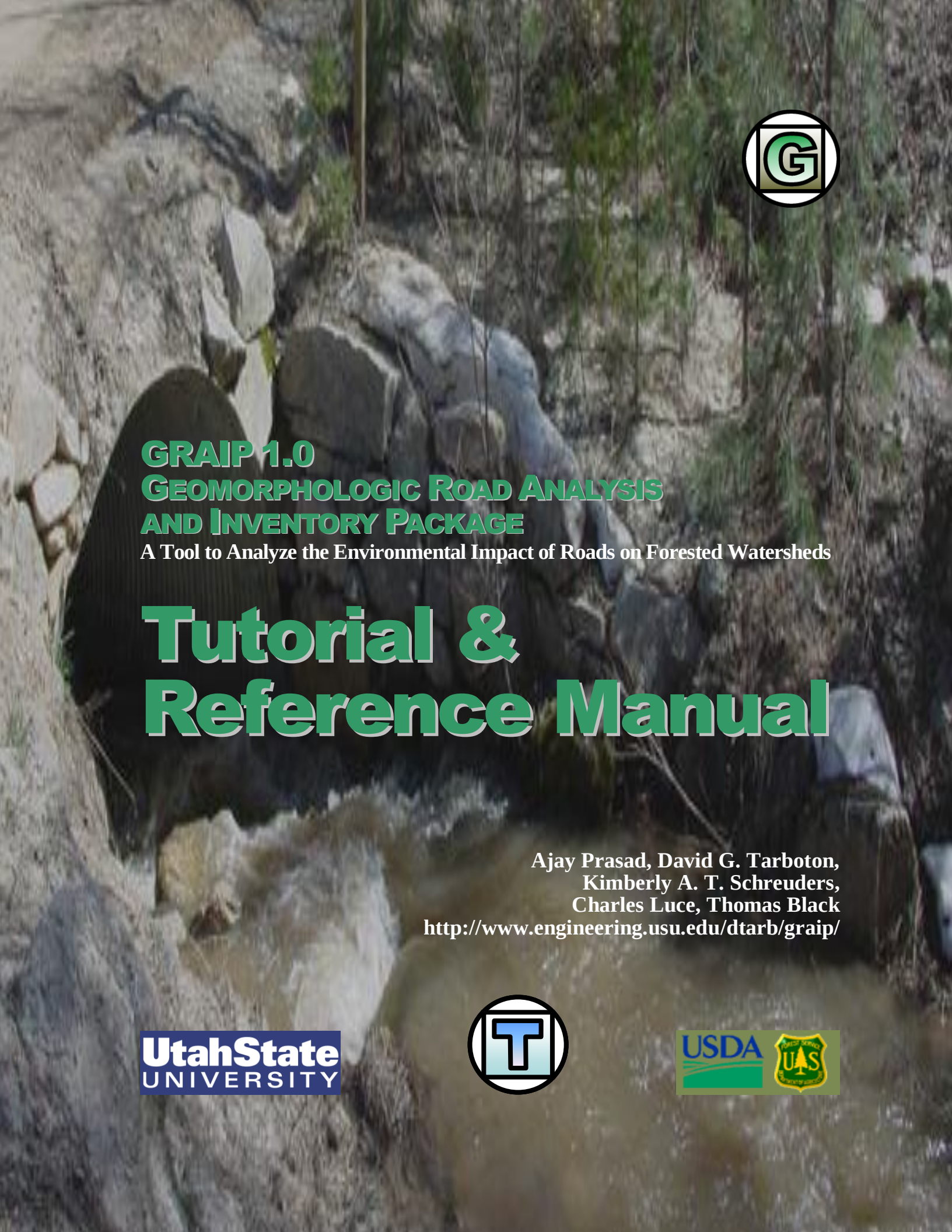

# GRAIP 1.0
# GEOMORPHOLOGIC ROAD ANALYSIS AND INVENTORY PACKAGE

**A Tool to Analyze the Environmental Impact of Roads on Forested Watersheds**

# Tutorial & Reference Manual

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## DISCLAIMERS

Although care has been taken in developing and testing GRAIP, errors and inadequacies may still occur, particularly in new applications. A user must therefore make the final evaluation as to the usefulness of GRAIP for their application. GRAIP is a tool to be used by investigators who have some knowledge and experience concerning analysis of the impact of roads on forested watersheds. It requires engineering judgment and common sense in developing input parameters and interpretation of the results.

The authors of GRAIP assume no liability or responsibility for the use of GRAIP, the interpretation of GRAIP results, or the consequences of management decisions that are based upon GRAIP. In no event shall the authors be liable for any damages whatsoever arising out of the use, or attempts to use GRAIP.

## DISTRIBUTION



GRAIP is distributed from http://www.engineering.usu.edu/dtarb/graip/.

## SUPPORT

There is no formal ongoing support for this freely distributed open source software. However, we are interested in feedback. If you find errors, have suggestions, or are interested in any later versions contact:

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## CONVENTIONS USED IN THIS MANUAL

A few conventions were established in developing this manual. Being aware of these conventions will make the manual easier to use.

**A.** Detailed step-by-step instructions for the user to execute are listed as numbered steps in grey boxes. These are used both for the steps in the installation of the software and steps in the tutorial.

**B.** Lists of items that are part of the general discussion and not specific steps to be executed are presented in lettered lists.

**C.** The symbol -> indicates the next level in a tree structure or in nested menus.

# INTRODUCTION

The Geomorphologic Road Analysis and Inventory Package (GRAIP) is a process and set of tools for analyzing the impact of roads on forested watersheds. This manual describes how to install and use this set of tools to perform a typical GRAIP analysis. Several tools were developed as part of GRAIP and are included with the package, such as the GRAIP Preprocessor and the GRAIP ArcGIS Toolbar. In addition, GRAIP also requires the use of several other software packages which must be acquired separately. This includes ArcGIS 9.1/9.2, TauDEM, Hawth's Tools and SINMAP2.0.

GRAIP performs the following analyses to derive information on the environmental impact of roads on forested watersheds:

**A.** Calculates and analyzes the production of road-based sediment and the input of that sediment into the stream network.

**B.** Calculates the impact of road drainage on terrain stability and the potential for the formation of gullies due to erosion.

**C.** Identifies fish passage passability at road-stream crossings and analyzes the resulting contiguity and fragmentation of the stream network fish habitat.

## OVERVIEW

The construction and use of forest roads can have a significant negative impact on geomorphic processes and erosion patterns in forested basins. To analyze this impact, the Tarboton Group and the USDA Forest Service (USFS) developed the GRAIP (Geomorphologic Road Analysis and Inventory Package) process. Charles Luce and Thomas Black of the Forest Service developed much of the theory and the road inventory based approach which forms the foundation of GRAIP. Most of the work on the GRAIP tools was done by Ajay Prasad as his MS project under the supervision of David Tarboton. GRAIP is designed to help forest managers effectively manage road and road drainage systems and hence minimize the negative impacts of forest roads.

The GRAIP process begins by creating a detailed road inventory using GPS (Global Positioning System) based surveys. Then, a GRAIP analysis uses a number of GIS tools including the GRAIP tools along with a DEM (Digital Elevation Model) to derive environmental impact information from this inventory. Please note that the GRAIP system requires that the shapefiles developed as part of the road inventory and the DEM all must use the same coordinate system. GRAIP makes the assumption that they are the same, without actually checking to see that that is the case.

The GRAIP analysis begins by using the GRAIP Preprocessor, a standalone application, to review the road inventory data for inconsistencies, document the inconsistencies, adjust and filter the data, and then builds the GRAIP database and the consolidated drain point and road shapefiles. This process ensures a minimum data quality and allows the data to be represented in a structured format that is more suitable for analysis.

The remainder of the analysis is performed using a number of tools including the GRAIP Toolbar, an ArcGIS 9.1/9.2 toolbar, that performs the heart of the analysis. In addition, a GRAIP analysis uses ArcGIS 9.1/9.2, TauDEM, Hawth's Tools and SINMAP2.0.

The GRAIP Toolbar performs a number of analysis functions. The first group of functions calculates the sediment production for each road segment from slope, length, road surface condition and flow path vegetation. Road segment sediment production is then accumulated at each drain point. Digital elevation model (DEM) derived overland flow directions are then used to accumulate the sediment input to each stream segment. The second group of functions analyzes the impact of road drainage on terrain stability by calculating the specific discharge due to road drainage and using this, together with slope, as inputs to an infinite plane slope stability model. An erosion sensitivity index calculated using slope and contributing road length at each drain point is also calculated to predict gullying. The final function group analyzes the fragmentation of stream network fish habitat due to potential blockage of fish passage at stream crossings.

## INSTALLATION

### *Prerequites*

A GRAIP analysis requires a number of software packages that are not included with GRAIP and they should be installed prior to installing GRAIP:

1. Install ArcGIS with an ArcInfo and Spatial Analysis license. For more information, see the installation information that came with ArcGIS or the website http://esri.com/.
2. Install TauDEM: The website http://hydrology.neng.usu.edu/taudem/ explains how to install and use the TauDEM toolbar.
3. Install SINMAP2.0: The website http://hydrology.neng.usu.edu/sinmap2 explains how to install and use the SINMAP toolbar.
4. Install Hawth's Tools: The website http://www.spatialecology.com describes how to install and use Hawth's analysis tools.

### *GRAIP Setup*

Once these packages have been installed, GRAIP itself can be installed.

5. Install the GRAIP Toolbar and GRAIP Preprocessor: The website http://www.engineering.usu.edu/dtarb/graip/ provides a link to the GRAIP GIS Tool setup file: "GRAIPSetup.exe". Download GRAIPSetup.exe and save it to your working folder. Double click to run the setup.

This will install GRAIP in the designated folder (by default C:\Program Files\GRAIP). The GRAIP installation includes:

**A.** An executable, GRAIPPreprocessor.exe, and 3 binary libraries, consolidateShp.dll, agGRAIP.dll and graipCOMDLL.dll. These file make up both the Preprocessor and the ArcGIS toolbar.

**B.** The GRAIP database template, GRAIP.mdb, located in the graip db folder. This file is required by the Preprocessor.

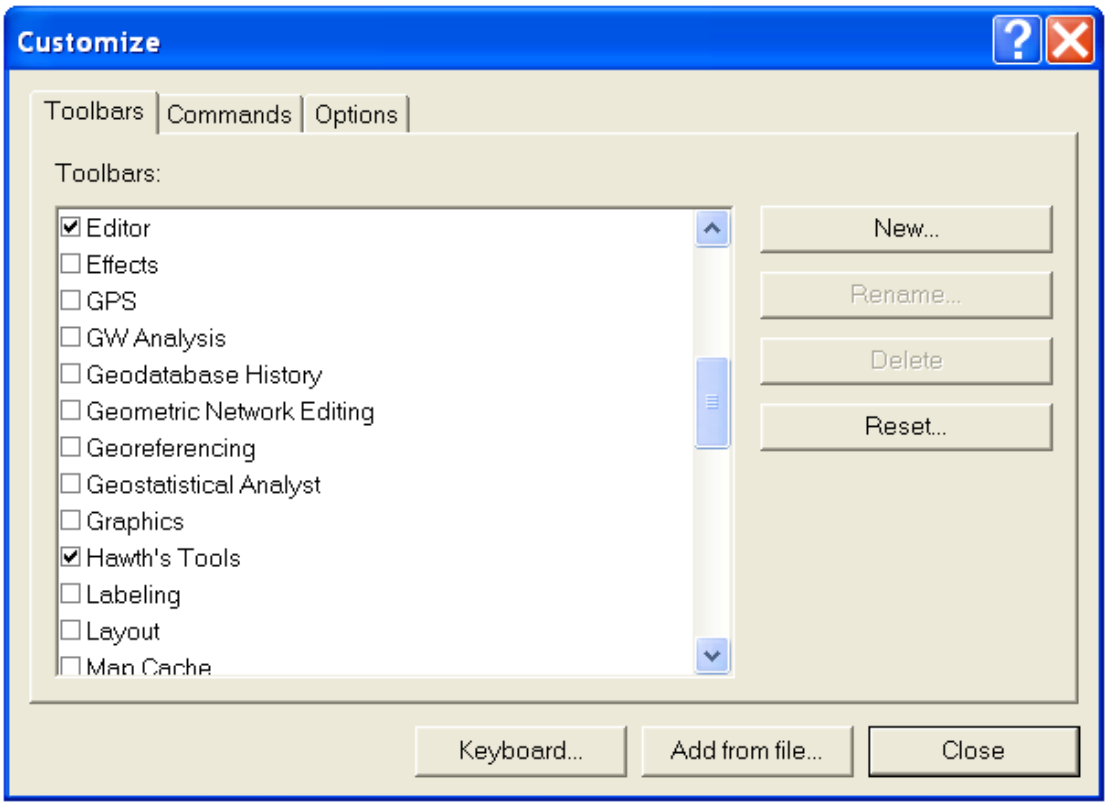
**C.** A tutorial folder that contains this manual and a zipped file of data needed for the tutorial. This zip file contains a 'demo' folder which contains the "dem" (ESRI Raster Grid) file and a shapefiles folder containing eight types of drain points shapefiles (BBdip.shp, Diffuse.shp, Ditchrel.shp, Lead_off.shp, ned.shp, Str_Xing.shp, sump.shp, waterbar.shp) and one road lines shapefile (road.shp).

**D.** A shortcut to the GRAIP Database Preprocessing tool that is installed in the Start-> Programs menu.

### *ArcGIS-GRAIP Toolbar Configuration*

**6.** Start ArcMap by clicking the windows Start button and selecting All Programs -> ArcGIS -> ArcMap.

**7.** Select Tool -> Customize to open this dialog:



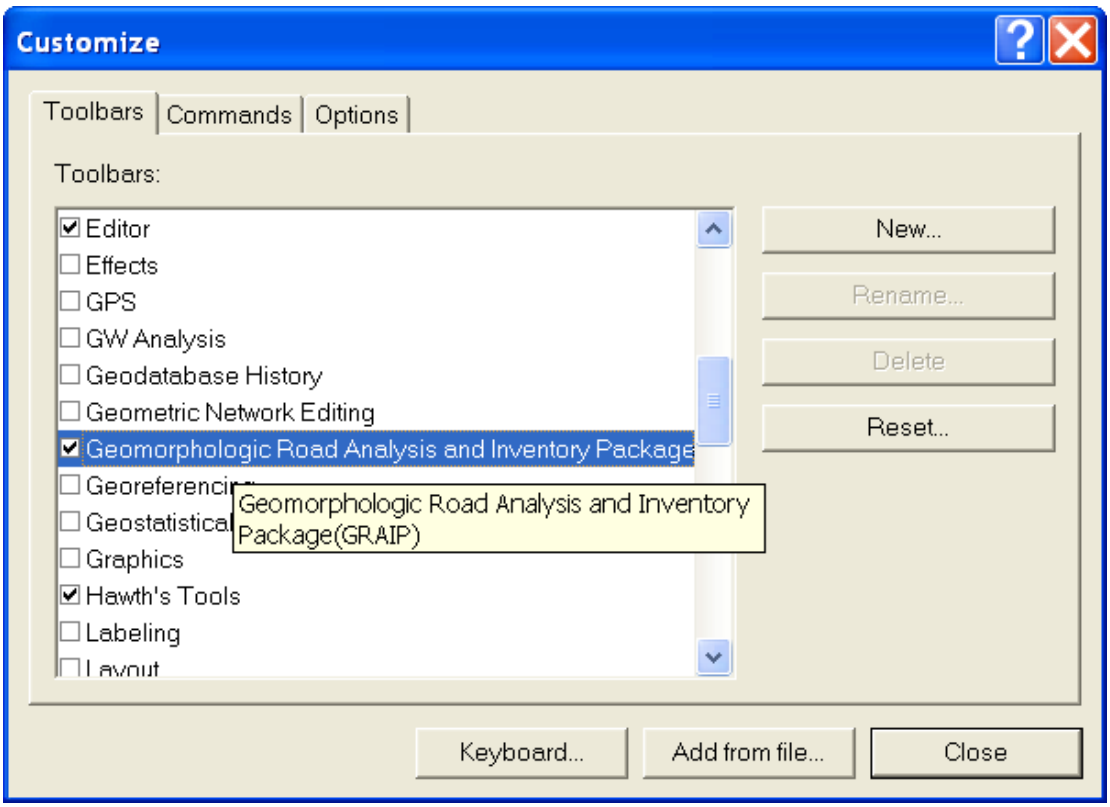

**8.** Click the Add from file… button to open the Open dialog.

**9.** Browse to the \Program Files\GRAIP folder.

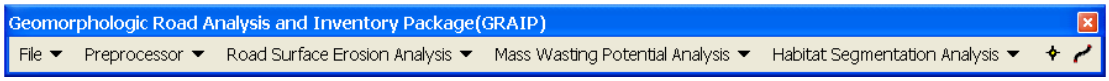
**10.** Select the agGRAIP.dll file, click the OK button.

**11.** Click the Close button.

**12.** Check the "Geomorphologic Road Analysis and Inventory Package (GRAIP)" checkbox.



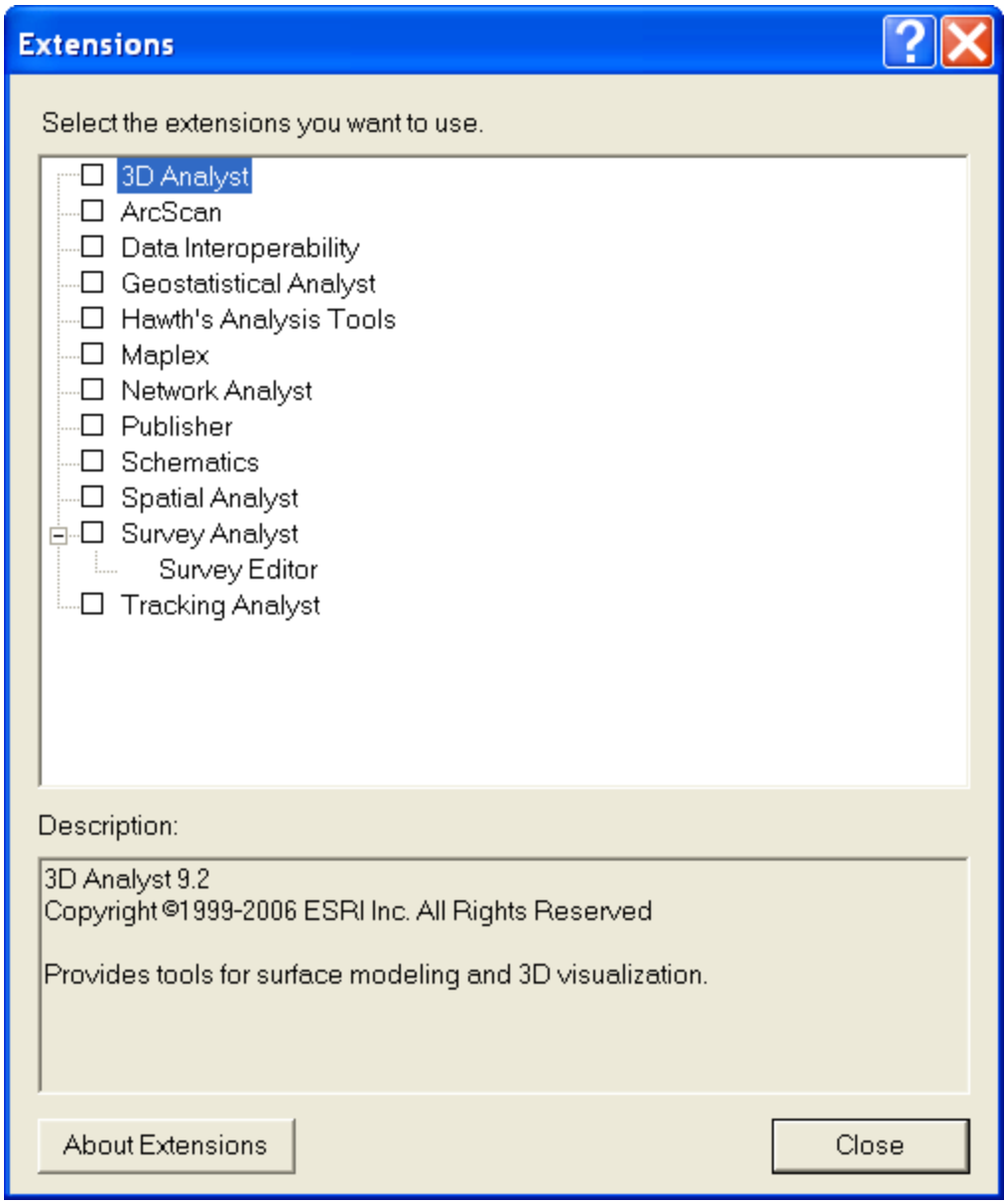

**13.** Click the "Close" button to make this toolbar visible.




### *ArcGIS-Spatial Analyst Configuration*

GRAIP uses features from ArcGIS' Spatial Analyst extension and so this extension must be unlocked. To do this:

**14.** Select Tool -> Extensions to open this dialog:




**15.** Click on Spatial Analyst and then click the Close button.

### *Installing the Tutorial Files*

If you wish to work through the tutorial examples, you will also need to install the tutorial files.

**16.** Unzip the C:\Program Files\GRAIP\tutorial\demo.zip file to a convenient working folder. For the purpose of the tutorial examples, we have used C:\demo.

# TUTORIAL

This tutorial describes the steps taken in a typical GRAIP analysis.

# PREPROCESSOR

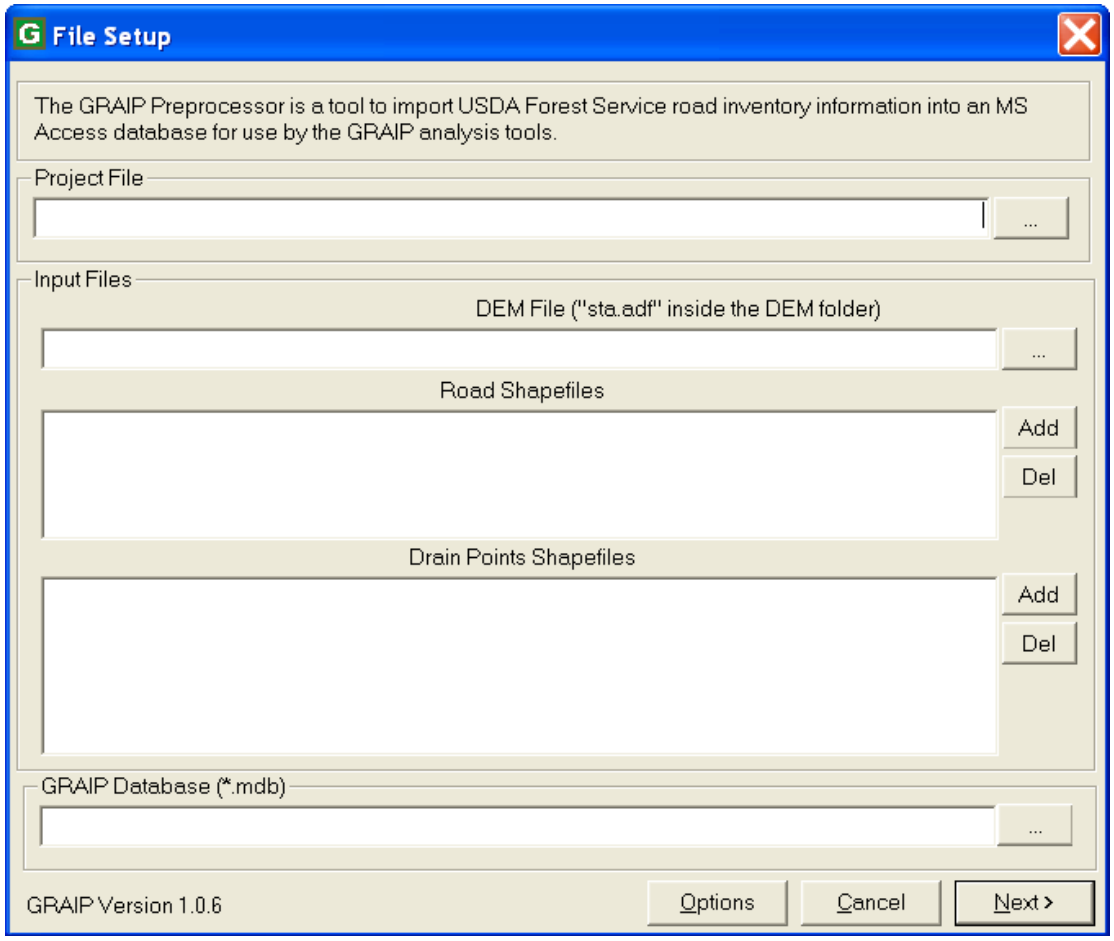
## *Introduction*

The GRAIP Preprocessor is an application that validates and imports USFS road inventory shapefile attributes into a relational database structure created in the MS Access file format. The purpose of this database (the GRAIP Database) is to enforce referential integrity and ensure consistency between related attributes. The Preprocessor helps to correct and/or screen out invalid or corrupt data so the user has a better dataset with which to perform the forest road impact analysis. It also consolidates multiple drain point and road line shapefiles, creating a single shapefile for each.

