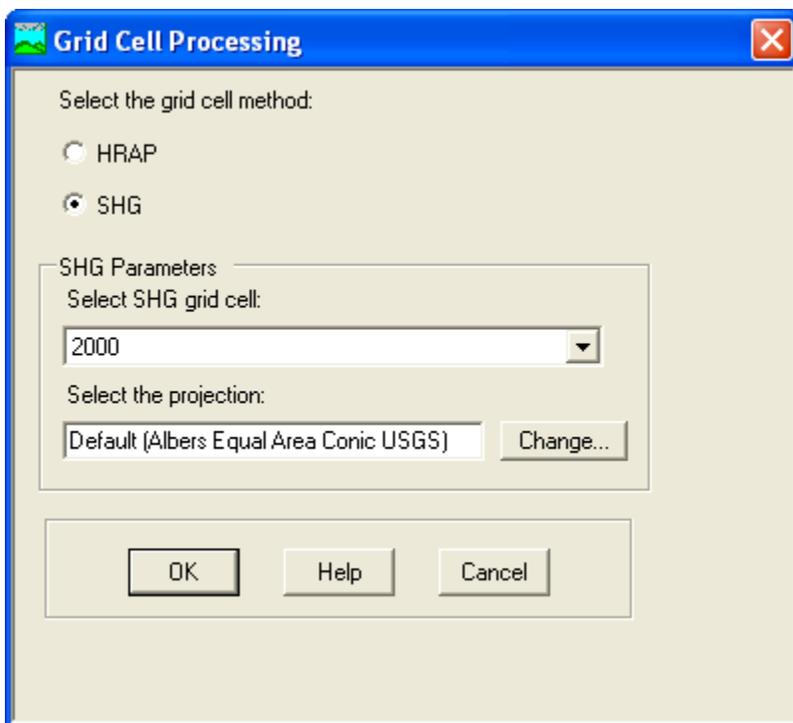
Figure 10-4. Grid Cell Processing.

- Select the **SHG** or **HRAP** grid cell method. In most cases the SHG method should be used. This option allows the user to select the grid size and the SHG projection preserves area, which is important when estimating hydrologic parameters.

- If the SHG grid cell method is selected, then the user must select the SHG grid cell resolution from the dropdown menu. A grid-cell resolution of 2000 meters is often suggested when working with radar rainfall data. At that resolution, a grid cell has an area of four square kilometers if it resides entirely within a subbasin. A smaller grid cell resolution can be used to capture heterogeneous watershed characteristics, like impervious area. The resolution of the parameter grids must match the resolution of the grid cell defined by the grid cell processing tool.

- The SHG grid uses the Albers Equal-Area projection by default. Do not change the default projection.

- Press **OK**.

- Verify the subbasin layer and flow direction grid are selected in the ***Grid Cell Computation*** editor as shown in Figure 10-5. If the user developed a flow length grid then it should be selected; however, it is not required. In most cases, the flow length grid will be set to "null". If created by the user, the flow length grid should contain the distance from the grid cell to the subbasin outlet. Enter a name for the new "Grid Cell Intersection" layer and press the **OK** button.
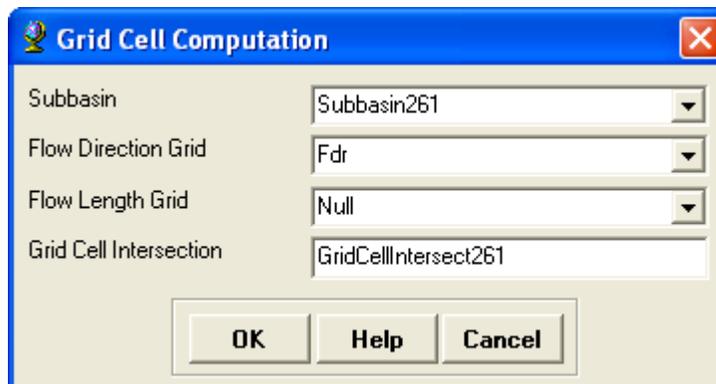
Figure 10-5. Grid Cell Computation Editor.

- Verify the "Projected Subbasin Layer" is selected and enter a name for the "Grid Cell Layer" in the ***Grid Cell View*** editor, shown in Figure 10-6. The "Projected Subbasin Layer" will automatically be created by the program and named using the subbasin layer name with "Proj" appended to the end. The "Grid Cell Layer" is a polygon layer of the grid.

- Press the **OK** button.
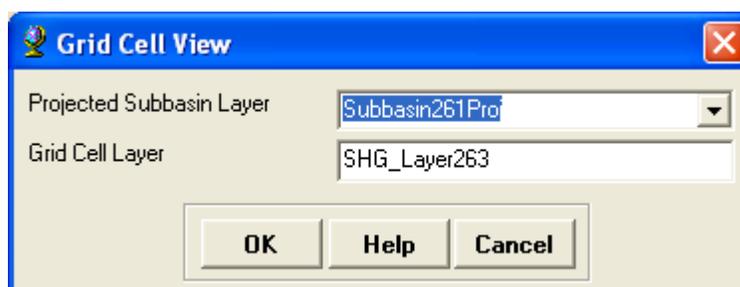
Figure 10-6. Grid Cell View Editor.

The grid cell processing tool will create a new data frame and populate it with three layers. All three layers are projected to the SHG or HRAP coordinate system. The layers include a polygon layer of the grid, polygon layer of the subbasin boundaries, and polygon layer of the intersection between the grid and subbasin boundaries as shown in Figure 10-7.

A new polygon layer showing the grid intersected with the subbasin polygons will be added to the project data frame. The attribute table contains

information that will be used by HEC-HMS when processing gridded data. This included grid cell location, polygon area, and travel length. The travel length is the average distance from the grid cell to the subbasin outlet as shown Figure 10-8. The travel length is used by HEC-HMS when the ModClark transform method is selected.

The grid cell layer's attribute table, shown in Figure 10-9, stores the results for the each grid cell.
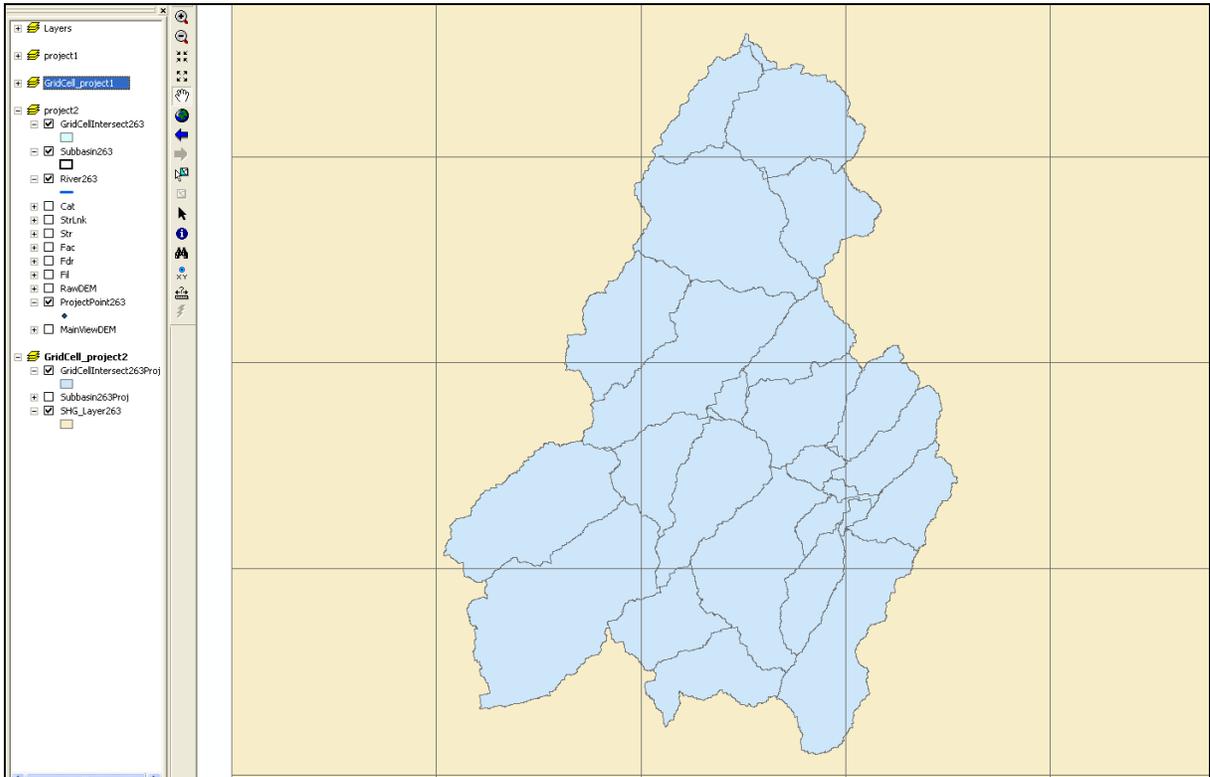
Figure 10-7. Intersection between Subbasins and SHG Grid.

Figure 10-8. Flow Length Displayed for Each Grid Cell.

Figure 10-9. Attribute Table for the Grid Cell Layer.

Subbasin Parameters from Raster

- This tool operates on a raster layer and computes the average hydrologic parameters for each subbasin. This tool is similar to the **Zonal Statistics** tool located on the **Spatial Analyst** toolbar and can be used to compute initial parameter estimates for a few of the loss methods in HEC-HMS. Future version of HEC-GeoHMS will allow for the estimation of more loss method parameters.

- Press **OK**.

- Press **OK**.

Table 10-1 shows parameters currently supported by HEC-GeoHMS. These are contained in the attribute table for the subbasin layer. Parameters not included in this list can still be estimated using GIS data; however, the parameter will have to be entered manually by the user into the HEC-HMS model. The grid layers used to estimate these parameters can be generated using the **Feature to Raster** tool on the **Spatial Analyst** toolbar or the **Features to Raster** tool accessible from the **Utility** menu on the **HEC-GeoHMS Project View** toolbar.

The curve number and initial abstraction parameters are used for the SCS Curve number loss method, the initial loss and constant loss parameters are used for the initial and constant loss method, and the initial deficit, maximum deficit, and constant loss are used by the deficit and constant loss method. The percent impervious parameter can be used for all loss methods in HEC-HMS. The **Subbasin Parameters from Raster** tool will populate the subbasin layer's attribute table with the basin average parameter values. HEC-GeoHMS will export this information to the HEC-HMS basin model file.

Steps

- Select **Hydrologic Parameters → Subbasin Parameters from Raster**. The ***Subbasin Parameters from Raster*** editor is shown in Figure 10-10.

- • Select the subbasin layer and all grid layers available for computing basin average parameters. The grids are developed by the user and should be added as layers in the data frame in order to be visible from the dropdown. The grids should be in the same projection as the subbasin layer.

- • Press **OK**.

Table 10-1. Parameters Contained in the Subbasin Layer's Attribute Tables.

Parameter	Field Heading in Subbasin Layer's Attribute Table	Description
Curve Number	BasinCN	Curve Number loss method parameter
Constant Loss	ConstLoss	C Initial and Constant loss method parameter
Initial Deficit	IDeficit	Deficit and Constant loss method parameter
Initial Abstraction	InitAbst	Curve Number loss method parameter
Initial Loss	InitLoss	Initial and Constant loss method parameter
Maximum Deficit	MaxDeficit	Deficit and Constant loss method parameter
Percent Impervious	PctImp	Used by all loss methods
Time of Concentration	Tc	Clark unit hydrograph parameter
Basin Lag	BasinLag	
2Year Rainfall	Rain2Yr	Used by HEC-GeoHMS for estimating time of concentration parameter
Design Rainfall	RainDesign	Used by HEC-GeoHMS for creating the Design Gage meteorological model file. This is used as the total storm rainfall.
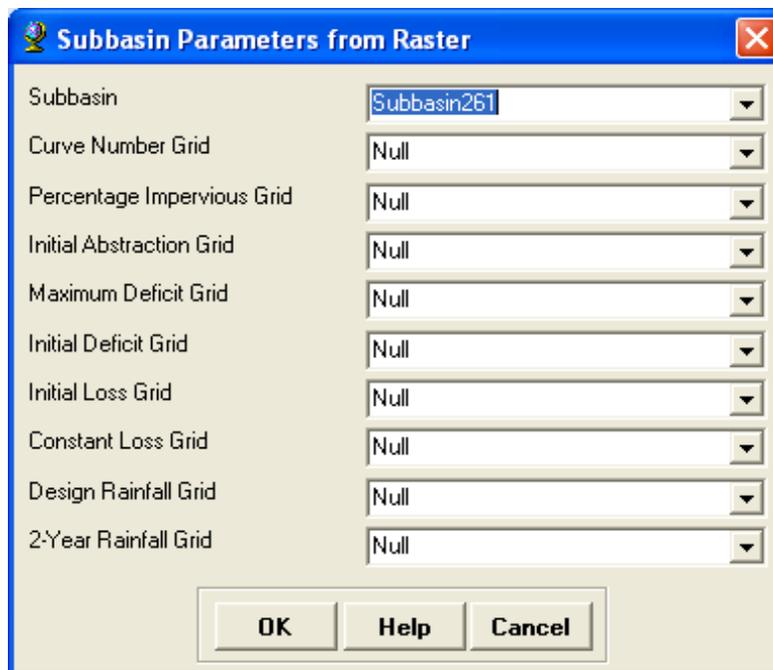
Figure 10-10. Subbasin Parameters from Raster Editor.

The subbasin averaged hydrologic parameters are stored in the subbasin layer's attribute table.

Subbasin Parameters from Features

This function operates on polygon features and computes the average hydrologic parameter for each subbasin. A new column will be added to the subbasin layer's attribute table containing the average parameter value. This information will not be automatically passed on to the HEC-HMS basin model file like output from the Subbasin Parameters from Raster tool. The user will have to edit the attribute table in order to do this.

Before the **Subbasin Parameters from Feature** tool can be used, the user must intersect the subbasin layer and the parameter layer using Arc Hydro. The following steps show how to use Arc Hydro to intersect two layers.

Steps for layer intersection using Arc Hydro

- Use ArcCatalog and import the parameter layer into the HEC-GeoHMS project geodatabase. After the parameter layer has been imported, use the **Add Data** button and add it to the project data frame.

- Select **Attribute Tools → Assign HydroID** from the **Arc Hydro Tools** toolbar. From the *Assign HydroID* editor, shown in Figure 10-11, choose the correct layer, the parameter layer(s), in the list and select **Yes** to overwrite existing HydroIDs. Press **OK**. After this step, the attribute table for the parameter layer will contain a

new column named "HYDROID"" and the column will be populated with unique values.
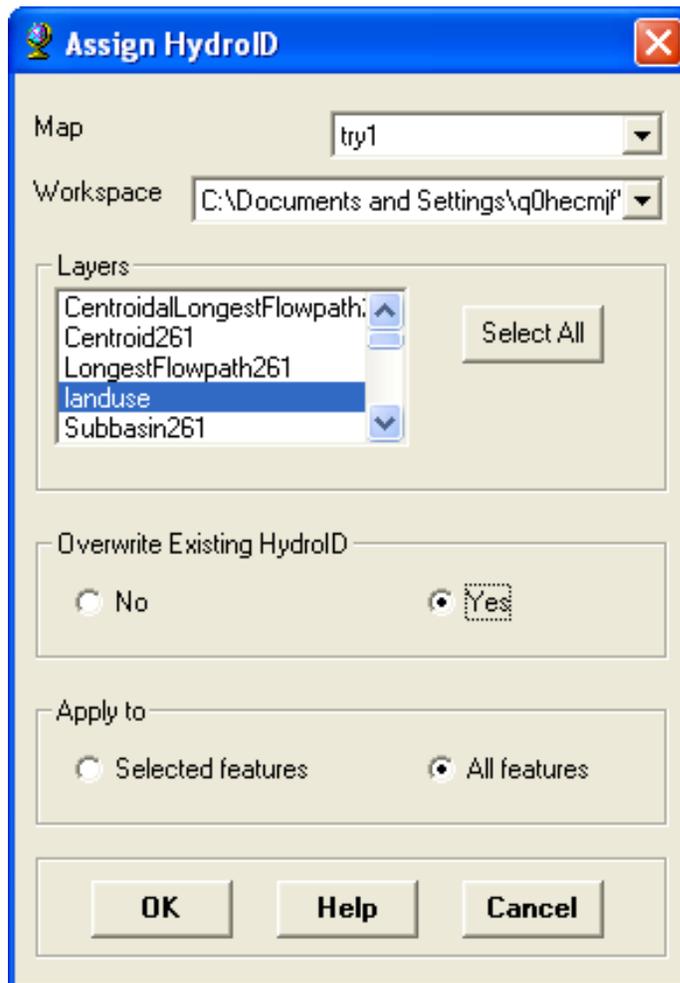
Figure 10-11. Assign HydroID Editor.

- Press the **Show ArcToolbox Window** button .

- Add the **Arc Hydro Tools** toolbox if not already added to ArcToolbox. To add this toolbox, place the mouse anywhere in the ArcToolbox window and press the right mouse button. Select the **Add Toolbox** option as shown in Figure 10-12.
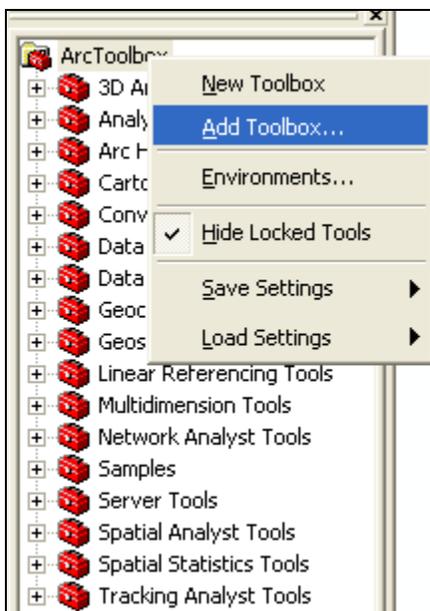
Figure 10-12. Add a Toolbox to ArcToolbox.

- Navigate to the Arc Hydro Tools toolbox. The default location will be C:\Program Files\ArcGIS\ArcToolbox\Toolboxes. Select **Arc Hydro Tools** and press the **Open** button.

- Expand the Arc Hydro Tools toolbox and select **Utility**. Open the **Intersect Areas** tool as shown in Figure 10-13.
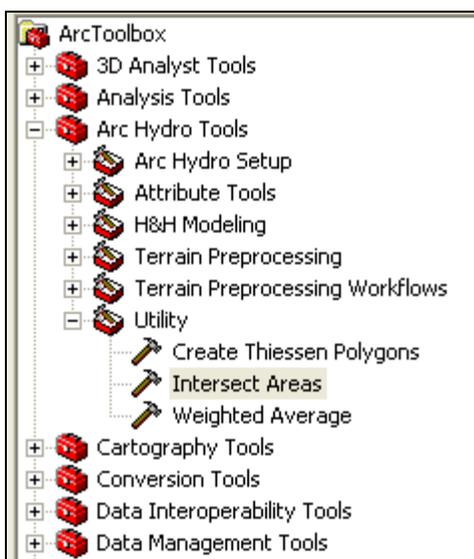
Figure 10-13. Intersect Areas Tool.

- Figure 10-14 shows the ***Intersect Areas*** editor. Choose the **Input From Layer**. This should be the parameter layer.

- Choose the **Input To Layer**. This should be the subbasin layer.

- Enter a name for the output layer. This layer is created by intersecting the parameter and subbasin layers.

The output layer is the intersection of the parameter and subbasin layers. Figure 10-15 shows the attribute table of the intersection layer. Notice the PctFrom and PctTo columns. These will be used by the **Subbasin Parameters from Features** tool to compute subbasin average parameter values.
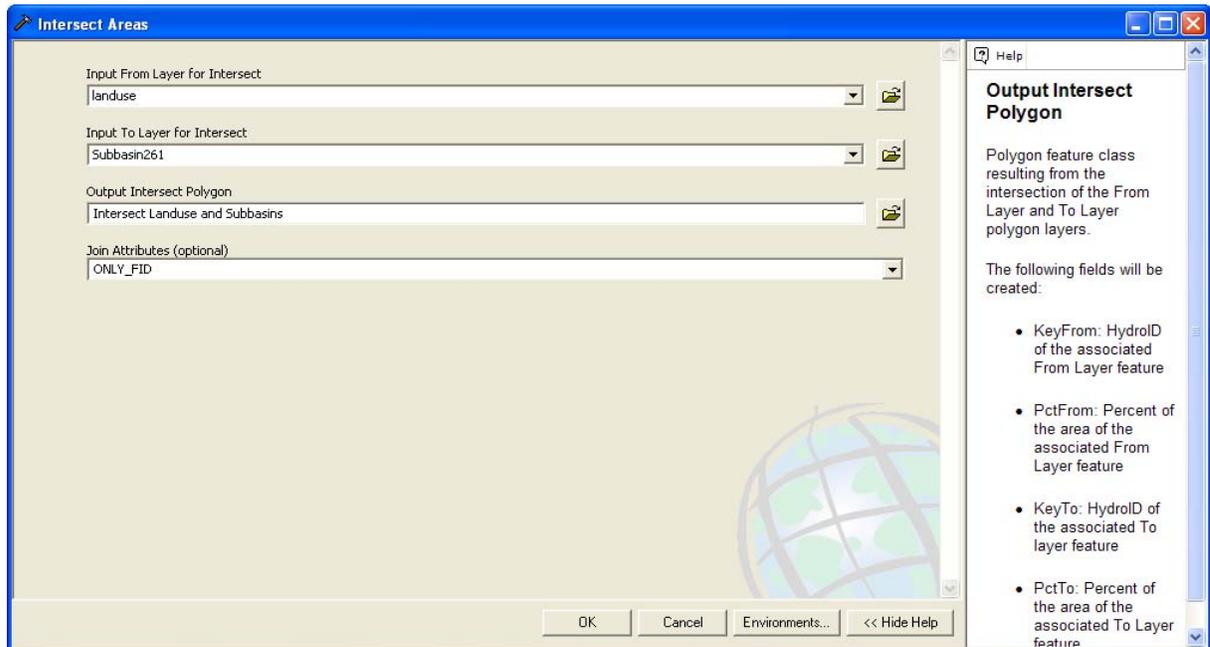
Figure 10-14. Intersect Areas Dialog.

Figure 10-15. Attribute Table of Intersected Layer.

Steps for using the Subbasin Parameter from Features tool

- Select **Hydrologic Parameters → Subbasin Parameters from Features** on the **HEC-GeoHMS Project View** toolbar. The *Subbasin Parameters from Features* editor is shown in Figure 10-16.

- Select the parameter layer.

- Select the attribute field in the parameter layer to be averaged for each subbasin.

- Select the subbasin layer.

- Select the intersect layer. This layer was created by intersecting the parameter and subbasin layers.

- Press **OK**.
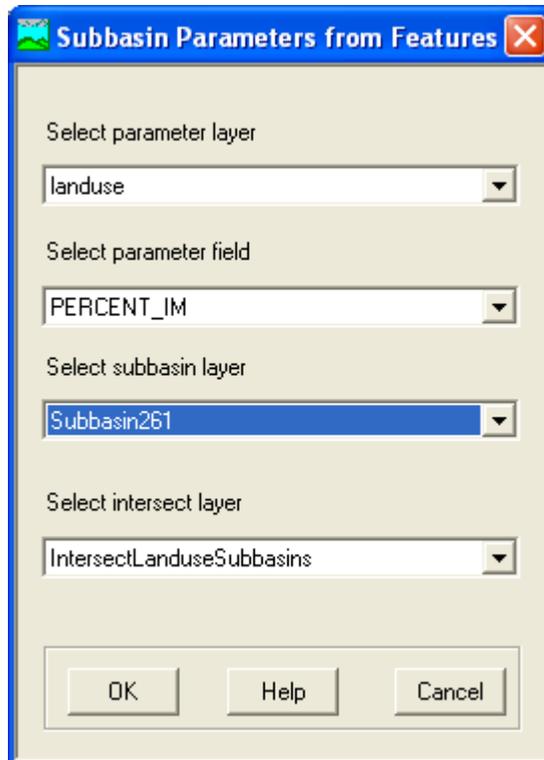
Figure 10-16. Subbasin Parameters from Features Editor.

The selected parameter in the parameter field is now estimated as an average quantity over each subbasin. A new column is added to the subbasin layer's attribute table that contains this averaged parameter value. The user can manually enter the parameter values computed by this tool into the HEC-HMS model or edit the subbasin layer's attribute table so that the information will be written by HEC-GeoHMS to the HEC-HMS basin model file. To do this, the user can use the field calculator to copy the data field created by the Subbasin Parameters from Features tool to the appropriate column in the subbasin layer's attribute table. For example, if the Subbasin Parameters from Features tool was used to compute the average impervious area for each subbasin then the user should copy this information to the "PctImp" field.

Muskingum-Cunge and Kinematic Wave Parameters

This tool facilitates manual entry of Muskingum-Cunge and Kinematic Wave routing parameters. In most cases, the user will not be able to get accurate channel geometry from the DEM, which is often too coarse. However, the user can use as-built drawings, photos, survey data, and other information that show channel shape and geometry as shown in Figure 10-17. This information can provide a basis for the user to specify channel dimension, shape, and other parameters.
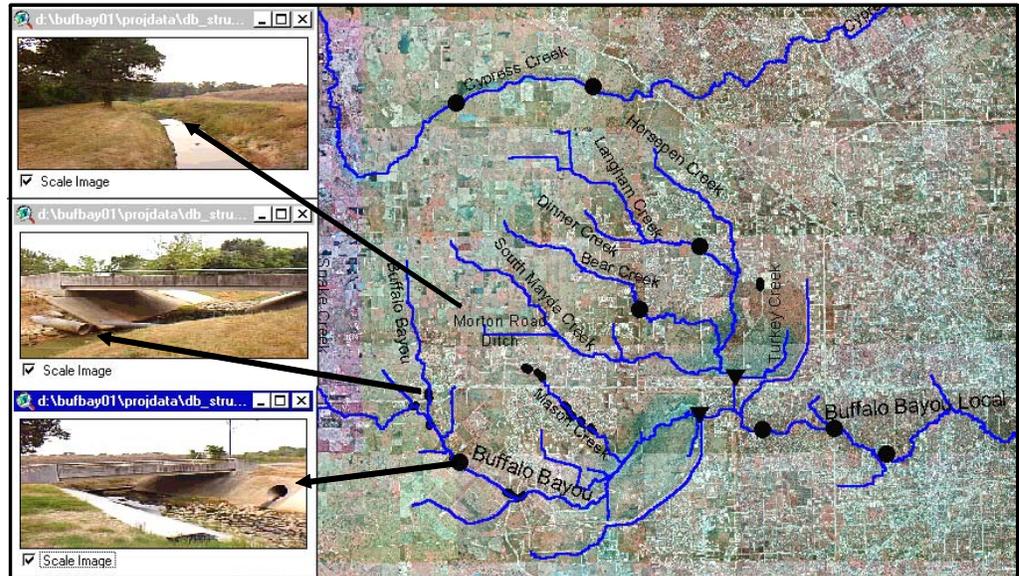
Figure 10-17. Field Survey Data and Photographs.

Steps

- Select at least one river segment.

- Select **Hydrologic Parameters → Muskingum-Cunge and Kinematic Wave Parameters.**

- Choose the river layer.

- Enter the bottom width of the channel, channel side slopes, and the channel's roughness coefficient (Manning's n) as shown in Figure 10-18.   The user must enter the bottom width in the units of the HMS model because unit conversion will not be performed.

Figure 10-18. Muskingum-Cunge and Kinematic Wave Parameters.

This function creates or updates the following attribute fields in the river layer.

- ChnShapeMusk: Muskingum-Cunge channel shape.
- ChnShapeKine: Kinematic Wave channel shape.
- ChnWidth: Channel width.
- ChnSdSlp: Channel side slope.
- ChnManN: Channel Manning's n.

Time of Concentration

The time of concentration is estimated in accordance to the Natural Resource Conservation Service (NRCS) TR-55 methodology. The following information is required to estimate travel time, two-year 24-hour rainfall amount, slopes, flow distance of precipitation excess on the land's surface for the three NRCS flow regimes - sheet flow, shallow concentrated flow, and channel flow. These inputs are used to populate a Microsoft Excel template spreadsheet. Users are encouraged to check and overwrite these GIS derived parameters as well as provide additional inputs, such as Manning's roughness coefficient, channel cross-sectional area, and wetted perimeter. Users have full control over the spreadsheet to make changes to parameters and even equations, as appropriate.

The spreadsheet is launched from a HEC-GeoHMS menu. Oftentimes, HEC-GeoHMS is unable to locate Excel because the various directories that Excel can be installed. The user can help HEC-GeoHMS locate Excel by opening the Excel template, named tcV3.xls, before selecting **Hydrologic Parameters →**

TR55 Export Tt Parameters to Excel. If HEC-GeoHMS was installed to the default location then this file is located in the following directory, C:\Program Files\HEC\HEC-GeoHMS\bin.

The user should estimate the two-year 24-hour rainfall before running the TR-55 tools. The "Rain2Yr" field in the subbasin layer's attribute table should be populated. These values could be entered manually or the **Subbasin Parameters from Raster** or **Subbasin Parameters from Features** tools could be used. To be consistent with the TR-55 method, the precipitation intensity value should be in inches.

TR55 Flow Path Segments

This tool is used to define different flow regimes along the longest flow path. This tool places two points along the longest flow path for each subbasin. If no subbasin has been selected, the function processes all the subbasins. The first point, AA, marks the break between sheet flow and shallow concentrated flow. Point AA is by default located about 100 feet from the watershed divide along the longest flow path. The second point, BB, marks the break between shallow concentrated flow and the channel flow. Point BB is by default located where the longest flow path first encounters or intersects the channel. The user can manually edit the location of these points; however, they must fall on top of the longest flow path.

