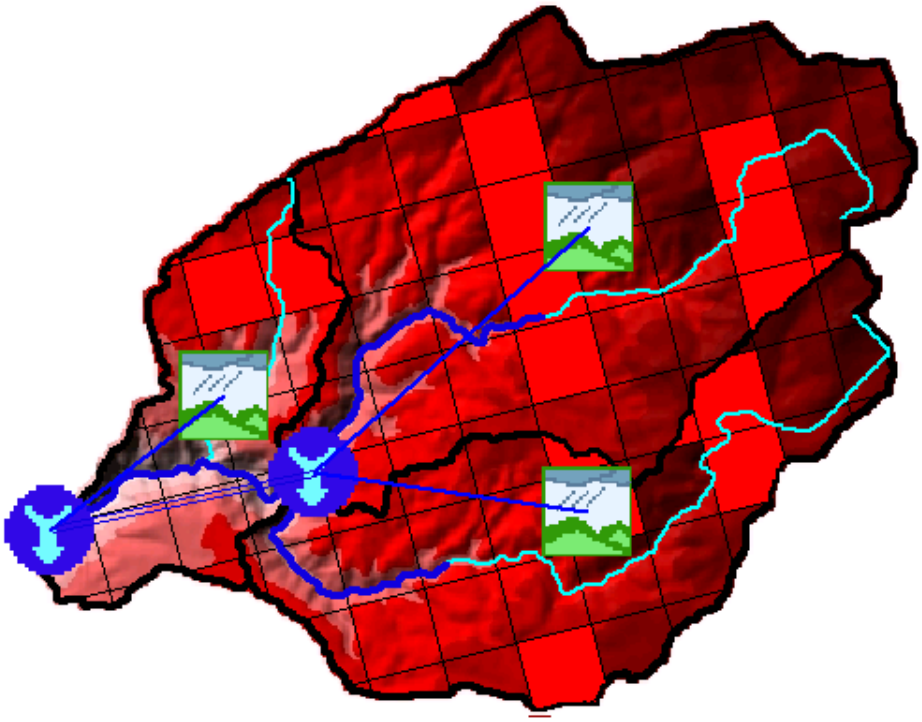
US Army Corps
of Engineers
Hydrologic Engineering Center

HEC-GeoDozer



User's Manual

Version 1.0
November 2009

CPD-91

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Christine Dartiguenave, ESRI
Sreeresh Sreedhar, ESRI
Matthew Fleming, HEC

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14. ABSTRACT

HEC-GeoDozer is specifically designed to process geospatial data for use with the Hydrologic Engineering Center's Geospatial Hydrologic Modeling Extension (HEC-GeoHMS). The tool allows users with limited GIS experience to edit terrain data and improve watershed delineations. ArcGIS® with the Spatial Analyst extension is required to use HEC-GeoDozer. ArcGIS® is a general purpose geographic information system (GIS) software program developed and copyrighted by the Environmental Systems Research Institute, Inc., Redlands, CA.

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DEM, spatial analyst, visualization, fill, projection, mosaic, flow direction, flow accumulation, reconditioning, fill sinks, fixed burn/fence, linear burn/fence, 3D burn/fence, polygon burn/fence, polygon, flood fill, elevation graphics, flow path tracing, watershed delineation

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US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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HEC-GeoDozer, User's Manual

Table of Contents

Foreword

HEC-GeoDozer is an extension for use with ArcGIS, a general purpose Geographic Information System software program developed and copyrighted by the Environmental Systems Research Institute, Inc., (ESRI) Redlands, CA. The HEC-GeoDozer extension was developed to support the Hydrologic Engineering Center's Geospatial Hydrologic Modeling Extension (HEC-GeoHMS) by providing tools for editing terrain data. These tools can be used to mosaic multiple terrain tiles into one continuous Digital Elevation Model (DEM) and to reproject the DEM to the required coordinate system. Additional tools available from the HEC-GeoDozer toolbar can be used to process the DEM to show the stream network. This GIS derived stream network can then be compared to published information for verification. If needed, tools are available from the HEC-GeoDozer toolbar for modifying the DEM to correct the stream network. Once corrected, the DEM can be used by HEC-GeoHMS to develop detailed subbasin boundaries and input files for Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS).

HEC-GeoDozer was developed using Research and Development funds.

CHAPTER 1 Getting Started

1.1 Setting up HEC-GeoDozer

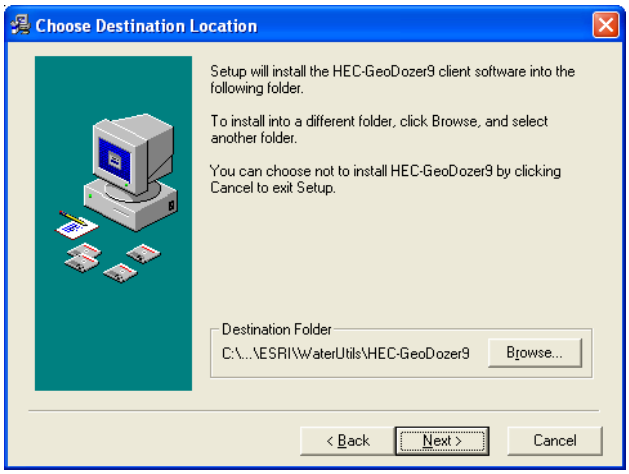
Software Requirements

- ArcGIS 9.2 or higher
- Spatial Analyst extension
- XML Parser version 3.0 or 4.0 (MSXML 3.0 or MSXML 4.0) – 4.0 recommended
- HEC-GeoHMS

Check whether HEC-GeoHMS is installed on the computer. If not, install HEC-GeoHMS and run the setup to install HEC-GeoDozer.

1.2 Run the Setup

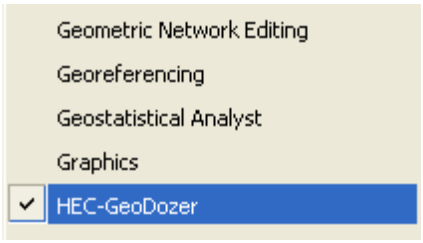
Run the setup by double-clicking on the file or using Add/Remove Programs.



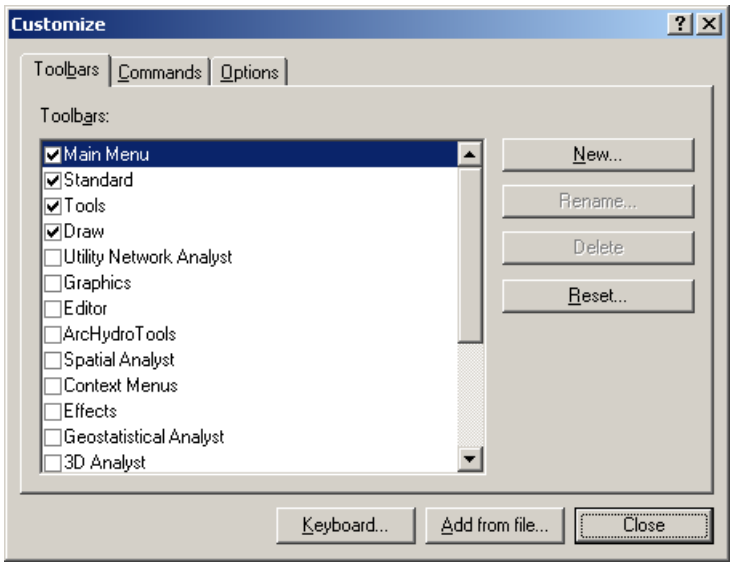
Follow the instructions to complete the setup.

1.3 Open ArcMap and Load the HEC-GeoDozer Toolbar

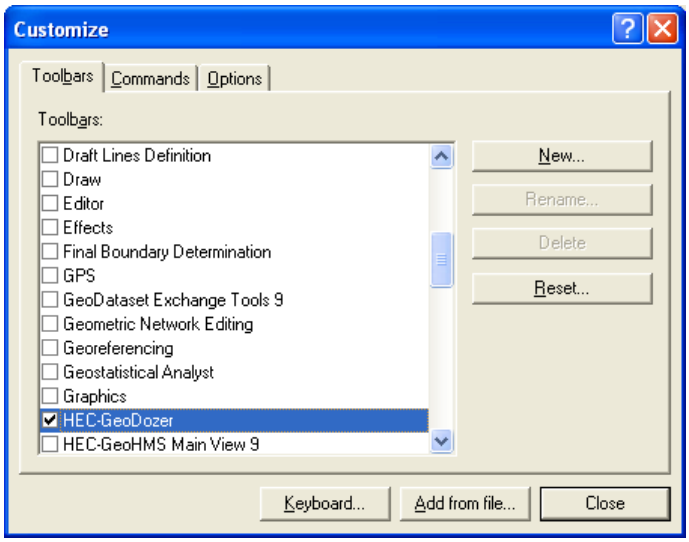
- Open ArcMap. Create a new empty map, and save it as DEMEditing.mxd (or any other name).
- Right click on the menu bar to open the context menu showing available tools.



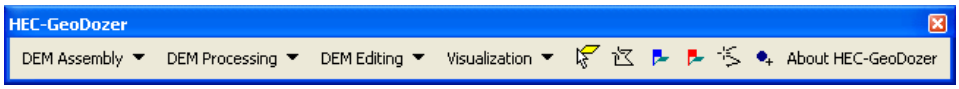
- If the HEC-GeoDozer menu does not appear in the list, click on "Customize".



- In the Customize dialog that appears, click on the "Add from file" button.
- Navigate to Geo_Dozer9.dll (installed by default under C:\Program Files\ESRI\WaterUtils\HEC-GeoDozer\bin), and click on “Open” to select the file.
- A dialog box will appear informing that the tools have been added to ArcMap. Click "OK".
- Check the box next to HEC-GeoDozer to turn it on. Click on "Close". You should now see the HEC-GeoDozer toolbar added to ArcMap.



- The HEC-GeoDozer toolbar is shown below.



Note: It is not necessary to load the Spatial Analyst, Utility Network Analyst, or Editor tools because the tools will automatically use their functionality on an as needed basis. These toolbars need to be loaded though if you want to use any general functionality that they provide (such as general editing functionality or network tracing).

However, the Spatial Analyst Extension needs to be activated, by clicking Tools>Extensions…, and checking the box next to Spatial Analyst.

CHAPTER 2 Data Management

2.1 Data Location

Data can be stored in any raster workspace or geodatabase, and loaded in the map.

Tables created with the HEC-GeoDozer are stored in the Vector target location, which defaults to a personal geodatabase located in the same directory as the map document and named after the mxd. For example, a table generated in the map document DEMEditing.mxd will be stored in a personal geodatabase called DEMEditing.mdb.

Vector data created with the HEC-GeoDozer will be stored by default in a new geodatabase that has the same name as the stored project (unless pointed to an existing geodatabase) and in the same directory where the project has been saved.

Raster data will be stored in a directory having the same name as the data frame in the map, and that is located in the directory where the project is stored.

The location of the vector, raster, and time series data can be explicitly specified using the function ApUtilities>Set Target Locations, that is available in the ApUtilities menu in the Arc Hydro toolbar. If the Arc Hydro tools are not installed, this function can be made available by adding the ApUtilities.dll, whose default location is C:\Program Files\ESRI\WaterUtils\ApFramework9\bin.

2.2 Temporary Grids

Some of the functions allow creating a temporary grid. A temporary grid is created whenever the name of the selected output raster is set to <Temporary>. A temporary grid has the following characteristics:

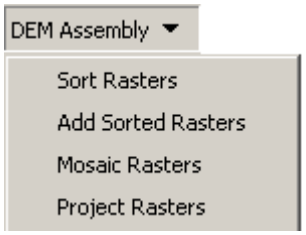
- A temporary grid is stored in the spatial analyst workspace
- A temporary grid becomes permanent when the mxd is saved.
- Edits to temporary grids are lost when the grid is made permanent.

The functions that allow creating temporary grids are:

- Convert Raster Type
- Fill Extent Visualization

CHAPTER 3 DEM Assembly Menu

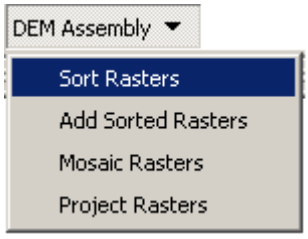
The DEM Assembly menu contains functions that allow assembling rasters sharing the same projection and characteristics.



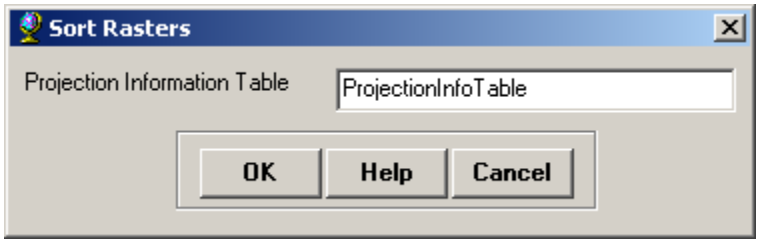
3.1 Sort Rasters

This function generates a Projection Information Table which identifies rasters with the same projection and grid cell size. The rasters must be in the same directory to be sorted.

- Select **DEM Assembly | Sort Rasters**.



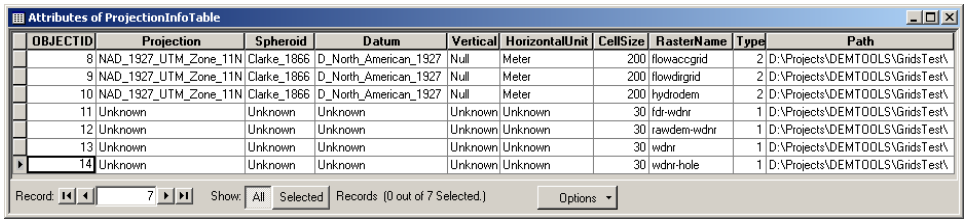
- Enter a name for the Projection Information Table. This table is created in the Vector target workspace, which is by default a personal geodatabase named after the map document and located in the same directory as the map document. For example, if the name of the mxd is DEMEditing.mxd, then the table will be stored in the geodatabase DEMEditing.mdb. The table will be overwritten if it already exists.



The function retrieves the projection information associated with each

raster and attributes the same type to the rasters having exactly the same projection information.

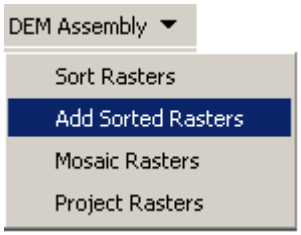
This table is automatically added to ArcMap and can be seen in the Source tab of the ArcMap Table of Contents. The table has the following structure:



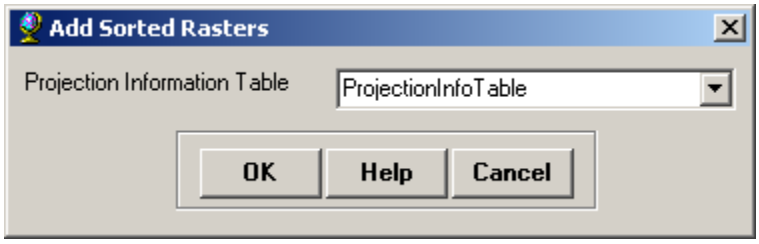
3.2 Add Sorted Rasters

This function adds the rasters sorted by the Sort Rasters function to the Table of Contents, grouping together in a data frame the rasters that have the same type in the input Projection Information table. The data frame receives the name of the type. For example, a raster of Type 1 will be added to the data frame Type1.

- Select **DEM Assembly | Add Sorted Rasters**.

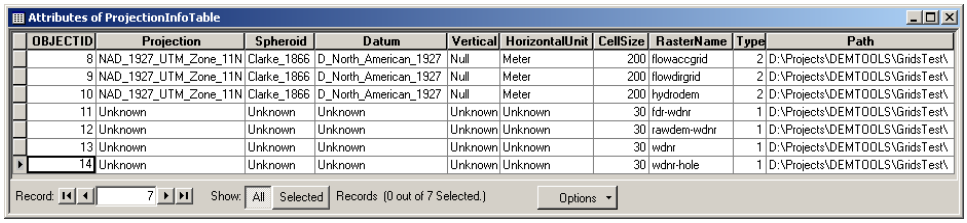


- Select the Projection Information Table in the list of available tables read from the Table of Contents.