## *Starting the Preprocessor*

**1.** Start the GRAIP Preprocessor by clicking the windows Start button and selecting All Programs -> GRAIP -> GRAIP Preprocessor.

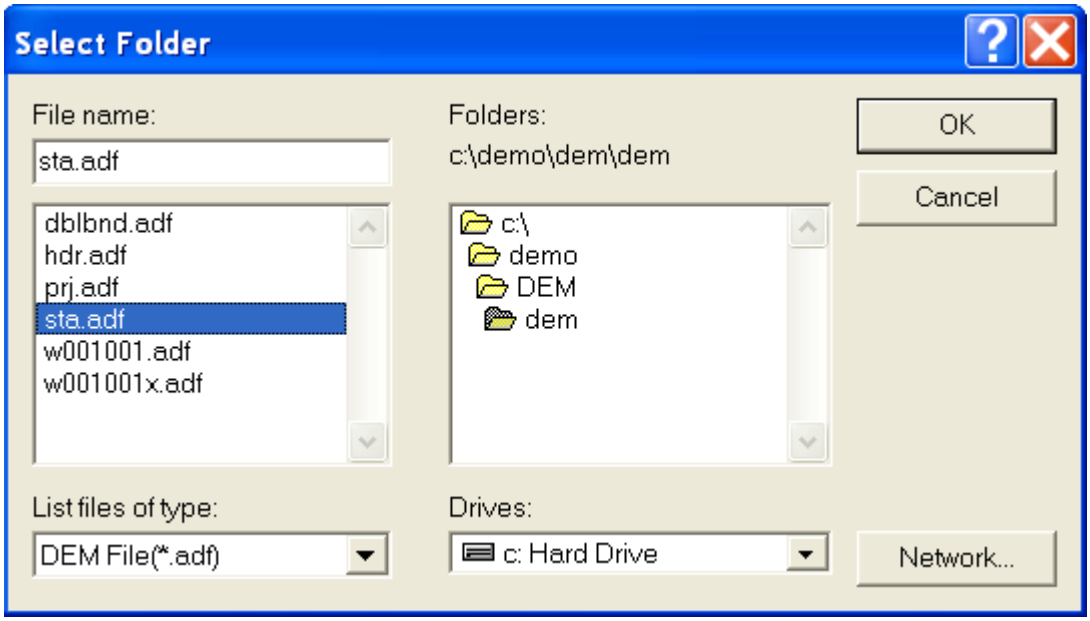
This screen will appear:




**2.** Click on the More Button (…) next to the Project File field. Browse to your tutorial working folder where you unzipped the demo data, use the file name "test.graip" and click Save.

An initial path and file name for the GRAIP Database file will be generated based on the path and file name selected.

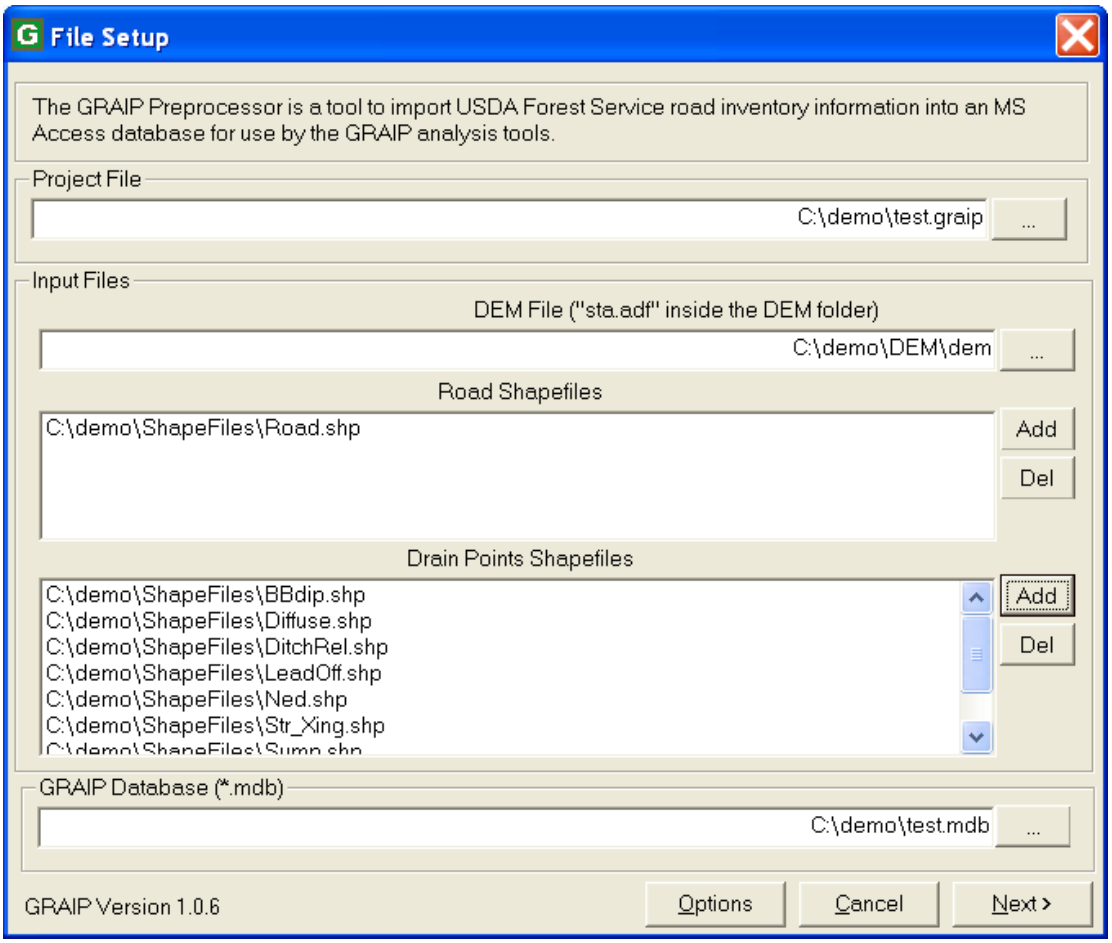
**3.** Click on the More button (…) next to the DEM File field. Browse to the \DEM\dem folder in your tutorial working folder, select the sta.adf file and click "OK". See the location of the DEM\dem\sta.adf file used in this example:



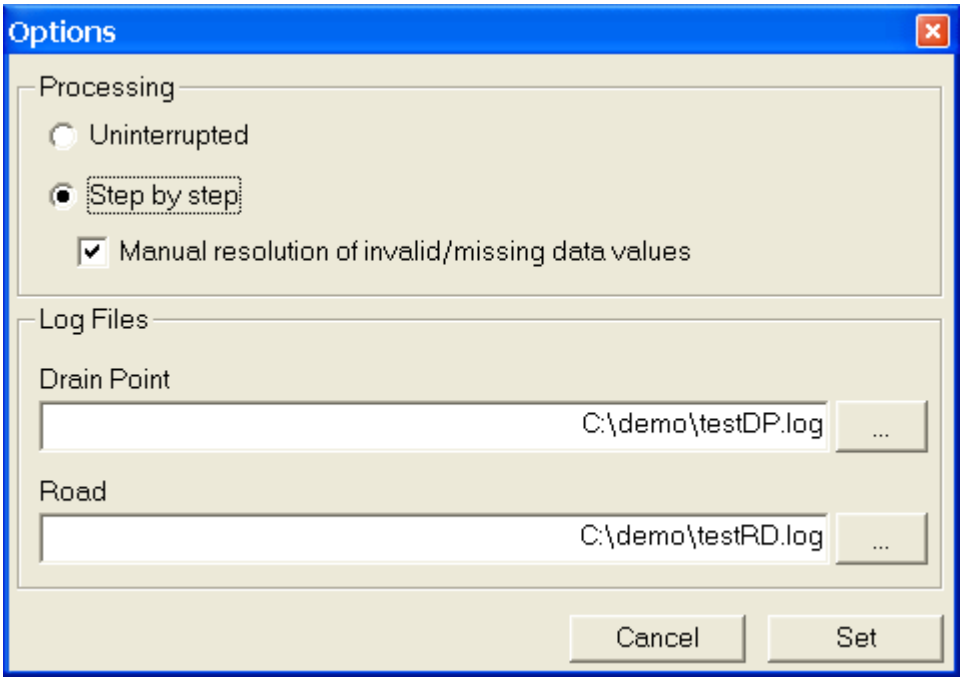

**4.** Click on the Add button adjacent to Road Shapefiles field. Browse to the \ShapeFiles\ folder in your tutorial working folder, select Select the Road.shp file, and click "OK".

**5.** Click on the Add button adjacent to Drain Points Shapefiles field. Select the following files from the Shapefiles directory by holding down the Ctrl key and clicking on each filename in this list: BBdip.shp, Diffuse.shp. DitchRel.shp, LeadOff.shp, Ned.shp, Str_Xing.shp, Sump.shp, WaterBar.shp. Release the Ctrl key and click OK.

Your screen should now look like this:




**6.** Click the "Options" button to open the dialog shown below:



The Options dialog allows you to choose the type of processing the Preprocessor will perform. Uninterrupted processing does not display any dialogs. It just uses all of the defaults and continues until all of the shapefiles are processed. Step by Step processing stops at each of the shapefile import screens allowing the user to adjust the options before importing each shapefile. Also if you choose Step by step processing, you have another choice to make, Manual resolution of invalid/missing values. If you select this option, anytime there is a value in an attribute field that is not in the dictionary for that field, a screen pops up to decide how to handle the situation. If you do not select this option, the preprocessor will use the default values and continue with the processing. In all cases, all data issues are logged for later review. This dialog also allows you to change the log file names and paths.

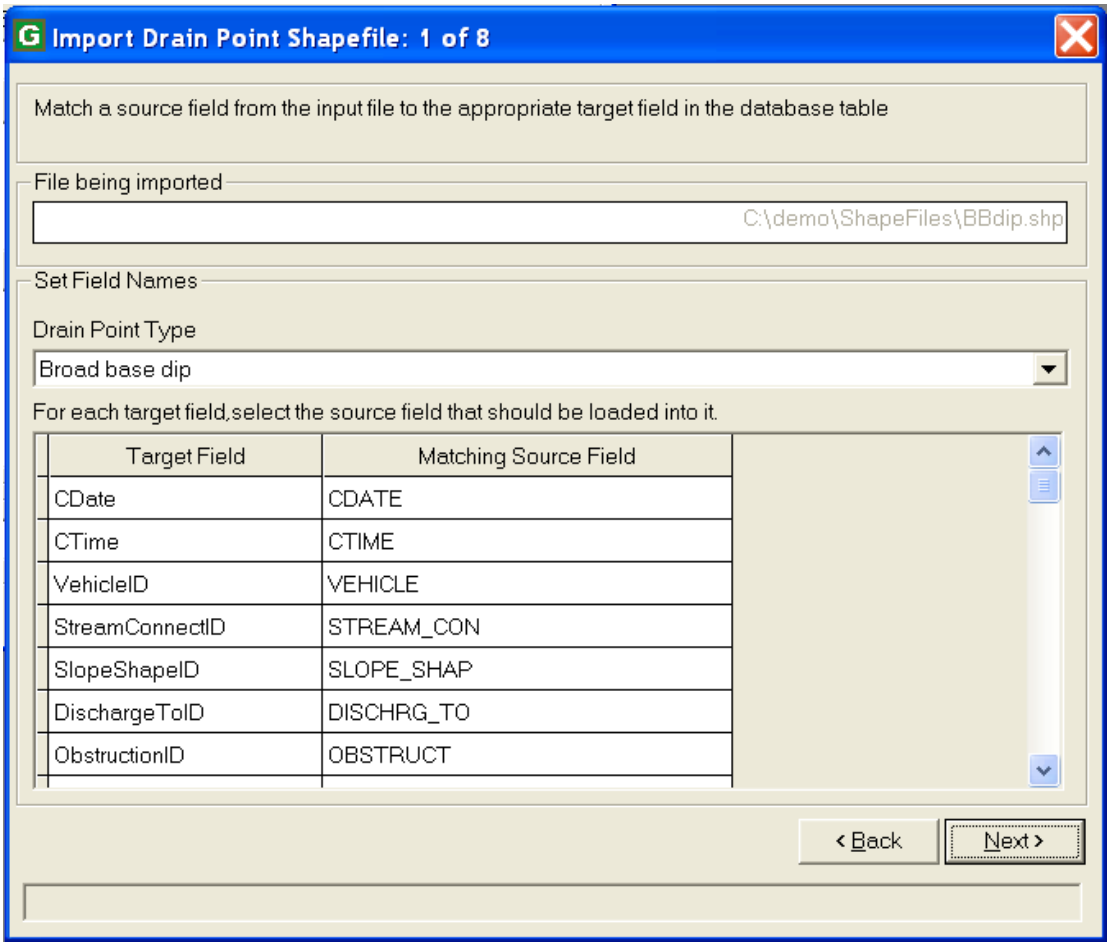
7. For the purpose of this tutorial, do not change any of the options. Just click Cancel".
8. Click Next.

The first Import Drain Point Shapefile screen for matching fields from the first drain point shapefile to the appropriate target field in the GRAIP database table appears.

Before proceeding let's see what has been done. If you look in the working folder where the demo data was unzipped, you should see that a new GRAIP project file (test.graip) has been created which holds the lists of files that are part of the project. A new MS Access database file (test.mdb and test.ldb) has also been created. All the shapefile attributes will be validated and stored in this database file. Two logfiles (testDP.log and testRD.log) have been created as well.

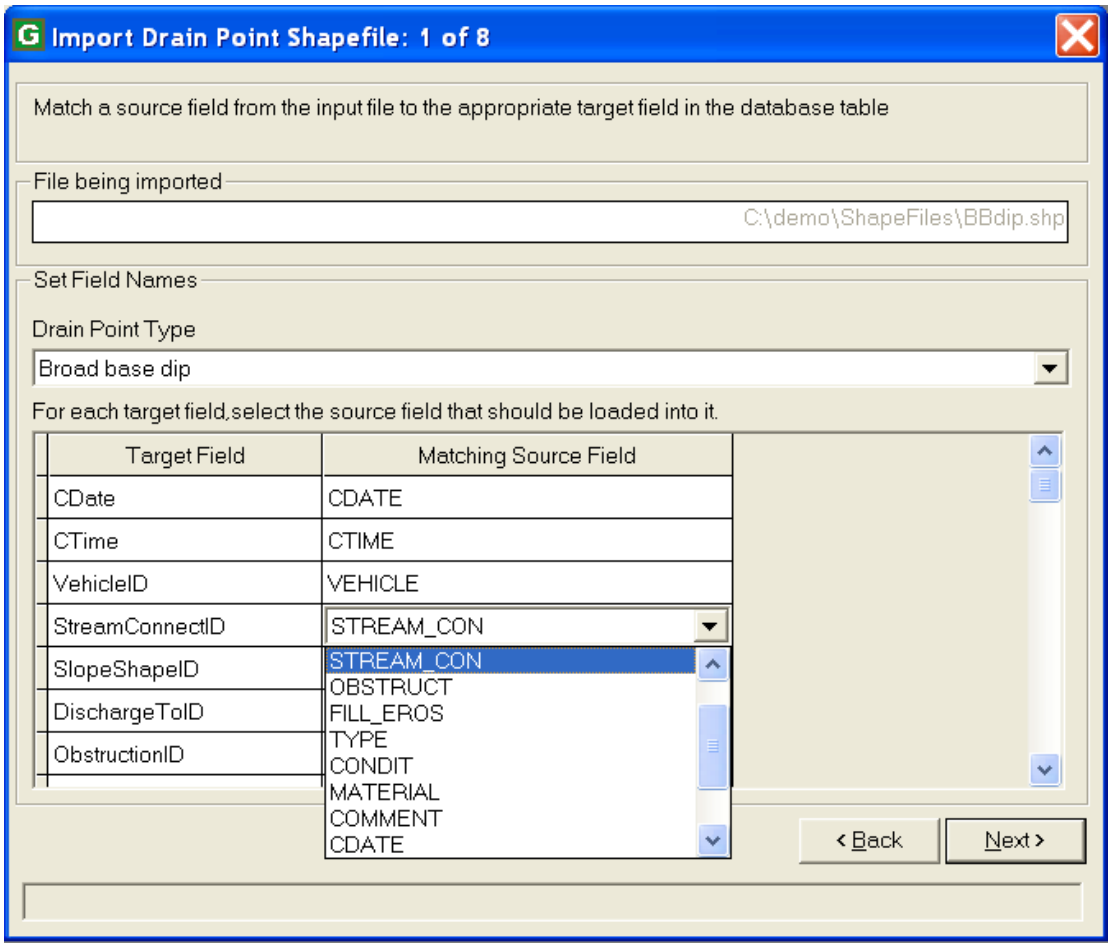
### *Import Drain Point Attributes*

Let's now return to the first Import Drain Point Shapefile screen shown:




The File being imported field displays the path of the next drain point shapefile to be imported. This comes from the list of shapefiles identified earlier. The Drain Point Type default value is automatically selected by the program based on the name, but can be changed by the user.

The Set Field Names table is used to designate the fields from the drain point shapefile that will be imported into the GRAIP database. The Target Field column lists the fields in the GRAIP database and the Matching Source Field column indicates how each field in the GRAIP database is to be filled, either with a default value or from a field in the drain point shapefile. The tool will attempt to match the fields by default, but if no default is found, "<No Match Use Default>" is used. If any of the default values need to be changed, click on that row in the Matching Source Field column and a list of choices will appear on a drop down menu:

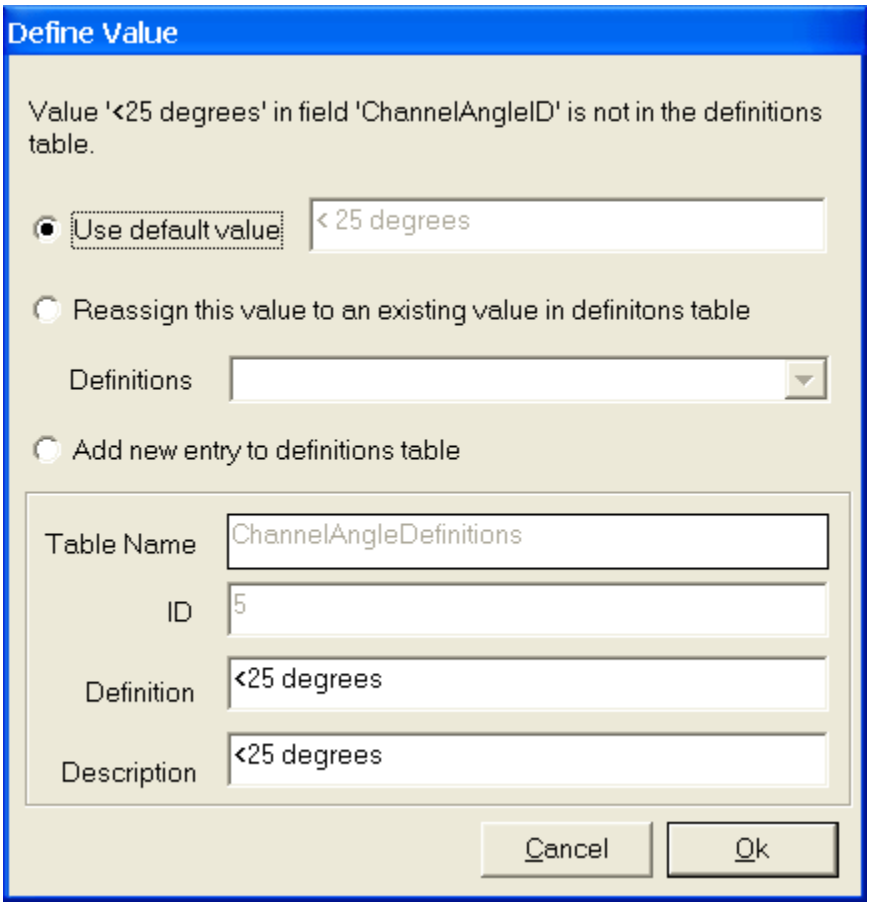



**9.** In this example, the defaults are acceptable, so click Next.

A progress bar will appear at the bottom of the screen while the shapefile is imported.

**10.** For the 2nd to 5th drain point shapefiles the defaults are acceptable so continue to click next.

As the Str_Xing shapefile is being imported (the 6th of 8) after you have clicked Next on its Drain Point Import Screen, an attribute value of "<25 degrees" is found in the ChannelAngleID field, which is not defined in the ChannelAngleDefinitions table. The Define Value dialog appears to help you resolve this issue:




You now need to decide how you want the Preprocessor to handle all occurrences of this undefined value in this field. Your choices are to use the default defined value for this field (shown next to the Use default value label), reassign all occurrences of this value to one of the existing defined values, or create a new definition for this value.

**11.** For this tutorial, click Use default value.

The choices made on resolving mismatched during data import are recorded in the DPErrorLog table and testDP.log file.

**12.** Click Ok.

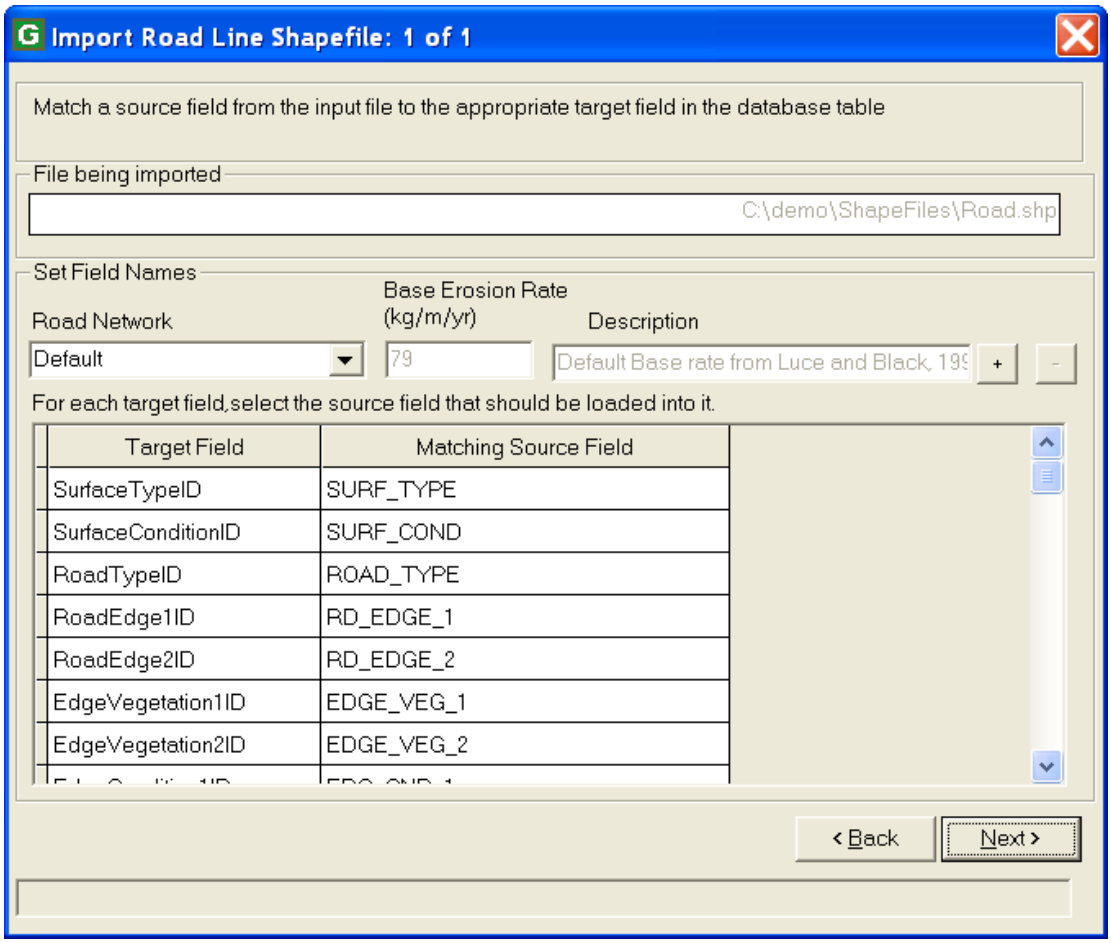
Once all of the invalid values in that drain point table are processed, the next drain points validate and import screen is displayed.

**13.** Continue these steps clicking "OK" or "Next" and resolving invalid/missing values until all the drain point shapefiles are imported to the database.

Once all the drain points shapefiles are validated and imported, the Road Lines import screen is displayed.