Steps

- Select **Hydrologic Parameters → TR55 Flow Path Segments**.
- Select the subbasin, river, and longest flow path layers in the *TR55 Flow Path Segments Computation* editor, as shown in Figure 10-19. Enter a name for the new "Flow Break Points" layer or accept the default name.
- Press **OK**.
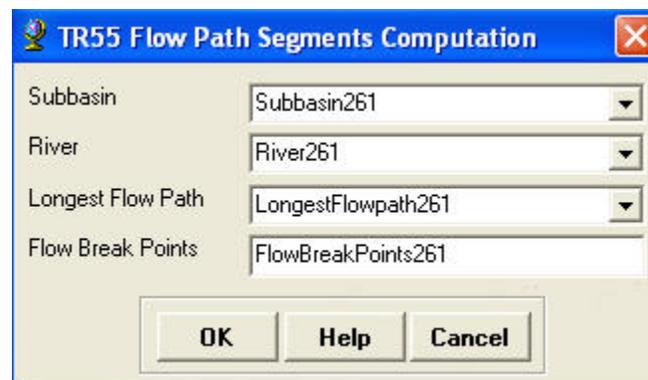
Figure 10-19. TR55 Flow Path Segments Computation Editor.

The tool creates the flow break point layer as shown in Figure 10-20. This layer contains a field titled "Name" which indicates whether the point is an "AA" or a "BB" point.
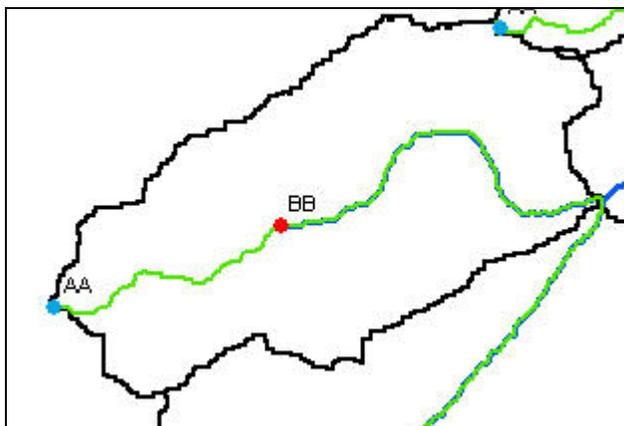
Figure 10-20. Flow Path Break Point Computation Result.

Once these points are placed by the program, the user has the flexibility to move them using the editing tools. The points must be located along the longest flow path.

The user can also apply the **Interactive Flow Path** tool, ![icon], to specify a different longest flow path, see subsequent section.

Interactive Flow Path

The user can use the **Interactive Flow Path** tool, ![icon], to generate an alternative longest flow path.

Steps

- Select the **Interactive Flow Path** tool, ![icon].
- Click on the location of the most hydraulically remote point in the subbasin

The tool shows the user the flow path for the location selected and allows the user to accept or reject the updated longest flow path. If the flow path is replaced, then attribute information will be updated.

TR55 Flow Segment Parameters

This function calculates the length and slope for the TR55 flow paths. It operates on a selected set of subbasins. If no subbasins are selected, the function processes all the subbasins.

The function extracts the elevations from the terrain at the starting and ending points of the longest flow paths and at the AA and BB flow break points.

Lengths are measured along the longest flow path between the four points of interest.

The function creates or updates the following fields in the longest flow path layer.

- ChSlopeFpf: Slope for the TR55 channel flow segment (ft/ft) between point BB and the end of the channel.

- ChLengthFt: Length of the TR55 channel flow segment (between the BB flow break point and the outlet of the sub basin) (ft).

- ShSlopeFpf: Slope for the TR55 shallow flow (overland flow) segment (ft/ft) between most remote point and AA.

- ConShLengthFt: Length of the TR55 concentrated shallow flow segment (between AA and BB flow break points) (ft).

- ConShSlopeFpf: Slope for the TR55 concentrated shallow flow segment (ft/ft) between point AA and BB.

- ShLengthFt: Length of the TR55 shallow flow (overland flow) segment (between start of the longest flow path and the AA flow break point) (ft).

Export TR55 Data

This function exports the data for the TR55 flow segments to a Microsoft Excel template workbook. The function operates on a selected set of subbasins in the subbasin layer. If no subbasin has been selected, the tool processes all the subbasins.

In the Excel spreadsheet, as shown in Figure 10-21, the blue areas (if the document is displayed in color) contain the data brought in from HEC-GeoHMS. The user can overwrite them if necessary, but those changes will not be transferred back to HEC-GeoHMS. The green areas contain data; however, the user should verify and edit these values to better reflect field conditions. The white and yellow areas contain computed values; therefore they should not be modified in any way. They will be recomputed whenever there are changes to the blue and green areas.

Figure 10-21. TR55 Travel Time Computation Spreadsheet.

The Excel spreadsheet will be stored automatically in the project directory within a folder named "XLSFiles". Once the travel time of each subbasin is

estimated, the user can press the calculator button, , to transfer the travel times back to HEC-GeoHMS.

The tool updates the following fields in the subbasin layer's attribute:

- Tc: Basin time of concentration (hours).
- BasinLag: Basin lag (hours), computed as 0.6*Tc.
- LagMethod: Method used for lag computations. The entry will be "TR55" for basins in which the TR55 method was used.

CN Lag Method

The **CN Lag Method** tool computes the basin lag time according to the equation below. This equation is based on the curve number method as described in the NRCS National Engineering Handbook, 1972 and was developed for application to watersheds of less than 2000 acres. The tool operates on a selected set of subbasins in the subbasin layer. If no subbasin has been selected, the function processes all the subbasins.

The user must populate the "BasinCN" and "BasinSlope" fields in the subbasin layer's attribute table before using this tool. The **Subbasin Parameters from**

Raster or **Subbasin Parameters from Features** tools can be used to estimate these parameters. A slope grid can be computed using the Slope tool on the Terrain Preprocessing menu (Arc Hydro Tools toolbar) or the Slope tool accessible from the Spatial Analyst toolbar.

$$Lag = \frac{(L^{0.8} * (S+1)^{0.7})}{(1900 * Y^{0.5})}$$

Where: Lag = basin lag time (hours)

L = hydraulic length of the watershed (feet)

$$S = \frac{1000}{CN} - 10$$

CN values between 50 to 95 are appropriate to this equation.

Y = basin slope (%)

This tool creates or updates the following fields in the subbasin layer's attribute table:

- BasinLag: Basin lag (hours).
- LagMethod: Method used for lag computations. For subbasins in which the CN lag method was used, the entry will be "CNLag".

CHAPTER 11

Hydrologic Modeling System

HEC-GeoHMS develops a number of hydrologic inputs for HEC-HMS: background-map files, basin model file, grid-cell parameter file, and meteorologic model files. This chapter will discuss the tools for generating HEC-HMS model files that are available under the **HMS** menu located on the **HEC-GeoHMS Project View** Toolbar. Below is an outline of Chapter 11.

Contents

- Map to HMS Units
- HMS Data Check
- HEC-HMS Basin Schematic
- HMS Legend
- Add Coordinates
- Prepare Data for Model Export
- Background Map
- Grid Cell Parameter File
- Basin File
- Generate ASCII Grids
- Generate DS from ASCII Grid
- Meteorologic Model
- HMS Project Setup
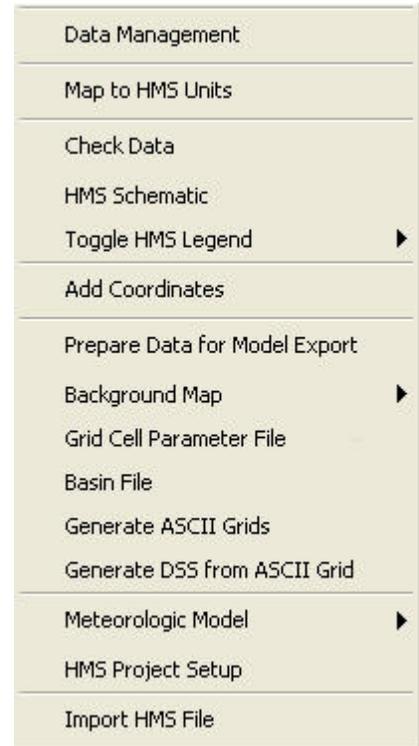
Map to HMS Units

This step converts the physical characteristics of reaches and subbasins to a user-selected unit system. The user has the option to convert the map units to English or International System (SI) units.

Steps

- Select **HMS → Map to HMS Units**.

- Confirm the correct layers are selected in the ***Map to HMS Units*** dialog as shown in Figure 11-1.
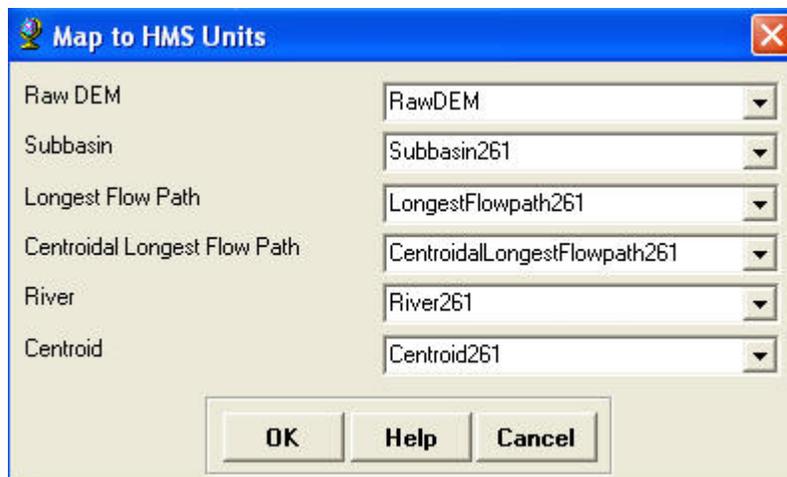
Figure 11-1. Map to HMS Units Editor.

- Select English or SI from the dropdown menu as shown in Figure 11-2 and press **OK**.
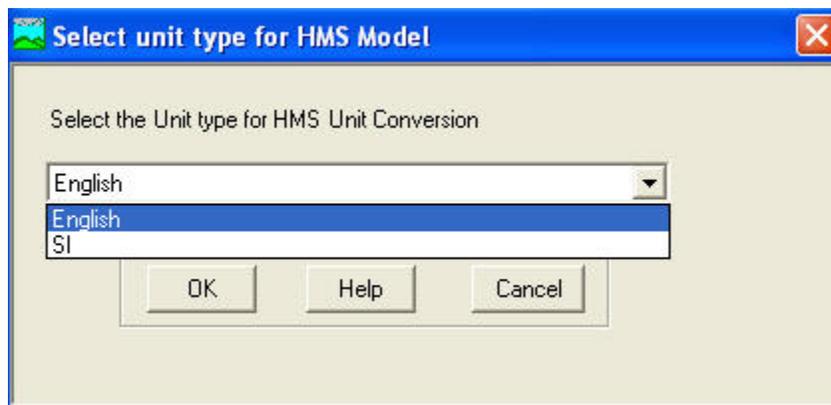
Figure 11-2. Select Units for HMS Model.

- Press **OK** in the confirmation message box.

The unit conversion operation results in additional columns added to the attribute table for the subbasin and river layers. The new columns will end in "HMS". For example, a column named "Area_HMS" is added to the subbasin layer's attribute table. The units for the data in this column will be square miles or square kilometers, depending on the selected unit system.

HMS Data Check

This step checks the datasets for consistency in describing the hydrologic structure of the model. For example, the program checks to make sure unique names were used for river reaches and subbasins. In addition, the program checks that rivers reaches and centroids are contained within a subbasin. This is needed for placement of the hydrologic element names and the hydrologic element connectivity. In general, the program keeps track of the relationship

between the stream segments, subbasins, and outlet points. These checks are necessary because the relationships between hydrologic elements may have been broken by unintentional use of subdivide and merge tools.

The program produces a text file, "SkelConsChk.txt", which contains the summary of the data check. This step does not fix any of the problems; however, the user can fix the problems manually using HEC-GeoHMS or HEC-HMS.

Steps

- Select **HMS → HMS Check Data**.
- Make sure the correct layers are selected in the *HMS Check Data* editor, as shown in Figure 11-3, and press **OK**.
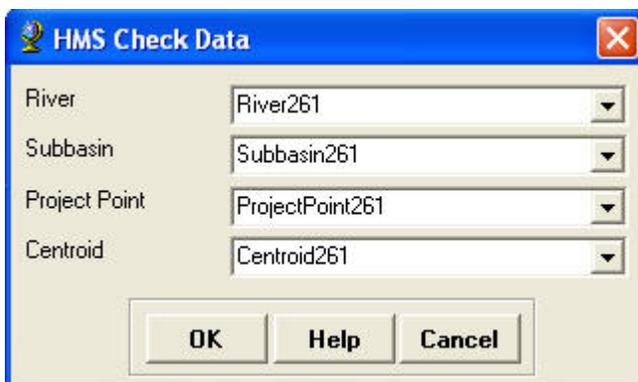
Figure 11-3. HMS Check Data Editor.

- Press **Yes** in the *HMS Check Data* dialog, Figure 11-4, to open the check data log file.
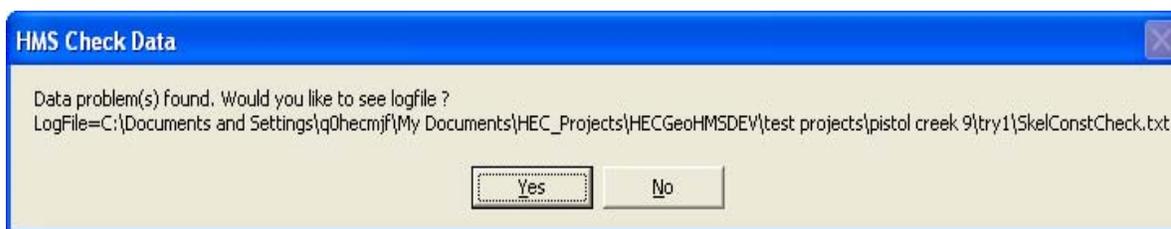
Figure 11-4. HMS Check Data Dialog.

Figure 11-5 shows an example summary check data file. Problems identified can be fixed using HEC-GeoHMS or HEC-HMS.

Figure 11-5. Check Data Result Summary.

HEC-HMS Basin Schematic

The HMS basin schematic is the GIS representation of the HEC-HMS model. This tool will build a simple hydrologic network that contains HEC-HMS model elements and shows their connectivity. This step creates an HMS Link layer, which shows the connectivity, and the HMS Node layer, which shows subbasin and junction node locations. Node locations for subbasins are placed at the centroid of the subbasin.

Steps

- Select **HMS → HMS Schematic**.
- Review the input layers and make sure the correct layers are selected in the *HMS Schematic* editor, shown in Figure 11-6.

Accept the default or enter a new name for the "HMS Link" and "HMS Node" layers and press **OK**.

Figure 11-6. HMS Schematic Editor.

- Press **OK** at the confirmation message.

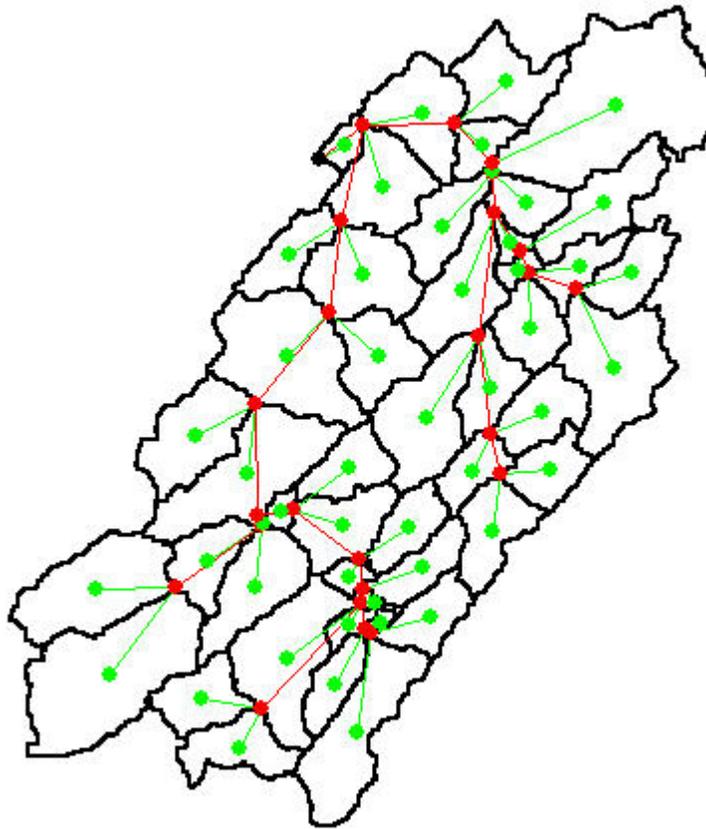The HMS schematic with ArcGIS symbols is shown in Figure 11-7.

Figure 11-7. Initial HMS Schematic with the Regular Legend.

HMS Legend

This tool uses the HEC-HMS element icons to represent point and line features in the HMS Node and HMS Link layers. The user has the option to toggle between the **HMS Legend** and the **Regular Legend**.

Steps

- Select **HMS → Toggle HMS Legend**.
- The user can toggle between **HMS Legend** and **Regular Legend**.

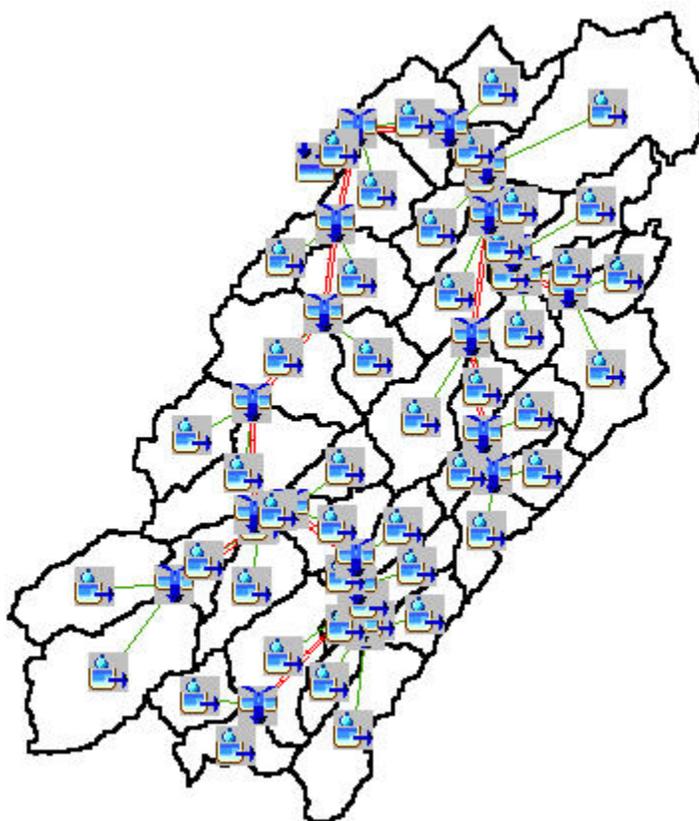The schematic with the **HMS Legend** is shown in Figure 11-8.

Figure 11-8. Schematic with HMS Legend.

Add Coordinates

This step attaches geographic coordinates to features in the HMS Node and HMS Link layers. The coordinates are added to the attribute tables. The attachment of coordinates allows GIS data to be exported to a non-proprietary ASCII format and still preserves the geospatial information.

Steps

- Select **HMS → Add Coordinates**.

- Make sure the correct layers are selected in the *Add Coordinates* editor, shown in Figure 11-9, and press **OK**.
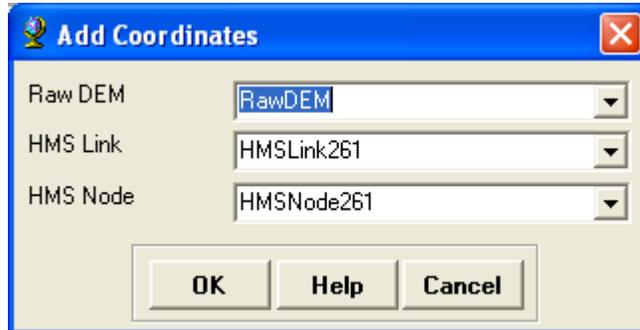

Figure 11-9. Add Coordinates Editor.

Figure 11-10 shows the attribute table for the **HMS Node** layer. The "CanvasX" and "CanvasY" fields contain the coordinate location for the hydrologic elements. The **HMS Link** layer contains additional information that describes orientation and flow direction for reach elements.

SrcType	CanvasX	CanvasY	Elevation	DownElemID	HyElemType
0	2569283.15	524254.44	858.18	-1	Sink
1	2566379.52	502966.78	1041.33	298	Subbasin
2	2567168.15	504424.44	1014.13	442	Junction
1	2565062.84	504791.06	1065.9	298	Subbasin
1	2570679.28	503543.35	1081.8	303	Subbasin
2	2571128.15	507154.44	995.44	441	Junction
1	2571497.73	507543.78	1016.58	306	Subbasin
2	2570948.15	507334.44	993.75	440	Junction
1	2569843.15	505294.73	1021.52	306	Subbasin
1	2573286.7	507732.68	1024.8	303	Subbasin
1	2570384.49	507410.86	1006.03	313	Subbasin
2	2570828.15	508234.44	986.31	439	Junction
1	2568167.16	506245.83	1013.4	313	Subbasin
1	2571293.89	508266.37	1016.21	318	Subbasin
2	2570858.15	508774.44	983.12	438	Junction
1	2561730.45	505634.68	1042.97	321	Subbasin

Figure 11-10. Attribute Table for the HMS Node Layer Populated with Coordinates.

Prepare Data for Model Export

An HMS basin model file contains the hydrologic data structure, which includes the hydrologic elements, their connectivity, and related parameters. HEC-GeoHMS can export some of the hydrologic parameters to the HMS basin model file; however, the user must finish parameterizing the basin model once it is imported into HEC-HMS.

Steps

- Select **HMS → Prepare Data for Model Export**.

- Make sure the correct subbasin and river layers are selected in the *Prepare Data for Model Export* editor, shown in Figure 11-11, and press **OK**.

Figure 11-11. Prepare Data for Model Export Editor.

This tool will gather parameter data stored in the attribute tables for the subbasin and river layers and prepare it for export to the HEC-HMS basin model file.

Background Map

Background map layers capture the geographic information of the subbasin boundaries and stream reaches. Two formats are available for creating background map layers, ASCII text file and shape file format. Both formats can be read by HMS. Shape file format does provide more flexibility in that the line properties can be edited in HEC-HMS. HEC-HMS has options for adjusting the color used to fill a polygon and to draw a line segment. The ASCII text file format is provided in Appendix B.

Steps

- Select **HMS → Background Map → Background Map File** or select **HMS → Background Map → Background Shape File**.

- If creating background shape files, make sure to select the subbasin and river layers in the *Background Shape File* editor, Figure 11-12. Press **OK**.

Figure 11-12. Background Shape File Editor.

.

- The ASCII text file and shape files will automatically be saved to the same directory as the project folder.

The HEC-HMS User's Manual shows how to load both the background map file and shape files. The background map file or shape files should be copied from the HEC-GeoHMS project directory to the HEC-HMS project directory before loading the files into an HEC-HMS project. This should help in managing model files and make it easier to pass an HEC-HMS project from one computer to another.

Grid-Cell Parameter File

This tool generates the grid cell parameter file that HEC-HMS requires to utilize gridded precipitation, a gridded loss method, or the ModClark transform method. The **Grid Cell Processing** step is required before the grid cell file can be created. You can access the Grid Cell Processing tool by selecting **Hydrologic Parameters → Grid Cell Processing**.

HEC-GeoHMS will create an ASCII file that contains the gridded subbasin information and automatically save it to the project directory. The grid-cell parameter file contains the x and y coordinates, grid cell area, and travel length to the subbasin outlet for each grid cell. The coordinates refer to the lower left corner of the grid cell. Appendix D shows how to compute the grid cell coordinates for both the SHG and HRAP grids. Figure 11-13 shows an example grid cell file. This file is divided into blocks of text for each subbasin. Each block of text lists the grid cells located in the subbasin and the coordinates, area, and travel length of each grid cell.

Figure 11-13. Example Grid Cell Parameter File.

Steps

- Select **HMS → Grid Cell Parameter File**.

- Make a note of the filename and its location and press **OK**.

The grid cell file should be copied from the HEC-GeoHMS project directory to the HEC-HMS project directory. This should help in managing model files and make it easier to pass an HEC-HMS project from one computer to another.
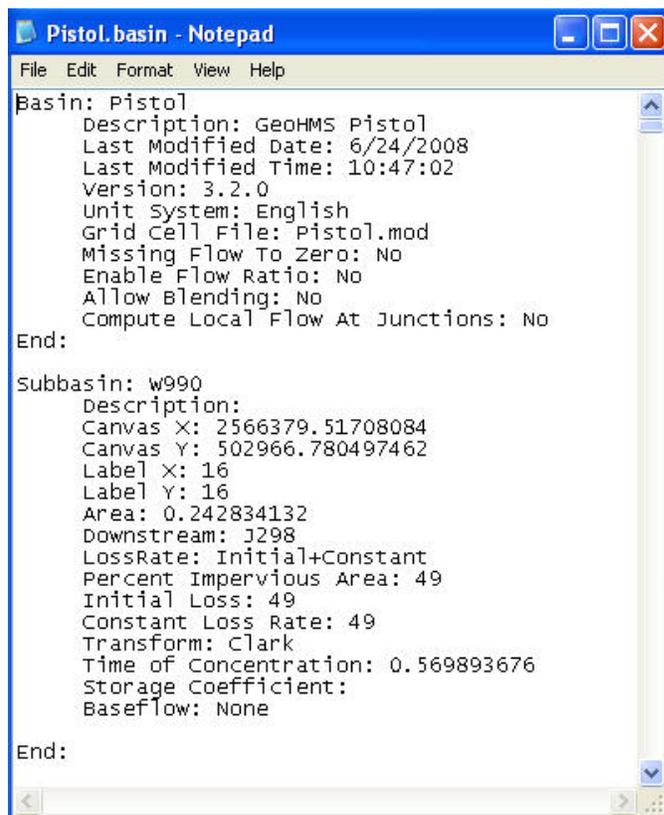
Basin File

The basin model captures the hydrologic elements, their connectivity, and related geographic information in an ASCII text file that can be loaded into an HEC-HMS project.

Steps

- Select **HMS → Basin File**.

- Make a note of the filename and its location and press **OK**.

An example basin model file, in ASCII format, is shown in Figure 11-14. This file can be imported directly into an HEC-HMS project. The HEC-HMS

User's Manual describes how to import basin model files into an existing HEC-HMS project.

Figure 11-14. Example HEC-HMS Basin Model File.

Generate ASCII Grids

The **Generate ASCII Grids** tool will create an ASCII grid file that can be imported into HEC-DSS. Precipitation and parameter grids must be in HEC-DSS format in order to be used by HEC-HMS. The Generate ASCII Grids tool is very limited in use. Only a few parameters are supported and this tool requires that the user add attributes to the grid cell intersect layer (this layer is created by the Grid Cell Intersect tool). These attributes must have specific column headings so that they are recognized. The supported parameters and the required column names include Basin Curve Number (BasinCN), Initial Loss Rate (InitLoss), Constant Loss Rate (ConstLoss), Percent Impervious Area (PctImp), and Maximum Deficit (MaxDeficit). The user must add these column names and then computed an average parameter value for each grid cell. There are a number of ways for manually populating the grid cell intersect layer. The following example shows one approach for populating the grid cell intersect layer with percent impervious data.

- Figure 11-15 shows a 500 meter SHG grid (created by the **Grid Cell Intersect** tool) on top of the subbasin boundary layer. Figure 11-16 shows an impervious area grid for this same area.

- The zonal statistics tool, **Spatial Analysis → Zonal Statistics**, was used to compute the average grid cell value for each 500 meter SHG grid cell.

