AUTOMATIC WATERSHED DELINEATION/CURVE NUMBER TOOL

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ABSTRACT

An automatic watershed delineation/Curve Number tool was developed by the Natural Resources Conservation in South Dakota to prepare needed input data for the Engineering Field Handbook, Chapter 2, EFH2 computer program. Data necessary to use the Curve Number Method includes drainage area, runoff curve number, longest watershed flow length, and average watershed slope. Additionally, the developed tool can be used to prepare data to run the runoff models WinTR55 and WinTR20.

The tool consists of two parts: automatic watershed delineation and Curve Number routine. In the automatic watershed delineation part, the drainage area, watershed length, and the average watershed slope are computed using U.S. Geological Survey (USGS) Digital Elevation Models (DEM). In the Curve Number routine part, the composite runoff Curve Number for the watershed delineated in part 1 is computed.

The watershed is delineated by using preprocessed Arc Hydro grids and/or the watershed tool in Arcmap (ArcGIS Desktop). Arc Hydro is a geospatial and temporal data model for water resources that operate within ArcGIS (Maidment, 2002). The USGS's 10- and 30-meter DEM grids and the National Hydrography Dataset data were used for the input for Arc Hydro and the watershed tool in Arcmap.

The final watershed delineation shapefile from part 1 is subdivided by the user into the land uses described in EFH2. Several forms with pre populated drop-downs are used to select the land use. This allows for efficiency as well as uniform inputs. There are several edit tools that have been put together to ease the process of editing, as well. The shapefile is intersected with pre-processed digital soils data to link the Hydrologic Soil Group with the land use. The tool then makes the appropriate calculations to arrive at a composite runoff curve number for the entire watershed. VBA was used to automate this part as well as to incorporate the models developed in Modelbuilder into a more user-friendly process.

The output from the tool includes a delineated watershed shapefile and a text file that has the needed input data for the EFH2 computer program. This includes the composite runoff curve number, the drainage area, the longest flow length, and the average watershed slope of the corresponding delineated watershed.

INTRODUCTION

The primary purpose of the automatic watershed delineation/Curve Number tool developed by the NRCS in South Dakota is to prepare the needed input data for the EFH2 computer program. The Engineering Field Handbook, Chapter 2, NEH 650.02, Estimating Runoff and Peak Discharge, outlines procedures to estimate peak discharge Data necessary to use the Curve Number Method includes drainage area, runoff curve number, longest watershed flow length, and average watershed slope.

Additionally, the developed tool can be used to prepare watershed data necessary data to run the runoff models WinTR55 and WinTR20. As these watersheds are much larger than the 2000 acres maximum drainage area for the Curve Number Method, the drainage delineation will be even more valuable and a huge time saver.

The tool that was developed consists of two parts: part 1 is the automatic watershed delineation and part 2 is the Curve Number routine. In the automatic watershed delineation part, the drainage area, watershed length, and the average watershed slope are computed using USGS DEMs. In the Curve Number routine part, the composite runoff Curve Number for the watershed delineated in part 1 is computed.

ArcGIS Desktop 9.2 is a requirement for the tool to run. This tool will not run in the ArcEditor version of ArcGIS.

AUTOMATIC WATERSHED DELINEATION

The first part of the tool is the delineation of the watershed using USGS DEM grids. Initially, 30-meter DEM grids were used to complete the watershed delineation as 10-meter DEM data was not available for all of South Dakota and because of file size restraints. The 30-meter grids along with the USGS's National Hydrography Dataset (NHD) were used as input to Arc Hydro to develop a set of preprocessed grids that cover all of South Dakota. Arc Hydro is a geospatial and temporal data model for water resources that operate within ArcGIS (Maidment, 2002). One of the advantages of using Arc Hydro was that the NHD could be used to burn in the streams to create a more hydrologically sound dataset.

Preprocessed grids were completed for 13 areas that cover all of South Dakota. The 13 areas corresponded to the major streams in South Dakota as shown in Figure 1 and included the Bad River, Belle Fourche River, Big Sioux River, Upper Cheyenne River, Lower Cheyenne River, Grand and Moreau Rivers, Upper James River, Lower James Vermillion Rivers, Lewis and Clark Lake, Upper Missouri River, Lower Missouri River, Upper Red and Minnesota Rivers, and White River. The Arc Hydro grid datasets generated for these 13 areas include the flow direction, flow accumulation, fill, watershed slope, and stream network grids.

