



# **Automated Geospatial Watershed Assessment (AGWA) to Aid in Sustaining Military Mission and Training**

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## **Guidance Documents for AGWA Tool AGWA-Facilitator Export Tool Facilitator Decision Support Tool**

**ESTCP Resource Conservation and Resiliency Program  
Project RC201308**

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**Automated Geospatial Watershed Assessment (AGWA) to Aid in Sustaining Military  
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**Table of Contents**

Introduction.....	1
SECTION 1: AGWA .....	1
AGWA Installation .....	3
Data Acquisition .....	4
Part 1: The USGS National Map: Source for DEM and Watershed Boundary data.....	5
Part 2: GeoSpatial Data Gateway: SSURGO Soils Database .....	7
Part 3. FAO Soil Map of the World .....	10
Part 4. GAP Landcover .....	12
Part 5. NLCD Landcover .....	13
Part 6. SWAT Precipitation.....	15
NOAA NCDC .....	15
NEXRAD .....	19
Meteorological Towers and Rain Gages .....	19
Part 7. KINEROS2 Precipitation.....	19
Design Storm Database .....	19
User-defined depth and duration .....	20
NOAA Precipitation Frequency Data.....	21
User-Defined Hyetograph .....	21
Data Management .....	23
Part 1: Projecting Data to a Common Coordinate System .....	23
Step 1: Add and view the data in ArcMap .....	23
Step 2: Project the Data to a Common Coordinate System.....	23
Step 3: Combine multiple datasets .....	26
Part 2: Clip the Data to a Suitable Project Area .....	27
Step 1: Create a Project Area Shapefile .....	27
Step 2: Clip the GIS Layers to the Buffered Project Area .....	31
Part 3: Preparing the Precipitation Data .....	32
SWAT Precipitation .....	32
KINEROS2 Precipitation .....	37
Part 4: Preparing the Soils Database .....	37
Step 1: Import Tabular Data into SSURGO Database .....	37
Step 2: Combine multiple soils datasets for your project area .....	40
AGWA Modeling Tutorial.....	41
Fort Bliss Army Base Range 88 Example.....	41
Part 1: Getting Started .....	42
GIS Data .....	43
Part 2: Modeling Runoff at the Basin Scale Using SWAT .....	45
Step 1: Delineating the watershed .....	46
Step 2: Discretizing or subdividing the watershed .....	48
Step 3: Parameterizing the watershed.....	50
Step 4: Preparing rainfall files.....	53
Step 5: Writing SWAT input files.....	56

## AGWA Tool Guidance Document - ESTCP Project RC201308

Step 6: Executing the SWAT model .....	58
Step 7: Viewing the results.....	59
Part 3: Modeling Runoff at the Small Watershed Scale Using KINEROS2.....	61
Step 8: Delineating the watershed.....	62
Step 9: Discretizing or subdividing the watershed.....	63
Step 10: Parameterizing the watershed elements for KINEROS2 .....	65
Step 11: Preparing rainfall files.....	68
Step 12 & 13: Writing KINEROS input files.....	72
Step 14 & 15: Executing the KINEROS2 model .....	73
Step 16: Viewing the results.....	74
Part 4: Creating a new land cover map (optional).....	76
Step 17. Using the Land Cover Modification Tool .....	76
Part 5: Modeling Post-development Runoff Using KINEROS2.....	79
Step 18: Parameterizing the watershed.....	79
Step 19: Writing KINEROS input files.....	80
Step 20: Executing the KINEROS2 model .....	81
Part 6: Comparing pre- and post-development results .....	82
Interpreting the results:.....	84
Follow-up discussion .....	84
AGWA Glossary and Acronyms .....	86
References.....	88
SECTION 2: AGWA-FACILITATOR EXPORT TOOL .....	89
Step 1: Opening an existing Facilitator DSS file .....	89
Step 2: Adding AGWA KINEROS2 Results for the 10yr 1hr database Alternative .....	91
Step 3: Adding AGWA KINEROS2 Results for the Precipitation Frequency Alternative .....	93
Step 4: Adding AGWA KINEROS2 Results for the 20140918 post Alternative .....	94
Step 5: Adding AGWA KINEROS2 Results for the 20140918 pre Alternative .....	95
Step 6: Saving the Facilitator DSS file.....	96
SECTION 3: FACILITATOR DECISION SUPPORT SYSTEM .....	97
The Decision-Making Process: What is Multi-Criteria Analysis?.....	97
Facilitator Installation .....	98
Getting Started.....	98
3 Major Stages.....	99
Overview of Menu Options.....	100
File menu .....	100
Window menu .....	101
View menu.....	101
Run menu.....	102
Help menu .....	102
Running the Facilitator .....	102
Step 1: Identify the Issue.....	103
Step 2: Consult Stakeholders.....	104
Step 3: Defining Your Alternatives.....	105
Step 4: Identifying Your Criteria .....	108
Step 5: Scoring the Alternatives.....	109
Step 6: Knowledge Input.....	110



AGWA Tool Guidance Document - ESTCP Project RC201308

Step 7: Creating a Hierarchy of Criteria.....	111
Step 8: Define Relative Importance of Criteria.....	112
Step 9: Analysis.....	113
Step 10: Viewing the Results .....	116
Step 11: Ordering the Results.....	117
Step 12: Prioritizing of Alternatives.....	117
Creating a report .....	119
Follow-up.....	121
Facilitator Use Cases.....	121
References.....	122
Appendix A.....	123

## Introduction

The main objective of this project was to demonstrate the Automated Geospatial Watershed Assessment Tool (AGWA; Miller et al., 2007; [www.tucson.ars.ag.gov/agwa](http://www.tucson.ars.ag.gov/agwa)) coupled with the Facilitator Decision Support System (DSS; <https://sourceforge.net/projects/facilitator/>) for scientifically-based watershed assessments to aid Department of Defense installation managers in sustaining their mission and meeting stewardship requirements in support of military testing and training. The purpose was to address installation watershed management concerns of flooding, erosion, analysis and rehabilitation of disturbed areas, and planning for future installation growth and mission expansion. The three demonstration sites were Fort Carson and Pinon Canyon Maneuver Site (PCMS) in Colorado, and Fort Bliss in Texas/New Mexico.

AGWA is linked to the Facilitator via the AGWA-Facilitator Export Tool. This tool in AGWA allows the transfer of AGWA model results, decision maker experience, and expert opinion to construct a Facilitator decision analysis document. This includes the results from AGWA simulations (i.e., peak flow and sediment yield), the management issue description and regulatory requirements defined for the area of interest, the stakeholder or decision maker information, and the list of initial management (base) criteria defined by the stakeholders.

This guidance document describes the techniques used to implement AGWA-Facilitator for watershed analysis, such as runoff from the hillslopes, erosion, and flow in the channels. Techniques presented include data acquisition, data preparation, model installation, implementation of AGWA, and interpretation of hydrologic model results, followed by implementation of the Facilitator decision support system. These techniques can be viewed as a cohesive methodology or split as needed to fulfill other watershed-based tasks. Fort Bliss is used as the example study location, but the methods and data types can be applied to any location.

This Guidance Document is presented in three sections: Section 1: AGWA; Section 2: AGWA-Facilitator Export Tool; and Section 3: Facilitator.

## SECTION 1: AGWA

AGWA is a publicly available Geographic Information Systems (GIS) interface jointly developed by the U.S. Environmental Protection Agency (EPA– ORD), United States Department of Agriculture (USDA) Agricultural Research Service (ARS), and the University of Arizona (UA). AGWA is currently designed as an ArcGIS add-in, for the ESRI ArcGIS commercial software (<https://www.esri.com/en-us/arcgis/about-arcgis/overview/>), which requires the user to purchase the software, and have a computer with sufficient RAM and storage capacity to effectively use it (minimum of four gigabytes of RAM). The AGWA tool supports watershed modeling along a continuum of spatial and temporal scales, ranging from hillslopes (~hectares) to large watersheds (>1000 km<sup>2</sup>) and from individual storm events (minute time steps) to continuous simulation (daily time steps over multiple years) (Guertin et al., 2015). It employs

nationally available data layers to parameterize, execute, and visualize outputs of its embedded watershed models.

AGWA can evaluate the runoff and erosion impacts from several best management practices (BMPs) including brush removal, revegetation, watering locations, retention/detention ponds, and prescribed fire at the hillslope or watershed scale (Guertin et al., 2015). Management tools available in AGWA include the land cover modification tool for land cover change; the burn severity tool using burn severity maps for post-fire assessment; the military disturbance tool to evaluate vegetation and soil changes from military training maneuvers; the storage tool to design, place and evaluate erosion control structures; and an urban tool to evaluate the effects of new developments on runoff with and without green infrastructure practices (permeable pavements, detention basins, or rainwater harvesting). AGWA's current outputs include runoff (volumes and peaks), erosion, and sediment yield, plus nitrogen and phosphorus with the SWAT model. These outputs can be derived for any stream reach within the discretized watershed, enabling the analysis of management actions in a pre- or post-disturbance scenario.

AGWA contains the Soil and Water Assessment Tool (SWAT; Arnold et al., 1998; Arnold and Fohrer, 2005; <http://swat.tamu.edu/>), the KINematic Runoff and EROsion model (KINEROS2; Smith et al., 1995; Semmens et al., 2008; Goodrich et al., 2012; [www.tucson.ars.ag.gov/kineros](http://www.tucson.ars.ag.gov/kineros)), and RHEM (Rangeland Hydrology and Erosion model; Nearing et al., 2011; <https://apps.tucson.ars.ag.gov/rhem/docs/>). Utilization of the KINEROS2 and SWAT models within the AGWA framework enables users to conduct watershed modeling and assessments at multiple temporal and spatial scales over a range of environmental conditions using freely available national data (i.e., topography, soils, land cover, and precipitation). The RHEM model requires additional detailed vegetation and ground cover data. The steps to run the models in AGWA are: 1) watershed delineation; 2) model selection and watershed discretization; 3) watershed parameterization; 4) precipitation input; 5) model input file creation; 6) model execution; and 7) model results visualization and analysis.

SWAT is a continuous simulation model that was designed for predicting watershed response to land management practices for large basins over long periods of time (Arnold et al., 1998). It uses a modified Curve Number methodology to partition rainfall into infiltration and overland flow, and reports water and sediment yields on a daily, monthly, or annual time-step (Miller et al., 2007). In contrast, KINEROS2 is an event specific model that details the processes of interception, infiltration, surface runoff, and erosion from small watersheds (Woolhiser et al., 1990). KINEROS2 uses event-specific rainfall depth to determine peak discharge values. RHEM is used to model runoff and erosion from hillslope modeling elements when detailed vegetation and ground cover information are available. All three models predict runoff, erosion, and sediment transport, making them applicable to a wide variety of land use issues.

AGWA is best suited for evaluation of the relative change in runoff and erosion from land disturbance such as ground maneuvers, fire, urbanization, or road construction, and to identify

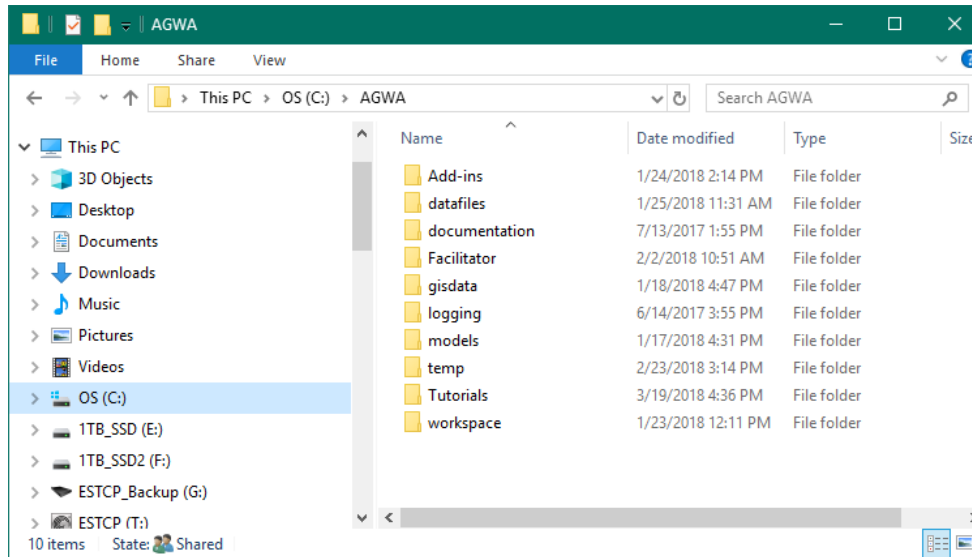
sensitive and “at-risk” areas at the site and downstream. High-quality rainfall-runoff observations are required for calibration and confidence in quantitative model predictions (Goodrich et al., 2012). AGWA is aimed towards natural resources professionals who do not necessarily have a background in hydrology or watershed modeling. However, some proficiency in GIS is helpful.

This document is intended to complement the more detailed tutorials and associated data supplied to each installation during this project, or that are available on the AGWA website ([www.tucson.ars.ag.gov/agwa](http://www.tucson.ars.ag.gov/agwa)). Installation of the AGWA tool is presented first, followed by steps for Data Acquisition (how to obtain the data needed to run AGWA and its models), and Data Management (preparing the data for use in AGWA). The final part is an AGWA tutorial created for Fort Bliss that demonstrates how to use AGWA with SWAT and KINEROS2, how to create the precipitation input files, apply the Land Cover Modification Tool, and perform a relative change analysis.

### AGWA Installation

If AGWA is not already installed on your computer, all of the required data to install and run AGWA are provided on the AGWA website download page, found at <https://www.tucson.ars.ag.gov/agwa/>. To install AGWA, perform the following steps:

1. Download the AGWA *add-in* for your version of ArcGIS and the supporting data directory:
  - a. AGWA 3.x Add-in for ArcGIS 10.X
  - b. AGWA 3.X Directory
2. Extract the contents of the *agwa\_add-in* zip file to a permanent location of your choice on your hard drive.
  - a. Double-click on the file **AGWA Desktop Add-In.esriAddIn** to install AGWA.
  - b. Click the “**Install Add-In**” button when the ESRI ArcGIS Add-In Installation Utility form appears.
  - c. Click “**OK**” when the “Installation Succeeded” form appears.
3. Extract the contents of the “AGWA\_3x\_directory” zip file so the “AGWA” directory is located at the C:\ location. The directory structure should look like the illustration below. The *datafiles*, *documentation*, and *models* folders are the only critical folders that must be in the *AGWA* directory; the other folders are shown as a suggested organizational aid.



## Data Acquisition

The first step in any AGWA project is to obtain the necessary input data. At a minimum, AGWA requires three GIS layers to help derive all the necessary input parameters for SWAT and KINEROS2:

- Digital Elevation Model (DEM):** This layer is used by AGWA in determining watershed boundaries, topography, and other model-specific parameters. DEMs are publicly available from multiple sources including the United States Geological Survey's (USGS) National Map, <https://viewer.nationalmap.gov/>. AGWA accepts any resolution DEM, including high resolution LiDAR data, if the units are in meters.
- Land Cover:** This integer raster dataset represents the distribution of landscape classes across a study area. Several types of datasets are supported by AGWA, including the National Land Cover Dataset (NLCD; <https://www.mrlc.gov/finddata.php>), and National Gap Analysis Project (GAP; <https://gapanalysis.usgs.gov/gaplandcover/>) land covers. Additionally, users may use custom datasets if an associated land cover look-up table exists or is created. NLCD data are also available from The National Map website.
- Soils:** Soils data are delivered as a polygon shapefile or feature class representing the soil types, with a database containing related soil properties. AGWA requires soil properties to parameterize the models. Supported classifications include the Soil Survey Geographic (SSURGO), the State Soil Geographic (STATSGO) databases for the United States, and the Food and Agriculture Organization Digital Soil Map of the World (FAO). STATSGO and SSURGO data are available from the Web Soil Survey website <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>, or the Geospatial Data Gateway website <https://datagateway.nrcs.usda.gov/GDGOrder.aspx> by state and county. The FAO Soils Database is available at <http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/en/>.

The next sections describe these data sources and the methods to acquire the data. These datasets should be stored in an easy to find location on your computer. We recommend creating a **gisdata** folder within the **C:\AGWA\** directory with new folders for each study area. For example, data relevant to Fort Bliss would be stored in the **C:\AGWA\gisdata\FortBliss\** folder. A **downloads** folder should also be created because most downloaded data will need to be manipulated in order to utilize it within AGWA. All data acquired in this section will be saved to **C:\AGWA\gisdata\FortBliss\downloads**. The urls in the following sections were current as of April 2019, but may have changed after that date.

### **Part 1: The USGS National Map: Source for DEM and Watershed Boundary data**

The USGS National Map includes several datasets that can be used to run AGWA: Elevation Products (3DEP; DEM 10 m (1/3 arc-second), 30 m (1 arc-second), and 1 m (for some areas); Hydrography (NHD and NHDPlus datasets, WBD watershed boundary datasets); and NLCD databases. We will use the National Map to obtain a 10 m DEM and the NHD WBD dataset for Fort Bliss. AGWA can use LiDAR or other high resolution digital elevation data if available.

You will need to define the boundary of your area of interest so you can identify and obtain the data to download. This area may be a Department of Defense Installation, a training area or range, a wildfire boundary, an urban development, or an incorporated city. The AGWA models are watershed-based, which do not conform to administrative or political boundaries; therefore, it is recommended to obtain a watershed boundary for your area of interest. Watershed boundaries are available from the National Hydrography Dataset (NHD; <https://nhd.usgs.gov/>) which includes a Watershed Boundary Dataset (WBD; <https://nhd.usgs.gov/wbd.html>) that defines the areal extent of surface water drainage to a point, accounting for all land and surface areas. NHD data can be found in many online locations; however, the easiest to navigate will be the USGS National Map Viewer. These areas of interest along with the NHD dataset will guide data download and influence which watersheds are modeled using AGWA. We recommend buffering your area of interest/watershed boundary to at least 100 m to ensure you capture the entire area when clipping out data. If you are using a DoD installation boundary, for example, determine if your area of interest includes watersheds that extend beyond the installation boundary. If so, it is recommended that you extract all watersheds that intersect the boundary, and buffer them to at least 100 m.

1. Begin by visiting The USGS National Map Data Delivery page at <https://viewer.nationalmap.gov/basic/>. A new tab will open where you can zoom into your area of interest, for example, Fort Bliss (Figure 1).
  - 1.1. Select the HUC watersheds from the Datasets window. Click the box for **Hydrography (NHDPlus HR, NHD, WBD)**
    - 1.1.1. Click the box for “**All Subcategories**”.
    - 1.1.2. For “**Data Extent**”, select “**HU-8 Subbasin**”. The names and outlines of the HUC8 Subbasins will appear on the map.
    - 1.1.3. For “**File Format**” select either **Shapefile** or **File GDB 10.1** (your choice).

- 1.1.4. On the map, place the cursor on “Subbasin 13050003” and click. This will highlight the HU-8 watershed for the western portion of Fort Bliss. Click the “**Find Products**” button. Note that to capture all of Fort Bliss you will need to repeat this and the next step for Subbasin 13040100, and Subbasin 13050004. The downloaded zipped files will be named similar to [NHD\\_H\\_13050003\\_HU8\\_Shape.zip](#)
- 1.1.5. Click “**Thumbnail**” for each product to see the area it covers. Click the “**cart +**” button to add the data to your Cart.
- 1.2. Use the “Draw Rectangle” tool (the square black box icon on the left side of the map) to draw a box around your area of interest. Be sure to make your rectangle large enough to capture the extent of all watersheds intersecting Fort Bliss.
- 1.3. Select the DEM data. In the Datasets panel on the left side of the screen, check the box for **Elevation Products (3DEP)** to expand that section.
  - 1.3.1. Click the box for “[1/3 arc-second DEM](#)”, and then click the “**Find Products**” button to see what is available, and click on “**Results**” to view the products if they are not visible.
  - 1.3.2. Click “**Thumbnail**” for each product to see the area it covers. You may need to download more than one product to cover your entire area. For Fort Bliss, you will need to download four products that will be named similar to [n33w106.zip](#).
  - 1.3.3. Click the “**cart +**” to add the data to your Cart. Close the panel for **Elevation Products**.
- 1.4. Click on the “**View Cart**” button to view your selections and Download your data and the Metadata.
- 1.5. The DEM data are grid data in UTM NAD83. The NHD data will be in Geographic NAD83 Coordinates. Save the zipped files in the [C:\AGWA\gisdata\FortBliss\downloads](#) folder.



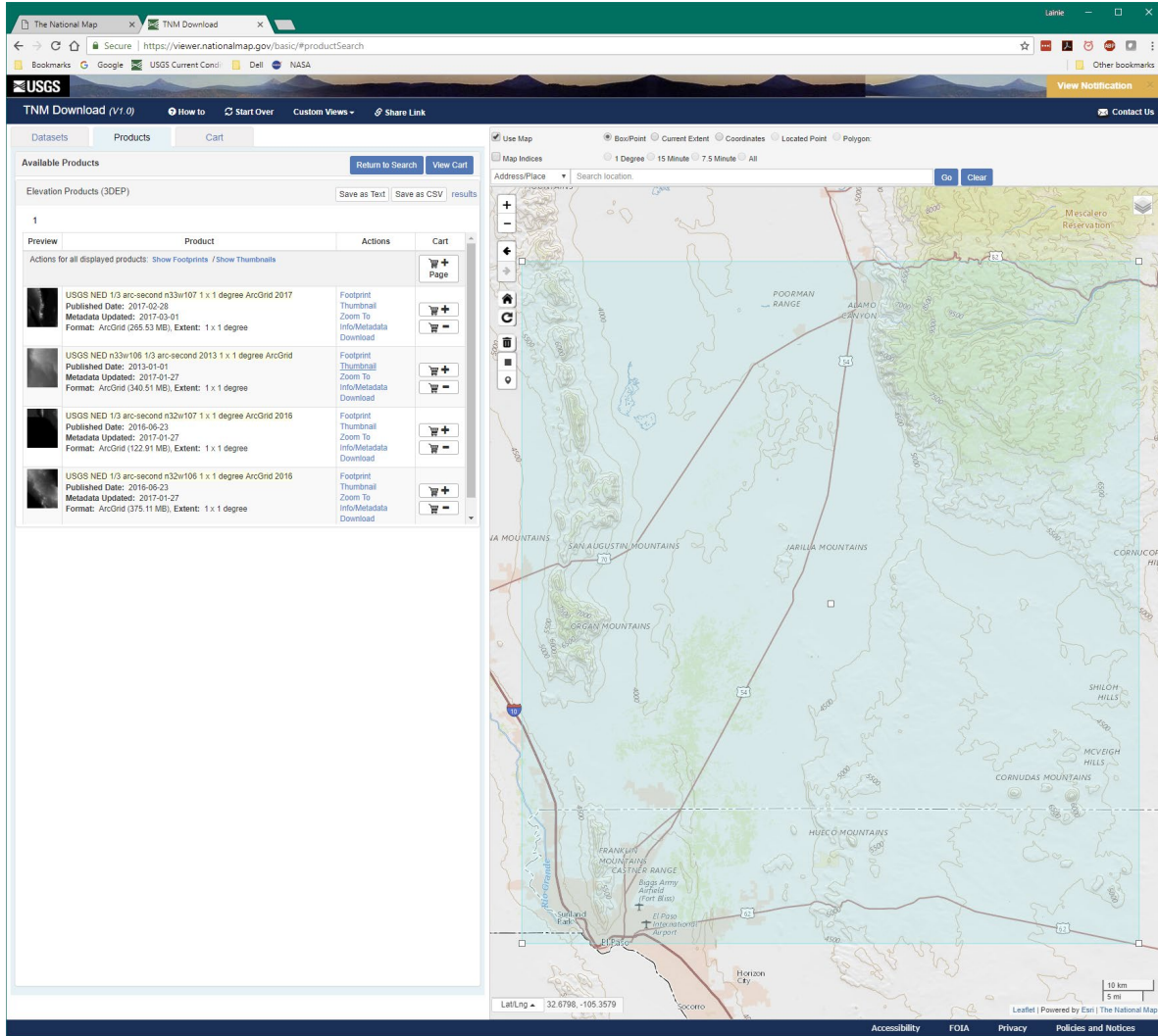


Figure 1. The USGS National Map Products Downloads page

## Part 2: GeoSpatial Data Gateway: SSURGO Soils Database

The USDA-NRCS maintains the Geospatial Data Gateway (Figure 2;

<https://datagateway.nrcs.usda.gov/GDGHome.aspx>) for acquiring geospatial data including the NHD datasets, NRCS version of the Watershed Boundary Datasets, and STATSGO and SSURGO soils data. Other useful data such as orthoimagery are also available at this website. Use this site to download the Soil Survey Geographic (SSURGO), or the State Soil Geographic (STATSGO) databases for your area of interest.

The Digital General Soil Map of the United States, or STATSGO2, is a broad-based inventory of soils and non-soil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale of 1:250,000 in the continental U.S., Hawaii, Puerto Rico, and the Virgin Islands, and 1:1,000,000 in Alaska

([https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2\\_053629](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053629)).



The SSURGO dataset was developed from digitized county-level maps that were created following standardized field methodologies and vary spatially from 1:12,000 to 1:63,360 ([https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2\\_053627](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627)). SSURGO data are recommended, although not all areas of the U.S. are available.

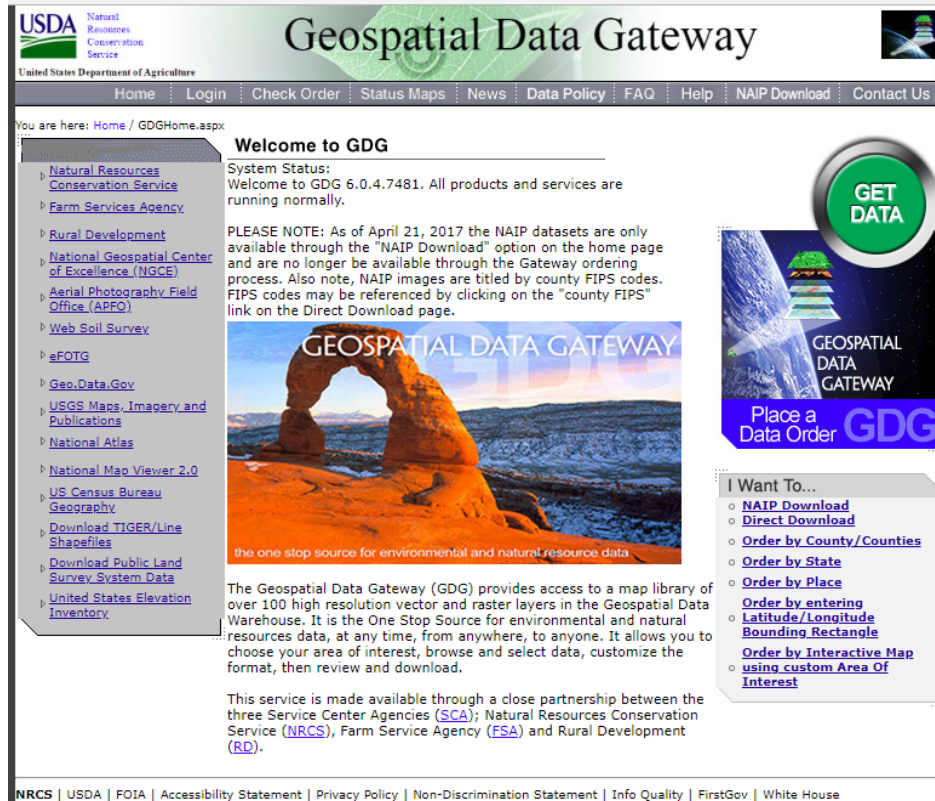
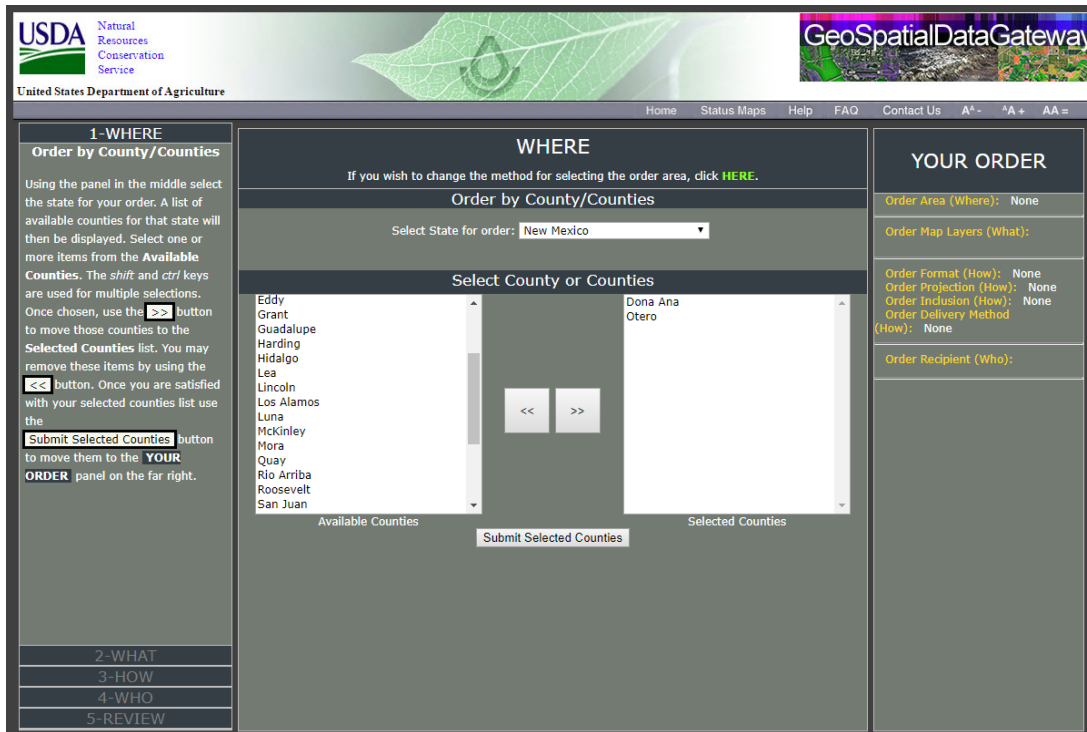


Figure 2. The USDA-NRCS Geospatial Data Gateway home page

2. Go to the website <https://datagateway.nrcs.usda.gov/GDGHome.aspx> and click on the green “Get Data” button to select the soils database for your area of interest.
  - 2.1. On the WHERE screen, select your state, New Mexico, and then select the counties of interest, Dona Ana and Otero (**Error! Reference source not found.**)
  - 2.2. Click the “Submit Selected Counties” button. Note that for this example at Fort Bliss, you will also need to download the data for El Paso County in Texas.
  - 2.3. The list of available map layers is shown on the next WHAT screen. Scroll down to select the section for Soils data. If SSURGO data are available, it is recommended to use those data; otherwise use STATSGO, which are obtained using these same steps. Note that only STATSGO data are available for the Texas portion of Fort Bliss. Also note that there are no SSURGO data for the northeast corner of Fort Bliss. If your watershed extends into these areas, you will need to use STATSGO data. Click the green CONTINUE button.
  - 2.4. Select the “Soil Survey Spatial and Tabular Data (SSURGO 2.2)” box, and click the green “+”. Notice that the SSURGO data are provided as 8 maps, one of which is all

of Fort Bliss. Because many of the watersheds on Fort Bliss extend beyond the installation boundary, you will need more than one SSURGO dataset for hydrologic watershed-based modeling, unless you are modeling a small watershed contained entirely within the Fort Bliss boundary. Click the green CONTINUE button.



**Figure 3. Geospatial Data Gateway WHERE screen for selecting soils data**

- 2.5. On the HOW screen, review the YOUR ORDER panel on the right hand side of the screen. SSURGO data include spatial and tabular data, and are delivered in only one format, as an ESRI Shapefile. Click the green CONTINUE button.
- 2.6. Enter your email address on the WHO screen, then click the green CONTINUE button.
- 2.7. Review the information on the REVIEW screen, and click the green PLACE ORDER button if the information is correct. Notice there is an estimated time for how long it will take to complete your order.
- 2.8. You will receive an email when your data are ready to be downloaded as a zip file. Save the file(s) to your **C:\AGWA\gisdata\FortBliss\downloads** folder.
- 2.9. For Fort Bliss, you will receive two emails for the SSURGO data, each with a zipped file containing additional zipped files. The files will be named similar to **wss\_SSA\_NM690\_soildb\_US\_2003\_(2014-09-26).zip**. This is because multiple soils databases are required to cover the entire New Mexico portion of Fort Bliss. You will need to repeat these steps to download the SSURGO data for the portions of Fort Bliss in El Paso County, Texas.

2.10. Double-click on each zip file to unzip it, and then extract the data to a new folder in the **C:\AGWA\gisdata\FortBliss\downloads** folder using the name of the original file. For example, **wss\_SSA\_NM688\_soildb\_US\_2003\_(2017-09-09)**. These folders will each include a subfolder named “soils” with additional zipped files. Unzip each one and locate the folder with the name of the soils data (e.g. NM688). This folder contains a blank database named “soildb\_US\_2003.mdb” and two folders named “spatial” and “tabular” (Figure 4). You will populate each blank database by importing the associated tabular data for use in AGWA in the next section, Data Management.

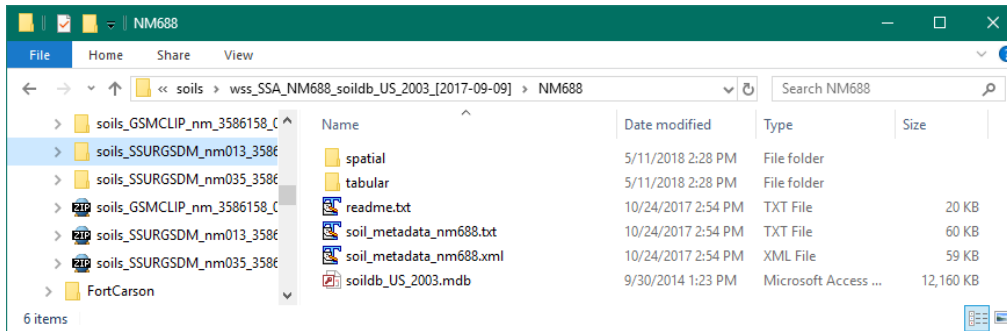


Figure 4. SSURGO file structure

### Part 3. FAO Soil Map of the World

When using AGWA outside of the U.S. or when your watershed crosses the U.S. border into Canada or Mexico, you must use the FAO soils data.