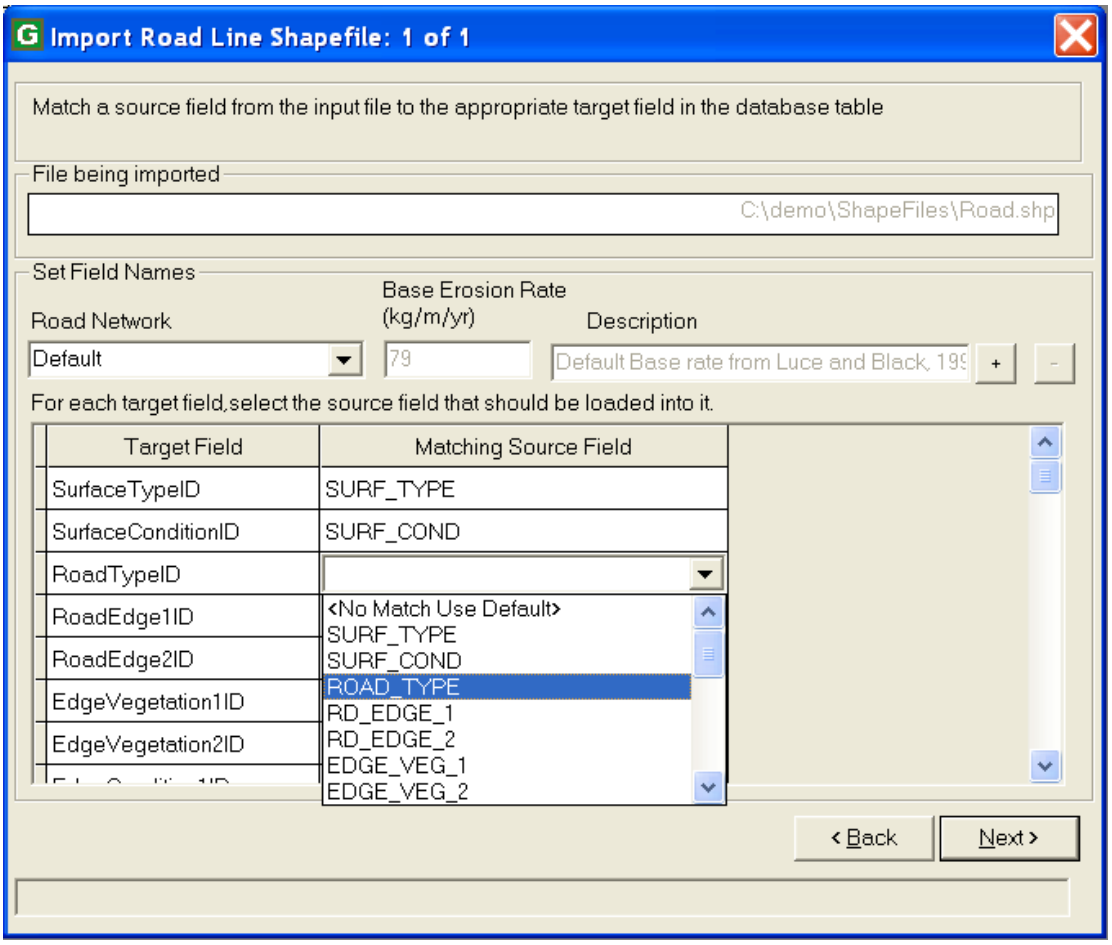
### *Import Road Lines Attributes*

The Road Lines Import screen looks like this:



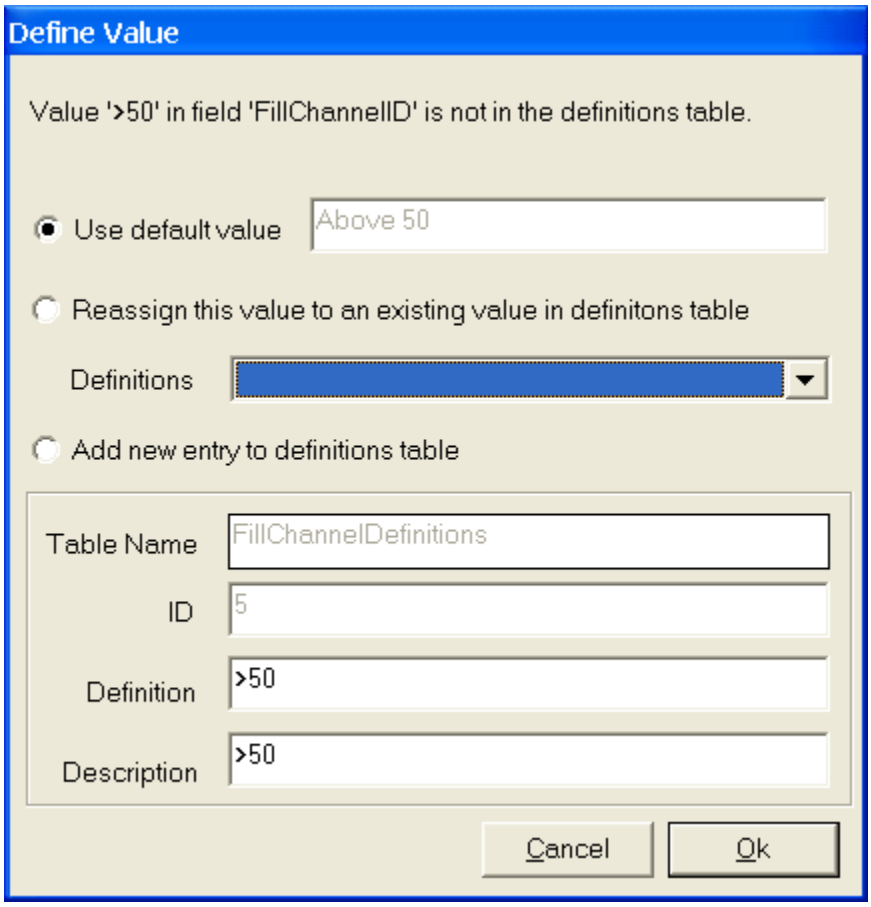

The File being imported field displays the path of the road line shapefile to be imported. This comes from file selected in the initial Preprocessing screen. The Road Network field shows the road network type. The Base Erosion Rate field shows the rate associated with this road network type. The Description field gives an explanation for the base rate used. The + button is used to add an additional road network type along with it's associated base rate and description. The - button is used to remove a road network type and its associated base erosion rate. The Default road network type cannot be removed.

The Set Field Names table is used to designate the fields from the drain point shapefile that will be imported into the GRAIP database. The Target Field column lists the fields in the GRAIP database and the Matching Source Field column indicates how each field in the GRAIP database is to be filled, either with a default value or from a field in the drain point shapefile. The tool will attempt to match the fields by default, but if no default is found, "<No Match Use Default>" is used. If any of the default values need to be changed, click on that row in the Matching Source Field column and a list of choices will appear on a drop down menu:




**14.** In this example, the defaults are acceptable, so click Next.

As the Road.shp shapefile is being imported, an attribute value of >50' is found in the FillChannelID field, which is not defined in the FillChannelDefinitions table. The Define Value dialog appears to help you resolve this issue:

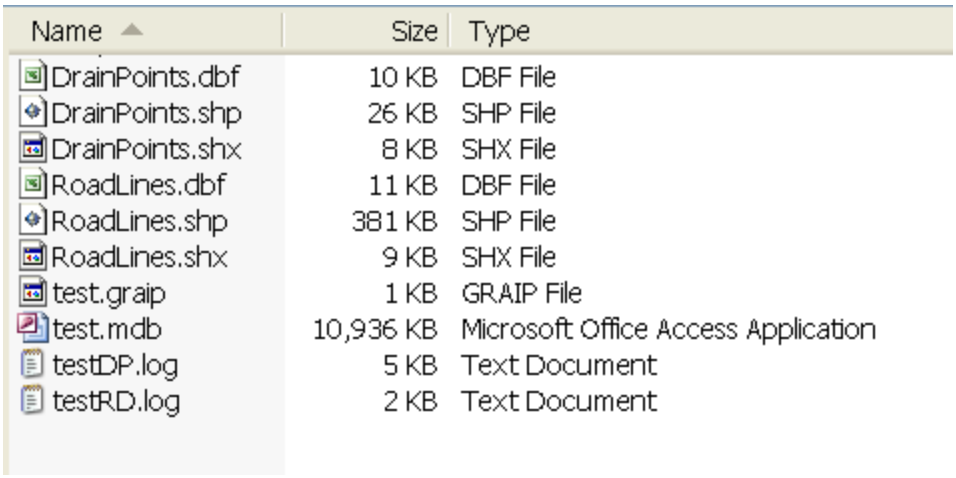



15. Click Use default value and click "OK".
16. Continue resolving invalid/missing values until the road line shapefile is imported to the database.

The consolidate shapefiles progress bar will appear while the shapefiles are being consolidated.

### *Preprocessor Output Files*

Here is a list of the output files created by the GRAIP Database Preprocessor tool:



| Name | Size | Type |
|---|---|---|
| DrainPoints.dbf | 10 KB | DBF File |
| DrainPoints.shp | 26 KB | SHP File |
| DrainPoints.shx | 8 KB | SHX File |
| RoadLines.dbf | 11 KB | DBF File |
| RoadLines.shp | 381 KB | SHP File |
| RoadLines.shx | 9 KB | SHX File |
| test.graip | 1 KB | GRAIP File |
| test.mdb | 10,936 KB | Microsoft Office Access Application |
| testDP.log | 5 KB | Text Document |
| testRD.log | 2 KB | Text Document |

The output files include 2 log files that identify the issues found with the data during operation of the preprocessor. A copy of this information can also be found in 2 of the tables in the Access database file.

## DATA PREPARATION

This data preparation step should be done before using the GRAIP GIS Tool:

**17.** Start ArcMap by clicking the windows "Start" button and selecting All Programs -> ArcGIS -> ArcMap.

**18.** Click the Add Data tool from ArcMap's Standard toolbar, browse to the DEM folder in the demo folder, select the dem grid and click Add.

**19.** Perform the Basic Grid Analysis -> Select Base DEM grid … and Basic Grid Analysis -> Do All functions of the TauDEM toolbar. See http://hydrology.neng.usu.edu/taudem/ for more information.

Now you need to identify the outlet of the watershed you will be working with. To do this, use ArcCatalog to create a new empty point type shapefile named "Outlet".

**20.** Start ArcCatalog by selecting Tools -> ArcCatalog.

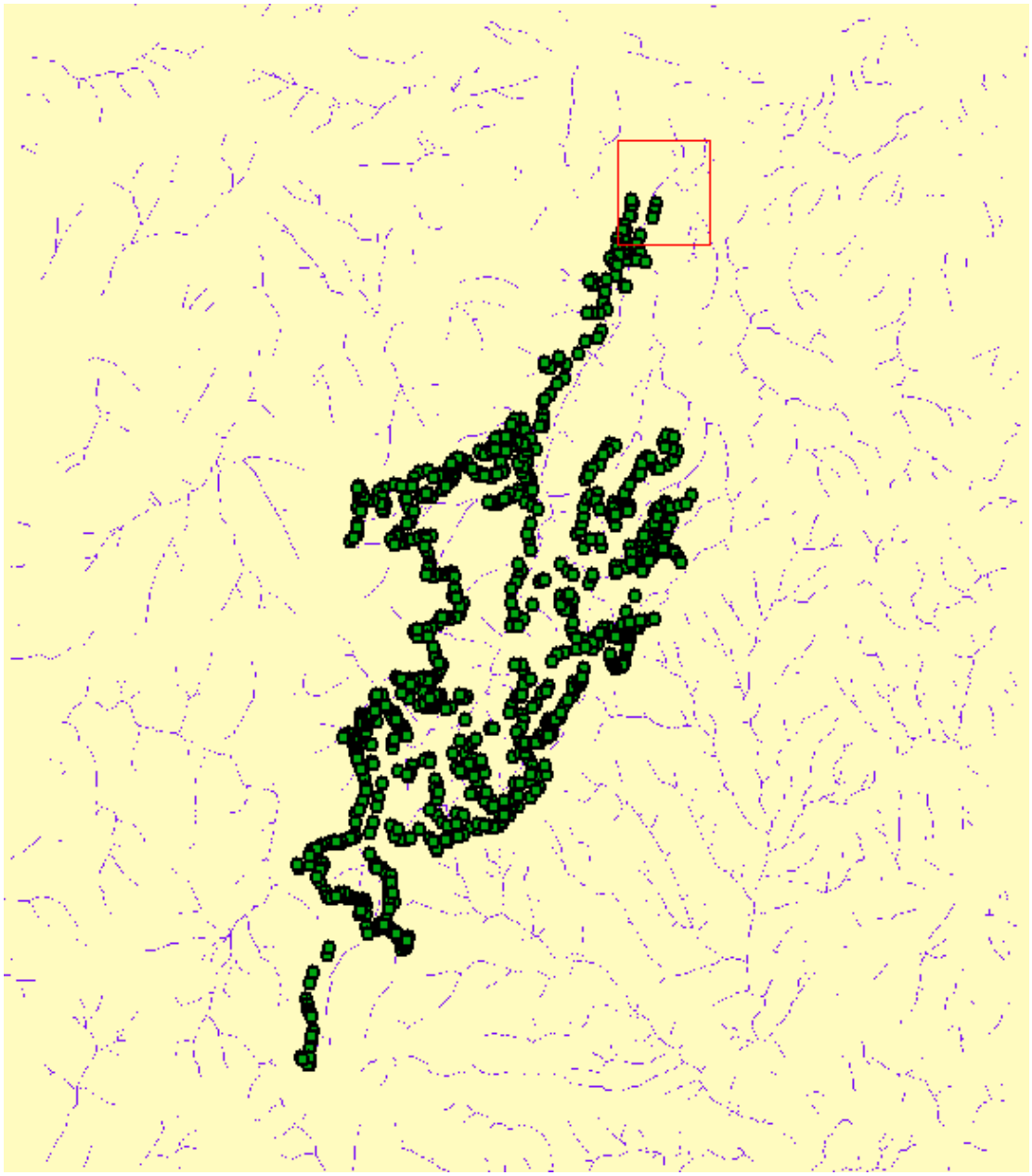
**21.** Right click on the Shapefile folder in the demo folder where you are working and select 'New/Shapefile...'. Set the name 'Outlet' and set the feature class to point. Click OK to create the shapefile.

Then add the outlet point to the new shapefile.

**22.** Switch back to ArcMap. Click the Add Data tool from ArcMap's Standard toolbar, browse to the Shapefiles folder in the demo folder and select Outlet.shp. If the Editor toolbar is not visible, Select View -> Toolbars -> Editor to display it. Select Editor -> Start Editing from the Editing toolbar. Select the \demo\Shapfiles folder and click OK. Select Outlet.shp, and click Start Editing.

**23.** Use the layer demsrc.src to ensure that you are locating a point on a stream path. Click the Add Data tool from ArcMap's Standard toolbar, to add the DrainPoints shapefile.

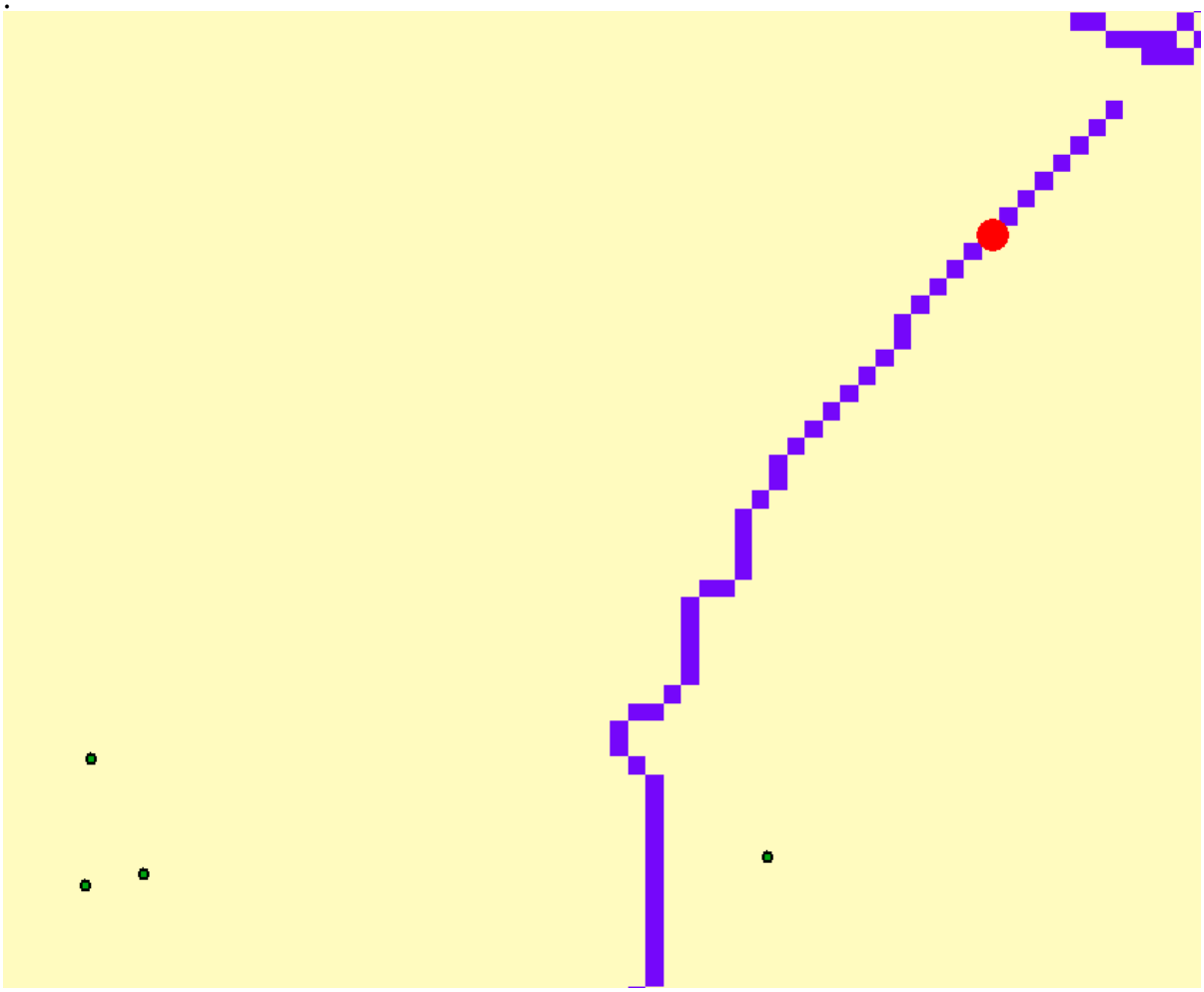
The demsrc.src layer with the DrainPoints file looks like this (except it won't have the red box):



**24.** Use the Magnifying Glass tool to zoom in on the downstream area of the watershed (which was highlighted by the red box in the previous image).

**25.** Use the Sketch tool to carefully locate a point at the outlet of the watershed (downstream of all of the drain points).

Your point should look something like this:



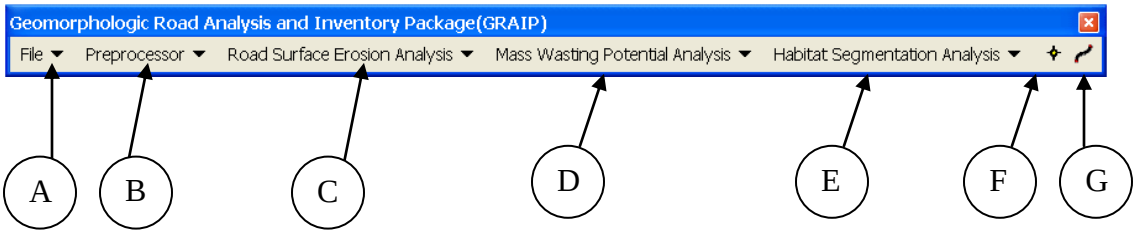
**26.** Select Editor -> Stop Editing, and then Save.

If you had difficulties creating the outlet file and adding your outlet point, instead you can use the Outlet1.shp file that is in the demo folder. Outlet.shp (or Outlet1.shp if you are using the pre-built file) is now a one point shapefile.

**27.** Run the Network Delineation functions of the TauDEM toolbar using Outlet.shp as the outlets file to delineate a stream network based on the DEM. See http://hydrology.neng.usu.edu/taudem/ for more information.

## GRAIP Toolbar Menu & Tools

The GRAIP toolbar has the following menus:



**A.** **File Menu**—to set and adjust project settings and files.

**B.** **Preprocessor Menu**—to perform several preliminary steps necessary to a GRAIP analysis

**C.** **Road Surface Erosion Analysis Menu**—to quantify sediment production from forest roads and its delivery to streams.

**D.** **Mass Wasting Potential Analysis Menu**—to quantify the impact of forest roads on terrain stability and gullying potential.

**E.** **Habitat Segmentation Analysis Menu**—to analyze and demarcate fish habitat segmentation due to failed or blocked culverts.

In addition to the menus, there are two tools on the GRAIP toolbar:

**F.** **Drain Rex**—to trace the road segments draining to a particular drain point. (Rex being the faithful dog to sniff out where road segments drain.)

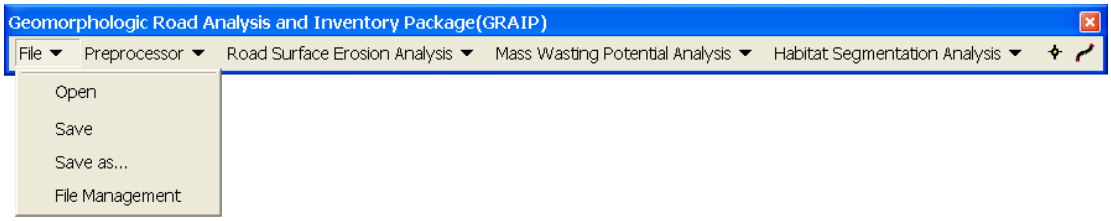
**G.** **Road Rex**—to find drain points to which a particular road segment is draining.

## FILE MENU

### *Open Function*

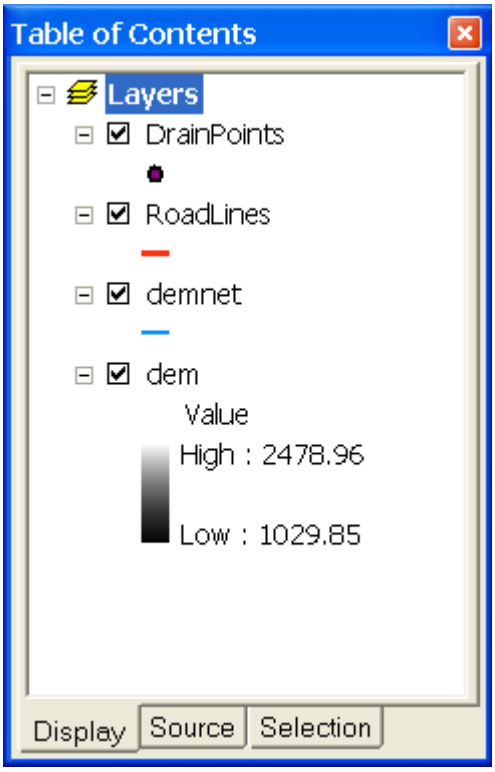
The Open function opens the project file that contains information about files and paths for the GRAIP analysis that was created by the GRAIP Preprocessor.

**28.** Select "File" -> "Open" from the GRAIP Toolbar.

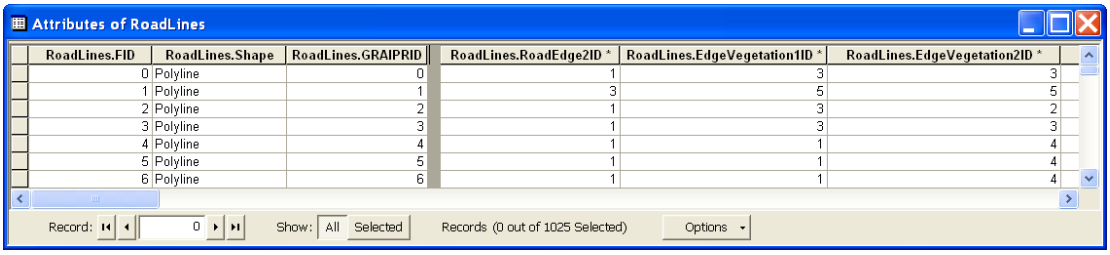



**29.** In the Open dialog, browse to your working folder and select the test.graip project file that was created by the GRAIP Preprocessor. Click Open.