As can be seen on Figure 1, there was a lot of overlap between the 13 areas. This was due to in part to the uncertainty of the major watershed divisions as the 10- and 12-digit USGS Hydrologic Units (HUs) were not yet completed for South Dakota. The final HUs have now been finalized and involved some major revisions of the 8-digit boundaries.

The watershed is delineated by using the Arc Hydro preprocessed grids and the watershed tool in Arcmap (ArcGIS Desktop);

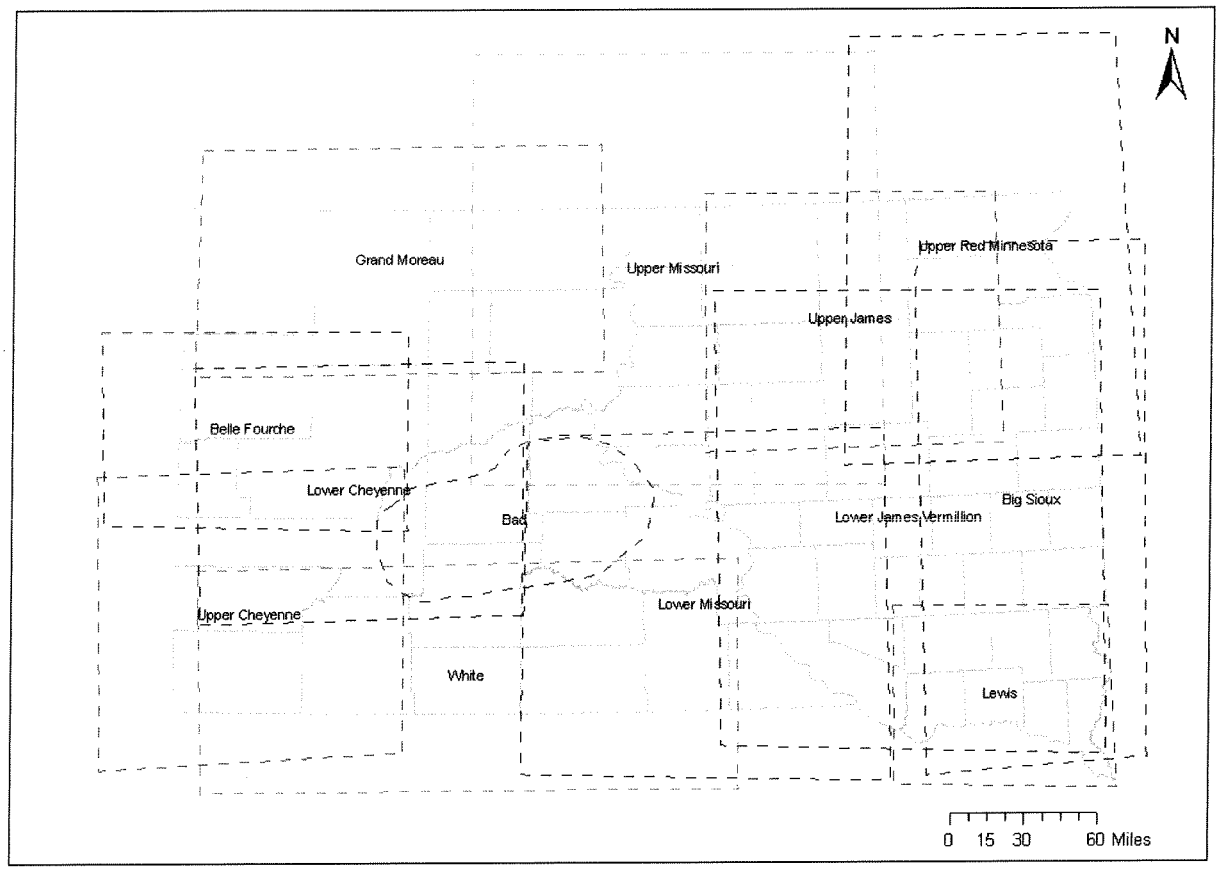

Figure 1. Location of 30-meter watershed delineation areas for South Dakota.