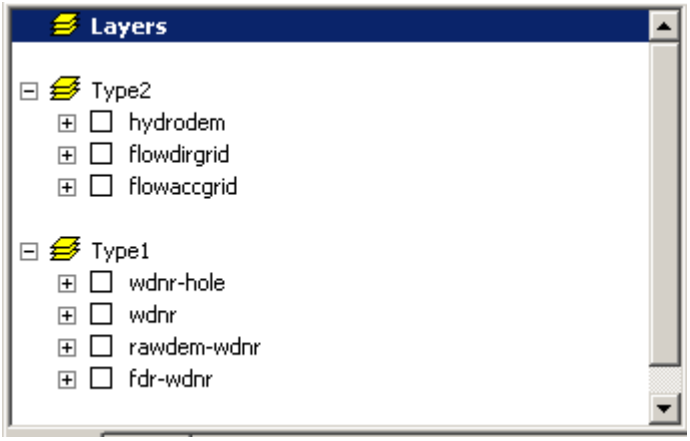


The function checks the content of the selected Projection Information table and creates one data frame in Arc Map for each type defined in the table. It then adds each raster listed in the table to the data frame corresponding to this type. The directory storing the rasters is read from the 'Path' attribute of the ProjectionInfoTable.

For example, selecting the following table:



would generate the following Table of Contents:

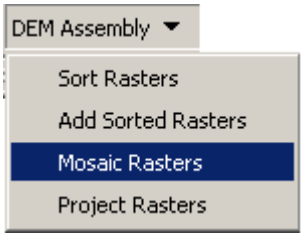


Note: Only the data from the active data frame is displayed in ArcMap. To activate a data frame, right-click that data frame and select Activate.

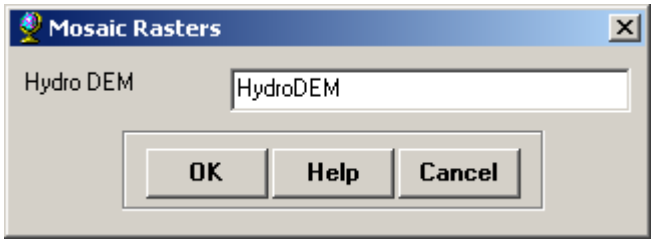
3.3 Mosaic Rasters

This function mosaics together rasters from the active data frame that are selected in the Table of Contents of ArcMap. Mosaic will average the values of the overlapping input cells.

- Select the rasters to mosaic in the Table of Contents of ArcMap (Note: You need to be in the Display tab of the Table of Contents).
- Select **DEM Assembly | Mosaic Rasters**.



- Enter a name for the merged raster. Default name is HydroDEM.

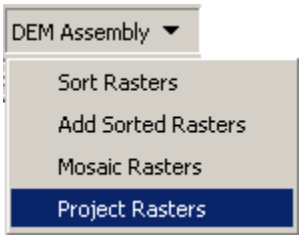


The resulting raster is adding to the active data frame in the ArcMap Table of Contents.

3.4 Project Rasters

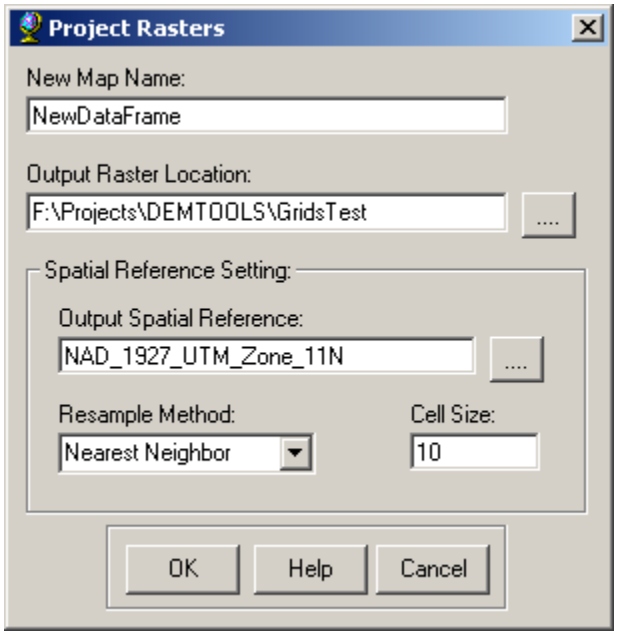
This function allows projecting the rasters selected in the ArcMap Table of Contents into the desired projection system.

- Select the rasters that you want to project in the Table of Contents of ArcMap. The rasters may be in different data frames.
- Select **DEM Assembly | Project Rasters**.



The following window is displayed on the screen:

- Enter a name for the data frame where the projected output layers will be added. Projected rasters have the same name as the original rasters.

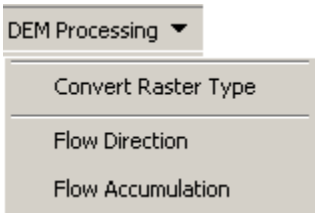


- Select the output raster location: this location defaults to the location of the input rasters.
- Select the output Spatial Reference Settings and click OK.

The function adds the resulting projected rasters in the specified Data Frame in the Table of Contents of Arc Map.

CHAPTER 4 DEM Processing Menu

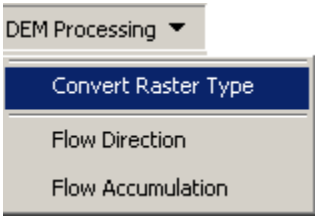
DEM Processing uses a DEM to compute flow direction and flow accumulation grids. Once preprocessed, the DEM and its derivatives can be used for visualizing watersheds, flow paths and streams based on the flow accumulation threshold. The GIS approach to hydrologic analysis requires a terrain model that 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. Tools on the DEM Processing menu can be used to visualize the stream network to determine whether edits are needed to create a hydrologically corrected DEM. This is an iterative process. Once edits are made to the DEM then tools from the DEM Processing menu can be used to visualize the updated stream network.



4.1 Convert Raster Type

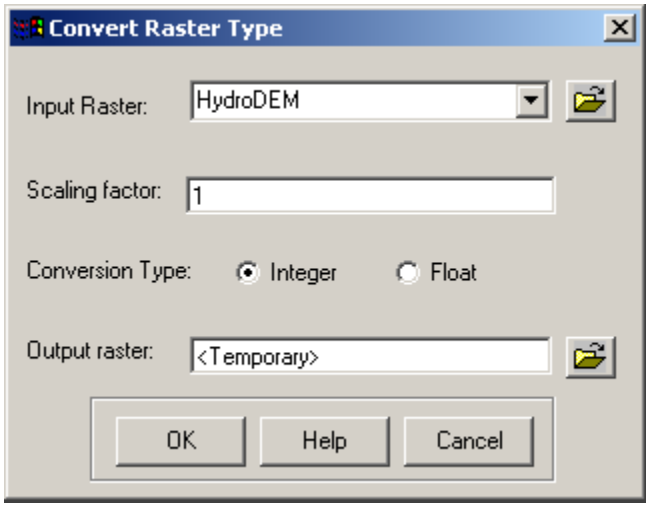
Convert Raster Type is a generic function to convert integer rasters to float and vice versa. A user specified scaling factor is used during the conversion. For example, an input floating-raster in meters can be converted into an integer raster in decimeters by specifying a scaling factor of “10”. When converting from floating-point to integer, the numbers are rounded to the closest integer. If the decimal part of the floating-point value is “.5”, this number is rounded to the greater integer value.

- Select **DEM Processing | Convert Raster Type**



The following window is displayed:

- Select the input raster. The function lists all the rasters from the active data frame in the Table of Contents, and also allows browsing to a raster location.



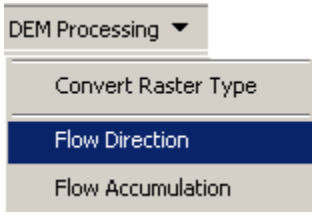
- Enter a scaling factor: this is the number by which the input raster will be multiplied. The resulting raster will then be rounded if needed. Default value is 1.
- Select the output choice (i.e. the type of the output raster). Default is integer.
- Select the name and location of the output raster. Default value is temporary, i.e. a temporary raster named ConversionX is generated, where X is incremented. The function also allows browsing to the desired output location and entering a new raster name.
- Click OK.

The output raster is created and added to the ArcMap table of contents.

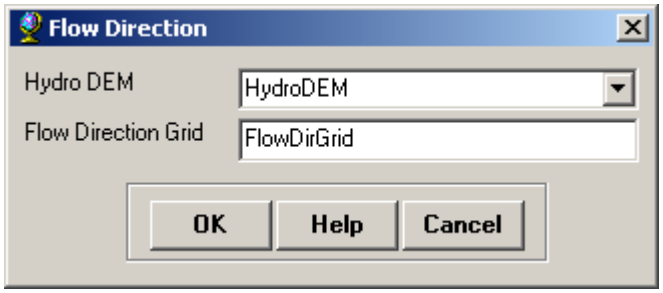
4.2 Flow Direction

This function computes the flow direction for a given grid. The values in the cells of the flow direction grid indicate the direction of the steepest descent from that cell.

- Select **DEM Processing | Flow Direction**.



- Select the hydrologically corrected DEM, Hydro DEM. The output is the Flow Direction Grid, named by default "FlowDirGrid". This default name can be overwritten.

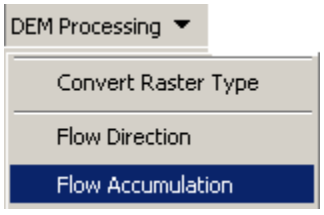


- Press OK. Upon successful completion of the process, the flow direction grid is added to the map.

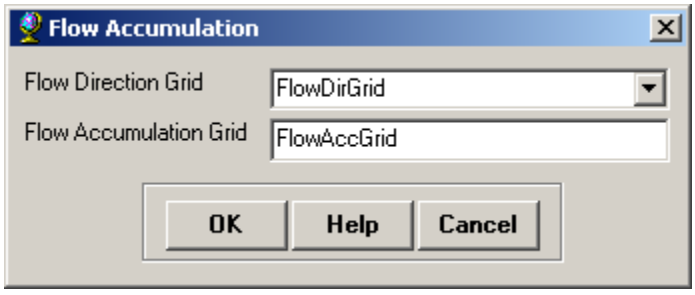
4.3 Flow Accumulation

This function computes the flow accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid.

- Select **DEM Processing | Flow Accumulation**.



- Select the Flow Direction grid. The output is the Flow Accumulation Grid with the default name of "FlowAccGrid" that can be overwritten.



- Press OK. Upon successful completion of the process, the flow accumulation grid is added to the map.

CHAPTER 5 DEM Editing Menu

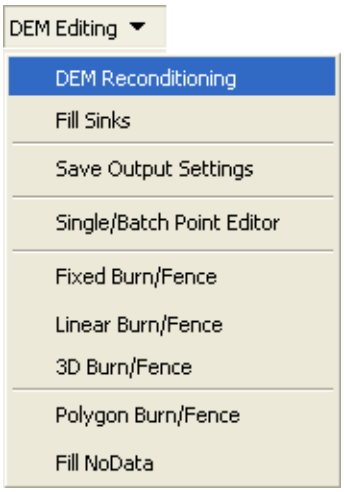
DEM Editing contains a series of functions that allows the user to perform edits on a DEM. These edits are necessary for creating a hydrologically corrected DEM. A hydrologically corrected DEM is one in which all depressions have been filled and water flows across the landscape from cell to cell based on the direction of the greatest elevation gradient.

5.1 DEM Reconditioning

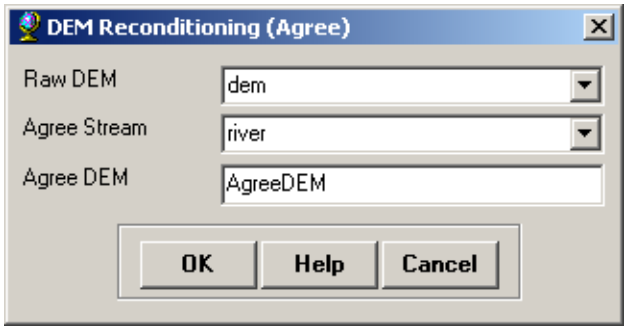
This function modifies a DEM by imposing linear features onto it (burning/fencing). It is an implementation of the AGREE method developed at the University of Texas at Austin in 1997. For a full reference to the procedure refer to the web link http://www.ce.utexas.edu/prof/maidment/GISHYDRO/ferdi/research/agree/agree.html.

The function needs a DEM and a linear feature class (river). Both have to be present in the map document and in the same projection.

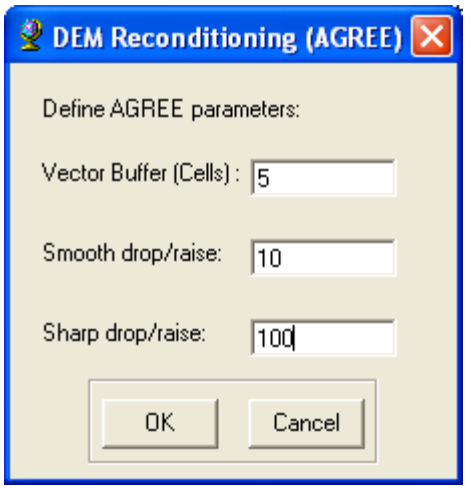
- Select **DEM Editing | DEM Reconditioning**.



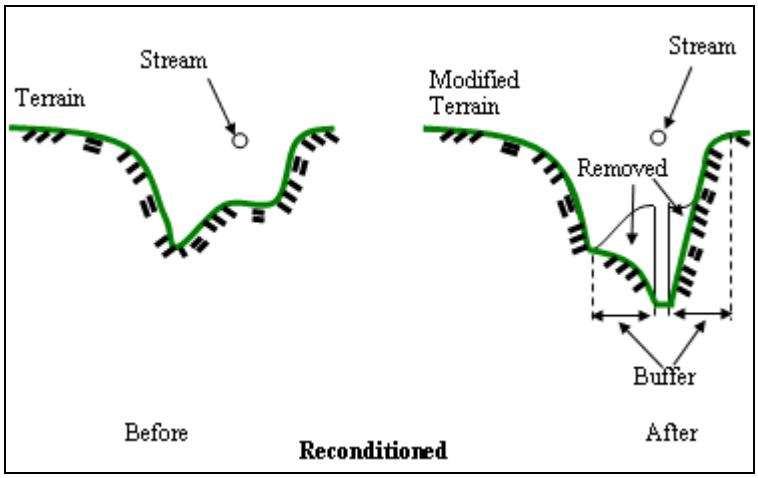
- Select the appropriate Raw DEM and Agree Stream layer. The output DEM is named by default AgreeDEM.



- Set the three reconditioning parameters. The vector buffer is the number of cells around the Agree stream layer for which the smoothing will occur. The smooth drop/raise is the amount (in vertical units) that the river will be dropped if the number is positive or the fence will raised if the number is negative. The sharp drop/raise is the additional amount (in vertical units) that the river will be dropped if the number is positive or the fence will raised if the number is negative. This amount is on top of the smooth drop/raise.



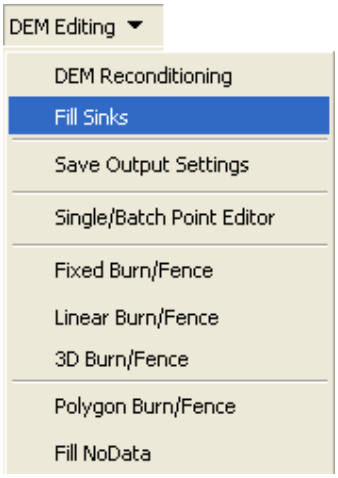
Example of Terrain Reconditioning on Cross Section Profile



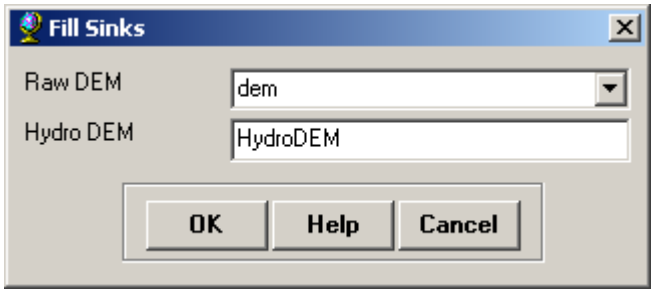
5.2 Fill Sinks

This function fills the sinks in a grid. If a cell is surrounded by cells with higher elevations, the water is trapped in that cell and cannot flow. The Fill Sinks function modifies the elevation value to eliminate these problems.