To download the GIS layer from the Food and Agriculture Organization’s GeoNetwork, go to <http://www.fao.org/geonetwork/srv/en/metadata.show?currTab=simple&id=14116> (Figure 5).

3. Click on “Distribution” on the left side of the screen, then on the page that opens go to the “Transfer Options” section, and select **Digital Soil Map of the World – ESRI shapefile format** (Figure 6).
  - 3.1. Save the zip file in your **C:\AGWA\gisdata\FortBliss\downloads** folder, and unzip it to a folder with the same name. This file covers the entire world, and is in Geographic WGS84 coordinates.
  - 3.2. The next section, Data Management, will explain how to project and clip the data to your area of interest.

# AGWA Tool Guidance Document - ESTCP Project RC201308

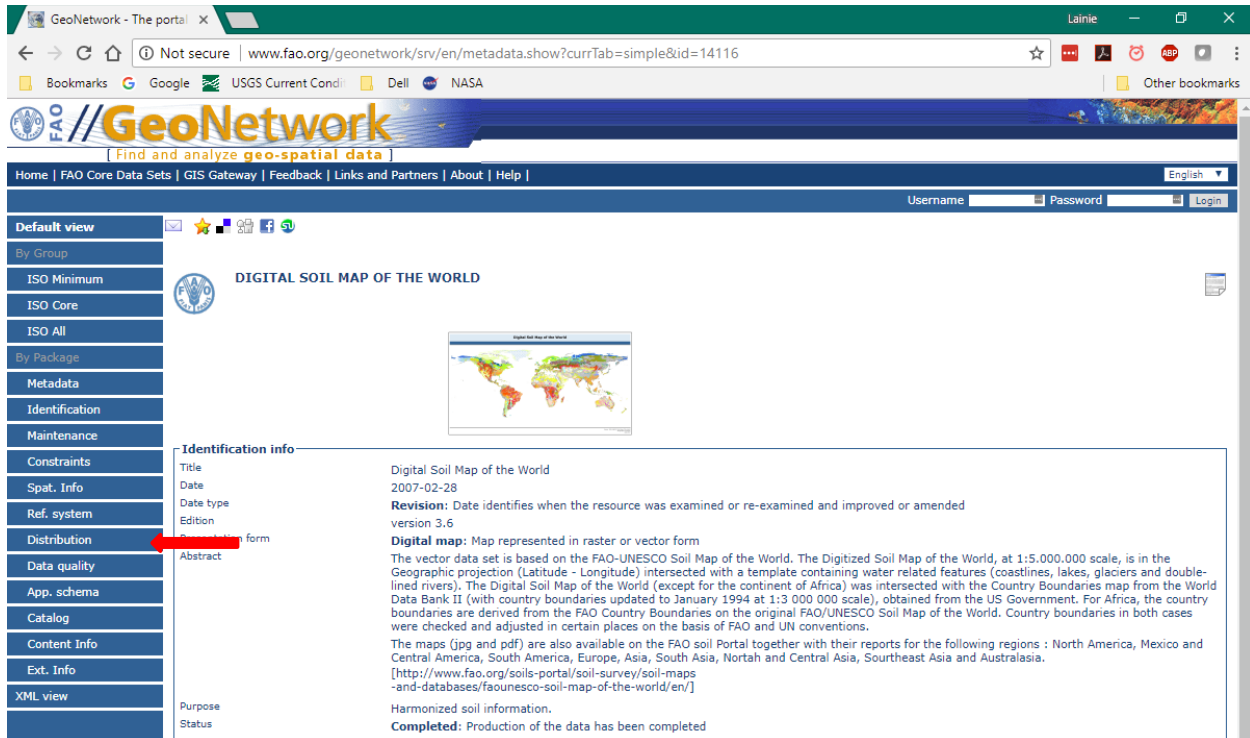


Figure 5. FAO Soil Map of the World home page

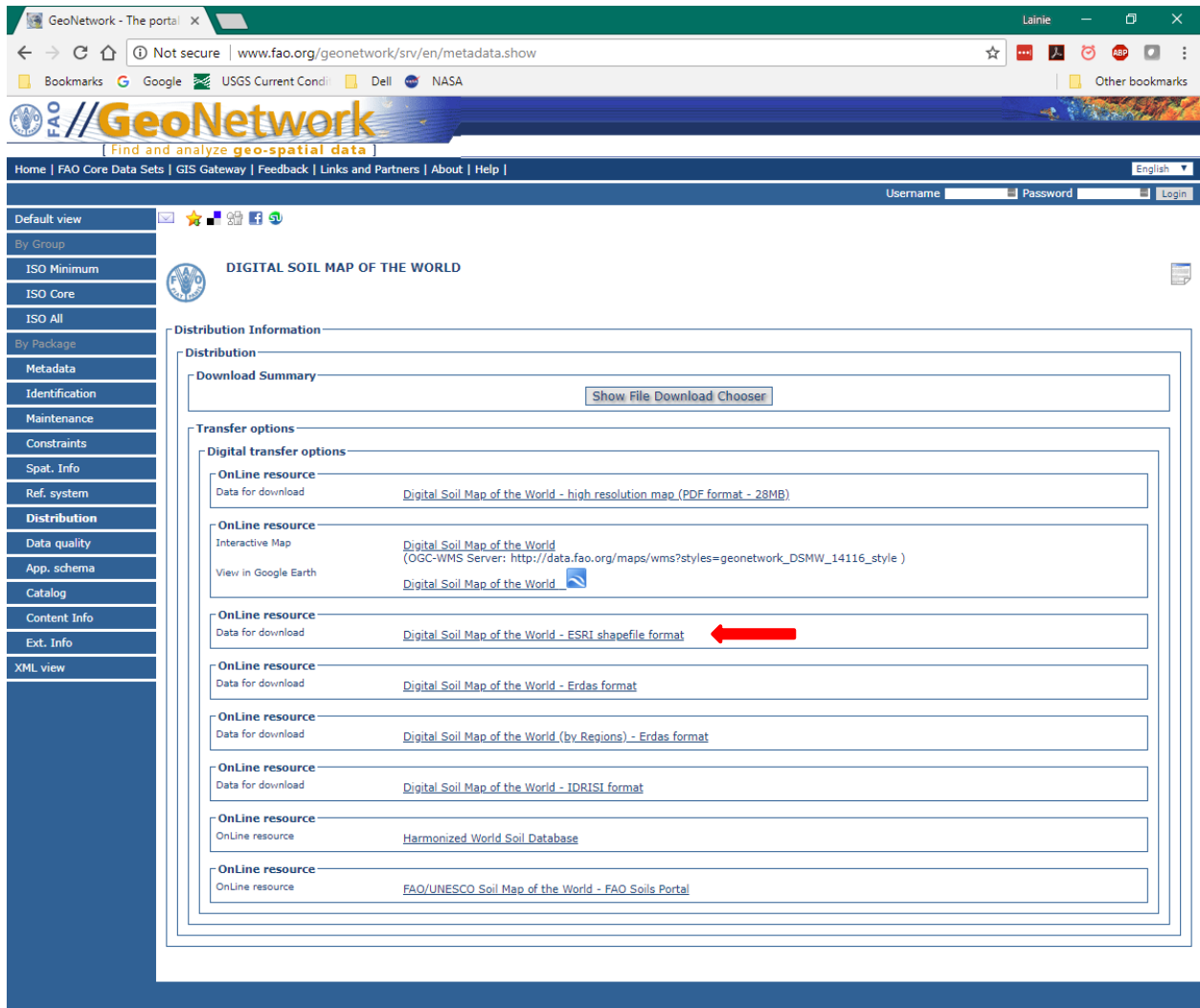


Figure 6. FAO Data selection page

#### Part 4. GAP Landcover

AGWA can use several different land cover datasets to characterize and parameterize watersheds. Gridded land cover datasets represent the distribution and variability of landscape classes across a study area. In general, it is recommended that users acquire land cover data that extends beyond the boundaries of the study area and watershed for successful parameterization.

AGWA currently supports GAP, MLRC/NLCD, and NALC land cover grids. The GAP and NLCD data are more current than the NALC data, which are best used for historic land cover change analyses as they are available only for 1973, 1986, and 1991. Users may utilize other land cover datasets if an associated land cover look-up table exists or is created that matches the format of the AGWA look-up tables. In AGWA the cover type, interception, Manning's N, percent impervious, and curve numbers (for hydrologic soils groups A, B, C, and D) are all obtained from the land cover layer using a land cover look up table that is included with the

AGWA package (Burns et al., 2007). These values were determined for each of the vegetation classes from expert opinion and previously published look-up tables (Miller et al., 2002).

The GAP Landcover data are available from the USGS's Gap Analysis Program (GAP: <https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap>) National Land Cover dataset (USGS National Gap Analysis Program, 2012). The GAP data combines data generated by regional GAP projects with LANDFIRE data (<https://www.landfire.gov/>) to provide information on the distribution of native vegetative types, modified and introduced vegetation, developed areas, and agricultural areas, in a seamless coverage for the entire United States (USGS National Gap Analysis Program, 2012). The southwest portion of the dataset was derived through the classification of 30-meter, multi-seasonal Landsat Enhanced Thematic Mapper Plus (ETM+) satellite images that were acquired between 1999-2001 (Lowry et al., 2007). The imagery was classified into 590 land use classes following NatureServe's Terrestrial Ecological Systems Classification framework for natural and semi-natural land cover (Comer et al., 2003).

4. Download the USGS GAP Analysis data from the USGS GAP Downloads webpage at <https://gapanalysis.usgs.gov/gaplandcover/data/download/>.
  - 4.1. Scroll down to the **Download by State or Territory** section where a map and list of states allows you to download by state (Figure 7). Select your state, e.g. New Mexico for Fort Bliss. Note that part of Fort Bliss is in Texas, so you will also download that state. The zipped file will be named similar to **gaplf2011lc\_v30\_NM.zip**.
  - 4.2. Save the zip file in your **C:\AGWA\gisdata\FortBliss\downloads** folder and unzip it to a folder with the same name.

### Part 5. NLCD Landcover

The National Land Cover Database 2011 (NLCD 2011) is created by the Multi-Resolution Land Characteristic (MRLC) Consortium (<https://www.mrlc.gov/>). It uses a 16-class land cover classification scheme that has been applied consistently across the United States at a spatial resolution of 30 meters. NLCD 2011 is based primarily on a decision-tree classification of three 2011 Landsat images, and other data. NLCD data are also available for 2001 and 2006, allowing for analysis of land cover change and trends across the United States.

5. Go to <https://www.mrlc.gov/> and click on the "Data" link at the top of the page (Figure 8), and select **Downloads**.
  - 5.1. Scroll down to the "NLCD 2011 Land Cover (CONUS)" box, and select **Download**.
  - 5.2. Save the zip file to your folder. It will be named similar to **nlcd\_2011\_landcover\_2011\_edition\_2014\_10\_10.zip**.
  - 5.3. Unzip the data, which is a raster layer covering the entire United States in the Albers Equal Area Conic project with a datum of NAD83. Save the data to a folder with the same name.



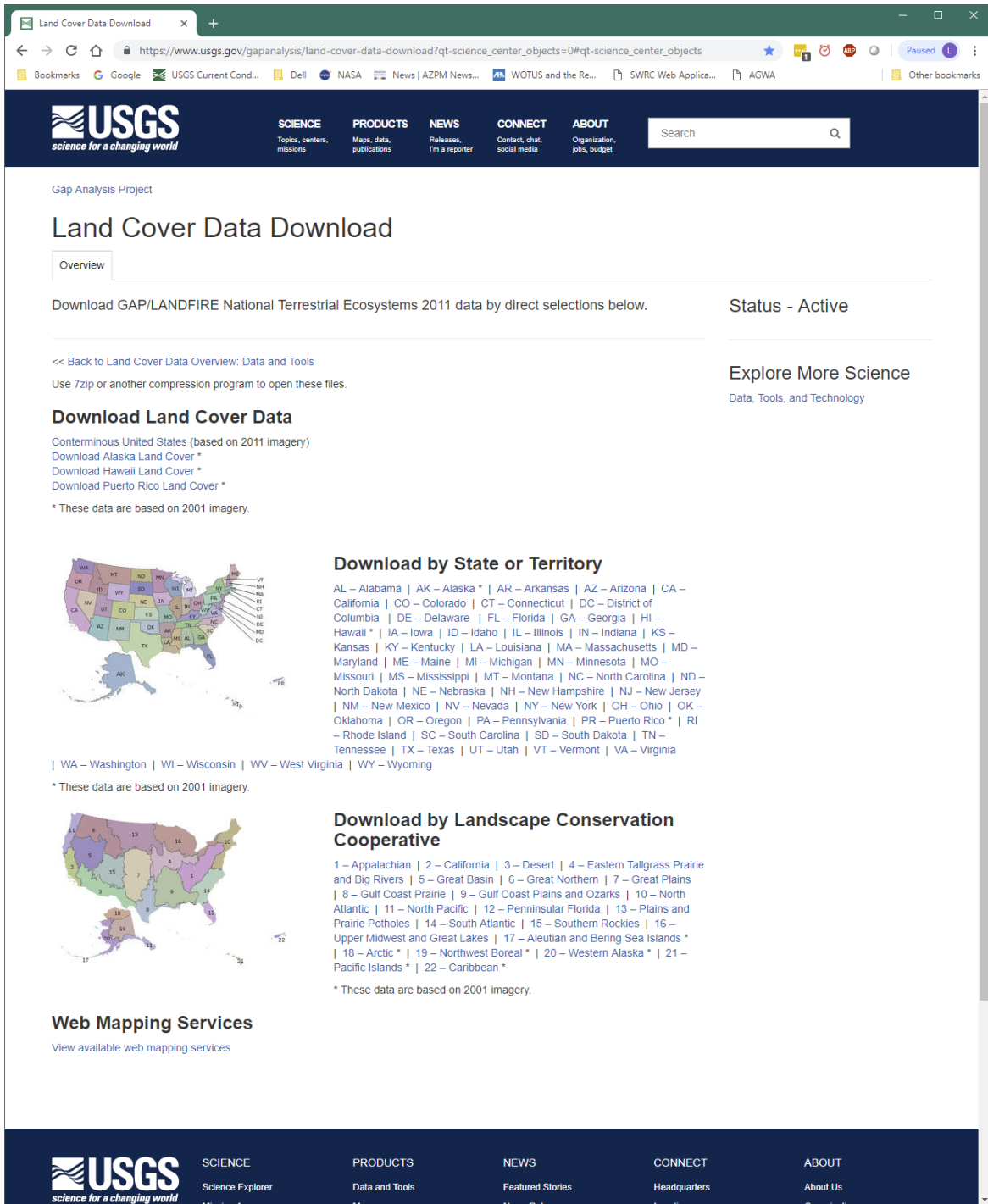


Figure 7. USGS GAP Analysis Project Land Cover download page

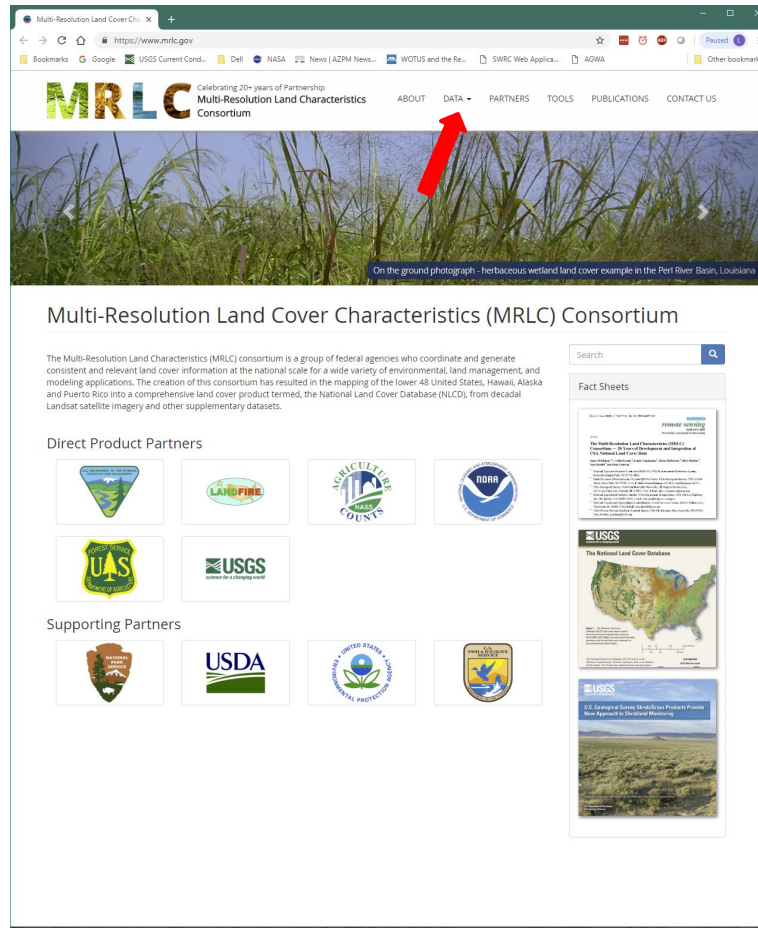


Figure 8. MRLC website page for obtaining NLCD data

### Part 6. SWAT Precipitation

AGWA provides a means for preparing rainfall files in the required format for input to SWAT or KINEROS2. This section presents the methods for creating precipitation inputs for SWAT; the next section will address KINEROS2 precipitation data. For SWAT, the user must have a *dbf* file containing the continuous, daily estimates of rainfall for the rain gages that will be used. The daily precipitation (mm) values are arranged chronologically by year and Julian calendar day for each rain gage location. For multiple gages, AGWA uses a built-in tool that distributes the values using Thiessen polygons to compute the weighted rainfall depth falling on each subwatershed (Miller et al., 2007). Precipitation data for SWAT may be obtained from NOAA’s National Climatic Data Center (NCDC) from NEXRAD data, or from local meteorological data.

#### NOAA NCDC

The daily climate data needed to run SWAT can be obtained from the NOAA National Climatic Data Center’s (NCDC) Climate Data Online interactive map application (Figure 9)

<https://www.ncdc.noaa.gov/cdo-web/datatools>.



- Go to the NOAA NCDC Webpage for Climate Data Online Data Tools at <https://www.ncdc.noaa.gov/cdo-web/datatools> and select “Select a Location” (Figure 9). We will use the Orogrande, New Mexico, station for this example.

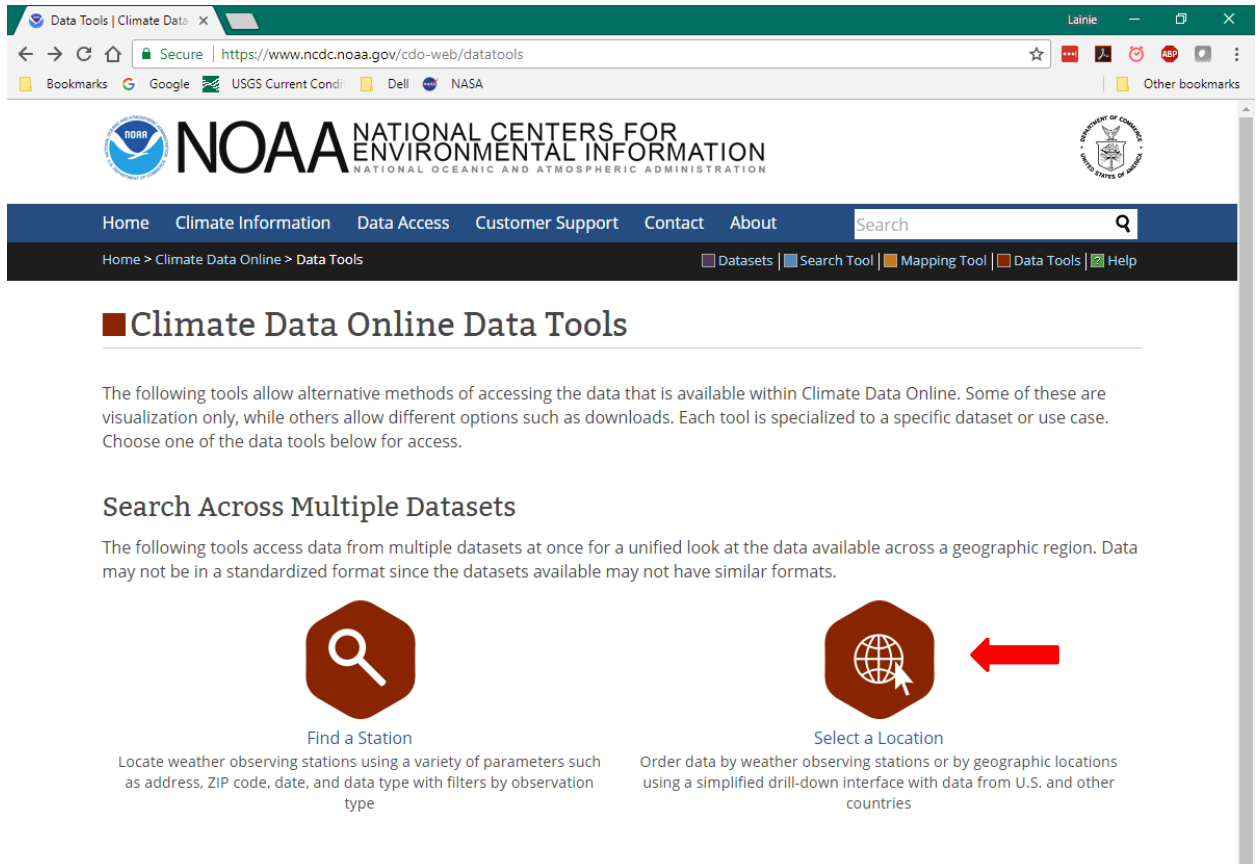


Figure 9. NCDC Climate Data home page

- On the next screen (Figure 10), in the “*Select a Dataset*” box, select “**Daily Summaries**”.
- Select “**County**” in the “*Select a Location Type*” box.
- Select “**New Mexico**” in the “*Select a State*” box.
- Select “**Otero County, NM**” in the “*Select a County*” box.
- The list of available stations will display when you select Otero County. Scroll down and click on the orange box “**ADD TO CART**” next to “**OROGRANDE, NM US**”.
- Go to your Cart by hovering on the orange box at the top of the screen “**Cart (Free Data) 1 item**”, and clicking on “**VIEW ALL ITEMS**”.

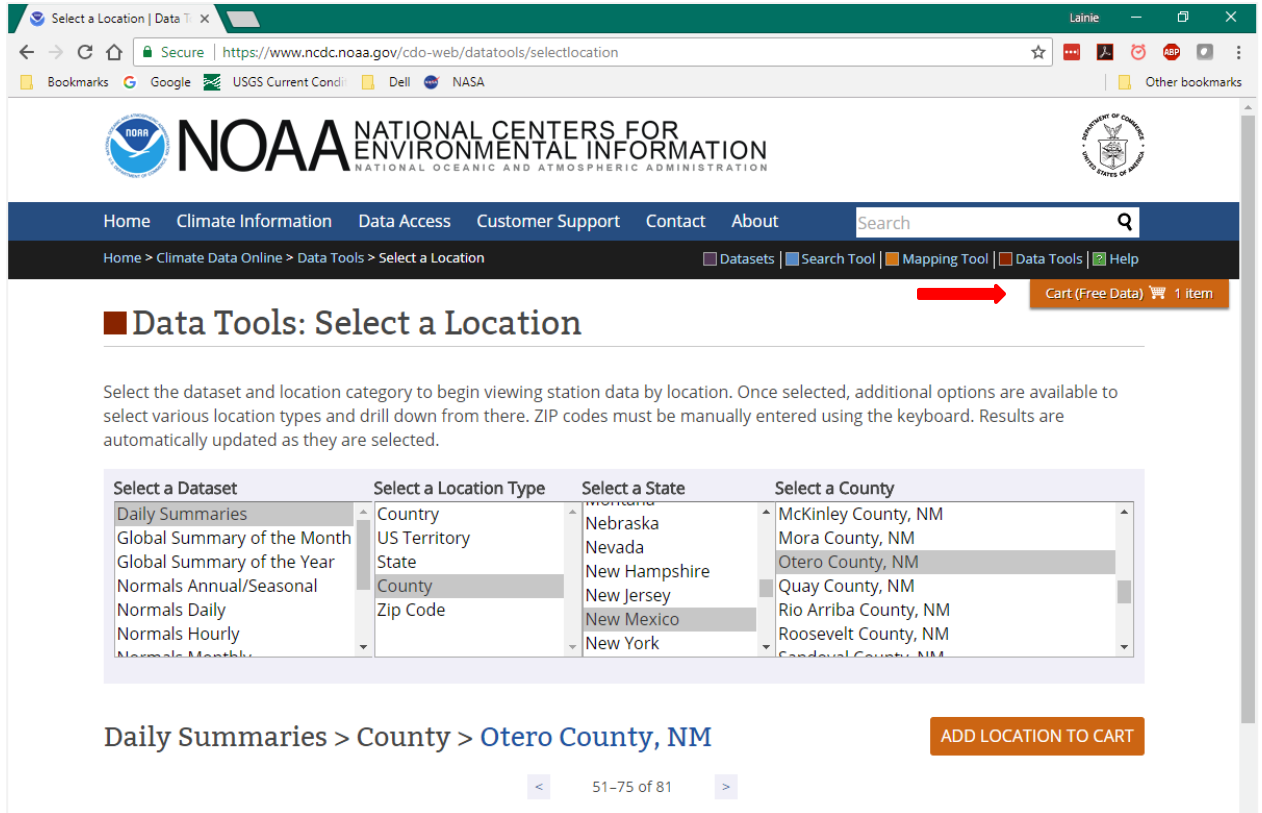
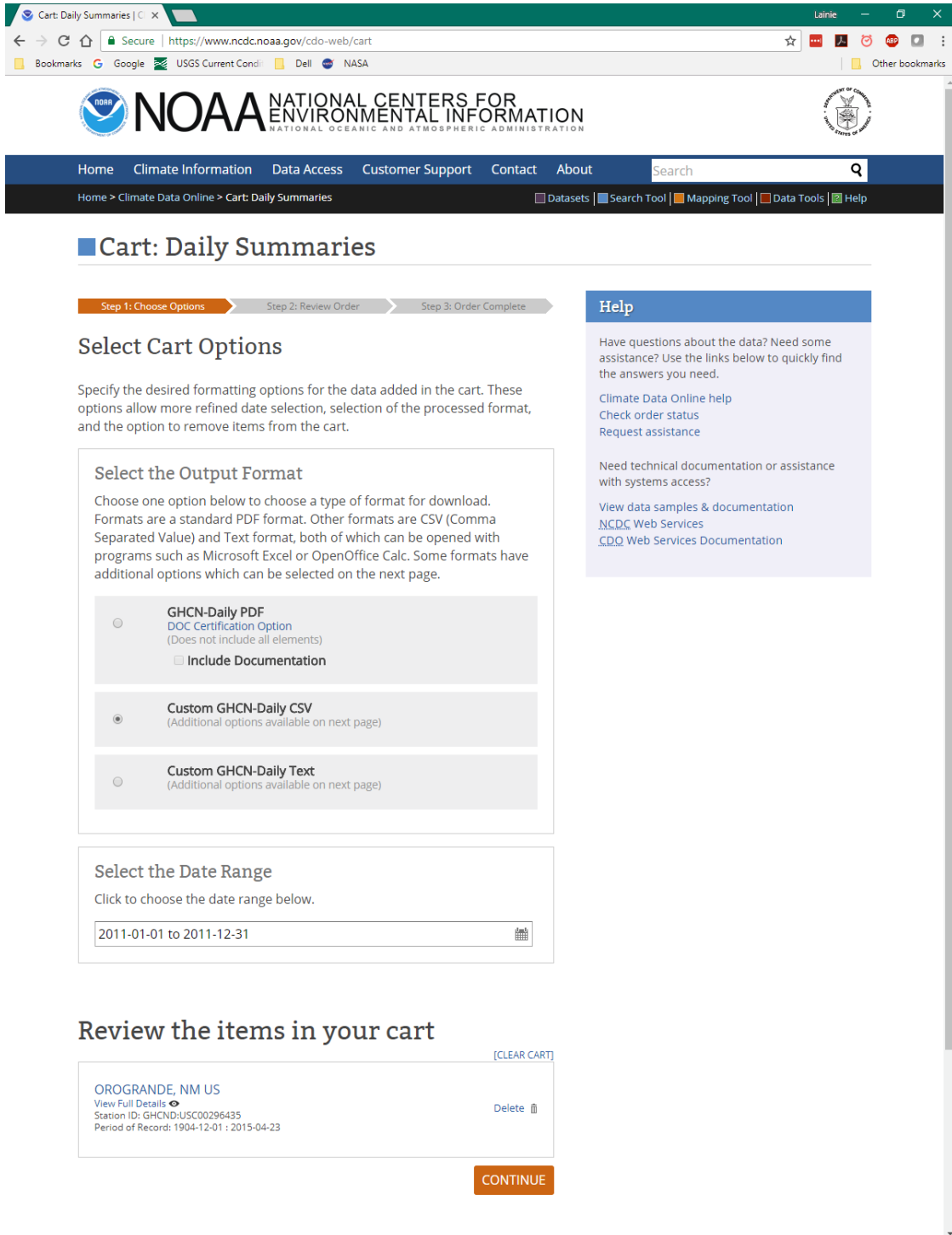


Figure 10. NCDC Select a Location page

- 6.7. On the “**Select Cart Option**” screen (Figure 11), click the radio button next to “**Custom GHCN-Daily CSV**” to download your data as a comma delimited file.
- 6.8. In the “**Select the Date Range**” box, use the drop down menus to select “**2011 Jan. 1 to 2011 Dec. 31**”, for this example. You may select any date range, but we will use 2011 for this example. Click “**APPLY**”.
- 6.9. Click “**CONTINUE**”.
- 6.10. On the next screen, leave “Station Name” checked, check the Geographic Location box, change the “Units” to “Metric” (data will be in mm).
- 6.11. In the “Select data types...” box, expand the “Precipitation” item in the. Check the box next to “Precipitation (PRCP)”, and click “**CONTINUE**”.
- 6.12. Review the information to be sure it is correct. Enter your email address and click “**SUBMIT ORDER**”.
- 6.13. You will be sent an email with a link to download your data as a .csv file. Depending on the number of years and types of data requested, you will receive an Order Complete email within minutes. Save this .csv file in your **C:\AGWA\gisdata\FortBliss\downloads** folder. Creating the precipitation input file for SWAT from this file will be demonstrated in the Data Management section of this document.

# AGWA Tool Guidance Document - ESTCP Project RC201308



**Figure 11. NCDC Select Cart Options page**

**NOTE:** This short of a time period (one year) is not recommended for adequate watershed analysis; however, for the purpose of this demonstration a one year time period allows us to more easily walk through all necessary steps in formatting, model simulations, and interpretation.

### ***NEXRAD***

Next-Generation Radar (NEXRAD) data can also be used in AGWA if properly formatted. The data are collected through a network of 160 high-resolution Weather Surveillance Radar-1988 Doppler (WSR-88D) radars that constantly scan the near surface, detecting precipitation and atmospheric movement using a Precipitation Processing System (PPS) algorithm described in detail in Fulton et al. (1998). The data are organized to provide spatially continuous precipitation estimates over a 4x4 km<sup>2</sup> grid, and may provide better coverage than the NCDC data. NEXRAD data are available from NOAA at <https://www.ncdc.noaa.gov/data-access/radar-data/nexrad>. Because additional software and tools are typically required to extract and manipulate these data, we will not use these data in this example.

### ***Meteorological Towers and Rain Gages***

In addition to the NEXRAD and rain gage data sources, meteorological towers (met towers) within the installation boundaries can provide precipitation and temperature data. These data can be evaluated as an input for SWAT and used to create storms needed for KINEROS2 using the procedures described in the Data Management section.

### **Part 7. KINEROS2 Precipitation**

KINEROS2 is designed to use rainfall events as opposed to the daily rainfall totals used in SWAT. AGWA allows you to create rainfall data for KINEROS2 in 4 ways:

1. Design storm depth and duration from the AGWA design storm database.
2. User-defined depth and duration.
3. Design storm depth and duration based on NOAA precipitation frequency maps.
4. User-defined hyetograph.

This section will illustrate how to acquire the first three types of rainfall files, and the Data Management section will show how to prepare the data for use in AGWA.

### ***Design Storm Database***

7. AGWA has a built in design storm database which contains return period depths for a limited number of locations. This table can be found in the **C:\AGWA\datafiles\precip\** folder with the file name ***dsgnstrm.dbf***. To use this precipitation input for KINEROS2, the ***dsgnstrm.dbf*** table must be added to the map document. These design storms are from the NOAA Atlas 14 Point Precipitation Frequency Estimates. The data for Orogrande (Table 1) and other locations are available at [https://hdsc.nws.noaa.gov/hdsc/pfds/pfds\\_map\\_cont.html](https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). The values in these tables may be used to create additional locations in the ***dsgnstrm.dbf*** file, or may be used directly in AGWA using the User-defined depth and duration input option (see next section).