A second tool was developed using 10-meter DEMs to complete more accurate watershed delineation than the 30-meter version of the tool. The watershed again is delineated by using preprocessed grids and the watershed tool in Arcmap (ArcGIS Desktop); however, Arc Hydro was not used to create the preprocessed grids necessary for watershed delineation because of the increased file size and complexity. Instead, the tools in ArcGIS were used to create the preprocessed grids. One draw back to not using Arc Hydro was that the streams from the NHD could not be used to create a more hydrologically sound dataset. However, the smaller grid size made burning of the streams into the elevation grids less critical.

For the 10-meter watershed delineation tool, South Dakota was divided up into 19 areas (13 areas covering most of the state) corresponding to the 10- and 12- Hydrologic Units that cover South Dakota as shown on Figure 2. Integer grids were used to minimize the grid file sizes.

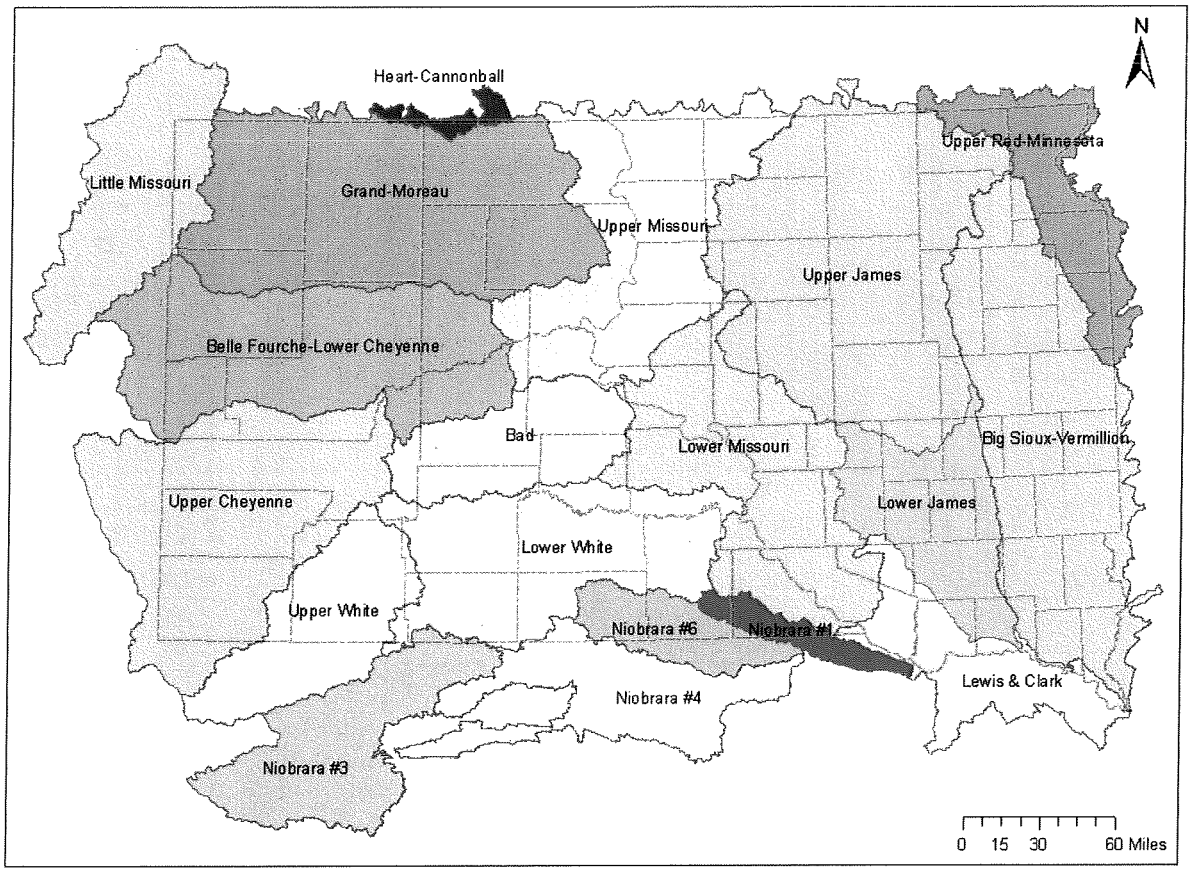

Figure 2. Location of 10-meter watershed delineation areas for South Dakota.