Once this has been opened, the DEM, DrainPoints.shp, RoadLines.shp and demnet.shp files will be loaded and displayed in ArcMap. ArcMap's Table of Contents should look like this:



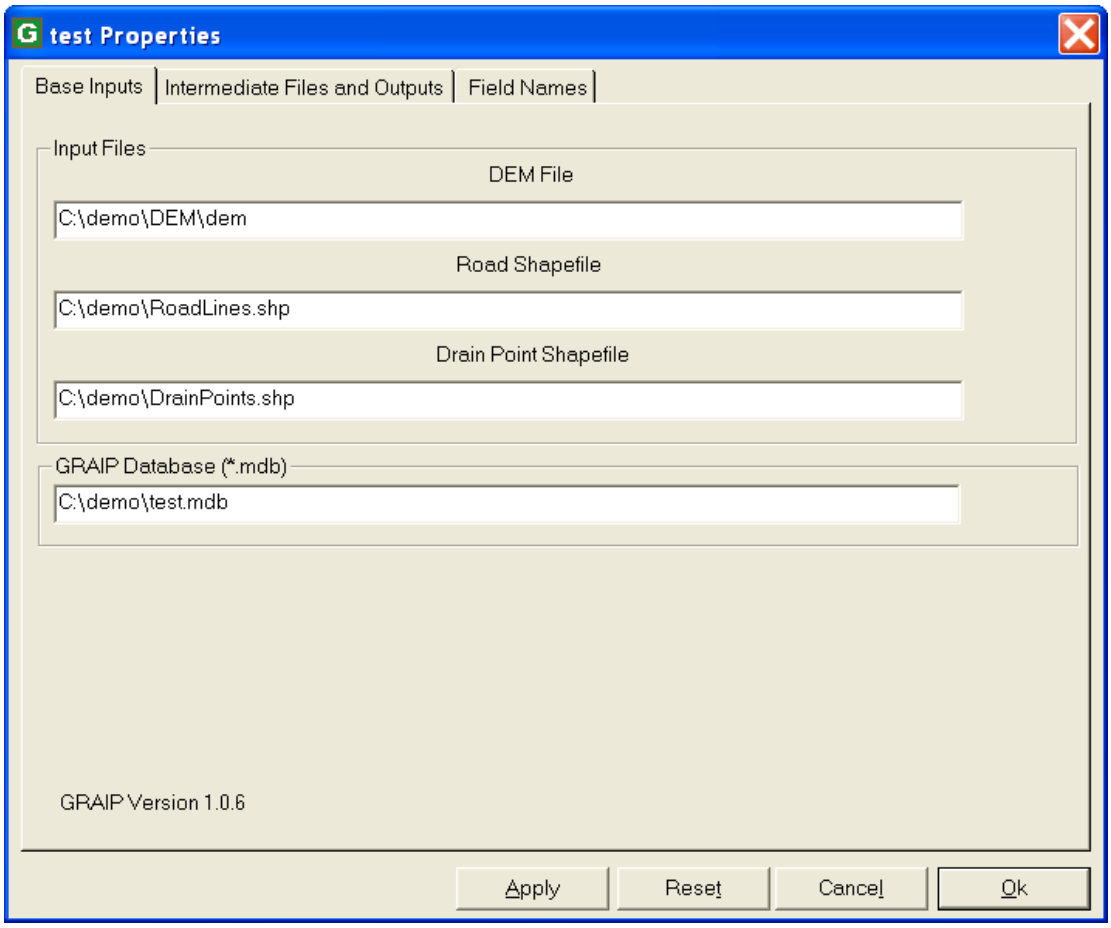

When the project file is used to load the files, the RoadLines and DrainPoints shapefiles are also joined to their corresponding tables in the GRAIP Database (*.mdb) so that the attributes are available for analysis. This allows to open the RoadLines shapefile attribute table and see the data stored in the RoadLines database table:




### *File Management Function*

To view the default file names and paths that will be used for this analysis or if there is a need to change any of the files or file paths for any of the input, intermediate or output files, use the File Management function.

**30.** Select File -> File Management to open the File Management dialog as shown:




Here you can review the default file names and make any necessary adjustments. For this tutorial, we will not make any changes.

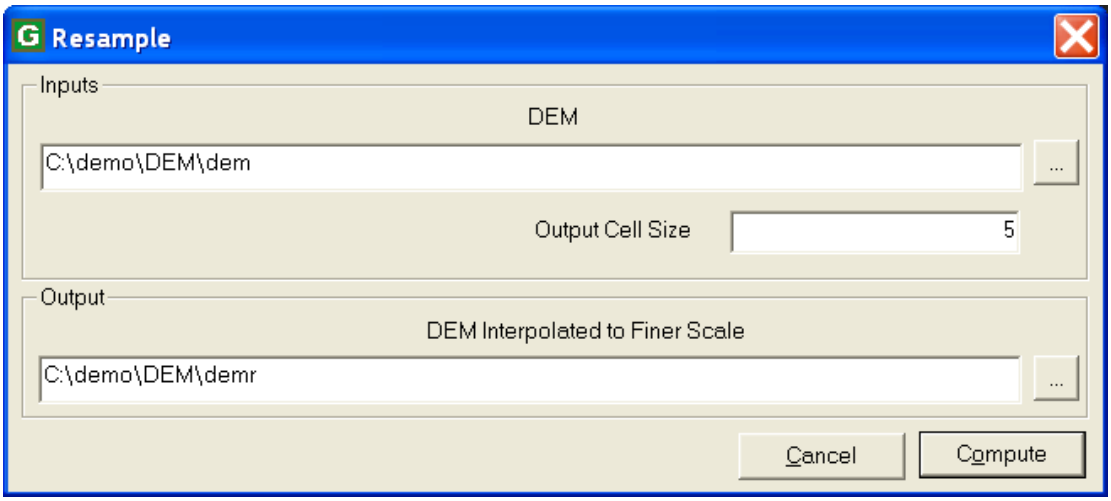
**31.** Click Cancel.

## PREPROCESSOR MENU

### *Resample DEM Function*

This function resamples a DEM to a finer scale using the cubic convolution method from the ArcGIS Toolbox.

**32.** Select Preprocessor -> Resample DEM on the GRAIP Toolbar to get the "Resample" dialog as shown here:

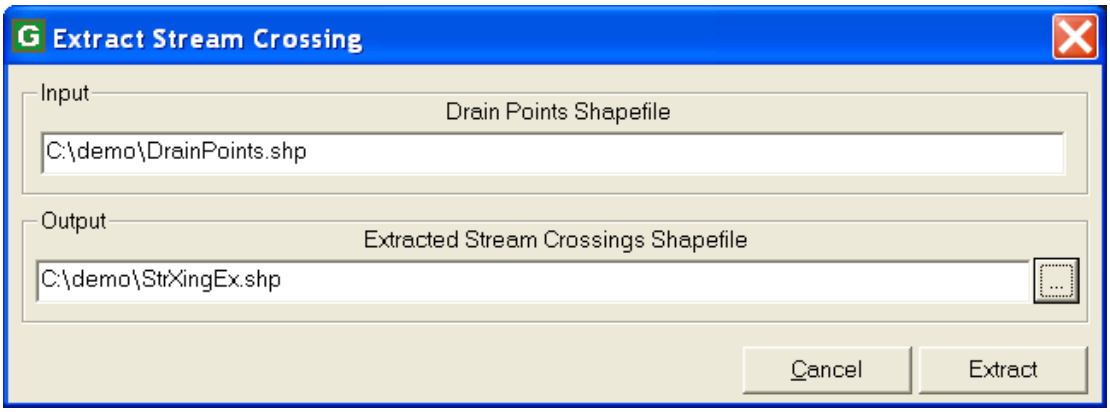



**33.** Click Compute.

### *Extract Stream Crossings Function*

This function extracts the stream crossing drain points from the consolidated DrainPoints shapefile created by the GRAIP Preprocessor.

**34.** Select Preprocessor -> Extract Stream Crossings from the GRAIP toolbar to get the screen shown:



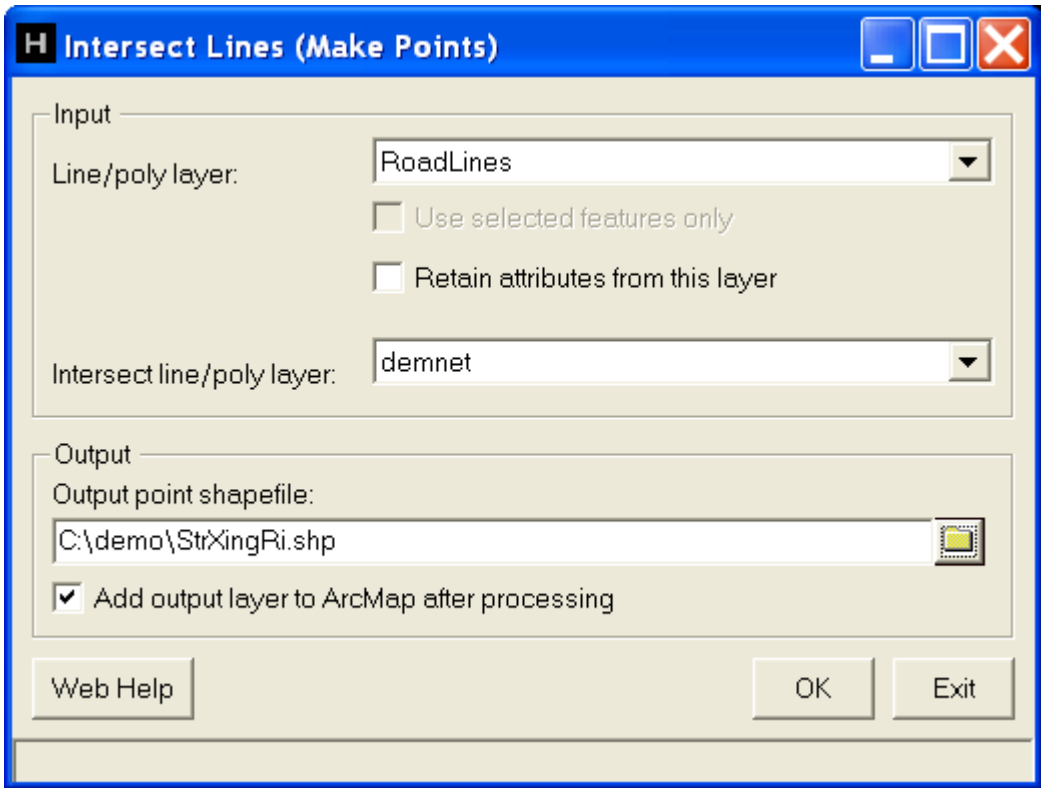

**35.** Click "Extract".

### *Hawth's Tool-Intersect Lines (Make Points) Function*

This function creates a shapefile containing points that are the intersections of the roads from the RoadLines shapefile with the stream network generated by TauDEM.

**36.** Select Hawth's Tools -> Vector Editing Tools -> Intersect Lines (Make Points) from the Hawth's Tools toolbar to get the "Intersect Lines (Make Points)" dialog.

**37.** Select RoadLines as the Line/poly layer, demnet as the Intersect line/poly layer and for the Output point shapefile, browse to the folder you are using for this tutorial and name the file StrXingRi.shp so the screen looks like this:



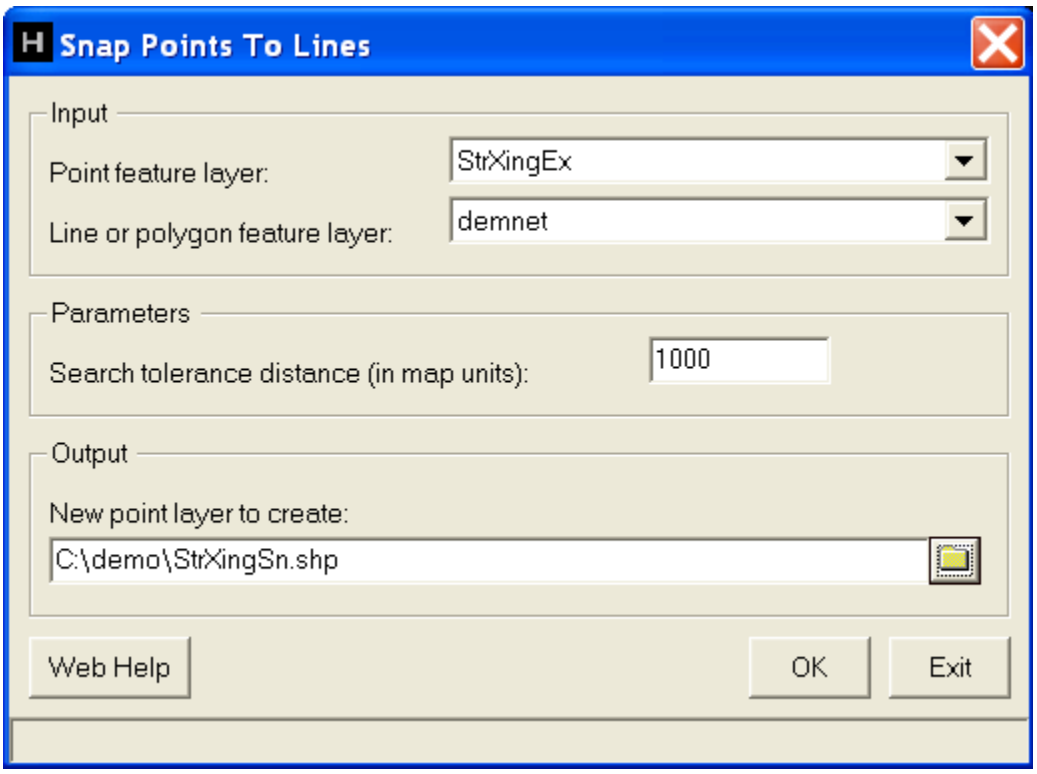

**38.** Click the OK button. Click OK on the confirmation screen.

### *Hawth's Tools-Snap Points to Lines Tool Function*

This function will create a new point shapefile that contains the drainpoints after they have been adjusted so that they actually lie on the preliminary stream network that was created by TauDEM.

**39.** Select Hawth's Tools -> Vector Editing Tools -> Snap Points to Lines Tool from the Hawth's Tools toolbar to get the "Snap Points To Lines" dialog.

**40.** Select StrXingEx as the Point feature layer and demnet as the Line or polygon feature layer. For the New point layer to create, browse to the folder you are using for the tutorial and name the file "StrXingSn.shp".




**41.** Click the OK button. Click OK again on the confirmation screen.

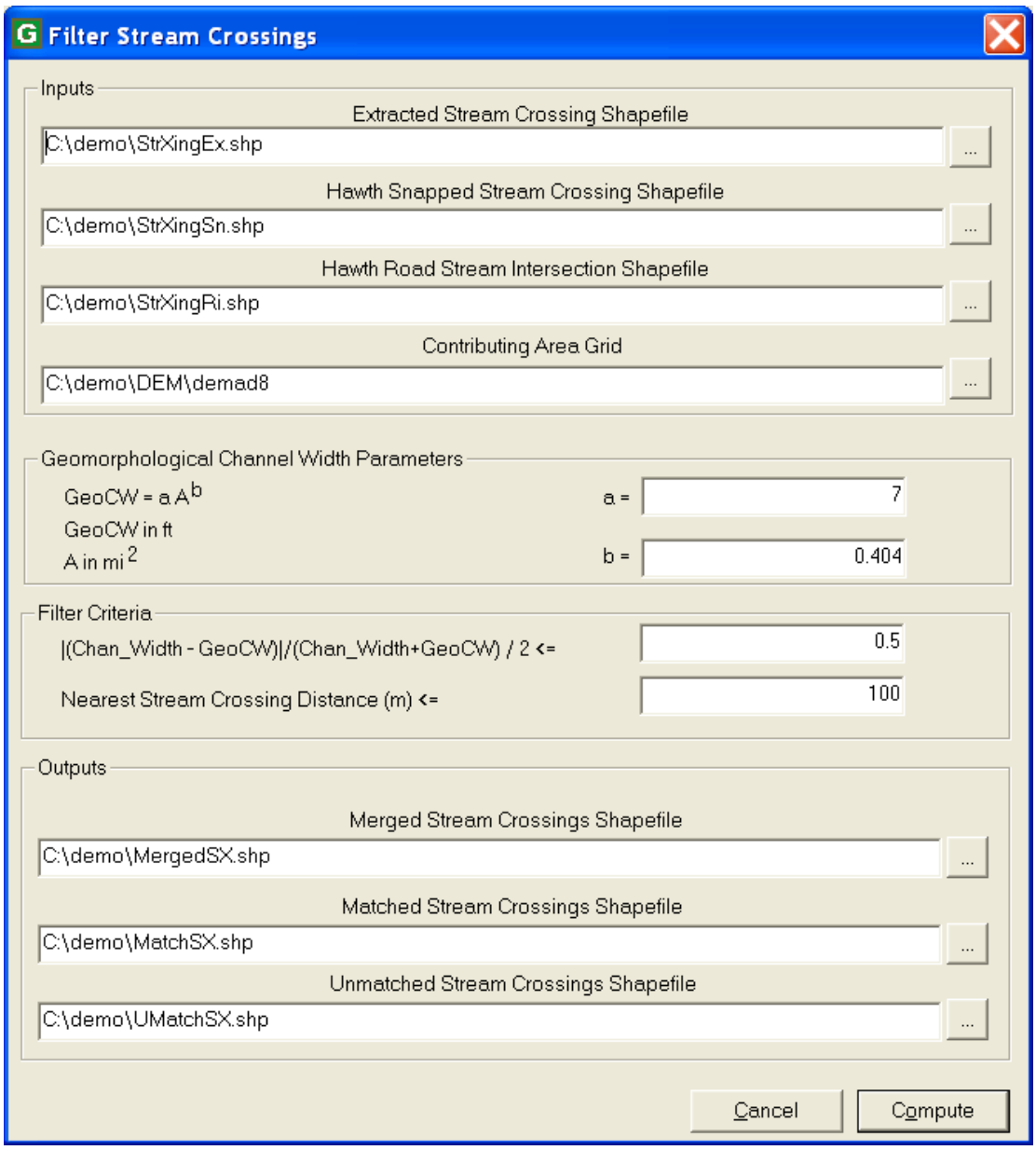
### *Filter Stream Crossings Function*

This function automatically associates the appropriate points on the stream network from the snapped stream crossings file (StrXingSn.shp), and the points that are road-stream intersections (StrXingRi.shp), with nearby surveyed stream crossings (StrXingEx.shp), screened according to nearness and a geomorphologically derived channel width criterion. Three shapefiles are created by this function, one containing all of the merged stream crossings (MergedSX.shp), one containing only the matched stream crossings (MatchSX.shp) and the last containing only the unmatched stream crossings (UMatchSX.shp).

The goal of this function is to position each surveyed stream crossing from StrXingEx.shp on the stream network. This is attempted by examining both the nearest position on the stream to which the stream crossing can be snapped (StrXingSn.shp) and the nearest road stream intersection (StrXingRi.shp). Points that passed one or both of these criteria are in MatchSX.shp. The user should in most cases be able to accept these without further analysis. The surveyed stream crossings for which there was no match found are placed in UMatchSX.shp.

Please Note: This function requires the ArcInfo license.

**42.** Select Preprocessor -> Filter Stream Crossings from the GRAIP toolbar from the GRAIP toolbar as shown:




**43.** Click Compute.

At this point, the user might want to use ArcGIS or other GIS tools to review the unmatched stream points, examining why they are not placed on a stream, making appropriate edits to place them on a stream, and/or identifying situations requiring further examination in the field. For the purposes of this tutorial, we will accept the matched and unmatched stream crossing shapefiles as they were created.

### *ArcGIS Combine Outlets Task*

Now you need to use the ArcGIS tools to create a revised outlets file that contains a combination of all of the matched on-stream points along with the original outlet points from the original outlets file (outlet.shp). As part of this you need to make sure that the Id field is unique. Since the Ids of the matched stream points are already unique, you just need to make sure that the Id of the original outlet is not a duplicate

of any of the matched stream point Ids. Also, be sure not to change any of the matched stream point Ids since they are used in the fish habitat analysis.

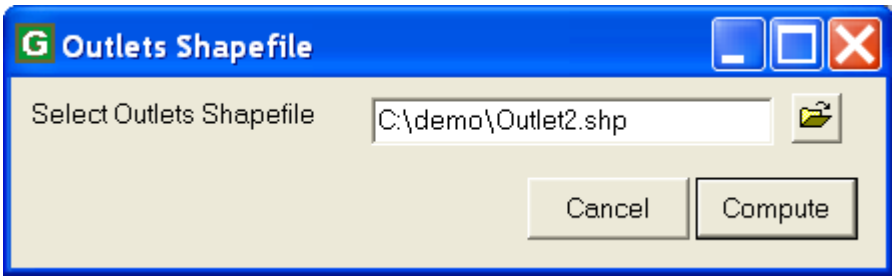
**44.** Select Editor -> Start Editing from ArcMap's Editor toolbar to show the Start Editing dialog. Click on the C:\demo folder (or the folder that contains the outlet.shp file) and click OK. You will receive a warning abou the editing being in a different coordinate system. Click Start Editing. In the Editor toolbar, set the taret layer to "Outlet." Right click on the MatchSX layer and select "Open Attribute Table" to show the Attributes of MatchSX dialog. Click the Options button and select "Select All". Select Edit -> Copy. Click on the Close Box. Right click on the Outlet layer and select "Open Attribute Table" to show the Attributes of Outlet dialog. Select Edit ->Paste. Click on the Close Box. Select Editor -> Stop Editing. Click Yes when asked if you want to save your edits.

If you have any difficulty with this step, you can use the Outlet2.shp file that is in the demo folder.

### *Create TauDEM Stream Network Function*

This function runs the TauDEM Stream Network utility to create a new stream network shapefile using the revised outlets shapefile which contains both the original outlet point as well as the corrected stream crossing points. This revised stream network shapefile is similar to the previous version except that the stream segments are split at stream crossings.

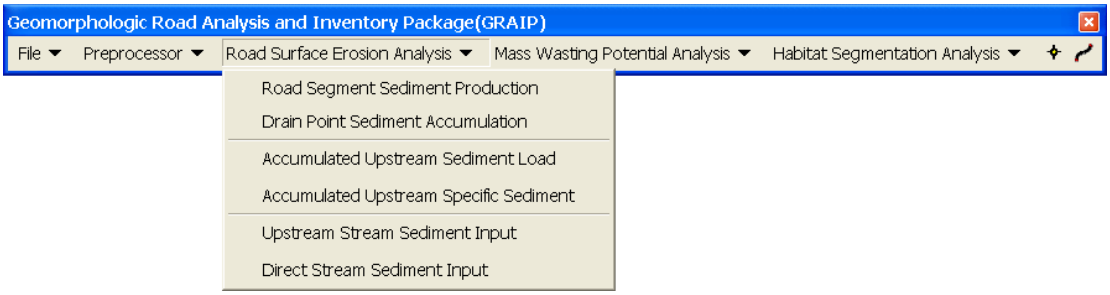
**45.** Select Preprocessor->Create TauDEM Stream Network from the GRAIP toolbar to get the Outlets Shapefile screen shown:




**46.** Click Compute. When asked if it is OK to overwrite files, click OK.

## ROAD SURFACE EROSION ANALYSES MENU

The functions on the GRAIP toolbar menu Road Surface Erosion should be run in sequence from top to bottom.



### *Road Segment Sediment Production Function*

The Road Segment Sediment Production function calculates sediment production values for each stream segment according to:

$$E_i = \frac{aLSrv}{2}$$

where E is the erosion from each forest road segment in kg/yr, i indicates the side of the road, *a* is the annual base erosion rate (with 79 kg/yr being the default, although a different value could be defined for each road segment shapefile when it is imported with the preprocessor), *L* is the road segment length, *S* is the slope, *r* is the road surface multiplier which varies depending on the type of road surface, and *v* is the flow path vegetation multiplier which varies depending on the density of the flow path vegetation. Please realize that *LS* is also equal to the difference in maximum and minimum elevations in the road segment.

The three parameters, *a*, *r* and *v* are stored in the following field/tables in the project database which for the tutorial is located at C:\demo\test.mdb:

**A.** *a* (annual based erosion rate) --> BaseRate field in the RoadNetworkDefinitions table

**B.** *r* (road surface multiplier) --> Multiplier field in the SurfaceTypeDefinitions table

**C.** *v* (flow path vegetation multiplier) --> Multiplier field in the FlowPathVegDefinitions table

These parameters can be edited prior to executing this step by double clicking on the test.mdb file in the file explorer. Then double click on the table for the desired parameter and edit the field listed for that parameter. Changes are automatically saved when you exit each record.