A new field titled "PctImp" was added to the grid cell intersect layer. This field was populated with output from the zonal statistics tool, as shown in Figure 11-17. Figure 11-18 shows the grid cell intersect layer with the "PctImp" (percent impervious area) field displayed. The difference in Figure 11-16 and Figure 11-18 is the resolution of the grid. The original percent impervious grid had a grid cell size of 50 meters, whereas the grid cell intersect layer has a grid cell size of 500 meters.
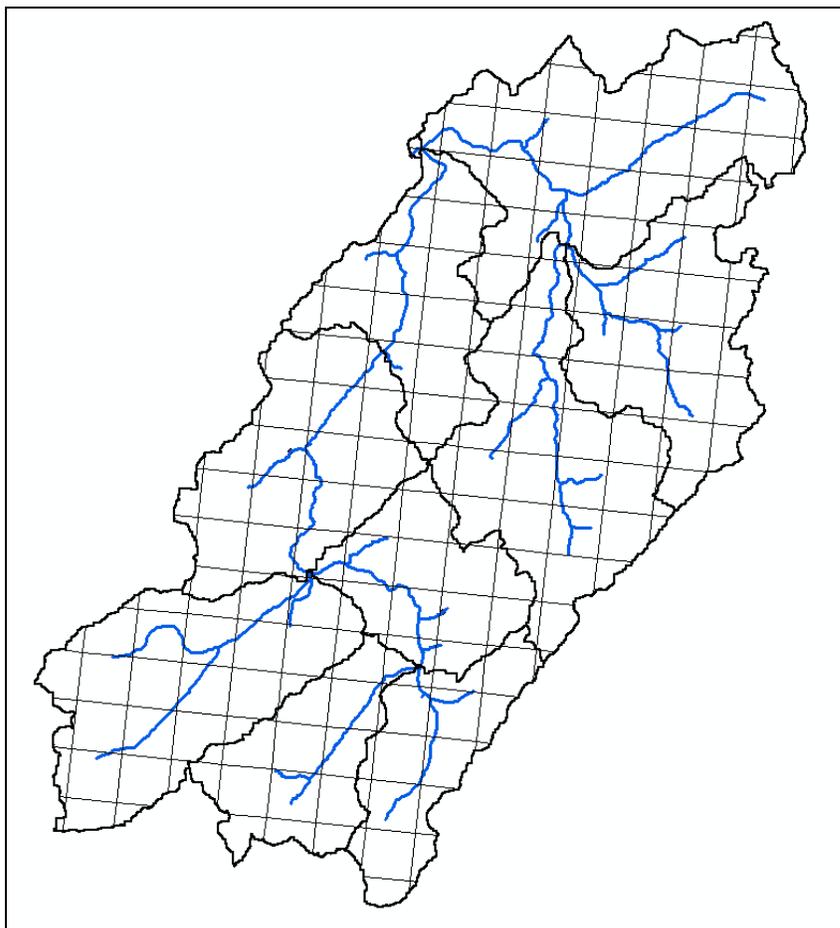

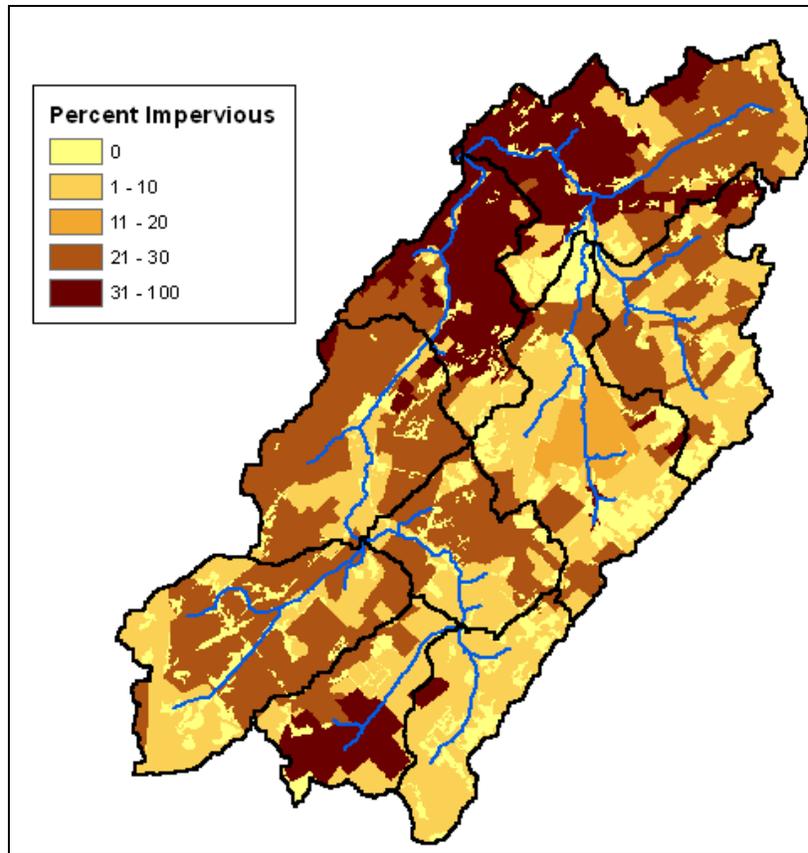**Figure 11-15.** Grid Cell Layer Displayed on Top of Subbasin Boundary.

Figure 11-16. Percent Impervious Grid.

Attributes of GridCellIntersect261

OBJECTID	Shape *	DrainID	Name	Mod_Area	FlowLength	Cell_ID	Cell_Area	Cell_X	Cell_Y	Pctimp
1	Polygon	92	W920	0.000787	3.218798	107	250000	2148	2944	1.666670
2	Polygon	93	W930	0.112309	3.026897	170	250000	2151	2944	4.145830
3	Polygon	93	W930	0.004508	3.177404	191	250000	2152	2944	5.000000
4	Polygon	82	W820	0.009133	4.369028	24	250000	2144	2945	10.094300
5	Polygon	82	W820	0.004558	4.034926	24	250000	2144	2945	10.094300
6	Polygon	82	W820	0.154497	4.20014	45	250000	2145	2945	5.160060
7	Polygon	82	W820	0.049321	3.85503	66	250000	2146	2945	4.927540
8	Polygon	92	W920	0.143534	2.928915	108	250000	2148	2945	16.343599
9	Polygon	92	W920	0.123607	2.625049	129	250000	2149	2945	14.198100
10	Polygon	92	W920	0.108143	2.839169	150	250000	2150	2945	7.722390
11	Polygon	93	W930	0.044132	2.450411	150	250000	2150	2945	7.722390
12	Polygon	93	W930	0.248091	2.625521	171	250000	2151	2945	4.615380
13	Polygon	93	W930	0.081787	2.563609	192	250000	2152	2945	4.474430

Figure 11-17. Grid Cell Intersect Layer with Percent Impervious Area.
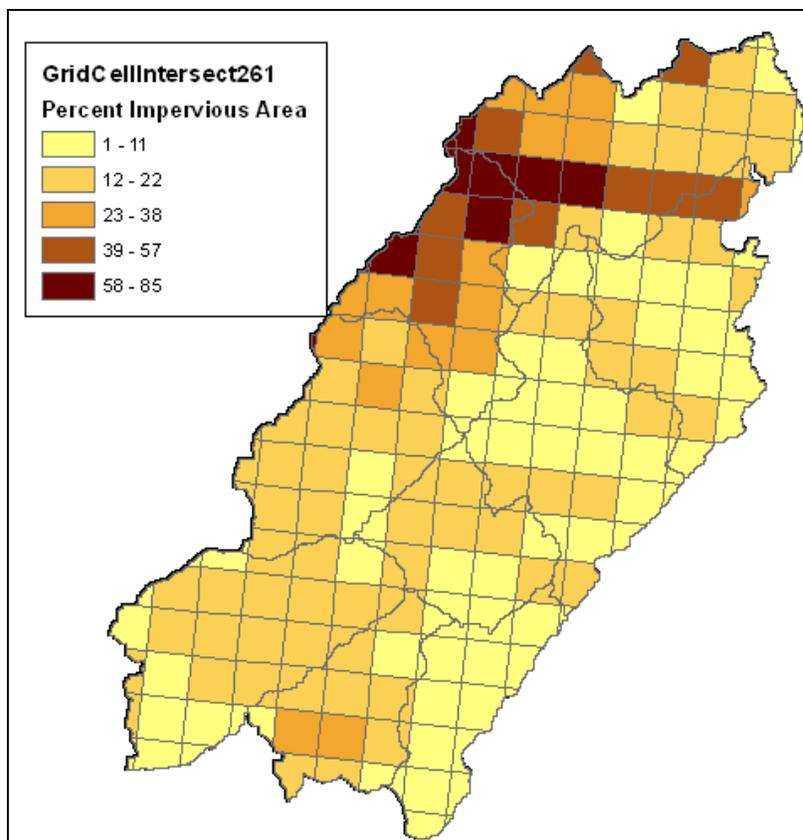
Figure 11-18. Average Percent Impervious Area for 500 Meter SHG.

Steps for using the Generate ASCII Grid tool

- Select **HMS → Generate ASCII Grids**.

- Select the parameter for which the ASCII grid will be created in the *Generate ASCII Grids* editor, shown in Figure 11-19. The attribute table for the grid cell intersect layer should contain the appropriate field names and data before this is selected.

Figure 11-19. Generate ASCII Grids Editor – Select Parameter.

- Choose the grid cell intersection layer as shown in Figure 11-20 and press **OK**.

Figure 11-20. Generate ASCII Grids Editor – Grid Cell Intersection Layer.

- Make a note of the filename and its location and press **OK**.

The ASCII file is required for the next tool on the HMS menu, **Generate DSS from ASCII Grid**. This tool is discussed in the next section. The ASCII file created by HEC-GeoHMS will be in the same projection as the selected grid, HRAP or SHG. As mentioned, the **Generate ASCII Grid** tool is very limited in use. Standard GIS tools can be used to create ASCII grid files that can be imported into HEC-DSS. The **Raster to ASCII** tool, available from the **Conversion Tools** toolbox, is a more generic tool that can be used to convert a grid in ESRI Grid format to an ASCII grid file. The user must create a raster coverage before using the **Raster to ASCII** tool. It is important that the raster coverage be in the same projection as the grid system, SHG or HRAP. Appendix D provides more detail for both projections. In addition, the grid coverage must have the same extents and cell size as the grid cell layer. The grid cell layer is created by the **Grid Cell Processing** tool. The grid cell layer shows the grid extents before the intersection with the subbasin boundary, as shown in Figure 11-21. The layer is automatically added to the "GridCell" data frame.
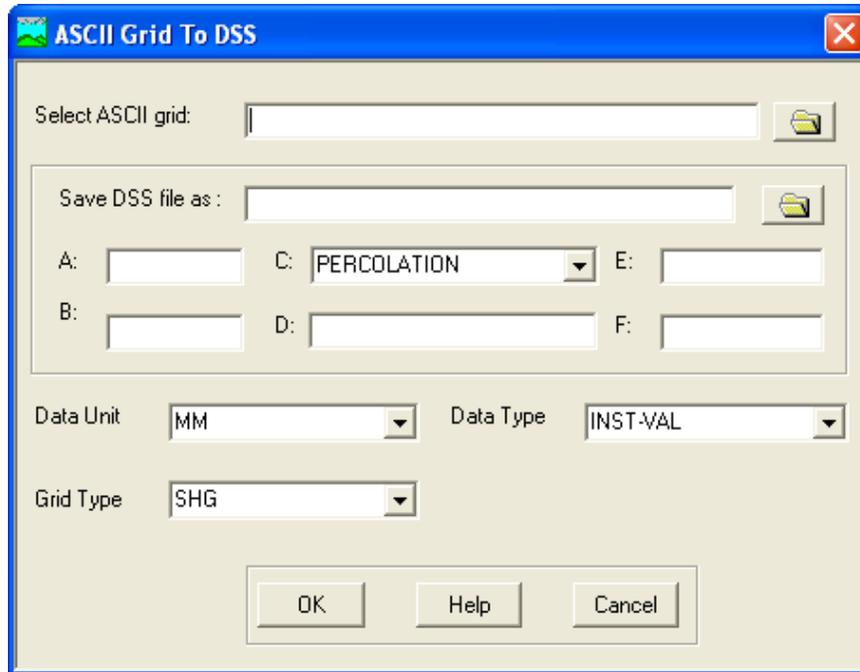
Figure 11-21. Grid Cell Layer.

Generate DSS from ASCII Grid

This tool converts a grid in ASCII format to grid in HEC-DSS format. Grids must be in HEC-DSS format before they can be used by HEC-HMS. To open this tool, select **HMS → Generate DSS from ASCII Grids**.

The *ASCII Grid To DSS* dialog is shown in Figure 11-22. At the top of the editor, the user is required to select an ASCII grid file and choose an existing or create a new HEC-DSS file. Then, the user can enter pathnames for describing the data. The a-part pathname is used to describe the grid format, either HRAP or SHG. If the SHG system is used then also include the cell size, like SHG500. The B-part pathname is used to describe the project area. This could be the name of the drainage basin. The C-part name is used to identify the data type. The D- and E-part names are necessary if dealing with time-series data, like precipitation data. If working with parameter grids, like curve number, then leave the D- and E-part fields empty. The format for these fields is "ddmmmyyyy:tttt" (01Jan2000:0100). Finally, the F-part name is used to describe how the data was created, like "estimated" or "observed". The "Data Unit", "Data Type", and "Grid Type" fields contain drop down lists. Refer to Chapter 5 in the HEC-HMS User's Manual for a description of required units, data types, and c-part pathnames.

Figure 11-22. ASCII Grid to DSS Editor.

Meteorologic Model

It is not necessary to create meteorologic model files in HEC-GeoHMS; however, the tool is available. It is recommended that the meteorologic model(s) be created within the HEC-HMS project. HEC-GeoHMS contains four options for creating a meteorologic model, as shown in Figure 11-23. All four meteorologic model options create a meteorologic model file (*.met extension) and a gage file (*.gage extension). The gage file contains a list of precipitation gages used by the meteorologic model.
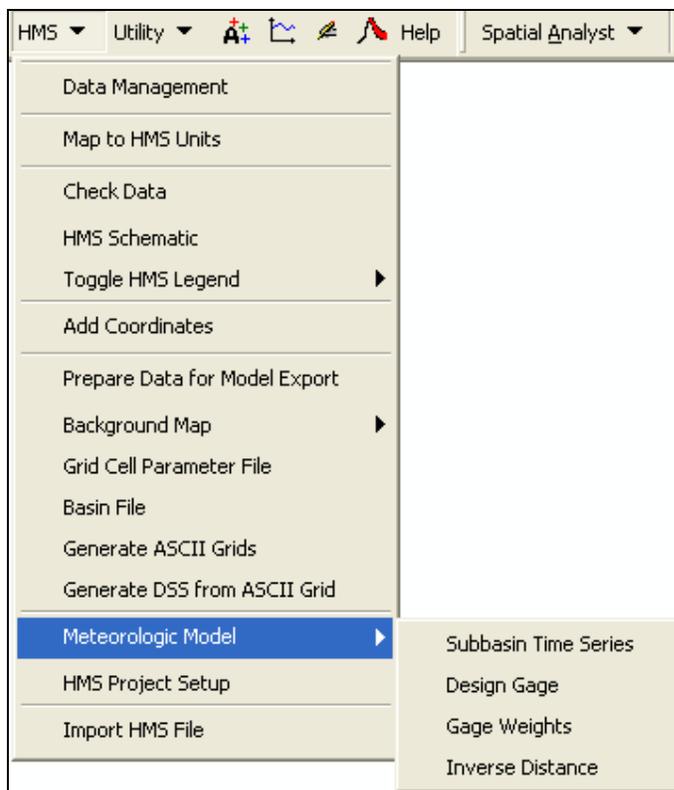
Figure 11-23. Options for Creating a Meteorologic Model.

The **Subbasin Time Series** and **Design Gage** options are very similar to one another. When selected, HEC-GeoHMS will create meteorologic models that use the Specified Hyetograph method (Specified Hyetograph is the name used by HEC-HMS). The Design Gage option allows the user to specify a total storm depth for each subbasin. The user needs to enter information in the "RainDesign" field contained in the subbasin layer's attribute table, as shown in Figure 11-24. This can be done manually or by using the **Subbasin Parameters from Raster** tool available from the **Hydrologic Parameters** menu.

Figure 11-24. Attribute Table for Subbasin Layer.

Steps for Subbasin Time Series Meteorologic Model

- Select **HMS → Meteorologic Model → Subbasin Time Series**.

- Make sure the subbasin layer is selected in the ***Meteorologic Model Definition*** editor, shown in Figure 11-25, and press **OK**.
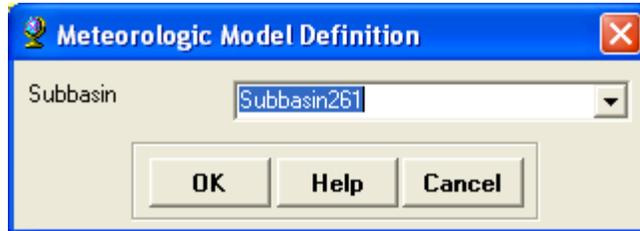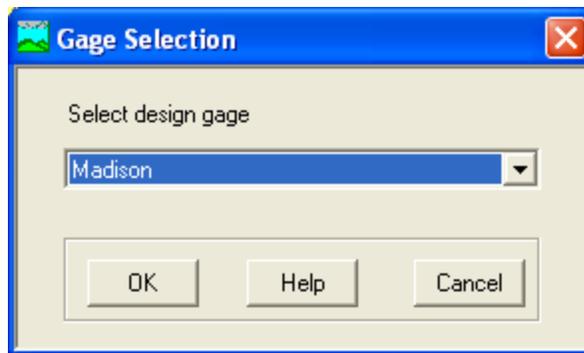

Figure 11-25. Meteorologic Model Definition Editor.

- A window will open showing the location where the meteorologic model and gage files were saved.

HEC-GeoHMS will assume a separate precipitation hyetograph for each subbasin and automatically name the precipitation gage using the subbasin name.

Steps for Design Gage Meteorologic Model

- Select **HMS → Meteorologic Model → Design Gage**.

- Make sure the subbasin layer is selected in the ***Meteorologic Model Definition*** editor, shown in Figure 11-26, and press **OK**.
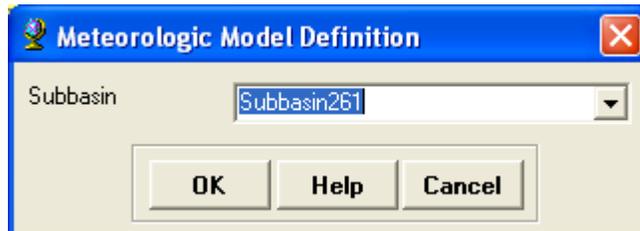
Figure 11-26. Meteorologic Model Definition Editor.

- Choose a gage in the ***Gage Selection*** editor, as shown in Figure 11-27. Currently, there are only three gages in the list. If these gages are not appropriate for your study, then just choose one. It will be used as a place holder until you can modify it within the HEC-HMS project.

Figure 11-27. Gage Selection Editor.

- A window will open showing the location where the meteorologic model and gage files were saved.

Steps for Gage Weights Meteorologic Model

The **Gage Weights** option will create a meteorologic model for the Gage Weights method. This option requires the user to have created a Thiessen polygon layer and then intersected the Thiessen polygons with the subbasin boundary layer. The following steps show how to created Thiessen polygons, intersect them with the subbasin layer, and then create the meteorologic model using the **Gage Weights** tool. You must have an ArcInfo or ArcEditor license in order to create Thiessen Polygons.

- Using ArcCatolog, import the precipitation gages into the HEC-GeoHMS project geodatabase (import into the same location as the subbasin layer). Also, make sure the precipitation gages are in the same projection as the subbasin layer.

- Use Arc Hydro to assign a unique hydro ID to each precipitation gage. Select **Attribute Tools → Assign HydroID**.

- Choose the precipitation gage layer in the list and select the **Yes** radio button to overwrite existing hydro IDs in the *Assign HydroID* editor, as shown in Figure 11-28. Press **OK**.
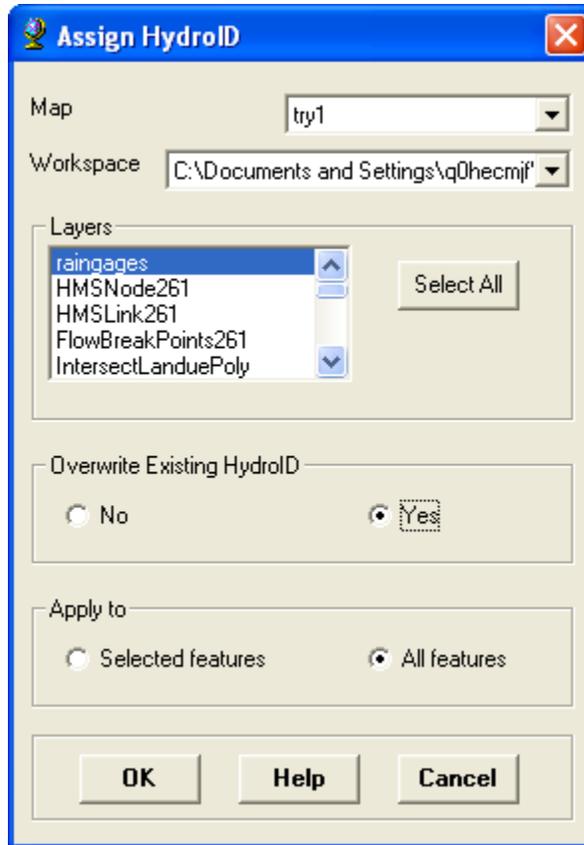
Figure 11-28. Assign HydoID Editor.

- Select **Utility → Gage Thiessen Polygon** from the **HEC-GeoHMS Project View** toolbar.

- Make sure the precipitation gage layer is selected and enter a name for the Thiessen polygon layer in the *Gage Thiessen Polygon* editor as shown in Figure 11-29.

Figure 11-29. Gage Thiessen Polygon Editor.

- An example Thiessen polygon layer is shown in Figure 11-30. This layer must be intersected with the subbasin boundary layer in order to compute weights that can be applied to each subbasin. Open ArcToolbox and open the **Intersect Areas** tool located in the **Arc Hydro Tools → Utility** toolbox.
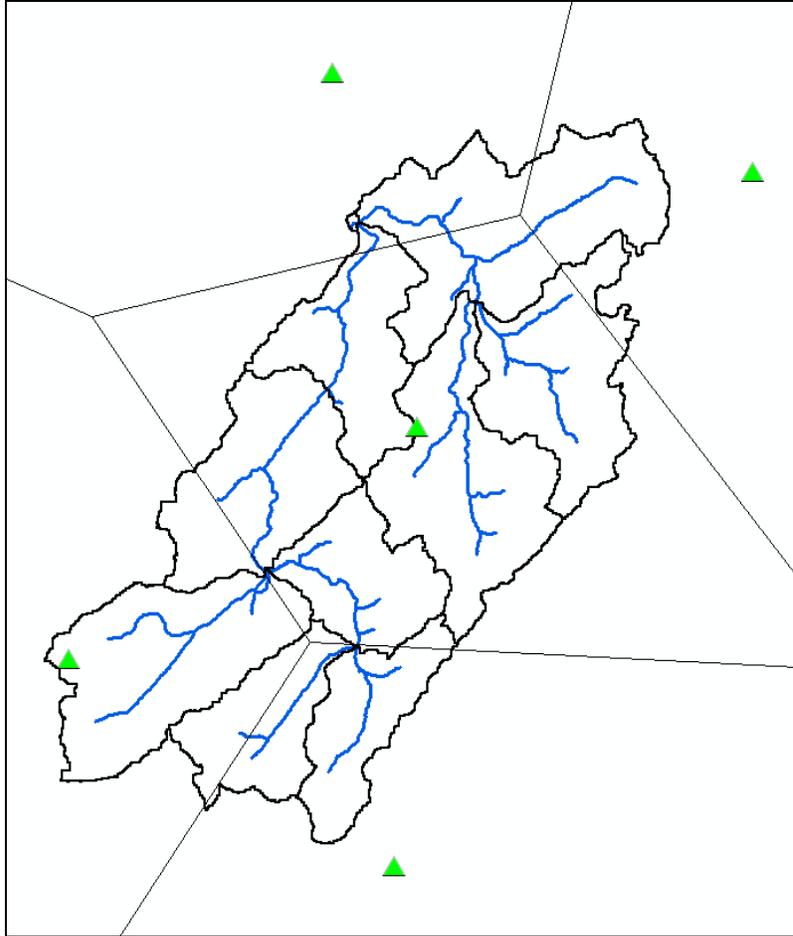
Figure 11-30. Thiessen Polygons.

- Figure 11-31 shows the ***Intersect Areas*** editor. The "Input From Layer" should be set to the Thiessen polygon layer, the "Input To Layer" should be set to the subbasin layer. Enter a name and choose a directory for the intersected layer; you should choose the project geodatabase as the location of the output layer. Figure 11-32 shows results from intersecting the Thiessen polygon layer with the subbasin boundary layer.
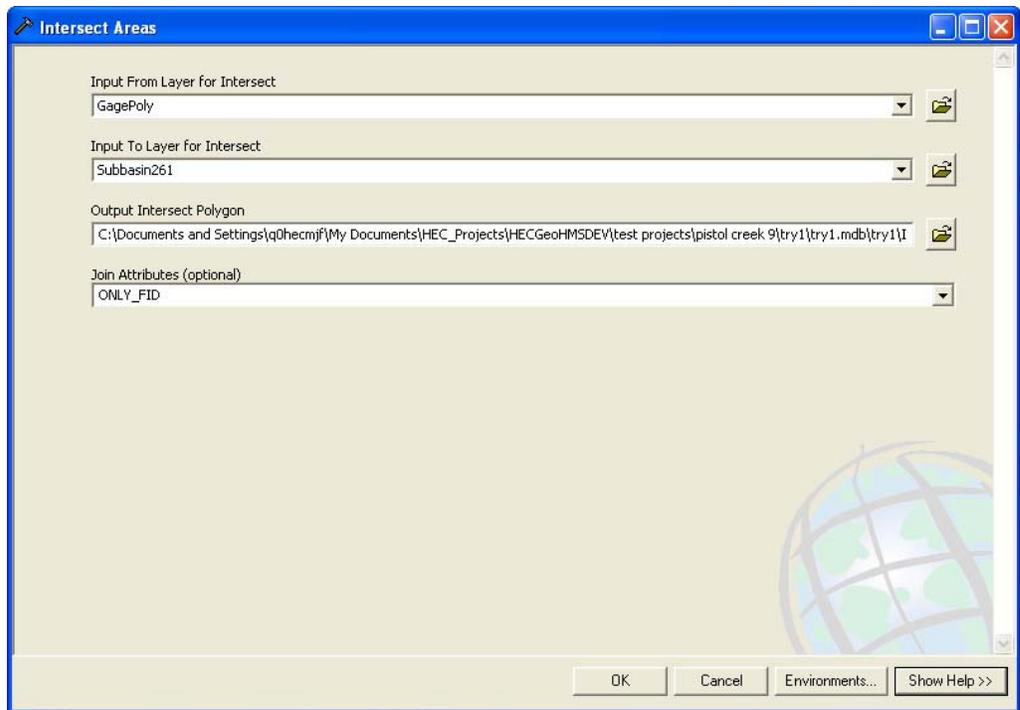
Figure 11-31. Intersect Areas Editor.
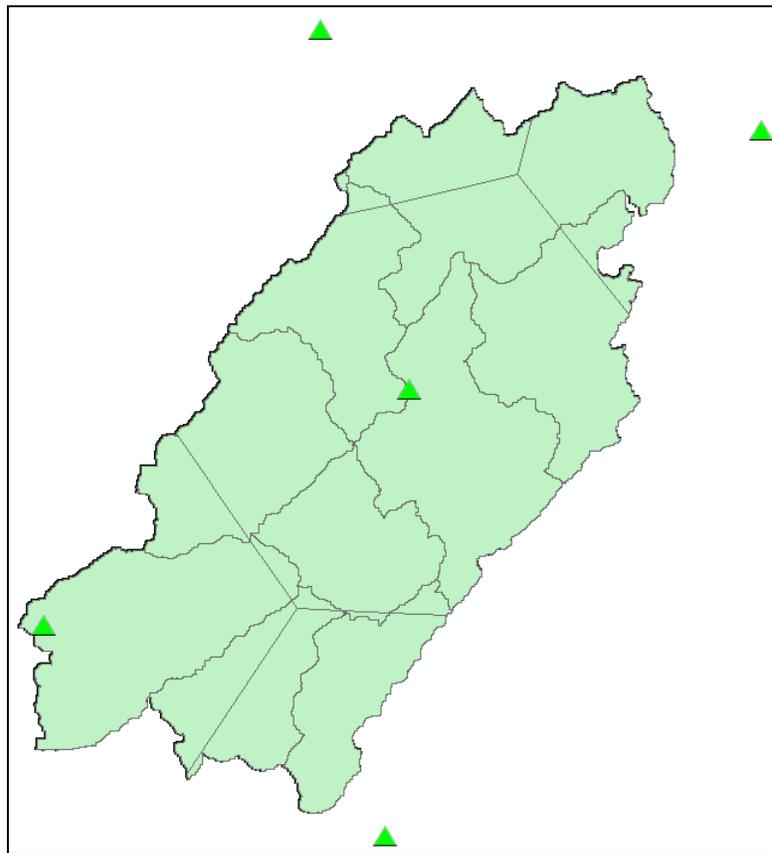
Figure 11-32. Thiessen Polygons Intersected with Subbasin Boundaries.

- The gage weights meteorologic model can be created after the Thiessen polygon layer is intersected with the subbasin boundary layer. Select **HMS → Meteorologic Model → Gage Weights**.

- Make sure the correct subbasin, Thiessen polygon, and intersect layers are selected in the *Weighted Gage* editor, shown in Figure 11-33, before pressing the **OK** button.
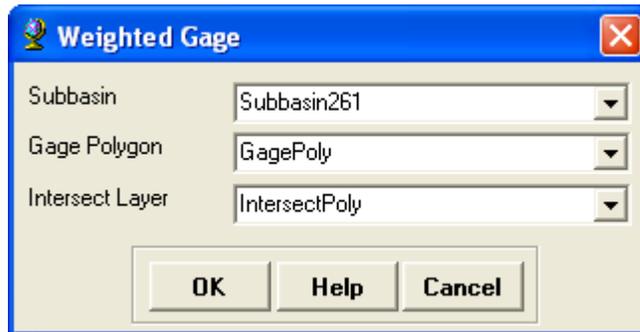
Figure 11-33. Weighted Gage Editor.

- A window will open showing the location where the meteorologic model and gage files were saved.

Steps for Inverse Distance Meteorologic Model

The **Inverse Distance** option will create a meteorologic model for the Inverse Distance method. This option requires the user to have a precipitation gage layer. The following steps show how to prepare a precipitation gage layer and use the **Inverse Distance** meteorologic model tool.

- Using ArcCatolog, import the precipitation gages into the HEC-GeoHMS project geodatabase (import into the same location as the subbasin layer). Also, make sure the precipitation gages are in the same projection as the subbasin layer.

- Use Arc Hydro to assign a unique hydro ID to each precipitation gage. Select **Attribute Tools → Assign HydroID**.