Modelbuilder (a component of Arcmap that allows automation of a series of processes) was used to join the necessary Arcmap tools necessary to do watershed delineation and to compute the average watershed slope and longest flow length corresponding to the delineated watershed. An option is available (once the watershed has been delineated using the preprocessed grid datasets) to edit the watershed shapefile. This was added due to the inherent error in using 10- and 30-meter DEM grids and to inject local drainage knowledge. This allowed an increased correlation

of the watershed delineation with the contours on the USGS's 1:24,000 Digital Raster Graphs (DRGs).

Preprocessed grids were used to minimize the process time of the watershed delineation. As a comparison, a model also was developed in Modelbuilder that directly used the DEM grid to do the watershed delineation in real time; however, the computation time was excessive as compared to using the preprocessed grids. This real time method may be more appropriate when using elevation data such as LIDAR.

CURVE NUMBER METHOD

The final watershed delineation shapefile from part 1 (i.e. see Figure 3) is subdivided by the user into the land uses (see Figure 4) described in NEH 650.02. Several forms with pre populated drop-downs are used to select the land use. This allows for efficiency as well as uniform inputs. There are several edit tools that have been put together to ease the process of editing, as well.

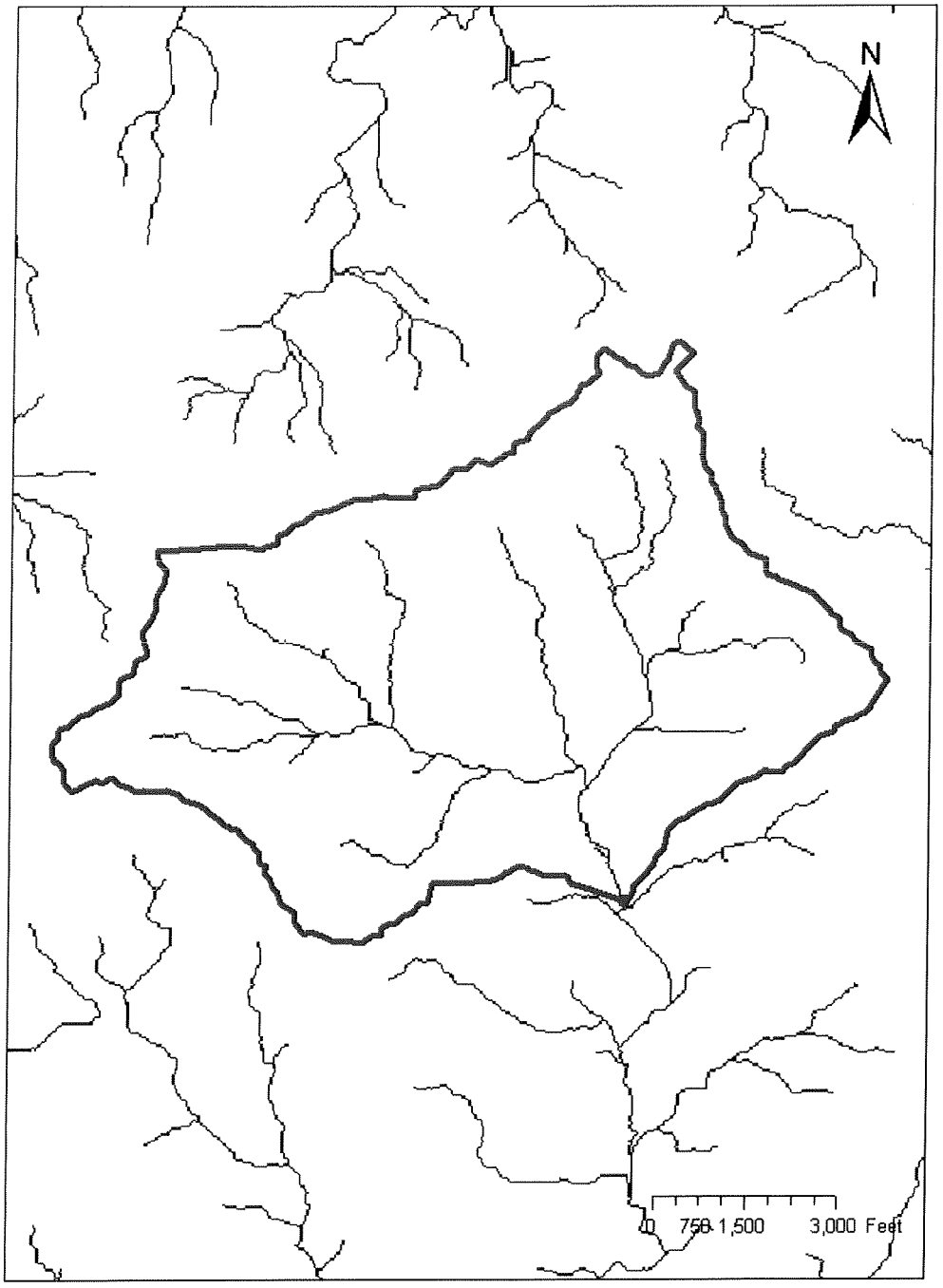

Figure 3. Watershed delineation using 10- or 30-meter preprocessed grids.

The watershed delineation shapefile is intersected with pre-processed digital soils data to link the Hydrologic Soil Group with the land use (see Figure 4). The tool then makes the appropriate calculations to arrive at a composite runoff curve number for the entire watershed. VBA was used to automate this part as well as to incorporate the models developed in Modelbuilder into a more user-friendly process. The tool then saves the needed files in a directory specified by the user.