- Select **DEM Editing | Fill Sinks**.



- Select the Raw DEM (or DEM created using DEM Reconditioning). The output is the Hydro DEM, named by default "HydroDEM". This name can be overwritten.



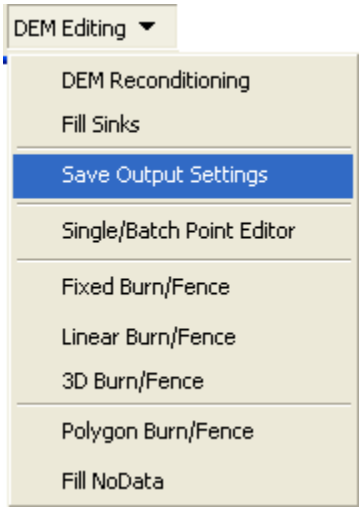
- Press OK. Upon successful completion of the process, the Hydro DEM is added to the map.

5.3 Save Output Settings

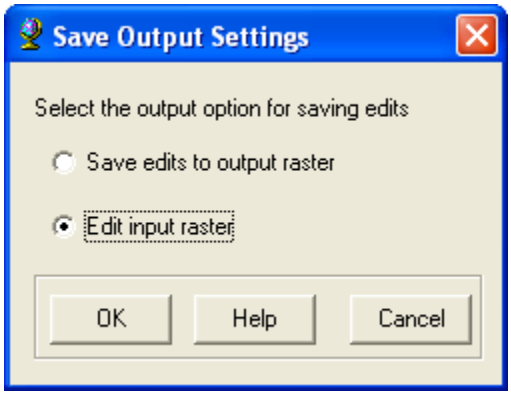
This function allows setting whether some of the tools on the DEM Editing menu will save the edits directly in the input raster or in a new output raster. The functions that use this feature are:

- Single/Batch Point Editor
- Fixed Burn/Fence
- Linear Burn/Fence
- 3D Burn/Fence
- Polygon Burn/Fence

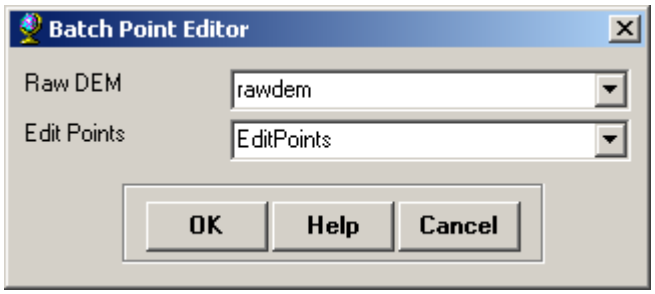
- Select **DEM Editing | Save Output Settings**



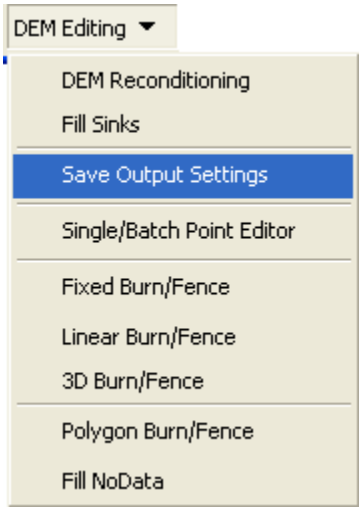
- Select **Edit input raster** and click OK.



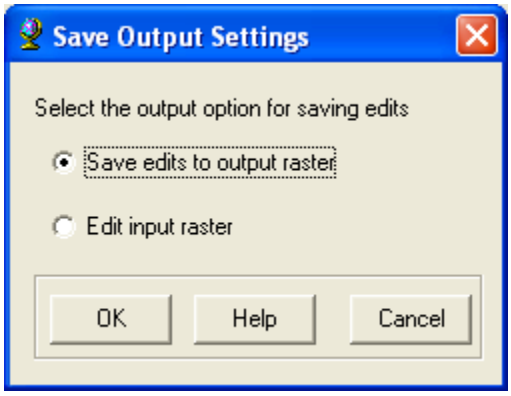
Edits will be applied to the input raster and no new raster will be created. For example, below is the Batch Point Editor. Notice the editor contains no field for specifying the name of the output raster. Edits will be saved into the Raw DEM.



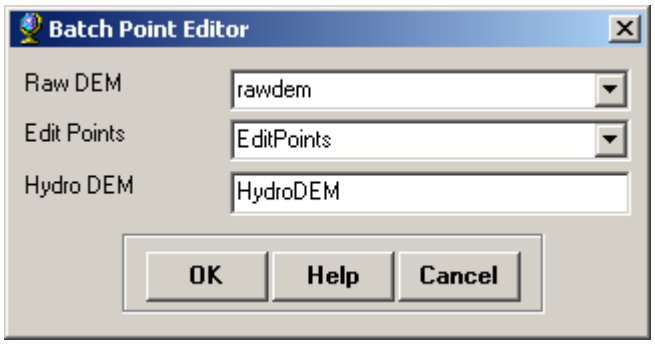
- Select **DEM Editing | Save Output Settings**



- Select **Save edits to output raster** and click OK.



Edits will be saved to a new raster and the input raster will not be edited. For example, below is the Batch Point Editor. Notice the editor contains a field to enter the name of the output raster (Hydro DEM). Edits will be saved to the output raster.

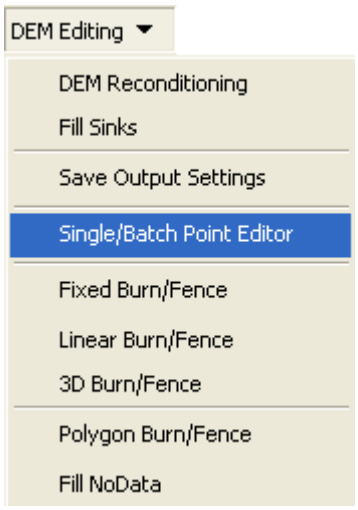


5.4 Single/Batch Point Editor

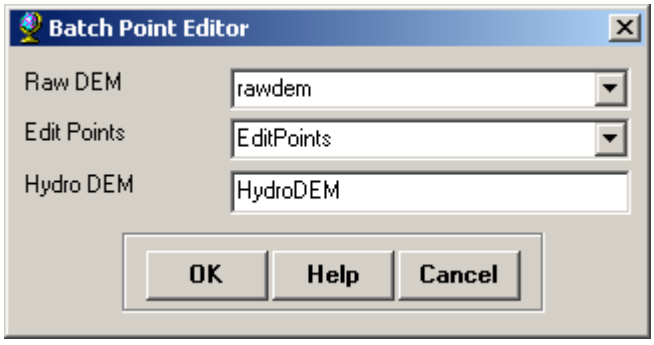
This function edits the cells in the input DEM located under the selected points of the Edit Points input feature class. If no points are selected, the function edits all cells located under a point from the Edit Points feature class. The new elevation is read from the field selected by the user. The edited raster will be the same as the input raster, except at the location of the points. The input point feature class may be either generated using the Add Edit Point tool or added by the user.

Refer to section 7.1 Add Edit Point to create the point feature class using the Add Edit Point tool.

- Select **DEM Editing | Single/Batch Point Editor.**



- Select the Raw DEM to edit.
- Select the Edit Points layer that contains the modified elevation values to apply to the DEM.
- Enter a name for the output DEM (Hydro DEM) if saving results to a new raster.
- Click OK.

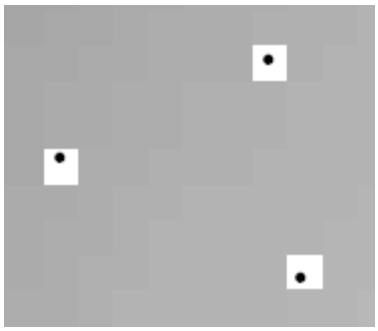


or

The following window is displayed on the screen.

- Select the field containing the new elevation values in the Edit Points layer and click OK.

The function edits the cells located under the selected points of the Edit Points layer. The edited raster is the same as the input raster, except for the cells located under the Edit Points which are updated with the values read from the specified field.

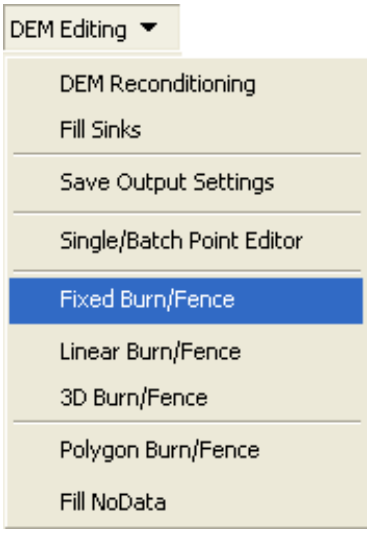


Note: The statistics and the legend associated to the new DEM will not reflect the new values. You will need to add the raster to ArcMap to update the statistics/legend.

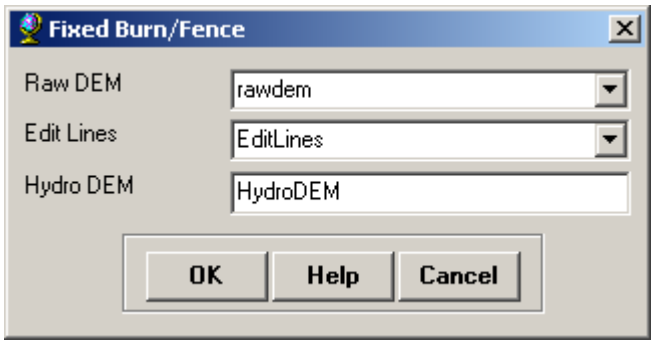
5.5 Fixed Burn/Fence

This function edits the values of the cells located under the selected line features of the input Edit Lines feature class (or all line features if no features are selected). The values used for the edits are read from the elevation field selected by the user. The Edit Lines feature class must be created by the user or it can be an existing line layer.

- Select **DEM Editing | Fixed Burn/Fence**.

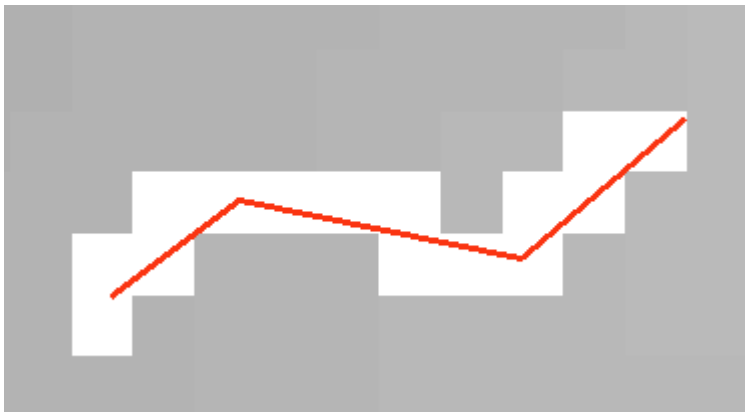


- Select the Raw DEM to edit.
- Select the Edit Lines layer.
- Enter a name for the output DEM (Hydro DEM) if saving results to a new raster.
- Click OK.



- Select the field storing the new elevation value for each line.

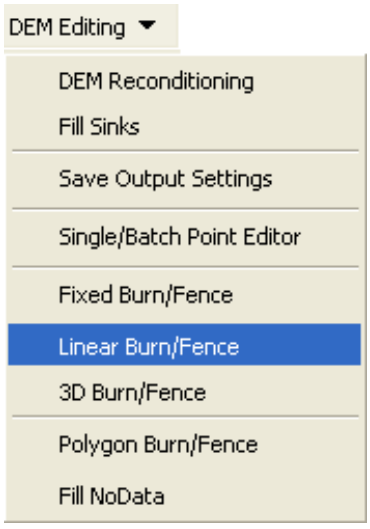
The function edits the cells located under the selected lines of the input Edit Lines feature class. These cells are updated with the values retrieved from the elevation field specified by the user.



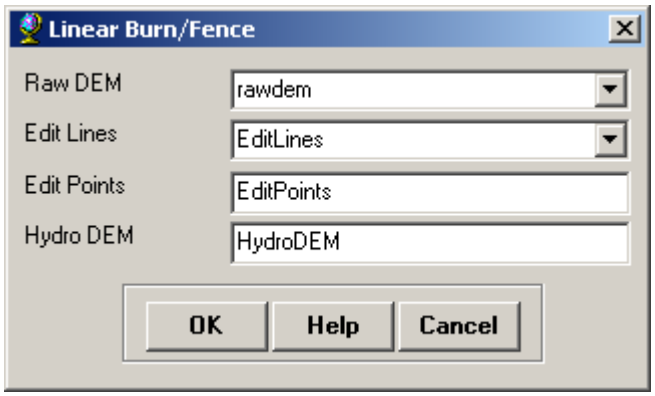
5.6 Linear Burn/Fence

This function edits the cells located at specific intervals under the selected lines (or all the lines if none are selected) of the input Edit Lines feature class. The values used for editing are computed by linearizing the elevation of the two cells located at the start and at the end of the lines.

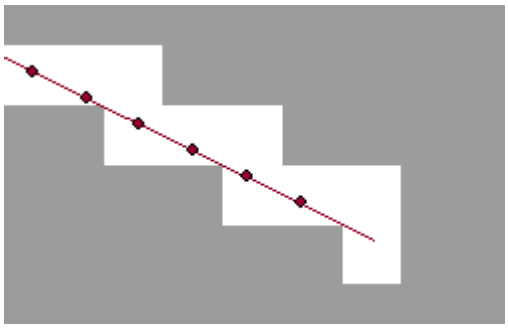
- Select **DEM Editing | Linear Burn/Fence**.



- Select the Raw DEM to edit.
- Select the Edit Lines layer.
- Enter a name for the Edit Points layer that will store the old and linearized elevations.
- Enter a name for the output DEM (Hydro DEM) if saving results to a new raster.
- Click OK.



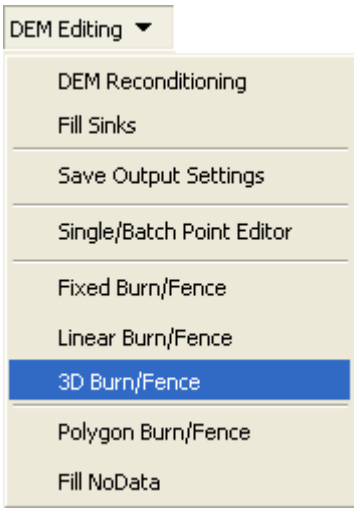
For each selected feature in the Edit Lines layer, the function retrieves the elevation values from the Raw DEM at the start and at the end of that feature. It then starts from the from-node of the line and locates a point at a distance of stepsize/2. Then the function locates additional points along the line at the interval of stepsize. By default, stepsize is equal to the grid cell size * 0.75. The function stores the first point found in each cell (except the first and the last cell) in the Edit Points layer. The function takes the elevations at the end points and linearly interpolates between them and assigns the new elevation values to the points in the Edit Points layer. Finally, the function edits grid cells in the input DEM using elevations from the Edit Points layer.



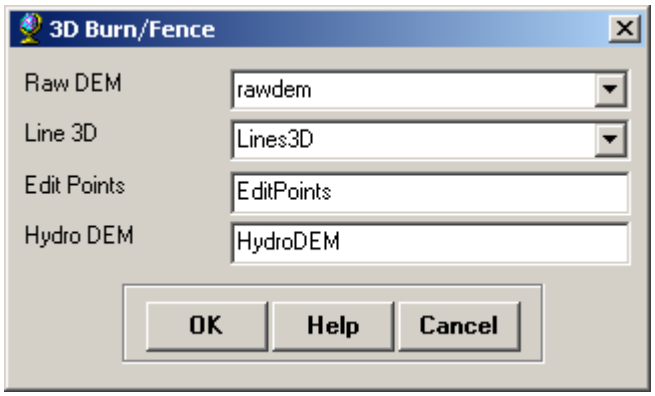
5.7 3D Burn/Fence

This function edits the cells located at specific intervals under the selected 3D lines (or all the lines if none are selected) of the input Line 3D feature class. The values used for editing are computed by linearizing the elevation from the vertices of the lines. The 3D Line feature class may, for example, be generated by HEC-GeoRAS or created in ArcCatalog and populated in ArcMap.