- Choose the precipitation gage layer in the list and select the **Yes** radio button to overwrite existing hydro IDs in the *Assign HydroID* editor, shown in Figure 11-34. Press **OK**.
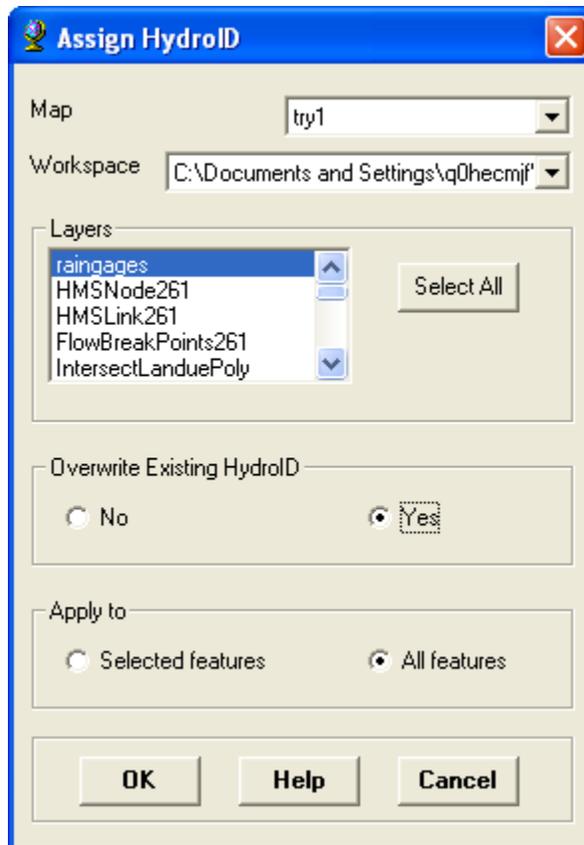
Figure 11-34. Assign HydroID Editor.

- Select **Utility → Add Latitude Longitude** from the **HEC-GeoHMS Project View** toolbar.

- Make sure the precipitation gage layer is selected in the *Add Latitude Longitude* editor, shown in Figure 11-35, and press **OK**.

Latitude and longitude coordinates will be added to the precipitation gage layer's attribute table.

Figure 11-35. Add Latitude Longitude Editor.

- Use the **Add Latitude Longitude** tool to also assign coordinates to the centroid layer.

- The inverse distance meteorologic model can be created after the coordinate information is added to the precipitation gage and

centroid layers. Select **HMS → Meteorologic Model → Inverse Distance**.

- Make sure the correct subbasin, subbasin centroid, and precipitation gage layers are selected in the *Inverse Distance* editor, shown in Figure 11-36, before pressing the **OK** button.
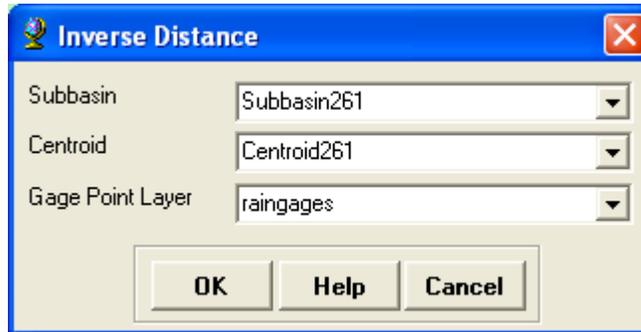
Figure 11-36. Inverse Distance Editor.

A window will open showing the location where the meteorologic model and gage files were saved.

HMS Project Setup

You do not have to use the **HMS Project Setup** tool to create an HEC-HMS project. You can use HEC-HMS to create a project and then import the basin model and background map files. The **HMS Project Setup** tool creates a subdirectory and copies all HEC-HMS project files that were created by HEC-GeoHMS to this subdirectory. This includes the basin, meteorologic, gage, grid cell, and background map files.

Steps

- Select **HMS → HMS Project Setup**.
- Choose a directory for the HEC-HMS project in the *Select Project Location* editor, shown in Figure 11-37, and press **OK**.
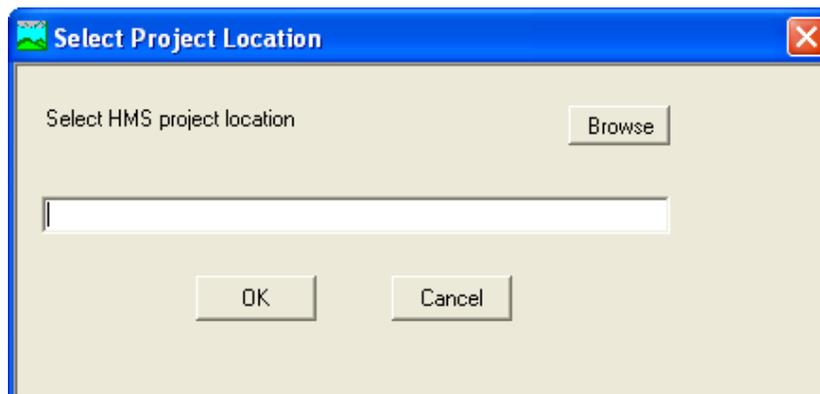
Figure 11-37. Select Project Location Editor.

- As shown in Figure 11-38, press the **Yes** button to copy HEC-HMS project files to the new location.
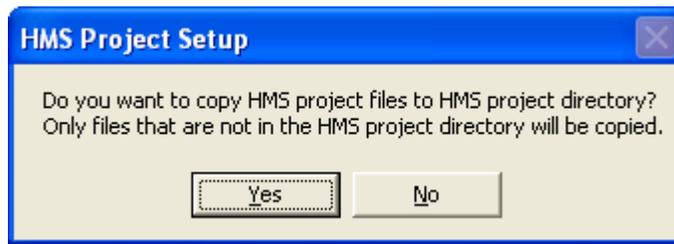

Figure 11-38. HMS Project Setup Dialog.

Once imported into HEC-HMS, parameters not estimated from GIS data will need to be defined. In addition, quality control of the input generated by HEC-GeoHMS should be performed before computing simulations and viewing results from the HEC-HMS model.

C H A P T E R   1 2

Utilities

Tools available from the **Utilities** menu, **HEC-GeoHMS Project View** toolbar, assist in the estimation of hydrologic parameters. You do not have to use these tools to create an HEC-HMS project. This menu contains tools for creating a curve number grid, parameter grids, Thiessen polygons, and a tool for extracting the latitude and longitude coordinates for a point layer.

| Generate CN Grid |
| Features to Rasters |
| Gage Thiessen Polygon |
| Add Latitude Longitude |

Curve Number Grids

The Generate CN Grid tool is useful for creating curve number grids. In order to use this tool you must create a polygon layer that merges both land use and soil type data. The following description shows how to create a land use / soil type layer.

Before merging land use and soil type polygon layers together, the attribute table for both layers must contain specific column headings.   Figure 12-1 shows an example soil type polygon layer. Notice the attribute table contains columns named "PctA," "PctB," "PctC," and "PctD." These columns contain the percentage of each hydrologic soil group (A, B, C, and D) in the soil layer polygons. The user must add these columns to the soil layer and populate the attribute table. This information can be found using the State Soil Geographic (STATSGO) database or the county Soil Survey Geographic (SSURGO) database. Both soil databases are available from the Natural Resources Conservation Service, http://soils.usda.gov/.   Figure 12-2 shows an example land use polygon layer. Notice the attribute table contains a column named "Landuse." This column contains a unique numerical value for each land use type. The user must add this column and populate the attribute table. Any land use layer can be used, publicly available or user created.

Use the **Union** tool to merge the land use and soil type layers. The union tool will include attributes from both layers in the merged dataset. The **Union** tool is available from the **Analysis Tools → Overlay** toolbox. Figure 12-3 shows the attribute table of the land use / soil type layer after the union operation. Notice the attribute table contains a "Landuse", "PctA", "PctB", "PctC", and "PctD" columns.
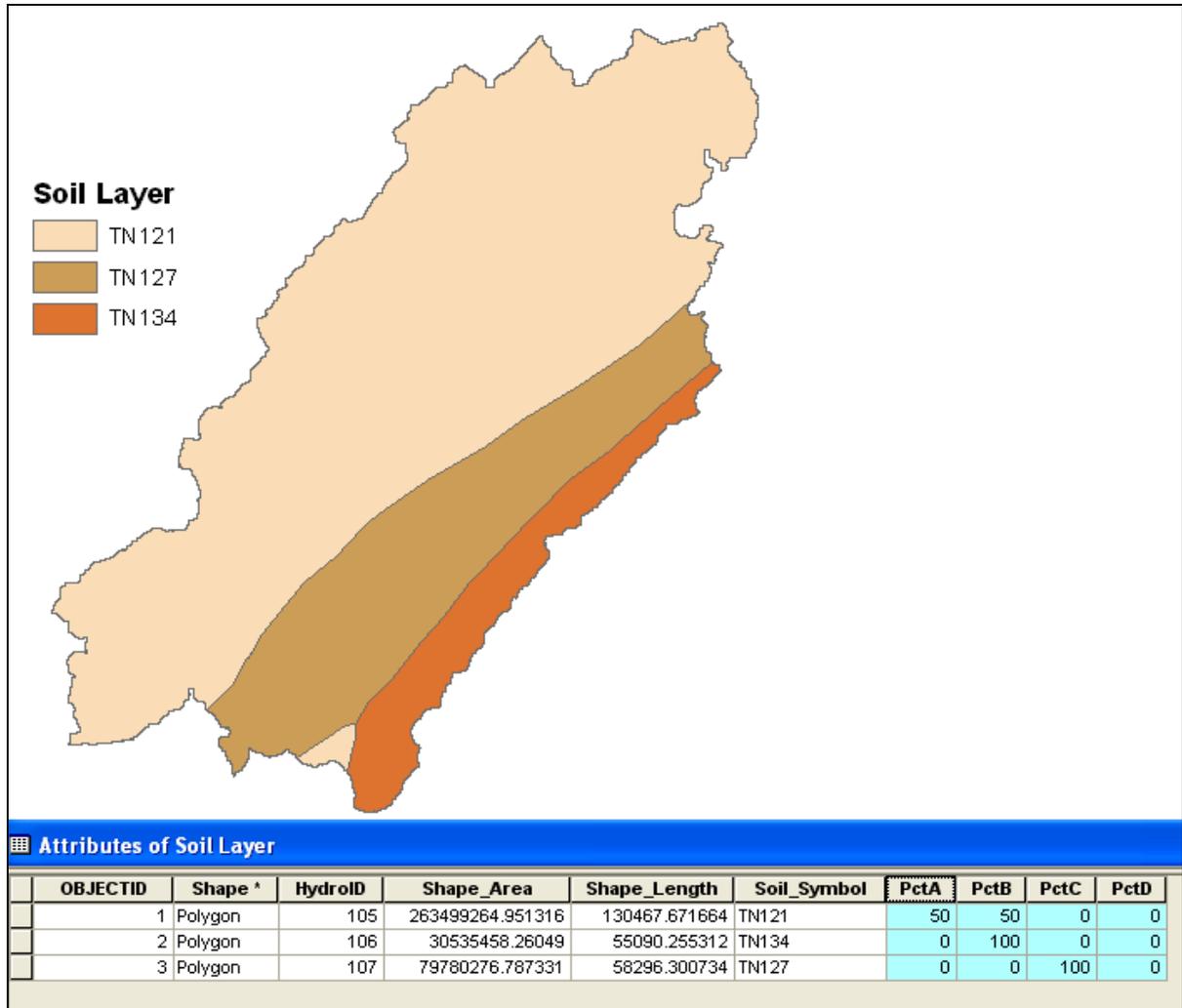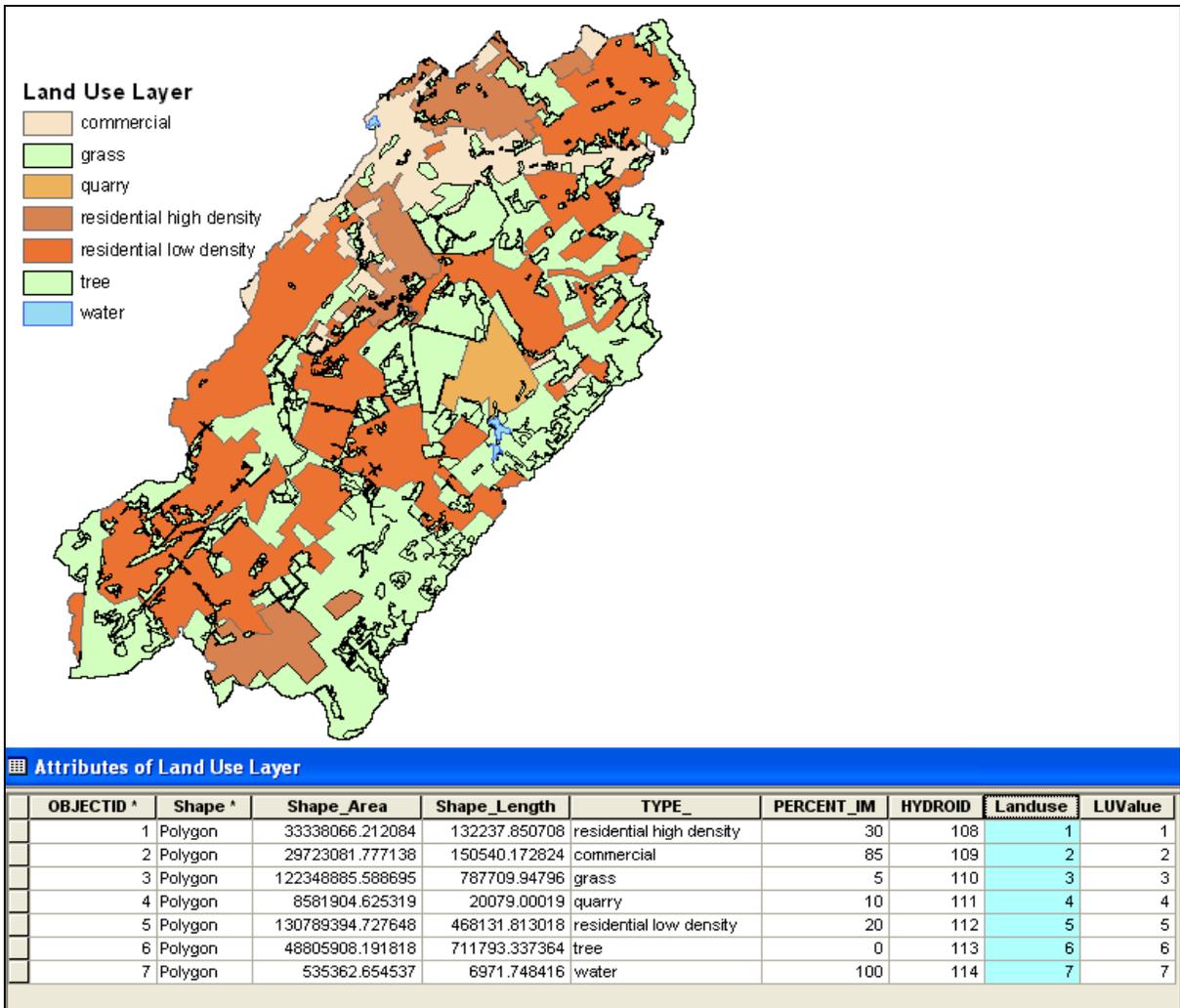
Soil Layer

- TN121
- TN127
- TN134

Attributes of Soil Layer

	OBJECTID	Shape *	HydroID	Shape_Area	Shape_Length	Soil_Symbol	PctA	PctB	PctC	PctD
	1	Polygon	105	263499264.951316	130467.671664	TN121	50	50	0	0
	2	Polygon	106	30535458.26049	55090.255312	TN134	0	100	0	0
	3	Polygon	107	79780276.787331	58296.300734	TN127	0	0	100	0

Figure 12-1. Soil Layer with Attribute Table.

Figure 12-2. Land Use Layer with Attribute Table.

OBJECTID *	Shape *	Shape_Area	Shape_Length	TYPE_	Soil_Symbol	Landuse	PctA	PctB	PctC	PctD
32	Polygon	1215.996728	865.699243	commercial	TN121	2	50	50	0	0
3	Polygon	28943902.829826	144543.599366	commercial	TN121	2	50	50	0	0
4	Polygon	713975.297463	5699.310158	commercial	TN127	2	0	0	100	0
76	Polygon	1.870364	47.727099	commercial	TN121	2	50	50	0	0
19	Polygon	4806.120831	2006.637062	commercial	TN121	2	50	50	0	0
73	Polygon	23.393275	27.707596	commercial	TN121	2	50	50	0	0
59	Polygon	60.068045	72.693858	commercial	TN121	2	50	50	0	0
34	Polygon	3138.815315	3328.402837	commercial	TN121	2	50	50	0	0
36	Polygon	55957.385261	5036.508049	commercial	TN121	2	50	50	0	0
52	Polygon	6022.661634	782.639219	grass	TN127	3	0	0	100	0
50	Polygon	93.578402	422.785545	grass	TN127	3	0	0	100	0
48	Polygon	80.116842	186.037799	grass	TN134	3	0	100	0	0

Figure 12-3. Attribute Table for the Merged Land Use and Soil Type Layer.

The **Generate CN Grid** tool also requires a lookup table that relates land use and hydrologic soil groups to a curve number. The user is required to create the curve number lookup table. Figure 12-4 shows an example lookup table. The lookup table must have fields named "LUValue", "A", "B", "C", and "D". The "LUValue" column refers to the land use type (numbers should correlate to those in the "Landuse" column from the land use / soil type layer). Columns A", "B", "C", and "D" refer to the hydrologic soil group. These columns should contain a curve number that is appropriate for the land use and hydrologic soil group combination. For example, row 1 in Figure 12-4 shows a curve number of 61 will be assigned to polygons that have a land use of 1 with a hydrologic soil group of A.

OID	OBJECTID	LUValue	A	B	C	D
0	1	1	61	75	83	87
1	2	2	89	92	94	95
2	3	3	57	68	76	84
3	4	4	98	98	98	98
4	5	5	81	88	91	93
5	6	6	51	58	64	72
6	7	7	98	98	98	98

Figure 12-4. Example Curve Number Lookup Table.

The **Generate CN Grid** tool can be used after the merged land use and soil type layers and curve number lookup table have been created.

Steps

- Select **Utility → Generate CN Grid**.
- Select the Hydro DEM, curve number polygon layer (land use/soil type layer), and the curve number lookup table in the ***Generate CN Grid*** editor as shown in Figure 12-5. Enter a name for the curve number grid and press **OK**.
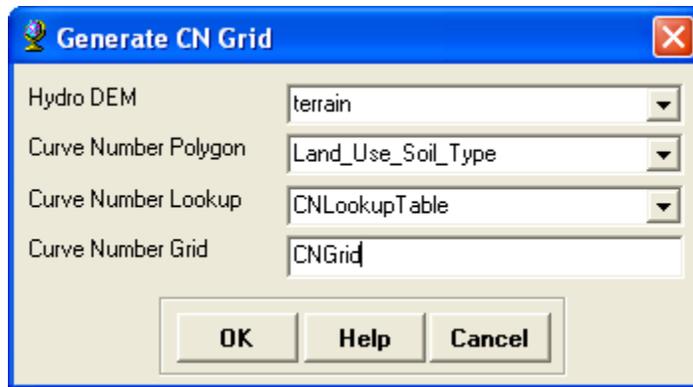
Figure 12-5. Generate CN Grid Editor.

The program will automatically add a "CN" field to the land use / soil type attribute table and populate it with the computed curve number. Figure 12-6 shows an example curve number grid created by the **Generate CN Grid** tool. This grid could be used to estimate the average curve number for each subbasin.
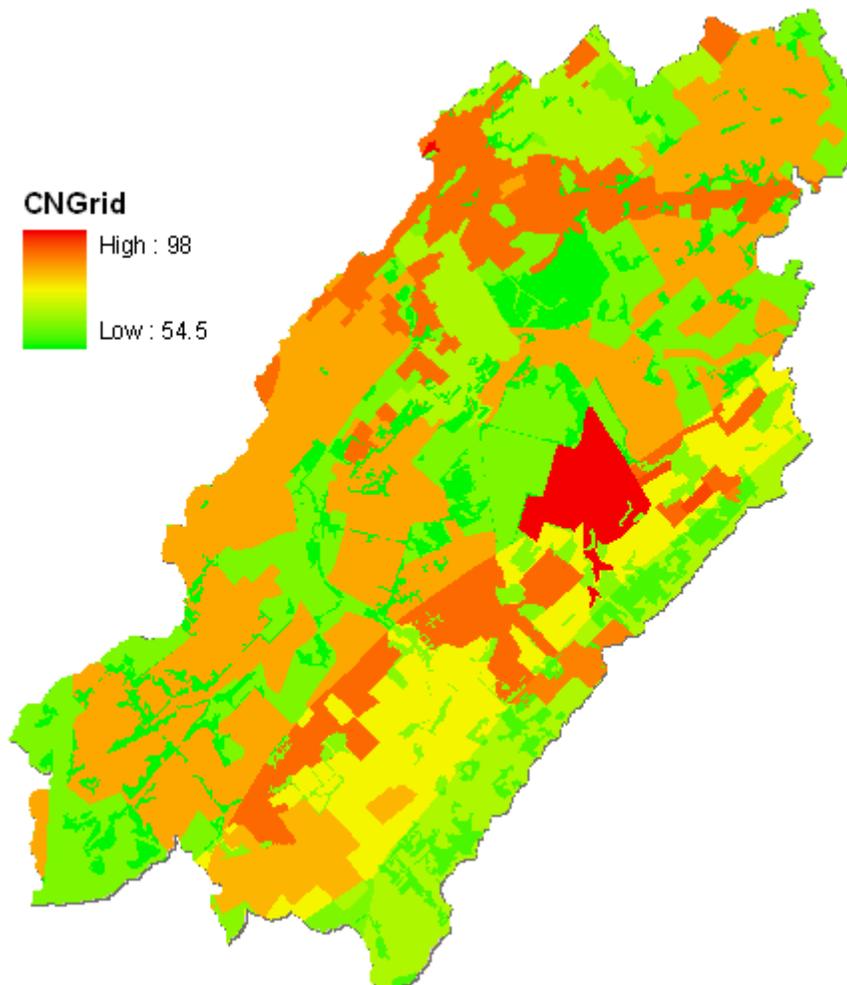

Figure 12-6. Curve Number Grid Computed by the Generate CN Grid Tool.

Features to Raster

The **Features to Raster** tool can be used to convert a polygon layer to a raster coverage (this can also be done using the **Feature to Raster** tool on the **Spatial Analyst** toolbar). An example is used to describe the use of this tool. For this example, a land use layer was reprojected to the same projection as the SHG layer. The land use layer contains an impervious area estimate for each polygon, as shown in Figure 12-7. The **Zonal Statistics** tool on the **Spatial Analyst** toolbar was used to estimate the average impervious area value for each 500 meter grid cell in the SHG layer, as shown in Figure 12-8. The **Feature to Raster** tool will be used to create a raster coverage with the same extents and cell size of the SHG layer.

Steps

- Select the **Utility → Features to Rasters**.

- The ***Select features for converting to raster*** editor is shown in Figure 12-9.
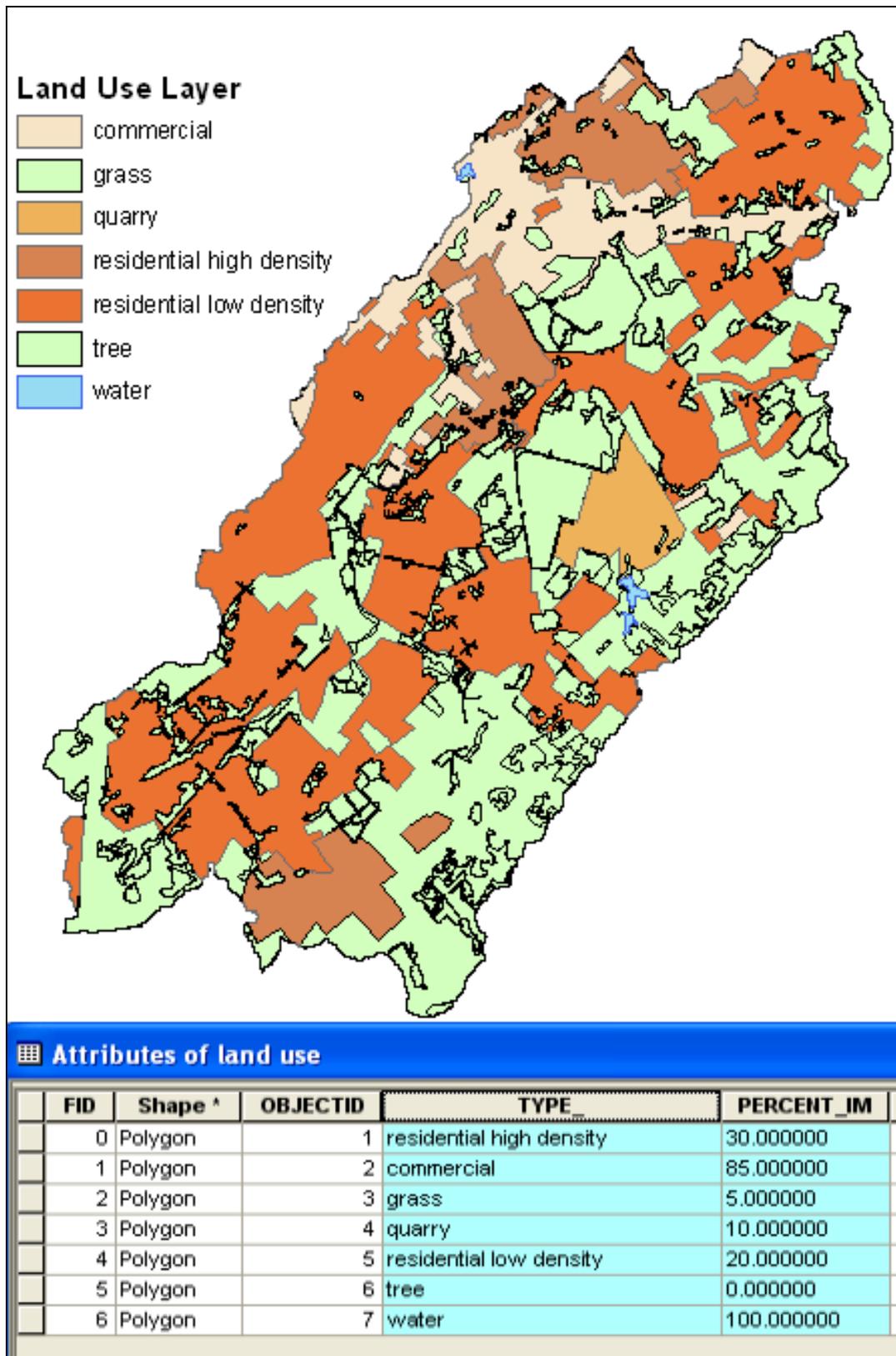
Figure 12-7. Land Use Layer with Percent Impervious Area.
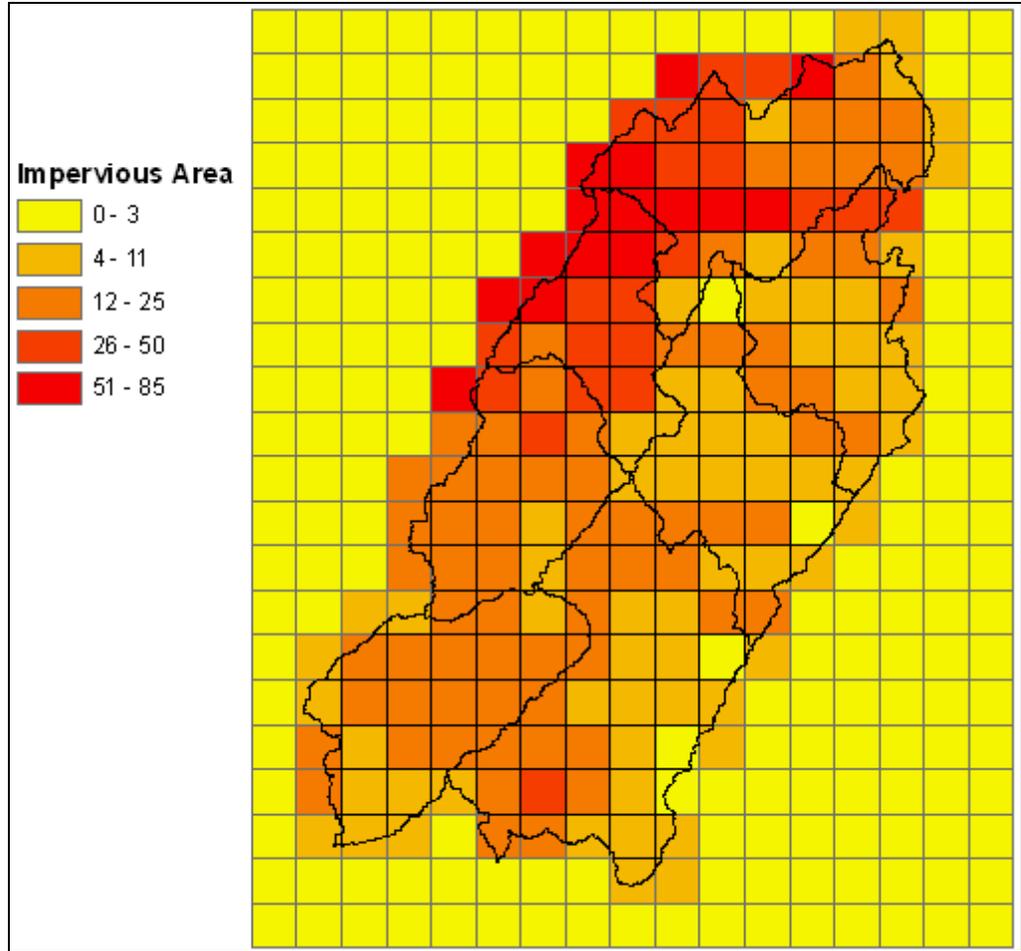
Figure 12-8. SHG layer with Impervious Area Assigned to each Grid Cell.
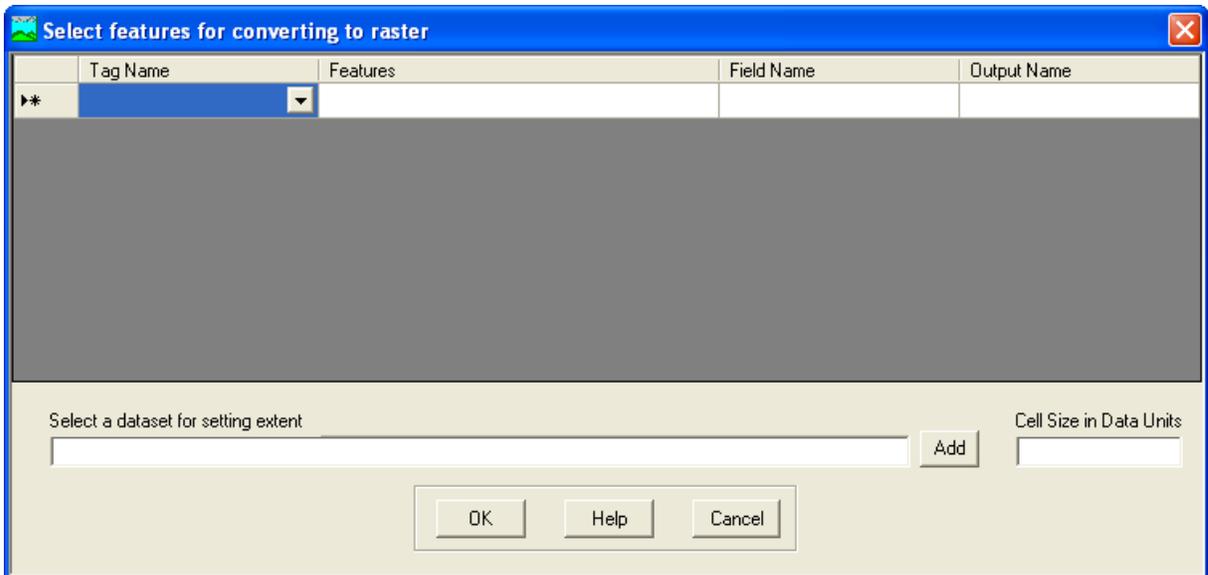
Figure 12-9. The Select Features for Converting to Raster Editor.