**Table 1. NOAA Atlas 14 Point Precipitation Frequency Estimates for Orogrande, New Mexico**

**PF tabular**

<b>PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup></b>										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.228 (0.201-0.259)	0.294 (0.262-0.335)	0.399 (0.353-0.453)	0.478 (0.421-0.544)	0.584 (0.512-0.666)	0.669 (0.585-0.765)	0.759 (0.659-0.862)	0.853 (0.736-0.972)	0.982 (0.833-1.12)	1.09 (0.917-1.24)
10-min	0.347 (0.306-0.394)	0.448 (0.399-0.510)	0.607 (0.538-0.690)	0.727 (0.641-0.828)	0.888 (0.779-1.01)	1.02 (0.890-1.16)	1.16 (1.00-1.31)	1.30 (1.12-1.48)	1.49 (1.27-1.70)	1.65 (1.40-1.89)
15-min	0.430 (0.379-0.489)	0.555 (0.494-0.632)	0.753 (0.667-0.856)	0.901 (0.794-1.03)	1.10 (0.965-1.26)	1.26 (1.10-1.44)	1.43 (1.24-1.63)	1.61 (1.39-1.83)	1.85 (1.57-2.11)	2.05 (1.73-2.34)
30-min	0.579 (0.511-0.659)	0.747 (0.666-0.851)	1.01 (0.898-1.15)	1.21 (1.07-1.38)	1.48 (1.30-1.69)	1.70 (1.49-1.94)	1.93 (1.67-2.19)	2.17 (1.87-2.47)	2.49 (2.12-2.84)	2.76 (2.33-3.15)
60-min	0.716 (0.632-0.815)	0.925 (0.824-1.05)	1.25 (1.11-1.43)	1.50 (1.32-1.71)	1.83 (1.61-2.09)	2.10 (1.84-2.40)	2.39 (2.07-2.71)	2.68 (2.32-3.06)	3.09 (2.62-3.51)	3.41 (2.88-3.90)
2-hr	0.837 (0.738-0.955)	1.09 (0.968-1.25)	1.48 (1.30-1.69)	1.77 (1.55-2.01)	2.16 (1.89-2.46)	2.47 (2.13-2.80)	2.79 (2.39-3.16)	3.13 (2.65-3.54)	3.57 (2.99-4.05)	3.92 (3.26-4.44)
3-hr	0.902 (0.802-1.03)	1.16 (1.03-1.33)	1.55 (1.38-1.76)	1.85 (1.63-2.09)	2.25 (1.98-2.54)	2.57 (2.24-2.90)	2.90 (2.50-3.27)	3.23 (2.77-3.64)	3.70 (3.12-4.17)	4.05 (3.38-4.56)
6-hr	1.03 (0.926-1.16)	1.32 (1.18-1.50)	1.73 (1.54-1.97)	2.04 (1.81-2.30)	2.46 (2.16-2.76)	2.78 (2.44-3.12)	3.11 (2.70-3.48)	3.43 (2.95-3.86)	3.87 (3.30-4.36)	4.21 (3.57-4.74)
12-hr	1.13 (1.00-1.26)	1.44 (1.28-1.62)	1.87 (1.67-2.09)	2.19 (1.94-2.45)	2.62 (2.31-2.91)	2.93 (2.58-3.26)	3.25 (2.84-3.62)	3.57 (3.10-3.97)	4.00 (3.43-4.44)	4.31 (3.69-4.81)
24-hr	1.29 (1.14-1.47)	1.64 (1.45-1.87)	2.11 (1.85-2.40)	2.47 (2.15-2.80)	2.93 (2.55-3.34)	3.28 (2.85-3.76)	3.64 (3.14-4.19)	4.00 (3.43-4.63)	4.47 (3.80-5.22)	4.83 (4.07-5.68)
2-day	1.37 (1.21-1.54)	1.73 (1.54-1.96)	2.22 (1.97-2.51)	2.61 (2.30-2.94)	3.12 (2.74-3.54)	3.53 (3.06-4.01)	3.94 (3.39-4.50)	4.35 (3.71-5.01)	4.92 (4.13-5.70)	5.36 (4.45-6.27)
3-day	1.46 (1.30-1.63)	1.85 (1.65-2.08)	2.38 (2.12-2.67)	2.79 (2.48-3.13)	3.34 (2.95-3.76)	3.76 (3.29-4.24)	4.19 (3.63-4.76)	4.63 (3.97-5.28)	5.21 (4.41-5.99)	5.66 (4.74-6.57)
4-day	1.55 (1.39-1.72)	1.97 (1.77-2.19)	2.54 (2.28-2.83)	2.98 (2.65-3.31)	3.56 (3.16-3.97)	4.00 (3.52-4.48)	4.45 (3.88-5.01)	4.90 (4.24-5.55)	5.50 (4.68-6.28)	5.96 (5.04-6.86)
7-day	1.79 (1.61-1.99)	2.27 (2.04-2.52)	2.95 (2.65-3.27)	3.46 (3.09-3.84)	4.16 (3.70-4.62)	4.70 (4.16-5.24)	5.27 (4.63-5.89)	5.84 (5.08-6.57)	6.62 (5.66-7.52)	7.22 (6.10-8.28)
10-day	1.95 (1.74-2.19)	2.49 (2.23-2.79)	3.24 (2.90-3.62)	3.83 (3.41-4.29)	4.64 (4.09-5.18)	5.26 (4.60-5.92)	5.91 (5.12-6.67)	6.57 (5.65-7.49)	7.47 (6.34-8.57)	8.18 (6.85-9.48)
20-day	2.44 (2.19-2.71)	3.11 (2.80-3.45)	4.03 (3.63-4.47)	4.72 (4.23-5.24)	5.64 (5.04-6.27)	6.34 (5.63-7.05)	7.05 (6.22-7.86)	7.76 (6.81-8.68)	8.70 (7.54-9.83)	9.42 (8.07-10.7)
30-day	2.83 (2.56-3.13)	3.62 (3.27-3.99)	4.65 (4.20-5.12)	5.42 (4.90-5.95)	6.42 (5.77-7.05)	7.16 (6.41-7.87)	7.89 (7.02-8.74)	8.62 (7.60-9.62)	9.57 (8.34-10.8)	10.3 (8.87-11.7)
45-day	3.41 (3.09-3.75)	4.33 (3.93-4.78)	5.51 (5.01-6.10)	6.37 (5.77-7.03)	7.46 (6.73-8.24)	8.26 (7.43-9.13)	9.04 (8.10-10.0)	9.78 (8.72-10.9)	10.7 (9.49-12.1)	11.4 (10.0-12.9)
60-day	3.89 (3.55-4.27)	4.94 (4.51-5.42)	6.28 (5.74-6.91)	7.24 (6.59-7.94)	8.44 (7.65-9.24)	9.30 (8.41-10.2)	10.1 (9.14-11.1)	10.9 (9.80-12.1)	11.9 (10.6-13.2)	12.6 (11.2-14.1)

<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

**User-defined depth and duration**

AGWA accepts precipitation data as depths (in) from a pre-defined table of precipitation frequency estimates based on a specific return interval and duration (Table 1). Typical design storms used in KINEROS2 are based on 5, 10, 25, 50, or 100-year, 1-hour storms. Note that applying a design storm created from a single point estimate across an entire watershed tends to result in an overestimation of runoff due to the failure to account for the spatial heterogeneity of the input data (Miller et al., 2002).

- To enter precipitation data as depth, use the Point Precipitation Frequency Estimates table (Table 1), and select the depth for the design storm. For this example, select the depth for a 10 year 1 hour storm, which is 1.5 inches (38 mm).

### ***NOAA Precipitation Frequency Data***

NOAA's Atlas 14 Precipitation Frequency Estimates in GIS Compatible Format Data Server (PFDS; Figure 12) provides Precipitation Frequency Estimates in partial duration series depths or as annual maximum series (NOAA PFDS, 2017). We use the partial duration series because it provides all events within the period of record that are higher than a threshold, as opposed to the annual maximum series which includes only the highest values for each year. The gridded dataset is available for most of the United States and is separated in Volumes 1-10 by region. For this example, we will obtain the dataset for a 10 year 1 hour storm for the Southwestern United States. These estimates will be very similar to the depths obtained from the Point Precipitation Frequency Estimates table (Table 1), but can provide a more accurate estimate for your location.

9. Visit NOAA at [http://hdsc.nws.noaa.gov/hdsc/pfds/pfds\\_gis.html](http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_gis.html). Scroll down the page (Figure 12) and use the pull-down menus to select your data to download.
  - 9.1. In the Volume: box, select **1: Semiarid Southwest**
  - 9.2. Select the type of data: **Precipitation frequency estimates**
  - 9.3. Select the Series: **Partial duration series**
  - 9.4. Select Average recurrence interval: **10-year**
  - 9.5. Select Duration: **60-minute**
  - 9.6. Click on the "***Click here to begin download***" button to download the zipped ascii file and save it in your **C:\AGWA\gisdata\FortBliss\downloads** folder.
  - 9.7. Unzip the file and save it to **C:\AGWA\datafiles\precip\**
  - 9.8. Project this raster to UTM Zone 13, Datum WGS84. Name the raster so you know what it is: "**sw10y60min84**" (i.e. Southwest, 10 year 60 minute data in WGS84 datum).

This is a raster layer of the Southwestern U.S., with precipitation estimates in inches (times 1000) and is ready for use in AGWA. AGWA will automatically divide the values by 1000 and multiply by 25.4 to get mm, as required for KINEROS2.

### ***User-Defined Hyetograph***

If users have their own event data, this information can be organized so that for each time step there is a corresponding depth in millimeters, or intensity in mm per hour. This information can be used as a direct input for the KINEROS2 model.

To acquire this information, various web based data repositories are available; however, the most detailed information will likely come from a local source familiar with the study area, the watershed, or any instrumentation on site.




The screenshot shows a web browser window displaying the NOAA Atlas 14 Precipitation Frequency Estimates in GIS Compatible Format page. The browser's address bar shows the URL: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds\_gis.html. The page header includes the NOAA logo and the title 'NOAA's National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server (PFDS)'. The main content area features a title 'NOAA Atlas 14 Precipitation Frequency Estimates in GIS Compatible Format' and a paragraph explaining that the page provides access to NOAA Atlas 14 precipitation frequency estimates with upper and lower bounds of the 90% confidence interval in GIS compatible format. Below this, there is a 'DOWNLOAD GIS DATA:' section with a list of 10 volumes, each with a brief description and a link to download. A table provides instructions for anonymous ftp, including actions like 'Open ftp to the server', 'Login as anonymous user', 'Give the password', 'Switch to binary mode', 'Change directory', 'Get one file', 'Get several files', and 'Quit ftp'. The footer contains contact information for the National Oceanic and Atmospheric Administration, National Weather Service, Office of Water Prediction (OWP), and links for Disclaimer, Credits, Glossary, Privacy Policy, About Us, and Career Opportunities.

Figure 12. NOAA Atlas 14 Precipitation Frequency Estimates in GIS Compatible Format

## Data Management

Data acquisition described in the previous section is the first step in preparing to use AGWA; however, data management is important for proper implementation in AGWA. Some of the data acquired in the previous Data Acquisition section and saved to the


**C:\AGWA\gisdata\FortBliss\downloads** folder will be used in this part of the guidance document. Data management consists largely of projecting the data to a common coordinate system, and clipping it to the area of interest. Although this section focuses on a limited set of data sources, the same process can be used to organize and format other data. Other local data, such as LiDAR, should also be projected and clipped as described in this section.

Begin by opening ArcCatalog. Folder connections to drives and folders where your data are stored must be established if they are not already. To establish new folder connections, click the **Connect To Folder** button  on the menu bar at the top of the screen. Select drive (C:).

### Part 1: Projecting Data to a Common Coordinate System

Although ArcMap can project “on the fly” when displaying data layers and a common coordinate system is not required to view the data, it is necessary that all data be in a common coordinate system for AGWA to run properly. This part will describe how to project your data.


#### Step 1: Add and view the data in ArcMap

10. Click on the **Add Data** button  below the menu bar at the top of the screen, and navigate to **C:\AGWA\gisdata\FortBliss\downloads\**. You may need to establish a folder connection as you did previously in ArcCatalog.

10.1. Select the data you downloaded in the Data Acquisition part of this document: the DEM, the SSURGO soils layers, the NLCD landcover layer, and the HUC12 layer. To select more than one layer at a time, click and hold the shift key.

10.2. Click **Add**.

**NOTE:** ArcMap may ask if you would like to build pyramids for the raster datasets you are adding; click **Yes**.



Look at the data you have available to you to familiarize yourself with the area. Layers can be reordered, turned on/off, and their legends collapsed to suit your preferences and clean up the display. If the layers cannot be reordered by clicking and dragging, the **List By Drawing Order** button  may need to be selected at the top of the **Table Of Contents**.


#### Step 2: Project the Data to a Common Coordinate System

Projecting data to a common coordinate system is a necessary step to use the data in AGWA, and is a generally sound practice for any type of GIS analysis. This example explains how to project data to a common coordinate system for Fort Bliss; you will need to determine the proper coordinate system for other locations. The DEM, soils, NHD HUC, and land cover data will need



to be projected. Note that you will need more than one of each type of data to completely cover all of the Fort Bliss watersheds.

11. Verify the current coordinate system of the data frame.
  - 11.1. Right click on  **Layers** in the Table of Contents and select Properties. If the **Current coordinate system** is not **WGS\_1984\_UTM\_Zone\_13N**, then perform the following steps. If it is in this coordinate system, skip to Step 12.
  - 11.2. In the Coordinate System tab, open the Projected Coordinate Systems item
    - 11.2.1. Open **UTM**
      - 11.2.1.1. Open **WGS 1984**
      - 11.2.1.2. Open **Northern Hemisphere**
      - 11.2.1.3. Select **WGS 1984 UTM Zone 13N**
    - 11.2.2. Click **OK** to save the coordinate system and leave the Data Frame Properties Window. Save the map document and continue.
12. Verify the current projection of the layers (DEM, soils data, NHD, and land cover).
  - 12.1. Coordinate systems for each of the layers can be found by double clicking on the layer then opening the Source tab. In the Property window, scroll down and verify that the Spatial Reference XY Coordinate System is **WGS\_1984\_UTM\_Zone\_13N**. If not, then perform the following steps.
  - 12.2. First project the feature classes (soils, and NHD Watershed Boundary), and then the rasters (DEM, and NLCD) to the **WGS\_1984\_UTM\_Zone\_13N** coordinate system. Open ArcToolbox using the ArcToolbox button  in the Standard Toolbar in ArcMap.
  - 12.3. Navigate to **Data Management Tools > Projections and Transformations**.
    - 12.3.1. Double-click on the **Project** tool to project the feature classes.
      - 12.3.1.1. **Input Dataset or Feature Class**: double-click and select the layer. For the NHD Watershed Boundary, go to the subbasin folders for “NHD\_H\_13050003\_HU8”, “NHD\_H\_13040100\_HU8”, and “NHD\_H\_13050004\_HU8”. From the **WBD** subfolder for the geodatabase, or the **Shape** subfolder for the shapefile, select the **WBDHU12** shapefile or feature class for each one in turn. You will need to project each one. Note that the name of the HU12 layer is the same for all subbasins; therefore, you must give each one a unique name when you project it (e.g. **WBDHU12\_13050003\_wgs84**).
      - 12.3.1.2. **Input Coordinate System**: Do nothing; this will be automatically populated.
      - 12.3.1.3. **Output Dataset or Feature Class**: Right-click, and select **Browse**. Navigate to the folder **C:\AGWA\gisdata\FortBliss\**. Add information to the file name to identify it and indicate it is in WGS84: **13050003\_wgs84**.

12.3.1.4. **Output Coordinate System:** Click on the *Spatial Reference Properties* button . Expand the *Projected Coordinate Systems* folder, expand the *UTM* folder, expand the *WGS84* folder, expand the *Northern Hemisphere* folder, and then select **WGS 1984 UTM Zone 13N**. Click **OK**.

12.3.1.5. **Geographic Transformation:** Leave as is.

12.3.2. Click **OK**. The *Project* tool will create a new shapefile in the specified coordinate system.

12.4. Repeat for all feature classes not in the **WGS 1984 UTM Zone 13N** projection. For the soils data, select and project the **soilmu\_a\_nmXXX.shp** shapefiles in the “*spatial*” folders of the different surveys.

**NOTE:** Projected data may not automatically be added to the map. To add the data, click the **add data** button and select these features. Remove the unprojected data from your map document.

12.5. Return to ArcToolbox, and project the DEM and NLCD rasters.


12.6. Navigate to **Data Management Tools > Projections and Transformations > Raster**. Double-click on the *Project Raster* tool.

12.7. Project the DEM data. (Note that you can use the BATCH option to project the NLCD Landcover data at the same time.) You will need four DEMs to cover all of Fort Bliss. Repeat these steps for each one, or use the Batch feature to project all four at once.

12.7.1. **Input Raster:** double-click and select your raster, **grdn33w106\_13**.

12.7.2. **Input Coordinate System:** do nothing; this will be automatically populated.

12.7.3. **Output Raster Dataset:** right-click and select **Browse**. Navigate to the folder **C:\AGWA\gisdata\FortBliss\**. Name the file to indicate it is in WGS84: **33w10613wgs84**.

12.7.4. **Output Coordinate System:** double-click and select the Spatial Reference Properties button . Expand the *Projected Coordinate Systems* folder, expand the *UTM* folder, expand the *WGS84* folder, expand the *Northern Hemisphere* folder, then select **WGS 1984 UTM Zone 13N**. Click **OK**.

12.7.5. **Geographic Transformation:** leave as is.


12.7.6. **Resampling Technique:** click the drop-down arrow and select **Bilinear**.

12.7.7. Leave the remaining fields as is.

12.7.8. Click **OK**. The *Project Raster* tool will create a new DEM.

If you downloaded more than one grid, you will need to project each one, and then Mosaic them to create one continuous raster. The next step will show how to do this.

12.8. Project the NLCD Landcover data.

- 12.8.1. **Input Raster:** double-click and select [NLCD2011\\_LC\\_N30W105.tif](#).
- 12.8.2. **Input Coordinate System:** do nothing; this will be automatically populated.
- 12.8.3. **Output Raster Dataset:** right-click and select **Browse**. Navigate to the folder `C:\AGWA\gisdata\FortBliss\`. Name the file to indicate it is in WGS84: [NLCD2011wgs84](#).
- 12.8.4. **Output Coordinate System:** double-click and select the Spatial Reference Properties button . Expand the **Projected Coordinate Systems** folder, expand the **UTM** folder, expand the **WGS84** folder, expand the **Northern Hemisphere** folder, then select [WGS 1984 UTM Zone 13N](#). Click **OK**.
- 12.8.5. **Geographic Transformation:** leave as is.
- 12.8.6. **Resampling Technique:** click the drop-down arrow and select [NEAREST](#).
- 12.8.7. Leave the remaining fields as is.
- 12.8.8. Click **OK**. The **Project Raster** tool will project the landcover data.

**NOTE:** Projected data may not be added to the map automatically.

### **Step 3: Combine multiple datasets**

13. **HUC12 Watershed Boundaries.** Combine the three HUC12 layers using the **Union** tool in ArcToolbox. Navigate to **Analysis Tools > Overlay > Union** and double-click on the **Union** tool.
  - 13.1. **Input Features:** Add the three projected HUC12 layers:  
[WBDHU12\\_13050003\\_wgs84](#), [WBDHU12\\_13040100\\_wgs84](#), and [WBDHU12\\_13050004\\_wgs84](#)
  - 13.2. **Output Feature Class:** Right-click and select **Browse**. Navigate to the folder `C:\AGWA\gisdata\FortBliss\`. Use a file name to indicate the WBD datasets, for example [WBDHU12\\_ftbliss\\_wgs84.shp](#).
    - 13.2.1. Leave all defaults, and click **OK**.
14. **DEM rasters.** Combine the four DEM's into one DEM for Fort Bliss.
  - 14.1. In ArcToolbox, navigate to **Data Management Tools > Raster > Raster Dataset** and double-click on the **Mosaic To New Raster** tool.
    - 14.1.1. **Input Rasters:** Select the four rasters.
    - 14.1.2. **Output Location:** Right-click and select **Browse**. Navigate to the folder `C:\AGWA\gisdata\FortBliss\`
    - 14.1.3. **Raster Dataset Name with Extension:** Name the new raster something meaningful, such as [dem10mbliss](#). There is no extension for an ESRI grid (or raster).
    - 14.1.4. **Spatial Reference for Raster:** Leave this blank, the rasters are already projected.

- 14.1.5. **Pixel Type:** select **32\_BIT\_FLOAT**. This will allow decimals.
  - 14.1.6. **Cellsize:** Leave as is.
  - 14.1.7. **Number of Bands:** Enter **1**.
  - 14.1.8. **Mosaic Operator:** Leave as default “LAST”. This will use the data from the last raster for the final values.
  - 14.1.9. **Mosaic Colormap Mode (optional):** Leave as default “FIRST”.
  - 14.1.10. Click **OK**. This can take several minutes.
- 14.2. In ArcToolbox Navigate to **Data Management Tools > Raster > Raster Properties** and double-click on the **Calculate Statistics** tool so the values are stretched across all rasters.
- 14.2.1. **Input Raster Dataset:** Select **dem10mbliss**.
  - 14.2.2. Leave all other fields as the default. Click **OK**.

## Part 2: Clip the Data to a Suitable Project Area

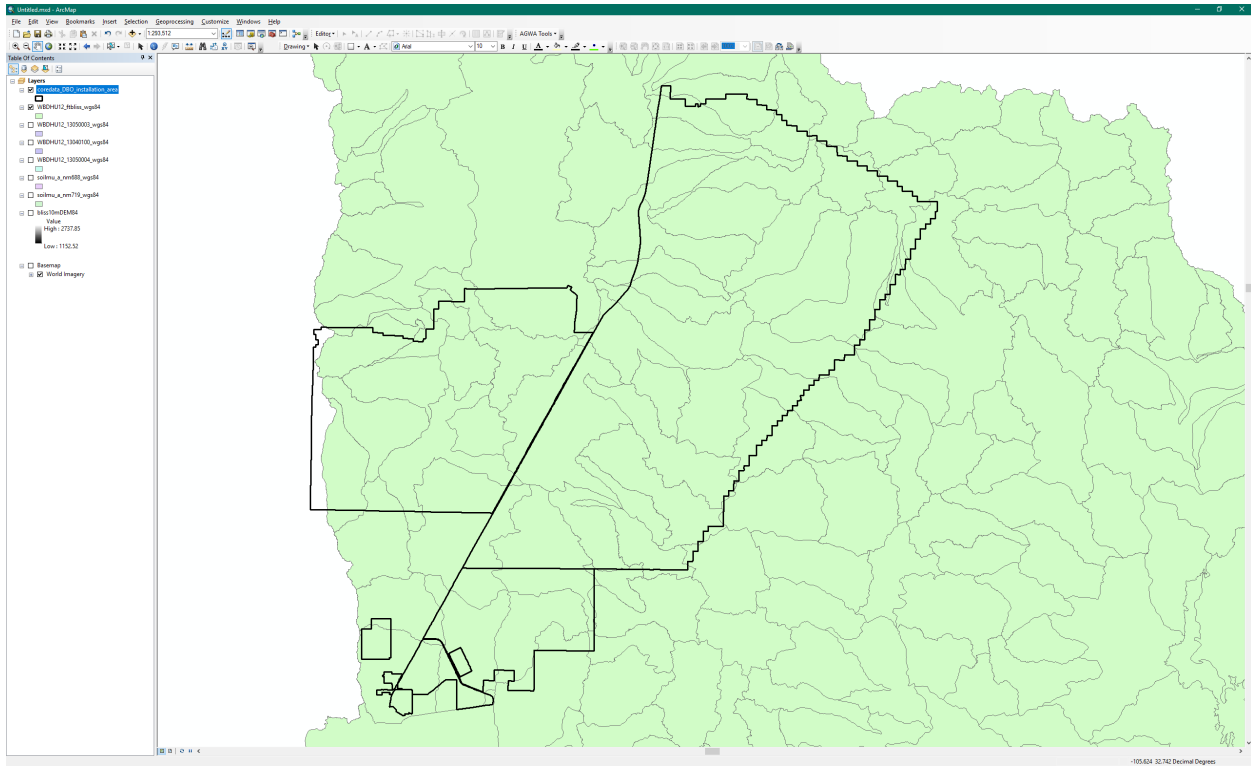
In this part, the projected data will be clipped to the project area. Depending on the original dataset sizes and the clipped areas of interest, this may significantly reduce processing time during AGWA’s steps involving raster data.

### Step 1: Create a Project Area Shapefile

Deciding on a suitable clip size depends on your data and area of interest. For a burned area scenario, the fire perimeter would be the project area. Or you may be working with a training area, range, or other disturbed site. However, watersheds do not conform to these boundaries, so a project area representing the watershed is needed. Using the HUC12 watershed boundary from the NHD dataset can provide a good starting point for a clip size.

In this example, the intersection of the HUC12 subbasins and the Fort Bliss boundary will be used. Most military installations have an advanced GIS geodatabase that includes a boundary feature class. Fort Bliss’s boundary layer is “**coredata\_DBO\_installation\_area**”, and we will use that layer in this example.

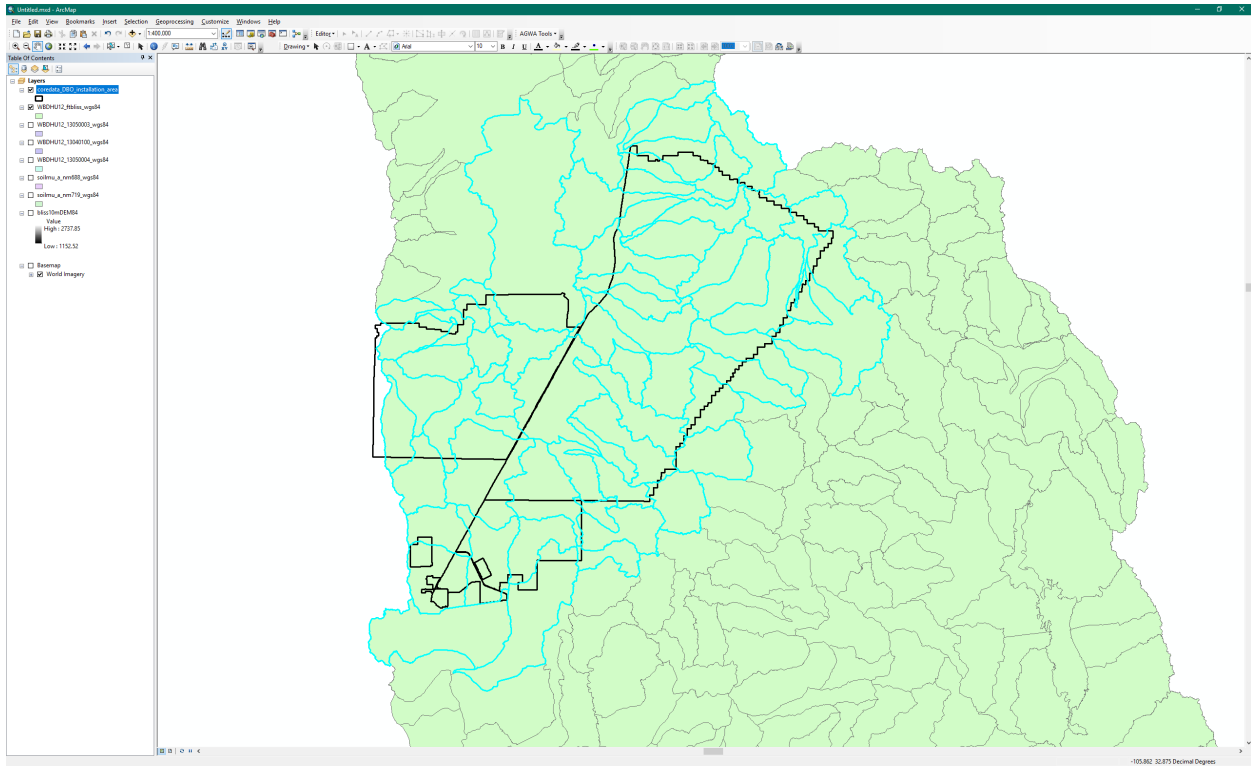
15. View the project area.
  - 15.1. In the Table of Contents, turn on the **coredata\_DBO\_installation\_area** and the **WBDHU12\_ftbliss\_wgs84.shp** layers. Turn all other layers off. Drag the **coredata\_DBO\_installation\_area** layer above the **WBDHU12\_ftbliss\_wgs84.shp** layer. Zoom to the **coredata\_DBO\_installation\_area** layer.
  - 15.2. Change the symbology of **coredata\_DBO\_installation\_area** so it is hollow (Figure 13).



**Figure 13. Map of Fort Bliss and HUC12s**

Notice that the boundary crosses numerous HUC12 watershed boundaries. It’s a good idea to include all HUC12 watersheds that intersect Fort Bliss so the resulting data can be used for any project at Fort Bliss.

16. Select all the HUC12s that intersect with the Fort Bliss boundary.
  - 16.1. In the **Selection** menu on the ArcMap menu bar, choose **Select by Location ...**
    - 16.1.1. **Selection method:** **select features from**
    - 16.1.2. **Target layer(s):** check **WBDHU12\_ftbliss\_wgs84.shp**
    - 16.1.3. **Source layer:** select **coredata\_DBO\_installation\_area**
    - 16.1.4. **Spatial selection method for target layer feature(s):** **intersect the source layer feature**
  - 16.2. Click **OK**.



**Figure 14. Map showing HUC 12 watersheds that intersect Fort Bliss with blue highlight**

All the HUC12s that intersect with the Fort Bliss boundary are now selected (Figure 14).

16.3. Open ArcToolbox again. Create a new shapefile of only the selected HUC12s.

16.3.1. Navigate to *Analysis Tools > Extract*.

16.3.2. Double-click on the *Select* tool to open the tool.

16.3.2.1. *Input Features*: **WBDHU12\_ftbliss\_wgs84.shp**

16.3.2.2. *Output Feature Class*: Click the *Browse* button. Navigate to **C:\AGWA\gisdata\FortBliss\**. Name the file **HUC12\_ftbliss**.

16.3.2.3. *Expression (optional)*: Leave blank.

16.3.3. Click **OK**. Wait for the *Select* tool to run, which will create a new shapefile of only the selected HUC12s (Figure 15).

16.3.4. Zoom to the new layer **HUC12\_ftbliss**, and place the boundary layer above it. Turn off the **WBDHU12\_ftbliss\_wgs84.shp** layer.

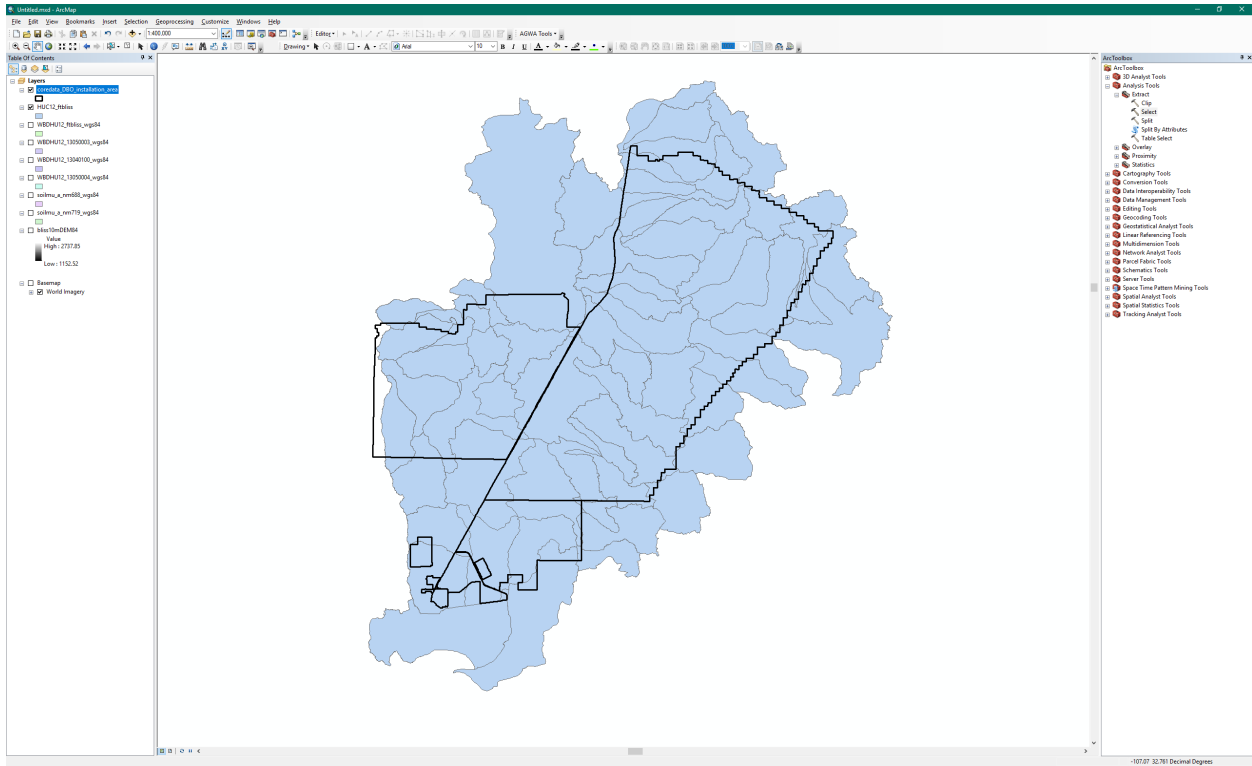


Figure 15. Map of new feature class of HUC12s that intersect Fort Bliss

17. Dissolve all the polygons that intersect Fort Bliss, and buffer the resulting polygon.

17.1. In ArcToolbox double-click **Data Management Tools > Generalization > Dissolve**.

17.2. **Input Features:** select **HUC12\_ftbliss**.

17.3. **Output Feature Class:** **HUC\_ftbliss**.

17.4. Leave the rest as defaults, and click **OK**.

18. Buffer the HUC12 outline by 1km in case the DEM drainages do not match the HUC data exactly.

18.1. In ArcToolbox navigate to **Analysis Tools > Proximity**

18.2. Double-click on the **Buffer** tool to open the tool.

18.3. **Input Features:** **HUC\_ftbliss**

18.4. **Output Feature Class:** Click the **Browse** button.