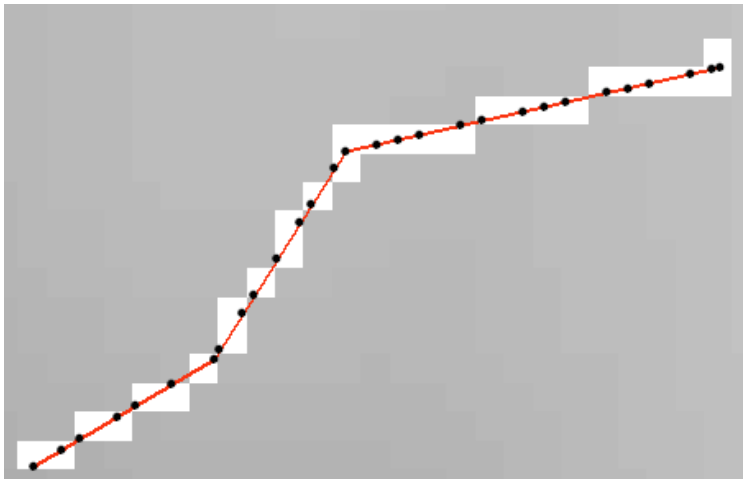
- Select **DEM Editing | 3D Burn/Fence**.



- Select the Raw DEM to edit.
- Select the Line3D feature class.
- Enter a name for the Edit Points layer that will store the location of the vertices, the current DEM elevation (Elevation_Old), and the Z value of the vertex from the 3D line feature class (Elevation_New).
- Enter a name for the output DEM (Hydro DEM) if saving results to a new raster.
- Click OK.



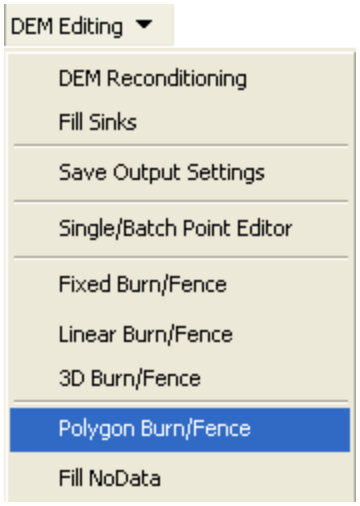
The function edits the cells and adds the output DEM (when relevant) and the Edit Points feature class to the Table of Contents.



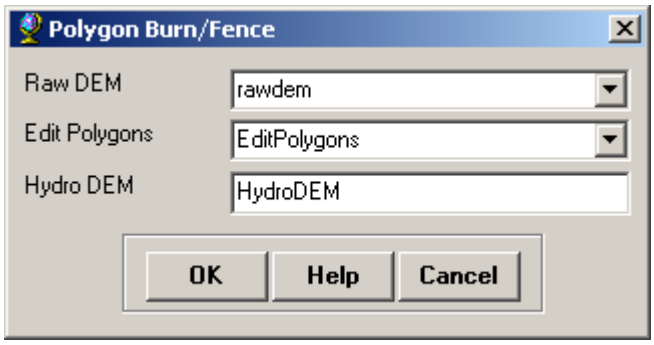
5.8 Polygon Burn/Fence

This function edits the cells located under the selected polygon features (or all polygon features if none are selected) of the input Edit Polygons feature class. All grid cells located below a polygon will be assigned the same elevation value, creating a flat area in the terrain. The elevation values used for editing are read from the elevation field specified by the user. The Edit Polygons feature class needs to exist and be populated with elevation values before the tool can be used.

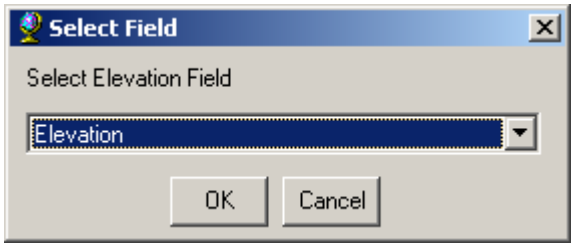
- Select **DEM Editing | Polygon Burn/Fence**.



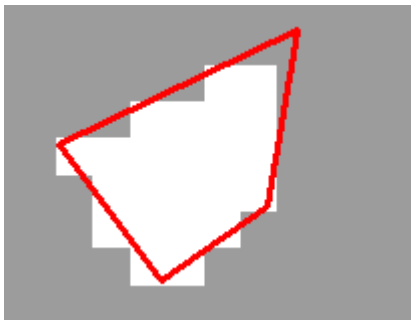
- Select the Raw DEM to edit.
- Select the Edit Polygons feature class containing elevation values to use for editing.
- Enter a name for the output DEM (Hydro DEM) if saving results to a new raster.
- Click OK.



- Select the field in Edit Polygons feature class that contains the elevation values for editing. Click OK.



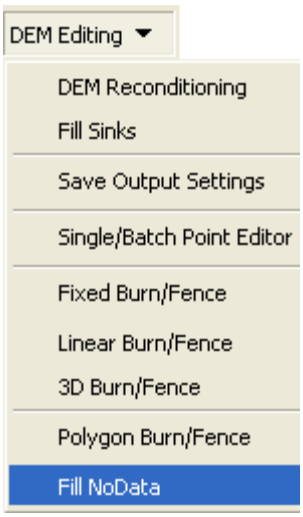
The function locates the cells overlaid by the polygons, updates the grid cell values with the values read from the selected field in the Edit Polygons feature class. The edited DEM (when relevant) is added to the ArcMap Table of Contents.



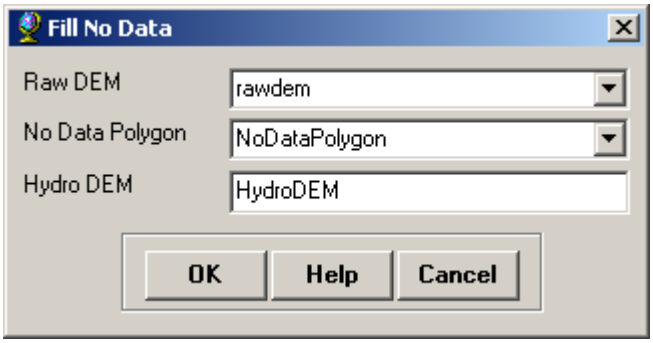
5.9 Fill NoData

This function fills the NoData cells in the input DEM that are located within the selected polygons of the NoData polygon feature class. The NoData polygon feature class may be created with the function Identify NoData (see Section 6.5).

- Select the polygons within the NoData polygon feature class containing NoData cells to fill.
- Select **DEM Editing | Fill NoData**.

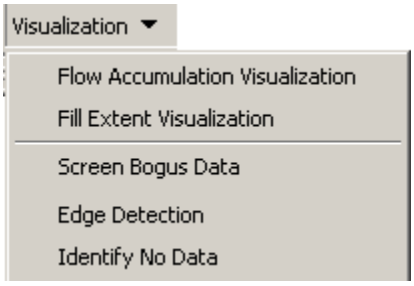


- Select the input DEM and the NoData Polygon feature class defining the area where NoData cells will be filled.
- Enter a name for the output DEM (Hydro DEM) if saving results to a new raster.
- Click OK.



The NoData cells of the input Raw DEM located within NoData Polygons are filled based on the average values of the neighboring grid cells.

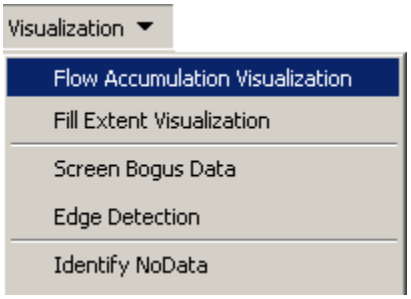
CHAPTER 6 DEM Visualization Menu



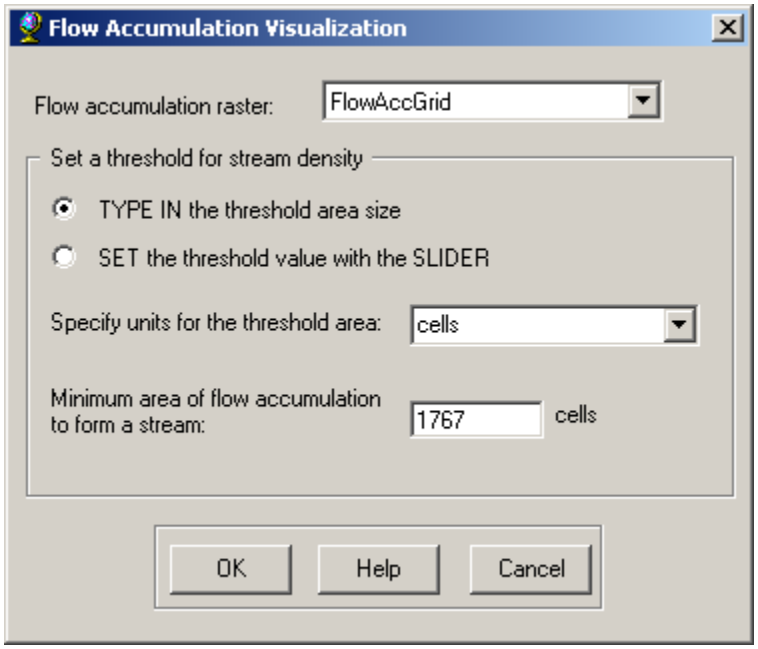
6.1 Flow Accumulation Visualization

This function modifies the legend of the flow accumulation grid based on a given threshold. The threshold may be specified as a number of cells, a percentage of the total flow accumulation, or an area. Default values correspond to 1% of the total area or flow accumulation.

- Select **Visualization | Flow Accumulation Visualization**.

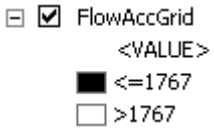


The following window is displayed:



- Select the input Flow Accumulation Grid.
- Select a method to define the threshold.
- Specify the units for the threshold area if relevant. Area units are available only if the raster has a projection file with information on the unit (file prj.adf).
- Enter a value for the threshold.
- Click OK.

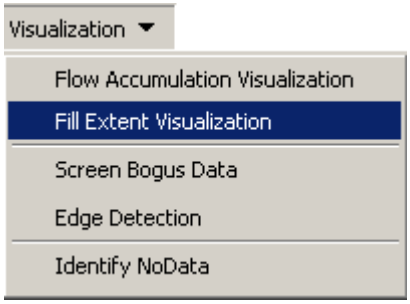
The legend of the input flow accumulation raster in the Table of Contents is modified according to the selected threshold. The threshold represents a flow accumulation value and is rounded to the closest integer value (A number with a decimal part of 0.5 is rounded to the integer that is immediately greater).



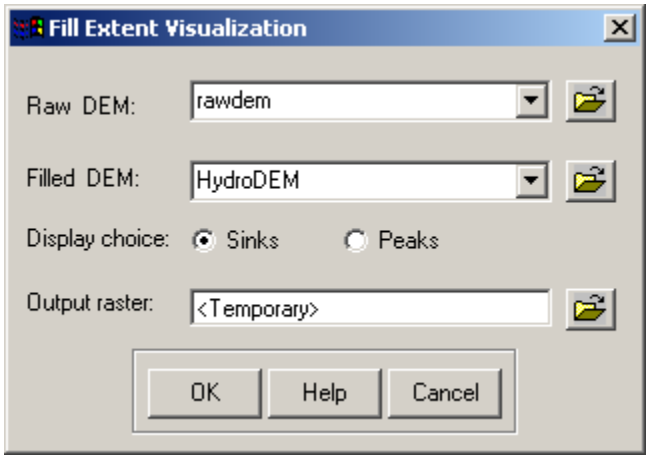
6.2 Fill Extent Visualization

This function generates a raster showing the difference between the Filled DEM and the original Raw DEM. The resulting grid may show either the sinks or the peaks removed. To show the sinks, the function subtracts the Filled DEM from the Raw DEM, and changes all the zeros (i.e. identical values) into NoData cells.

- Select **Visualization | Fill Extent Visualization**.



- Select the original DEM (before using the Fill Sinks function) as the Raw DEM.
- Select the DEM resulting from the Fill Sinks operation as the Filled DEM.
- Select whether to display the sinks or the peaks that were removed from the Fill Sinks operation.
- Select the name of the output raster. If the raster is of type <Temporary>, a temporary raster named either Filled Sinks1 or Cut Peaks1 depending on the selected display will be created.

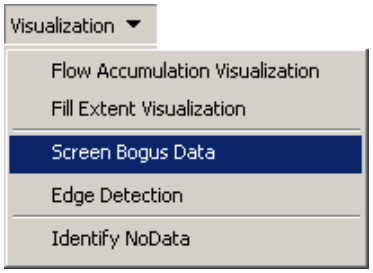


If peaks or sinks are found, the differential raster showing these peaks/sinks is added to the Table of Contents. Otherwise the user is warned that no peaks/sinks were found.

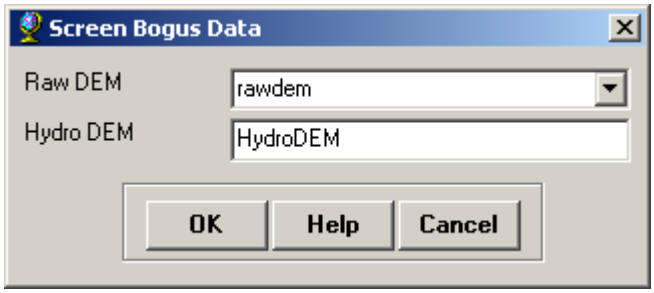
6.3 Screen Bogus Data

This function screens a DEM by removing the cells whose values are not in a specified range. The cells that do not meet the criteria become NoData cells in the output DEM.

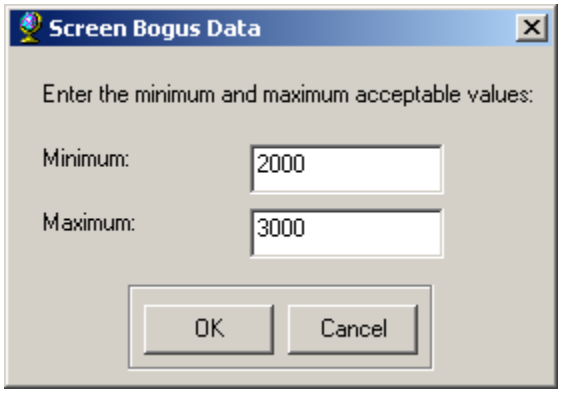
- Select **Visualization | Screen Bogus Data**.



- Select the Raw DEM to screen.
- Enter a name for the output DEM and click OK.



- Enter the minimum and maximum values allowed in the output DEM, and click OK.

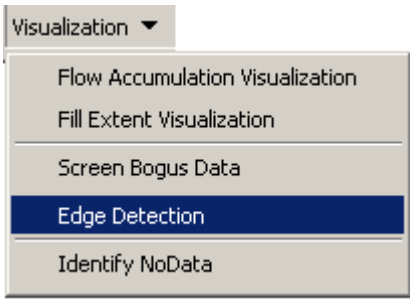


The function generates the output DEM by keeping the cells that meet the criteria, and replacing the others with NoData cell. The output raster is added to the Table of Contents.

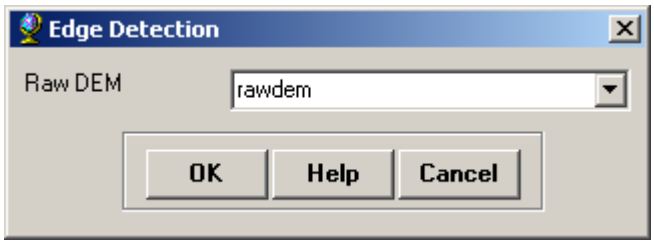
6.4 Edge Detection

This function applies a high-pass filter on the selected DEM to detect the presence of edges.

- Select **Visualization | Edge Detection**.



- Select the raster to analyze.

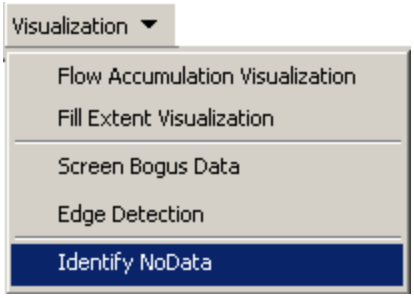


The function generates and adds to the Table of Contents a raster named Edge that allows visualizing whether edges are present in the input raster.