- Choose the parameter that the new raster coverage will represent in the **Tag Name** drop down list. The list of names in the tag name list corresponds to the parameter names in the subbasin layer's attribute table. If the polygon coverage you want to convert to a raster does not correspond to one of the options in the list then just choose any tag name.

- Select the **Feature** input field to open another widow that will let you select the polygon layer to convert to a raster coverage.

- The **Field Name** input field is used to select the field from the selected layer's attribute table. This field will be used as the "value" in the raster coverage.

- Enter a name for the new raster coverage in the **Output Name** field.

- Choose an existing dataset to set the extents of the new raster coverage. If trying to create a parameter grid for import into HEC-DSS then it is important that the SHG or HRAP layer is used to set the extent of the new raster coverage.

- Finally, set the cell size. If trying to create a parameter grid for import into HEC-DSS then the cell size must be the same cell size used in the Grid Cell Processing step.

Gage Thiessen Polygon

The **Gage Thiessen Polygon** tool will create Thiessen polygons given a point layer. These polygons could then be used to compute gage weights and subbasin average precipitation. This tool requires an **ArcInfo** or **ArcEditor** license and a point layer of precipitation gage locations.

Steps

- Select **Utility → Gage Thiessen Polygon**.

- Select a precipitation gage layer and enter a name for the Thiessen polygon layer in the *Gage Thiessen Polygon* editor as shown in Figure 12-10. Press **OK**.

Figure 12-10. Gage Thiessen Polygon Editor.

Figure 12-11 shows a Thiessen polygon layer created using five precipitation gages. The Thiessen polygon layer can be used to compute the weights to apply to each gage when computing subbasin average precipitation.
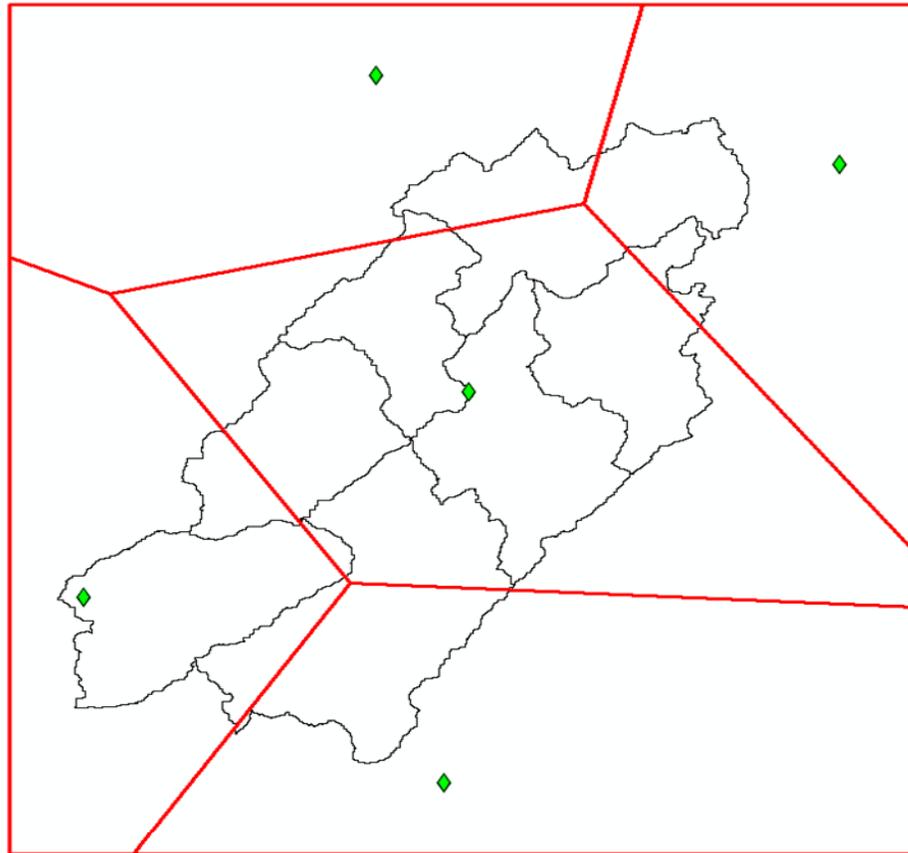
Figure 12-11. Thiessen Polygons Created by the Gage Thiessen Polygon Tool.

Add Latitude and Longitude

The **Add Latitude Longitude** tool will add latitude and longitude coordinates to any point layer. The only requirement for this tool is a point layer.

Steps

- Select **Utility → Add Latitude Longitude**.
- As shown in Figure 12-12, choose a point layer and press **OK**.

Figure 12-12. Add Latitude Longitude Editor.

This tool will automatically add the latitude and longitude coordinates to the point layer's attribute table, as shown in Figure 12-13.

Attributes of raingages

OBJECTID_1 *	Shape *	name	LatDMS	LongDMS
1	Point	gage1	-83_57_59	35_41_15
2	Point	gage2	-84_0_38	35_42_42
3	Point	gage3	-83_54_55	35_45_53
4	Point	gage4	-83_58_21	35_46_36
5	Point	gage5	-83_57_43	35_44_12

Figure 12-13. Latitude and Longitude Coordinates Added to the Rain Gage Layer.

C H A P T E R   1 3

Example Application - American River Basin

The purpose of this chapter is to illustrate the major steps in the development of a hydrologic model using HEC-GeoHMS Version 4.2. The study watershed is a portion of the American River Basin, just east of Sacramento, California. The watershed consists of 4,817 square kilometers (1,860 square miles). The digital elevation model has been assembled to represent the watershed terrain. In addition, stream flow gages have been compiled into a data layer of gage locations and will be used as delineation points.

Overview

This chapter provides a detailed example of how to perform a drainage analysis on a digital terrain model for the development of an HEC-HMS model. The following tasks will be performed in the presentation of this example. Processing times for most tasks are shown based on a Pentium Based PC Intel Core Duo CPU @ 2.5 GHz with 3.5 GB of memory. Beside the hardware specifications, the terrain grid size is the most important factor in determining the time required to perform most of the operation.

The sample data for this exercise includes the DEM ("amerriver_dem") and gage outlet locations ("hec1ga"). The sample data can be downloaded from the HEC-GeoHMS webpage, http://www.hec.usace.army.mil/software/hec-geohms/download.html. The completed project is also available from the HEC-GeoHMS webpage.

Task I. Preprocess the Terrain Model

1. Open a new empty ArcMap project.
2. Add the Arc Hydro Tools toolbox to ArcToolbox.
3. Load the Arc Hydro and HEC-GeoHMS toolbars.
4. Load the terrain data.
5. Save the project.
6. Perform drainage analysis by processing the terrain using the 8-pour point approach.
7. Extract project specific data.

Task II. Basin Processing

8. Revise subbasin delineation.
9. Extract physical characteristics of streams and subbasins.
10. Develop hydrologic parameters.
11. Develop HMS inputs.

Task III. Hydrologic Modeling System

12. Setup an HMS model with inputs from HEC-GeoHMS.

Task I. Preprocess the Terrain Model

1. Open a new empty ArcMap project as shown in Figure 13-1.
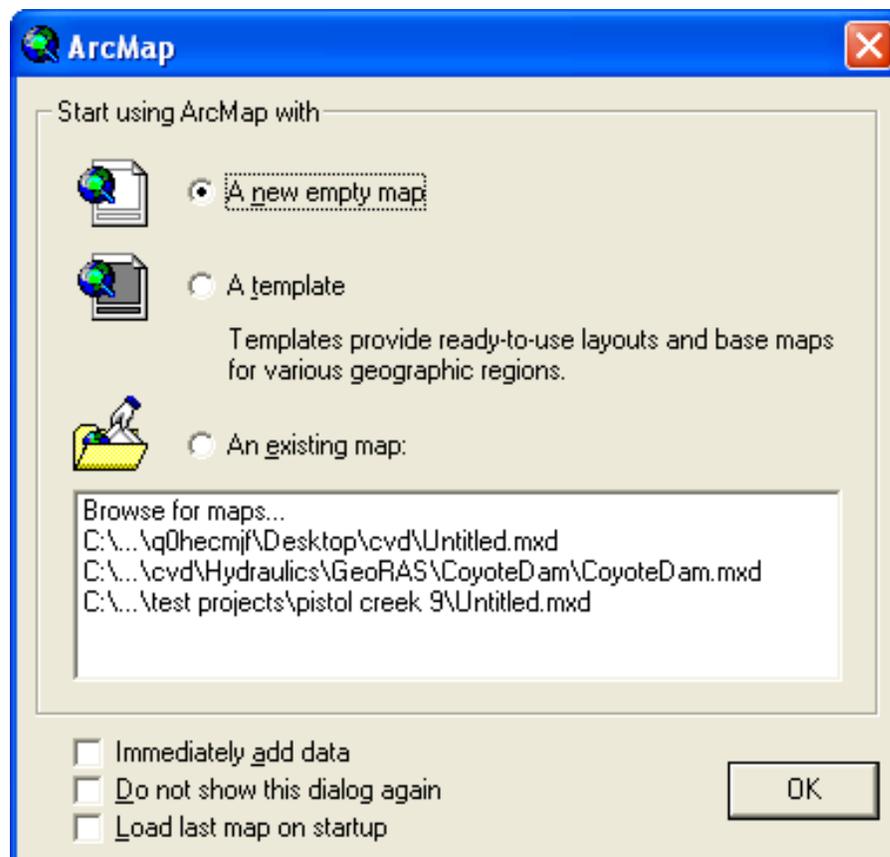
Figure 13-1. Create a New Empty ArcMap Project.

2. Add the Arc Hydro Tools toolbox to ArcToolbox (Figure 13-2).
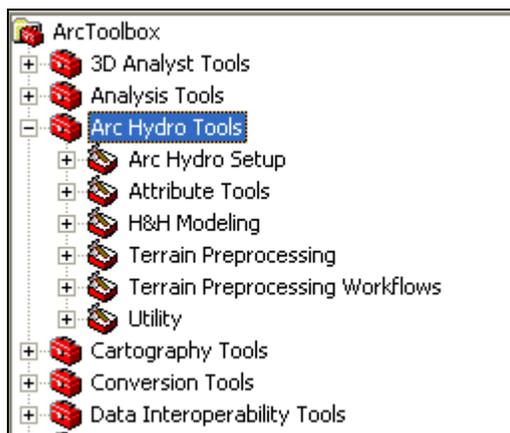
Figure 13-2. Arc Hydro Tools Toolbox.

Load the Arc Hydro and HEC-GeoHMS toolbars.

- Select **Tools → Extensions…** and turn on Spatial Analyst.

- Select **Tools → Customize…** and check the **Arc Hydro Tools 9**, **HEC-GeoHMS Main View 9**, **HEC-GeoHMS Project View 9** toolbars.

When properly installed and loaded, the Arc Hydro and HEC-GeoHMS toolbars are shown Figure 13-3.
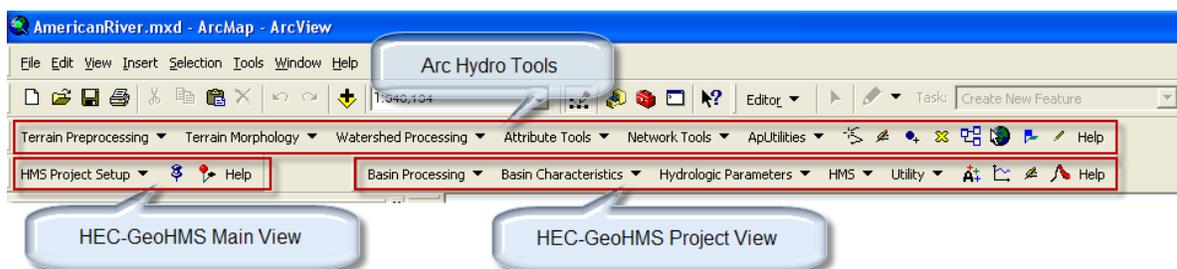
Figure 13-3. Arc Hydro Tools and HEC-GeoHMS Toolbars.

3. Load the terrain data.
   - Add data to the **Layers** data frame

   - Click the **Add Data** button and add the terrain data, amerriver_dem.

   - View the properties of the terrain by right-clicking on the terrain data and selecting **Properties**. Note that there are about ten million (2834 rows * 3662 columns) cells at a thirty meters resolution (Figure 13-4). This covers a rectangular area of 9340 sq km (3606 sq mi), which encompasses this study watershed of 4817 sq km (1860 sq mi).
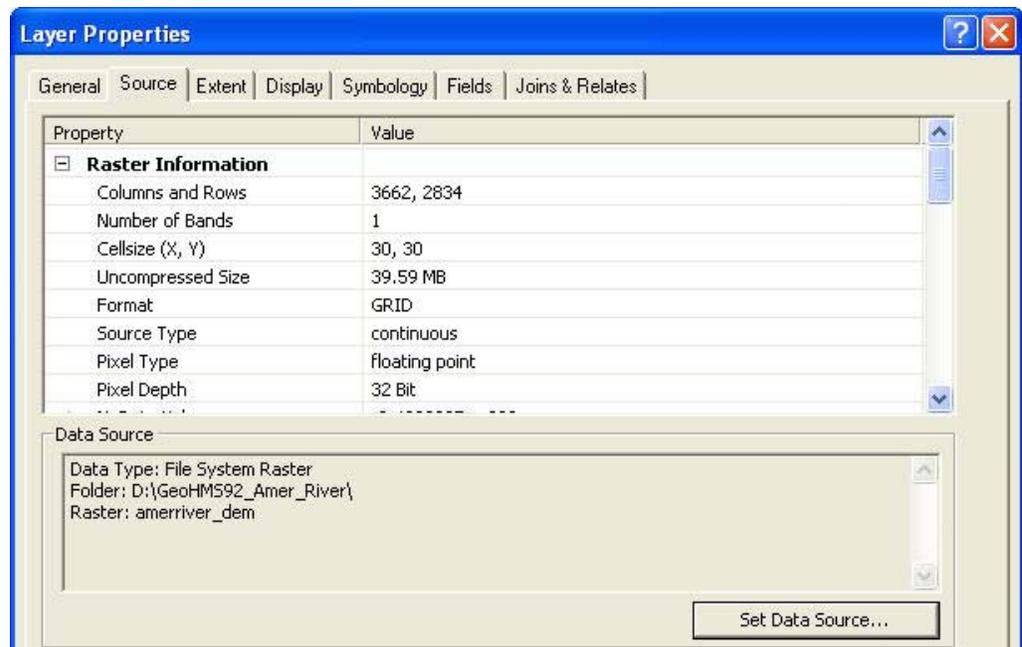
Figure 13-4. Layer Properties Dialog.

The coordinate system for the data frame will be set to the terrain data's coordinate system because this was the first dataset added to the ArcMap document.

4. Save the project.
    - Save the project to a new empty directory on the local computer. No other ArcMap document should be in this directory. For this example, the project was named "AmericanRiver" and saved to the "…\ GeoHMS92 Amer River" directory. The location of the project is important because subsequent derived datasets are stored in this directory.

5. Perform drainage analysis by processing the terrain using the 8-point pour approach.

   A. Fill Sinks

    - With Arc Hydro Tools 9, select **Terrain Preprocessing → DEM Manipulation → Fill Sinks**.

    - Confirm that the DEM input is "amerriver_dem". The output of the HydroDEM is "Fil" as shown in Figure 13-5.
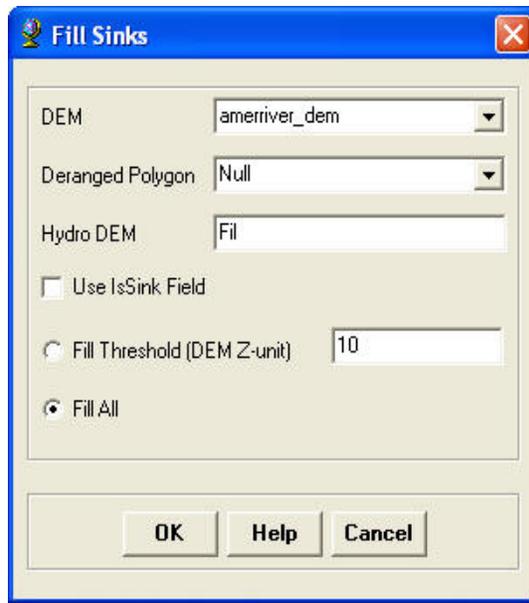
Figure 13-5. Fill Sinks Editor.

- Press **OK**. This step takes about four minutes. The filled DEM is shown in Figure 13-6
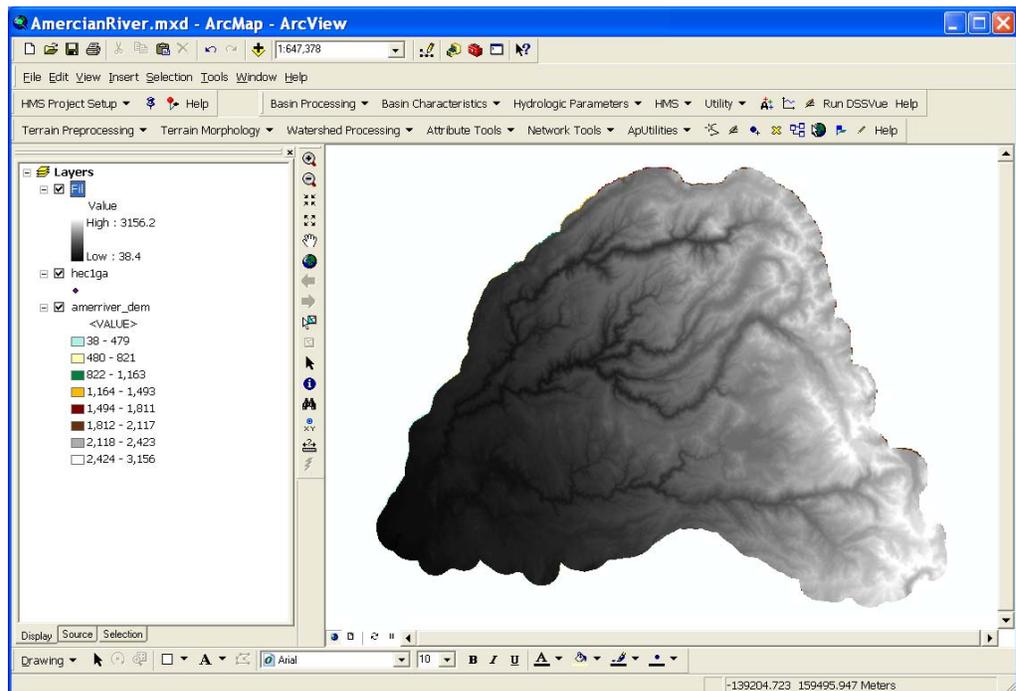
Figure 13-6. Fill Sinks Grid.

B. Flow Direction

- Select **Terrain Preprocessing → Flow Direction**.
- Confirm that the input of the HydroDEM is "Fil". The output of the Flow Direction Grid is "Fdr".

- Press **OK**. This step takes less than a minute. The flow direction grid is shown in Figure 13-7
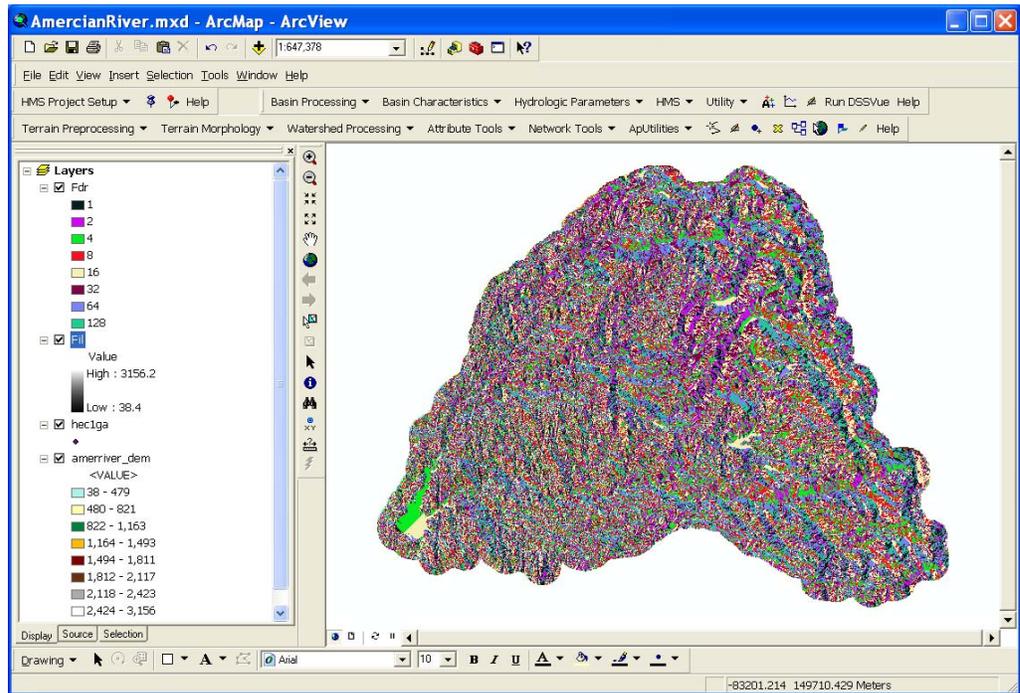
Figure 13-7. Flow Direction Grid.

C. Flow Accumulation

- Select **Terrain Preprocessing → Flow Accumulation**.

- Confirm that the input of the Flow Direction Grid is "Fdr". The output of the Flow Accumulation Grid is "Fac".

- Press **OK**. This step takes about three minutes. The flow accumulation grid is shown in Figure 13-8
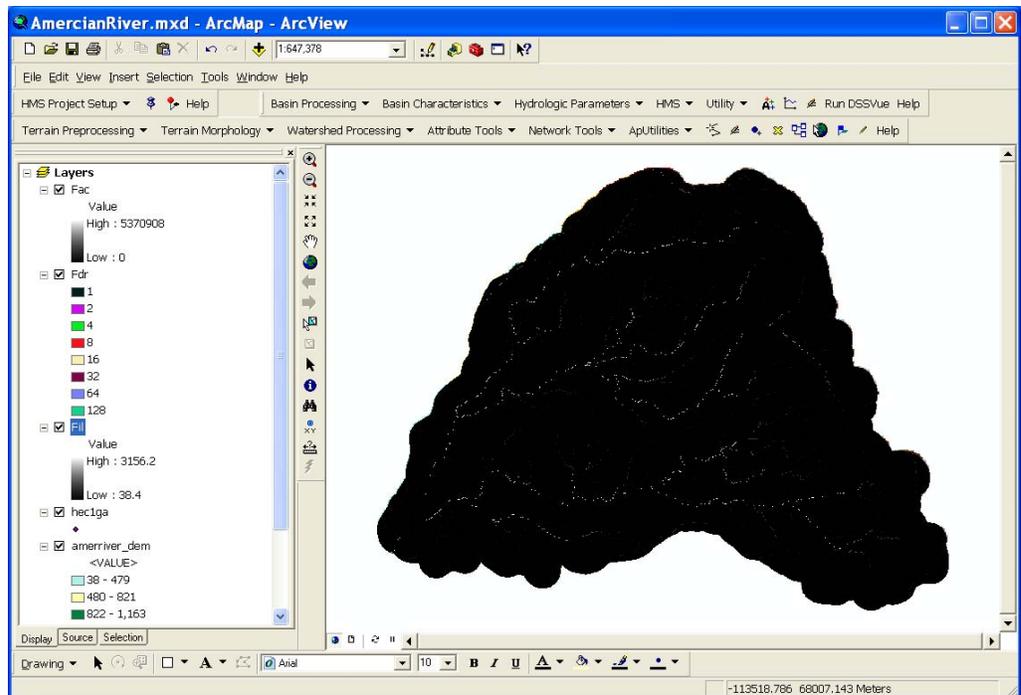
Figure 13-8. Flow Accumulation Grid.

The above screen does not appear complete, but it is. Zoom-in to a part of the basin to display the details of the grid cells that make up the flow accumulation grid as shown in Figure 13-9. The grid cell value is computed by summing the total number of grid cells that flow into each grid cell. Grid cells with a value of 0 are located on the topographic divide and grid cells with a large value make up the stream network.
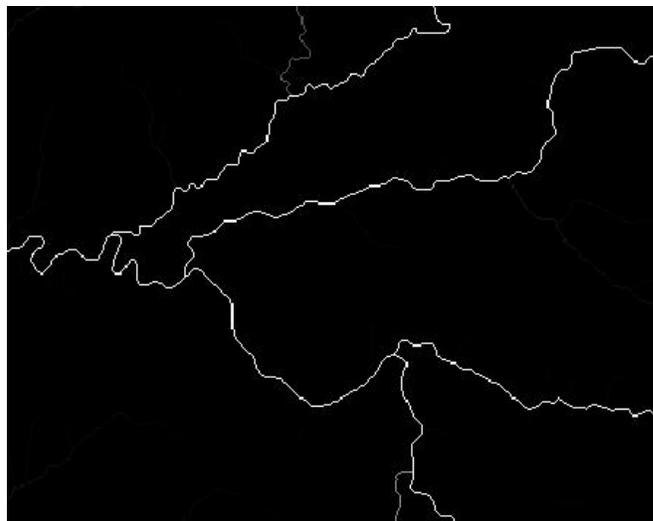
Figure 13-9. Flow Accumulation Grid Showing Detailed Stream Network.

D. Stream Definition

- Select **Terrain Preprocessing → Stream Definition**.

- Confirm that the input of the Flow Accumulation Grid is "Fac". The output of the Stream Grid is "Str".

- Accept the default Stream Threshold as shown in Figure 13-10 and press **OK**. This step takes less than a minute.
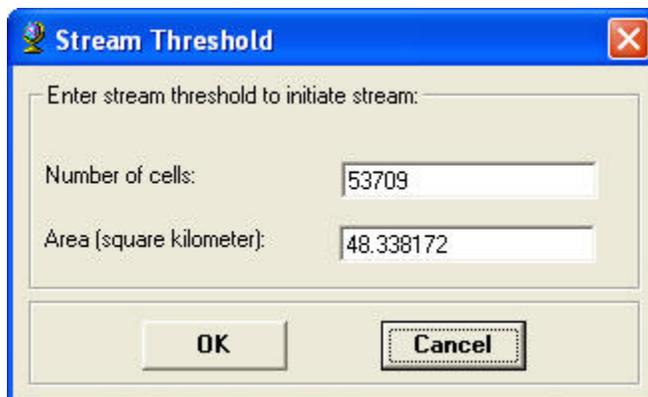
Figure 13-10. Define the Stream Threshold.

Zoom-in to see the grid cells that make up the stream definition grid as shown in Figure 13-11.
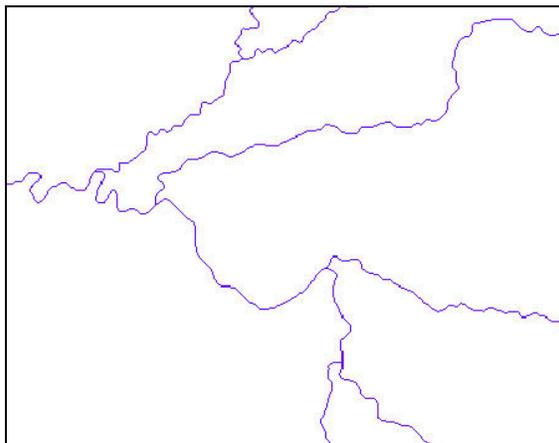
Figure 13-11. Stream Definition Grid.

E. Stream Segmentation

- Select **Terrain Preprocessing → Stream Segmentation**.