18.5. Navigate to **C:\AGWA\gisdata\FortBliss\**. Name the file **HUC\_buff1km.shp**.

18.6. **Distance [value or field]:**

18.6.1. Select the **Linear** unit radiobutton.

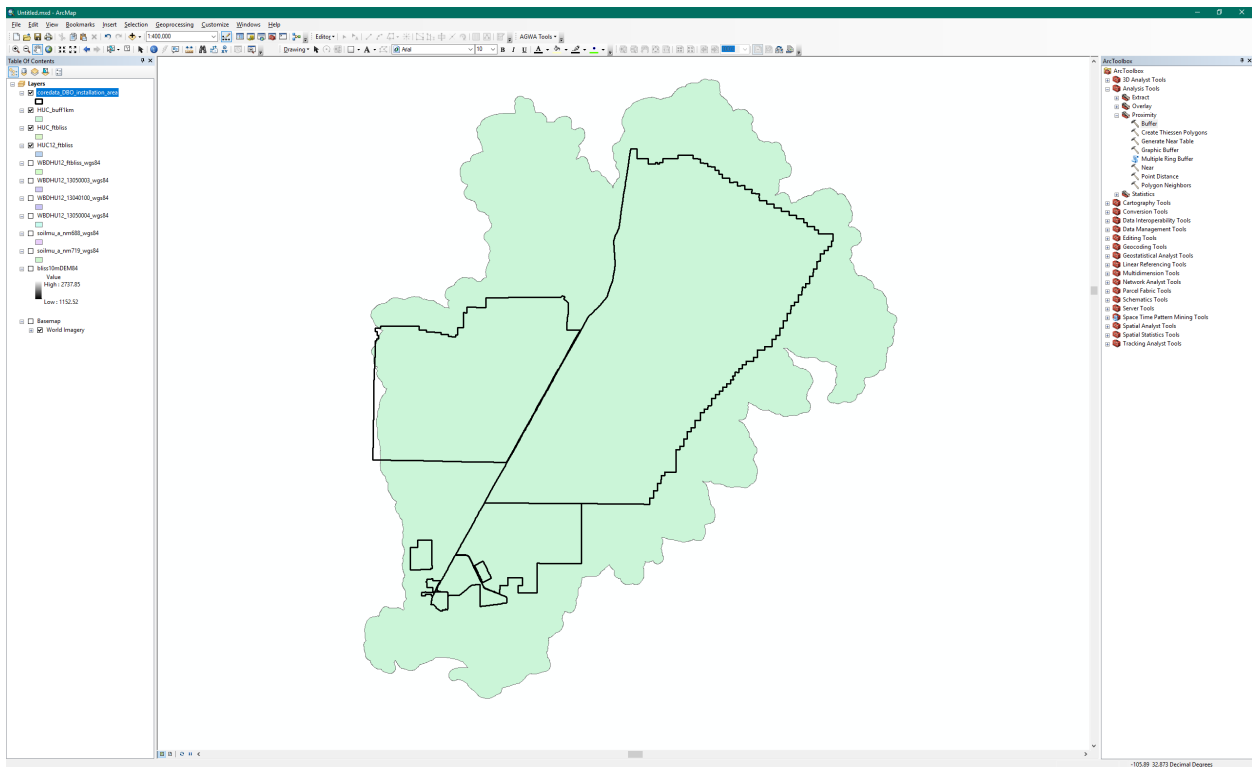
18.6.2. Type **1000**.

18.6.3. Leave the units as **Meters**.

18.6.4. Leave all other fields as the defaults.



18.6.5. Click **OK**. The **Buffer** tool will create a new shapefile (Figure 16) called **HUC\_buff1km.shp**.




**Figure 16. Map of buffered and dissolved HUC 12 polygons for Fort Bliss**

**Step 2: Clip the GIS Layers to the Buffered Project Area**

Now that a suitable, buffered project area has been created, the large DEM and land cover layers can be clipped to that extent.

19. Use the Raster **Clip** tool to clip the rasters to the project area.
  - 19.1. In ArcToolbox navigate to **Data Management Tools > Raster > Raster Processing**.
    - 19.1.1. Right-click on the **Clip** tool and select **Batch**.
      - 19.1.1.1. **Input Raster**: Double-click and select **dem10mbliss**.
      - 19.1.1.2. **Rectangle**: Leave as is
      - 19.1.1.3. **Output Raster Dataset**: Right-click and navigate to **C:\AGWA\gisdata\FortBliss\**. Name the layer **dem10mftbliss**.
      - 19.1.1.4. **Output Extent**: double-click and select **HUC\_buff1km**.
      - 19.1.1.5. **NoData Value**: do nothing
      - 19.1.1.6. **Use Input Features for Clipping Geometry**: right-click and select **Open**
      - 19.1.1.7. Check the **Use Input Features for Clipping Geometry** box.



- 19.1.1.8. **Maintain Clipping Extent**: do nothing.
- 19.1.2. Click the **Add Row** button . Fill out the second row.
  - 19.1.2.1. **Input Raster**: double-click and select **NLCD2011wgs84**.
  - 19.1.2.2. **Rectangle**: do nothing.
  - 19.1.2.3. **Output Feature Class**: Right-click and select **Browse**. Navigate to **C:\AGWA\GISdata\FortBliss\**. Name the layer **nlcd2011\_bls**.
  - 19.1.2.4. **Output Extent**: double-click and select **HUC\_buff1km**.
  - 19.1.2.5. **NoData Value**: do nothing
  - 19.1.2.6. **Use Input Features for Clipping Geometry**: right-click and select **Open**
  - 19.1.2.7. Check the **Use Input Features for Clipping Geometry** box.
  - 19.1.2.8. **Maintain Clipping Extent**: do nothing.
- 19.1.3. Click **OK**. Wait for the **Clip** tool to run, which will create new, clipped, DEM and land cover rasters.

### Part 3: Preparing the Precipitation Data

This section will show how to prepare the precipitation data that has been downloaded so that it can be used in AGWA for SWAT or KINEROS2.

#### SWAT Precipitation

SWAT requires an **unweighted precipitation file** and a **rain gage point theme** for input into AGWA. The **unweighted precipitation file** contains a minimum of three fields: YEAR, DAY, and a gage ID field named G<gage id>. DAY is the Julian day of the year (1-366) with values repeating for each year in the record. It is recommended that at least 30 years of record are used to capture long term trends of a climatic region; however, due to data availability this may not always be possible. Missing data should be indicated with by “-99”. The **rain gage point theme** includes a gage id that must match the ids in the gage id field of the **unweighted precipitation file**.

This section will guide you through creating a point file for rain gages and formatting the unweighted precipitation file for input. The example will be for only one rain gage acquired from GHCN; however, the same process can be repeated for multiple gages from any data source.

- 20. Prepare the precipitation data.
  - 20.1. Open the NOAA NCDC **.csv** file in Excel and save this file as **6435\_pcp.csv** (the last 4 digits of the station ID) in the **C:\AGWA\gisdata\FortBliss\downloads** folder.
  - 20.2. Format the Precipitation data.
    - 20.2.1. Delete the first five columns of data (STATION, NAME, LATITUDE, LONGITUDE, and ELEVATION).
    - 20.2.2. Save the file as an Excel workbook file.
    - 20.2.3. Rename the PRCP column to “**G6435**”, to indicate the gage ID.

20.2.4. Insert three columns next to the DATE column. Change the format of these columns to **General** or **Number** (not DATE).

20.2.5. Label the columns **DATE**, **YEAR**, and **DAY**

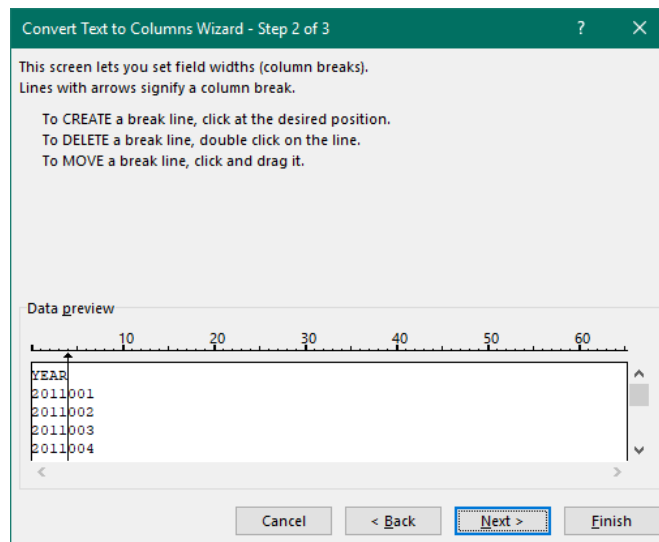
20.2.6. Populate the **DATE** column using the following formula, starting at the second row:

=TEXT(A2,"yyyy")&TEXT((A2-DATEVALUE("1/1/"&TEXT(A2,"yy"))+1),"000")

20.2.7. Copy this column. Paste **VALUES only** to the **YEAR** column.

20.2.8. Use the **Text to Columns** tool (in the Data tab), select **Column C**, and used **Fixed Width**. Click **Next**.

20.2.9. Add a break line after the year 2011. Click **Next**.



20.2.10. Click **Finish**. This will separate the date into **YEAR** and **JULIAN DAY**.

20.2.11. Delete columns A and B. You should now have 3 columns, labeled **YEAR**, **DAY**, and **G6435**. If the YEAR and DAY columns have values after the decimal point, remove those values by decreasing the number of decimal places to "0".

20.2.12. Save this file.

20.3. Populate missing values with "-99"

20.3.1. Writing precipitation data in AGWA will run smoothly if all of the input files are correctly configured. However, the configuration of these files can be very time consuming. This step will outline the process of adding missing dates and populating them. Start by looking through the data you downloaded. For this case, we have data for 2011. So we expect to have 365 days of precipitation

measurements (e.g., 365 cells below the heading **G6435**). A leap year would have 366 days.

20.3.2. To check for missing data you can use any Excel counting tool. For this example, simply select all of the cells below G6435 to display a count in the bottom row of the Excel window.



20.3.3. This indicates we have 326 days of data, and are therefore missing 39 days. With the date formatted in Julian day it should be easy to locate where these days are. The first missing day is 17, so insert a row above Julian day 18.

20.3.4. Fill in the date accordingly then populate the G6435 column with “-99”.

1	YEAR	DAY	G6435
2	2011	1	1
3	2011	2	0
4	2011	3	0
5	2011	4	0
6	2011	5	0
7	2011	6	0
8	2011	7	0
9	2011	8	0
10	2011	9	0
11	2011	10	0
12	2011	11	0
13	2011	12	0
14	2011	13	0
15	2011	14	0
16	2011	15	0
17	2011	16	0
18	2011	17	-99
19	2011	18	0
20	2011	19	0
21	2011	21	0
22	2011	22	0
23	2011	23	0

20.3.5. Continue this process identifying all gaps in the data, adding a row for each date gap, and populating it with the correct day and “-99”.

20.4. Save the file. For larger datasets, this may be automated using a variety of software products.

21. Prepare the rain gage point file.

21.1. Open the original raw **.csv** file again from the Downloads folder.

21.2. Save it as **6435\_gage.csv** in the **C:\AGWA\gisdata\FortBliss\** folder.

21.3. Delete everything except rows 1 and 2. Save the file.

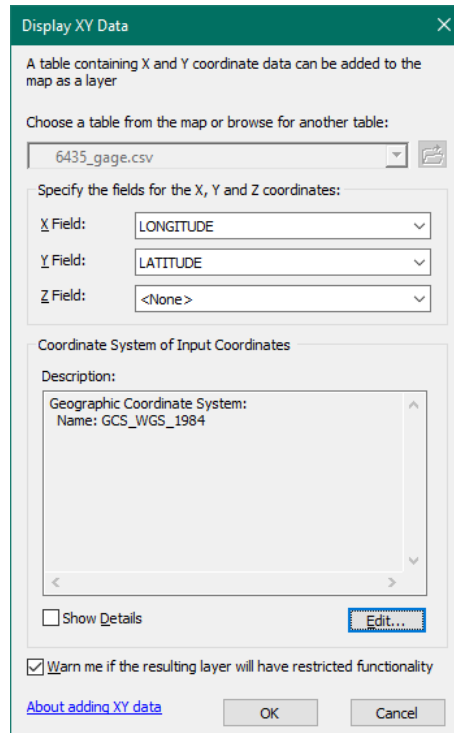
21.4. Add two new columns to the end: **END\_DATE** and **GAGE\_ID**

21.4.1. **END\_DATE** will be populated with **20111231**

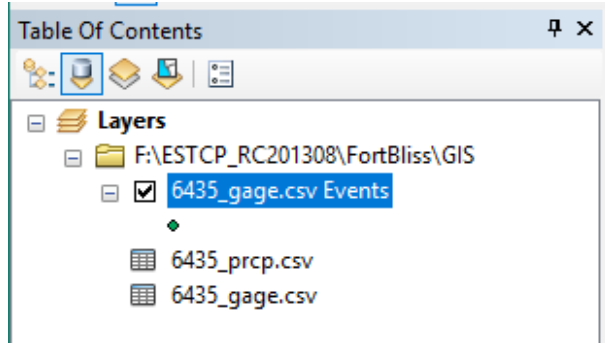
21.4.2. **GAGE\_ID** will be populated with **6435**

STATION	NAME	LATITUDE	LONGITUDE	ELEVATION	DATE	PRCP	END_DATE	GAGE_ID
USC00296435	OROGRANDE, NM US	32.3788	-106.0924	1286.6	1/1/2011	0	20111231	6435

22. Create the rain gage point theme shapefile and the precipitation data table.
  - 22.1. Use the **Add Data** button to add both the **6435\_pcp.csv** and the **6435\_gage.csv** to the map document.
  - 22.2. Create the rain gage point theme. In the table of contents, right click on the **6435\_gage.csv** file
    - 22.2.1. Select **display XY Data**.
      - 22.2.1.1. **X Field: Longitude**
      - 22.2.1.2. **Y Field: Latitude**
      - 22.2.1.3. **Z Field: None**
      - 22.2.1.4. **Coordinate System of Input Coordinates:** Select **Edit**
        - 22.2.1.4.1. Expand **Geographic Coordinate Systems** → **World**
        - 22.2.1.4.2. Select **WGS 1984**
      - 22.2.1.5. Click **OK**



- 22.2.2. A dialogue box will appear with “**Table Does Not Have Object-ID Field**”. Click **OK**. A new Event will appear in the table of contents. This will need to be exported to become a permanent shapefile.



- 22.3. Export the Event as a shapefile.

22.3.1. Right click on the Event.

22.3.2. **Select data** → **Export Data...**

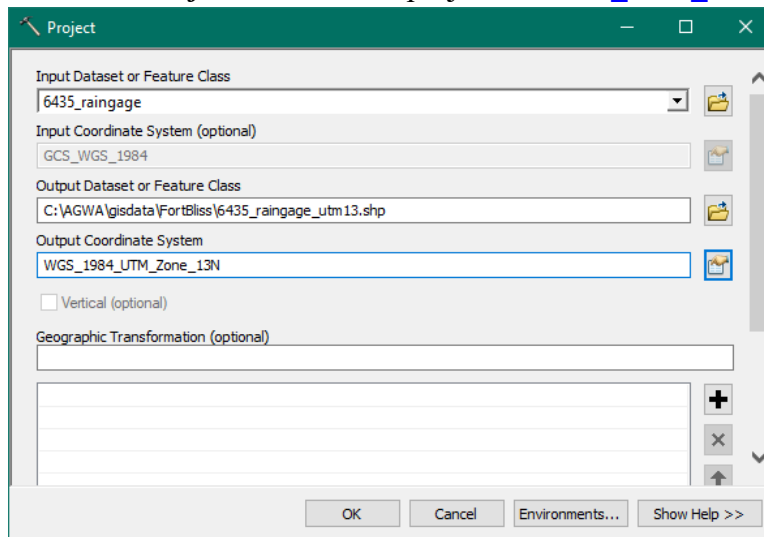
22.3.3. Browse to the **C:\AGWA\gisdata\FortBliss\** folder and save it as a shapefile named **6435\_raingage.shp**

22.3.4. Click **OK**.

22.3.5. When prompted to add the exported data to the map as a layer, click **Yes**.

- 22.4. Project the new shapefile.

22.4.1. Open the **Project Tool** in **ArcToolbox** → **Data Management** → **Projections and Transformations**, and project to **WGS\_1984\_UTM\_ZONE\_13N**.



22.4.2. Click **OK**.

- 22.5. Create the precipitation data dBase Table.

22.5.1. Right click on the **6435\_pcp.csv** file in the ArcMap table of contents.

22.5.2. Select **Data** → **Export...**

22.5.3. Click on the folder icon, and browse to **C:\AGWA\gisdata\FortBliss\**

22.5.3.1. **Name:** 6435\_pcp.dbf

22.5.3.2. **Save as type:** dBASE Table.

22.5.3.3. Click **Save**.

22.5.3.4. Click **OK**.

22.5.3.5. Click **YES** to add the new table to the map document.

This completes the preparation of the two files needed for writing SWAT precipitation.

### ***KINEROS2 Precipitation***

KINEROS2 is designed to use rainfall events as opposed to the daily rainfall totals used in SWAT. AGWA allows you to create rainfall data for KINEROS2 in 4 ways:

- Design storm depth and duration from the design storm database.
- Design storm depth and duration based on NOAA precipitation frequency maps.
- User-defined depth and duration.
- User-defined hyetograph.

KINEROS2 precipitation data are stored in the simulation folder associated with precipitation, and are created directly using the AGWA forms. Therefore, the steps to create the first three types of precipitation files will be shown later in the AGWA Modeling – KINEROS2 section. Hyetograph data are not generally available, so we will skip that method.

### **Part 4: Preparing the Soils Database**

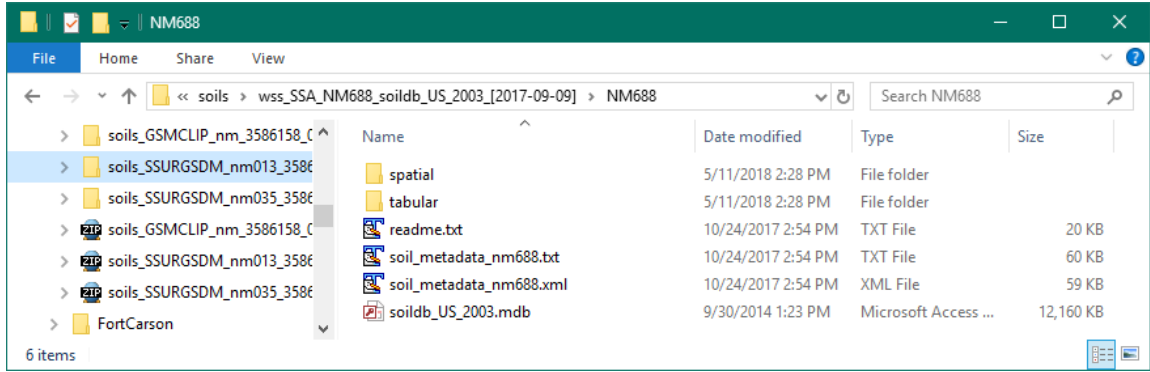
Although the GIS layers in the SSURGO soils database are ready for AGWA modeling, one final step is necessary. This involves importing the tabular soils data into to the SSURGO MS Access database. This is necessary for AGWA to access the correct soils information in the soils tables.

#### ***Step 1: Import Tabular Data into SSURGO Database***

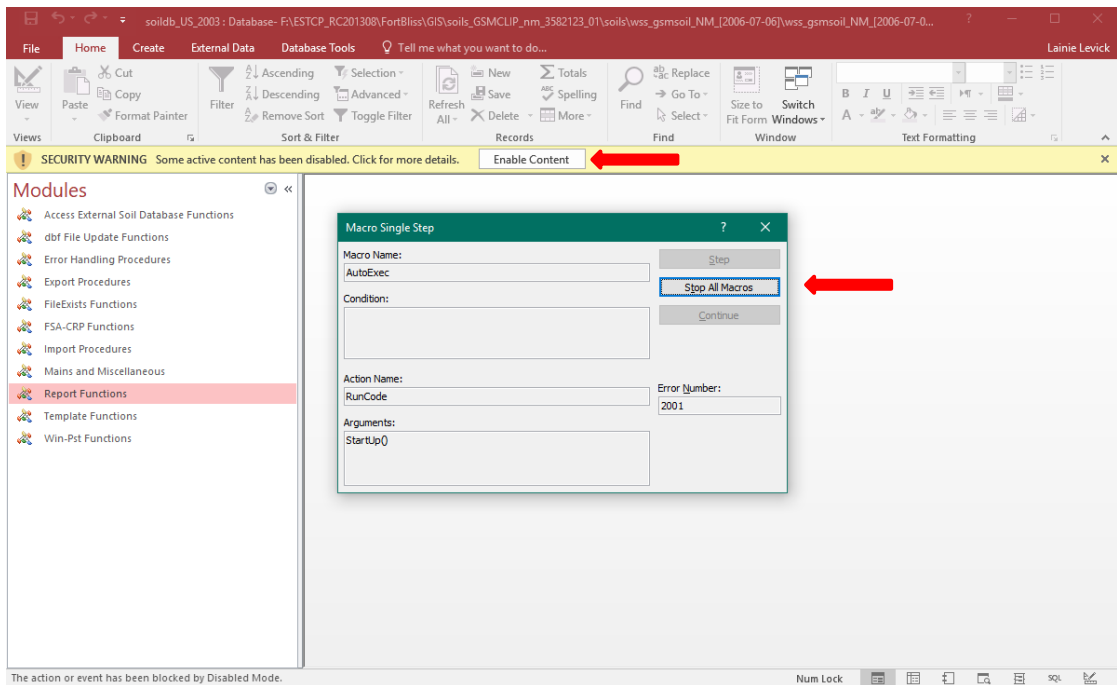
23. Go to one of your SSURGO soils database folders that you unzipped in the Data Acquisition section. For example,

**C:\AGWA\gisdata\FortBliss\wss\_SSA\_NM688\_soildb\_US\_2003\_(2017-09-09)**. Each folder will include a subfolder named “**soils**” with additional zipped files. Unzip each one and locate the folder with the name of the soils data (e.g. NM688). This folder contains a blank database named “**soildb\_US\_2003.mdb**”, and two folders named “**spatial**” and “**tabular**”. You will populate each blank database by importing the associated tabular data for use in AGWA.

## AGWA Tool Guidance Document - ESTCP Project RC201308



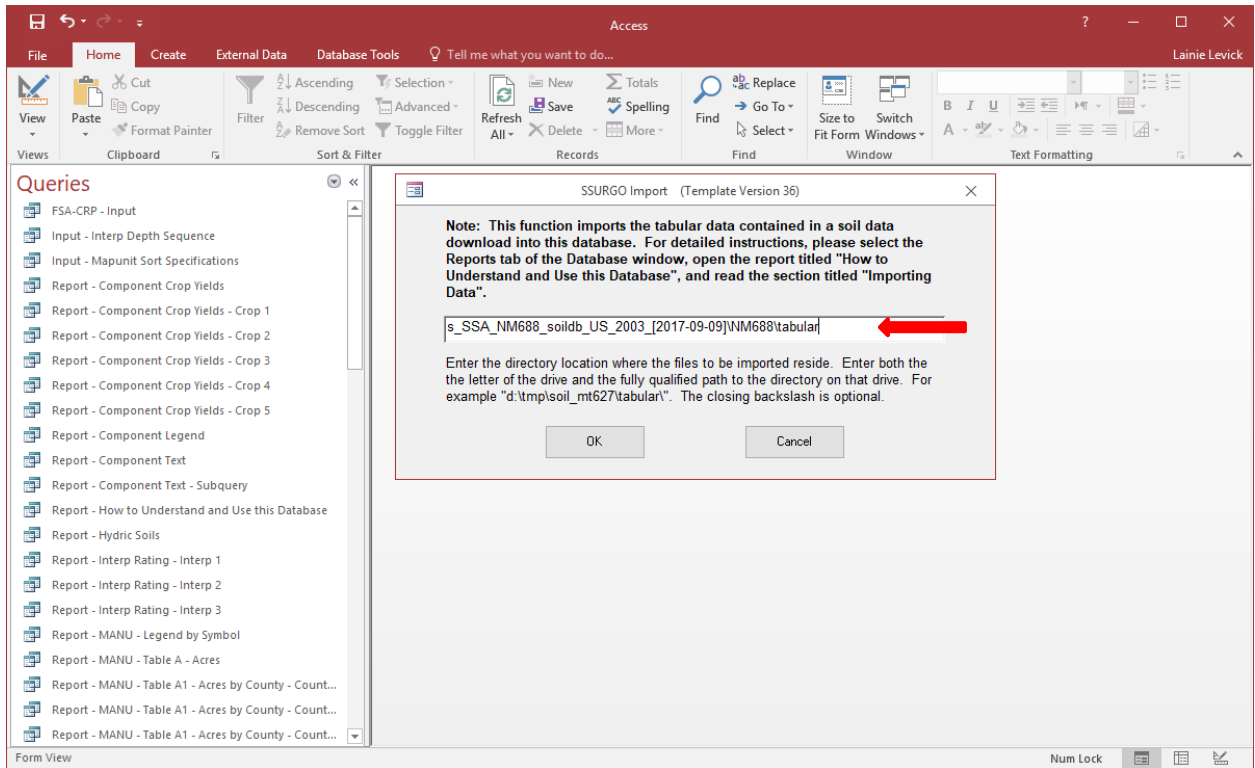
23.1. To import the tabular data, double-click on the database to open it in Microsoft Access (required). Click on the “**STOP ALL MACROS**” button, and then click on “**Enable Content**” at the top of the screen.



23.2. The SSURGO import screen will open. Copy the full path of the “**tabular**” folder and paste it into the form. Click **OK**. Access will now import the tables into the database (this can take a few minutes).

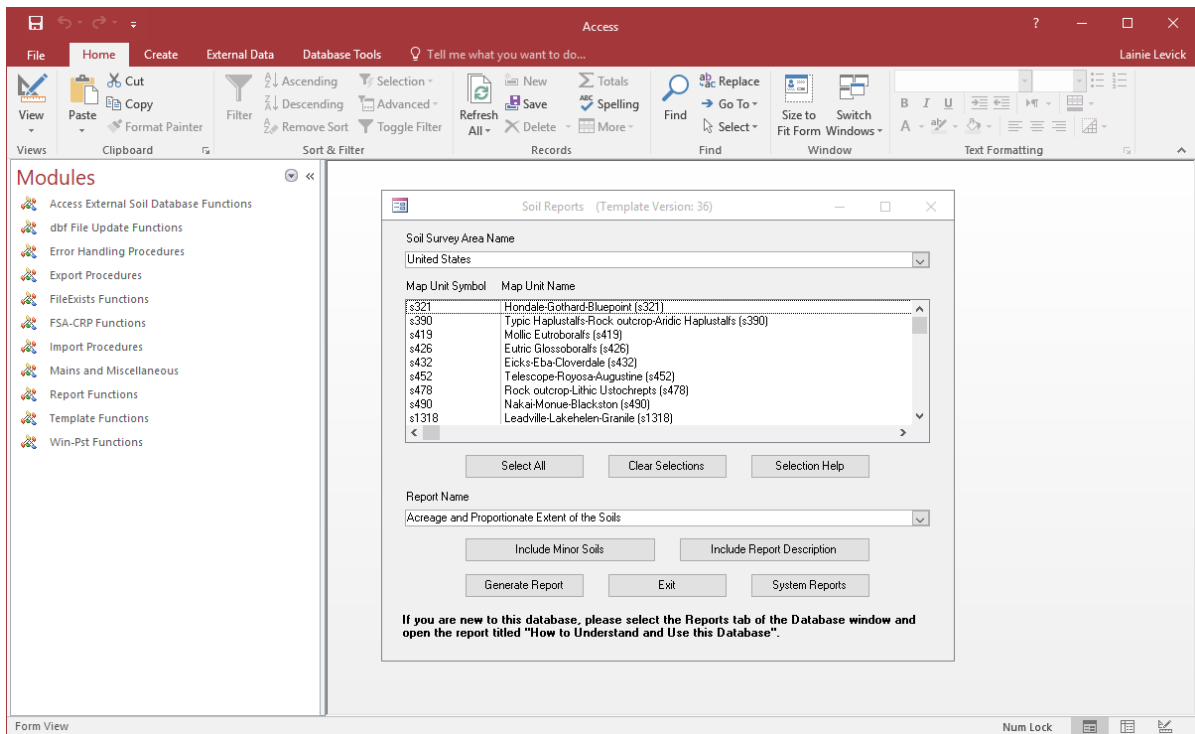


# AGWA Tool Guidance Document - ESTCP Project RC201308



23.3. When the Soil Reports screen appears, click “Exit”, and close Access.

23.4. Repeat these steps to unzip and import all SSURGO databases.



**Step 2: Combine multiple soils datasets for your project area**

24. **SSURGO Soils Data.** If you require more than one SSURGO dataset to cover the watersheds in your study area, you will need to combine them. After they have been projected to a common coordinate system, use the **Union** tool in ArcToolbox to combine the spatial data, and then use Access to combine the tabular data. More details are included next.

24.1. Combine the spatial data. Navigate to **Analysis Tools > Overlay > Union** and double-click on the **Union** tool.

24.1.1. **Input Features:** Add your datasets. For this example, we will combine **NM646, NM688, NM690, NM719, and NM781**. These are all of the SSURGO datasets available for Fort Bliss; however, they do not cover all of the installation or the watersheds intersecting the boundary. Therefore, only areas of interest completely contained within these datasets can use SSURGO data. Otherwise, use STATSGO data.

24.1.2. **Output Feature Class:** Right-click and select **Browse**. Navigate to the folder **C:\AGWA\gisdata\FortBliss\**. Use a file name to indicate the soils datasets, for example **ssurgo\_ftbliss\_all**.

24.1.3. Leave all defaults, and click **OK**.

24.1.4. Combine the tabular data into one database. Select one of the SSURGO datasets to use as the main one and open it by double-clicking on it. For this example, we will use the **NM719** SSURGO dataset because it covers just Fort Bliss.

24.1.4.1. Navigate to and double-click on **NM719 > soildb\_US\_2003.mdb**. Note that all SSURGO datasets have a database with this same name, so be sure you are selecting the correct dataset.

24.1.4.2. **Exit** out of the Soil Reports menu.

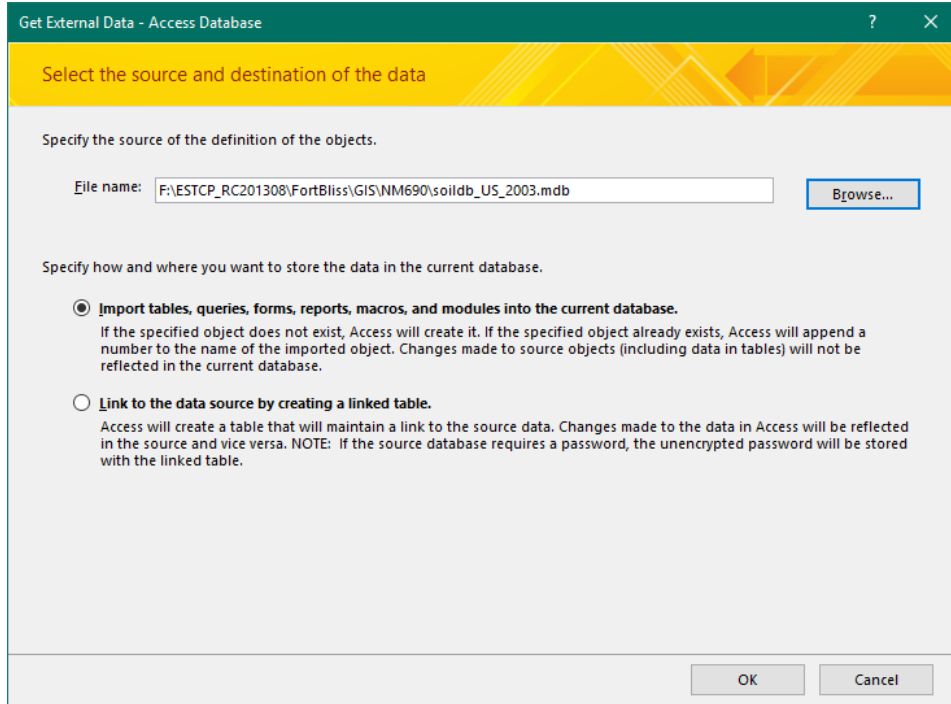
24.1.4.3. **External Data tab:** select **Access**

24.1.4.4. **Get External Data – Access Database:** Browse to the database in one of your other Fort Bliss SSURGO soils. Note that you must have already imported the tabular data into the database (see Step 1 of this Part 4). Click **OK**.

24.1.4.5. **Import Objects:** Click **Select All**. Click **OK**.

Repeat for all SSURGO databases.

24.1.4.6. **Save Import Steps:** leave the box unchecked and **Close** the form. Close Access.