The Road Sediment Production function populates the following fields in the RoadLines table in the GRAIP database, test.mdb:

**A.** **Length**-Road length (meters)

**B.** **SedProd1**-Sediment production for one side of the road (kg/yr)

**C.** **SedProd2**-Sediment production for the other side of the road (kg/yr)

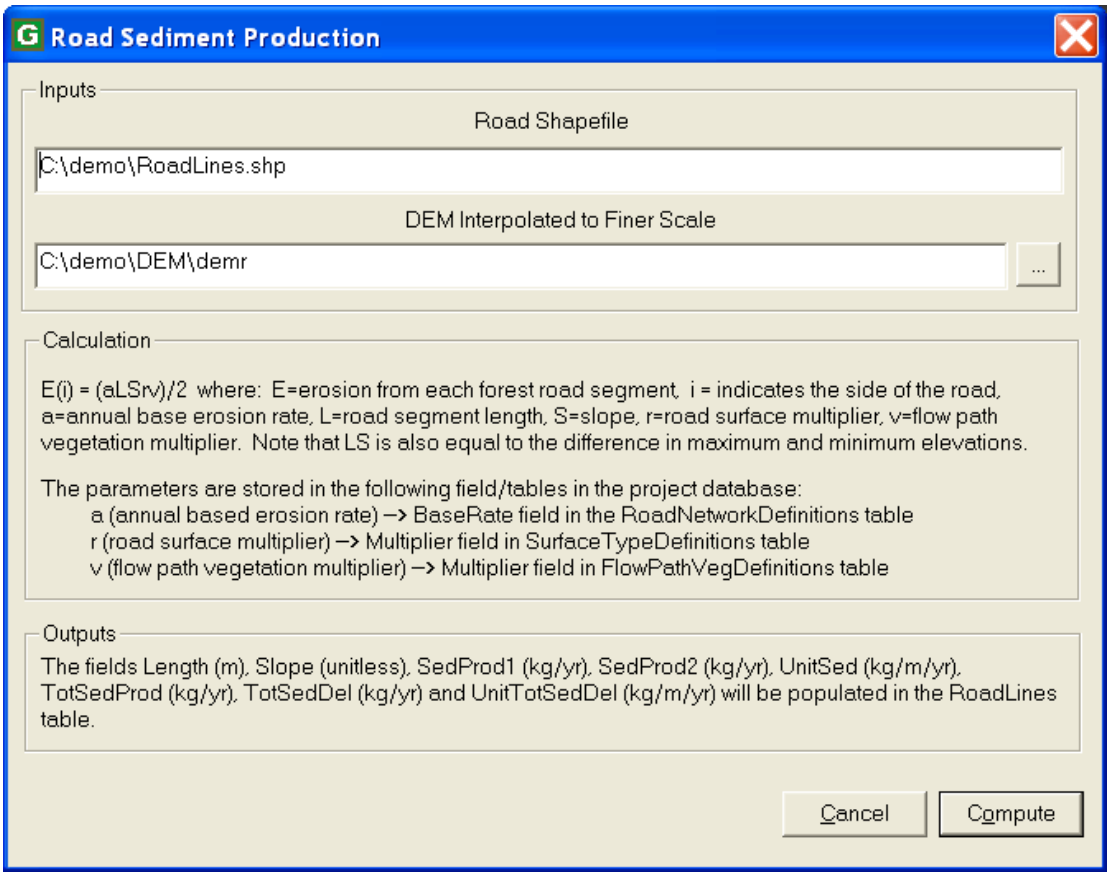
**D.** **UnitSed**-Unit sediment production from the road segment (kg/m/yr)

**E.** **TotSedProd**-SedProd1+SedProd2 (kg/yr)

**F.** **TotSedDel**-Sediment delivered to streams (calculated using stream connection information for each road) (kg/yr)

**G.** **UnitTotSedDel**-TotSedDel/Length (kg/m/yr)

**47.** Select Road Surface Erosion Analysis -> Road Segment Sediment Production function to show this screen:




**48.** Click Compute.

### *Drain Point Sediment Accumulation Function*

This function calculates sediment accumulation values for each drain point. As part of this, the following drain point fields are populated:

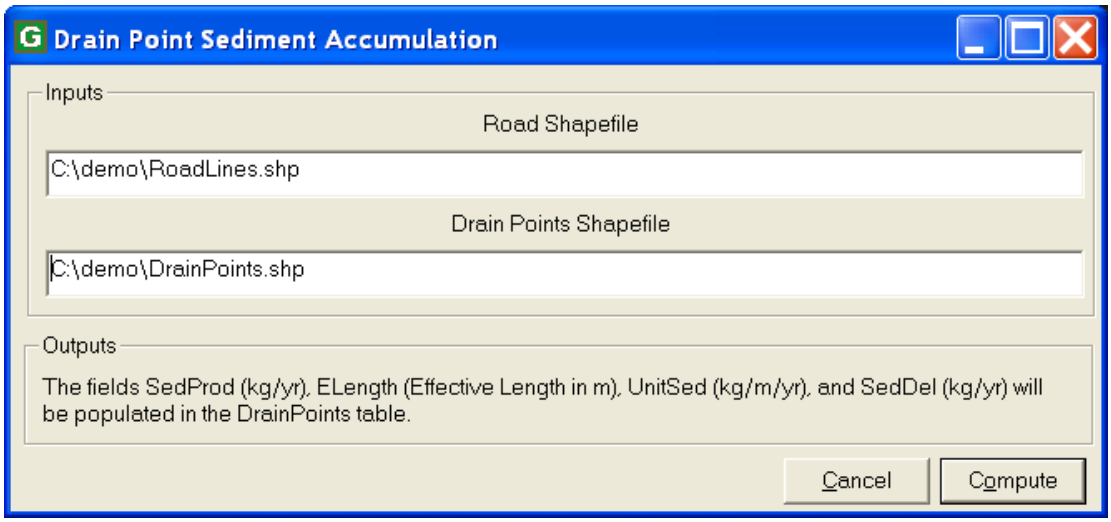
**A.** SedProd-Total accumulated sediment load at each drain point due to road surface erosion (kg/yr)

**B.** ELength-Effective length of road draining to each drain point (meters)

**C.** UnitSed-SedProd/Elength (kg/m/yr)

**D.** SedDel-Sediment delivery depending on stream connection (kg/yr)

**49.** Select Road Surface Erosion Analysis ->Drain Point Sediment Accumulation function to open this screen:




**50.** Click Compute.

### *Accumulated Upstream Sediment Load Function*

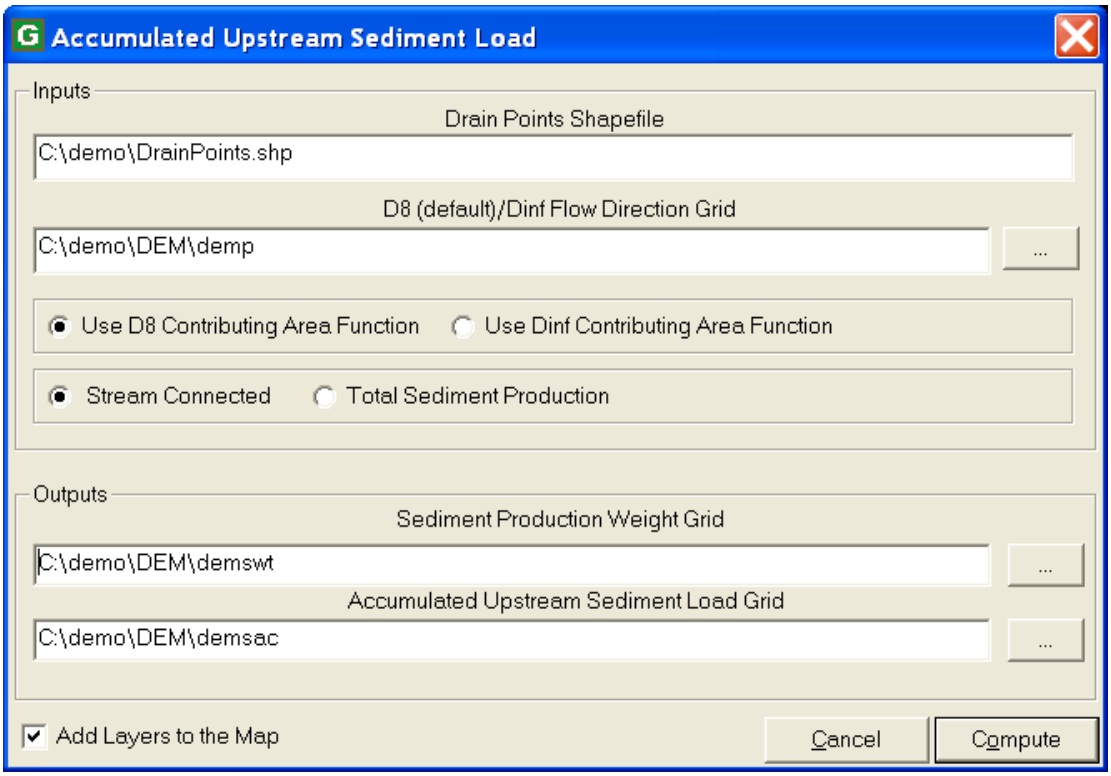
This function creates the following output grids:

**A.** Weight grid with Drain Point accumulated sediment load (with a *swt name format).

**B.** Weighted Sediment Accumulation grid (with a *sac name format).

The user can select between D8 and Dinf Contributing area functions.

**51.** Select Road Surface Erosion Analysis-> Accumulated Upstream Sediment Load function in the GRAIP toolbar to show this screen:

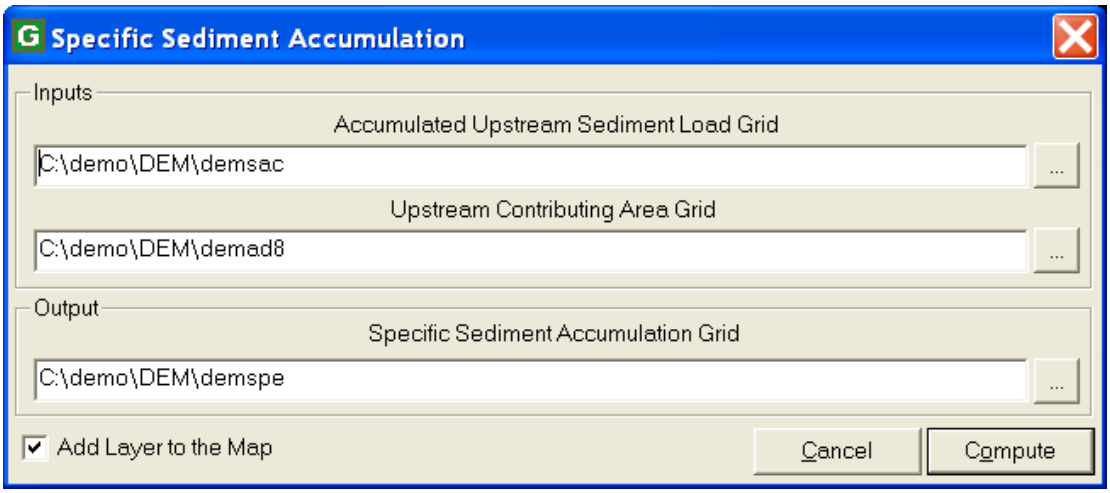



**52.** Click Compute.

### *Accumulated Upstream Specific Sediment Function*

This function creates the upstream specific sediment accumulation grid (with a *spe name format).

**53.** Select Road Surface Erosion Analysis -> Accumulated Upstream Specific Sediment function to show the following screen.




**54.** Click Compute.

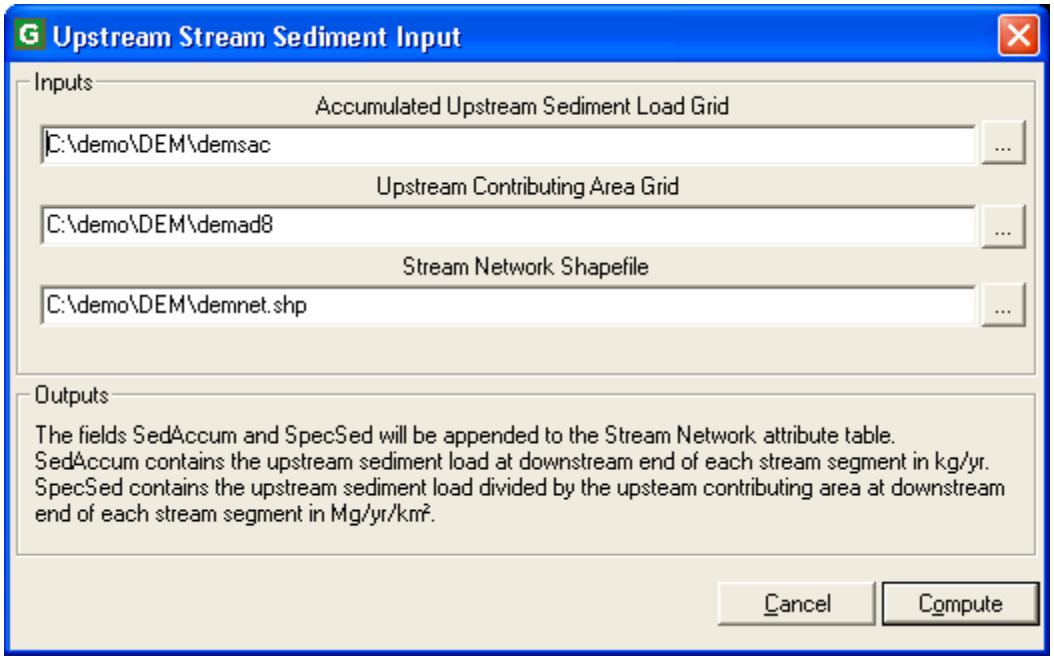
### *Upstream Stream Sediment Input Function*

This function calculates sediment accumulation for the downstream end of each stream segment. The following fields are appended to the stream network shapefile (that has a *net.shp name format):

**A.** **SedAccum**-Accumulated Sediment Inputs for each stream segment (kg/yr).

**B.** **SpecSed**-Accumulated Specific Sediment Load per unit area for each stream segment (Mg/km2/yr).

**55.** Select Road Surface Erosion Analysis-> Upstream Stream Sediment Input function to show this screen.




**56.** Click Compute.

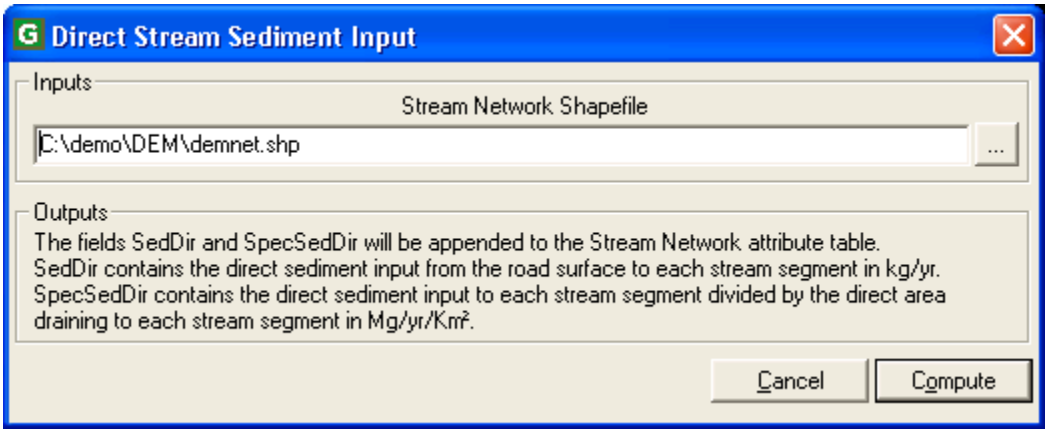
### *Direct Stream Sediment Input Function*

This function calculates the sediment load for the area draining directly to stream segment. These fields are appended to the stream network shapefile (that has a *net.shp name format).

**A.** **SedDir**-Direct Sediment Inputs for each stream segment (kg/yr).

**B.** **SpecSedDir**-Direct Specific Sediment Load per unit area for each stream segment (Mg/km2/yr).

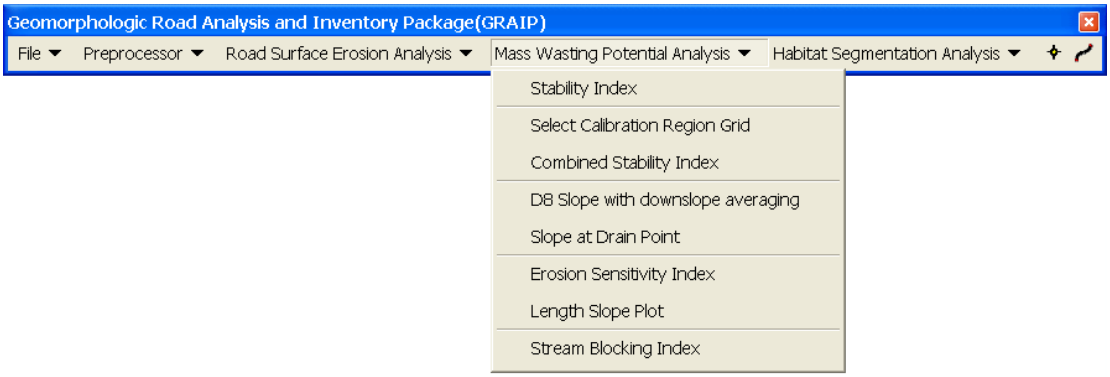
**57.** Select Road Surface Erosion Analysis->Direct Stream Sediment Input function from the GRAIP toolbar to show this screen:




**58.** Click Compute.

## MASS WASTING POTENTIAL ANALYSIS MENU

The functions on the Mass Wasting Potential Analysis Menu (Figure 20) should be run in a sequence from top to bottom.




### *SINMAP 2.0 Stability Index & Calibration Region Grid Functions*

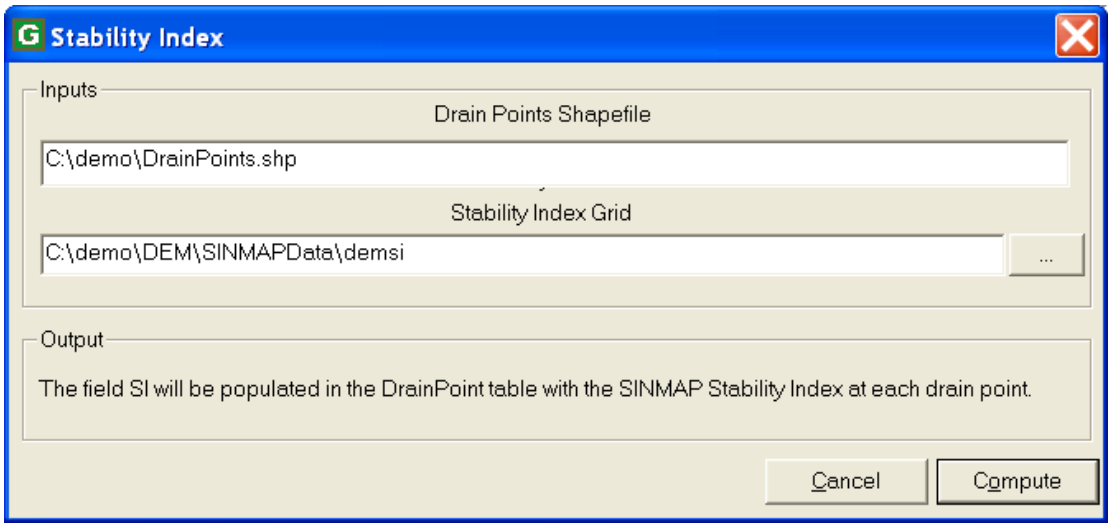
SINMAP2.0 is used to create a Stability Index (SI) grid and a calibration region grid from the DEM. Calibration regions are areas within which single lower bound and upper bound calibration parameters values can represent T/R, dimensionless cohesion, friction angle (ø) and soil density (ρ).

**59.** Run SINMAP 2.0 to create a Stability Index (SI) grid (C:\demo\DEM\SINMAPData\demsi) and a calibration region grid (C:\demo\DEM\SINMAPData\demcal) from the DEM. For more information on using SINMAP 2.0, see http://hydrology.neng.usu.edu/sinmap2/.

### *Stability Index Function*

This function looks up the Stability Index grid values at each drain point and stores them in the SI field in the DrainPoints table.

**60.** Select Mass Wasting Potential Analysis -> Stability Index from the GRAIP toolbar to show this screen:

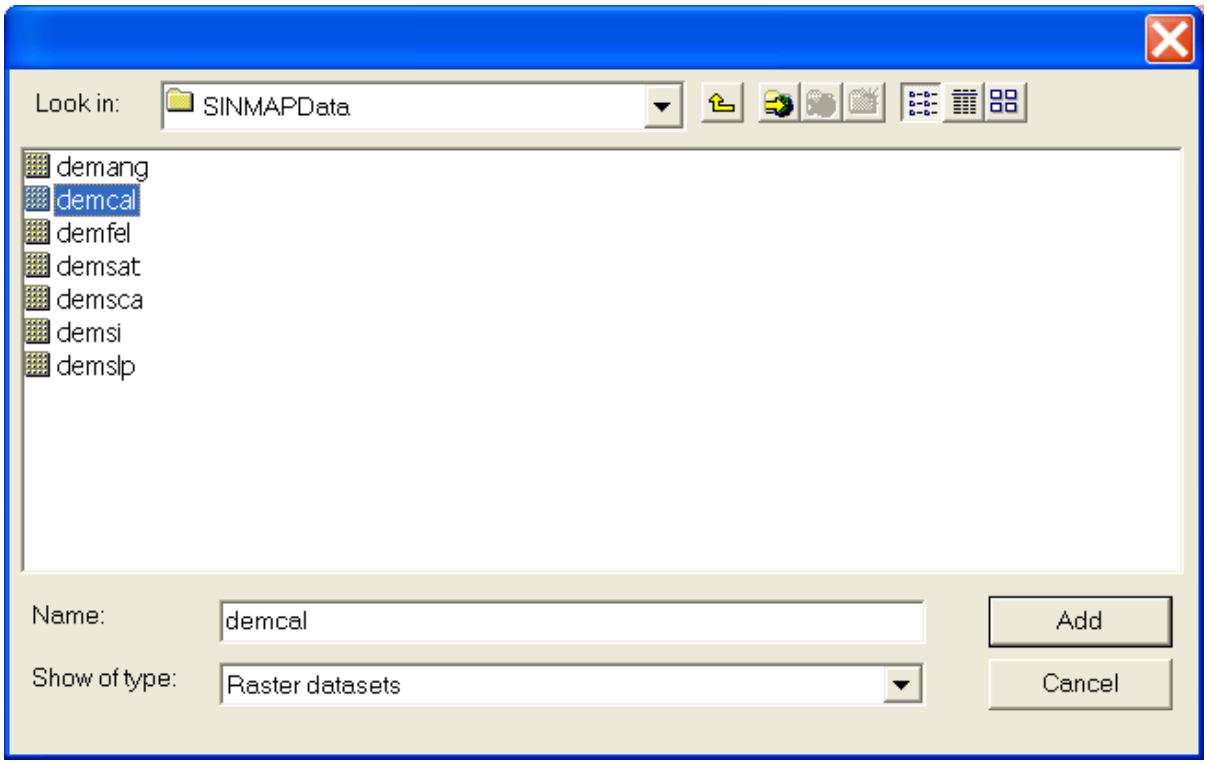



**61.** Click compute.

### *Combined Stability Index Function*

This function creates a Combined Stability Index Grid (with a *sic file format) and stores the value from that grid at each drain point in the SIR Field of the drain pint table in the GRAIP database.

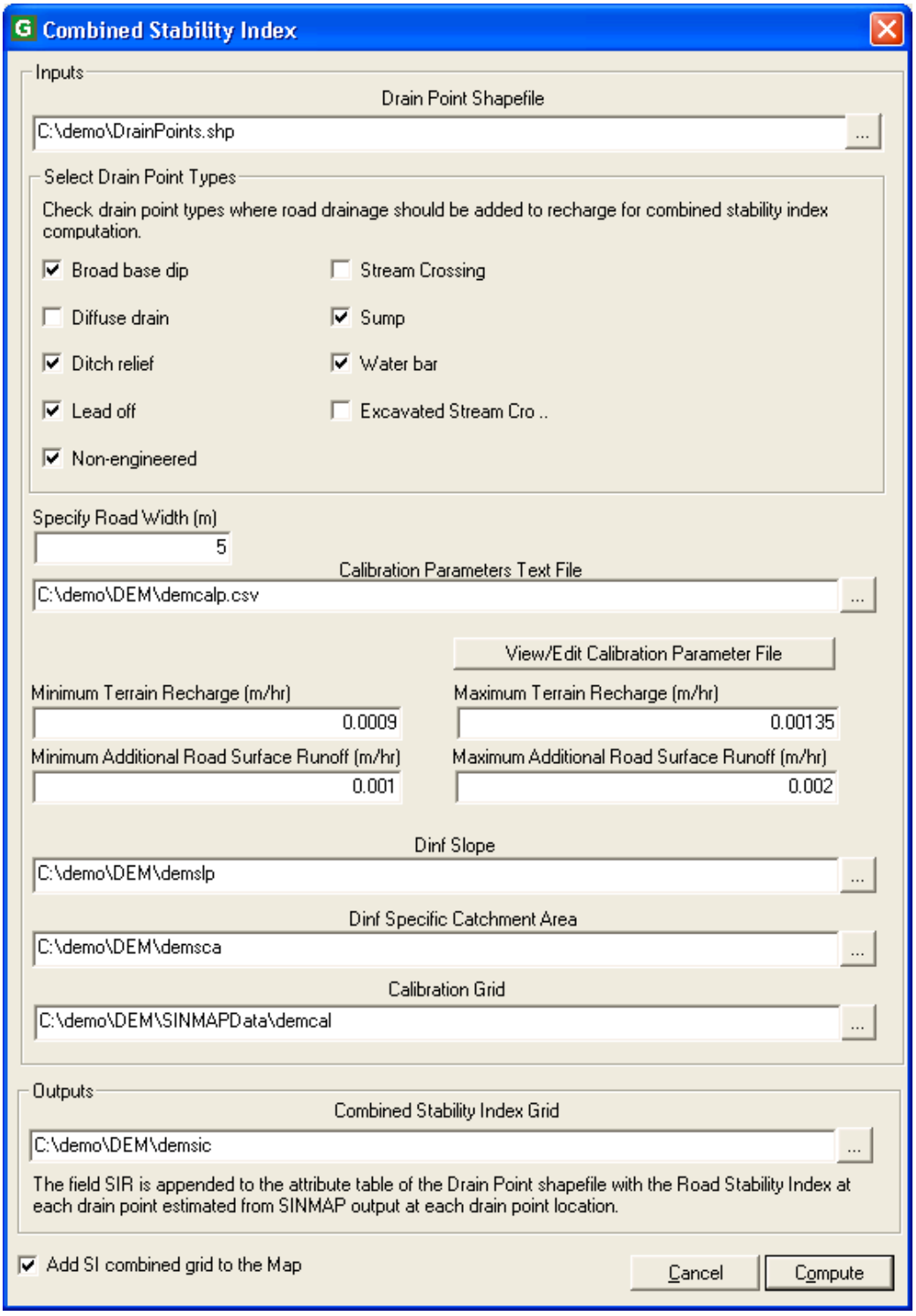
**62.** Select Mass Wasting Potential Analysis -> Select Calibration Region Grid and browse to the calibration region grid (C:\demo\DEM\SINMAPData\demcal) to get the screen shown:



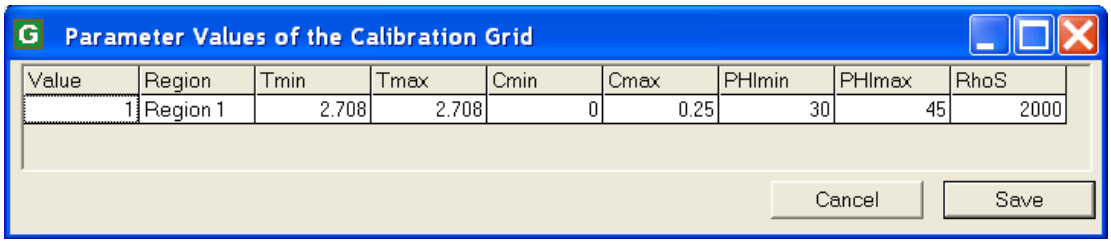
**63.** Click the "Add" button.