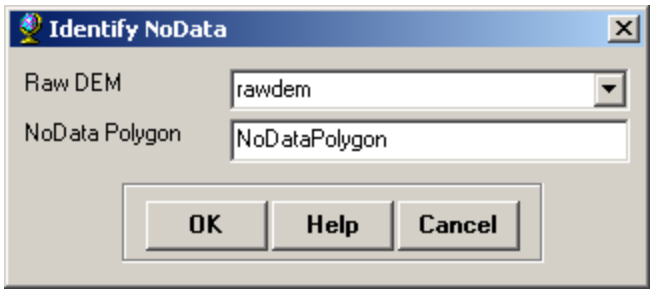
6.5 Identify NoData

This function identifies the NoData cells in a raster.

- Select **Visualization | Identify NoData**.



- Select the input DEM to analyze.
- Enter a name for the output NoData Polygon layer that will define the areas of the input DEM where NoData cells are located.
- Click OK.



The resulting NoData Polygon layer is added to the Table of Contents. It contains two types of polygons defined with the field GRIDCODE:

- 0: NoData cells are outside the polygon.
- 1: the polygon contains only NoData cells.

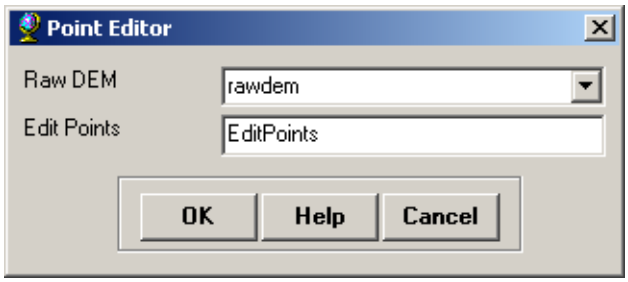
Note: Only polygons having a GRIDCODE = 1 should be selected when using the DEM Editing | Fill NoData tool.

CHAPTER 7 Tools

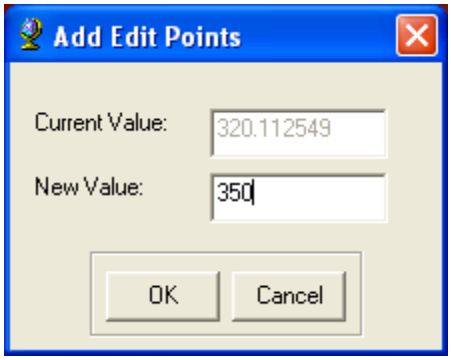
7.1 Add Edit Point

This function creates a point at a user specified location, retrieves the value from the input DEM, and allows the user to enter a new elevation value.

- Click on the icon  in the HEC-GeoDozer toolbar.
- Select the Raw DEM for which you want to enter custom elevation values at specific locations.
- Enter a name for the Edit Points layer that will store the locations as well as the grid cell values read from the raster and those entered by the user.
- Click OK.

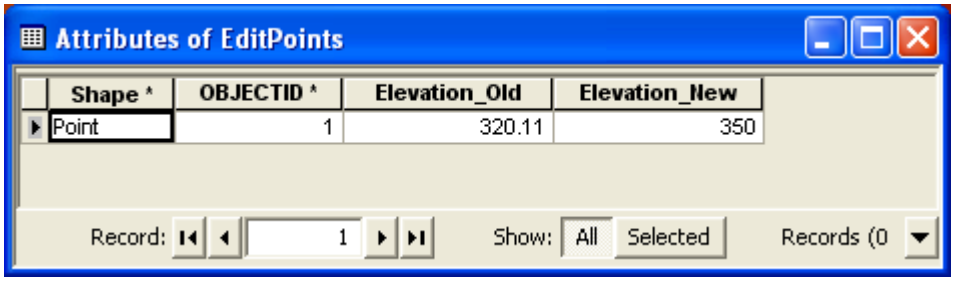


- Click on the map at the location where you want to enter a custom cell value. The following window opens, where "Current Value" is the cell value read from the Raw DEM at the location selected by the user and New Value is the value to be entered by the user.



- Enter the desired custom value and click OK.

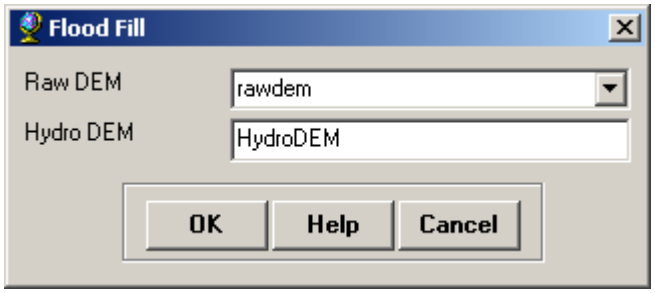
- Open the attribute table of the Edit Points layer. The Elevation_Old field stores the value read from the input raster and the Elevation_New field contains value entered by the user.



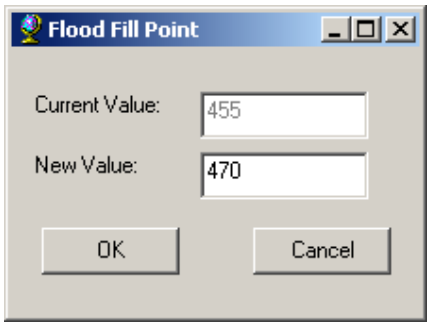
7.2 Flood Fill

This function updates the input DEM at a user specified location. A form provides the current elevation under the user specified location and an input box for the new elevation. All the grid cells adjacent to the cell located under the selected point that have the same original elevation will also be updated with the new elevation.

- Click on the icon  in the HEC-GeoDozer toolbar.
- Select the Raw DEM for which you want to enter custom values at specific locations.
- Enter a name for the output DEM (Hydro DEM) and click OK.



- Click on the map at the desired location. The function places a graphic point on the map at the selected location and displays the following window containing the cell value retrieved from the input Raw DEM.



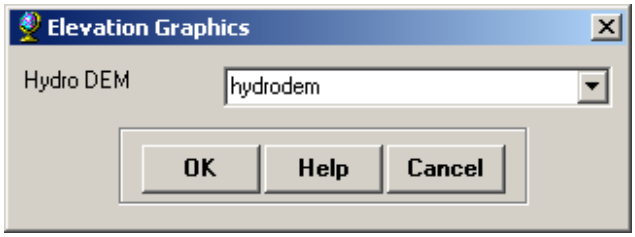
- Enter the desired new grid cell value and click OK.

The function retrieves the value of the selected cell and looks for adjacent cells having the same values. The function then creates a new raster that is identical to the input Raw DEM except for all the adjacent cells, which receive the new value. This new raster is added to the ArcMap Table of Contents.

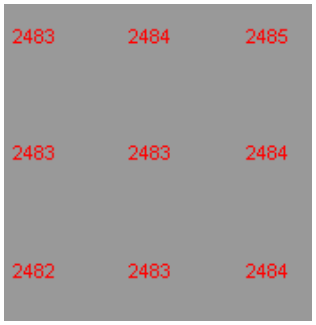
7.3 Elevation Graphics

This function displays the grid cell value for all grid cells in the input DEM that are located within the visible extent of the map.

- Zoom to the extent you are interested in (Note: selecting a big extent increases the processing time).
- Click on the icon  in the HEC-GeoDozer toolbar.
- Select a DEM whose cell values you want to display and click OK.



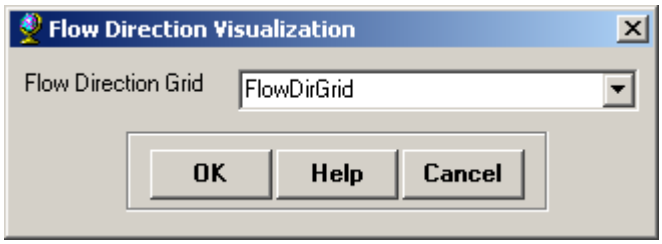
The function displays in red graphics the cell values for all the cells in the visible extent.



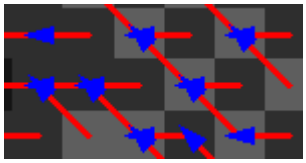
7.4 Flow Direction Visualization

This function displays the flow direction, as an arrow, in every grid cell within the current map extent.

- Zoom to the extent of interest (Note: selecting a big extent increases the processing time).
- Click on the icon  in the HEC-GeoDozer toolbar.
- Select the Flow Direction Grid and click OK.



The function displays the flow directions with an arrow graphic for each grid cell in the visible extent.

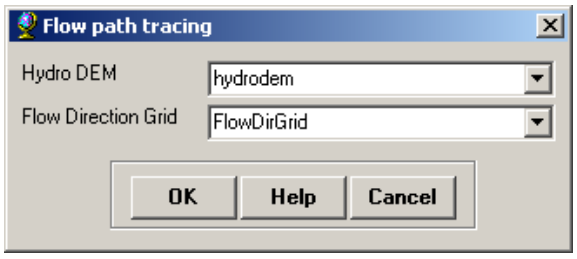


7.5 Flow Path Tracing

This tool displays the flow path based on the original Flow Direction Grid and the flow path based on the modified DEM. This helps visualize modifications to the flow path resulting from the edits to the DEM.

- Click on the icon  in the HEC-GeoDozer toolbar.
- Click on the map at the location from which the trace will start.
- Select the DEM with modified elevations as the Hydro DEM and

the original Flow Direction Grid.
- Click OK.

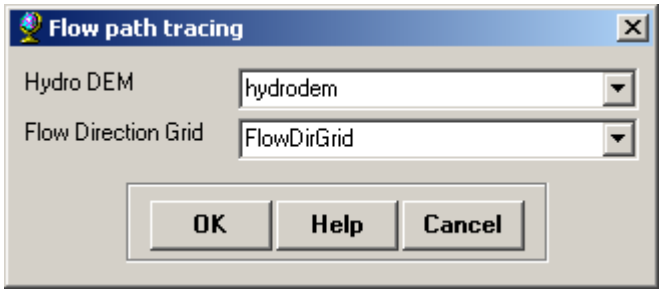


The function displays the original flow path in red and the modified flow path in blue.

7.6 Watershed Delineation

This tool displays the watersheds in the current map extent based on the original flow direction grid and on the modified DEM. Two polygon graphics will be generated in different color to show the watersheds.

- Zoom in to the desired map extent.
- Click on the icon  in the HEC-GeoDozer toolbar.
- Click on the map at the location where the delineation should be performed.
- Select the DEM with modified elevations as the Hydro DEM and the original Flow Direction Grid.
- Click OK.

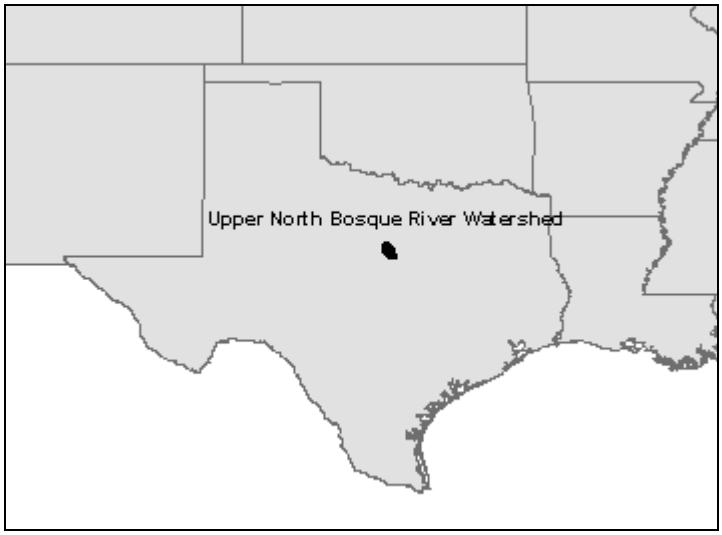


The function delineates two watersheds at the specified location based on each of the two inputs: the watershed corresponding to the original flow direction grid is displayed in red, and the watershed corresponding to the modified DEM is displayed in blue.

CHAPTER 8 Example Application

This chapter provides an example application for using HEC-GeoDozer to prepare a terrain dataset for HEC-GeoHMS. Not all the tools available from the HEC-GeoDozer toolbar will be used in the example; however, demonstration of the most useful tools is included. The example dataset covers the Upper North Bosque River Watershed (UNBRW), located in central Texas. DEMs, 10-meter resolution, were downloaded from the USGS National Map Seamless Server, http://seamless.usgs.gov/index.php. The National Hydrograph Dataset (NHD), available from the USGS, was used to verify the stream network generated by the DEM. The National Hydrograph Dataset is available from http://nhd.usgs.gov/data.html.

The sample data for this exercise includes two DEMs ("usgs0911547" and “usgs12702080”) and a shapefile of the USGS published stream network ("NorthBosqueRiverReaches"). The sample data can be downloaded from the HEC-GeoDozer webpage, http://www.hec.usace.army.mil/software/hec-geodozer. The completed project is also available from the HEC-GeoDozer webpage.

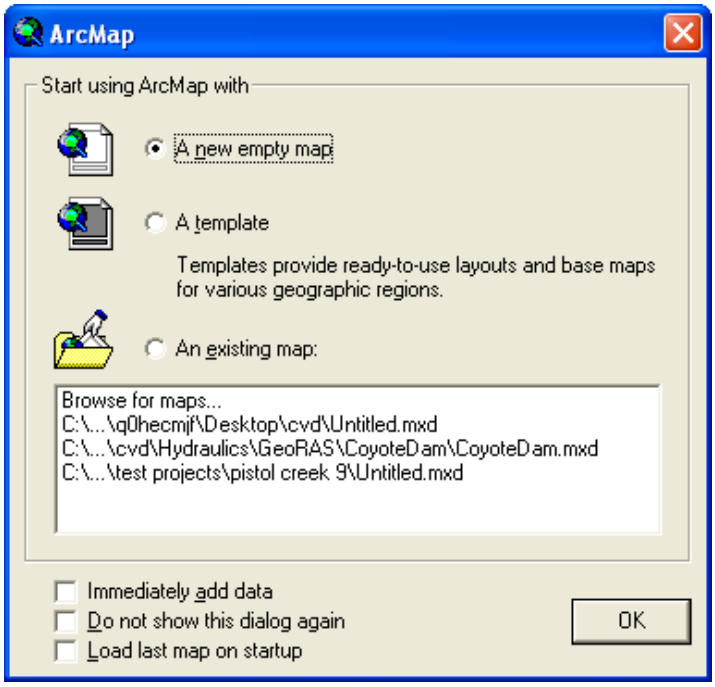


Steps for processing the raw DEM data include 1) mosaic multiple DEM tiles to create one continuous DEM of the entire project area, 2) project the DEM, 3) remove NoData cells in the DEM, 4) determine the stream network from the DEM, 6) compare GIS derived stream network with published information, and if necessary 7) edit the DEM to force the correct stream network.

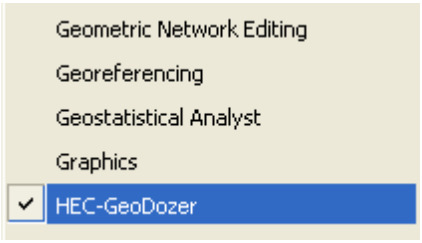
8.1 Start ArcMap and Load DEMs

The following steps show how to prepare an ArcMap document for HEC-GeoDozer.

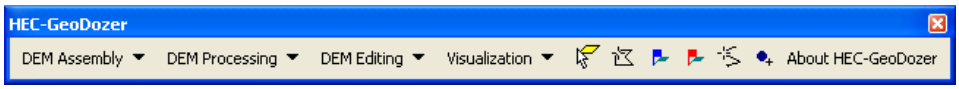
- Open a new empty ArcMap document.



- Right click on the menu bar to open the context menu showing available tools. Turn on HEC-GeoDozer.