## AGWA Modeling Tutorial

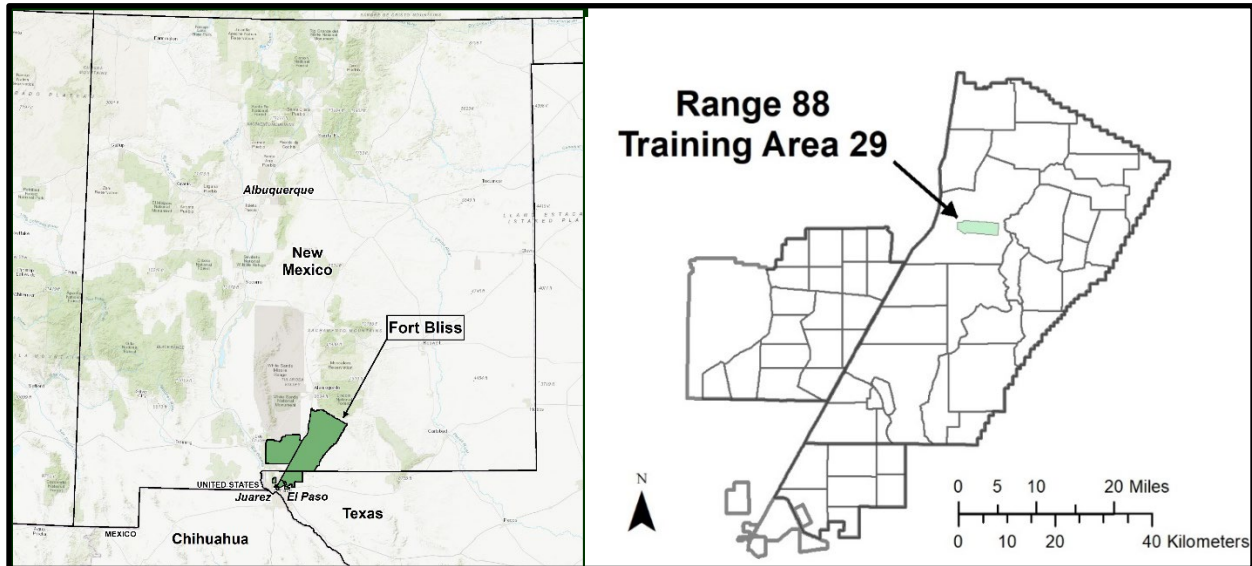
This section demonstrates how to use AGWA to perform a SWAT and a KINEROS2 simulation, including viewing and comparing results. The AGWA Glossary and Acronyms document at the end of this section includes definitions and explanations for many of the terms used here.

### Fort Bliss Army Base Range 88 Example

For this Guidance Document, we will use an example at Range 88 in Training Area 29 at Fort Bliss Army Base, Texas/New Mexico (Figure 17) that is based on a tutorial exercise developed for this ESTCP project. Fort Bliss is located in southern New Mexico and west Texas, in the northern Chihuahuan Desert. Average annual precipitation is 8.8 inches (22.4 centimeters), with most rain falling during the short duration, high intensity summer monsoon storms. Surface flows are generally rare and ephemeral except during monsoon storms when flash floods may occur. This exercise was developed in response to a flood event that damaged multiple facilities at Range 88, and shows the value of the AGWA tool in identifying areas of relatively higher runoff, peak flow, and erosion before planning new developments.

There are few rain gages or stream flow gages in the area around Fort Bliss; however, precipitation data exist from several sources that can be used for hydrologic modeling. This exercise will investigate those sources, and the effects of various types of precipitation inputs on local hydrology. In addition, the importance of accurate input data will be demonstrated. This applies particularly to army training lands that are regularly disturbed by training activities, where land cover and topography can change dramatically. Current land cover data and high

resolution digital elevation models (i.e. LiDAR) that represent those changes will provide the best modeling results. LiDAR data are available for Fort Bliss, and will be used in this example.



**Figure 17. Location of Fort Bliss Army Base, and Range 88, the example used in this guidance document**

### Part 1: Getting Started

Start ArcMap with a new empty map. Save the empty map document as **tutorial\_BlissR88** in the **C:\AGWA\workspace\tutorial\_BlissR88\** folder. The default workspace location will need to be created by clicking the **Make New Folder** button in the window that opens.

**TIP** Always use a meaningful name to help identify the map document. Map documents can be saved anywhere, but for project organization and to help navigate to the project workspace via the ArcCatalog window in ArcMap, we suggest saving the map document in the **workspace\tutorial\_BlissR88** folder.

If the **AGWA Toolbar** is not visible, turn it on by selecting **Customize > Toolbars > AGWA Toolbar** on the ArcMap Main Menu bar. Once the map document is opened and saved, set the Home, Temp, and Default Workspace folders by selecting **AGWA Tools > Other Options > AGWA Preferences** on the **AGWA Toolbar**, and entering the following information.



- **Home:** **C:\AGWA\**
- **Temp:** **C:\AGWA\temp\**
- **Default Workspace:** **C:\AGWA\workspace\tutorial\_BlissR88\**

The default workspace location will need to be created by clicking on the **Make New**


**Folder** button in the window that opens if you did not create it when saving the map document earlier.

The **Home** directory contains all of the look-up tables, datafiles, models, and documentation required for AGWA to run. If this is set improperly or you are missing any files, you will be presented with a warning that lists the missing directories or files that AGWA requires.

The **Temp** directory is where some temporary files created by AGWA will be placed. You may want to routinely delete files and directories in the Temp directory if you need to free up space or are interested in identifying the temporary files associated with your next AGWA use.

The **Default Workspace** directory is where delineation geodatabases will be stored by default. This can be a helpful timesaver during the navigation process if you have a deeply nested directory structure where you store AGWA outputs.

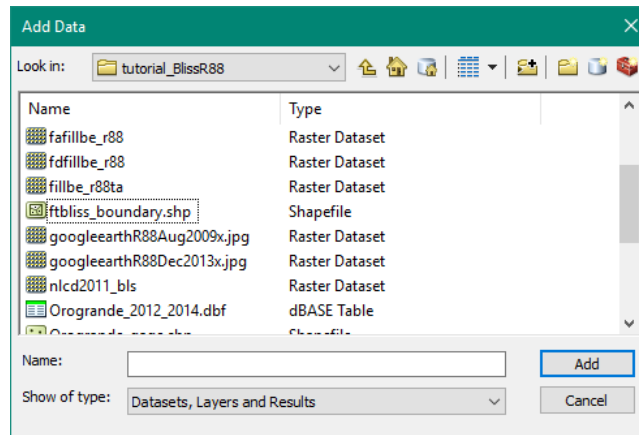
### **GIS Data**

Before adding data to the map, connections to drives and folders where your data are stored must be established if they have not been already. To establish folder connections if they don't already exist, click on the **Add Data** button  below the menu bar at the top of the screen. In the **Add Data** form that opens, click the **Connect To Folder** button and select **OS (C:)**.

Once the folder connection is established, navigate to the **C:\AGWA\gisdata\tutorial\_BlissR88\** folder and add the following datasets and layers. Note that during an actual AGWA training this tutorial and all GIS data would be provided.

- **..\disturbed.shp** – polygon outline of the disturbed area in Range 88
- **..\fillbe\_r88ta** – Filled digital elevation model (derived from 2006 LiDAR bare earth 1.5 m data)
- **..\fdfillbe\_r88** – Flow direction raster (created from **fillbe\_r88ta**)
- **..\fafillbe\_r88** – Flow accumulation raster (created from **fdfillbe\_r88**)
- **..\ftbliss\_boundary.shp** – Fort Bliss boundary
- **..\googleearthR88Aug2009x.jpg** – georeferenced Google Earth image of the area around Range 88 from August 2009, before the area was developed for trainings
- **..\googleearthR88Dec2013x.jpg** - georeferenced Google Earth image of the area around Range 88 from December 2013, after the area was developed and used for trainings
- **..\nlcd2011\_bls** – 2011 NLCD land cover data for Fort Bliss
- **..\nlcd2011\_new** – 2011 NLCD land cover data modified to represent recent land cover conditions at Range 88
- **..\NM719\spatial\soilmu\_a\_nm719\_wgs84.shp** – SSURGO soils for Fort Bliss

- **..\Orogrande\_gage.shp** –Orogrande, New Mexico, climate station information, from the National Climate Data Center, <https://www.ncdc.noaa.gov>, for use in SWAT
- **..\Orogrande\_2012\_2014.dbf** – precipitation data for the Orogrande, New Mexico, climate station, from NOAA’s online database, for 2012-2014, for use in SWAT
- **..\PondsR88.shp** – point layer for the two detention ponds at the western end of Range 88, constructed following the flood event in September 2014
- **..\r88bldg\_outlet.shp** – watershed outlet for the subwatershed near Range 88 buildings, for KINEROS2 simulations
- **..\r88outlet.shp** - watershed outlet for the western portion of Range 88, for SWAT simulations
- **..\Range88.shp** –Range 88 boundary
- **..\streamline2500.shp** – Stream network created from the flow accumulation raster with threshold of 2500 cells (LiDAR 1.5 m), and converted to a shapefile, for visually locating watershed outlets
- **..\sw10yr60ma\sw10y60min84** – the precipitation frequency raster for the Southwest US, for the 10 year 1 hour design storm, projected to WGS84, for use in KINEROS2




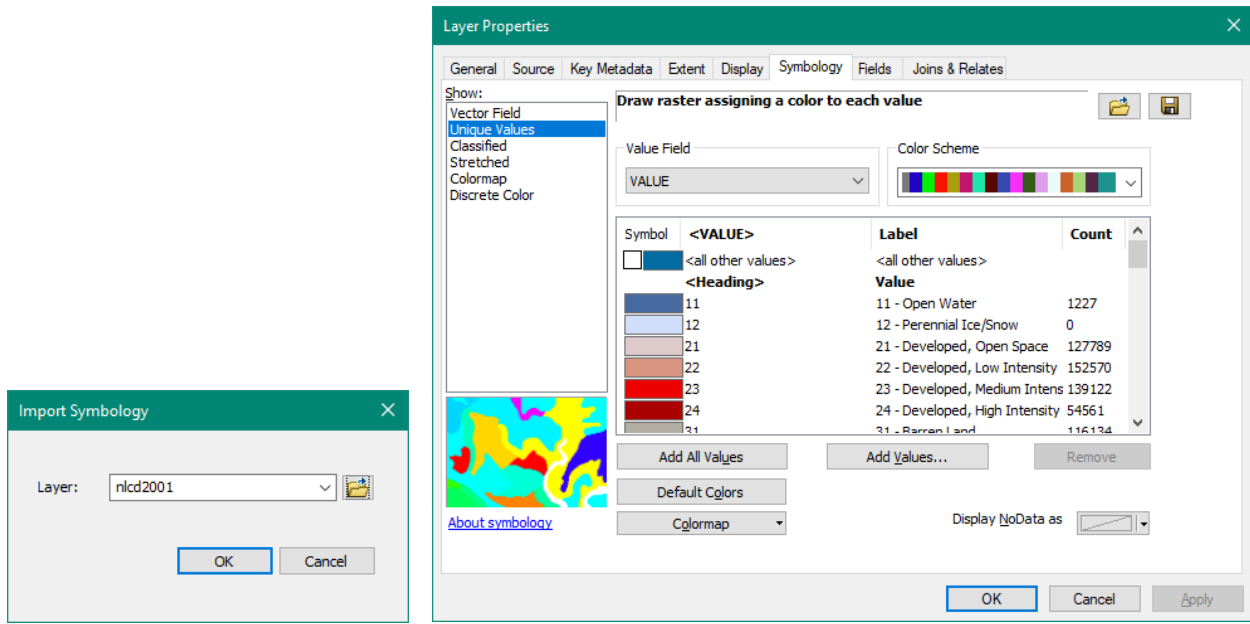
You will also need to add some other data to the project. To do this, again click on the **Add Data** button. Navigate to the **C:\AGWA\datafiles\** folder and add the following files:

- **..\precip\dsgnstrm2017.csv** – return period rainfall for KINEROS2, with precipitation frequency data included for Orogrande, New Mexico
- **..\wgn\wgn\_us83.shp**–weather generator stations for SWAT
- **..\lc\_luts\mrlc2001\_lut.dbf** – the lookup table for the NLCD land cover data

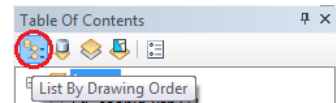
To better visualize the different land cover types and associate the pixels with their classification, load a legend into the NLCD dataset. To do this, right click the layer name of the **nlcd2011\_bls** dataset in the **Table of Contents** and select **Properties** from the context menu that appears. Select the **Symbology** tab from the form that opens. In the **Show** box on the left side of the form,



select **Unique Values** and click the  button on the right. Click the file browser button in the **Import Symbology** form, navigate to and select **C:\AGWA\datafiles\renderers\nalc2001.lyr**, click on **Add**, and click **OK** to apply the symbology and exit the **Import Symbology** form. Click on **Apply** in the **Layer Properties** form and then on **OK** to exit this form. The land cover classes for the 2001 NALC data are the same as the 2011 NLCD data, so this symbology can be applied.



At this point, we have all the data necessary to start modeling: topography, soils, land cover, and rainfall. Take a look at the data you have available to you to familiarize yourself with the area. Layers can be reordered, turned on/off, and their legends collapsed to suit your preferences and clean up the display. If the layers cannot be reordered by clicking and dragging, the **List By Drawing Order** button may need to be selected at the top of the **Table Of Contents**. Zoom back to the Range 88 region by right-clicking on the **Range88** layer in the list of layers and selecting **Zoom To Layer**.



Save the map document and continue.

## Part 2: Modeling Runoff at the Basin Scale Using SWAT

In this part, you will define a watershed at the western end of Range 88, and use the SWAT model to evaluate how a large rainfall event affects the subwatersheds at the location that flooded in 2014. You will run this model for conditions before the area was disturbed for trainings (i.e. before the roads, and buildings were developed) to gain an understanding of the natural flow paths.

There are several steps involved in modeling a watershed using AGWA: delineation; discretization or subdividing into model elements (planes and streams); parameterization of



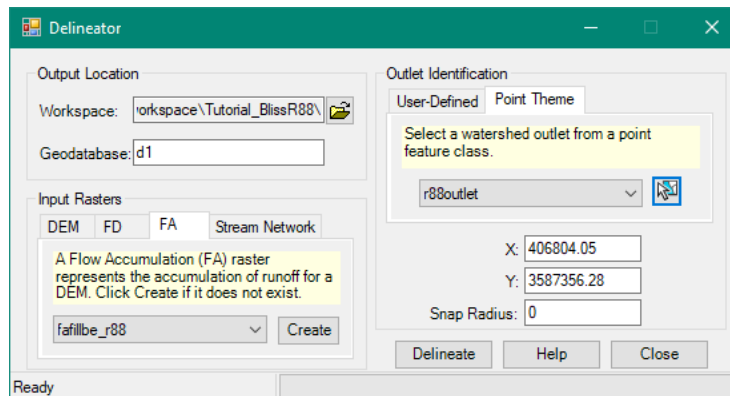
topographic, land cover, and soil properties; precipitation definition; writing model input files; model execution; and importing and viewing results. This tutorial will cover each of these steps.

### Step 1: Delineating the watershed

Delineating creates a feature class that represents the entire area or watershed draining to a user-specified outlet. To determine the outlet location, obtain a DEM of your area of interest, and then use AGWA to create the flow direction, flow accumulation, and stream network layers. You can then view the stream network to identify the watershed outlet downstream of your area of interest. For this tutorial, the outlet has already been identified for you as **r88outlet.shp**, and the stream network is **streamline2500.shp**. To orient yourself, turn on these layers: **disturbed**, **r88outlet**, and **googleearthR88Dec2013x.jpg**. Zoom to the **disturbed** layer, which represents most of the area disturbed by the development of the new training range.

1. Perform the watershed delineation by selecting **AGWA Tools > Delineation Options > Delineate Watershed**.

**DESCRIPTION** In the **Delineator** form, several parameters will be defined including the output location, name of the delineation, digital elevation model (DEM), flow direction grid (FD), flow accumulation grid (FA), watershed outlet location, and a search radius from the outlet location which AGWA will use to locate the most downstream point to use as the watershed outlet.



#### 1.1. **Output Location** box

- 1.1.1. **Workspace** textbox: navigate to and select/create **C:\AGWA\workspace\tutorial\_BlissR88\**

**DESCRIPTION** The workspace specified is the location on your hard drive where the delineated watershed is stored as a feature class in a geodatabase.

- 1.1.2. **Geodatabase** textbox: enter **d1**

**NOTE** You will be required to change the name of the geodatabase if a geodatabase with the same name exists in the selected workspace.

#### 1.2. **Input Rasters** box. Use the 2006 LiDAR data (pre-disturbance).

- 1.2.1. **DEM** tab: select **fillbe\_r88ta** (do not click **Fill**)
- 1.2.2. **FD** tab: select **fdfillbe\_r88** (do not click **Create**)


1.2.3. **FA** tab: select **fafillbe\_r88** (do not click **Create**)

1.2.4. **Stream Network**: do nothing, the stream network layer is provide

1.3. **Outlet Identification** box

1.3.1. **Point Theme** tab: select **r88outlet** (see the image below for location)

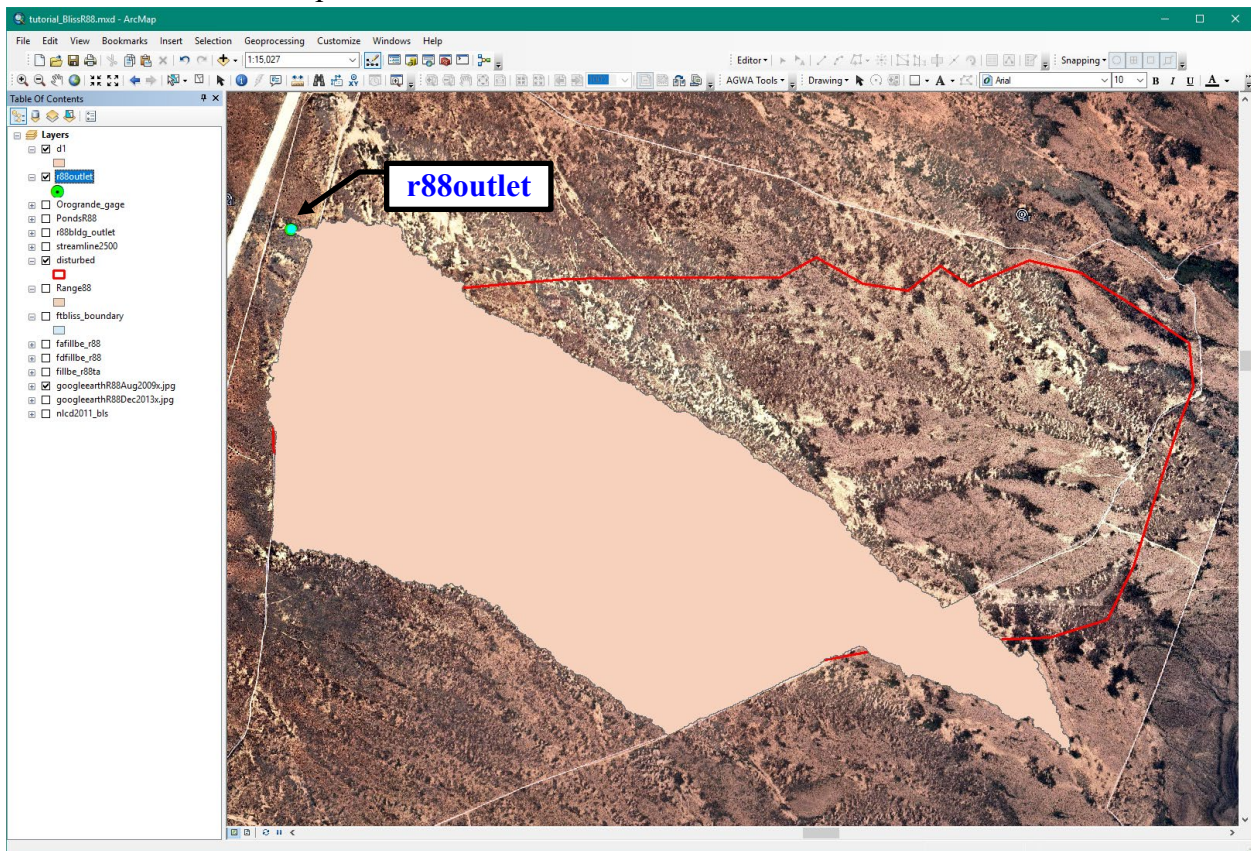
**NOTE**: Examine the location of **r88outlet** and the stream network **streamline2500** in relation to the surface features in Range 88. This outlet location was selected to include the streams that will affect the buildings along the west end of Range 88. You may need to zoom in and change the symbology (change the color and line thickness) to see the stream network.

1.4. Click the **Select Feature** button  and click and drag to draw a rectangle around the point **r88outlet**.

**NOTE** The selection is restricted to the selected point theme. If more than one point exists in the selected point theme and the drawn rectangle intersects multiple points, the first intersected point in the point theme attribute table will be selected.

1.5. Click **Delineate**. Your watershed should look like the map below. Notice the effect of the road along the southeast portion of the watershed on the watershed delineation, creating a straight-line boundary, visible because of the high resolution LiDAR DEM.

1.6. Save the map document and continue.



AGWA has now delineated the watershed and generated a geodatabase named *d1*. Inside the geodatabase, a feature class, also named *d1*, that represents the delineated watershed has been created, and the selected outlet point, whether user-defined or selected from an existing point theme, will be copied into a separate feature class named *d1\_point*.

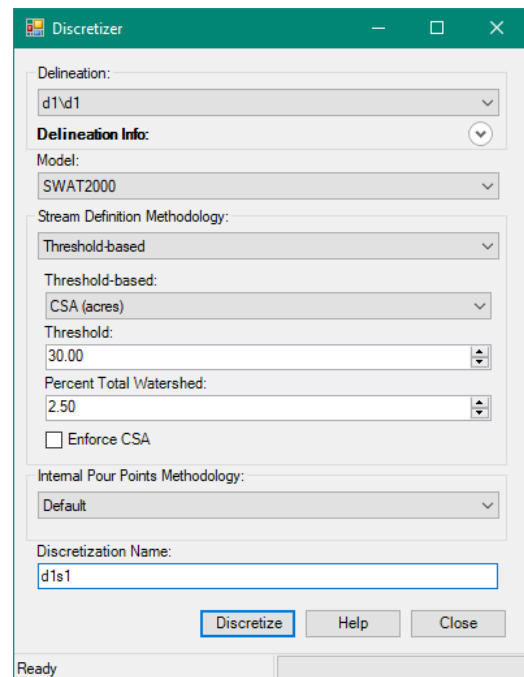
**Step 2: Discretizing or subdividing the watershed**

Discretizing breaks up the delineated watershed into model specific hillslope elements and creates a stream feature class that drains those elements.

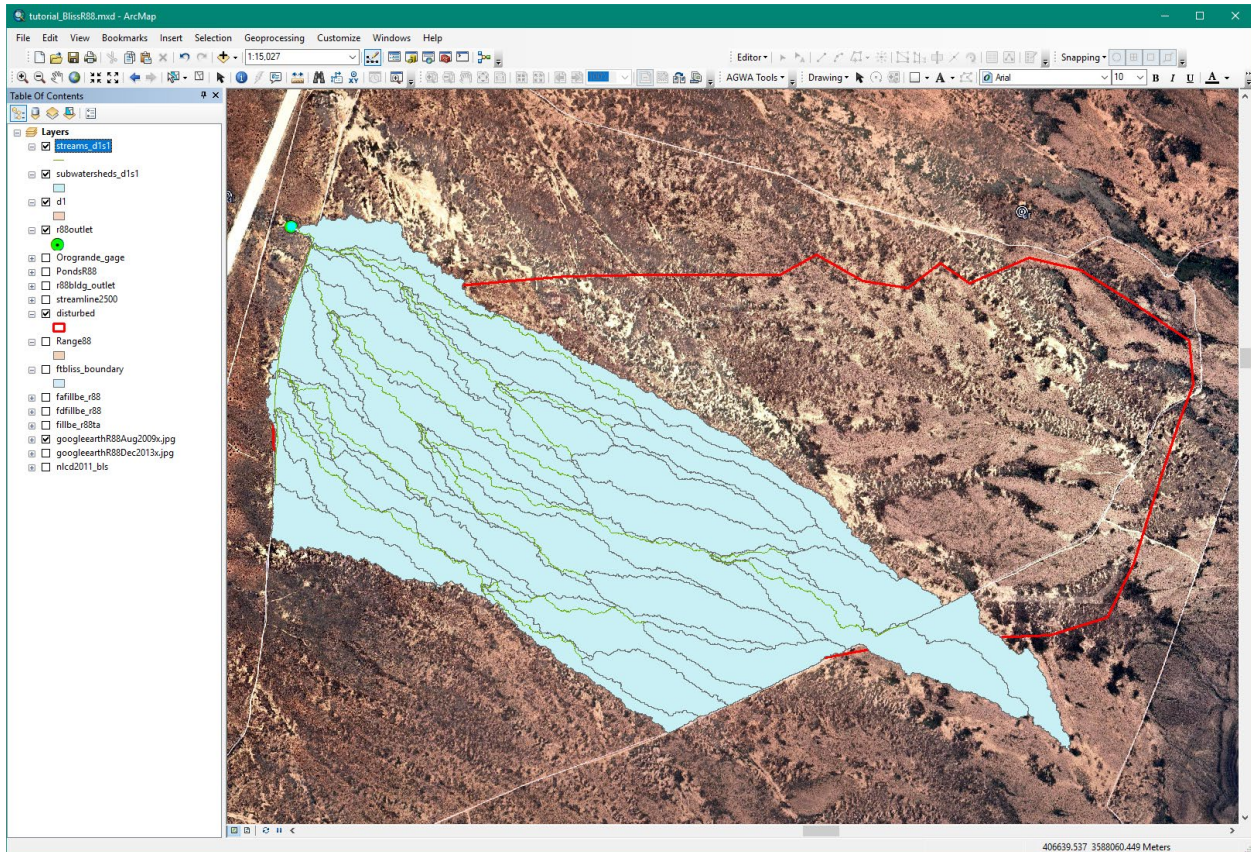
2. Perform the watershed discretization by selecting **AGWA Tools > Discretization Options > Discretize Watershed**.

**DESCRIPTION** In the Discretizer form, you will define several parameters including which model to use, the complexity of the discretization, the name of the discretization, and whether additional pour points will be used to further control the subdivision of the watershed. See the AGWA Glossary and Acronyms at the end of this AGWA section for descriptions of these terms.

- 2.1. **Delineation:** select **d1\d1**
- 2.2. **Model:** select **SWAT2000**
- 2.3. **Stream Definition Methodology:** select **Threshold-based**
  - 2.3.1. **Threshold-based:** select **CSA (acres)**
  - 2.3.2. **Threshold:** enter **30**
  - 2.3.3. **Percent Total Watershed:** do nothing (Note: this value will change when we change the threshold)
  - 2.3.4. **Enforce CSA:** leave unchecked
- 2.4. **Internal Pour Points Methodology:** select **Default**
- 2.5. **Discretization Name:** enter **d1s1** (for discretization 1, SWAT 1)
- 2.6. Click **Discretize**
- 2.7. Save the map document and continue. Your map should look like the image below.







The **CSA, or Contributing/Channel Source Area**, determines the complexity of the watershed discretization. It is a threshold value (percent of total watershed area, or acres) that defines first order channel initiation, or the upland area required for channelized flow to begin. Smaller CSA values result in a more complex watershed, and larger CSA values result in a less complex watershed. The default CSA in AGWA is set to 2.5% of the total watershed area. The discretization process creates a subwatersheds layer with the name **subwatersheds\_d1s1** and a streams layer named **streams\_d1s1**. In AGWA, discretizations are referred to with their geodatabase name as a prefix followed by the discretization name given in the Discretizer form, e.g. **d1d1s1**. Enforcing the CSA will cause all subwatersheds to be approximately the same area as the upland areas.

The **Internal Pour Points Methodology** panel allows the user to select point locations to further subdivide the watershed and split elements and channels at specific locations, such as at a detention basin or stream gage. Options are: 1) Default, pour points are determined by the discretizer; 2) Enforce CSA, element sizes are equal to or less than the CSA threshold; 3) User-defined, pour points are added manually by clicking on the map; and 4) Point Theme, use an existing point theme to select pour points.

### ***Step 3: Parameterizing the watershed***

Parameterizing defines model input parameters based on topographic, land cover, and soils properties to represent the physical properties of the watershed and used to write the model input files. We will parameterize the watershed using pre-disturbance data: the 2006 LiDAR, and the 2011 NLCD.

3. Perform the element, land cover, and soils parameterization of the watershed by selecting ***AGWA Tools > Parameterization Options > Parameterize.***

- 3.1. ***Input*** box

- 3.1.1. ***Discretization:*** select **d1\d1s1**

- 3.1.2. ***Parameterization Name:*** enter **p\_r88pre**

- 3.2. ***Elements*** box

- 3.2.1. ***Parameterization:*** select **Create new parameterization**

- 3.2.2. Click **Select Options**. The ***Element Parameterizer*** form opens.

**DESCRIPTION** **Element parameterization** defines the topographic properties of the subwatershed and channel elements. The properties defined depend on the model, but examples of SWAT properties include mean elevation, maximum flow length, and average slope for subwatershed elements; and routing sequence, average slope, and channel dimensions for channel elements.

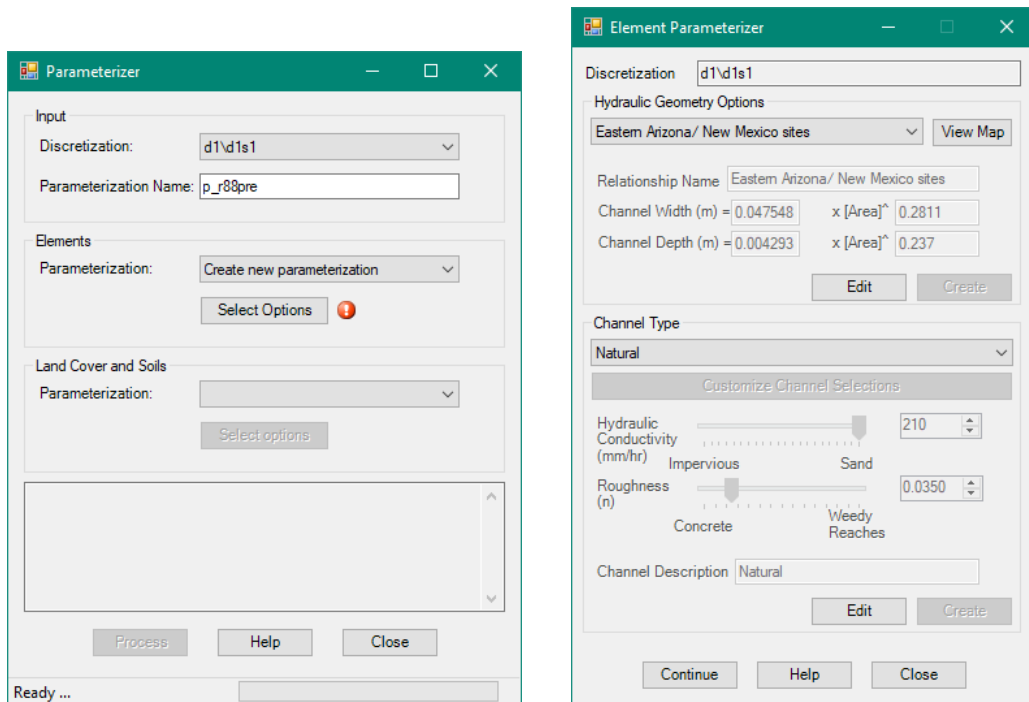
- 3.3. In the ***Element Parameterizer*** form

- 3.3.1. ***Hydraulic Geometry Options:*** select **Eastern Arizona/ New Mexico sites**

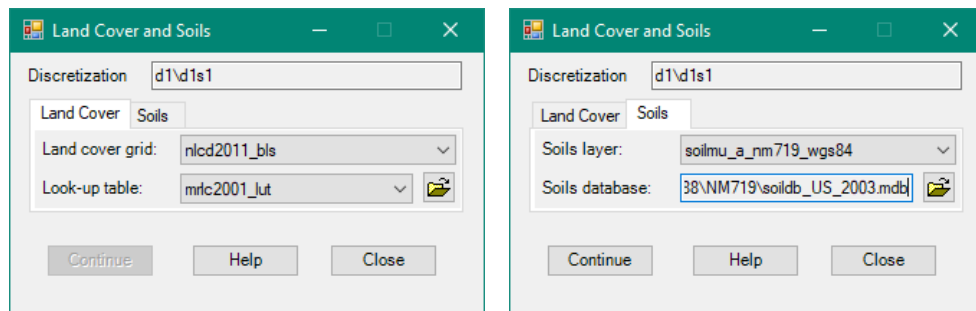
- 3.3.2. ***Channel Type*** box: select **Natural**

**\*\* OPTIONAL \*\*** The **Hydraulic Geometry Options** set channel dimensions using relationships between channel contributing area and channel depth/height, and vary with location. When choosing the hydraulic geometry relationship that best fits the watershed being modeled, note that there could be multiple relationships that intersect spatially with the study area. The **View Map** button allows the user to see which relationships apply to their watershed location. Once clicked, the map will show the attribute table with each relationship that intersects the study area and the user will be able to click on and see the spatial extent of the selected relationships. Selecting an appropriate hydraulic geometry relationship will improve the depiction of channel geometries and will increase the performance of the model.

There are three *channel types* available: Default, Natural, and Developed. The **Default** channel type, unless edited, is equivalent to the *Walnut Gulch Watershed, AZ* relationship, and is equivalent to the **Natural** channel type. The **Natural** channel type reflects a sandy channel bottom with high infiltration and a winding but clean channel with roughness set to 0.035 Manning’s n. The **Developed** channel type reflects a concrete channel with zero infiltrability, very low roughness set to 0.010 Manning’s n, and the fraction of channel armored against erosion equal to 1. These values may be edited on the fly when not customizing a channel selection. If modified parameter values are desired with a custom channel selection, use the **Edit** and **Create** buttons with the trackbars or numeric textboxes to create a new channel type before customizing the channel selection.