The grid is added to ArcMap and default combined stability index parameters are written to the parameter file (suffix *calp.csv).

**64.** Select Mass Wasting Potential Analysis -> Combined Stability Index from the GRAIP toolbar to show this screen:



The View/Edit Calibration Parameter File button on the Combined Stability Index dialog can be used to open the Parameter Values of the Calibration Grid dialog shown:




These parameters are user adjustable. But for the purposes of this tutorial, we will not open the dialog. The user may also select a different combined stability index calibration parameters file. If doing so, ensure that the value column matches the values in the grid or else an error may occur.

Note that this function computes a combined stability index considering terrain drainage and additional road surface runoff. Road surface runoff is evaluated only at the drain point types indicated. Additional runoff from other drain points is not considered. Road surface runoff is evaluated as road width times the road surface runoff parameters given times the effective length of road segments to each drain point.

**65.** Click Compute.

The output and intermediate files created are:

**A.** Minimum and maximum depth of terrain runoff generated (with *rmin and *rmax file formats).

**B.** Specific discharge due to road drainage for Minimum runoff and Maximum runoff (with *rdmin and *rdmax file formats).

**C.** Combined Stability Index Grid (with a *sic file format).

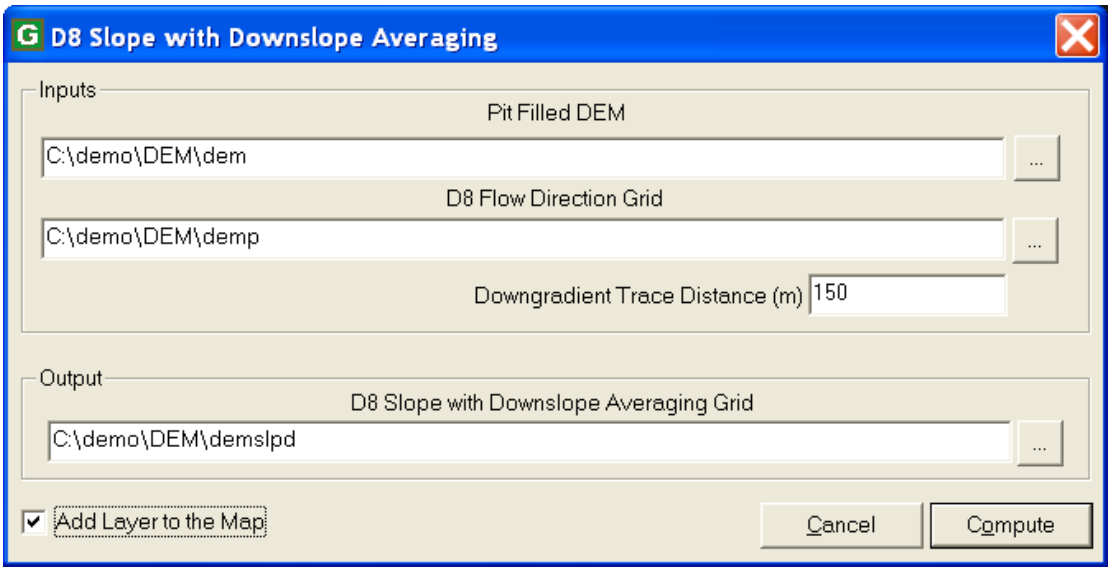
The intermediate outputs (A) and (B) are not added to ArcMap. The output file (C) is added if the "Add SI combined grid to the Map" checkbox is checked which is the default.

In this function, stability index (SI) due to terrain contributing area can be calculated by setting the road surface runoff to be 0, and SI due to road runoff only can be computed setting terrain recharge to be 0. The SI values from the grid are used to identify SI values to store in the SIR Field in for each drain point in the GRAIP database.

### *D8 Slope Grid with Downslope Averaging Function*

This function uses the D8 flow directions approach to trace downslope and find the average slope for each grid cell over the specified averaging distance. The output from this function is the slope grid with downslope averaging (Suffix .slpd).

**66.** Select Mass Wasting Potential Analysis -> D8 Slope Grid with downslope averaging from the GRAIP toolbar to show this screen:

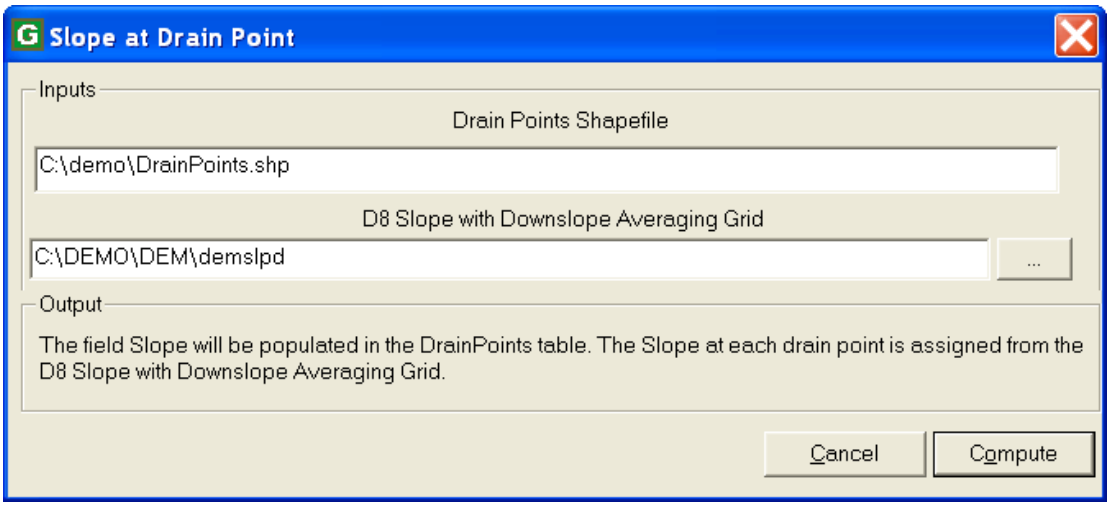



**67.** Click Compute.

### *Slope at Drain Point Function*

This function calculates the slope at each drain point and stores it in the Slope field in the DrainPoints table of the GRAIP database.

**68.** Select Mass Wasting Potential Analysis -> Slope at Drain Point from the GRAIP toolbar to open this screen:

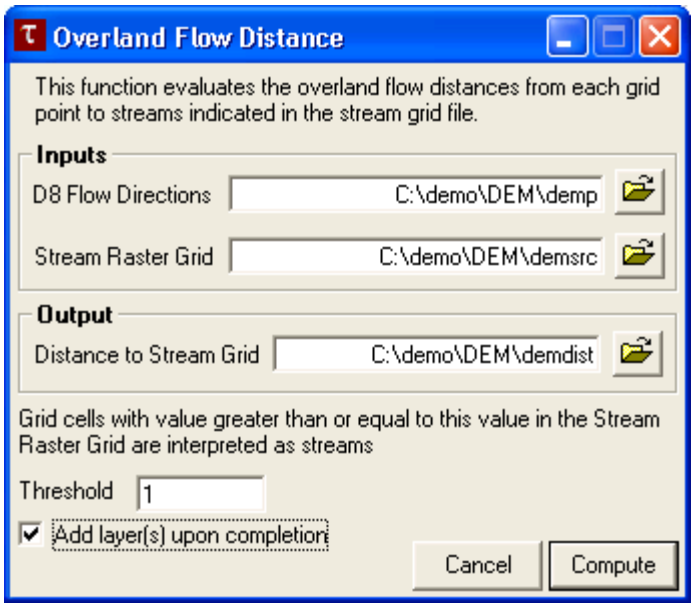



**69.** Click Compute.

### *Distance to Stream Function*

TauDEM includes a function to evaluate Flow Distance to Streams.

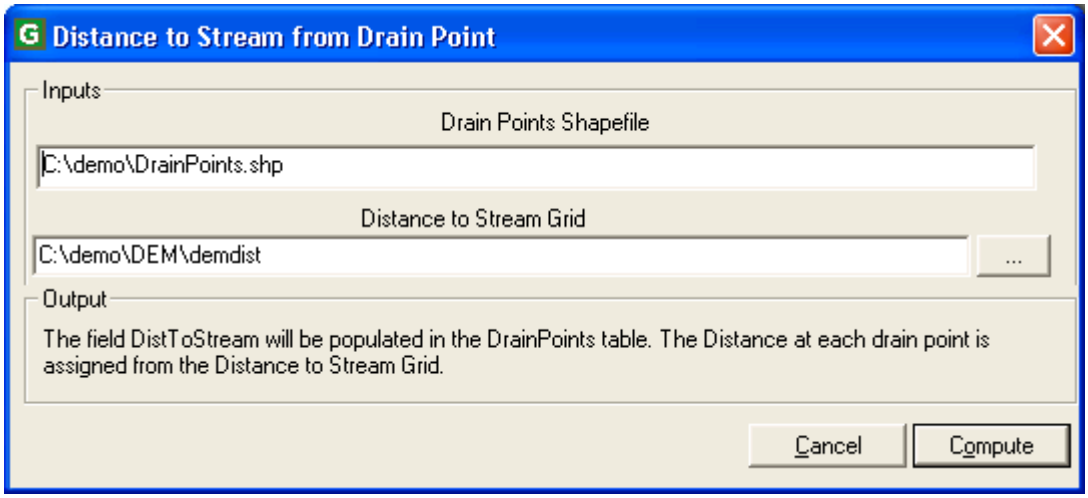
**70.** Select Specialized Grid Analysis -> Flow Distance to Streams from the TauDEM toolbar to open this screen:




**71.** Click Compute.

### *Distance to Stream From Drain Point*

**72.** Select Mass Wasting Potential Analysis -> Distance to Stream from Drain Point from the GRAIP toolbar to open this screen:

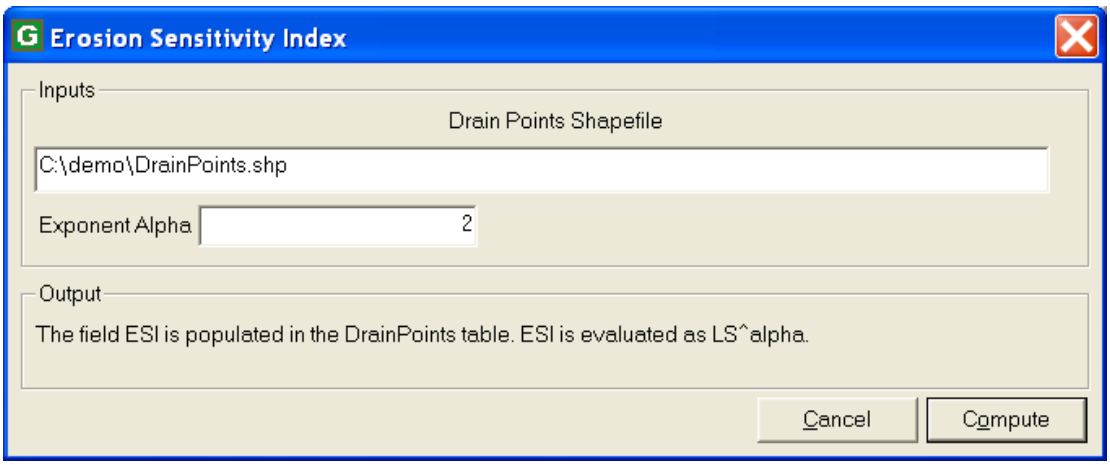



**73.** Click Compute.

### *Erosion Sensitivity Index Function*

This function populates the ESI field in the DrainPoint table ESI is calculated as $LS^{\alpha}$ where S is the slope and L is the Effective Length of the road draining to each drain point.

**74.** Select Mass Wasting Potential Analysis -> Erosion Sensitivity Index from the GRAIP toolbar to show this screen:

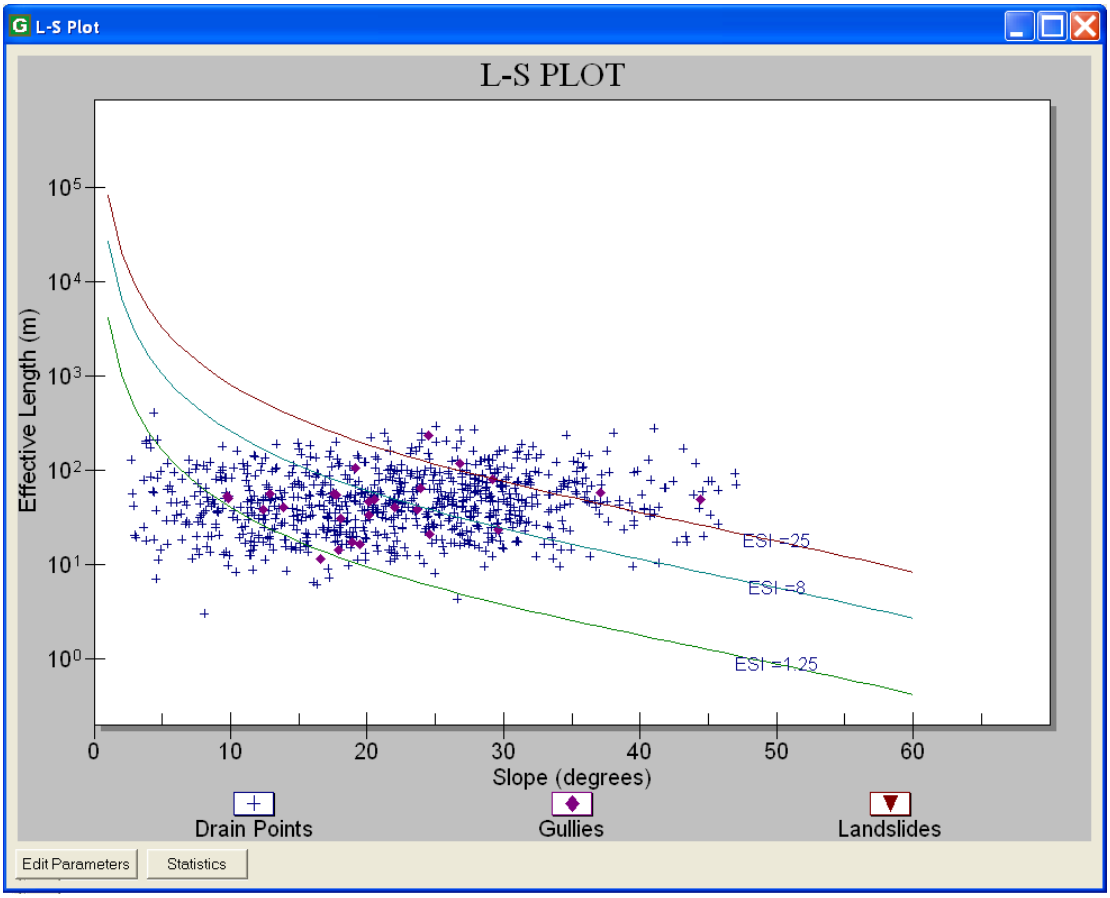



**75.** Click Compute.

### *Length Slope Plot Function*

This function shows the Length-Slope plot with Length on the Y-axis and Slope on the X-axis.

**76.** Select Mass Wasting Potential Analysis -> Length Slope Plot from the GRAIP toolbar to show this screen:



**77.** Click the Close icon in the upper right corner of the dialog.

### *Stream Blocking Index Function*

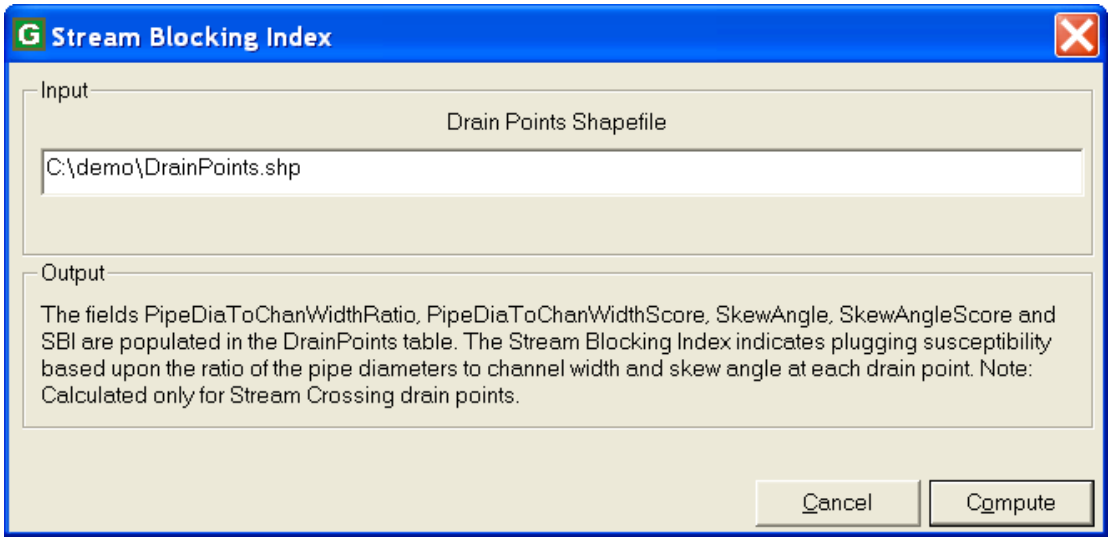
This function populates these fields in the DrainPoints table in the GRAIP database:

**A.** SBI: Stream Blocking Index indicating plugging susceptibility based on the ratio of pipe diameters to channel width ratio class and skew angle score.

**B.** PipeDiaToChannelWidthScore: Ratio of pipe diameter divided by channel width ratio class.

**C.** SkewAngleScore: Skew angle score.

**78.** Select Mass Wasting Potential -> Stream Blocking Index from the GRAIP toolbar to show this screen:



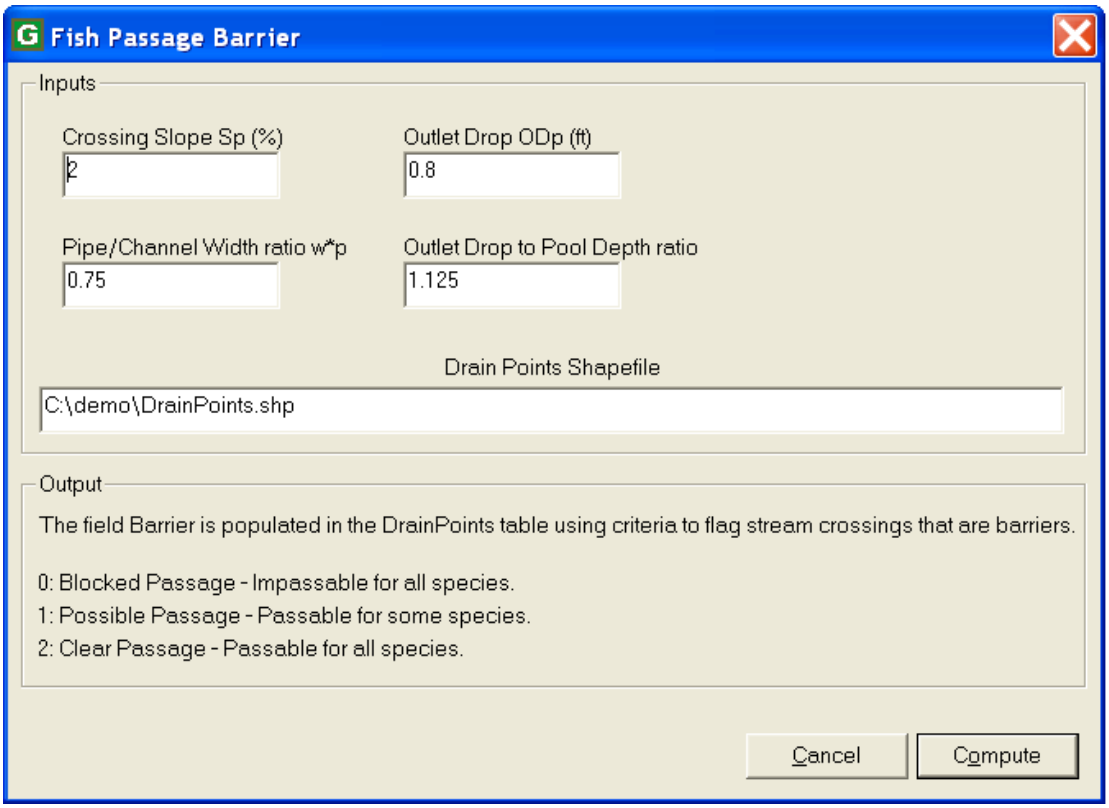

**79.** Click Compute.

## HABITAT SEGMENTATION ANALYSIS MENU

### *Fish Passage Barrier Function*

This function identifies the fish passage barriers and assigns an identifier representing the status of the stream crossing: 0-Blocked Passage, 1- Possible Passage and 2- Clear Passage. This identifier is used to populate the Barrier field in the DrainPoints table in the GRAIP database. Possible Passage identifies the stream crossings that may be passable to some species, but not to others.

**80.** Select Habitat Segmentation Analysis -> Fish Passage Barrier from the GRAIP Toolbar to show this screen:

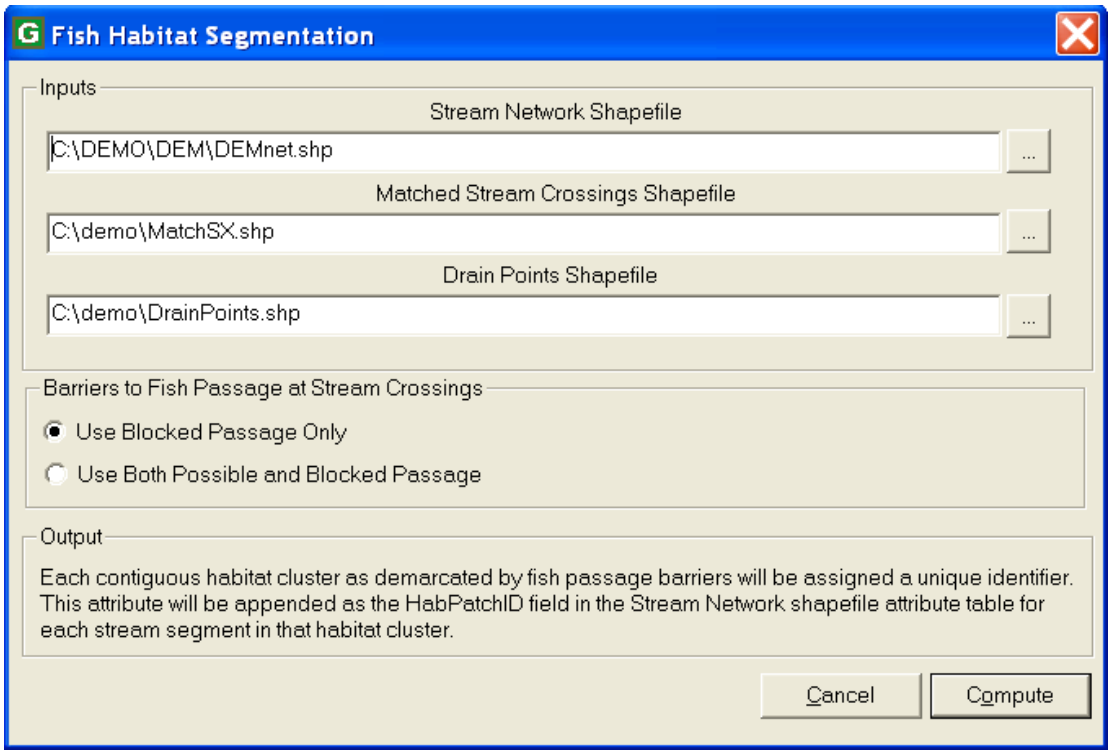



**81.** Click Compute.

### *Fish Habitat Segmentation Function*

This function assigns an identifier to each stream segment indicating the habitat cluster to which it belongs. The habitat cluster identifier is appended to the TauDEM stream network shapefile attribute table.