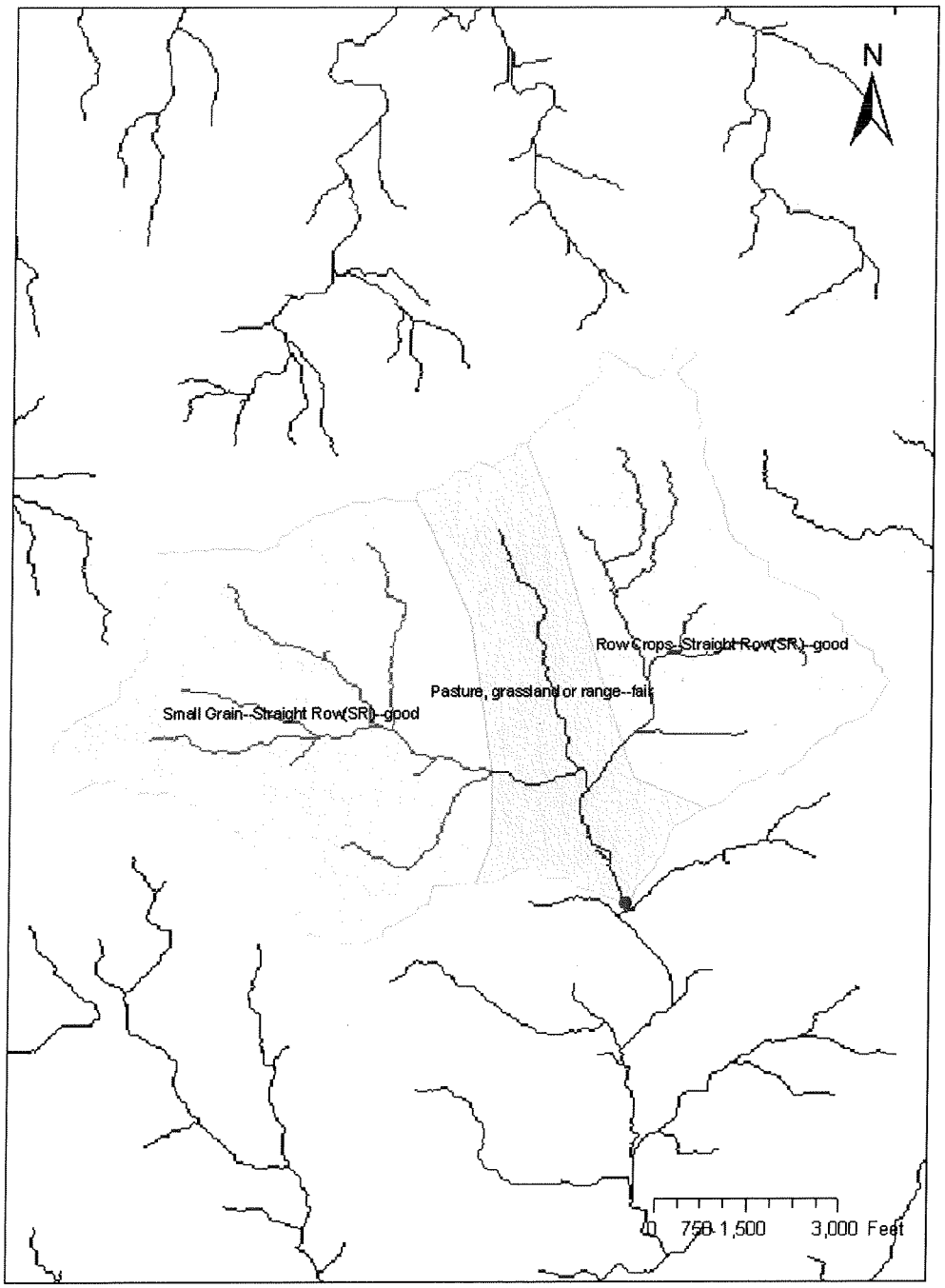

Figure 4. Landuse subdivision of watershed delineation.

OUTPUT

The output from the automatic watershed delineation/Curve Number tool includes a delineated watershed shapefile and a text file that has the needed input data for the EFH2 computer program. This includes the composite runoff curve number, the drainage area, the longest flow length, and the average watershed slope of the corresponding delineated watershed.

A sample output from this tool is as follows:

```
Friday, Dec 4 2009
-------------------------------------------------

Field number 1  rcn is 78

Field number 1  area is 509.5 Acres

Field number 2  rcn is 69

Field number 2  area is 352.7 Acres

Field number 3  rcn is 75

Field number 3  area is 743.6 Acres

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The weighted avg rcn for the 3 fields is 75
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The total area for the 3 fields is 1605.8 Acres
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The Longest Flow Length is 13290.4 Feet
-------------------------------------------------
The Average Slope for the Watershed is 1.04 %
-------------------------------------------------
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SUMMARY

An automatic watershed delineation/Curve Number tool has been developed by the Natural Resources Conservation in South Dakota to prepare needed input data for the EFH2 computer program. The tool also can be used to prepare input for the runoff models WinTR55 and WinTR20.