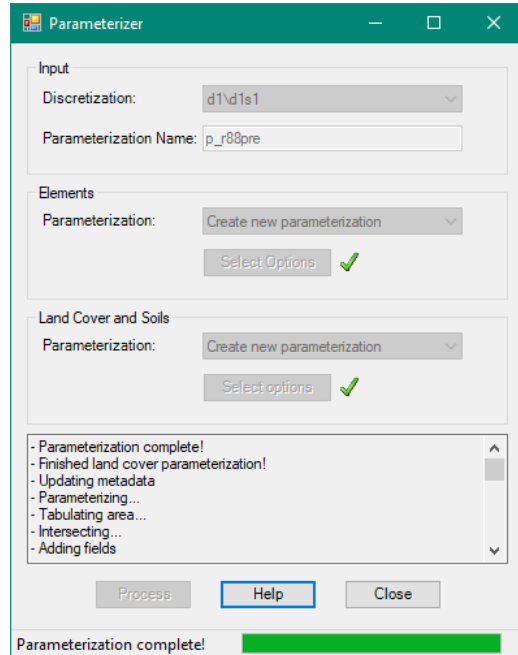
- 3.3.3. Click **Continue**. You will be returned to the *Parameterizer* form to create the Land Cover and Soils parameterization.
- 3.4. In the *Land Cover and Soils* box of the *Parameterizer* form
  - 3.4.1. **Parameterization**: select **Create new parameterization**
  - 3.4.2. Click **Select Options**. The *Land Cover and Soils* form opens.
- 3.5. In the *Land Cover and Soils* form
  - 3.5.1. **Land Cover** tab
    - 3.5.1.1. **Land cover raster**: select **nlcd2011\_bls** (this is the 2011 land cover for the Fort Bliss area)
    - 3.5.1.2. **Look-up table**: select **mrlc2001\_lut**  
**NOTE** If the **mrlc2001\_lut** table is not present in the combobox, you may have forgotten to add the table to the map earlier. If this is the case, click on the **Add Data** button and browse to the **C:\AGWA\datafiles\lc\_luts\** folder and select the **mrlc2001\_lut.dbf**, then select the **mrlc2001\_lut** table from the combobox.
  - 3.5.2. **Soils** tab
    - 3.5.2.1. **Soils layer**: select **soilmu\_a\_nm719\_wgs84**
    - 3.5.2.2. **Soils database**: Browse to the **C:\AGWA\gisdata\tutorial\_BlissR88\NM719\** folder and select **soildb\_US\_2003.mdb**



- 3.6. Click **Continue**. You will be returned to the *Parameterizer* form where the **Process** button will now be enabled.
- 3.7. In the *Parameterizer* form, click **Process**. When the parameterization is complete, close the *Parameterizer* form.



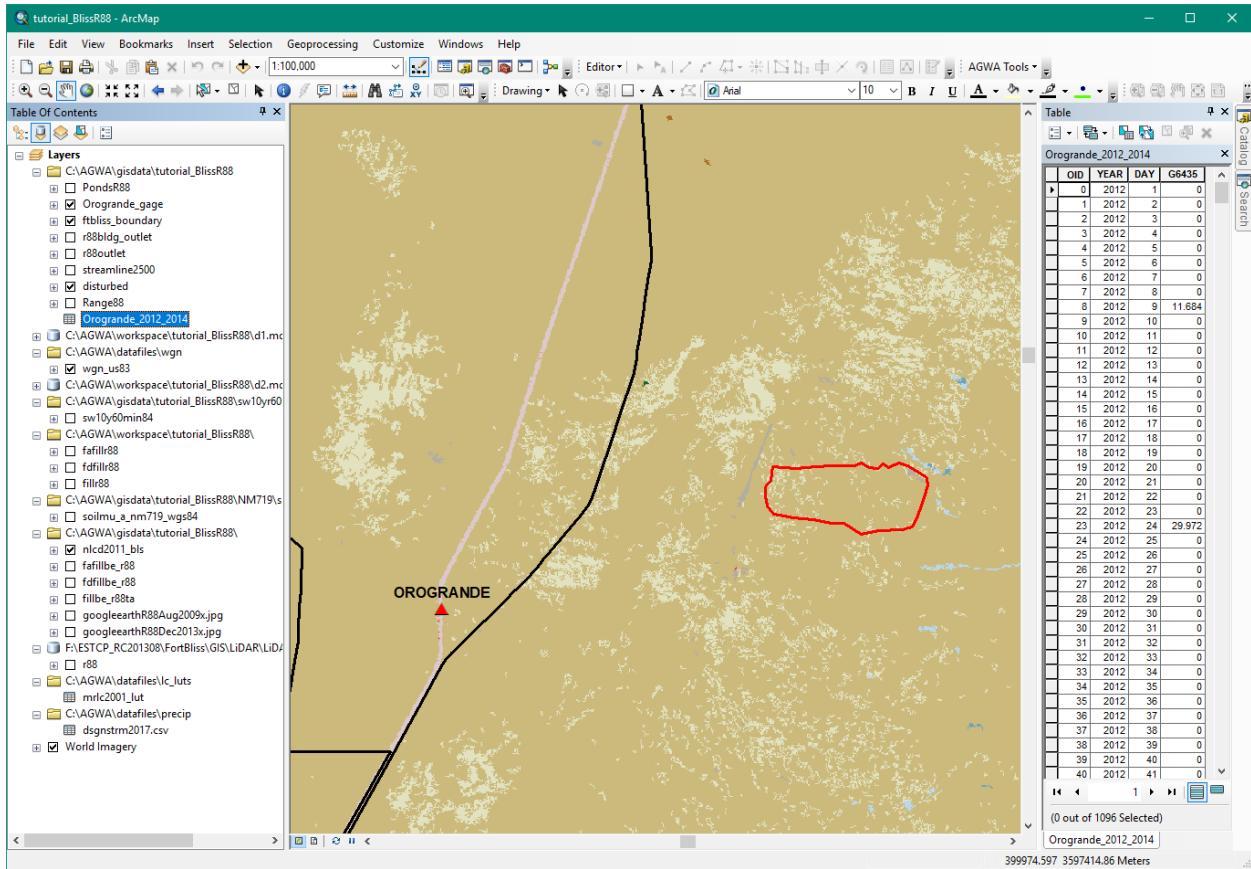
The parameterization look-up tables for the overland flow and stream elements have now been created to store the model input parameters representing the physical properties of the watershed before the area was developed for training.



#### Step 4: Preparing rainfall files

AGWA provides a means for preparing rainfall files in SWAT- or KINEROS-ready format. For SWAT, the user must have a *dbf* file containing the continuous, daily estimates of rainfall for the rain gages within the study area, and a point shapefile with the location information for the rain gages. Daily rainfall data for the gage at Orogrande, New Mexico, is provided to you in the **Orogrande\_2012-2014.dbf** file. This file was created using data for Orogrande from NOAA’s historical online climate data, and by filling in missing data from Weather Underground for Alamogordo, NM. Open the file to view its structure. SWAT requires precipitation data be provided with 3 fields: year, day (Julian day), and gage number (as Gxxxx). See the image below with the **Orogrande\_2012-2014.dbf** file open on the right side of the image. The rain gage information is provided in the **Orogrande\_gage.shp** file. Instructions for creating SWAT precipitation files were shown in the Data Management section of this document, in Part 3.

**NOTE:** Because the NOAA data had so much missing data that were filled in from a different station, we do not recommend using the results from this analysis or this precipitation data file for planning or facility design.



When AGWA is used expressly as a hydrologic modeling tool, it is critical that the rainfall data be spatially distributed across the watershed. A large body of literature exists regarding the crucial nature of spatially distributed rainfall data. In this exercise however, we will use a single rain gage to generate a uniform rainfall file across all model elements. This is clearly a huge deviation from using distributed, observed data, but there is a sound reason for doing so in change detection work. We are interested in the impacts of land cover change on hydrologic response, but the spatial variability in rainfall can have confounding effects on the analysis, overwhelming the isolated changes within the subwatershed elements. Using uniform rainfall serves to isolate the effects of land cover change independent of the rainfall.

4. Write the SWAT precipitation file for the watershed by selecting **AGWA Tools > Precipitation Options > Write SWAT Precipitation.**

4.1. **SWAT Precipitation Step 1** form,

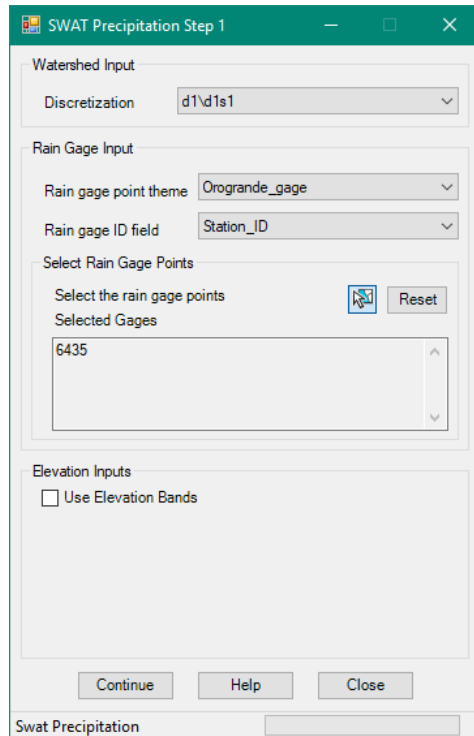
4.1.1. **Watershed Input** box:

4.1.1.1. **Discretization:** select **d1\d1s1**

4.1.2. **Rain Gage Input** box:

4.1.2.1. **Rain gage point theme:** select **Orogrande\_gage**

4.1.2.2. **Rain gage ID field:** select **Station\_ID**



#### 4.1.3. *Select Rain Gage Points* box

- 4.1.3.1. Click the **Select Feature** button to select the **Orogrande** rain gage in the view (the figure above displays the location of the gage; you may have to zoom out). The id number, **6435**, of the selected gage will be displayed in the *Selected Gages* textbox.

#### 4.1.4. *Elevation Inputs* box:

- 4.1.4.1. *Use Elevations Bands* checkbox: leave unchecked.

#### 4.1.5. Click **Continue**.

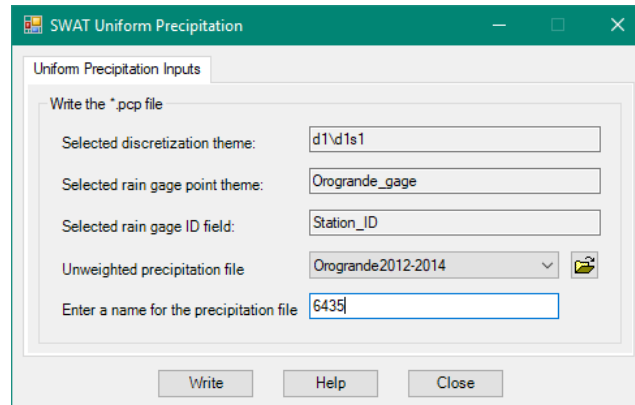
### 4.2. *SWAT Uniform Precipitation* form

#### 4.2.1. *Write the \*.pcp file* box:

- 4.2.1.1. *Selected discretization theme: d1\d1s1*
- 4.2.1.2. *Selected rain gage point theme: Orogrande\_gage*
- 4.2.1.3. *Selected rain gage ID field: Station\_ID*
- 4.2.1.4. *Unweighted precipitation file: select Orogrande\_2012-2014*
- 4.2.1.5. *Enter a name for the precipitation file: enter 6435*

**TIP** Using the gage ID (the last 4 digits in this case) of the selected gage as the filename can help keep track of the precipitation files in case other data are used for comparison in different simulations.

- 4.2.1.6. Click **Write**. The form will automatically close once the file is written.



The **6435.pcp** file will be written to the folder **C:\AGWA\workspace\tutorial\_BlissR88\d1\d1s1\precip\**. AGWA will look in this folder for available precipitation files when writing the SWAT model input files. You can open this file to view its contents using a text editor.

**\*\* Optional \*\*** If AGWA is given a number of rain gages scattered throughout the study area, it will generate a Thiessen rainfall map and distribute observed rainfall on the various watershed elements using an area-weighting scheme. You can try using two different sources of rainfall data for SWAT: uniform and distributed. In this example you will use a single gage (uniform), but you could also try running SWAT with multiple gages (distributed). In this way, you can investigate the impacts of rainfall input on hydrologic modeling.

### **Step 5: Writing SWAT input files**

Writing the model input files creates a simulation directory and writes all required input files for the model. When writing the input files, AGWA loops through the features of the selected discretization and reads the model parameters from the parameterization look-up tables.

5. Write the SWAT input files by selecting **AGWA Tools > Simulation Options > SWAT2000 Options > Write SWAT2000 Input Files**.

#### 5.1. **Basic Inputs** tab:

5.1.1. **Watershed** box: select **d1\d1s1**

5.1.2. **Parameterization** box: select **p\_r88pre**

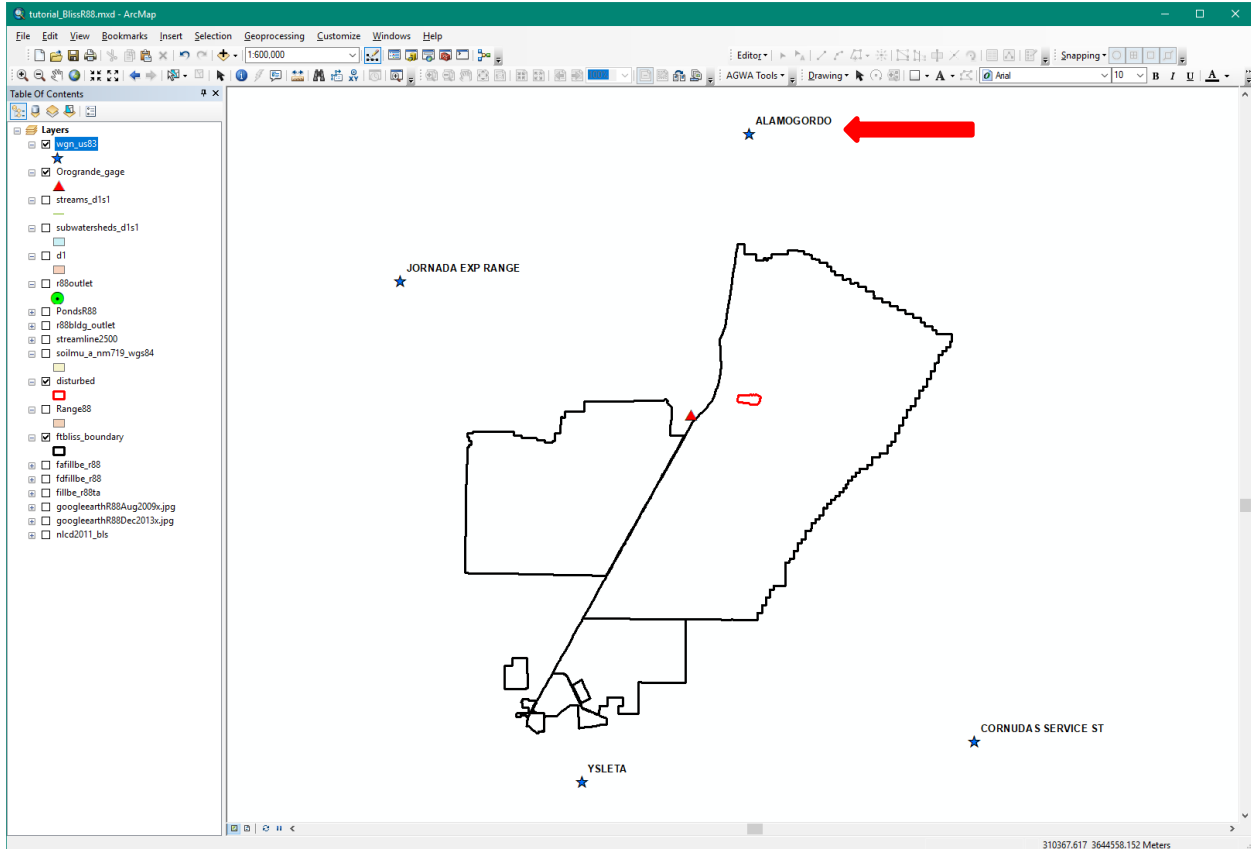
#### 5.1.3. **Climate Inputs** tab:

5.1.3.1. **Weather Generator** box:

5.1.3.1.1. **Select WGN Theme:** select **wgn\_us83**

5.1.3.1.2. **Selected Station:** Use the select button to select **Alamogordo** (you will have to zoom out to see this station located north of Fort Bliss; see the figure below).

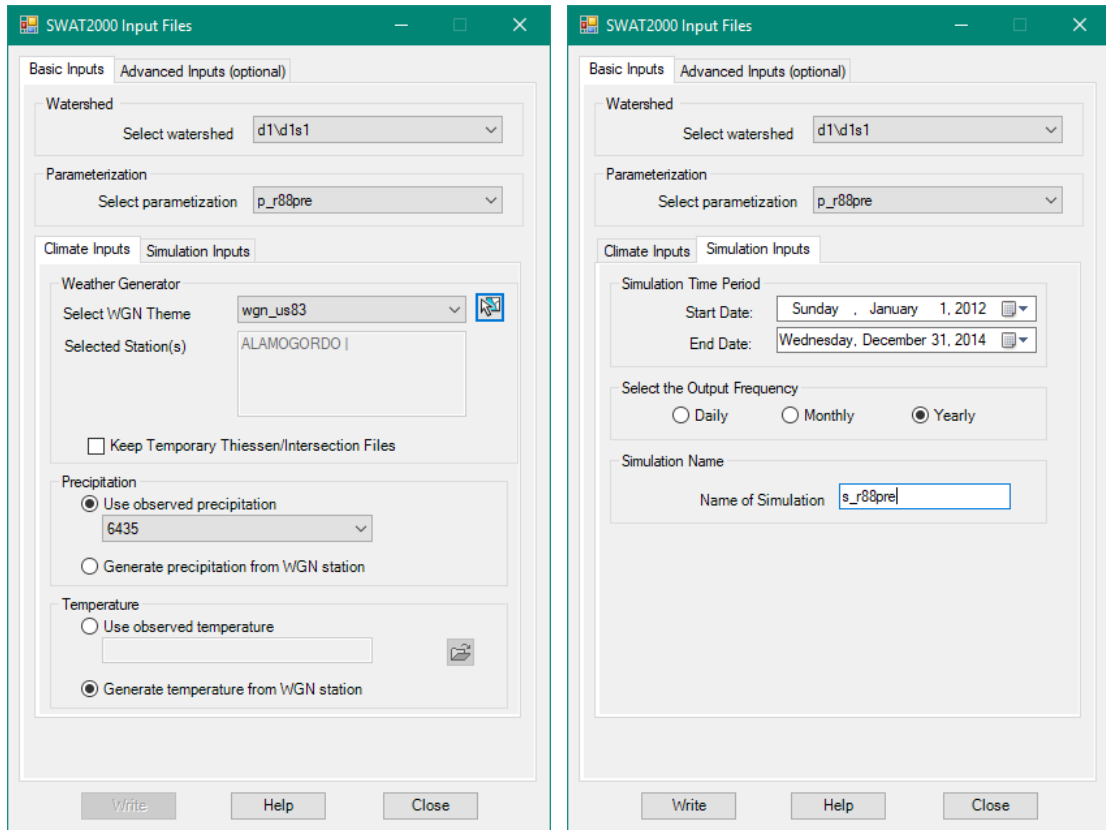
- 5.1.3.1.3. **Keep Temporary Thiessen/Intersection Files:** leave unchecked
- 5.1.3.2. **Precipitation** box:
  - 5.1.3.2.1. **Use observed precipitation:** select **6435** (the precipitation file you created using Orogrande data)
- 5.1.3.3. **Temperature** box:
  - 5.1.3.3.1. Select: **Generate temperature from WGN station**



- 5.1.4. **Simulation Inputs** tab:
  - 5.1.4.1. **Simulation Time Period** box (the time period of the Orogrande data):
    - 5.1.4.1.1. **Start Date:** select **Sunday, January 1, 2012**
    - 5.1.4.1.2. **End Date:** select **Wednesday, December 31, 2014**
  - 5.1.4.2. **Select the Output Frequency** box: select **Yearly**
  - 5.1.4.3. **Simulation Name** box: enter **s\_r88pre**

This is the simulation name and, consequently if you set names and locations as specified thus far, it will also be the folder name the SWAT results are placed in within the **C:\AGWA\workspace\tutorial\_BlissR88\d1\d1s1\simulations\** folder.

5.1.5. Click **Write**. The form will close automatically once the file is written.

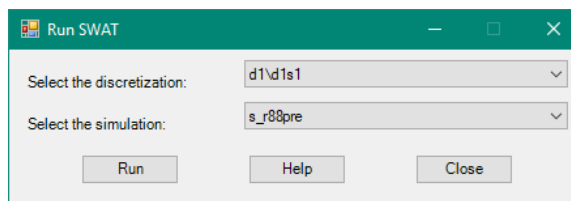


### Step 6: Executing the SWAT model

Executing the SWAT model opens a command window where the model is executed.

6. Execute the SWAT model by selecting **AGWA Tools > Simulation Options > SWAT2000 Options > Execute SWAT2000 Model**.
  - 6.1. **Select the discretization:** select **d1\vd1s1**
  - 6.2. **Select the simulation:** select **s\_r88pre**
  - 6.3. Click **Run**.

A command window will open and show the execution of SWAT for the 3-year simulation period. The command window will stay open so that successful completion can be verified. Press any key to continue and close the command window.



```

C:\WINDOWS\system32\cmd.exe
C:\AGWA\workspace>pushd C:\AGWA\workspace\tutorial_BlissR88\d1\d1s1\simulations\s_r88pre\
C:\AGWA\workspace\tutorial_BlissR88\d1\d1s1\simulations\s_r88pre>swat2000
      SWAT2000
    Soil & Water Assessment Tool
      PC Version
Program reading from file.cio . . . executing

Executing year 1
Executing year 2
Executing year 3

Execution successfully completed

C:\AGWA\workspace\tutorial_BlissR88\d1\d1s1\simulations\s_r88pre>popd
C:\AGWA\workspace>pause
Press any key to continue . . .
  
```

6.4. Close the *Run SWAT* form.

### *Step 7: Viewing the results*

After the SWAT execution is complete, the SWAT output files must be imported into AGWA before displaying the spatially distributed results, such as runoff, infiltration, and other water balance results. These results represent the average over the simulation period, three years in this case (2012-2014). Note that since the model was not calibrated, the results for each subwatershed should be viewed relative to the other subwatersheds, and not as absolute values.

7. Import the SWAT results by selecting *AGWA Tools > View Results > SWAT Results > View SWAT2000 Results*.

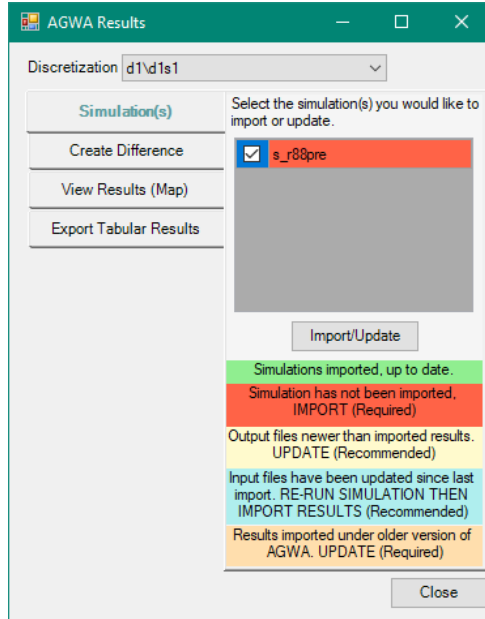
7.1. *Discretization*: select **d1\d1s1**

7.2. *Simulation* tab:

7.2.1. Check box for **s\_r88pre**

7.2.2. Click **Import/Update**. The box will turn green and the check box will clear when the import is complete.





7.3. Experiment with the results visualization by choosing different results to display.

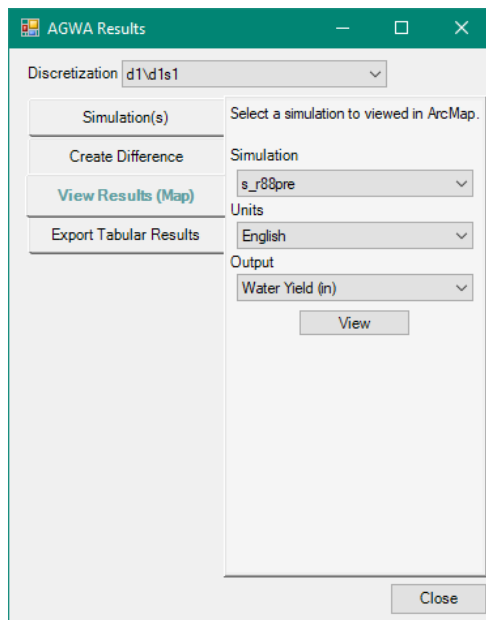
7.3.1. *View Results (Map)* tab

7.3.1.1. **Simulation**: select **s\_r88pre**

7.3.1.2. **Units**: select **English**

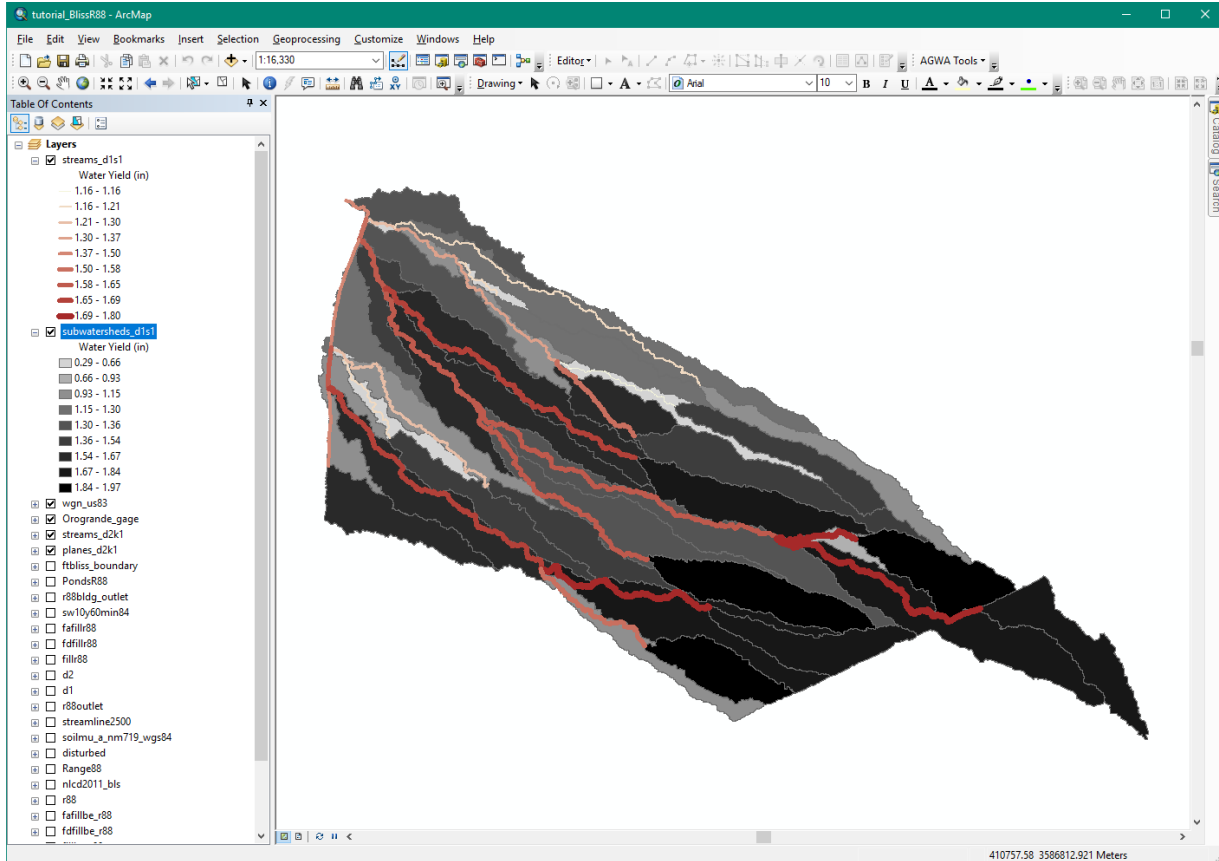
7.3.1.3. **Output**: select **Water Yield (in)**

7.3.1.4. Click **View**.



The results for the **s\_r88pre** simulation with the **Water Yield (in)** output should look like the image below. Review the spatial distribution of surface runoff predicted by SWAT for the subwatersheds. Notice that water yield was relatively low in the area near the buildings on the

west end of Range 88 that flooded in 2014, based on the 2011 (pre-development) land cover. Use the *identify tool* to click on one of the darker subwatersheds to see the hydrologic information provided by SWAT. Remember that because the model was not calibrated, it is best to view the results for each subwatershed in relation to the other subwatersheds.



### Part 3: Modeling Runoff at the Small Watershed Scale Using KINEROS2

In the previous section, we viewed the spatial distribution of water yield before any development or training disturbance occurred. These basin scale assessments are quite useful for detecting potential problem areas. For example, notice that the subwatersheds draining to and at the building that flooded in 2014 showed relatively low water yield. Turn on the **PondsR88** layer (the detention basins built to capture flow at that building) to locate this area. In this part, we will use KINEROS2 to zoom in to that area to investigate the changes and effects on runoff from simulated rainfall events. First, we will simulate pre-development conditions, then we will evaluate post-development conditions, and finally difference them to see how the development of Range 88 affected local hydrology.

In the last exercise we used SWAT, a continuous simulation model, to simulate runoff for 3 years on a yearly basis, and obtained outputs based on the averages for those three years. In

contrast, KINEROS2 is an event-based model, and we will use design storms to simulate the runoff and sediment yield resulting from a single storm event.

### **Step 8: Delineating the watershed**

As in Part 2 for SWAT, the first step in KINEROS2 is to delineate the watershed of interest. For this part, we will select the outlet of the watershed downstream (west) of the buildings at Range 88 that flooded during the September 2014 storm event. The outlet shapefile is provided to you as **r88bldg\_outlet.shp**. Turn off the SWAT **subwatersheds\_d1s1** and **streams\_d1s1** layers, and turn on the **r88bldg\_outlet** and **disturbed** layers to orient yourself. We will first run KINEROS2 with the pre-development data as we did with SWAT.

#### 8. Perform the watershed delineation by selecting **AGWA Tools > Delineation Options > Delineate Watershed**.

##### 8.1. **Output Location** box

8.1.1. **Workspace** textbox: navigate to and select/create

**C:\AGWA\workspace\tutorial\_BlissR88\**

**DESCRIPTION** The workspace specified is the location on your hard drive where the delineated watershed is stored as a feature class in a geodatabase.

8.1.2. **Geodatabase** textbox: enter **d2**

**NOTE** You will be required to change the name of the geodatabase if a geodatabase with that name exists in the selected workspace.

##### 8.2. **Input Rasters** box

8.2.1. **DEM** tab: select **fillbe\_r88ta** (do not click **Fill**)

8.2.2. **FD** tab: select **fdfillbe\_r88** (do not click **Create**)

8.2.3. **FA** tab: select **fafillbe\_r88** (do not click **Create**)

8.2.4. **Stream Network** tab: leave blank

##### 8.3. **Outlet Identification** box

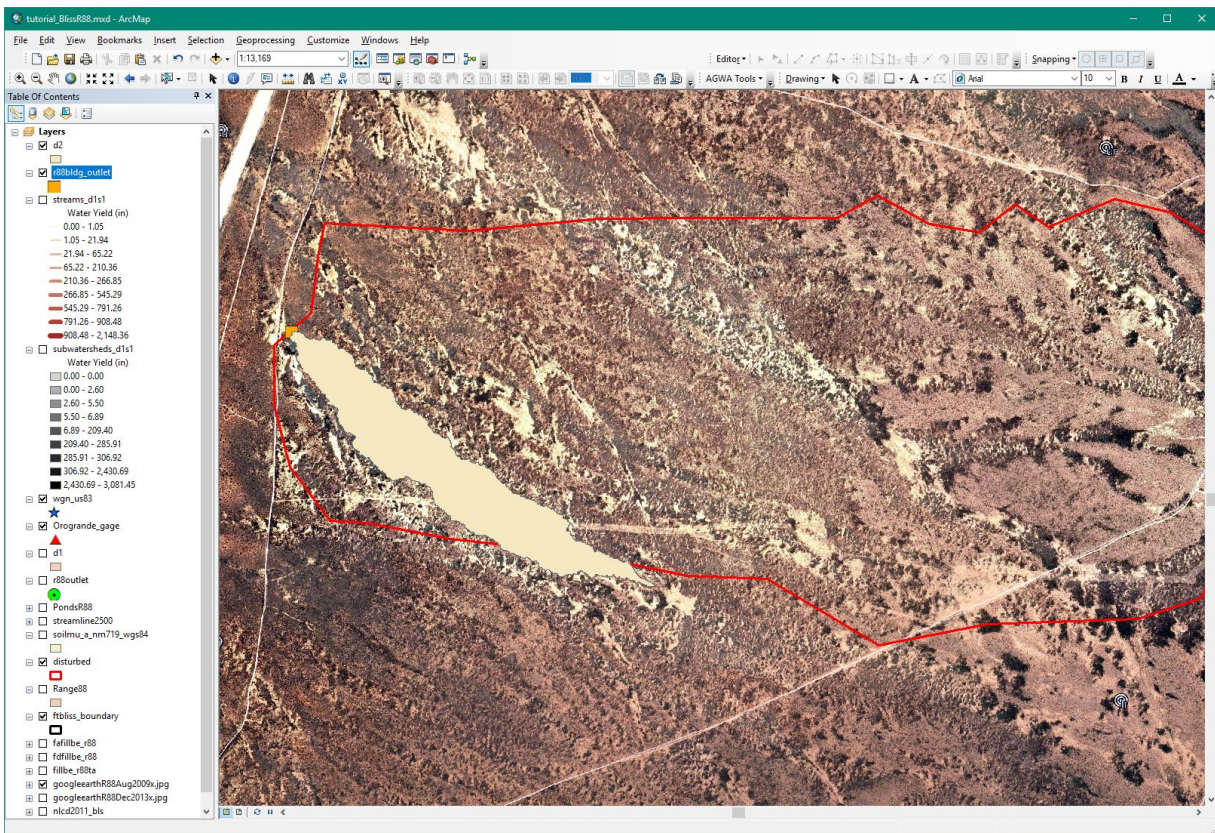
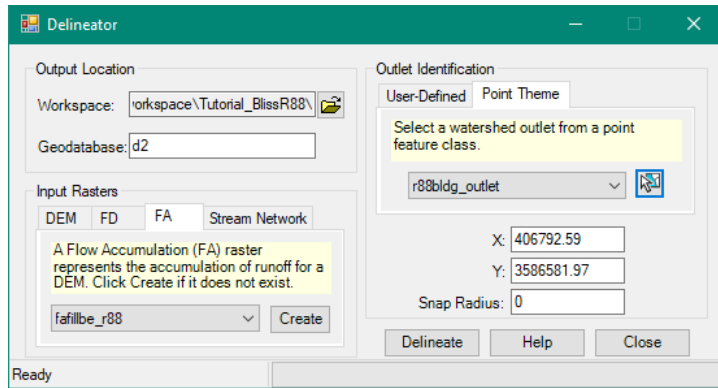
8.3.1. **Point Theme** tab: select **r88bldg\_outlet**

8.3.2. Click the **Select Feature** button, and click and drag to draw a rectangle around the point.

**NOTE** If more than one point exists in the selected point theme and the drawn rectangle intersects multiple points, the first intersected point in the point theme attribute table will be selected.