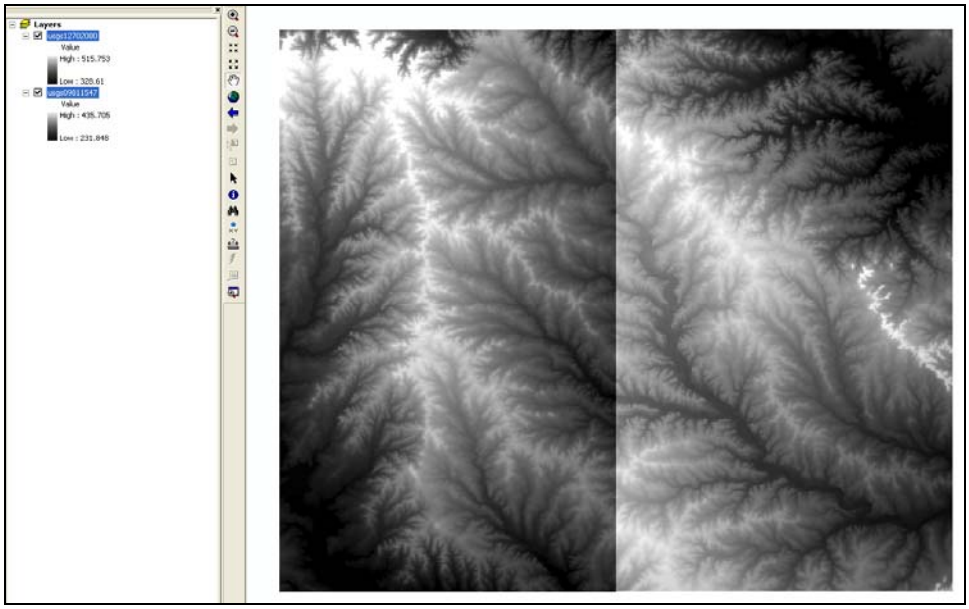


- You should now see the HEC-GeoDozer toolbar added to ArcMap.



Note: It is not necessary to load the Spatial Analyst, Utility Network Analyst, or Editor tools because the HEC-GeoDozer tools will automatically use their functionality on an as needed basis. However, the Spatial Analyst Extension needs to be activated, click Tools>Extensions… and check the box next to Spatial Analyst.

- Add the DEM data to ArcMap. Press the **Add Data** button and navigate to the "…\GeoDozerExample\USGS Terrain Data" folder. Add both raster layers, usgs09811547 and usgs12702080.

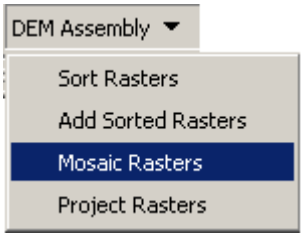


- Save the project to a new empty directory on the local computer. No other ArcMap document should be in this directory. For this example, the project was named "UpperNorthBosqueRiver" and saved to the "…\GeoDozerExample" directory. The location of the project is important because subsequently derived datasets are stored in directories relative to the ArcMap project.

8.2 Mosaic DEMs

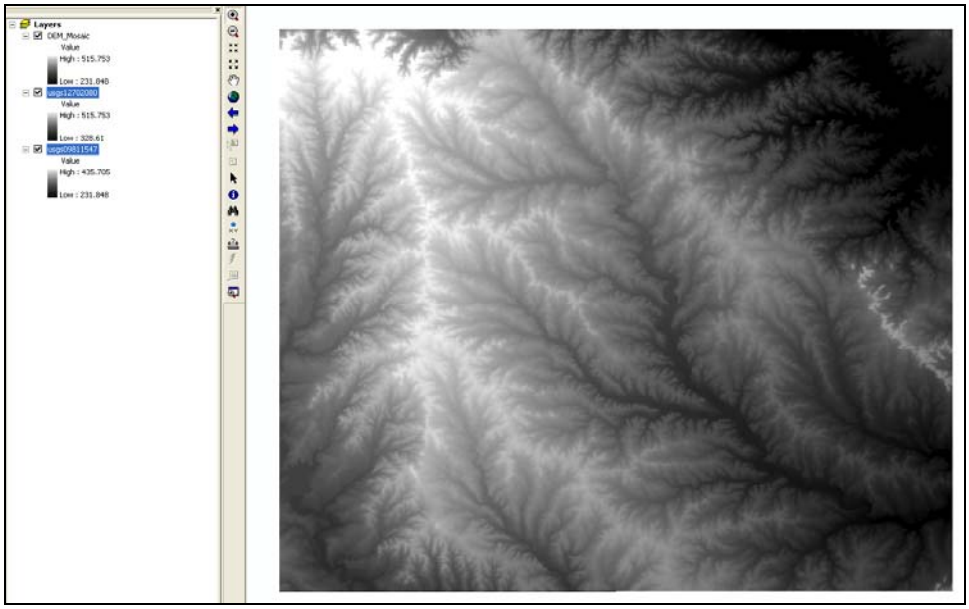
The drainage area for the Upper North Bosque River Watershed is approximately 360 square miles (at the Hico USGS stream gage). The DEM data downloaded from the USGS was divided into two tiles. The mosaic tool was used to merge these two DEMs into one DEM.

- Select the rasters to mosaic in the Table of Contents (Note: You need to be in the Display tab of the Table of Contents).
- Select **DEM Assembly | Mosaic Rasters**.



- Enter a name of “DEM_Mosaic” for the output raster.

The result is one DEM of the entire project area.

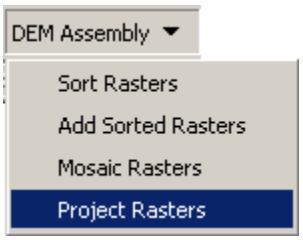


8.3 Project the DEM

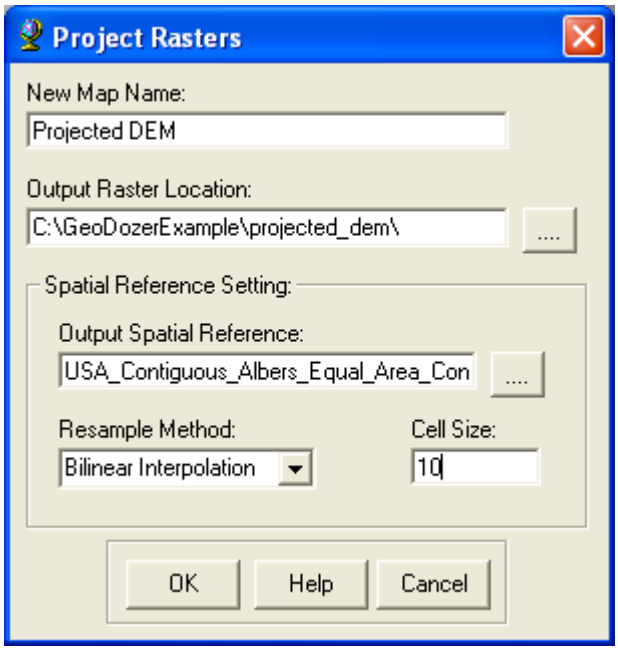
DEMs downloaded from the USGS will be in geographic coordinates. In order to use HEC-GeoHMS, the DEM must be projected. HEC-GeoHMS can work with data projected in Albers-Equal Area, Universal Transverse Mercator (UTM), Transverse Mercator, Lambert, and State Plane coordinate systems. For this example the DEM will be projected into the Albers-Equal Area projection, shown below.

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

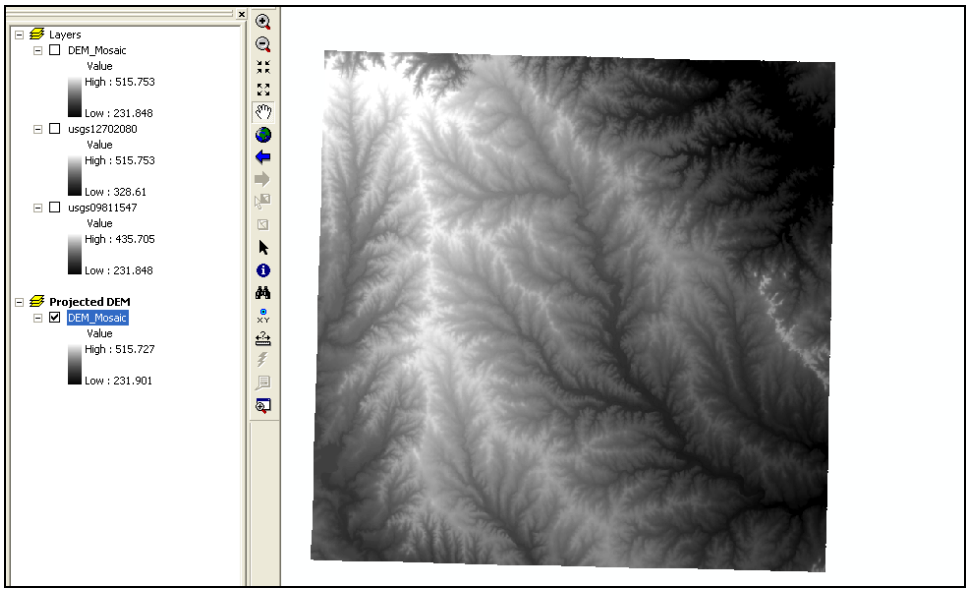
- Select the “DEM_Mosaic” raster in the Table of Contents.
- Select **DEM Assembly | Project Rasters**.



- Enter a name of "Projected DEM" for the data frame where the projected DEM will be added.
- Select the output raster location, this location defaults to the location of the input rasters. Enter an output location of "…\GeoDozerExample\projected_dem\".
- Choose the **USA_Contiguous_Albers_Equal_Area_Conic_USGS** coordinate system for the **Output Spatial Reference**. This coordinate system is located in the **Projected Coordinate Systems** | **Continental** | **North America** folder.
- Choose the Bilinear Interpolation resampling method.
- Enter an output cell size of 10 (meters) and click OK.



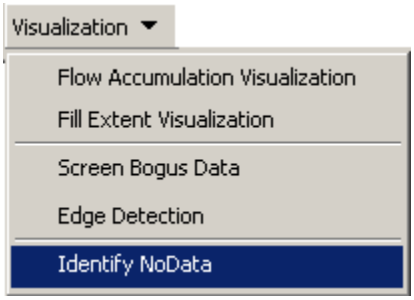
The tool adds the resulting projected DEM to the "Projected DEM" data frame.



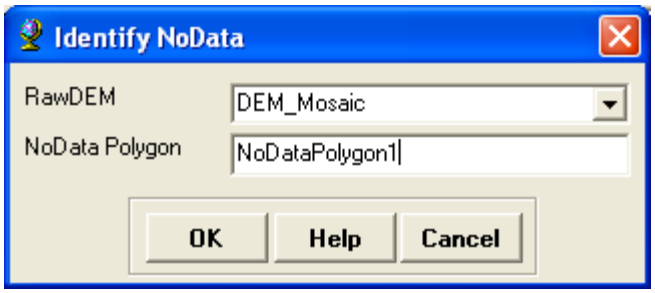
8.4 Remove NoData Cells

Sometimes DEMs will contain grid cells with NoData. These represent areas with no elevation data. HEC-GeoHMS will not be able to correctly determine the drainage network when NoData cells are present in the DEM. HEC-GeoDozer contains tools that identify NoData cells and then removes them using an average value from surrounding grid cells.

- Activate the **Projected DEM** data frame.
- Select **Visualization | Identify NoData**.



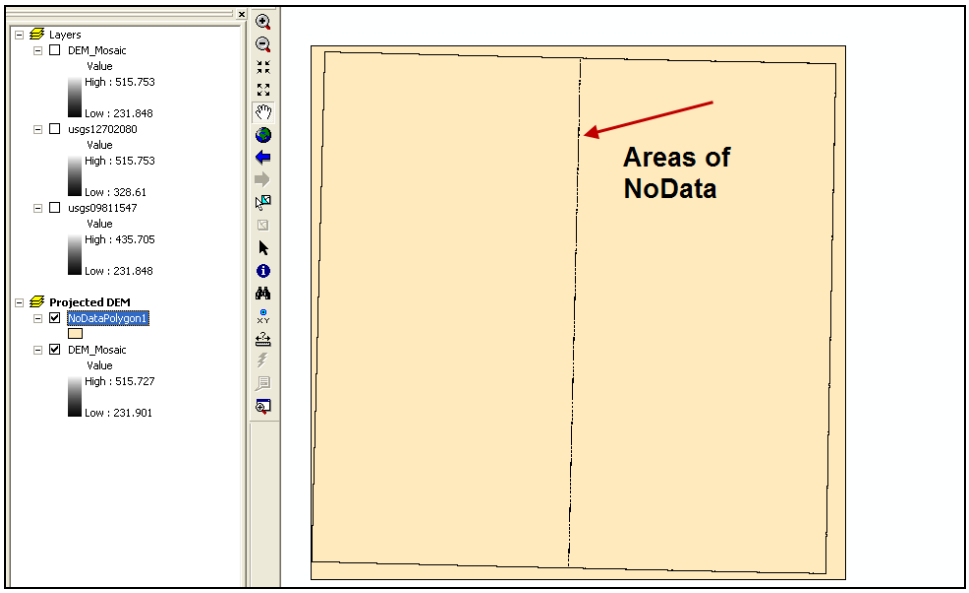
- Select the input DEM to analyze, "DEM_Mosaic".
- Enter a name for the output NoData Polygon layer, "NoDataPolygon1". This layer will define areas in the input DEM where NoData cells are located.
- Click OK.



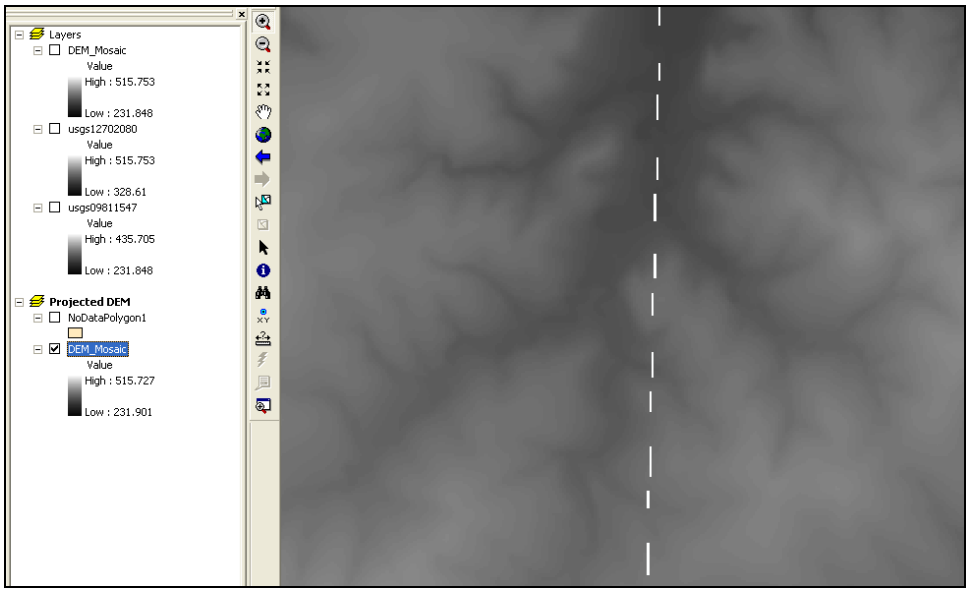
The resulting NoData Polygon layer is added to the Table of Contents. It contains two types of polygons defined with the field GRIDCODE:

- 0: NoData cells are outside the polygon.
- 1: the polygon contains only NoData cells.

The following figure shows the NoData polygon layer that is created. Notice the areas of NoData happen to fall along the boundaries of the adjacent DEMs.

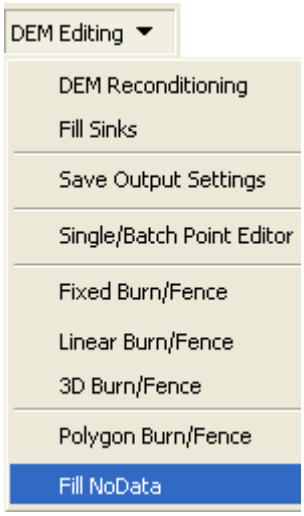


The following figure shows a few of the NoData grid cells.