- As shown in Figure 13-12, confirm that the input of the Flow Direction Grid is "Fdr" and Stream Grid is "Str". The output of the Stream Link Grid is "StrLnk".
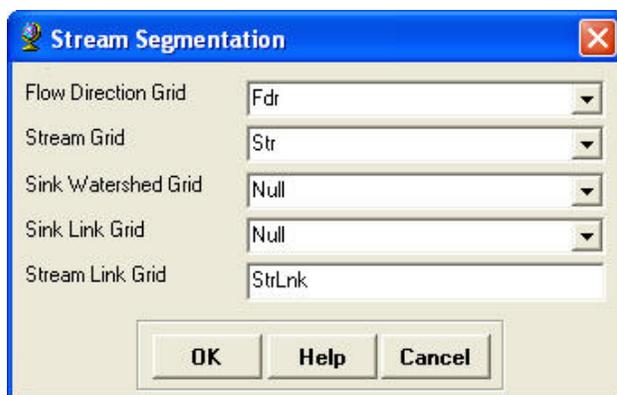
Figure 13-12. Stream Segmentation Editor.

- Press **OK**. This step takes less than a minute.

F. Catchment Delineation

- Select **Terrain Preprocessing → Catchment Grid Delineation**.

- Confirm that the input of the Flow Direction Grid is "Fdr" and Link Grid is "StrLnk". The output of the Catchment Grid is "Cat".

- Press **OK**. This step takes less than a minute. The catchment grid is shown in Figure 13-13.
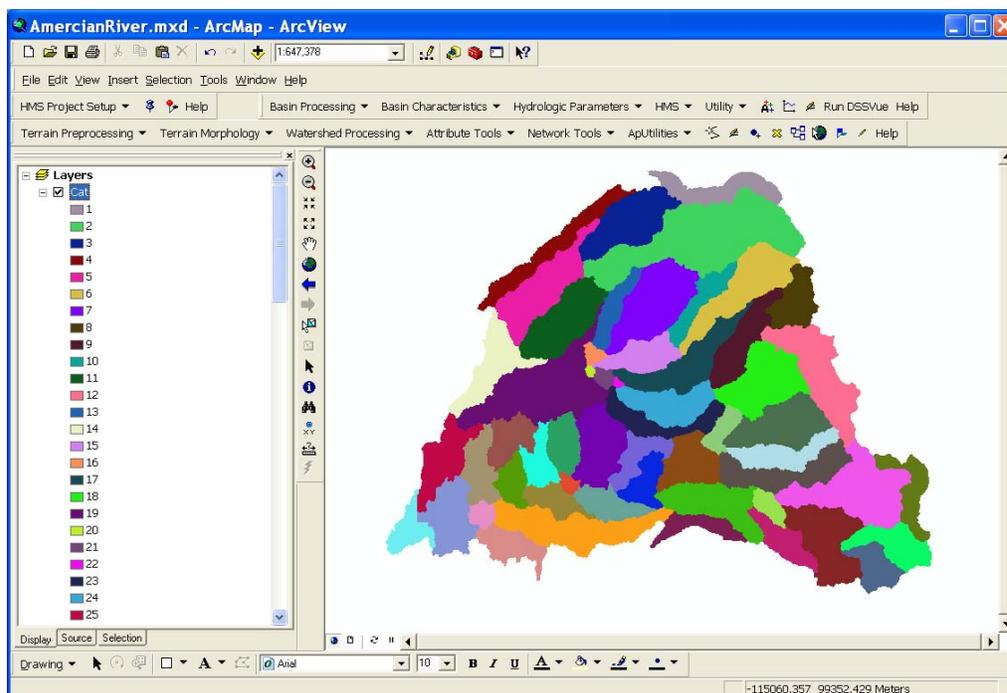
Figure 13-13. Catchment Grid.

G. Catchment Polygon Processing

- Select **Terrain Preprocessing → Catchment Polygon Processing**.

- Confirm that the input of the Catchment Grid is "Cat". The output of the Catchment is "Catchment".

- Press **OK**. This step takes less than a minute. The catchment polygons are shown in Figure 13-14.
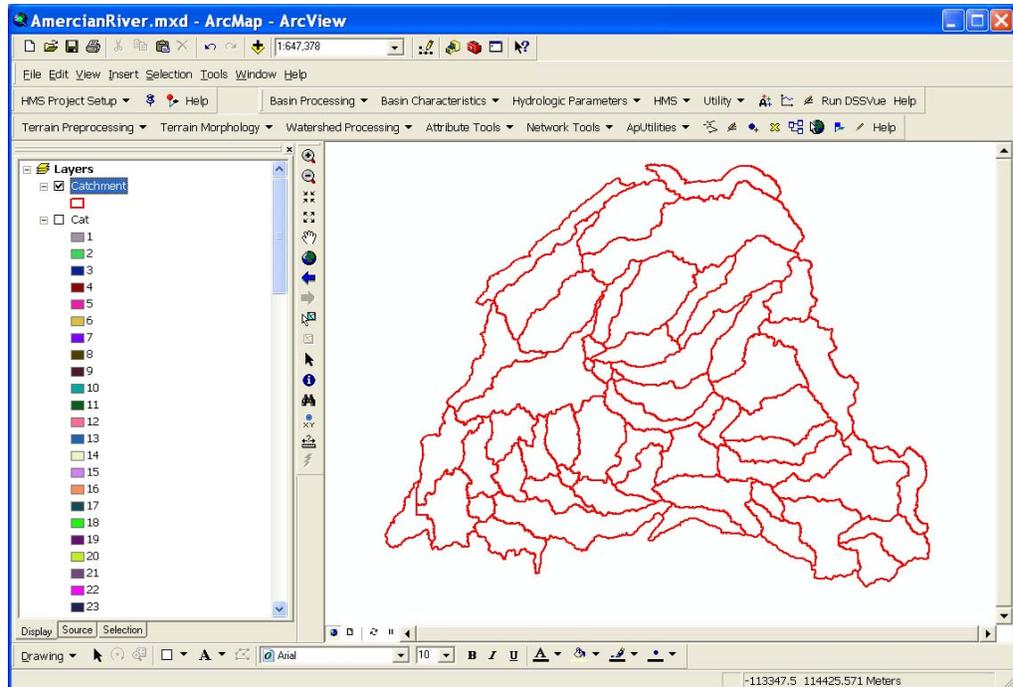
Figure 13-14. Catchment Polygons.

H. Drainage Line Processing

- Select **Terrain Preprocessing → Drainage Line Processing**.

- Confirm that the input of the Stream Link Grid is "StrLnk" and Flow Direction Grid is "Fdr". The output of the Drainage Line is "DrainageLine".

- Press **OK**. This step takes less than a minute. The drainage lines are shown in Figure 13-15.
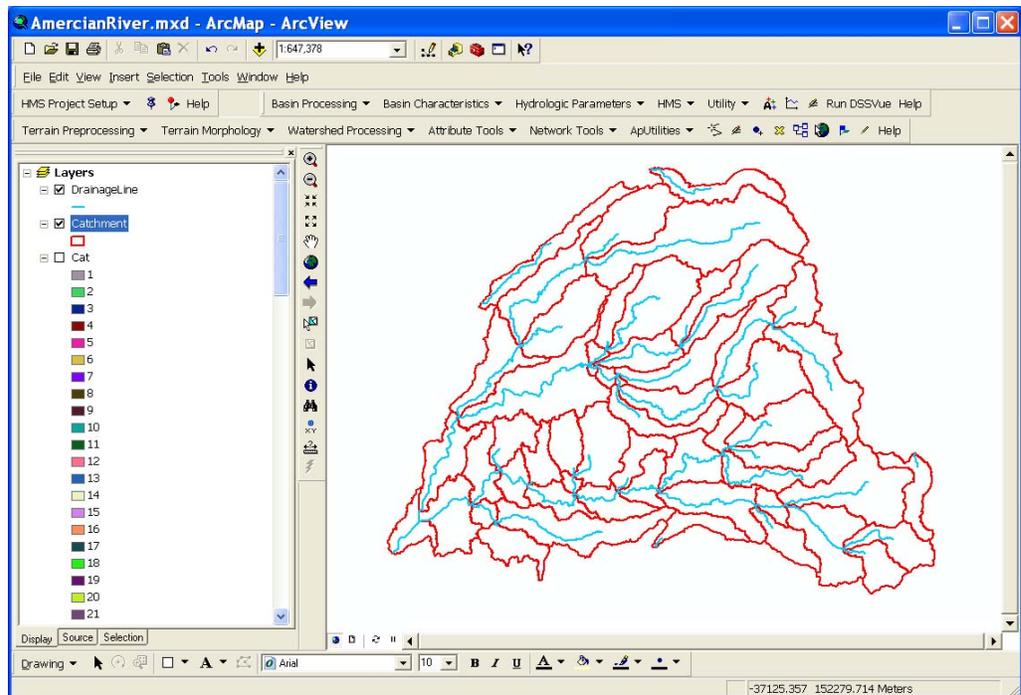
Figure 13-15. Drainage Lines.

I. Watershed Aggregation

- Select **Terrain Preprocessing → Adjoint Catchment Processing**.

- Confirm that the input of the Drainage Line is "DrainageLine" and Catchment is "Catchment". The output of the Adjoint Catchment is "AdjointCatchment".

- Press **OK**. This step takes less than a minute. The aggregated catchment layer is shown in Figure 13-16.
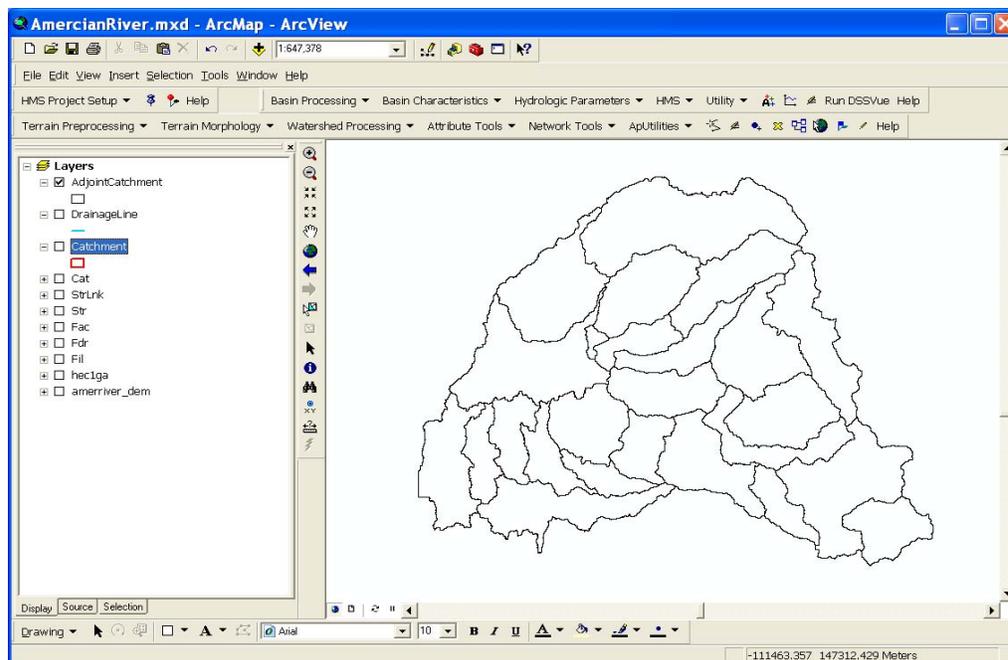
Figure 13-16. Aggregated Catchments.

6. Extract project specific data.

So far, we used tools on the Arc Hydro Tools toolbar to develop initial
delineations for the entire DEM. In the next step, the study area is defined by
identifying an outlet. HEC-GeoHMS will extract data for the drainage area
upstream of the defined outlet. A new ArcMap data frame will be populate
with the project specific data. Tools on the **HEC-GeoHMS Project View**
toolbar can be used to interactively delineate the project area and create input
files for an HEC-HMS project.

- Add the stream flow gage layer called "hec1ga" to the Data Frame
  to help determine the outlet location.

- Make the "hec1ga" layer active and identify the gage shown in
  Figure 13-17.
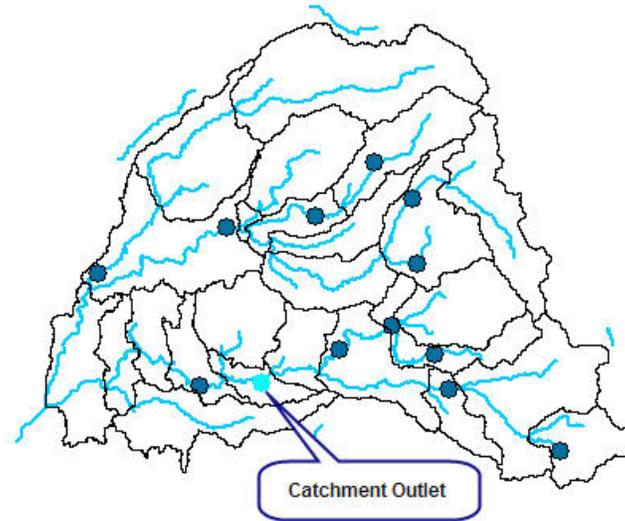
Figure 13-17. Stream Gage used as Catchment Outlet.

- The identified gage has a drain area of about 493 sq. miles. This can be found in the attribute table for the hec1ga layer. Look in the "DRAIN_AREA" column.

- Zoom in on this gage and make the "Strlnk" layer visible as shown in Figure 13-18.
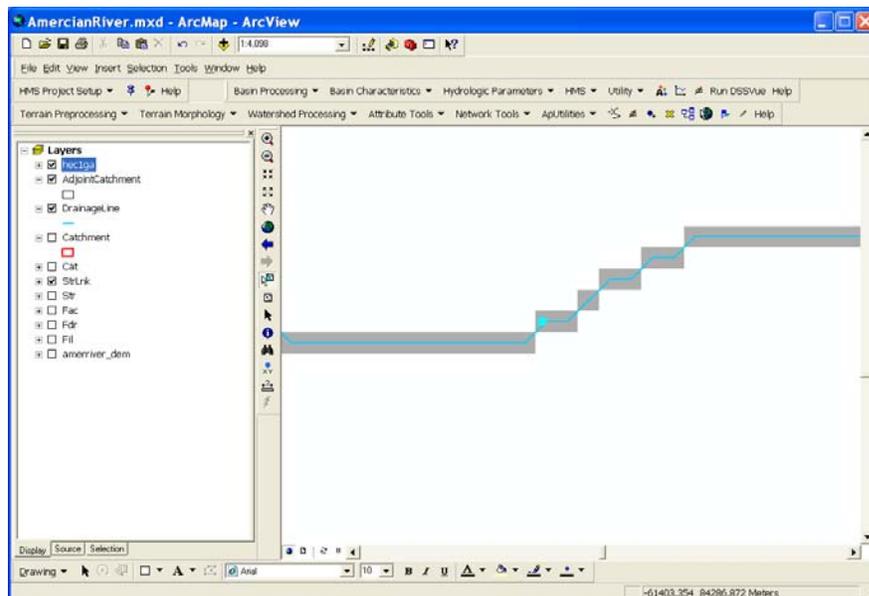
Figure 13-18. Location of Stream Gage.

- Now let's analyze the watershed that drains to this stream gage.

- From the **HEC-GeoHMS Main View 9** toolbar, select **HMS Project Setup → Start New Project**.

- Press **OK** in the *Start New Project* window. Accept the default names for the Project Area and Project Point layers.

- The *Define a New Project* editor is shown in Figure 13-19. Enter "ProjAmer" as the project name.

- Enter "GeoHMS of American River" as the project description.

- Press **OK**.
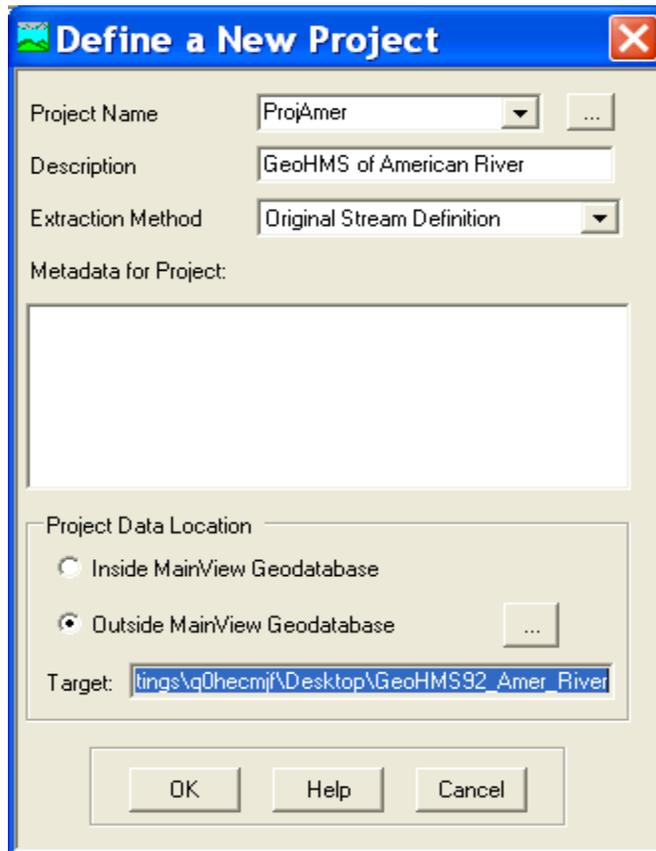
Figure 13-19. Define a New Project Editor.

- Read the information in the *Start New Project* window before closing it.

- Select **Add Project Points**, and click on the cell located at the gage to specify the outlet location as shown in Figure 13-20.
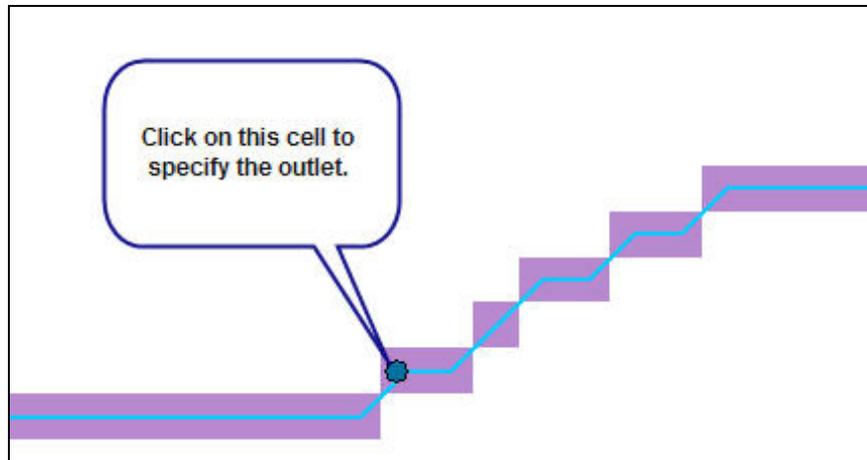
Figure 13-20. Define Study Outlet.

- Name the outlet point "Outlet_Amer" and accept "Outlet1" for the description (Figure 13-21).
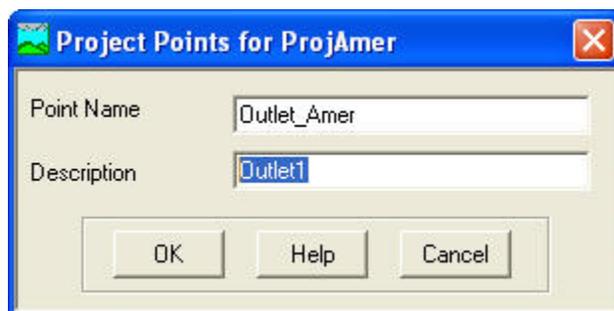
Figure 13-21. Project Points Editor.

- Press **OK**.
- Select **HMS Project Setup → Generate Project**.
- Verify the proper data layers are used as shown in Figure 13-22 and press **OK**.
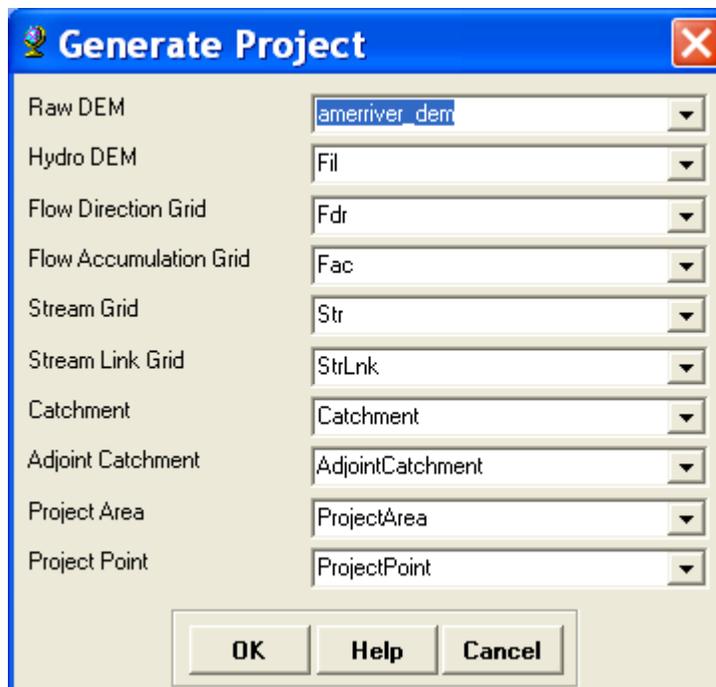
Figure 13-22. Define Project Data.

- Press **Yes** to create a project for the highlighted area.

- Press **OK** to accept the default names in the *New Project Layer Names* window.

- If the user wants to see the extracted catchment relative to the entire watershed, activate the Layers data frame and turn on the ProjectArea layer as shown in Figure 13-23.
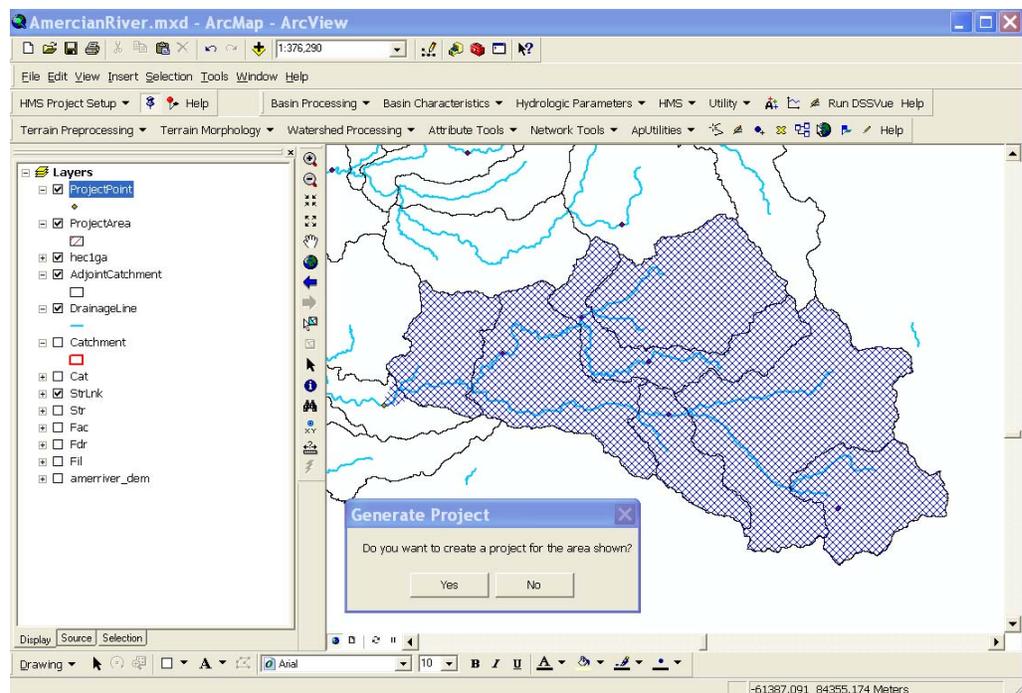
Figure 13-23. Project Area to be Extracted.

The pertinent datasets are extracted for the area above the outlet and added to the **ProjAmer** data frame (Figure 13-24). These datasets will be used for additional basin processing, extracting basin characteristics, and developing HEC-HMS inputs.
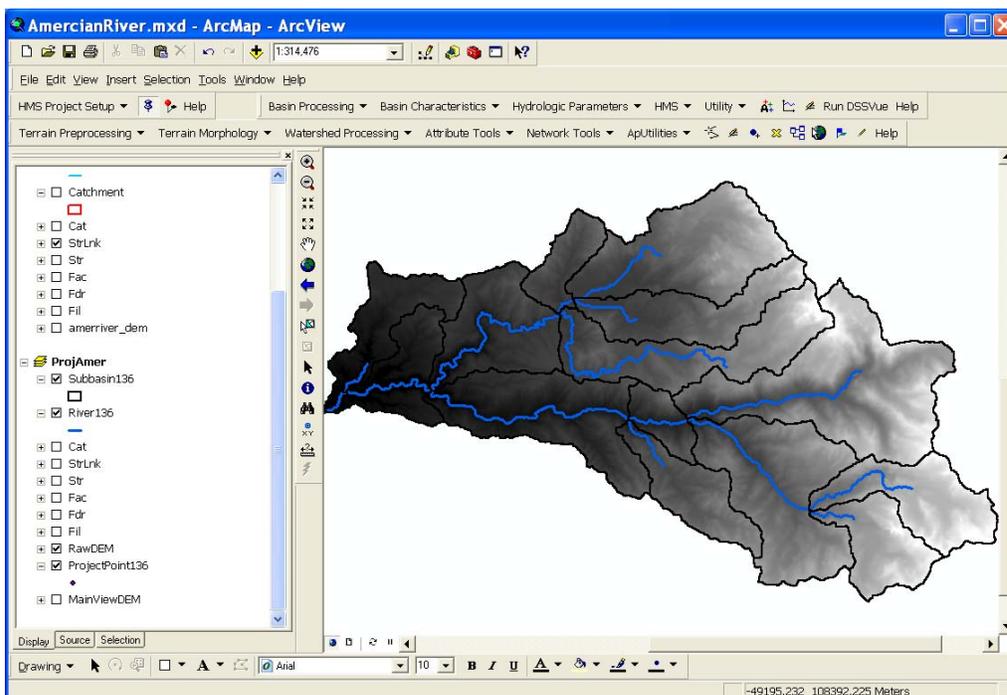
Figure 13-24. Project Data Frame with Extracted Data.

Task II. Basin Processing

7. Revise subbasin delineation.

   A. Merge Basins

   This process merges selected subbasins into one.

   - Select the four subbasins shown in Figure 13-25 with the **Select Features** tool, ⬚.

   - Select **Basin Processing → Basin Merge**.

   - Press **Yes** to accept the resulting merged subbasin.
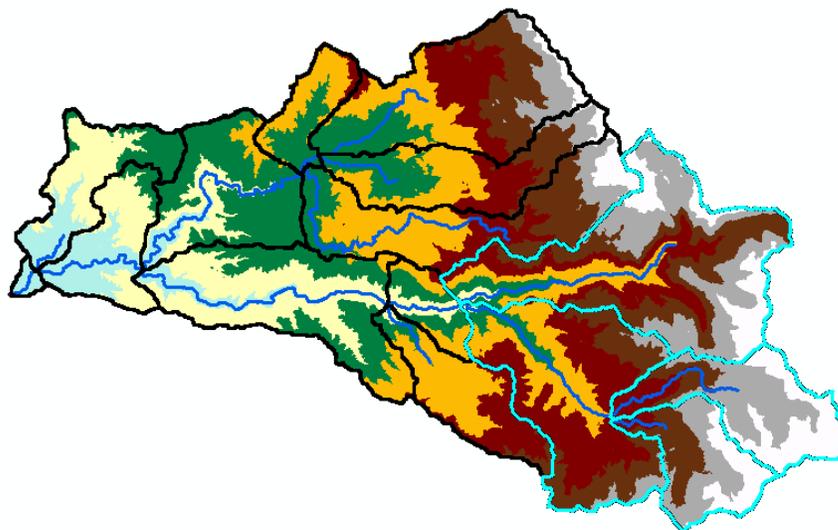
Figure 13-25. Highlighted Subbasins to be Merged.
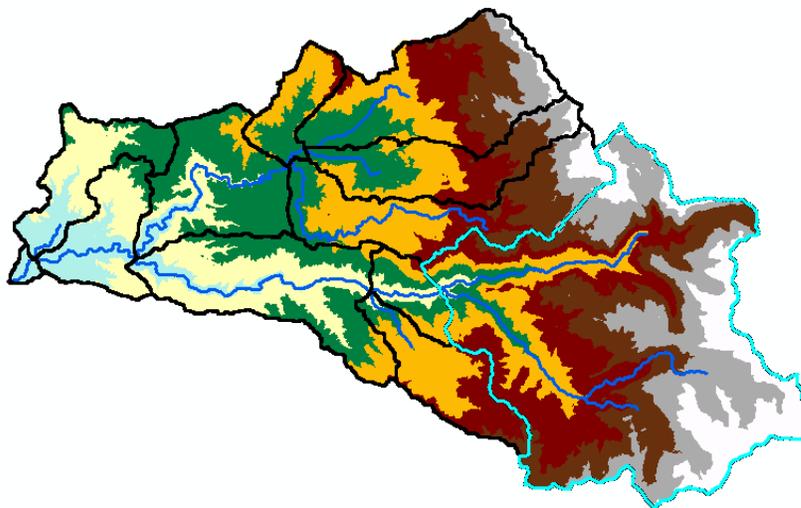
The result of the merged subbasin is shown in Figure 13-26.

Figure 13-26. Merged Subbasin.

B. Subdivide a Basin

- Add the hec1ga layer to the ProjAmer data frame (drag and drop from the Layers data frame to the ProjAmer data frame).