##### 8.4. Click **Delineate**

8.5. Save the map document and continue. Your map should look like the image below, which is shown with a pre-development basemap.



### Step 9: Discretizing or subdividing the watershed

Discretizing breaks up the delineated watershed into model specific elements and creates a stream feature class that drains the elements. KINEROS2 model elements differ from SWAT model elements in that planes are split into lateral elements by the stream feature class, whereas for SWAT they are not split. After the September 2014 flooding event two new detention basins were constructed to capture storm water. We will use the shapefile for these basins in the discretization ([PondsR88.shp](#)) so you will be able to view the peak flow and runoff at those locations.



9. Perform the watershed discretization by selecting **AGWA Tools > Discretization Options > Discretize Watershed**.

**DESCRIPTION** In the Discretizer form, several parameters will be defined including the model to use, the complexity of the discretization, the name of the discretization, and whether additional pour points will be used to further control the subdivision of the watershed.

9.1. **Delineation:** select **d2\d2**

9.2. **Model:** select **KINEROS**

**NOTE** SWAT and KINEROS2 require significantly different watershed subdivisions and their watershed topology is not interchangeable, so be sure to select the **KINEROS** model and not SWAT.

9.3. **Stream Definition Methodology:** select **Threshold-based**

9.3.1. **Threshold-based:** select **CSA (acres)**

9.3.2. **Threshold:** leave as **2.66**

9.3.3. **Percent Total Watershed:** leave as **2.50**.

9.3.4. **Enforce CSA:** leave unchecked

9.4. **Internal Pour Points Methodology:** select **Point Theme**

**DESCRIPTION** Pour points can be used to force the subdivision of watershed elements at user-supplied points, either by clicking on the map or by selecting points from a point theme. Pour points can be used to help subdivide the watershed or define locations such as detention basins or rain gages.

**NOTE:** See AGWA Modeling Part 2 Step 2 for more information on the CSA and Pour Points.

9.4.1. **Point Theme:** select **PondsR88**

9.4.2. **ID Field:** select **ID**

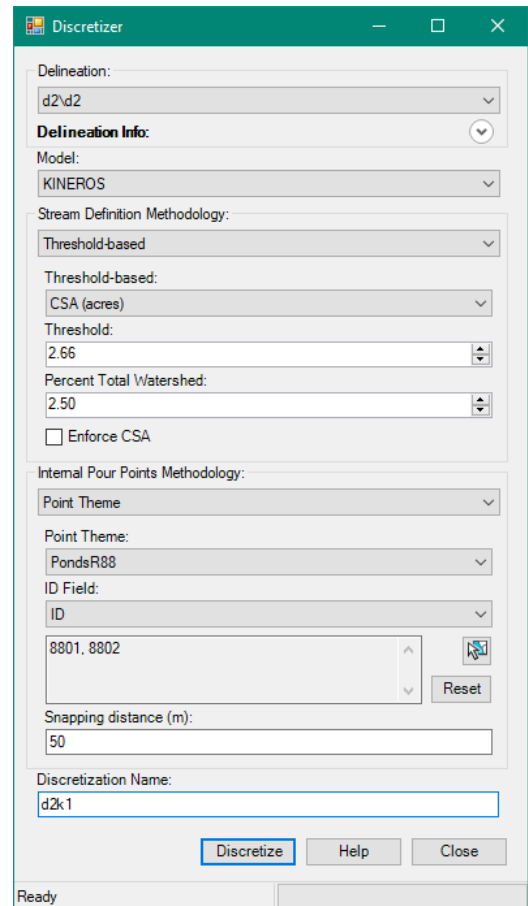
9.4.3. Use the **Select Tool** to click and drag a box around the two ponds.

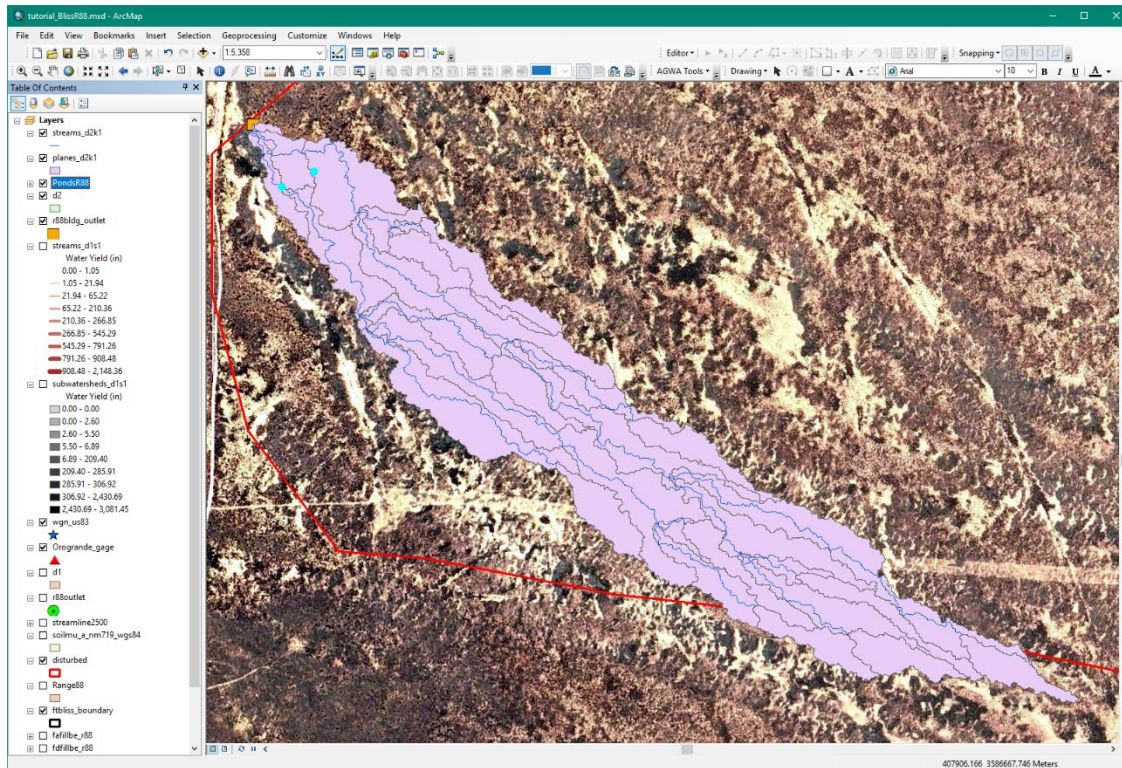
9.4.4. **Snapping distance (m):** enter **50.0** (to help the watershed elements split near both ponds)

9.5. **Discretization Name:** enter **d2k1**

9.6. Click **Discretize**

9.7. Save the map document and continue. Your map should look like the image below.





### Step 10: Parameterizing the watershed elements for KINEROS2

As with SWAT, each of the watershed elements needs to be characterized by the topographic, hydraulic geometry, flow length, land cover, and soils properties.

10. Perform the element, land cover, and soils parameterization of the watershed by selecting **AGWA Tools > Parameterization Options > Parameterize.**

10.1. **Input** box

10.1.1. **Discretization:** select **d2\d2k1**

10.1.2. **Parameterization Name:** enter **p\_r88pre** (for pre-development)

10.2. **Elements** box

10.2.1. **Parameterization:** **Create new parameterization**

10.2.2. Click **Select Options.** The **Element Parameterizer** form opens.

10.3. In the **Element Parameterizer** form

10.3.1. **Slope Options:** select **Uniform**

10.3.2. **Flow Length Options:** select **Geometric Abstraction**

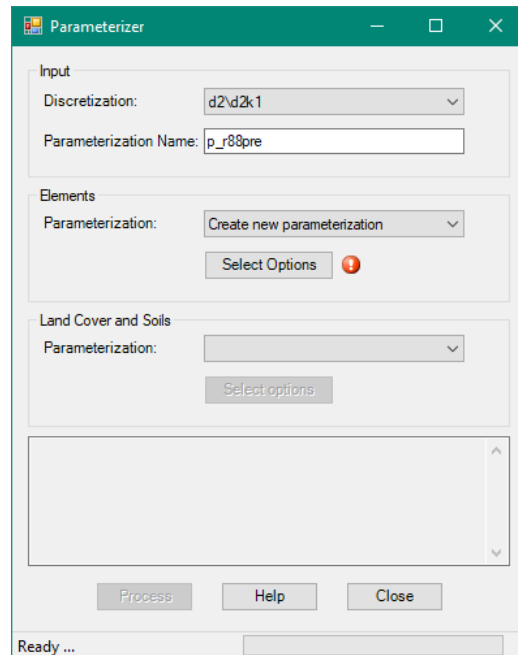
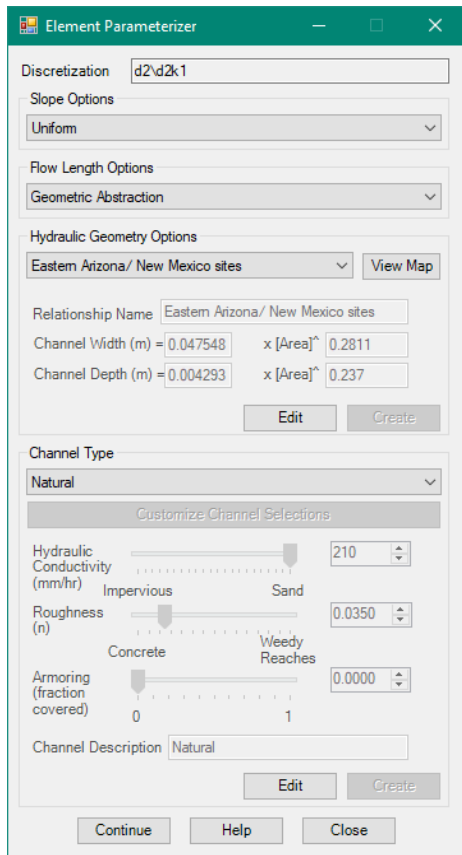
10.3.3. **Hydraulic Geometry Options:** select **Eastern Arizona/New Mexico sites**

10.3.4. **Channel Type:** select **Natural**

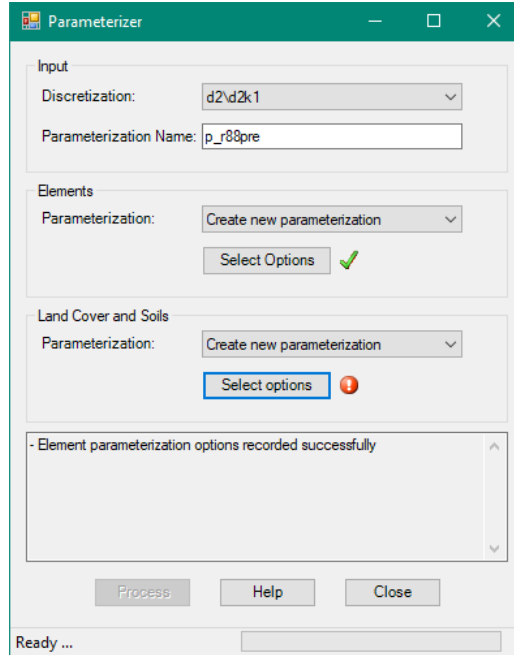
10.3.5. Click **Continue.** You will be returned to the **Parameterizer** form to create the Land Cover and Soils parameterization.

The **Hydraulic Geometry Options** set channel dimensions using relationships between channel contributing area and channel depth/height. When choosing the hydraulic geometry relationship that best fits the watershed being modeled, note that there could be multiple relationships that intersect spatially with the study area. The **View Map** button allows the user to see which relationships apply to their watershed location. Once clicked, the map will show the attribute table with each relationship that intersects the study area and the user will be able to click on and see the spatial extent of the selected relationships. Selecting an appropriate hydraulic geometry relationship will improve the depiction of channel geometries and will increase the performance of the model.

There are three *channel types* available: Default, Natural, and Developed. The **Default** channel type, unless edited, is equivalent to the *Walnut Gulch Watershed, AZ* relationship, and is equivalent to the **Natural** channel type. The **Natural** channel type reflects a sandy channel bottom with high infiltration and a winding but clean channel with roughness set to 0.035 Manning’s n. The **Developed** channel type reflects a concrete channel with zero infiltrability, very low roughness set to 0.010 Manning’s n, and the fraction of channel armored against erosion equal to 1. These values may be edited on the fly when not customizing a channel selection. If modified parameter values are desired with a custom channel selection, use the **Edit** and **Create** buttons with the trackbars or numeric textboxes to create a new channel type before customizing the channel selection.





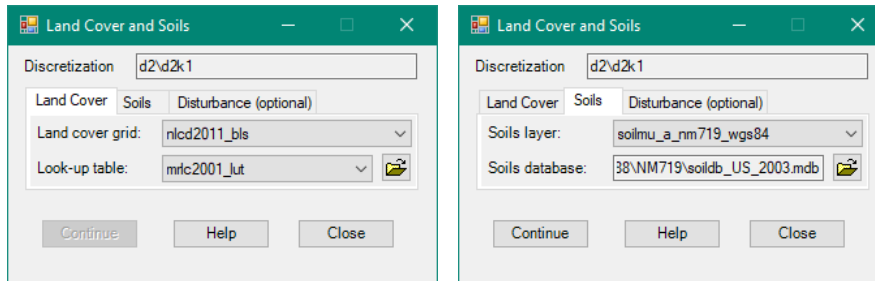


10.4. Return to the **Land Cover and Soils** box of the **Parameterizer** form:

10.4.1. **Parameterization**: select **Create new parameterization**

10.4.2. Click **Select Options**. The **Land Cover and Soils** form opens.

10.5. In the **Land Cover and Soils** form:



10.5.1. **Land Cover** tab

10.5.1.1. **Land cover raster**: select **nlcd2011\_bls**

10.5.1.2. **Look-up table**: select **mrlc2001\_lut**

10.5.2. **Soils** tab

10.5.2.1. **Soils layer**: select **soilmu\_a\_nm719\_wgs84**

10.5.2.2. **Soils database**: Browse to the

**C:\AGWA\gisdata\tutorial\_BlissR88\NM719\** folder and select **soildb\_US\_2003.mdb**

10.6. Click **Continue**. You will be returned to the **Parameterizer** form where the **Process** button will now be enabled.

10.7. In the **Parameterizer** form, click **Process**. Close the form when parameterization is complete.

### *Step 11: Preparing rainfall files*

KINEROS2 is designed to use rainfall events as opposed to the daily rainfall totals used in SWAT. AGWA allows you to create rainfall data for KINEROS2 in 4 ways, described in the previous sections of this Guidance Document:

1. Design storm depth and duration from the design storm database.
2. Design storm depth and duration based on NOAA precipitation frequency maps.
3. User-defined depth and duration.
4. User-defined hyetograph.

For this exercise, you will create the first three types of rainfall files. We do not have hyetograph data, so we will skip that method. You will learn how to create the following precipitation files:

1. A 10-year 1-hour design storm from the **dsgnstrm2017.csv** database, for a 1.5 inch (38.10 mm) rainfall depth. AGWA has a number of return period events for several locations stored in this database. Open this file to view the storms for Orogrande that were added to this database for this tutorial. At the top of the *Table of Contents*, click the second icon *List By Source*, and right click on the **dsgnstrm2017.csv** file, and click **Open**. Scroll down to see the Orogrande data. These design storms are from the NOAA Atlas 14 Point Precipitation Frequency Estimates for Orogrande (see the table below) available at [https://hdsc.nws.noaa.gov/hdsc/pfds/pfds\\_map\\_cont.html](https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html)
2. A 10-year 1-hour design storm from the NOAA precipitation frequency map, of 1.52 inches (38.56 mm). Notice that this is the same event as the one from the **dsgnstrm2017.csv** database, but is a different way of generating design storm data. This raster, **sw10y60min84**, has been provided to you for this design storm, but to create the raster for a different design storm or location follow these instructions:
  - a. Go to NOAA's Precipitation Frequency Data Server [https://hdsc.nws.noaa.gov/hdsc/pfds/pfds\\_gis.html](https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_gis.html)
  - b. Scroll down the page and select your area of interest: **Semiarid Southwest**
  - c. Select the type of data: **Precipitation frequency estimates**
  - d. Select the series: **Partial duration series**
  - e. Select average recurrence interval: your choice (we used **10 year**)
  - f. Select Duration: your choice (we used **1 hour**)
  - g. Click on the "**Click here to begin download**" button to download a zipped ascii file
  - h. Unzip this file (it is a raster), and project it to **UTM Zone 13, Datum WGS84**  
This is a raster layer of the Southwest US, with precipitation estimates in inches (times 1000) and is ready for use in AGWA. AGWA will automatically divide the values by 1000 and multiply by 25.4 to get mm, as required for KINEROS2.
3. The **September 18, 2014** storm event, with a depth of 2.29 inches (58.17 mm) and a duration of 24 hrs. Based on the table above, this would be between a 5 and 10 year 24 hour event. Since this is a daily rainfall total, we will enter this as a 24 hour event. Note

that the KINEROS2 results will reflect that this is a 24 hour event as opposed to the 1 hour events used for the other precipitation data.

All rainfall events will be applied uniformly across the watershed. Alternatively, the storm center location and radius can be defined to apply the rainfall event on a specific part of the watershed.

**NOAA Atlas 14 Point Precipitation Frequency Estimates for Orogrande, New Mexico**

**PF tabular**

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) <sup>1</sup>										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.228 (0.201-0.259)	0.294 (0.262-0.335)	0.399 (0.353-0.453)	0.478 (0.421-0.544)	0.584 (0.512-0.666)	0.669 (0.585-0.765)	0.759 (0.659-0.862)	0.853 (0.736-0.972)	0.982 (0.833-1.12)	1.09 (0.917-1.24)
10-min	0.347 (0.306-0.394)	0.448 (0.399-0.510)	0.607 (0.538-0.690)	0.727 (0.641-0.828)	0.888 (0.779-1.01)	1.02 (0.890-1.16)	1.16 (1.00-1.31)	1.30 (1.12-1.48)	1.49 (1.27-1.70)	1.65 (1.40-1.89)
15-min	0.430 (0.379-0.489)	0.555 (0.494-0.632)	0.753 (0.667-0.856)	0.901 (0.794-1.03)	1.10 (0.965-1.26)	1.26 (1.10-1.44)	1.43 (1.24-1.63)	1.61 (1.39-1.83)	1.85 (1.57-2.11)	2.05 (1.73-2.34)
30-min	0.579 (0.511-0.659)	0.747 (0.666-0.851)	1.01 (0.898-1.15)	1.21 (1.07-1.38)	1.48 (1.30-1.69)	1.70 (1.49-1.94)	1.93 (1.67-2.19)	2.17 (1.87-2.47)	2.49 (2.12-2.84)	2.76 (2.33-3.15)
60-min	0.716 (0.632-0.815)	0.925 (0.824-1.05)	1.25 (1.11-1.43)	1.50 (1.32-1.71)	1.83 (1.61-2.09)	2.10 (1.84-2.40)	2.39 (2.07-2.71)	2.68 (2.32-3.06)	3.09 (2.62-3.51)	3.41 (2.88-3.90)
2-hr	0.837 (0.738-0.955)	1.09 (0.968-1.25)	1.48 (1.30-1.69)	1.77 (1.55-2.01)	2.16 (1.89-2.46)	2.47 (2.13-2.80)	2.79 (2.39-3.16)	3.13 (2.65-3.54)	3.57 (2.99-4.05)	3.92 (3.26-4.44)
3-hr	0.902 (0.802-1.03)	1.16 (1.03-1.33)	1.55 (1.38-1.76)	1.85 (1.63-2.09)	2.25 (1.98-2.54)	2.57 (2.24-2.90)	2.90 (2.50-3.27)	3.23 (2.77-3.64)	3.70 (3.12-4.17)	4.05 (3.38-4.56)
6-hr	1.03 (0.926-1.16)	1.32 (1.18-1.50)	1.73 (1.54-1.97)	2.04 (1.81-2.30)	2.46 (2.16-2.76)	2.78 (2.44-3.12)	3.11 (2.70-3.48)	3.43 (2.95-3.86)	3.87 (3.30-4.36)	4.21 (3.57-4.74)
12-hr	1.13 (1.00-1.26)	1.44 (1.28-1.62)	1.87 (1.67-2.09)	2.19 (1.94-2.45)	2.62 (2.31-2.91)	2.93 (2.58-3.26)	3.25 (2.84-3.62)	3.57 (3.10-3.97)	4.00 (3.43-4.44)	4.31 (3.69-4.81)
24-hr	1.29 (1.14-1.47)	1.64 (1.45-1.87)	2.11 (1.85-2.40)	2.47 (2.15-2.80)	2.93 (2.55-3.34)	3.28 (2.85-3.76)	3.64 (3.14-4.19)	4.00 (3.43-4.63)	4.47 (3.80-5.22)	4.83 (4.07-5.68)
2-day	1.37 (1.21-1.54)	1.73 (1.54-1.96)	2.22 (1.97-2.51)	2.61 (2.30-2.94)	3.12 (2.74-3.54)	3.53 (3.06-4.01)	3.94 (3.39-4.50)	4.35 (3.71-5.01)	4.92 (4.13-5.70)	5.36 (4.45-6.27)
3-day	1.46 (1.30-1.63)	1.85 (1.65-2.08)	2.38 (2.12-2.67)	2.79 (2.48-3.13)	3.34 (2.95-3.76)	3.76 (3.29-4.24)	4.19 (3.63-4.76)	4.63 (3.97-5.28)	5.21 (4.41-5.99)	5.66 (4.74-6.57)
4-day	1.55 (1.39-1.72)	1.97 (1.77-2.19)	2.54 (2.28-2.83)	2.98 (2.65-3.31)	3.56 (3.16-3.97)	4.00 (3.52-4.48)	4.45 (3.88-5.01)	4.90 (4.24-5.55)	5.50 (4.68-6.28)	5.96 (5.04-6.86)
7-day	1.79 (1.61-1.99)	2.27 (2.04-2.52)	2.95 (2.65-3.27)	3.46 (3.09-3.84)	4.16 (3.70-4.62)	4.70 (4.16-5.24)	5.27 (4.63-5.89)	5.84 (5.08-6.57)	6.62 (5.66-7.52)	7.22 (6.10-8.28)
10-day	1.95 (1.74-2.19)	2.49 (2.23-2.79)	3.24 (2.90-3.62)	3.83 (3.41-4.29)	4.64 (4.09-5.18)	5.26 (4.60-5.92)	5.91 (5.12-6.67)	6.57 (5.65-7.49)	7.47 (6.34-8.57)	8.18 (6.85-9.48)
20-day	2.44 (2.19-2.71)	3.11 (2.80-3.45)	4.03 (3.63-4.47)	4.72 (4.23-5.24)	5.64 (5.04-6.27)	6.34 (5.63-7.05)	7.05 (6.22-7.86)	7.76 (6.81-8.68)	8.70 (7.54-9.83)	9.42 (8.07-10.7)
30-day	2.83 (2.56-3.13)	3.62 (3.27-3.99)	4.65 (4.20-5.12)	5.42 (4.90-5.95)	6.42 (5.77-7.05)	7.16 (6.41-7.87)	7.89 (7.02-8.74)	8.62 (7.60-9.62)	9.57 (8.34-10.8)	10.3 (8.87-11.7)
45-day	3.41 (3.09-3.75)	4.33 (3.93-4.78)	5.51 (5.01-6.10)	6.37 (5.77-7.03)	7.46 (6.73-8.24)	8.26 (7.43-9.13)	9.04 (8.10-10.0)	9.78 (8.72-10.9)	10.7 (9.49-12.1)	11.4 (10.0-12.9)
60-day	3.89 (3.55-4.27)	4.94 (4.51-5.42)	6.28 (5.74-6.91)	7.24 (6.59-7.94)	8.44 (7.65-9.24)	9.30 (8.41-10.2)	10.1 (9.14-11.1)	10.9 (9.80-12.1)	11.9 (10.6-13.2)	12.6 (11.2-14.1)

<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

11. Write the KINEROS2 precipitation files for the watershed by selecting *AGWA Tools* > *Precipitation Options* > *Write KINEROS Precipitation*. We will create the files one at a time.

11.1. *KINEROS Precipitation* form. Create the 10-year 1-hour design storm from the database.

11.1.1. *Discretization*: select **d2/d2k1**

- 11.1.2. **Storm Source:** select **Database**
- 11.1.3. **Database:** select **dsgnstrm2017.csv**
- 11.1.4. **Location:** select **OrograndeNM**
- 11.1.5. **Frequency (years):** select **10**
- 11.1.6. **Duration (hours):** select **1**
- 11.1.7. **Time Steps:** enter **7** (this results in 10 minute time steps for a one hour storm)
- 11.1.8. **Storm/hyetograph shape:** select **SCS Type II** (applies to most of the U.S.)
- 11.1.9. **Initial soil moisture:** select **0.2** (average soil moisture content for the arid southwest)
- 11.1.10. **Storm Location:** select **Apply to entire watershed**
- 11.1.11. **Precipitation filename:** enter **10yr1hr**
- 11.1.12. Click **Write**.
- 11.1.13. **AGWA KINEROS Precipitation** window: Click **Yes** to close the form.

The screenshot shows the 'KINEROS Precipitation' dialog box. The fields are as follows:

- Discretization: d2/d2k1
- Storm Source: Database
- Database: dsgnstrm2017.csv
- Location: OrograndeNM
- Frequency (years): 10
- Duration (hours): 1
- Time steps: 7
- Storm/hyetograph shape: SCS Type II
- Initial soil moisture: 0.20 (slider between 0.14 and 0.93)
- Storm location: Apply to entire watershed
- Filename: 10yr1hr

Buttons at the bottom: Write, Help, Close.

11.2. **KINEROS Precipitation** form. Create the precipitation file for the 10 year 1 hour design storm using the NOAA precipitation frequency grid for that design storm.

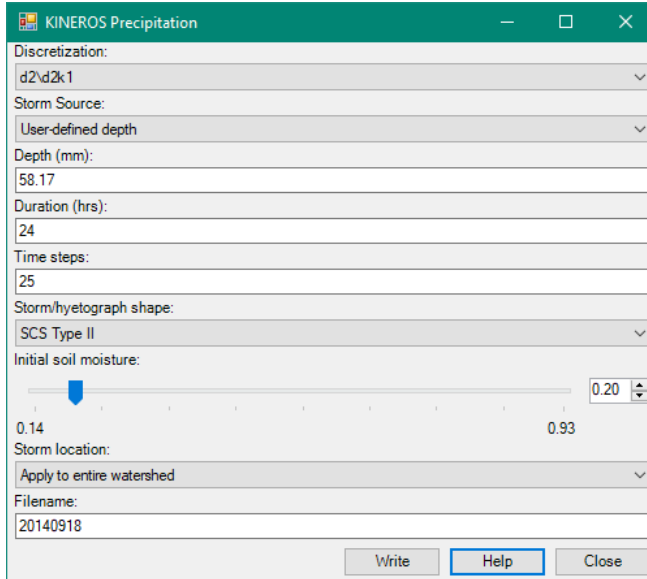
- 11.2.1. **Discretization:** select **d2/d2k1**
- 11.2.2. **Storm Source:** select **NOAA**
- 11.2.3. **Precipitation-frequency raster:** select **sw10y60min84** (the raster for the Southwest US, for the 10 year 1 hour design storm, projected to WGS84)
- 11.2.4. **Duration (hrs):** enter **1**
- 11.2.5. **Time steps:** enter **7**

- 11.2.6. **Storm/hyetograph shape:** select **SCS Type II** (applies to most of the U.S.)
- 11.2.7. **Storm location:** select **Apply to entire watershed**
- 11.2.8. **Filename:** enter **precipfreq10y1h**
- 11.2.9. Click **Write**.
- 11.2.10. **AGWA KINEROS Precipitation** window: Click **Yes** to close the form.
- 11.2.11. **Close** the KINEROS Precipitation form.

The screenshot shows the 'KINEROS Precipitation' dialog box. It has a green title bar and standard window controls. The form contains the following elements:

- Discretization:** A dropdown menu with 'd2\d2k1' selected.
- Storm Source:** A dropdown menu with 'NOAA' selected.
- Precipitation-frequency raster:** A dropdown menu with 'sw10y60min84' selected.
- Duration (hrs):** A text input field containing '1'.
- Time steps:** A text input field containing '7'.
- Storm/hyetograph shape:** A dropdown menu with 'SCS Type II' selected.
- Initial soil moisture:** A slider control with a blue arrow pointing to '0.20'. The scale ranges from 0.14 to 0.93.
- Storm location:** A dropdown menu with 'Apply to entire watershed' selected.
- Filename:** A text input field containing 'precipfreq10y1h'.
- Buttons:** 'Write', 'Help', and 'Close' buttons are located at the bottom right.

- 11.3. **KINEROS Precipitation** form. Create the precipitation file for the 2.29 inch storm event of September 18, 2014, using total depth and duration.
  - 11.3.1. **Discretization:** select **d2/d2k1**
  - 11.3.2. **Storm Source:** select **User-defined depth**
  - 11.3.3. **Depth (mm):** enter **58.17** (equal to 2.29 inches)
  - 11.3.4. **Duration (hrs):** enter **24**
  - 11.3.5. **Time Steps:** enter **25** (this will create one hour time steps for a 24 hour storm)
  - 11.3.6. **Storm/hyetograph shape:** select **SCS Type II** (the typical storm for most of the U.S.)
  - 11.3.7. **Initial soil moisture:** select **0.2**
  - 11.3.8. **Storm Location:** select **Apply to entire watershed**
  - 11.3.9. **Precipitation filename:** enter **20140918** (the date of the storm that flooded the buildings at Range 88)
  - 11.3.10. Click **Write**.
  - 11.3.11. **AGWA KINEROS Precipitation** window: Click **Yes** to close the form.
  - 11.3.12. **Close** the KINEROS Precipitation form.



You have just created three rainfall files for use in KINEROS2, one for the 10-year 1-hour design storm using the database, one for the 10-year 1-hour design storm using the NOAA precipitation frequency grid, and one for the September 18, 2014 rainfall event at Orogrande.

You may look at these files by navigating to

[C:\AGWA\workspace\tutorial\\_BlissR88\d2\d2k1\precip](C:\AGWA\workspace\tutorial_BlissR88\d2\d2k1\precip) and open each .pre file with a text editor.

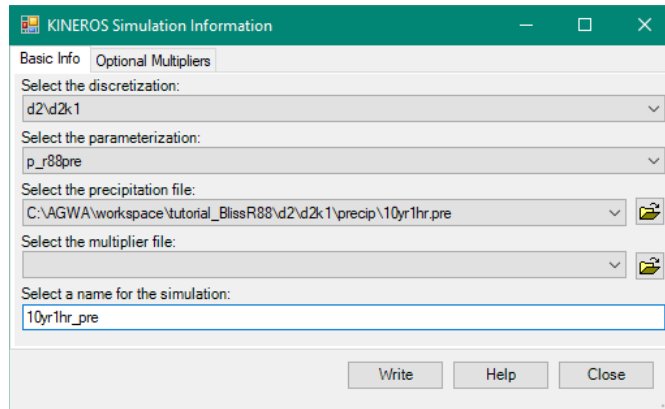
### **Step 12 & 13: Writing KINEROS input files**

We will write the input files for KINEROS2 using the three rainfall events. Since we used the 2011 NLCD data, we will label these files “pre”, to indicate pre-development of Range 88. As with SWAT, AGWA loops through features of the selected discretization and reads the model parameters from the parameterization look-up tables to write into the model input files.

12. Write the KINEROS input files using the design storm from the AGWA database by selecting *AGWA Tools > Simulation Options > KINEROS Options > Write KINEROS Input Files*.

#### 12.1. **Basic Info** tab:

- 12.1.1. **Select the discretization:** select [d2\d2k1](#)
- 12.1.2. **Select the parameterization:** select [p\\_r88pre](#)
- 12.1.3. **Select the precipitation file:** select [10yr1hr.pre](#)
- 12.1.4. **Select the multiplier file:** leave blank
- 12.1.5. **Select a name for the simulation:** enter [10yr1hr\\_pre](#)
- 12.1.6. Click **Write**. The form will automatically close once the file is written.



13. Repeat **Part 2, Step 12: Writing KINEROS input files** using the other two precipitation files as follows:

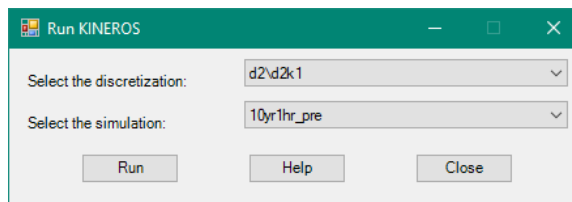
13.1. Use the NOAA design storm from the precipitation frequency data **precipfreq10y1h**, and name the simulation **pf10y1hpre**.