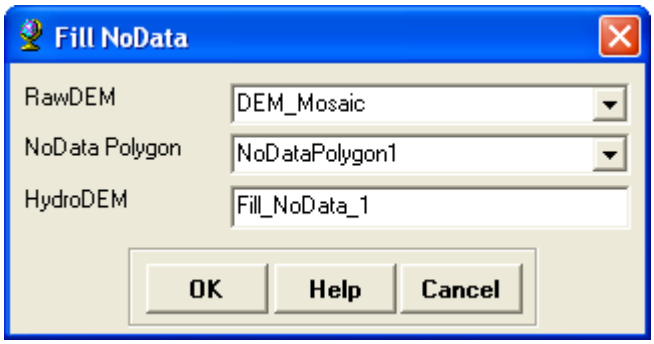


The NoData grid cells should be filled using the average elevation from neighboring grid cells.

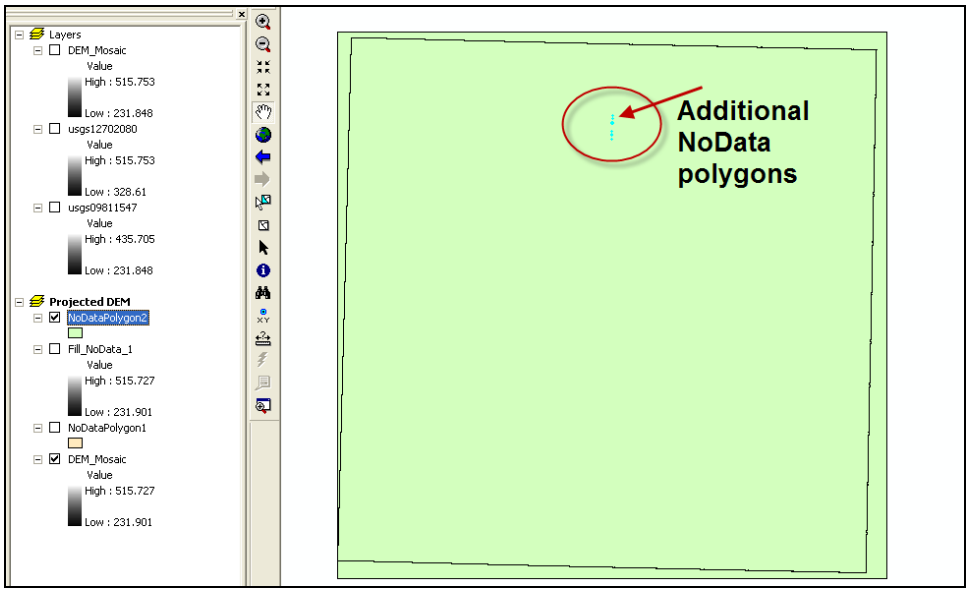
- Select the polygons within the NoData polygon layer. Only polygons with a GRIDCODE = 1 should be selected. For this example, all polygons with a GRIDCODE = 1 and an area less than 4500 square meters were selected.
- Select **DEM Editing | Fill NoData**.



- Select the input DEM, “DEM_Mosaic”, and the NoData Polygon layer, “NoDataPolygon1”.
- Enter a name for the output DEM, “Fill_NoData_1”.
- Click OK.



The **Identify NoData** tool should be run again to verify that all NoData cells have been filled. Six additional areas of NoData were identified in the example dataset. The **Fill NoData** tool was used a second time to fill in these grid cells. The input DEM was "Fill_NoData_1" and the input NoData polygon layer was "NoDataPolygon2". The output DEM was named "Fill_NoData_2". A third use of the **Identify NoData** tool showed no more NoData cells within the DEM.



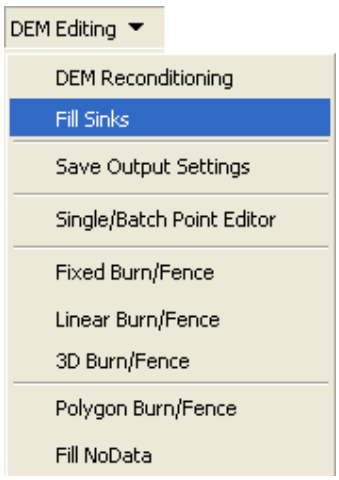
8.5 Determine the Stream Network

A new data frame named “Stream Network” was added to the ArcMap project and the final DEM from Section 8.4, “Fill_NoData_2”, was added to the Table of Contents.

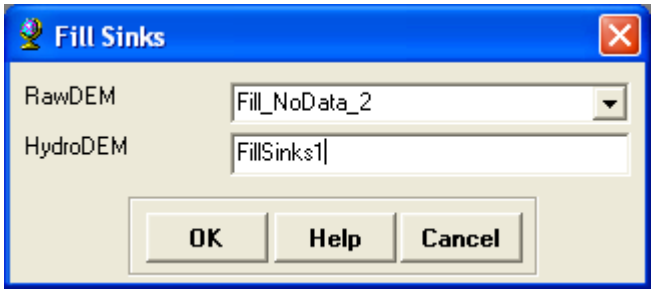
Tools from the **DEM Editing** and **DEM Processing** menus can be used to compute the stream network given a DEM. These include the **Fill Sinks**, **Flow Direction**, and **Flow Accumulation** tools. The GIS approach to hydrologic analysis requires a terrain model that is hydrologically corrected. 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. 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. 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 **Fill Sinks** tool will fill all sinks so that water flows across the DEM.

- Select **DEM Editing | Fill Sinks**.



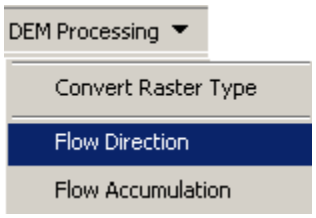
- Select the Raw DEM, “Fill_NoData_2”. Name the output DEM "FillSinks1".



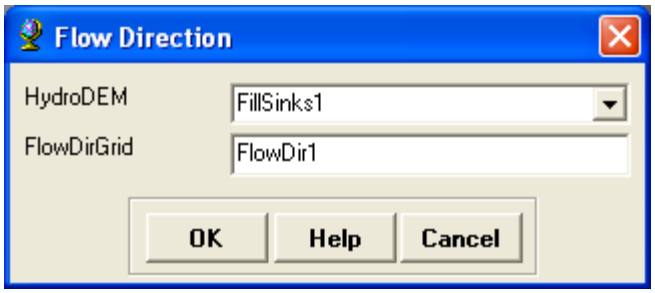
- Upon successful completion of the process, the filled DEM is added to the map.

The **Flow Direction** tool computes the flow direction for each grid cell in the input DEM. The values in the cells indicate the direction of the steepest descent from that cell.

- Select **DEM Processing | Flow Direction**.



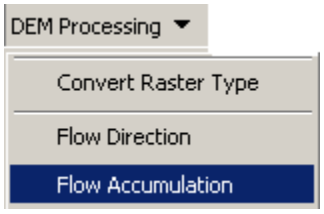
- Select the hydrologically corrected DEM, “FillSinks1”. The output flow direction grid was named “FlowDir1”.



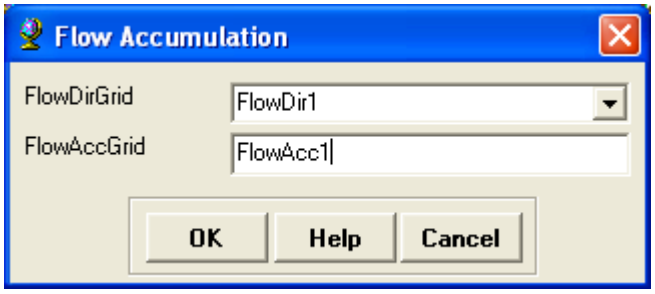
- Upon successful completion of the process, the flow direction grid is added to the map.

The **Flow Accumulation** tool creates a grid that contains the accumulated number of upstream cells draining into a given grid cell. Upstream drainage area at a given cell can be calculated by multiplying the flow accumulation value by the grid cell area. The flow accumulation grid shows the stream network.

- Select **DEM Processing | Flow Accumulation**.



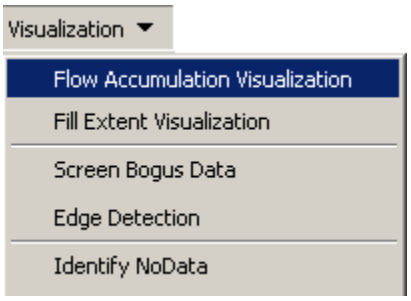
- Select the Flow Direction grid, “FlowDir1”. The output flow accumulation grid was named "FlowAcc1".



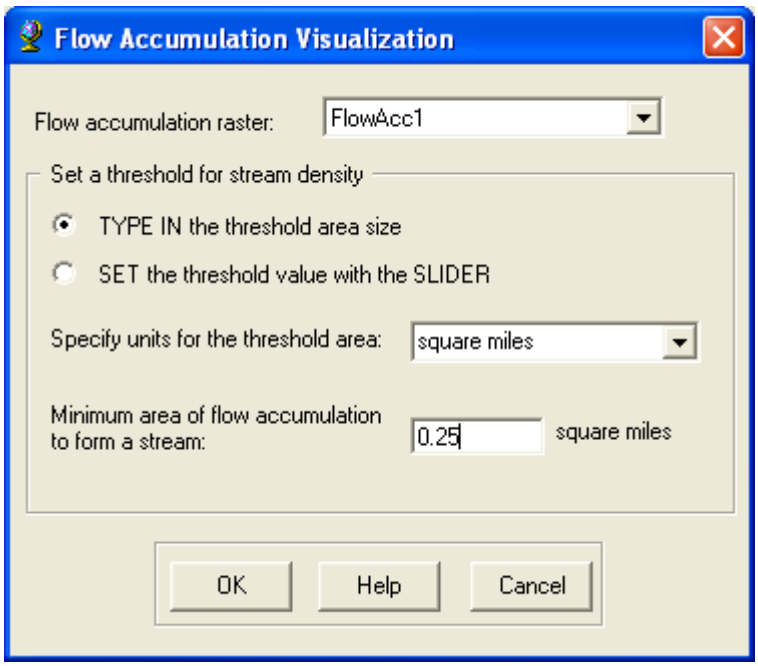
- Upon successful completion of the process, the flow accumulation grid is added to the map.

The **Flow Accumulation Visualization** tool can be used to better visualize the stream network as shown by the Flow Accumulation grid. This tool modifies the legend of the flow accumulation grid based on a given threshold. The threshold may be specified as a number of cells, a percentage of the total flow accumulation, or an area.

- Select **Visualization | Flow Accumulation Visualization**.

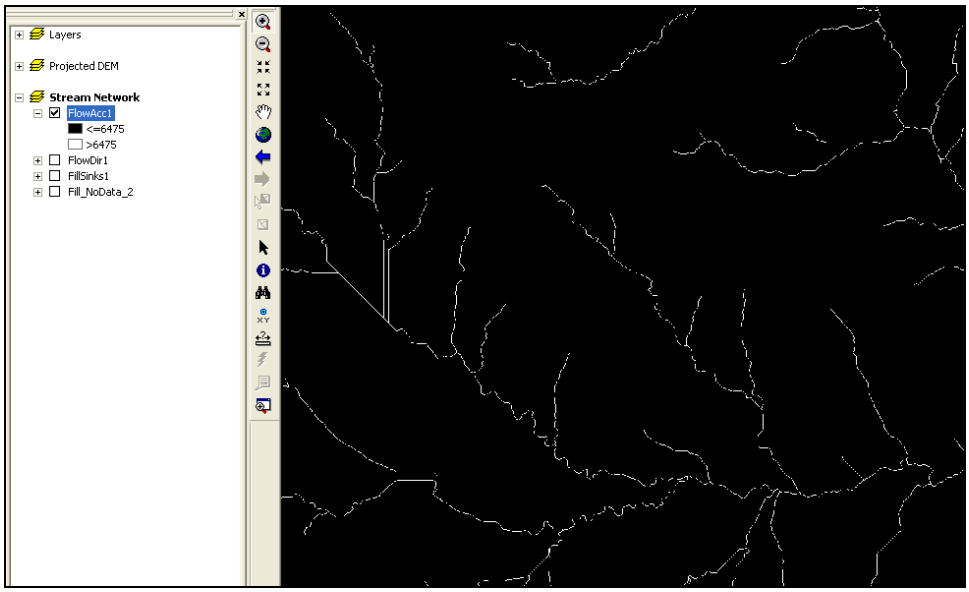


The following window is displayed:



- Select the Flow Accumulation Grid, "FlowAcc1".
- Specify square miles as the units for the threshold area.
- Enter a minimum area of 0.25 square miles.
- Click OK.

The legend of the input flow accumulation raster in the Table of Contents is modified so that all grid cells with a flow accumulation value greater than 0.25 miles (6475 grid cells) is displayed using a white shading; all grid cells below this threshold are shaded in black. Zoom into any area of the flow accumulation grid to see the detailed stream network.



8.6 Compare GIS Derived Stream Network with Published Data

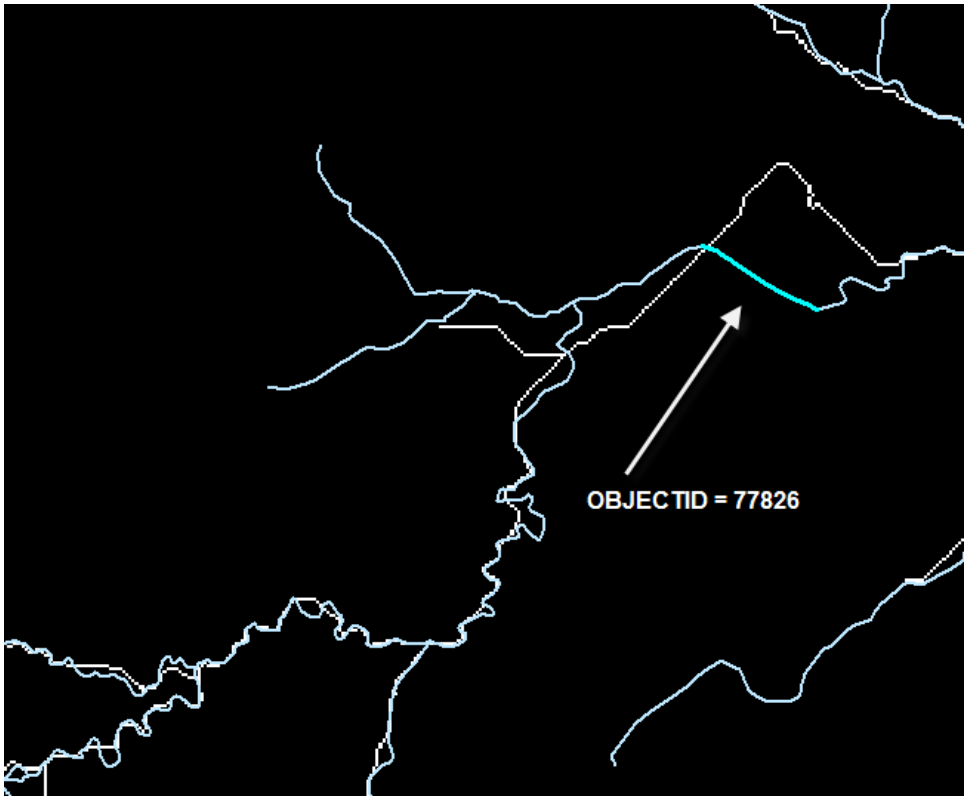
Add the NorthBosqueRiverReaches.shp shapefile to the Stream Network data frame (located in the "…GeoDozerExample\NHD Layers" folder). This shapefile was extracted from the National Hydrography Dataset and shows the stream network from USGS Topographic Maps. Make sure the NorthBosqueRiverReaches layer is displayed on top of the flow accumulation grid. Zoom into a few areas and compare the flow accumulation grid to the NorthBosqueRiverReaches layer. Overall, you should see good agreement between the two.

Find and select the reach segment in the NorthBosqueRiverReaches layer that has an OBJECTID of 77826 (open the attribute table and find this record). Zoom to the selected segment in the map.