The tool consists of two parts: automatic watershed delineation and Curve Number routine. In the automatic watershed delineation part, the drainage area, watershed length, and the average watershed slope are computed using 10- and 30-meter USGS DEM grids. In the Curve Number routine part, the composite runoff Curve Number for the watershed delineated in part 1 is computed.

The final watershed delineation is subdivided by the user into the land uses described in EFH2. Several forms with pre populated drop-downs are used to select the land use. This allows for efficiency as well as uniform inputs. The shapefile is intersected with pre-processed digital soils data to link the Hydrologic Soil Group with the land use. The tool then makes the appropriate calculations to arrive at a composite runoff curve number for the entire watershed.

The output from the tool includes a delineated watershed shapefile and a text file that has the needed input data for theEFH2 computer program. The output from the automatic watershed delineation/Curve Number tool includes the composite runoff curve number, the drainage area, the longest flow length, and the average watershed slope of the corresponding delineated watershed.

REFERENCES

Maidment, D.R. (2002). Arc Hydro – GIS for Water Resources. ESRI Press, Redlands, CA.

Niehus, C.A. (2008).USDA, NRCS, Automatic watershed delineation/Curve Number tool using 30-meter DEM grids.

Niehus, C.A. (2009).USDA, NRCS, Automatic watershed delineation/Curve Number tool using 10-meter DEM grids.

USDA, NRCS, Part 650, Engineering Field Handbook, Chapter 2, Estimating Runoff.

USDA, NRCS, National Engineering Handbook, Part 630, Hydrology.