**82.** Select Habitat Segmentation Analysis -> Fish Habitat Segmentation function from the GRAIP toolbar to show this screen:




**83.** Click Compute.

# REFERENCE MANUAL

## USFS ROAD INVENTORY TABLES DATA DICTIONARY

### *Roads Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SURF_TYPE | Road surface type |
| SURF_COND | Road surface condition |
| ROAD_TYPE | System road or high clearance |
| RD_EDGE_1 | Cut slope height or road edge feature |
| RD_EDGE_2 | Cut slope height 2 or road edge feature |
| EDGE_VEG_1 | Roadside vegetation density 1 |
| EDGE_VEG_2 | Roadside vegetation density 2 |
| EDG_CND_1 | Edge condition 1 |
| EDG_CND_2 | Edge condition 2 |
| FLOW_PATH1 | Location of flowing water 1 |
| FLOW_PATH2 | Location of flowing water 2 |
| FLWPTH_VG1 | Vegetation on flow path 1 |
| FLWPTH_VG2 | Vegetation on flow path 2 |
| FLWPTHCND1 | Condition of flow path 1 |
| FLWPTHCND2 | Condition of flow path 2 |
| FILL_CHAN | Fill slope toe to channel edge distance in feet |
| SURF_COV | Road surface cover |
| CDATE | Survey collection date |
| CTIME1 | Survey collection time 1 |
| CTIME2 | Survey collection time 2 |
| VEHICLE | Survey vehicle used |
| COMMENT | Additional information about the road segment |

### *Broad Based Dip Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SLOPE_SHAP | Shape of the slope |
| DISCHRG_TO | Destination of discharge (i.e., gully, forest floor) |
| STREAM_CON | Stream connection |
| OBSTRUCT | Debris in flow path of drain |
| FILL_EROS | Fill erosion present or not |
| TYPE | Broad based dip type |
| CONDIT | Condition of the drain point |
| MATERIAL | Material found in the drain point |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

### *Diffuse Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SLOPE_SHAP | Slope shape |
| DISCHRG_TO | Destination of discharge (i.e., gully, forest floor) |
| STREAM_CON | Stream connection present or not |
| OBSTRUCT | Debris in flow path of drain |
| FILL_EROS | Fill erosion present or not |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

### *Ditch Relief Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SIZE | Pipe diameter in inches |
| TYPE | Culvert material |
| SLOPE_SHAP | Slope shape |
| DISCHRG_TO | Destination of discharge (i.e., gully, forest floor) |
| STREAM_CON | Is there a stream connection? |
| FILL_EROS | Fill slope eroded below pipe? |
| FLOW_DIVER | Presence of flow diversion? |
| OBSTRUCT | Debris in flow path of drain? |
| FLOW_DIFFU | Flow diffuser type |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| PIPE_LEN | Pipe length in feet |
| CONDIT | Sediment occlusion |
| VEHICLE | Survey vehicle used |

### *Lead-off Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SLOPE_SHAP | Slope shape |
| DISCHRG_TO | Discharge to (i.e. gully, forest floor) |
| STREAM_CON | Stream connection present or not? |
| CONDIT | Condition |
| OBSTRUCT | Debris in flow path of drain |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

### *Non-Engineered Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SLOPE_SHAP | Slope shape |
| DISCHRG_TO | Destination of discharge (i.e., gully, forest floor) |
| STREAM_CON | Stream connection present or not? |
| OBSTRUCT | Debris in flow path of drain? |
| FILL_EROS | Fill erosion present or not? |
| CONDIT | Condition |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

### *Stream Crossing Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| TYPE | Culvert Material |
| R_PIPE_DIA | Round pipe diameter in inches |
| OVAL_PIPE | Oval pipe size |
| PIPE_LEN | Pipe length in feet |
| CHAN_WDTH | Channel width in feet |
| PIPE_NUM | Number of pipes used |
| FILL_DEPTH | Fill depth in feet |
| CONDIT | Condition |
| CHAN_ANGL | Angle between pipe and channel |
| BLOCK_TYP | Evidence of blockage |
| OUTLET_DRP | Outlet drop measured below pipe in feet and tenths |
| PL_DEPTH | Depth below outfall in feet and tenths |
| PIPE_GRADE | Grade measured in percent |
| SUBSTRATE | Crossing substrate |
| DEBRIS_FLW | Debris flow |
| FILL_EROS | Fill erosion |
| DIVERSION | Presence and direction of channel diversion |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

### *Sump Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| CONDIT | Condition |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

### *Water Bar Drain Point Shapefile Attribute Table*

| Field Name | Description |
|---|---|
| SLOPE_SHAP | Slope shape |
| DISCHRG_TO | Destination of discharge (i.e.; gully, forest floor) |
| STREAM_CON | Stream connection present or not? |
| OBSTRUCT | Debris in flow path of drain? |
| FILL_EROS | Fill erosion present or not? |
| TYPE | Drain point material |
| CONDIT | Condition |
| COMMENT | Comment |
| CDATE | Survey collection date |
| CTIME | Survey collection time |
| VEHICLE | Survey vehicle used |

# GRAIP DATABASE TABLES

## MASTER TABLES

### *DrainPoints Table*

| Field Name | Description | Menu Function |
|---|---|---|
| GRAIPDID | Unique drain point identifier. Primary key. | Preprocessor |
| DrainTypeID | Type of drain point | Preprocessor |
| CDate | Survey collection date | Preprocessor |
| CTime | Survey collection time. 10 character text field. | Preprocessor |
| VehicleID | Survey vehicle identifier | Preprocessor |
| DrainID | Numeric drain point identifier built from the CDATE, CTIME and VEHICLEID fields. Should be unique for each drain point. | Preprocessor |
| StreamConnectID | Stream connection present or not. Field not in SteamCrossing or Sump shapefiles. Data is populated by assuming 2 (Yes) for all StreamCrossing drain points and 1 (No) for all Sump drain points. | Preprocessor |
| Comments | Description or comments about the drain point feature | Preprocessor |
| SedProd | Accumulated road sediment load to each drain point (kg/yr) | Drain Point Sediment Accumulation |
| ELength | Effective length of the road draining to each drain point (m) | Drain Point Sediment Accumulation |
| UnitSed | Drain point unit sediment load (kg/m/yr) | Drain Point Sediment Accumulation |
| SedDel | Sediment load delivered to streams (kg/yr) | Drain Point Sediment Accumulation |
| SI | SINMAP stability index values at each drain point | Stability Index |
| SIR | SINMAP stability index values at each drain point accounting for road runoff | Stability Index |
| Slope | Slope at each drain point | Slope at Drain Point |
| ESI | Erosion sensitivity index (m) values at each drain point | Erosion Sensitivity Index |
| PipeDiaToChanWidthRatio | Ratio of culvert pipe diameter to channel width | Stream Blocking Index |

| | | |
|---|---|---|
| PipeDiaToChan WidthScore | Hazard score calculated from ratio of culvert pipe diameter to channel width | Stream Blocking Index |
| SkewAngle | Channel skew angle | Stream Blocking Index |
| SkewAngleScore | Hazard score calculated from channel skew angle | Stream Blocking Index |
| SBI | Stream blocking index indicating culvert plugging susceptibility | Stream Blocking Index |
| Barrier | Flag representing whether the drain point is a fish passage barrier or not. 0=totally blocked, 1=partially blocked, 2=totally open | Fish Passage Barrier |

### *RoadLines Table*

| Field Name | Description | Menu Function |
|---|---|---|
| GRAIPRID | Unique road line segment identifier | Preprocessor |
| CDate | Survey collection date | Preprocessor |
| CTime1 | Survey collection time 1. This is a 4 digit numeric field. | Preprocessor |
| CTime2 | Survey collection time 2. This is a 4 digit numeric field. | Preprocessor |
| VehicleID | Survey vehicle identifier | Preprocessor |
| OrigSourceCode | Original road line feature ID | Preprocessor |
| RoadNetworkID | Identifier for a road network. Base erosion rate depends on road network ID | Preprocessor |
| RoadTypeID | Identifier for type of the road (i.e.: system road, trail) | Preprocessor |
| OrigDrainID1 | Original drain point identifier for side one of the road | |
| OrigDrainID2 | Original drain point identifier for side two of the road | |
| GRAIPDID1 | Identifier of drain point that drains side one of the road | Preprocessor |
| GRAIPDID2 | Identifier of drain point that drains side two of the road | Preprocessor |
| SurfaceTypeID | Identifier representing road surface type. | Preprocessor |
| SurfaceConditionID | Identifier representing road surface condition | Preprocessor |
| SurfaceCoverID | Identifier representing the road surface cover | Preprocessor |
| RoadEdge1ID | Identifier for road side one edge information | Preprocessor |
| RoadEdge2ID | Identifier for road side two edge information | Preprocessor |
| EdgeVegetation1ID | Identifier for road side one edge vegetation | Preprocessor |

| | | |
|---|---|---|
| EdgeVegetation2ID | Identifier for road side two edge vegetation | Preprocessor |
| EdgeConditionID1 | Identifier for road side one edge condition | Preprocessor |
| EdgeConditionID2 | Identifier for road side two edge condition | Preprocessor |
| FlowPath1ID | Identifier for road side one flow path information | Preprocessor |
| FlowPath2ID | Identifier for road side two flow path information | Preprocessor |
| FlowPathVeg1 ID | Identifier for road side one flow path vegetation | Preprocessor |
| FlowPathVeg2 ID | Identifier for road side two flow path vegetation | Preprocessor |
| FlowPathCond1 ID | Identifier for road side one flow path condition | Preprocessor |
| FlowPathCond2 ID | Identifier for road side two flow path condition | Preprocessor |
| FillChannelID | Identifier giving road fill channel information | Preprocessor |
| HUCName | HUC Name | Preprocessor |
| Miles | Length of road segment (miles) | Preprocessor |
| Comments | Additional Comments about the road segment | Preprocessor |
| StreamConnect1ID | Identifier for road side one stream connectivity status | Preprocessor |
| StreanConnect2ID | Identifier for road side two stream connectivity status | Preprocessor |
| Length | Length of the road segment (m) | Road Segment Sediment Production |
| Slope | Slope of the road segment (unitless) | Road Segment Sediment Production |
| SedProd1 | Sediment production from side one of the road (kg/yr) | Road Segment Sediment Production |
| SedProd2 | Sediment production from side two of the road (kg/yr) | Road Segment Sediment Production |
| UnitSed | Unit sediment production from both sides of the road segment (kg/m/yr) | Road Segment Sediment Production |
| TotSedProd | Total sediment production from both sides of the road (kg/yr) | Road Segment Sediment Production |
| TotSedDel | Total sediment delivered to streams (kg/yr) | Road Segment Sediment Production |

| | | |
|---|---|---|
| UnitTotSedDel | Total unit sediment delivered to streams (kg/m/yr) | Road Segment Sediment Production |

### *BroadBaseDipAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| BroadBaseDipTypeID | Identifier representing Broad Base Dip type |
| SlopeShapeID | Identifier for drain point discharge slope shape |
| DischargeToID | Identifier for drain point discharge feature (e.g. gully, forest floor) |
| ObstructionID | Identifier for the presence of an obstruction |
| FillErosionID | Identifier for presence of fill erosion |
| BroadBaseDipConditionID | Identifier for broad base dip drain point condition |
| MaterialID | Identifier for material found in the drain point |

### *DiffuseDrainAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| SlopeShapeID | Identifier for drain point discharge slope shape |
| DischargeToID | Identifier for drain point discharge feature (e.g. gully, forest floor) |
| ObstructionID | Identifier for the presence of an obstruction |
| FillErosionID | Identifier for presence of fill erosion |

### *DitchReliefAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| SizeID | Identifier for the size of the drain point |
| PipeLength | Length of the culvert pipe used |
| DitchReliefTypeID | Identifier for ditch relief type |
| DitchReliefConditionID | Identifier for ditch relief condition |
| SlopeShapeID | Identifier for drain point discharge slope shape |
| DischargeToID | Identifier for drain point discharge feature (e.g. gully, forest floor) |
| FillErosionID | Identifier for presence of fill erosion |
| ObstructionID | Identifier for the presence of an obstruction |
| FlowDiversionID | Identifier for the presence of flow diversion |
| FlowDiffuserID | Identifier for flow diffuser type |

### *LeadOffAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| SlopeShapeID | Identifier for drain point discharge slope shape |
| DischargeToID | Identifier for drain point discharge feature (e.g. gully, forest floor) |
| LeadOffConditionID | Identifier for condition of lead off drain point |
| ObstructionID | Identifier for the presence of an obstruction |

### *NonEngAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| NonEngConditionID | Identifier for condition of Non-Engineered drain point |
| SlopeShapeID | Identifier for drain point discharge slope shape |
| DischargeToID | Identifier for drain point discharge feature (e.g. gully, forest floor) |
| ObstructionID | Identifier for the presence of an obstruction |
| FillErosionID | Identifier for presence of fill erosion |

### *StrXingAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| StrXingTypeID | Identifier for stream crossing type |
| PipeDimID | Identifier for culvert pipe dimension |
| PipeLength | Culvert pipe length (feet) |
| ChannelWidth | Channel width (feet) |
| PipeNumberID | Identifier for number of pipes used |
| FillDepth | Fill depth (feet) |
| StrXingConditionID | Identifier for condition of stream crossing drain point |
| FillErosionID | Identifier for presence of fill erosion |
| ChannelAngleID | Identifier for angle between stream and stream crossing |
| BlockTypeID | Identifier for the presence and type of stream crossing blockage |
| OutletDrop | Outlet channel drop (feet) |
| PoolDepth | Channel pool depth (feet) |
| PipeGradient | Stream crossing pipe gradient in percentage |
| SubstrateID | Identifier for substrate material |
| DebrisFlowID | Identifier for the presence of a debris flow |
| DiversionID | Identifier for the presence and direction of channel diversion |

### *SumpAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| SumpConditionID | Identifier for condition of sump drain point |

### *WaterBarAtt Table*

| Field Name | Description |
|---|---|
| GRAIPDID | Drain Point identifier. Foreign key to GRAIPDID in DrainPoints Table |
| WaterBarTypeID | Identifier for water bar type |
| SlopeShapeID | Identifier for drain point discharge slope shape |
| DischargeToID | Identifier for drain point discharge feature (e.g. gully, forest floor) |
| ObstructionID | Identifier for presence of obstruction |
| FillErosionID | Identifier for presence of fill erosion |
| WaterBarConditionID | Identifier for condition of water bar crossing drain point |

## PREFERRED VALUE TABLES

### *BlockTypeDefinitions*

| BlockTypeID | BlockType | Description |
|---|---|---|
| 1 | No | Stream crossing not blocked (Default) |
| 2 | Sediment Plume | Stream crossing blocked by sediment plume |
| 3 | Scoured road | Stream crossing blocked due to scoured road |
| 4 | Washed out road | Stream crossing blocked due to washed out road |
| 5 | Organic debris pile | Stream crossing blocked by organic debris pile |

### *BroadBaseDipCondDefinitions*

| BroadBaseDipConditionID | Condition | Description |
|---|---|---|
| 1 | No Problem | Default |
| 2 | Puddles on road | |
| 3 | Wetland in ditch | |
| 4 | Saturated fill | |

### *BroadBaseDipTypeDefinitions*

| BroadBaseDipTypeID | BroadBaseDipTypeName | Description |
|---|---|---|
| 1 | Grade Reversal | Default |
| 2 | Flat Ditch | |
| 3 | Constructed | |

### *ChannelAngleDefinitions*

| ChannelAngleID | ChannelAngle | Description |
|---|---|---|
| 1 | < 25 degrees | The flow changes direction by less than 25 degrees when entering stream crossing (Default) |
| 2 | 25-45 degrees | The flow changes direction by between 25 and 45 degrees when entering stream crossing |
| 3 | 45-75 degrees | The flow changes direction by between 45 and 75 degrees when entering stream crossing |
| 4 | > 75 degrees | The flow changes direction by more than 75 degrees when entering stream crossing |

### *DebrisFlowDefinitions*

| DebrisFlowID | DebrisFlow | Description |
|---|---|---|

| | | |
|---|---|---|
| 1 | No | Default |
| 2 | Yes | |

### *DischargeToDefinitions*

| DischargeToID | DischargeTo | Description |
|---|---|---|
| 1 | Forest Floor | Default |
| 2 | Gully | |
| 3 | Ditch | |
| 4 | Landslide | |
| 5 | Wetland | |
| 6 | Stream | |

### *DitchReliefCondDefinitions*

| DitchReliefConditionID | Condition | Description |
|---|---|---|
| 1 | 0 | Ditch relief drain in good condition (Default) |
| 2 | 1-20% | Ditch relief drain 1-20% blocked |
| 3 | 20-80% | Ditch relief drain 20-80% blocked |
| 4 | 80-100% | Ditch relief drain 80-100% blocked |
| 5 | Partially Crushed | Ditch relief drain partially crushed |
| 6 | Totally Crushed | Ditch relief drain totally crushed |
| 7 | Rusted Significantly | Ditch relief drain significantly rusted |
| 8 | Flows around pipe | Ditch relief drain flows around the pipe |

### *DitchReliefTypeDefinitions*

| DitchReliefTypeID | DitchReliefTypeName | Description |
|---|---|---|
| 1 | CMP (Steel) | Default |
| 2 | CON (Concrete) | |
| 3 | ALM (Aluminum) | |
| 4 | ABS (Plastic) | |
| 5 | WDN (LOG) | |

### *DiversionDefinitions*

| DiversionID | Diversion | Description |
|---|---|---|
| 1 | None | Default |
| 2 | 1 Direction | |
| 3 | 2 Direction | |

### *DrainTypeDefinitions*

| DrainTypeID | DrainTypeName | TableName | Description |
|---|---|---|---|
| 1 | Broad base dip | BroadBaseDipAtt | Attribute table name for Broad Base Dip type drain point |
| 2 | Diffuse drain | DiffuseDrainAtt | Attribute table name for Diffused type drain point |
| 3 | Ditch relief | DitchReliefAtt | Attribute table name for Ditch Relief type drain point |
| 4 | Lead off | LeadOffAtt | Attribute table name for Lead Off type drain point |
| 5 | Non-engineered | NonEngAtt | Attribute table name for Non-Engineered type drain point |
| 6 | Stream Crossing | StrXingAtt | Attribute table name for Stream Crossings type drain point |
| 7 | Sump | SumpAtt | Attribute table name for Sump type drain point |
| 8 | Water bar | WaterBarAtt | Attribute table name for Waterbar type drain point |

### *FillErosionDefinitions*

| FillErosionID | FillErosion | Description |
|---|---|---|
| 1 | No | Default |
| 2 | Yes | |

### *FlowDiffuserDefinitions*

| FlowDiffuserID | FlowDiffuser | Description |
|---|---|---|
| 1 | None | Default |
| 2 | Half pipe fabric | |
| 3 | Fabric hose | |
| 4 | Rip rap | |

### *FlowDiversionDefinitions*

| FlowDiversionID | FlowDiversion | Description |
|---|---|---|
| 0 | Unknown | Default |
| 1 | No | |
| 2 | Yes | |

### *LeadOffCondDefinitions*

| LeadOffConditionID | Condition | Description |
|---|---|---|
| 1 | No problem | Default |
| 2 | Gullied | |
| 3 | Not functional | |
| 4 | Excess deposition | |

### *MaterialDefinitions*

| MaterialID | MaterialName | Description |
|---|---|---|
| 1 | Crushed | |
| 2 | Native soil | Default |
| 3 | Vegetated | |
| 4 | Paved | |
| 5 | Cinder | |

### *NonEngCondDefinitions*

| NonEngConditionID | Condition | Description |
|---|---|---|
| 1 | Blocked ditch | Default |
| 2 | Diverted wheel track | |
| 3 | Broken berm | |
| 4 | Gully crosses road | |
| 5 | Outsloped | |

### *ObstructionDefinitions*

| ObstructionID | Obstruction | Description |
|---|---|---|
| 1 | None | Drain point not obstructed |
| 2 | Moderate | Drain point has moderate obstruction (Default) |
| 3 | Abundant | Drain point has considerable obstruction |

### *PipeDimDefinitions*

| PipeDimID | Dimension | Description |
|---|---|---|
| 0 | N/A | Default |
| 1 | 12 | Round 12 inch pipe |
| 2 | 15 | Round 15 inch pipe |
| 3 | 18 | Round 18 inch pipe |
| 4 | 24 | Round 24 inch pipe |
| 5 | 36 | Round 36 inch pipe |
| 6 | 48 | Round 48 inch pipe |
| 7 | 60 | Round 60 inch pipe |
| 8 | >60 | Pipe greater than 60 inches diameter |
| 9 | 13X17 | Oval pipe 13 inches x 17 inches |
| 10 | 15X21 | Oval pipe 15 inches x 21 inches |

| | | |
|---|---|---|
| 11 | 20X28 | Oval pipe 20 inches x 28 inches |
| 12 | 24X35 | Oval pipe 24 inches x 35 inches |
| 13 | 29X42 | Oval pipe 29 inches x 42 inches |
| 14 | 33X49 | Oval pipe 33 inches x 49 inches |
| 15 | 38X57 | Oval pipe 38 inches x 57 inches |

### *PipeNumberDefinitions*

| PipeNumberID | PipeNumber | Description |
|---|---|---|
| 0 | N/A | Default |
| 1 | 1 | |
| 2 | 2 | |
| 3 | 3 | |
| 4 | >3 | |

### *SizeDefinitions*

| SizeID | DSize | Description |
|---|---|---|
| 1 | <12" | Pipe size less than 12 inches |
| 2 | 12" | 12 inch pipe |
| 3 | 15" | 15 inch pipe |
| 4 | 18" | 18 inch pipe (Default) |
| 5 | 24" | 24 inch pipe |
| 6 | >24" | Pipe size greater than 24 inches |

### *SlopeShapeDefinitions*

| SlopeShapeID | SlopeShape | Description |
|---|---|---|
| 1 | Concave | |
| 2 | Planar | |
| 3 | Convex | |

### *StreamConnectDefinitions*

| StreamConnectID | StreamConnection | Description |
|---|---|---|
| 0 | Unknown | |
| 1 | No | Drain point discharge does not enter stream directly. (Default) |
| 2 | Yes | Drain point discharge enters stream directly |

### *StrXingCondDefinitions*

| StrXingConditionID | Condition | Description |
|---|---|---|
| 1 | Open and Sound | Default |
| 2 | Partially blocked | |

| | | |
|---|---|---|
| 3 | Totally blocked | |
| 4 | Partially crushed | |
| 5 | Totally crushed | |
| 6 | Rusted significantly | |
| 7 | Flows around pipe | |
| 8 | Scoured under bridge | |

### *StrXingTypeDefinitions*

| StrXingTypeID | StrXingTypeName | Description |
|---|---|---|
| 1 | Steel culvert round | Default |
| 2 | Steel culvert oval | |
| 3 | Steel arch bottomless | |
| 4 | Plastic culvert | |
| 5 | Baffled culvert | |
| 6 | Concrete culvert | |
| 7 | Log culvert | |
| 8 | Concrete ford | |
| 9 | Natural ford | |
| 10 | Aluminum culvert | |
| 11 | Bridge | |

### *SubstrateDefinitions*

| SubstrateID | Substrate | Description |
|---|---|---|
| 1 | Culvert Material | Default |
| 2 | Sand | |
| 3 | Gravel | |
| 4 | Boulders | |
| 5 | Bedrock | |
| 6 | Baffled | |
| 7 | Concrete | |

### *SumpCondDefinitions*

| SumpConditionID | Condition | Description |
|---|---|---|
| 1 | No problem | Default |
| 2 | Fill saturation | |
| 3 | Puddles on road | |

### *WaterBarCondDefinitions*

| WaterBarConditionID | Condition | Description |
|---|---|---|
| 1 | No problem | Default |
| 2 | Damaged | |
| 3 | Too small | |
| 4 | Drains inboard ditch | |

| | | |
|---|---|---|
| 5 | Wheel track damage | |

### *WaterBarTypeDefinitions*

| WaterBarTypeID | WaterBarTypeName | Description |
|---|---|---|
| 1 | Road material | Default |
| 2 | Fabricated material | |

### *EdgeConditionDefinitions*

| EdgeConditionID | EdgeCondition | Description |
|---|---|---|
| 1 | No problem | Default |
| 2 | Badly rilled | |
| 3 | Badly ravelling | |
| 4 | Badly slumping | |
| 5 | Bedrock | |

### *EdgeVegetationDefinitions*

| EdgeVegetationID | EdgeVegetation | Description |
|---|---|---|
| 1 | Default | Road side vegetation density is unknown or not specified (Default) |
| 2 | >75% | Road side vegetation density is greater than 75% |
| 3 | >50% | Road side vegetation density is greater than 50% |
| 4 | >25% | Road side vegetation density is greater than 25% |
| 5 | >10% | Road side vegetation density is greater than 10% |
| 6 | 0% | Road side vegetation density is less than 10% |