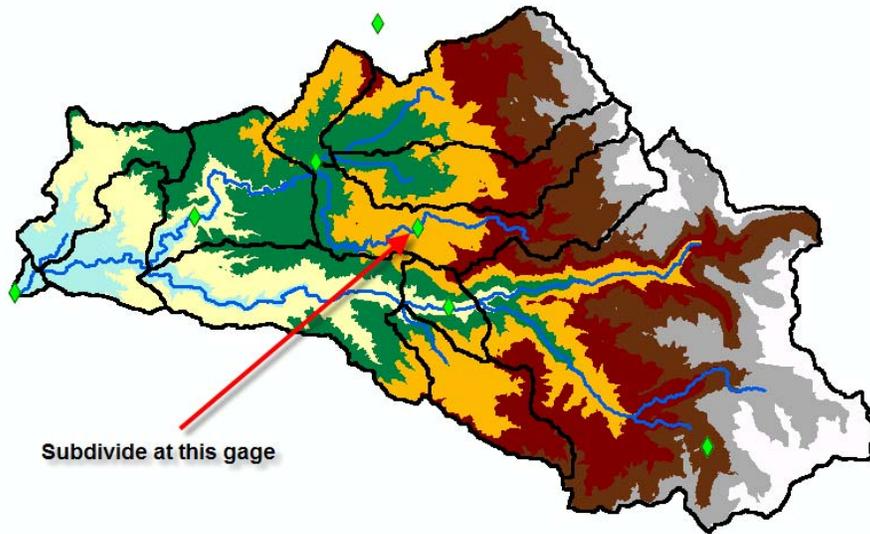- Zoom in on the gage location (Figure 13-27) and make the "Str" grid visible.

Figure 13-27. Subdivide Subbasin at Stream Gage Location.

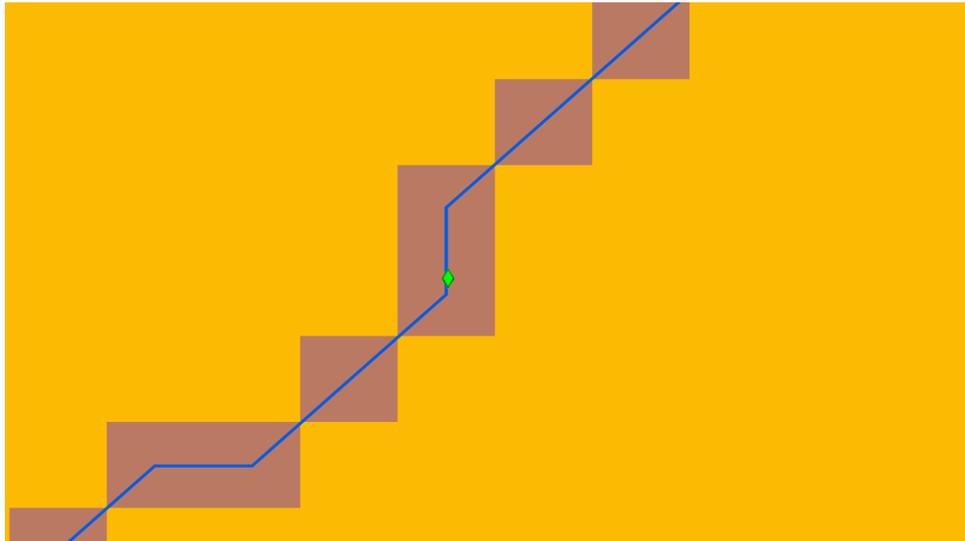- With the **Subbasin Divide** tool, , click on the cell shown in Figure 13-28 to subdivide the subbasin.

Figure 13-28. Subdivide by Clicking the Subbasin Divide Tool on the Stream Network.

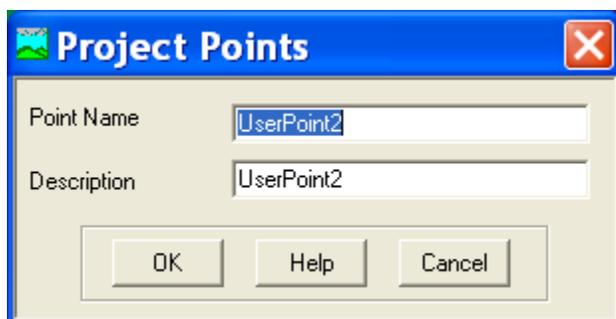- Use the default names in the ***Project Points*** dialog as shown in Figure 13-29.

Figure 13-29. Name the Subbasin Outlets using the Project Points Editor.

- Press **OK**.

The result of basin subdivision is shown in Figure 13-30.
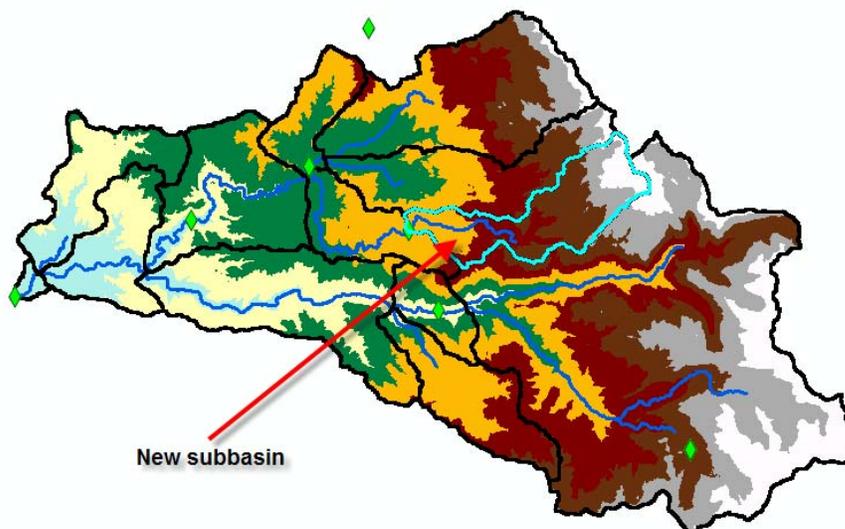

Figure 13-30. New Subbasin Created by the Subbasin Divide Tool.

C. Obtain River Profile

- Select the **River Profile** tool, .
- Verify that the proper data layers are used as shown in Figure 13-31.

Figure 13-31. River Profile Editor.

- Click on the highlighted river segment, as shown in Figure 13-32, to view the river profile.
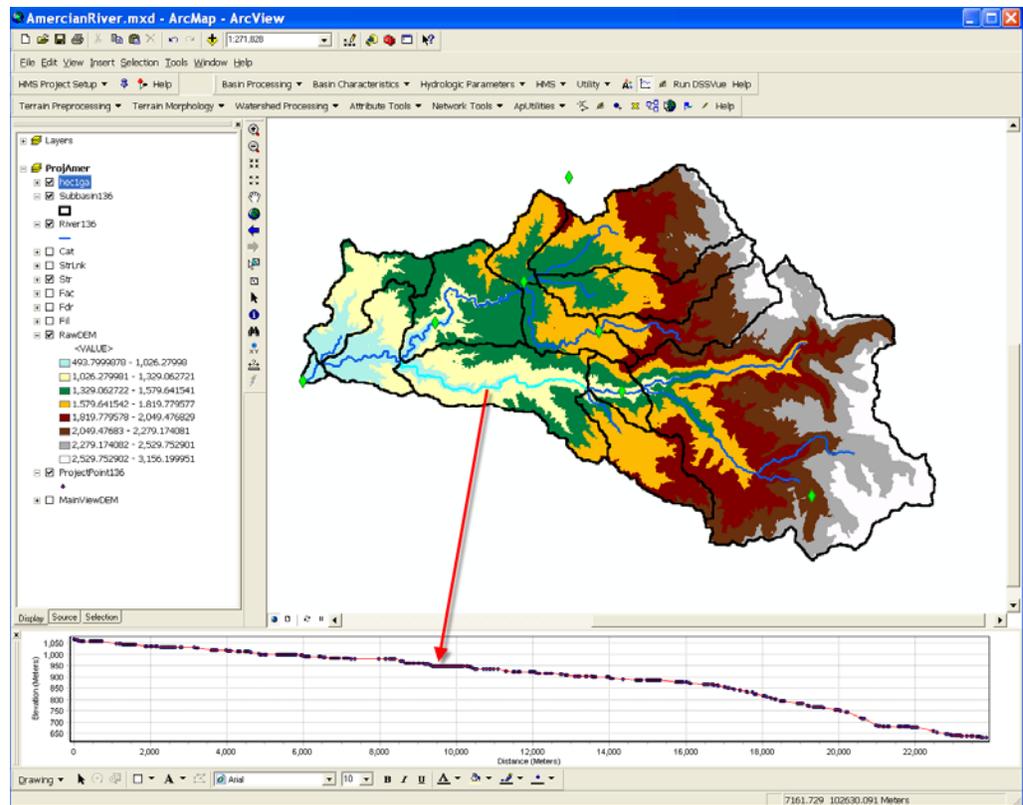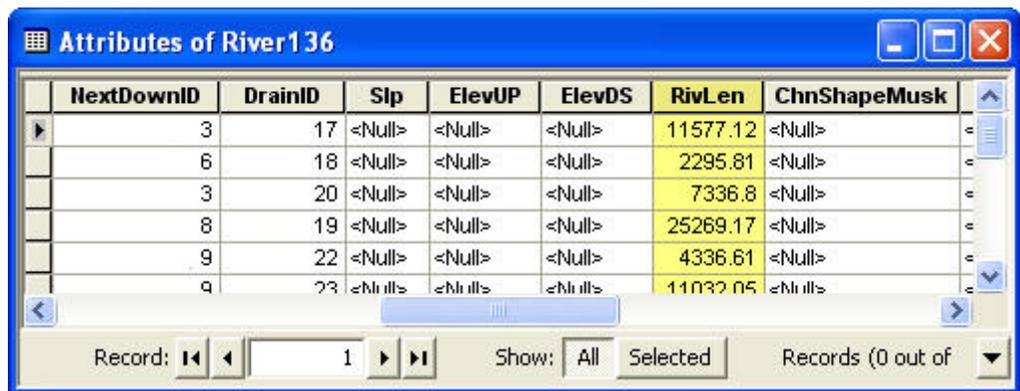

Figure 13-32. Profile for Selected Reach.

8. Extract physical characteristics of streams and subbasins.

The physical characteristics of streams and subbasins are extracted and saved in attribute tables.

A. River Length

- Select **Basin Characteristics → River Length**.

- Press **OK** after making sure the river layer is selected.

- A "RivLen" column in the attribute table is updated with estimates of the river length (Figure 13-33).

Figure 13-33. Attribute Table for the River Layer.

B. River Slope

- Select **Basin Characteristics → River Slope**.

- Press **OK** after making sure the DEM and river layer are selected.

- "Slp", "ElevUP", and "ElevDS" columns are updated in the river layer's attribute table (Figure 13-34).

Figure 13-34. Slope Attributes for the River Layer.

C. Longest Flow Path

- Select **Basin Characteristics → Longest Flow Path**.

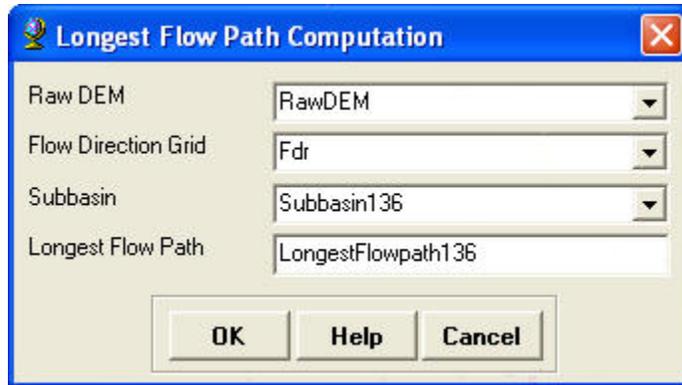- Review the input and output data layers as shown in Figure 13-35. Press **OK.** This step takes about one minute.

Figure 13-35. Longest Flow Path Computation Editor.

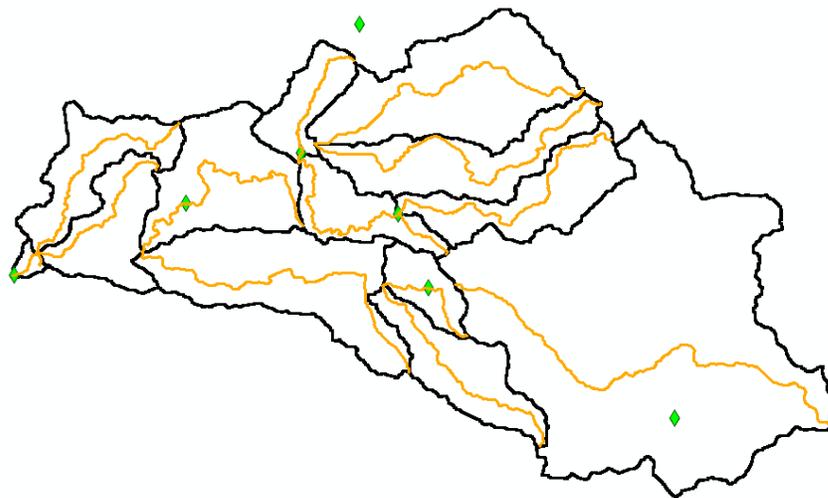The results of the longest flow path operation are shown in Figure 13-36.

Figure 13-36. Longest Flow Path Layer.

The longest flow path computation also stores the physical parameters in the attribute table as shown in Figure 13-37.

Shape *	OID *	Shape_Length	DrainID	LengthDown	LongestFL	Slp	ElevUP	ElevDS
Polyline	1	12025.874452	18	51247.316	12025.87	0.05	1992.1	1347
Polyline	2	28159.572491	17	69683.035	28159.57	0.05	2816.4	1476
Polyline	3	33498.872273	20	75016.121	33498.87	0.04	2722.6	1476
Polyline	5	21333.916652	22	24260.348	21333.92	0.05	1556.3	564
Polyline	6	25609.72401	33	83283.026	25609.72	0.05	2854.2	1600.9
Polyline	7	15891.458864	23	18811.677	15891.46	0.06	1539	564
Polyline	8	28132.404743	19	42084.675	28132.4	0.03	1566.4	630.1

Figure 13-37. Attribute Table for the Longest Flow Path Layer.

D. Basin Centroid

- Select **Basin Characteristics** → **Basin Centroid**.

- Select the **Center of Gravity Method** (Figure 13-38).
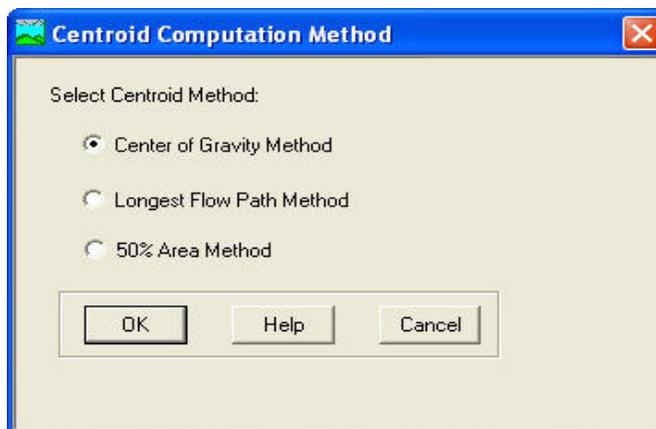

Figure 13-38. Select the Subbasin Centroid Method.

- Press **OK**.

- Make sure the subbasin layer is selected and accept the default name for the basin centroid layer. Press **OK**.

- A new data layer is created to represent the centroid locations as shown in Figure 13-39.
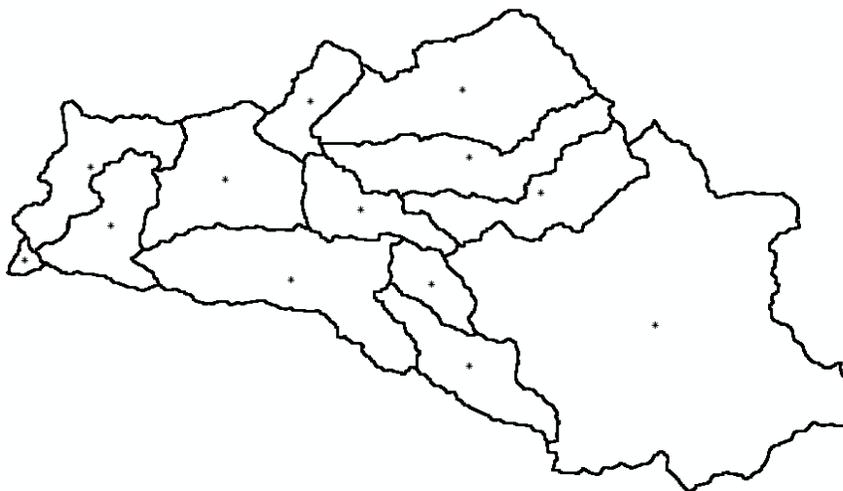

Figure 13-39. Subbasin Centroid Layer.

E. Centroid Elevation

- Select **Basin Characteristics** → **Centroid Elevation**.

- Make sure the raw DEM and centroid layer are selected and press **OK**.

An elevation field is added to the centroid layer's attribute table.

F. Centroidal Flow Path

- Select **Basin Characteristics → Centroidal Flow Path**.

- Make sure the subbasin, centroid, and longest flow path layers are selected. Accept the default name for the centroidal longest flow path and press **OK**.

A new data layer is created to represent the centroidal flow paths as shown in Figure 13-40.

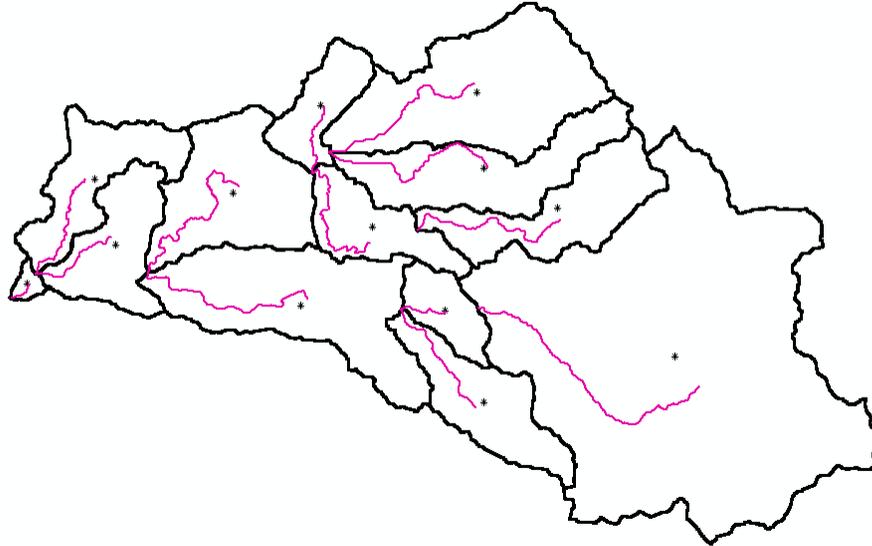**Figure 13-40.** Centroidal Longest Flow Path Layer.

9. Develop hydrologic parameters.

A. Select HMS Processes

- Select **Hydrologic Parameters → Select HMS Processes**.

- Make sure the subbasin and river layers are selected and press **OK**.

- Select **Initial+Constant** for Loss Method, **Clark** for Transform Method, **None** for Baseflow Method, and **Lag** for Route Method (Figure 13-41).
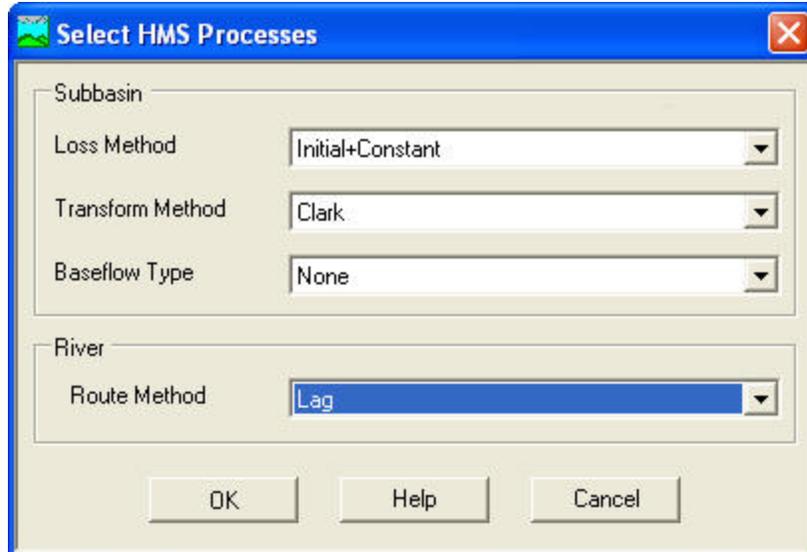
- Press **OK**.

Figure 13-41. Select HEC-HMS Modeling Methods.

B. River Auto Name

- Select **Hydrologic Parameters → River Auto Name**.

- Make sure the river layer is selected and press **OK**.

This step creates a "Name" column in the river layer's attribute table as shown in Figure 13-42. In a real study, you should manually edit the names.

Figure 13-42. River Reach Names.

C. Basin Auto Name

- Select **Hydrologic Parameters → Basin Auto Name**.

- Make sure the subbasin layer is selected and press **OK**.

This step creates a "Name" column in the subbasin layer's attribute table as shown in Figure 13-43. In a real study, you should manually edit the names.

Figure 13-43. Subbasin Names.

10. Develop HMS inputs.

   A. Map to HMS Units

   - Select **HMS → Map to HMS Units**.

   - Review the input data layers. Press **OK**.

   - Select **English** from dropdown menu as shown in Figure 13-44.

   - Press **OK**.
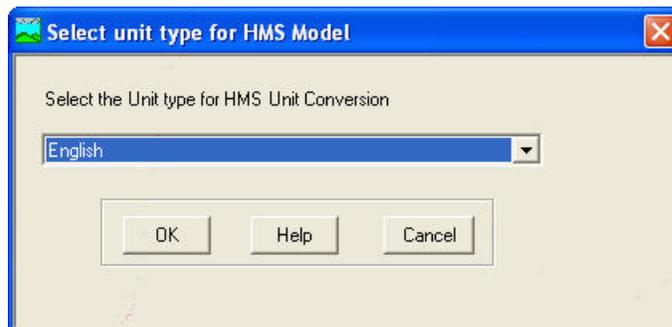
Figure 13-44. Select the Units System.

The results of the unit conversion are added columns to attribute tables for the subbasin (Figure 13-45) and river (Figure 13-46) layers. The added columns contain the ending "_HMS".

Figure 13-45. Area Field Added to the Subbasin Layer's Attribute Table.
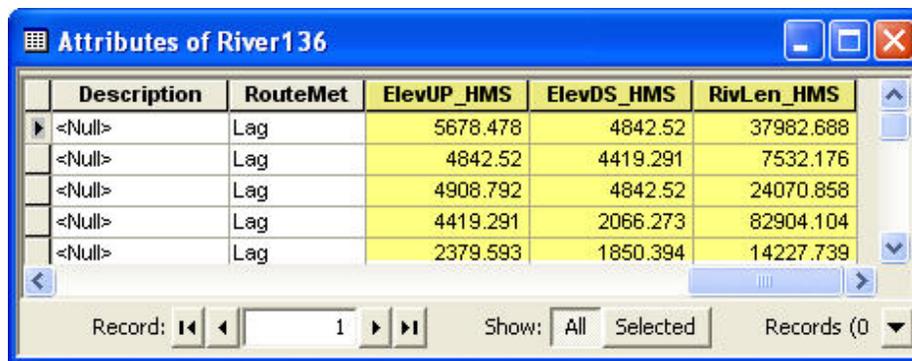
Figure 13-46. Elevation and Length Fields Added to the River Layer's Attribute Table**.**

B. HMS Check Data

- Select **HMS → HMS Check Data**.

- Verify the correct input datasets are selected as shown in Figure 13-47.
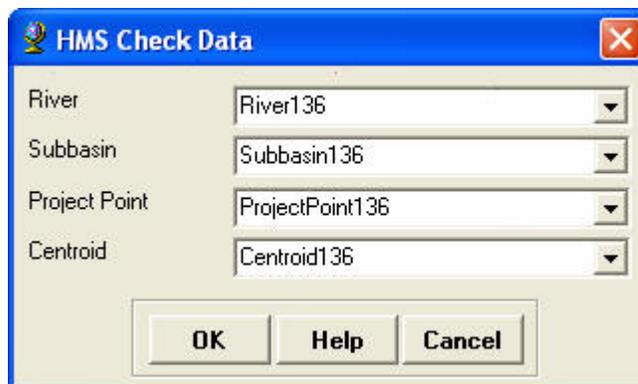
Figure 13-47. HMS Check Data Dialog.

- Press **OK**.

- Make a note of the file name and its location. Press **Yes** to review the file.

The output file, "SkelConsChk.txt", contains the results of the data check. A portion of the file is shown in Figure 13-48.
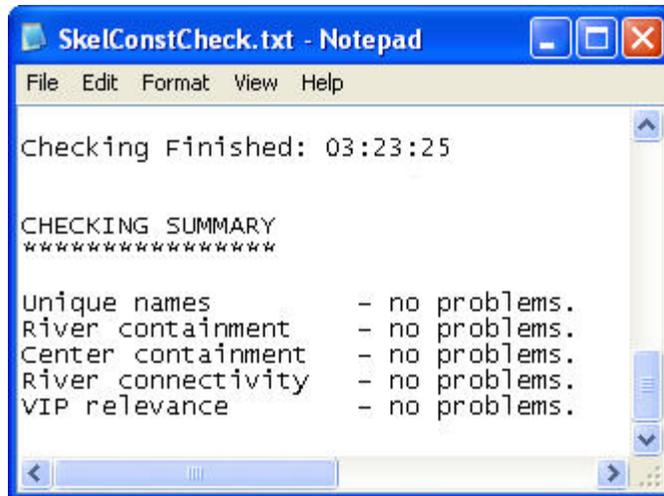
Figure 13-48. Portion of the Check Data File.

C. HMS Schematic

- Select **HMS → HMS Schematic**.

- Review the input and output datasets as shown in Figure 13-49. Press **OK**.
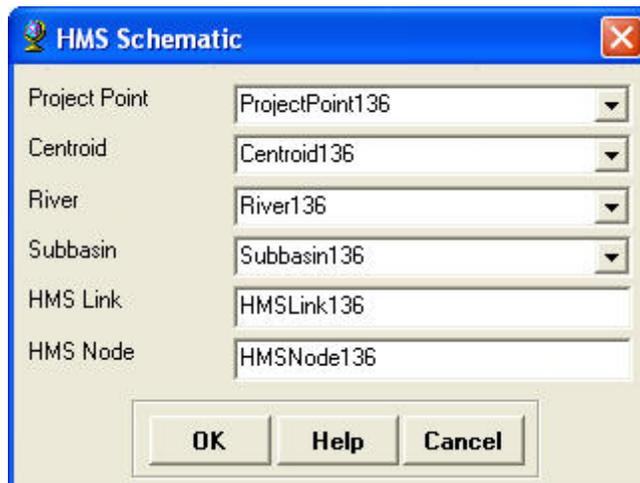
Figure 13-49. HMS Schematic Editor.

The HMS schematic with the regular legend symbols is shown in Figure 13-50.
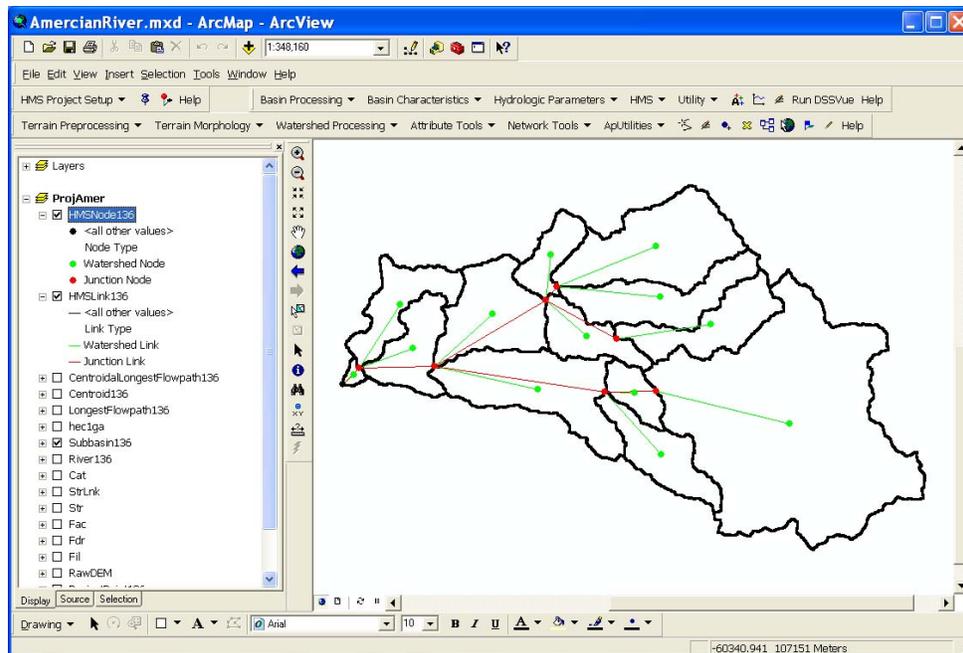
Figure 13-50. Schematic with Regular Legend Symbols.

D. HMS Legend

- Select **HMS → Toggle HMS Legend → HMS Legend**.