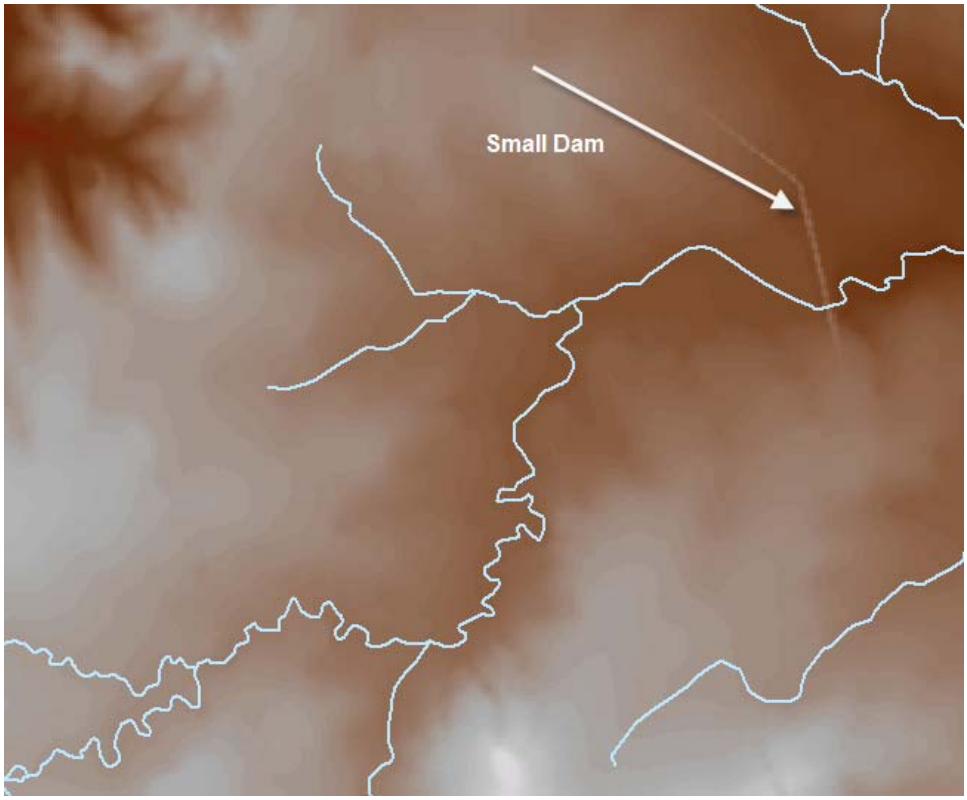
Attributes of NorthBosqueRiverReaches

FID	Shape *	OBJECTID	ComID	FDate	Resolution	GNIS_ID	GNIS_Name
1950	Polyline ZM	77519	97234441	8/21/2003	2		
1951	Polyline ZM	77528	97237973	8/21/2003	2		
1802	Polyline ZM	77820	97222339	8/21/2003	2	01375144	North Bosque River
1803	Polyline ZM	77822	97224985	8/21/2003	2		
1804	Polyline ZM	77823	97225425	8/21/2003	2		
1805	Polyline ZM	77824	97225561	8/21/2003	2	01347452	South Fork Little Green Creek
1806	Polyline ZM	77826	97226583	8/21/2003	2	01372188	North Fork North Bosque River
1807	Polyline ZM	77827	97227351	8/21/2003	2		
1808	Polyline ZM	77828	97227713	8/21/2003	2		
1809	Polyline ZM	77829	97227781	8/21/2003	2		
1810	Polyline ZM	77830	97228517	8/21/2003	2		
1811	Polyline ZM	77831	97229025	8/21/2003	2		
1812	Polyline ZM	77832	97229341	8/21/2003	2		
1813	Polyline ZM	77833	97229397	8/21/2003	2	01330362	Bell Branch
1814	Polyline ZM	77834	97229569	8/21/2003	2		

Record: 0 Show: All Selected Records (1 out of 3409 Selected) Options

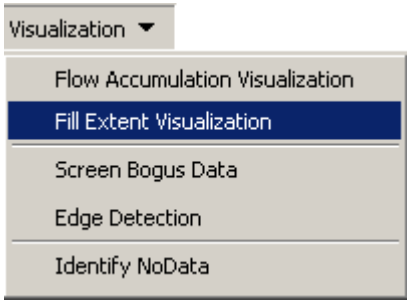


Notice how the published stream line is different than the flow accumulation grid at this location. An evaluation of the DEM, "Fill_NoData_2", shows a small dam at this location. In order for the GIS to create a hydrologically corrected DEM, one where the water flows across the terrain, the area behind the dam was filled in by the **Fill Sinks** tool. Filling in large areas often causes the GIS derived stream network to differ from the actual stream network.

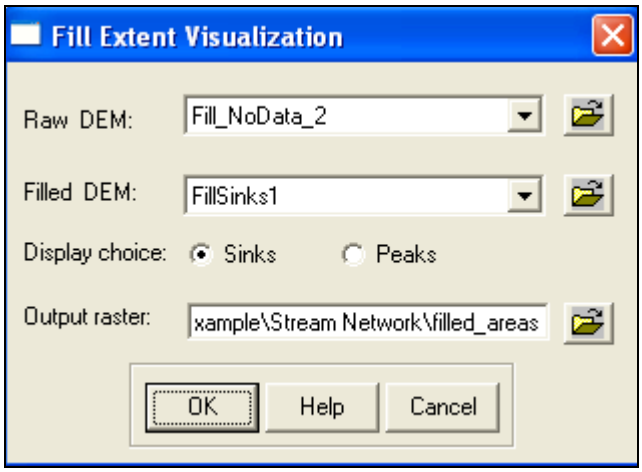


The **Fill Extent Visualization** tool will show how much of the raw DEM was filled in to create the filled DEM, "FillSinks1". This tool generates a raster showing the difference between the Filled DEM and the original Raw DEM. The resulting grid may show either the sinks or the peaks. To show the sinks, the function subtracts the Filled DEM from the Raw DEM, and changes all the zeros (i.e. identical values) into NoData cells.

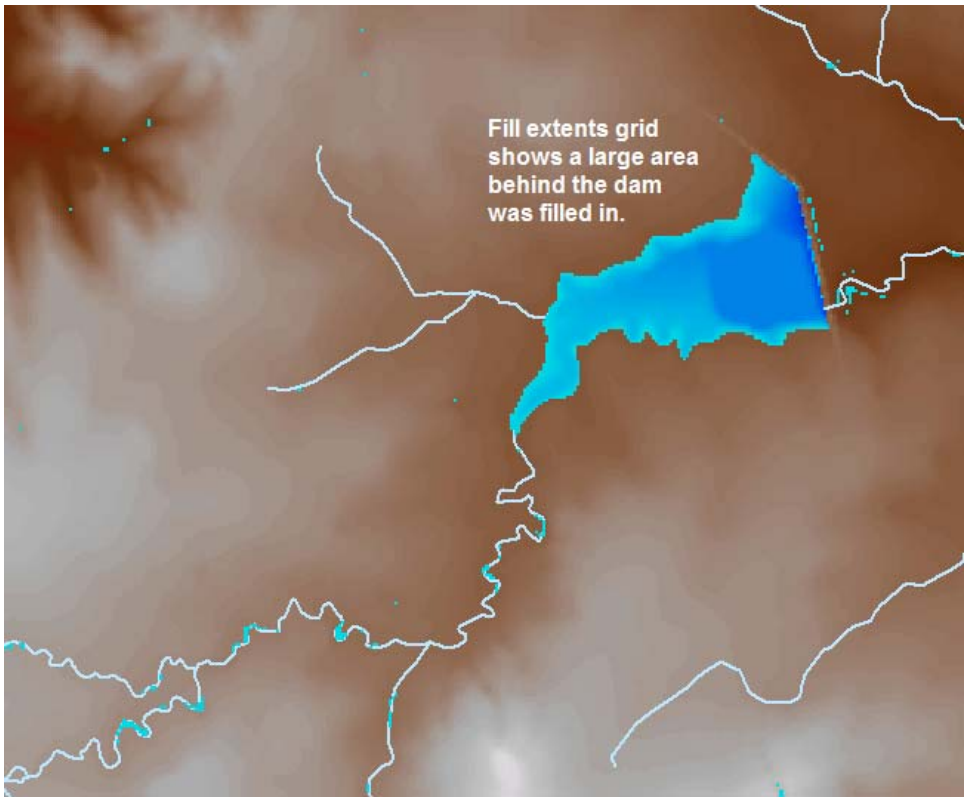
- Select **Visualization | Fill Extent Visualization**.



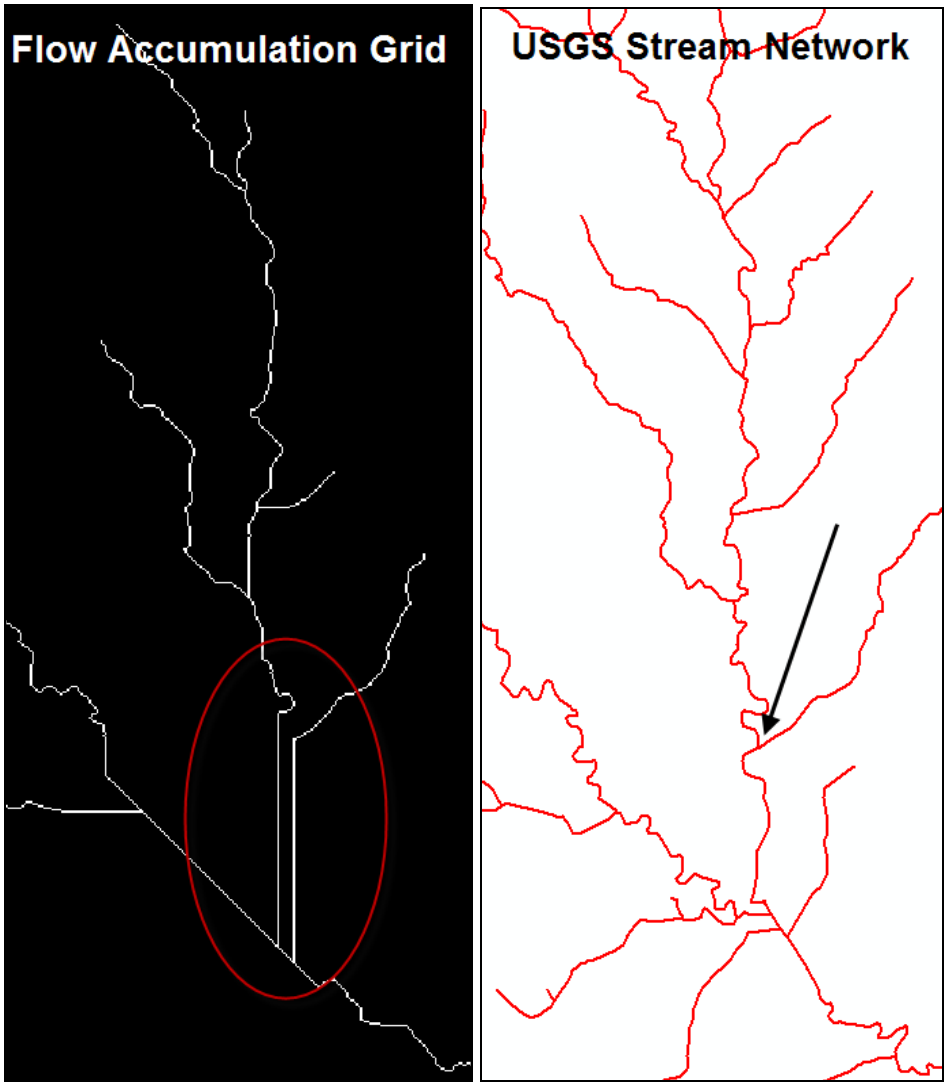
- Select "Fill_NoData_2" as the Raw DEM.
- Select "FillSinks1" as the Filled DEM.
- Select to display the sinks.
- Enter a name of "filled_areas" for the new grid.



The output raster shows a large area was filled in behind the dam in order to create a hydrologically corrected DEM. Typically, differences in the published stream network and the stream network generated from a DEM will occur around reservoirs.



Find and select the reach segment in the NorthBosqueRiverReaches layer that has an OBJECTID of 93301 (open the attribute table and find this record). Zoom to the selected segment in the map. Notice the flow accumulation grid shows two stream segments whereas the published stream network shows the streams merge before flowing into the main channel. HEC-GeoHMS would not be able to correctly subdivide this tributary due to errors in the DEM. The DEM needs to be edited so that the tributary correctly flows into the stream network.

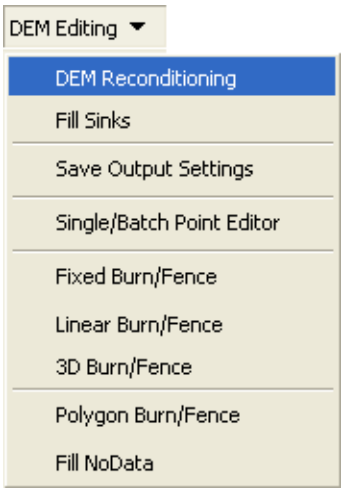


8.7 Edit the DEM

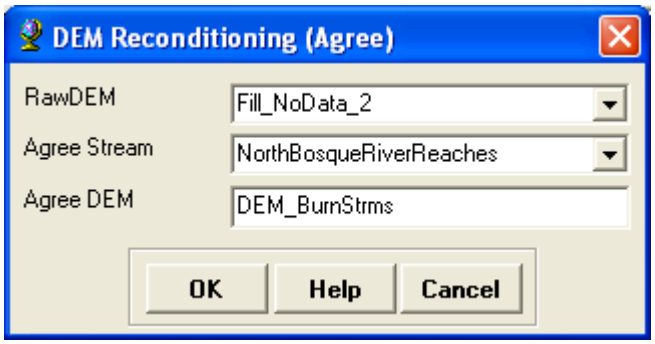
The above inconsistencies between the GIS derived stream network and the published USGS stream network can be fixed using tools from the **DEM Editing** menu. The **DEM Reconditioning** tool is best when a published stream network is available. The other tools on the **DEM Reconditioning** menu are better for editing small areas, like cutting a channel through a dam. For this example, the **DEM Reconditioning** tool is used to burn line features from the NorthBosqueRiverReaches shapefile into the DEM. This will force a stream network onto the DEM.

The **DEM Reconditioning** tool requires a DEM and a linear feature class (river). Both have to be present in the map document and in the same projection.

- Select **DEM Editing | DEM Reconditioning**.

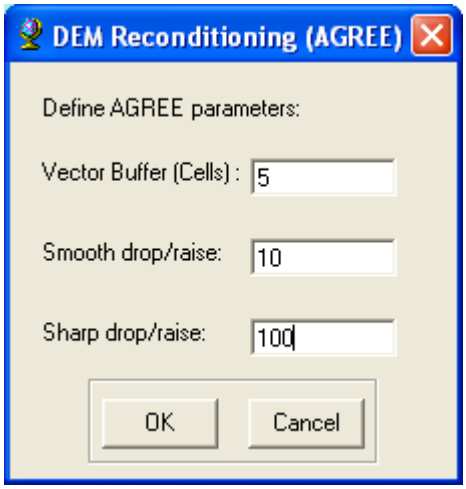


- Select "Fill_NoData_2" as the Raw DEM and "NorthBosqueRiverReaches" as the Agree Stream layer. Name the output DEM "DEM_BurnStrms".



- Set the three reconditioning parameters. The vector buffer is the number of cells around the Agree Stream layer for which the

smoothing will occur. The smooth drop/raise is the amount (in vertical units) that grid cells located beneath a line feature in the Agree Stream layer will be lowered (including buffer). The sharp drop/raise is the additional amount (in vertical units) that grid cells located beneath a line feature in the Agree Stream layer will be lowered. This amount is on top of the smooth drop/raise.



The Fill Sinks, Flow Direction, and Flow Accumulation tools were rerun after the DEM was edited. For this example, the **Fill Sinks** tool was used to fill sinks in the "DEM_BurnStrms" DEM. The output was named "FillSinks2". The flow direction grid was created using the "FillSinks2" grid. The new flow direction grid was named "FlowDir2". The flow accumulation grid was created using the "FlowDir2" grid. The new flow accumulation grid was named "FlowAcc2".

Use the **Flow Accumulation Visualization** tool to display all grid cells with a flow accumulation value greater than 0.25 square miles. Compare the stream network as shown in the flow accumulation grid to the published stream network. They should be similar.

Once the stream network from the DEM is acceptable, it can be used by HEC-GeoHMS to delineate subbasins and create input files for the HEC-HMS model. Verification of subbasin delineations should be made using available information, drainage areas at USGS stream gages and published subbasin boundaries from the National Hydrography Dataset. In some cases, the DEM will need to be edited to improve subbasin delineations. Tools available on the **DEM Editing** menu can be used in those cases.