### *FillChannelDefinitions*

| FillChannelID | FillChannel | Description |
|---|---|---|
| 1 | 0 | Fill slope ends right at channel |
| 2 | 1-20 | Distance from fill slope toe to channel is between 1 and 20 feet |
| 3 | 21-50 | Distance from fill slope toe to channel is between 21 and 50 feet |
| 4 | Above 50 | Distance from fill slope toe to channel is greater than 50 feet (Default) |

### *FlowPathCondDefinitions*

| FlowPathCondID | FlowPathCond | Description |
|---|---|---|
| 1 | No problem | Default |
| 2 | Gullied | |
| 3 | Buried | |
| 4 | Rutted | |
| 5 | Blocked | |
| 6 | Stream course | |
| 7 | Woody veg (%) | |

### *FlowPathDefinitions*

| FlowPathID | FlowPath | Description |
|---|---|---|
| 1 | Ditch | Default |
| 2 | Wheel tracks | |
| 3 | Base of cut | |
| 4 | Berm | |
| 5 | Diffuse | |

### *FlowPathVegDefinitions*

| FlowPathVegID | FlowPathVeg | Description | Multiplier |
|---|---|---|---|
| 1 | 110% | Unknown or unspecified road side flow path vegetation density (Default) | 1 |
| 2 | >75% | Road side flow path vegetated more than 75% | 0.14 |
| 3 | >50% | Road side flow path vegetated 50% to 75% | 0.14 |
| 4 | >25% | Road side flow path vegetated 25% to 50% | 0.14 |
| 5 | >10% | Road side flow path vegetated 10% to 25% | 1 |
| 6 | >0% | Road side flow path vegetated 0 to 10% | 1 |
| 7 | 0% | No road side flow path vegetation | 1 |

### *RoadEdgeDefinitions*

| RoadEdgeID | RoadEdge | Description |
|---|---|---|
| 1 | Fill | Road side feature is fill |
| 2 | 0' no ditch | Road side level with terrain, no ditch |
| 3 | 0-6' | Road side cut between 0 and 6 ft high (Default) |
| 4 | 6-18' | Road side cut 6 to 18 ft high |
| 5 | >18', 0% | Road side cut higher than 18 ft |

### *RoadNetworkDefinitions*

| RoadNetworkID | RoadNetwork | Description | BaseRate |
|---|---|---|---|
| 1 | Default | Default Base rate from Luce and Black, 1999 | 79 |
| 2 | Custom | Custom base rate for a specific study area | 79 |

### *RoadTypeDefinitions*

| RoadTypeID | RoadType | Description |
|---|---|---|
| 1 | System road | Default |
| 2 | High clearance road | |

### *SurfaceConditionDefinitions*

| SurfaceConditionID | SurfaceCondition | Description |
|---|---|---|
| 1 | Good | |
| 2 | Rilled/eroded | |
| 3 | Washboard | |
| 4 | Rutted | |
| 5 | Rocky | |

### *SurfaceCoverDefinitions*

| SurfaceCoverID | SurfaceCover | Description |
|---|---|---|
| 1 | >75% | Road surface is vegetated more than 75% (Default) |
| 2 | >50% | Road surface is vegetated between 50 and 75% |
| 3 | >25% | Road surface is vegetated between 25 and 50% |
| 4 | >10% | Road surface is vegetated between 10 and 25% |
| 5 | 0% | Road surface is vegetated between 0 and 10% |

### *SurfaceTypeDefinitions*

| SurfaceTypeID | SurfaceType | Description | Multiplier |
|---|---|---|---|
| 1 | Default | Default | 1 |
| 2 | Crushed rock | | 1 |
| 3 | Native | | 5 |
| 4 | Paved | | 0.2 |
| 5 | Herbaceous Veg | | 1 |
| 6 | Brush | | 1 |
| 7 | Trees > 4 in Dia | | 1 |
| 8 | Cinder | | 1 |

### *VehicleDefinitions*

| VehicleID | Vehicle | Description |
|---|---|---|
| 1 | Survey Truck | |

## UTILITY TABLES

### *FieldMatches*

| ID | AttTableID | DBField | DBFField |
|---|---|---|---|
| 1 | 0 | SurfaceTypeID | SURF_TYPE |
| 2 | 0 | SurfaceConditionID | SURF_COND |
| 3 | 0 | RoadTypeID | ROAD_TYPE |
| 4 | 0 | RoadEdge1ID | RD_EDGE_1 |
| 5 | 0 | RoadEdge2ID | RD_EDGE_2 |
| 6 | 0 | EdgeVegetation1ID | EDGE_VEG_1 |
| 7 | 0 | EdgeVegetation2ID | EDGE_VEG_2 |
| 8 | 0 | EdgeCondition1ID | EDG_CND_1 |
| 9 | 0 | EdgeCondition2ID | EDG_CND_2 |
| 10 | 0 | FlowPath1ID | FLOW_PATH1 |
| 11 | 0 | FlowPath2ID | FLOW_PATH2 |
| 12 | 0 | FlowPathVeg1ID | FLWPTH_VG1 |
| 13 | 0 | FlowPathVeg2ID | FLWPTH_VG2 |
| 14 | 0 | FlowPathCond1ID | FLWPTHCND1 |
| 15 | 0 | FlowPathCond2ID | FLWPTHCND2 |
| 16 | 0 | FillChannelID | FILL_CHAN |
| 17 | 0 | SurfaceCoverID | SURF_COV |
| 18 | 0 | CDate | CDATE |
| 19 | 0 | CTime1 | CTIME1 |
| 20 | 0 | CTime2 | CTIME2 |
| 21 | 0 | VehicleID | VEHICLE |
| 22 | 1 | Comments | COMMENT |
| 23 | 1 | CDate | CDATE |
| 24 | 1 | CTime | CTIME |
| 25 | 1 | VehicleID | VEHICLE |
| 26 | 1 | StreamConnectID | STREAM_CON |
| 27 | 1 | BroadBaseDipTypeID | TYPE |
| 28 | 1 | SlopeShapeID | SLOPE_SHAP |
| 29 | 1 | DischargeToID | DISCHRG_TO |
| 30 | 1 | ObstructionID | OBSTRUCT |
| 31 | 1 | FillErosionID | FILL_EROS |
| 32 | 1 | BroadBaseDipConditionID | CONDIT |
| 33 | 1 | MaterialID | MATERIAL |
| 34 | 1 | Comments | COMMENT |
| 35 | 2 | CDate | CDATE |
| 36 | 2 | CTime | CTIME |
| 37 | 2 | VehicleID | VEHICLE |
| 38 | 2 | StreamConnectID | STREAM_CON |
| 39 | 2 | SlopeShapeID | SLOPE_SHAP |

| | | | |
|---|---|---|---|
| 40 | 2 | DischargeToID | DISCHRG_TO |
| 41 | 2 | ObstructionID | OBSTRUCT |
| 42 | 2 | FillErosionID | FILL_EROS |
| 43 | 2 | Comments | COMMENT |
| 44 | 3 | CDate | CDATE |
| 45 | 3 | CTime | CTIME |
| 46 | 3 | VehicleID | VEHICLE |
| 47 | 3 | StreamConnectID | STREAM_CON |
| 48 | 3 | SizeID | SIZE |
| 49 | 3 | PipeLength | PIPE_LEN |
| 50 | 3 | DitchReliefTypeID | TYPE |
| 51 | 3 | DitchReliefConditionID | CONDIT |
| 52 | 3 | SlopeShapeID | SLOPE_SHAP |
| 53 | 3 | DischargeToID | DISCHRG_TO |
| 54 | 3 | FillErosionID | FILL_EROS |
| 55 | 3 | ObstructionID | OBSTRUCT |
| 56 | 3 | FlowDiversionID | FLOW_DIVER |
| 57 | 3 | FlowDiffuserID | FLOW_DIFFU |
| 58 | 3 | Comments | COMMENT |
| 59 | 4 | CDate | Date |
| 60 | 4 | CTime | Time |
| 61 | 4 | VehicleID | Vehicle |
| 62 | 4 | StreamConnectID | STREAM_CON |
| 63 | 4 | SlopeShapeID | SLOPE_SHAP |
| 64 | 4 | DischargeToID | DISCHRG_TO |
| 65 | 4 | LeadOffConditionID | CONDIT |
| 66 | 4 | ObstructionID | OBSTRUCT |
| 67 | 4 | Comments | COMMENT |
| 68 | 5 | CDate | CDATE |
| 69 | 5 | CTime | CTIME |
| 70 | 5 | VehicleID | VEHICLE |
| 71 | 5 | StreamConnectID | STREAM_CON |
| 72 | 5 | SlopeShapeID | SLOPE_SHAP |
| 73 | 5 | DischargeToID | DISCHRG_TO |
| 74 | 5 | ObstructionID | OBSTRUCT |
| 75 | 5 | FillErosionID | FILL_EROS |
| 76 | 5 | NonEngConditionID | CONDIT |
| 77 | 5 | Comments | COMMENT |
| 78 | 6 | CDate | CDATE |
| 79 | 6 | CTime | CTIME |
| 80 | 6 | VehicleID | VEHICLE |
| 81 | 6 | StrXingTypeID | TYPE |
| 82 | 6 | PipeDimID | R_PIPE_DIA |
| 83 | 6 | PipeDimID(Oval) | OVAL_PIPE |
| 84 | 6 | PipeLength | PIPE_LEN |
| 85 | 6 | ChannelWidth | CHAN_WDTH |
| 86 | 6 | PipeNumberID | PIPE_NUM |
| 87 | 6 | FillDepth | FILL_DEPTH |
| 88 | 6 | StrXingConditionID | CONDIT |
| 89 | 6 | ChannelAngleID | CHAN_ANGL |

| | | | |
|---|---|---|---|
| 90 | 6 | BlockTypeID | BLOCK_TYP |
| 91 | 6 | OutletDrop | OUTLET_DRP |
| 92 | 6 | PoolDepth | PL_DEPTH |
| 93 | 6 | PipeGradient | PIPE_GRADE |
| 94 | 6 | SubstrateID | SUBSTRATE |
| 95 | 6 | DebrisFlowID | DEBRIS_FLW |
| 96 | 6 | FillErosionID | FILL_EROSN |
| 97 | 6 | DiversionID | DIVERSION |
| 98 | 6 | Comments | COMMENT |
| 99 | 7 | CDate | CDATE |
| 100 | 7 | CTime | CTIME |
| 101 | 7 | VehicleID | VEHICLE |
| 102 | 7 | SumpConditionID | CONDIT |
| 103 | 7 | Comments | COMMENT |
| 104 | 8 | Cdate | Date |
| 105 | 8 | Ctime | Time |
| 106 | 8 | VehicleID | Vehicle |
| 107 | 8 | StreamConnectID | STREAM_CON |
| 108 | 8 | WaterBarTypeID | TYPE |
| 109 | 8 | SlopeShapeID | SLOPE_SHAP |
| 110 | 8 | DischargeToID | DISCHRG_TO |
| 111 | 8 | ObstructionID | OBSTRUCT |
| 112 | 8 | FillErosionID | FILL_EROS |
| 113 | 8 | WaterBarConditionID | CONDIT |
| 114 | 8 | Comments | COMMENT |

### *DPErrorLog Table Structure*

| Field Name | Description |
|---|---|
| Index | Unique identifier (Auto number in MS Access) |
| GRAIPDID | Identifier from DrainPoints table |
| DrainType | Type of the drain point (Eg: Broad Base Dip) |
| ErrorMessage | Validation error message |
| ActionTaken | Action taken to correct error |

### *RDErrorLog Table Structure*

| Field Name | Description |
|---|---|
| Index | Unique identifier (Auto number in MS Access) |
| GRAIPRID | Identifier from RoadLines table |
| RoadType | Type of road line (Eg: System road) |
| ErrorMessage | Validation error message |
| ActionTaken | Action taken to correct error |

### *MetaData*

| ID | IDFieldName | DefinitionTable |
|---|---|---|
| 1 | DrainTypeID | DrainTypeDefinitions |

| | | |
|---|---|---|
| 2 | VehicleID | VehicleDefinitions |
| 3 | StreamConnectID | StreamConnectDefinitions |
| 4 | BroadBaseDipTypeID | BroadBaseDipTypeDefinitions |
| 5 | SlopeShapeID | SlopeShapeDefinitions |
| 6 | DischargeToID | DischargeToDefinitions |
| 7 | ObstructionID | ObstructionDefinitions |
| 8 | FillErosionID | FillErosionDefinitions |
| 9 | BroadBaseDipConditionID | BroadBaseDipCondDefinitions |
| 10 | MaterialID | MaterialDefinitions |
| 11 | DitchReliefTypeID | DitchReliefTypeDefinitions |
| 12 | DitchReliefConditionID | DitchReliefCondDefinitions |
| 13 | FlowDiversionID | FlowDiversionDefinitions |
| 14 | FlowDiffuserID | FlowDiffuseDefinitions |
| 15 | LeadOffConditionID | LeadOffCondDefinitions |
| 16 | NonEngConditionID | NonEngCondDefinitions |
| 17 | StrXingTypeID | StrXingTypeDefinitions |
| 18 | PipeDimID | PipeDimDefinitions |
| 19 | PipeNumberID | PipeNumberDefinitions |
| 20 | StrXingConditionID | StrXingCondDefinitions |
| 21 | ChannelAngleID | ChannelAngleDefinitions |
| 22 | BlockTypeID | BlockTypeDefinitions |
| 23 | SubstrateID | SubstrateDefinitions |
| 24 | DebrisFlowID | DebrisFlowDefinitions |
| 25 | DiversionID | DiversionDefinitions |
| 26 | SumpConditionID | SumpCondDefinitions |
| 27 | WaterBarTypeID | WaterBarTypeDefinitions |
| 28 | WaterBarConditionID | WaterBarCondDefinitions |
| 29 | RoadNetworkID | RoadNetworkDefinitions |
| 30 | RoadTypeID | RoadTypeDefinitions |
| 31 | SurfaceTypeID | SurfaceTypeDefinitions |
| 32 | SurfaceConditionID | SurfaceConditionDefinitions |
| 33 | SurfaceCoverID | SurfaceCoverDefinitions |
| 34 | RoadEdge1ID | RoadEdgeDefinitions |
| 35 | RoadEdge2ID | RoadEdgeDefinitions |
| 36 | EdgeVegetation1ID | EdgeVegetationDefinitions |
| 37 | EdgeVegetation2ID | EdgeVegetationDefinitions |
| 38 | EdgeCondition1ID | EdgeConditionDefinitions |
| 39 | EdgeCondition2ID | EdgeConditionDefinitions |
| 40 | FlowPathVeg1ID | FlowPathVegDefinitions |
| 41 | FlowPathVeg2ID | FlowPathVegDefinitions |
| 42 | FlowPath1ID | FlowPathDefinitions |
| 43 | FlowPath2ID | FlowPathDefinitions |
| 44 | FlowPathCond1ID | FlowPathCondDefinitions |
| 45 | FlowPathCond2ID | FlowPathCondDefinitions |
| 46 | FillChannelID | FillChannelDefinitions |

## TauDEM Stream Network Shapefile Attribute table

The TauDEM stream network delineation function creates a stream network shapefile with the following attributes:

| Field | Description |
|---|---|
| LINKNO | Link Number. A unique number associated with each link (segment of channel between junctions) |
| DSLINKNO | Link Number of the downstream link. -1 indicates that this does not exist. |
| USLINKNO1 | Link Number of first upstream link |
| USLINKNO2 | Link Number of second upstream link. |
| DSNODEID | Node identifier for node at downstream end of stream reach. This identifier corresponds to the "id" attribute from the Outlets shapefile used to designate nodes. |
| Order | Strahler Stream Order |
| Length | Length of the link |
| Magnitude | Shreve Magnitude of the link. This is the total number of sources upstream |
| DS_Cont_Ar | Drainage area at the downstream end of the link. Generally this is one grid cell upstream of the downstream end because the drainage area at the downstream end grid cell includes the area of the stream being joined. |
| Drop | Drop in elevation from the start to the end of the link |
| Slope | Average slope of the link (computed as drop/length) |
| Straight_L | Straight line distance from the start to the end of the link |
| US_Cont_Ar | Drainage area at the upstream end of the link |
| WSNO | Watershed number. Cross reference to the *w.shp and *w grid files giving the identification number of the watershed draining directly to the link. |
| DOUT_END | Distance to the outlet from the downstream end of the link |
| DOUT_START | Distance to the outlet from the upstream end of the link |
| DOUT_MID | Distance to the outlet from the midpoint of the link |

The following attributes that record sediment input to the stream network and habitat patch clusters are added to the stream network shapefile by the GRAIP toolbar:

| Field | Description | Menu Function |
|---|---|---|
| SedAccum | Accumulated upstream sediment load from road surface at the downstream end of each stream segment (kg/yr) | Upstream Stream Sediment Input |
| SedDir | Direct sediment input from road surface to each stream segment (kg/yr) | Direct Stream Sediment Input |

| | | |
|---|---|---|
| SpecSed | Specific sediment accumulation to each stream segment defined as accumulated upstream sediment production divided by upstream contributing area at the downstream end of each stream segment ($Mg/yr/m^2$) | Upstream Stream Sediment Input |
| SpecSedDir | Direct specific sediment input to each stream segment divided by the direct area draining to each stream segment ($Mg/yr/m^2$) | Direct Stream Sediment Input |
| HabPatchID | A unique identifier for each contiguous habitat cluster as demarcated by fish passage barrier | Habitat Segmentation |

# GRAIP SourceCode Folder Organization

## ToolBarComDLL

Source code for C++ .dll that is used by the GRAIP Toolbar.

**VS 6 workspace:** COMDLL\rsamCOMDLL.dsw

**Release config compiles to:** COMDLL\ReleaseMinDependency\graipCOMDLL.dll

**Debug config compiles to:** C:\Program Files\GRAIP\graipCOMDLL.dll

**Depends on:**

**A.** RasterIO.dll (for execution)

**B.** RasterIO.lib (for compiling)

**C.** ShapeCode that is included in this folder

## ConsolidateShp

Source code for C++ .dll that is used by the GRAIP Preprocessor.

**VS 6 workspace:** consolidateShp.dsw

**Release config compiles to:** ReleaseMinSize\consolidateShp.dll

**Debug config compiles to:** C:\Program Files\GRAIP\consolidateShp.dll

**Depends on:**

**A.** ShapeLib that is included in this folder

## DatabasePreprocessor

Source code for VB executable that is the GRAIP Preprocessor.

**VB 6 project:** GRAIPPreprocessor.vbp

**Compiles to:** C:\Program Files\GRAIP\DBPreprocessor.exe

**Depends on:**

**A.** consolidateShp.dll

**B.** MS Access database file GRAIP DB\GRAIP.mdb to run

## ArcToolbar

Source code for VB .dll for ArcMap Plug-in.

**VB6 project:** agRSAM.vbp

**Compiles to:** C:\Program Files\GRAIP\agGRAIP.dll

**Depends on:**

**A.** tkTauDEM.dll

**B.** ToolBarComDLL.dll

**C.** sinmapCOMDLL.dll in C:\Program Files\TauDEM

**D.** C:\Program Files\GRAIP

**E.** C:\Program Files\SINMAP

**F.** Pro Essentials

### INSTALLATION

Installshield project for GRAIP. This gets files from ReleaseFiles that has the same structure as Program Files\GRAIP. Pro essentials is not distributed with GRAIP because it is part of SINMAP and GRAIP depends on SINMAP.

### RELEASEFILES

Contains release files that Installshield uses.

### RELEASESETUP

Contains output from installshield for distribution.

### DOCUMENTATION

Contains the wordprocessing and image files for the documentation.

# GRAIP 1.0 RELEASE NOTES

| Issue | Resolution |
|---|---|
| If you get the following error message: Run-time error '-2147467259 (80004005)': [Microsoft][ODBC Driver Manager] Data source name not found and no default driver specified | You need to create an ODBC Data Source called “dBASE Files” that uses the ODBC driver “Microsoft dBase Driver (*.dbf)”. |

### *Versions*

| Number | Release Date | Notes |
|---|---|---|
| 1.0.0 | 5/24/07 | |
| 1.0.1 | 6/4/07 | |
| 1.0.2 | 7/6/07 | |
| 1.0.3 | 7/10/07 | |
| 1.0.4 | 8/14/07 | Link between Roadlines and Drainpoints created from CDate, CTime and Vehicle fields |
| 1.0.5 | 9/14/07 | - If near match is found for Add Value, reassign is now initially selected.<br>- Added alpha and beta parameters to the Filter Stream Crossing Function.<br>- Added Slope to the Roadlines table.<br>- Added alpha parameter to the LS Plot Function.<br>- Clarified the meaning of Possible Passage. |
| 1.0.6 | 2/29/08 | - Added ability to have multiple input shapefiles of the same type.<br>- Expanded the length of several text fields in the database.<br>- Fixed the preprocessor so that the file info is saved when an additional file is added to an existing project.<br>- Delete Drainpoints and Roadlines index files when the shapefiles are deleted in the preprocessor so that expired index files don’t cause drain points and road line segments to disappear in ArcGIS. |
| 1.0.7 | 3/9/09 | - Fixed Elength calculation. |

| | | |
|---|---|---|
| | | - Fixed RemoveGrid function to only scan for GRID files rather than all raster dataset files. This prevents errors when there is another file with a raster dataset extension in the workspace.<br><br>- Corrected a few typos in the manual |
| 1.0.8 | 3/20/10 | - Fixed bug in the writing of parameters file for combined stability index function. The program should no longer overwrite parameters with the default parameters after they have been edited |
| 1.0.9 | 1/2/2014 | - Road sediment production function is now using elevation values at the start and end points avoiding the ESRI range function. This resolves the errors associated with the ESRI summarize by zones function giving a poor estimate of length time slope product.<br><br>- Upstream stream sediment input function is now using contributing area rather than elevation to determine the grid cell from the sediment accumulation grid (sac) to use for sediment load for each stream segment. In addition, it now uses the sediment accumulation one grid cell upstream from a junction for stream sediment accumulation. This resolves the issues of load from the downstream segment being incorrectly assigned to inflowing stream segments giving the appearance of sediment load creeping up streams.<br><br>- Upstream stream sediment input (specific sediment): The computation of specific sediment was omitting cell area. This has been corrected and the code changed to include the conversion factors required to report the results in $Mg/yr/km^2$.<br><br>- Direct stream sediment input: The logic for computation of direct stream sediment input has been changed to use sediment accumulation values computed for the stream network rather than grid values. This resolves an error that was occurring due to omitting the sediment contributions directly at stream junctions.<br><br>- The combined stability index function has been changed to include on its interface a series of check boxes identifying the drain points to be used in combined stability index evaluation. Prior to this change runoff from all drain points were always included in the calculation. A new column "CCSI" has been added to the DrainTypeDefinitions table to record the |

selection of drain types used in computation of combined stability index. User selection of drain types using the Combined Stability Index screen is saved to the database.

- A new function to determine distance to stream from drain points by looking up values calculated using TauDEM to has been added.

- The resample DEM function has been changed to use bilinear interpolation as opposed to cubic interpolation.

- Corrected a number of Preprocessor errors to improve error trapping and discrepancy identification in the Preprocessor to prevent entry of content into the database with inconsistent controlled vocabulary references.

- Generalized initialization in the Preprocessor to read attribute table names from DrainTypeDefinitions table rather than have them hardcoded.

- Fixed the database browse dialog so that it can more easily be used to select an existing start database.

- Added libraries to the installer for compatibility with Windows 7.

- Removed unnecessary Toolbar dependence upon SINMAP DLL

- Changed some hardcoded table names to be consistent with new database schema (PipeGrade was PipeGradient)

- Corrected the error in LSPlot incorrectly symbolizing points.

- Added the capability to the Stream Blocking Index function to control the stream crossing types for which SBI is evaluated. This is now controlled through a column (CSBI) in StrXingTypeDefinitions that indicates for each stream crossing type whether its SBI should be evaluated (or left at the initialization value of 0).

- Added error trapping to Toolbar to produce more explanatory errors when it encounters missing required information.

- Generalized the code for determining pipe diameters in Stream Blocking Index function to use diameter values from the controlled vocabulary table rather than infer pipe diameters from the controlled vocabulary identifier, thus

| | | |
|---|---|---|
| | | resolving errors that occurred due to the controlled vocabulary changing.<br><br>- Added error trapping to Fish Habitat Segmentation to trap for stream network shapefile name being too long for DBF database utility advising user to shorten name to run the function.<br><br>- Restructured recursion logic or Fish Habitat Segmentation to avoid opening a new database (ADODB) connection for each link that resulted in an error due to exceeding an allowable limit for large networks. |
| 1.0.10 | 6/25/2014 | - graipCOMDLL.dll code was modified not to hold all elevation data in memory rather read the elevation data on a per grid basis in order to accommodate large DEMS in Road Surface Erosion calculation.<br><br>- graipCOMDLL.dll code was modified to calculate road segment length to replace VB code that used to calculate length using ArcGIS library function. This code change was necessary to make the road sediment production function to work in Arc10. |