- The user can toggle between the **HMS Legend**, as shown in Figure 13-51, and the **Regular Legend**.
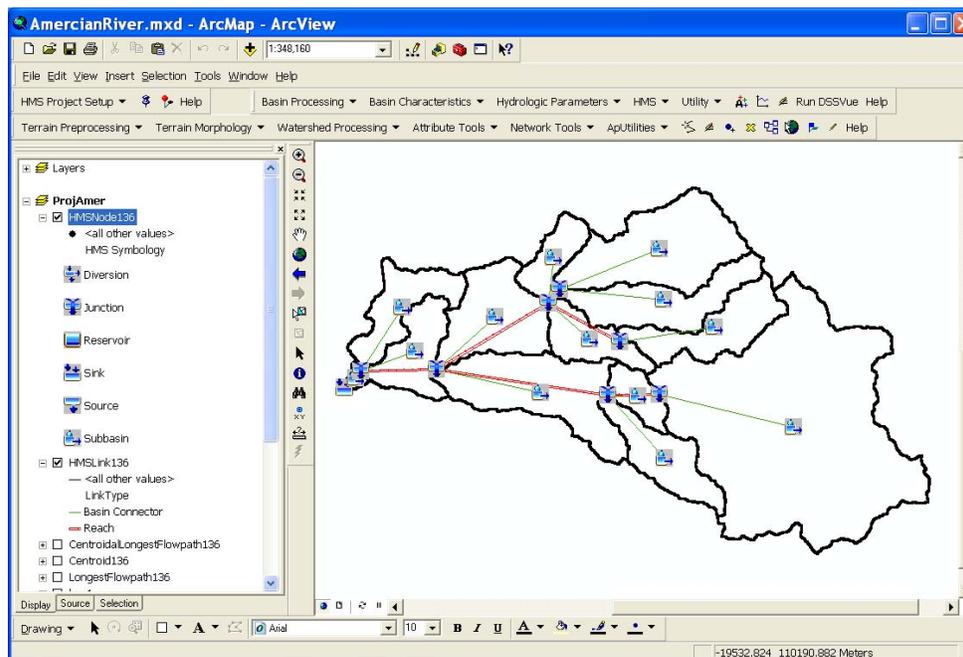
Figure 13-51. Schematic with HMS Legend Symbols.

E. Add Coordinates

This step attaches geographic coordinates to hydrologic elements in the HMSNode and HMSLink layers. The coordinates are saved to the attribute tables. The attachment of coordinates allows GIS data to be exported to a non-proprietary ASCII format and still preserve the geographic information.

- Select **HMS → Add Coordinates**.
- Review the input datasets as shown in Figure 13-52. Press **OK**.
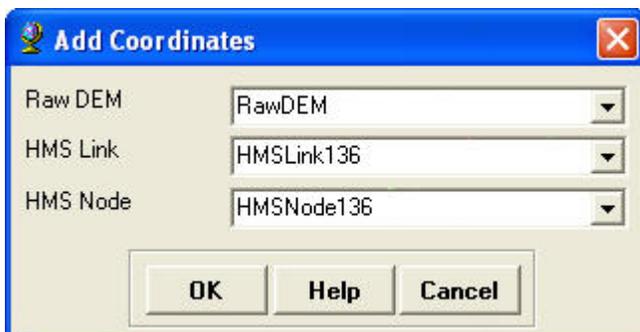
Figure 13-52. Add Coordinates Editor.

F. Prepare Data for Model Export

The **Prepare Data for Model Export** tool assembles the required HMS data for export to ASCII format.

- Select **HMS → Prepare Data for Model Export**.
- Review the input datasets as shown in Figure 13-53. Press **OK**.

Figure 13-53. Prepare Data for Model Export Dialog.

G. Background Map Files

The background map file option captures the geographic information of the subbasin boundaries and the stream network. Two options are available for creating background map files. The program can create an ASCII text file or shape files. HEC-HMS can read both file formats.

- Select **HMS → Background Map → Background Shape File**.
- Make sure the subbasin and river layers are selected and press **OK**.

- A window will open stating the shape files were successfully created. Press **OK**. These shape files are automatically saved in the project directory.

H. Basin File

The basin model file captures the hydrologic elements, their connectivity, and related geographic information in an ASCII text file that can be read by HEC-HMS.

- Select **HMS → Basin File**.

- Make a note of the file name and its location. Press **OK**.

Additional HEC-HMS project files can be created by HEC-GeoHMS; however, they are not necessary. The basin model file and background map files can be imported into an existing HEC-HMS project.

Task III. Hydrologic Modeling System

11. Setup an HEC-HMS model with inputs from HEC-GeoHMS.

A. Directory Setup

The user should create the HEC-HMS project first and then copy the background map files and basin model file to the HEC-HMS project folder. If other HEC-HMS project files were created by HEC-GeoHMS then these should be copied as well.

- Start the HEC-HMS program.

- Select **File → New**….

- Enter a project name of "American River Example" and a description of "GIS Application of HEC-GeoHMS to the American River Basin" as shown in Figure 13-54.

- Choose a directory to save the project.

- Select **U.S. Customary** for the unit system.

- Press the **Create** button.
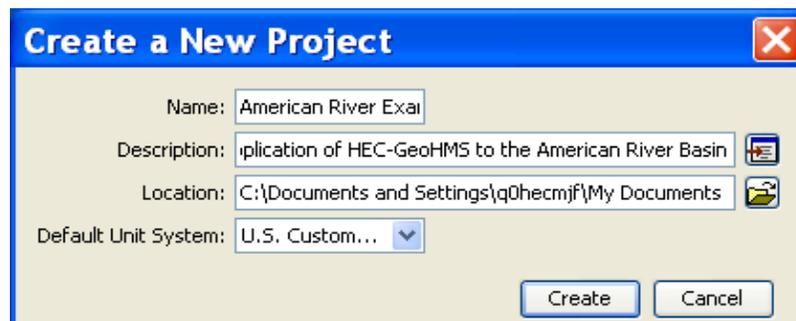
Figure 13-54. Create a new HEC-HMS Project.

Use Windows Explorer to copy the basin model file and the background map files to the newly created HEC-HMS project folder. The folder will have the same name as the project, "American River Example".

- To import the basin model file created by HEC-GeoHMS select **File → Import → Basin Model** (Figure 13-55).
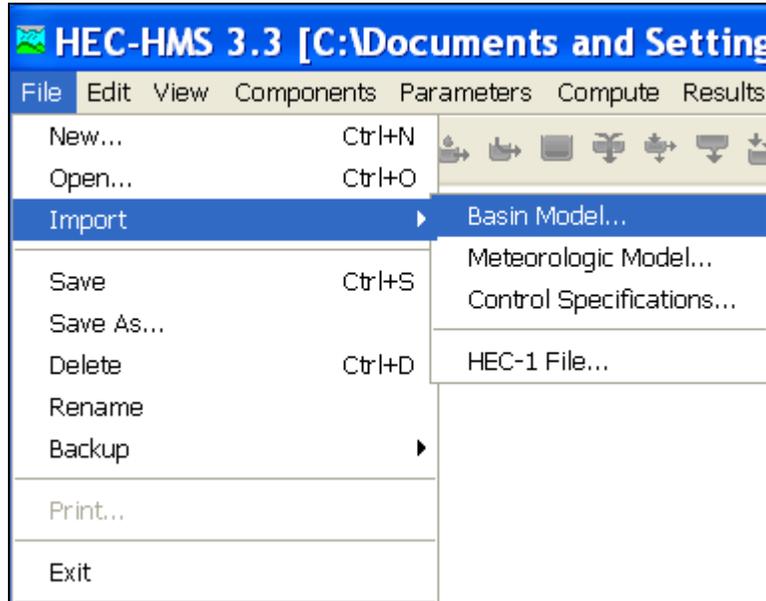
Figure 13-55. Import a Basin Model File into an Existing HEC-HMS Project.

- Navigate to the correct location and select the basin model file, "ProjAmer.basin".

- Press the **Select** button.

You should notice a **Basin Models** folder is added to the **Watershed Explorer**. The ProjAmer basin model is contained in this folder. When you select the ProjAmer basin model in the Watershed Explorer, the basin model map will open in the desktop area. All elements will be drawn on top of each other the very first time the map is opened after importing the basin model, as shown in Figure 13-56.
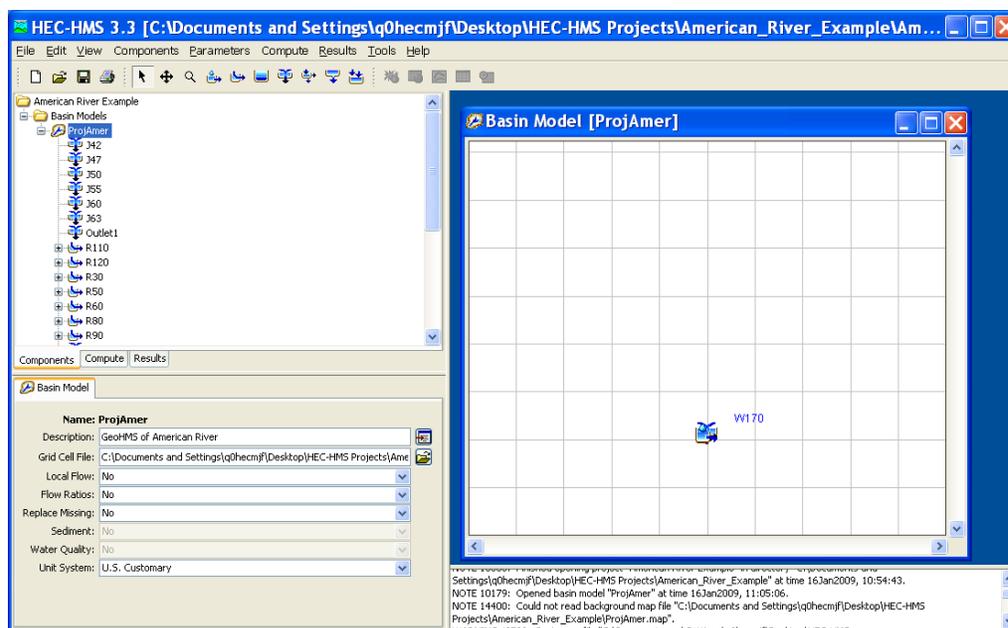
Figure 13-56. Map Extents after Import.

- Select the **View → Maximum Extents** menu option to open the *Maximum Extents* editor (Figure 13-57).

- Choose an extents method of **Union of All Elements** and a buffer of **25** percent.

- Click the **OK** button and the map will automatically resize. The element network will look similar to the HEC-GeoHMS project.
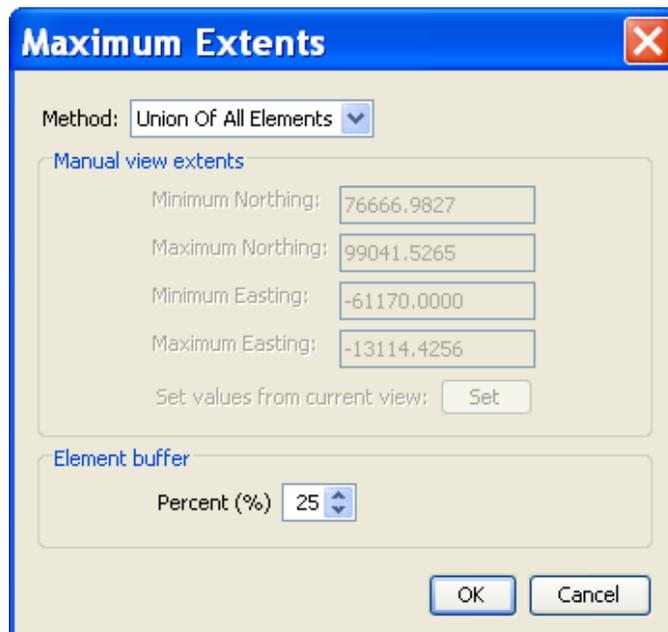
Figure 13-57. Set the Map Extents using the Maximum Extents Editor.

- Add the background map files by selecting **View → Background Maps**.

- Click the **Add** button in the *Background Maps* window (Figure 13-58).
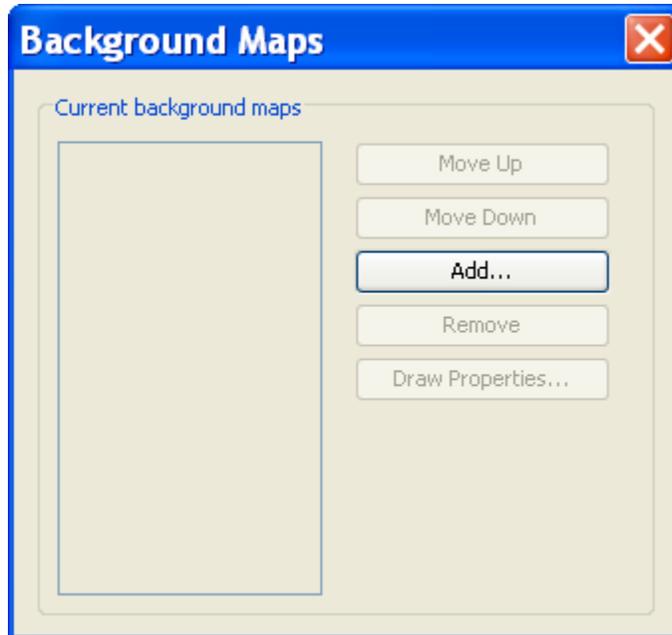
Figure 13-58. Add Background Maps using the Background Maps Editor.

- Change the file type to ESRI Shapefile (*.shp) and navigate to the directory where the background shape files are located as shown in Figure 13-59.
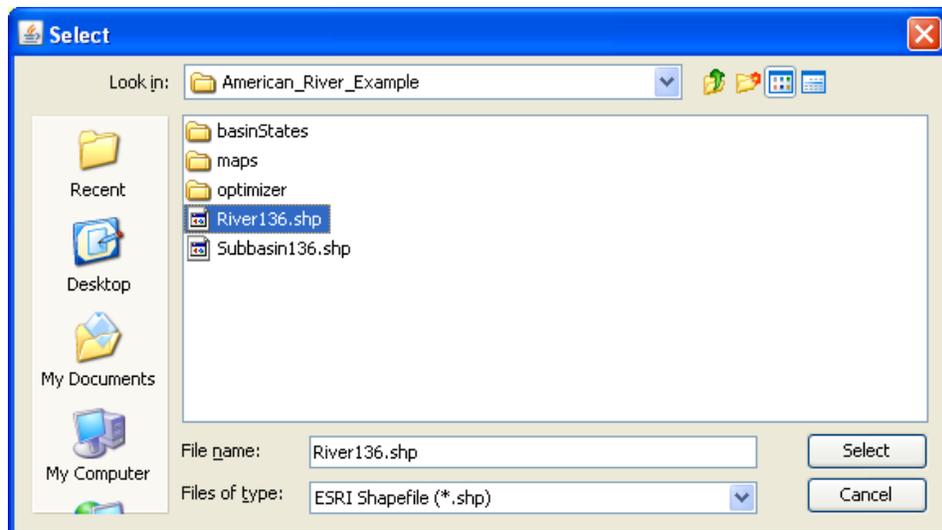
Figure 13-59. Select the Shape File to Add as a Background Map.

- Select the subbasin shape file and press the **Select** button. The shape file will be automatically added to the basin model map.

Next, add the river shape file to the map. The ***Background Maps*** editor can be used to order the shape files so that the river lines are drawn on top of the subbasin polygons and to edit the draw properties of the lines and polygons. Figure 13-60 shows the basin model map after importing the background shape files.
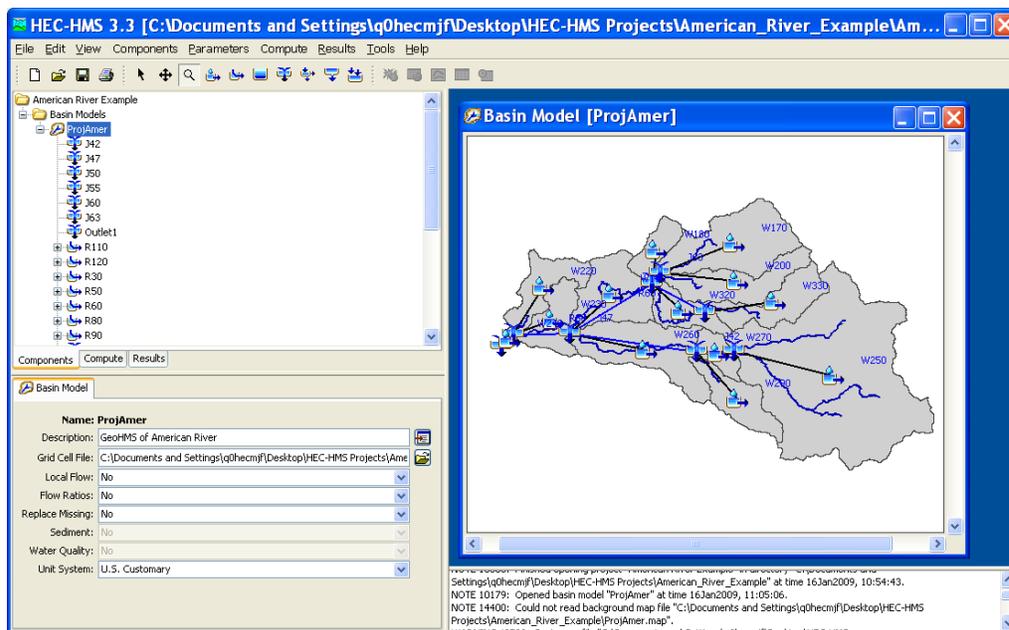
Figure 13-60. HEC-HMS Basin Model Map.

The next step in creating the HEC-HMS model is to enter subbasin and routing element parameters. Parameters could be estimated from previous studies or from a regional analysis. Then the model should be calibrated to historic rainfall-runoff events.

A P P E N D I X   A

References

Hydrologic Engineering Center (2000). *Hydrologic Modeling System (HEC-HMS): Technical Reference Manual.* U.S. Army Corps of Engineers, Davis, CA.

Hydrologic Engineering Center (2008). *Hydrologic Modeling System (HEC-HMS): User's Manual.* U.S. Army Corps of Engineers, Davis, CA.

Kull, D.W. and A.D. Feldman (1998). "Evolution of Clark's unit graph method to spatially distributed runoff". *J. Hydrologic Engineerin*g, 3(1), 9-19.

A P P E N D I X   B

Map File Format

Watershed boundaries and stream lines can be displayed as a background for hydrologic elements on the HEC-HMS **Basin Model** map. The use of a background map is optional and not required for any calculations. This appendix describes the background-map file format. The file can be produced using HEC-GeoHMS.

File Definition

Watershed boundary and stream line features are both defined in the same file, which is in plain ASCII format. Each feature type is contained in a separate section of the file; it is not important which section is first in the file. Each section begins with the keyword "MapGeo" followed by a colon and either "BoundaryMap" or "RiverMap" (Figure B-1).

```
MapGeo:   BoundaryMap
MapSegment:   closed
    582242.875000, 4174922.500000
    582220.875000, 4174961.500000
    582205.625000, 4175013.750000
    581981.000000, 4174672.750000
    582025.812500, 4174696.250000
    582068.812500, 4174711.000000
MapSegment:   closed
    582810.125000, 4174024.500000
    582874.687500, 4173973.750000
    582950.687500, 4173902.750000
    582554.000000, 4174000.250000
    582667.687500, 4174003.750000
    582810.125000, 4174024.500000
            MapGeo:   RiverMap
MapSegment:   open
    582750.187500, 4176706.000000
    582687.000000, 4176594.000000
    582657.375000, 4176468.500000
    582613.125000, 4176359.500000
    582482.125000, 4174521.500000
    582555.250000, 4174377.500000
    582555.250000, 4174378.000000
MapSegment:   open
    582941.500000, 4175098.500000
    582920.500000, 4175009.750000
    582912.312500, 4174956.500000
    582699.375000, 4174540.500000
    582618.250000, 4174468.250000
```

Figure B-1. Sample Background Map File.

A map segment defines a list of map coordinates that are connected by a line. A closed segment defines a polygon and an open segment defines a line. Closed segments are used for watershed boundaries and open segments are used for stream lines. Each segment begins with the keyword "MapSegment" followed by a colon and either "Closed" or "Open." The last coordinate in a closed segment is automatically connected to the first coordinate.

Segment coordinates are defined with x-y pairs. Map features are automatically scaled in the **Basin Model** map. Coordinates are therefore independent of projection, units, and offset. All segments must be in the same coordinate system.

A P P E N D I X   C

Grid-Cell Parameter File Format

The ModClark transform method requires a grid-cell file. The file defines cells for each subbasin. Parameters for each cell are also included in the grid-cell file. This appendix describes the grid-cell file format. The file can be produced using available geographic information system (GIS) tools.

File Definition

The grid-cell file begins with the keyword "Parameter Order" followed by a colon and parameter keywords indicating the order for reading parameters from the file (Figure C-1). The keyword "End" must be on a line by itself after the "Parameter Order" line. Valid parameter keywords are shown in Table C-1. Parameter keywords are not case sensitive and are separated by spaces. If the parameter order is not defined, it is assumed to be: Xcoord Ycoord TravelLength Area. The coordinate system of Xcoord and Ycoord used in the file must match the coordinate system used in the gridded DSS precipitation records. Typically the coordinate system will be either Hydrologic Rainfall Analysis Project (HRAP) or Standard Hydrologic Grid (SHG).

```
Parameter Order: Xcoord YCoord TravelLength Area
End:
Subbasin: 85
Grid Cell:   633   359    88.38     3.76
Grid Cell:   633   358    85.55    16.13
Grid Cell:   632   358    82.55    12.76
Grid Cell:   625   348    13.75    12.07
Grid Cell:   626   348    17.12     0.09
Grid Cell:   622   347    21.19     3.26
Grid Cell:   623   347    15.56     9.96
End:
Subbasin: 86
Grid Cell:   637   361    59.13     6.79
Grid Cell:   638   361    59.04     6.95
Grid Cell:   636   361    56.68     1.17
Grid Cell:   636   360    55.08    16.38
Grid Cell:   636   347    67.96     2.45
Grid Cell:   637   347    71.72     7.41
Grid Cell:   638   347    72.57     8.78
Grid Cell:   639   347    73.32     0.04
End:
```

Figure C-1. Sample Grid-Cell Parameter File.

Table C-1. Parameter Keyword Definitions.

Keyword	Definition	Units
XCoord	x-coordinate of the southwest corner of the cell	integer value
YCoord	y-coordinate of the southwest corner of the cell	integer value
TravelLength	travel time index from the cell to the subbasin outlet	kilometers
Area	area of cell within the subbasin	square kilometers

The data for a subbasin begins with the keyword "Subbasin" followed by a colon and the subbasin identifier. One line beginning with the keyword "Grid Cell" follows for each cell in the subbasin. Data for the subbasin ends with the keyword "End". Keywords are not case sensitive and may contain spaces. Blank lines can be included and lines beginning with "#" are ignored as comments. The same grid-cell file can be referenced by more than one subbasin, allowing data for many subbasins to be stored in the same file. The identifier for a subbasin must be exactly the same in the grid-cell file as it is in the basin model.

A P P E N D I X   D

Grids in HEC-DSS, HRAP, and SHG Grid Systems

Contents of a Grid Record in HEC-DSS

HEC-DSS records, including grid records, consist of a block of sequential data with an associated header array describing the data in the block. In a time-series record, the sequence represents the variation of a parameter's value through time at a fixed location. In a grid record, the sequence represents the variation of a parameter's value over a region of the earth's surface for a single interval of time. The header array of a grid record contains information about the parameter values (their units and some summary statistics) and the two-dimensional array in which they are stored (the number of rows and columns in the array, and the location of the grid in geo-referenced coordinates).

The contents of the header are described below for three types of grids. All grid headers contain basic parameter and grid extent information. In addition, the headers for HRAP grids and Albers equal-area grids (including SHG grids) contain additional descriptive information.

Storage of Grid Values

In the DSS file, grid parameter values are stored in a single array, starting with the value in the minimum-x, minimum-y (or lower left) cell in the two-dimensional array. The values proceed by row in increasing column numbers and increasing row numbers, as illustrated in the Figure D-1.
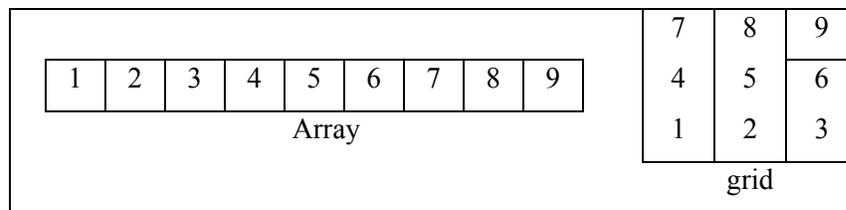
Figure D-1. One-Dimensional Array Storing Two-Dimensional Grid of Parameter Values.

The array of parameter values is always compressed before it is written to a DSS file. Two compression methods are used. One is a run-length encoding method, which replaces repeated zero values with the number of times zero was repeated. The second method is the deflate method, which is included in the zlib library described in RFC 1950. The deflate format and zlib are included in Javasoft's Java Development Kit Version 1.1 and higher.

Grid Header Contents

The contents of the grid header array are as follows:

Field	Type	Size (integers)
Info Flat Size	Integer	1
Grid Type	Integer	1
Grid Info Size	Integer	1
Start Time	Integer	1
End Time	Integer	1
Data Units	Text	3
Data Type	Integer	1
Lower Left Cell X	Integer	1
Lower Left Cell Y	Integer	1
Number of Cells X	Integer	1
Number of Cells Y	Integer	1
Cell Size	Float	1
Compression Method	Integer	1
Compressed Array Size	Integer	1
Compression Scale Factor	Float	1
Compression Base	Float	1
Max Data Value	Float	1
Min Data Value	Float	1
Mean Data Value	Float	1
Number of Ranges	Integer	1
Range Limit Table	Float	20
Range Counts	Integer	20
HRAP Headers append the following		
Data Source	Text	3
Albers Headers (including SHG) append the following		
Projection Datum	Integer	1
Projection Units	Text	3
First Standard Parallel	Float	1
Second Standard Parallel	Float	1
Central Meridian	Float	1
Latitude of Origin	Float	1
False Easting	Float	1
False Northing	Float	1
X Coordinate of Cell (0,0)	Float	1
Y Coordinate of Cell (0,0)	Float	1

HRAP Grid System

The Hydrologic Rainfall Analysis Project (HRAP) grid is a square-celled grid based on a Polar Stereographic map projection with the following parameters.

Units: Meters

Datum: Sphere (radius = 6371.2 km)

Standard Parallel: 60º 0' 0" North

Central Meridian: 105º 0' 0" West

The mesh (cell) size of the grid is 4.7625 km, and the grid Y axis is aligned parallel with the central meridian (105E W). The grid is registered so that the North Pole lies exactly 400 cells in the positive X direction and 1600 cells in the positive Y direction from the grid origin. Equivalently, the lower left corner of cell number (401, 1601) is located at the North Pole.

Examples

As examples of cell identification in the HRAP system, indices of cells containing points in the western U.S. and the eastern U.S. are given.

Western US:

The location 121º 45′ west, 38º 35' north (near Davis, California) projects to 260,174 m easting, 2,143,782 m northing, in the specified polar stereographic projection. In the HRAP system the indices of the cell containing this point are

i = 54

j = 450

Eastern US:

The location 76º 30′ west, 42º 25′ north (near Ithaca, New York) projects to 4,410,804 m easting, 3,018,420 m northing, in the specified polar stereographic projection. In the HRAP system the indices of the cell containing this point are

i = 926

j = 633

SHG Grid System

The standard hydrologic grid (SHG) is a variable-resolution square-celled map grid defined for the conterminous United States. The coordinate system of the grid is based on the Albers equal-area conic map projection with the following parameters.

Units: Meters

Datum: North American Datum, 1983 (NAD83)

1st Standard Parallel: 29º 30' 0" North

2nd Standard Parallel: 45º 30' 0" North

Central Meridian: 96º 0' 0" West

Latitude of Origin: 23º 0' 0" North

False Easting: 0.0

False Northing: 0.0

Users of the grid can select a resolution suitable for the scale and scope of the study for which it is being used. For general-purpose hydrologic modeling with NEXRAD radar precipitation data, HEC recommends 2000m cells, and HEC computer programs that use the SHG for calculation will select this cell size as a default. HEC will also support the following grid resolutions: 10,000 m, 5,000 m, 1,000 m, 500 m, 200 m, 100 m, 50 m, 20 m, 10 m. The grids resulting from the different resolutions will be referred to as SHG-2km, SHG-1km, SHG-500m and so on. A grid identified as SHG with no cell-size indication will be assumed to have 2km cells

For identification, each cell in the grid has a pair of integer indices (i, j) indicating the position, by cell count, of its southwest (or minimum-x, minimum-y) corner, relative to the grid's origin at 96W, 23N. For example the southwest corner of cell (121, 346) in the SHG-2km grid is located at an easting of 242000 m and a northing of 692000 m. To find the indices of the cell in which a point is located, find the point's easting and northing in the projected coordinate system defined above, and calculate the indices with the following formulas.

i = floor(easting / cellsize)

j = floor(northing / cellsize)

Where floor(x) is the largest integer less than or equal to x.

Examples

As examples of cell identification in the SHG system, indices of cells containing points in the western US and the eastern US will be given in the 1km, 2km, and 500 m SHG grids.

Western US:

The location 121° 45′ west, 38° 35′ north (near Davis, California) projects to -2185019 m easting, 2063359 m northing, in the specified Albers projection. In the SHG-2km system the indices of the cell containing this point are

$i = floor(-2185019 / 2000) = floor(-1092.5) = -1093$

$j = floor(2063359 / 2000) = floor(1031.7) = 1031$

In the SHG-1km grid the indices are (-2186, 2063), and in SHG-500m they are (-4371, 4126)

Eastern US:

The location 76° 30′ west, 42° 25′ north (near Ithaca, New York) projects to 1583506 m easting, 2320477 m northing, in the specified Albers projection. In the SHG-2km system the indices of the cell containing this point are

$i = floor(1583509 / 2000) = floor(791.8) = 791$

$j = floor(2320477 / 2000) = floor(1160.2) = 1160$

In the SHG-1km grid the indices are (1583, 2320), and in SHG-500m they are (3167, 4640).