13.2. Use the September 18, 2014 rainfall event **20140918**, and name the simulation **20140918pre**.

### **Step 14 & 15: Executing the KINEROS2 model**

We will run the KINEROS2 model with the input files for the three rainfall events that you just created. Executing the KINEROS2 model opens a command window where the model is executed. By default, the command window stays open so that success or failure of the simulation can be verified.

14. Run the KINEROS2 model by selecting **AGWA Tools > Simulation Options > KINEROS Options > Execute KINEROS Model**.



14.1. **Select the discretization:** select **d2\d2k1**

14.2. **Select the simulation:** select **10yr1hr\_pre** (using the design storm database)

14.3. Click **Run**.

A command window will open and show the execution of KINEROS2 for the 10-year, 1-hour storm from the AGWA database file. The command window will stay open so that successful completion can be verified.

14.4. Press any key to continue.



```

C:\Windows\System32\cmd.exe
Processing CHANNEL      14
Event Volume Summary:
      Rainfall      38.10000 mm      16427.66 cu m
Plane infiltration    25.55025      11016.55
Channel infiltration   6.72572      2899.94
Interception          0.71342      307.61
Outflow               5.07572      2188.51

Error (Volume in - Volume out - Storage) < 1 percent
Time step was adjusted to meet Courant condition
Total watershed area = 43.11721 ha
Sediment yield = 230.0171 kg/ha
Sediment yield by particle class:
Particle size (mm)    0.250      0.033      0.004
Yield (kg/ha)        103.4879   60.2161   66.3131

Elapsed time (sec) 005
Press any key to continue . . .
    
```

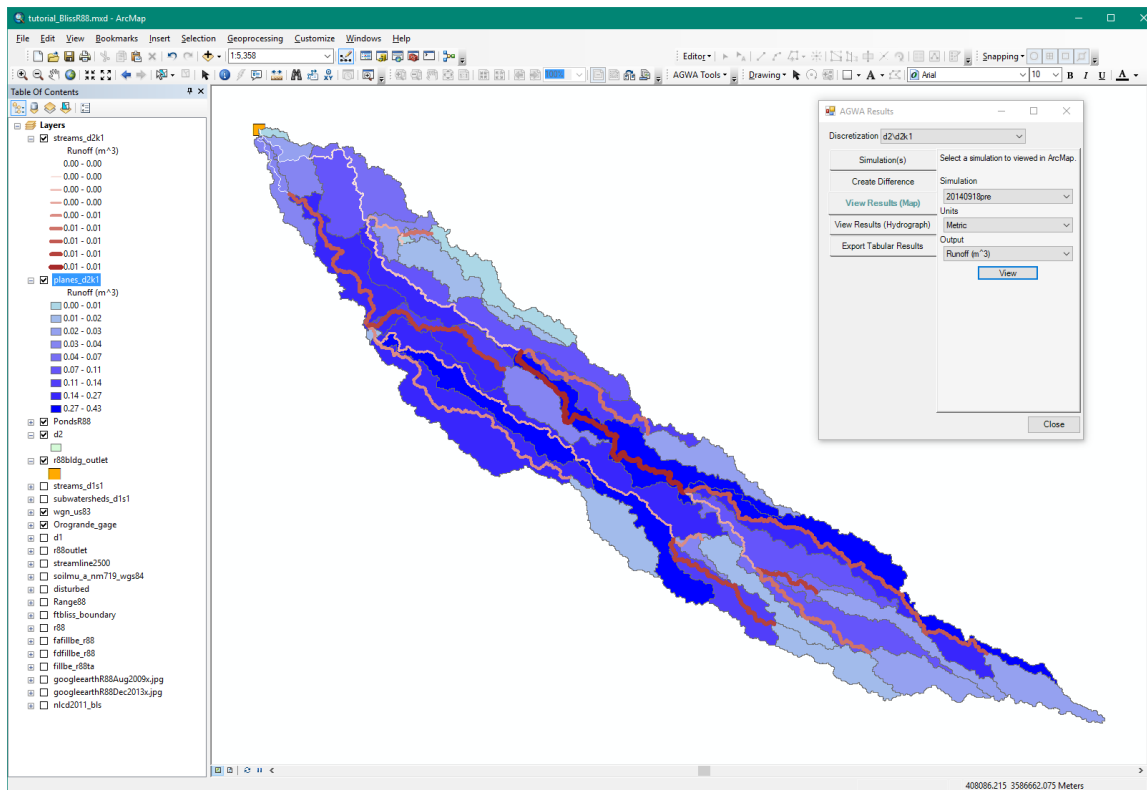
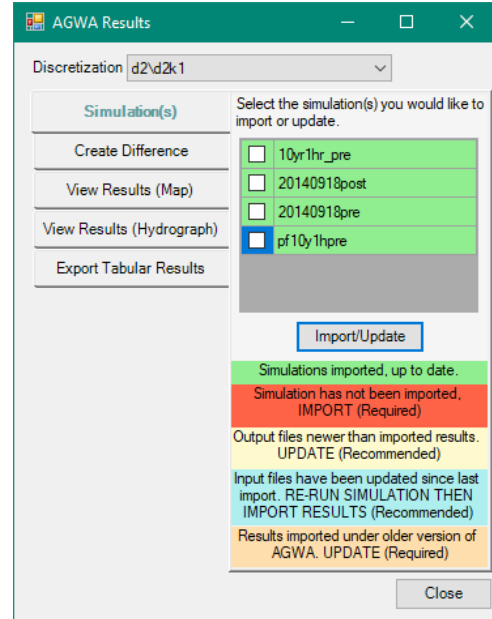
15. Repeat **Part 2, Step 14: Executing the KINEROS model** with the **pf10y1hpre** (from the precipitation frequency map), and with the **20140918pre** (from the actual storm event) simulation. Press any key to close the command window, and then **Close** the **Execute KINEROS Model** form.

**Step 16: Viewing the results**

Viewing the KINEROS2 results is identical to looking at SWAT results. After the KINEROS2 execution is complete, the KINEROS2 output files must be imported into AGWA before displaying the spatially distributed results, such as runoff, infiltration, and other water balance results. In addition to spatially distributed results, AGWA can also display hydrographs for the different discretization elements.

16. Import the KINEROS2 results from the three simulations by selecting **AGWA Tools > View Results > KINEROS Results > View KINEROS Results**.
  - 16.1. **Discretization**: select **d2\d2k1**
  - 16.2. **Simulation** tab:
    - 16.2.1. Check all boxes
    - 16.2.2. Click **Import/Update**. The check boxes will clear and the simulation boxes will turn green when the import is completed.
  - 16.3. Experiment with the results visualization by choosing different results to display.
    - 16.3.1. **View Results (Map)** tab

- 16.3.1.1. **Simulation:** select **10yr1hr\_pre**, **pf10y1hpre**, or **20140918pre**
- 16.3.1.2. **Units:** select **Metric**
- 16.3.1.3. **Output:** select **Runoff** ( $m^3$ )
- 16.3.1.4. Click **View**. The results for the **20140918pre** simulation with the **Runoff** ( $m^3$ ) output should look like the image below. View the results for the other simulations to see the differences across the watershed.



We have just simulated the watershed using land cover from *before* this area was developed for training uses. Next, we will simulate the watershed *after* development. To do this, we will first create a new land cover map in Part 4 to represent the mosaic of roads, facilities, bare ground, and vegetation that now exist in Range 88.

#### Part 4: Creating a new land cover map (optional)

In the previous step, we used the National Land Cover Dataset from 2011 to simulate pre-development conditions. However, this land cover dataset was created before Range 88 was developed for trainings and consequently does not accurately reflect the current land cover condition. While we can't easily create a new land cover map that shows the exact locations of the new roads and facilities, we can use the Land Cover Modification Tool in AGWA to create an approximation of that configuration. Therefore, before we continue with post-development analysis, we will create a new land cover map so that our parameterization is somewhat closer to actual conditions. If you don't have time to do this step, this land cover has already been created and you can add this layer from the gisdata folder ([nlcd2011\\_new1](#)), and skip ahead to Part 5.

When you performed the parameterization, AGWA defined the model input parameters for each hillslope and stream element based on topographic, land cover, and soils properties you specify. Model input parameters represent the physical properties of the watershed and are used to write the model input files; therefore, they are important for good modeling results.

#### Step 17. Using the Land Cover Modification Tool

17. Use the **Land Cover Modification Tool** to modify the *nlcd2011\_bls* land cover dataset so that it more closely reflects current land cover at Range 88. Select *AGWA Tools > Other Options > Land Cover Modification Tool*.

##### 17.1. *Input Land Cover* tab:

- 17.1.1. *Land cover raster*: select [nlcd2011\\_bls](#) (the pre-development land cover)
- 17.1.2. *Look-up table*: select [mrlc2001\\_lut](#)


##### 17.2. *Output Land Cover* tab:

- 17.2.1. *Output folder*: navigate to and select [C:\AGWA\workspace\tutorial\\_BlissR88\](#)
- 17.2.2. *New land cover name*: enter [nlcd2011\\_new](#)

##### 17.3. *Polygon Definition* tab:

- 17.3.1. *Polygon feature class*: select [disturbed](#) (to change the land cover within this polygon that represents the disturbed area)
- 17.3.2. *Create?* radiobuttons: select **No**

**NOTE:** The “[disturbed](#)” layer has already been created for you; however, if you have time you may create your own boundary of the disturbed area by selecting the **Yes** radio button, naming your new polygon shapefile, and using the tool to draw a polygon around the disturbed area. Save your polygon with a new name, such as [disturbed1](#), so it is not confused with the [disturbed](#) layer provided to you.

- 17.3.3. Select the **Select Features** tool  and drag a box around or intersect with the selected polygon feature class, [disturbed](#).

##### 17.4. *Modification Scenario* box:

17.4.1. **Random Distributions** tab: We will change the land cover within the disturbed polygon to approximate the current land cover of about 45% Barren Land (roads and parking areas) and 55% Scrub/Shrub, in a random pattern.

17.4.1.1. **Type 1:** Select **Barren Land** from the drop down menu

17.4.1.2. **%:** Enter **45**

17.4.1.3. **Type 2:** Select **Scrub/Shrub** from the drop down menu, for the vegetation.

17.4.1.4. **%:** Enter **55**

17.4.2. **Type of Distribution** box:

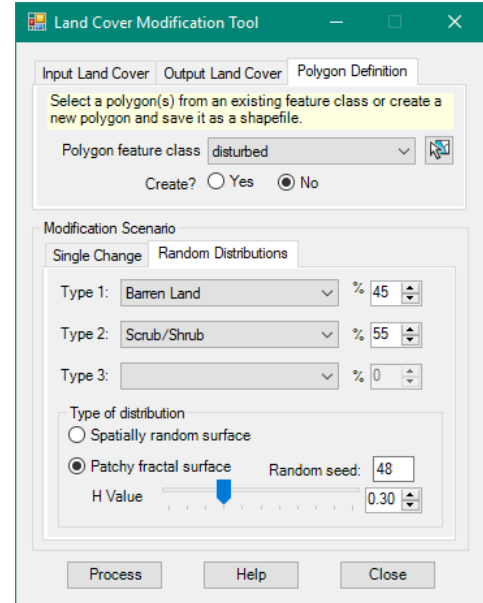
17.4.2.1. Select **Patchy fractal surface**

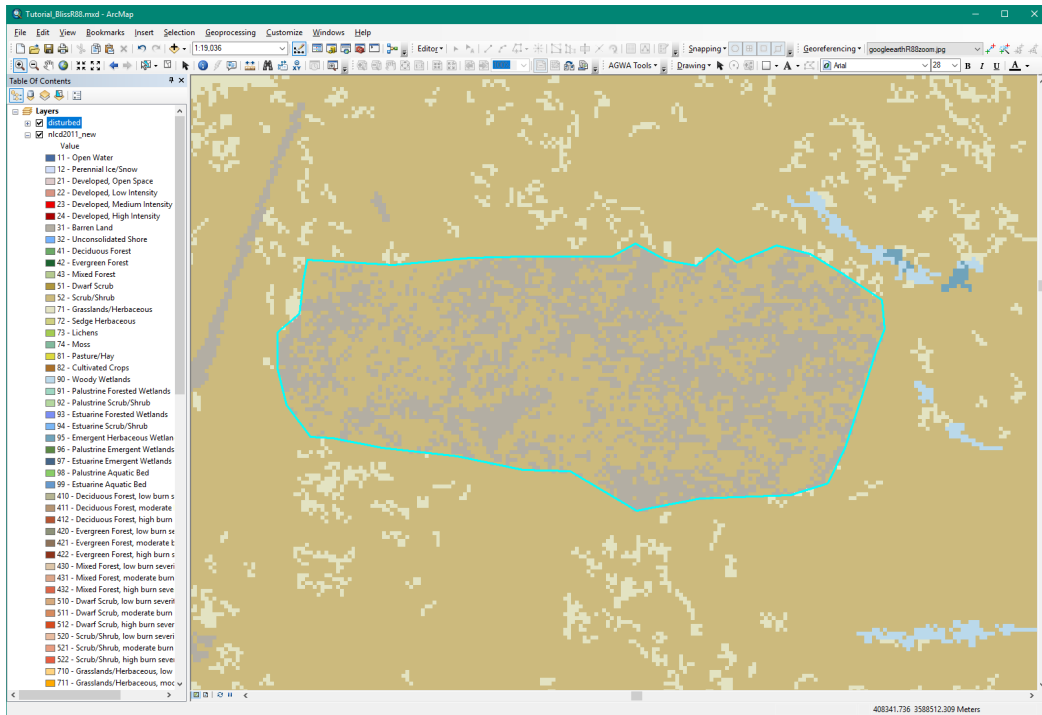
17.4.2.2. **Random seed:** Enter **48**

17.4.2.3. **H Value:** use the slider bar or enter **0.30**

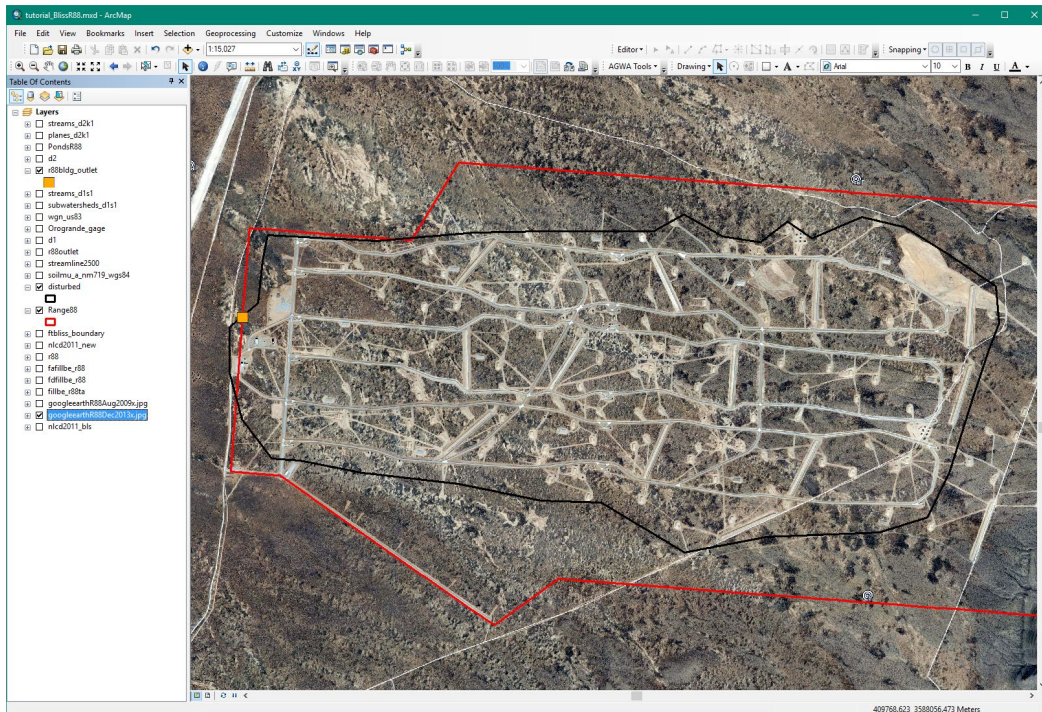
17.5. Click **Process**. Your new land cover layer, named **nlcd2011\_new**, should look similar to the image below after you have added the NLCD symbology. Notice that the two land cover types are arranged in a patchy distribution within the disturbed area, somewhat like but not exactly, like the current land cover configuration. If you have time, experiment with the random seed and H value to see how the patchy fractal algorithms change the arrangement of the barren land and scrub/shrub pixels. Higher H values produce a more clumped pattern.

17.6. Save the map document and continue.





New land cover [nlcd2011\\_new](#) showing a patchy fractal arrangement of Barren Land (gray) and Scrub/Shrub (tan) pixels. Compare this image to the December 2013 basemap below to see how the Barren Land (gray) areas very roughly approximate the roads and building locations.



December 2013 GoogleEarth basemap showing the arrangement of roads and facilities in the disturbed area in Range 88.



## Part 5: Modeling Post-development Runoff Using KINEROS2

In Part 3, we used KINEROS2 to simulate a small watershed draining the western end of Range 88 before it was developed for training, where flooding occurred from the September 2014 storm event. In this part, we will simulate the same area after development, using the new land cover layer we just created in Part 4. Since we will only be changing the land cover we can use the watershed delineation and discretization we already created, and go directly to the parameterization to create a new parameterization using the new land cover. Note that we are still using the 2006 LiDAR DEM that does not include the new roads and leveled or graded areas; therefore our simulation results will only represent land cover change. More current LiDAR and accurate land cover data are required for more realistic simulations.

### Step 18: Parameterizing the watershed

18. Perform the element, land cover, and soils parameterization of the watershed by selecting **AGWA Tools > Parameterization Options > Parameterize**.

- 18.1. **Input** box

- 18.1.1. **Discretization**: select **d2\d2k1**
- 18.1.2. **Parameterization Name**: enter **p\_r88post** (post-development)

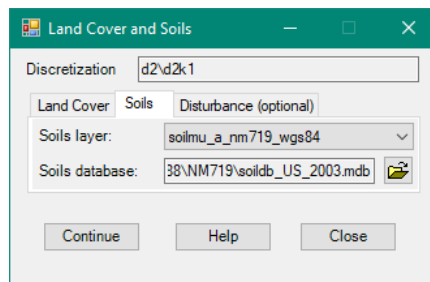
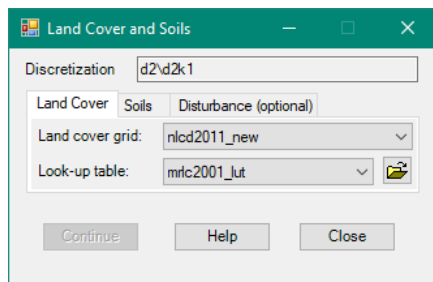
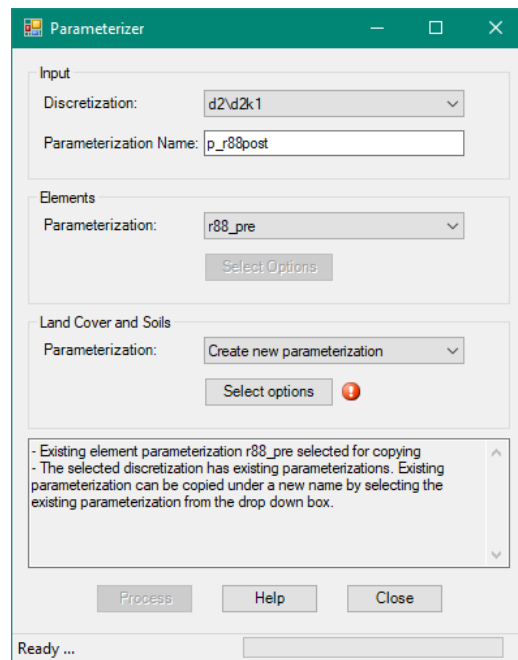
- 18.2. **Elements** box

- 18.2.1. **Parameterization**: **r88\_pre**  
 Since we are only changing the land cover, we can use the element parameterization from the previous part.

- 18.3. Return to the **Land Cover and Soils** box of the **Parameterizer** form

- 18.3.1. **Parameterization**: select **Create new parameterization**
- 18.3.2. Click **Select Options**. The **Land Cover and Soils** form opens.

- 18.4. In the **Land Cover and Soils** form



- 18.4.1. **Land Cover** tab

- 18.4.1.1. **Land cover raster**: select **nlcd2011\_new** (the new land cover)
- 18.4.1.2. **Look-up table**: select **mrlc2001\_lut**

18.4.2. **Soils** tab

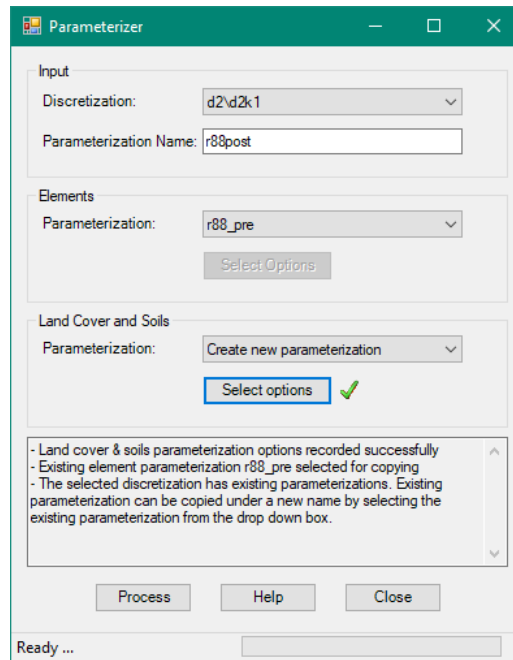
18.4.2.1. **Soils layer**: select **soilmu\_a\_nm719\_wgs84**

18.4.2.2. **Soils database**: Browse to the

**C:\AGWA\gisdata\tutorial\_BlissR88\NM719\** folder and select **soildb\_US\_2003.mdb**

18.5. Click **Continue**. You will be returned to the **Parameterizer** form where the **Process** button will now be enabled.

In the **Parameterizer** form, click **Process**. Close the form when parameterization is complete.



**Step 19: Writing KINEROS input files**

We will write the input files for KINEROS2 using the September 18, 2014 rainfall event and the post-development parameterization so we can compare pre and post development. You may experiment with the other rainfall events on your own.

19. Write the KINEROS input files by selecting **AGWA Tools > Simulation Options > KINEROS Options > Write KINEROS Input Files**.

**Basic Info** tab:

19.1. **Select the discretization**: select **d2\d2k1**

19.2. **Select the parameterization**: select **r88post**

19.3. **Select the precipitation file**: select **20140918.pre**

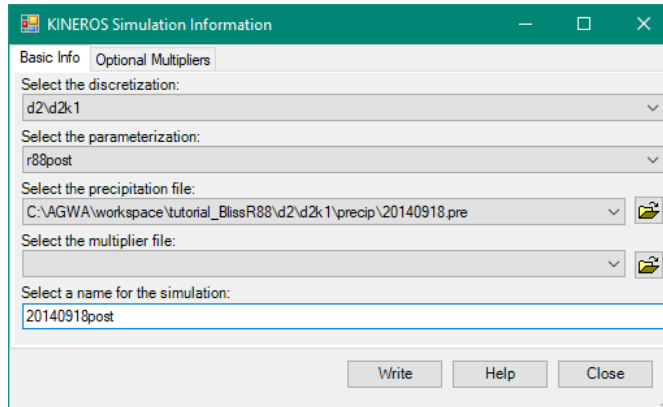
19.4. **Select the multiplier file**: leave blank

19.5. **Select a name for the simulation**: enter **20140918post**

19.6. Click **Write**. The form will automatically close once the file is written.



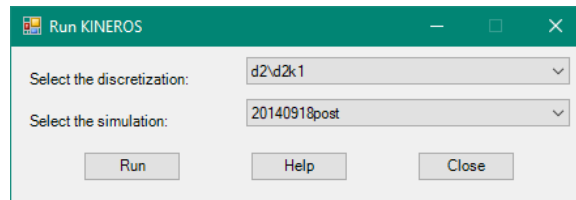
19.7. If you have time, repeat the above steps using the other two precipitation files, and name the simulations **10yr1hr\_post**, and **pf10y1hpost**.



### **Step 20: Executing the KINEROS2 model**

We will run the KINEROS2 model with the September 18, 2014 storm event with the post-development parameterization.

20. Run the KINEROS2 model by selecting **AGWA Tools > Simulation Options > KINEROS Options > Execute KINEROS Model**.
  - 20.1. **Select the discretization:** select **d2\d2k1**
  - 20.2. **Select the simulation:** select **20140918post**
  - 20.3. Click **Run**.



A command window will open, showing the execution of KINEROS2 for the storm, and stay open so that successful completion can be verified.

- 20.4. Press any key to continue.
- 20.5. Close the **Run KINEROS** form.
- 20.6. If you have time, repeat the above steps for the **10yr1hr\_post**, and **pf10y1hpost** simulations.

```

C:\Windows\System32\cmd.exe

Processing CHANNEL      14

Event Volume Summary:

      Rainfall      58.17000 mm      25081.28 cu m
Plane infiltration    57.03904      24593.64
Channel infiltration   0.57977      249.98
Interception          0.45093      194.43
Outflow               0.06747      29.09

Error (Volume in - Volume out - Storage) < 1 percent

Time step was adjusted to meet Courant condition

Time step is too large: element hydrographs are not well-represented!

Total watershed area = 43.11721 ha

Sediment yield = 1.620018 kg/ha

Sediment yield by particle class:

Particle size (mm)    0.250      0.033      0.004
Yield (kg/ha)        0.105928   0.416972   1.097118

Elapsed time (sec) 013
Press any key to continue . . .
    
```

### Part 6: Comparing pre- and post-development results

In this part, we will compare the KINEROS2 results for the pre- and post-development simulations, using the September 18, 2014 storm event. If you have time, you can repeat these steps for the other two precipitation events.

21. Import the KINEROS2 results from the two simulations by selecting *AGWA Tools > View Results > KINEROS Results > View KINEROS Results*.

21.1. *Discretization*: select **d2\d2k1**

21.2. *Simulation* tab:

21.2.1. Check all red boxes.

21.2.2. Click **Import/Update**. The check boxes will clear and the simulation boxes will turn green when the import is completed.

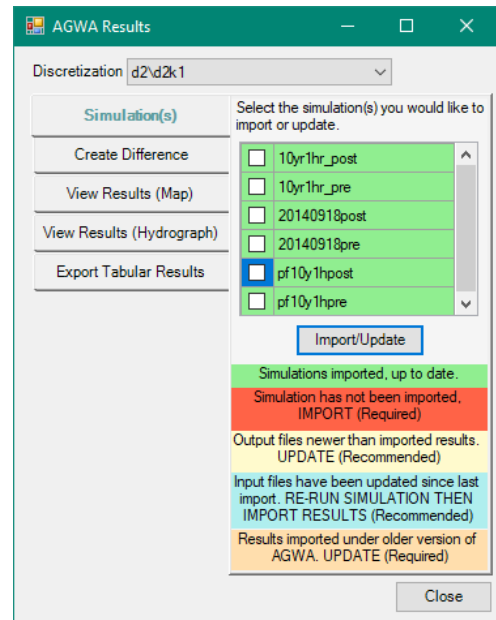
21.3. Click the **Create Difference** tab to create the difference between the pre- and post-development simulations, and experiment with the results visualization by choosing different results to display.

21.3.1. *Base Simulation*: select **20140918pre**

21.3.2. *Alternative Simulation*: select **20140918post**

21.3.3. *Change Type*: select **Percent**

21.3.4. *New Name*: enter **20140918post-pre\_pct**



21.3.5. Click **Create**. The percent difference has been created when the input boxes are cleared.

21.4. **View Results (Map)** tab

21.4.1. **Simulation:** select **20140918post-pre\_pct**

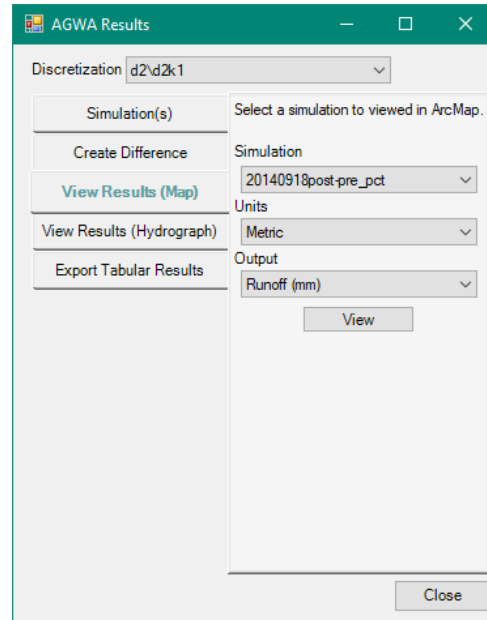
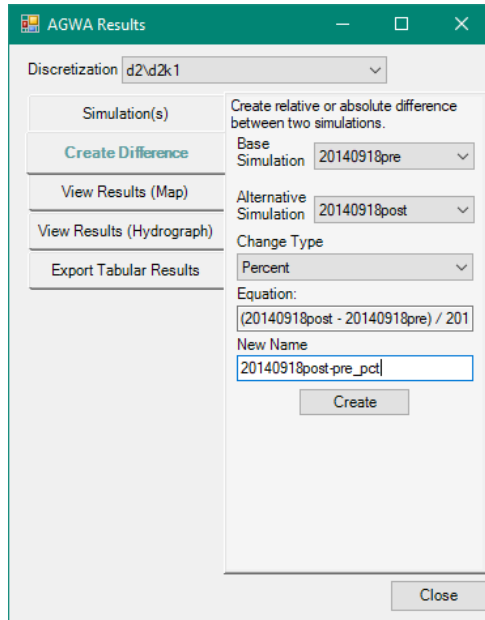
21.4.2. **Units:** select **Metric**

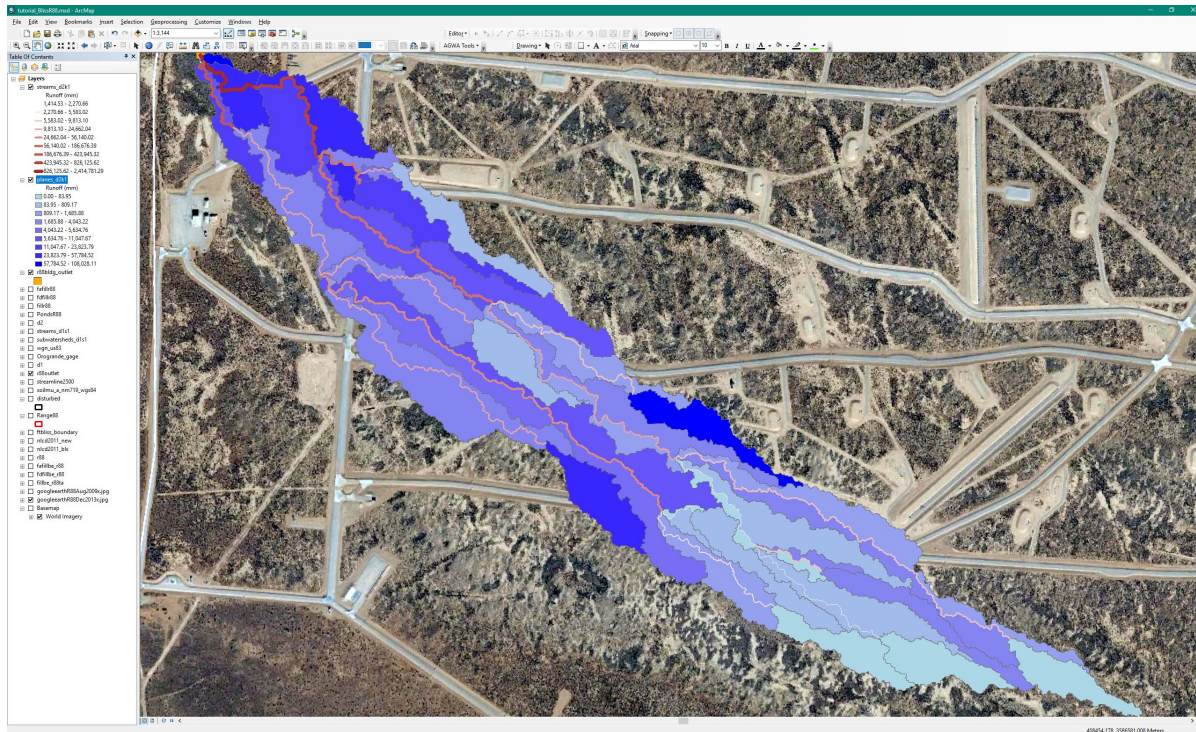
21.4.3. **Output:** select **Runoff (mm)**

21.4.4. Click **View**. The results for the **20140918post-pre\_pct** simulation with the **Runoff (mm)** output should look like the image below. The plane and stream elements show the percent change in runoff due to the new roads, activities, and facilities at Range 88. Darker colors and thicker lines indicate greater change.

21.4.5. Experiment with viewing other outputs. Click on the stream reaches upstream from the new detention basins to view runoff and peak flow at that point. Will these basins perform as expected under different precipitation events?

21.5. Leave the ArcMap project open so you can export the simulation results to the Facilitator DSS using the AGWA-Facilitator Export Tool, presented in the next section of this document.





### **Interpreting the results:**

When AGWA displays the results from a relative change analysis darker colors and thicker lines will indicate greater change. It is useful to look at where greater changes occur in relation to roads, urbanization, topography, and land cover. Use the Identify Tool in ArcMap to query stream reaches or planes at locations of interest to view the model outputs at those locations. These results can provide an understanding of where areas at risk of increased erosion or flooding due to land cover change from military training activities, road building, or new facilities and buildings may occur.

### **Follow-up discussion**

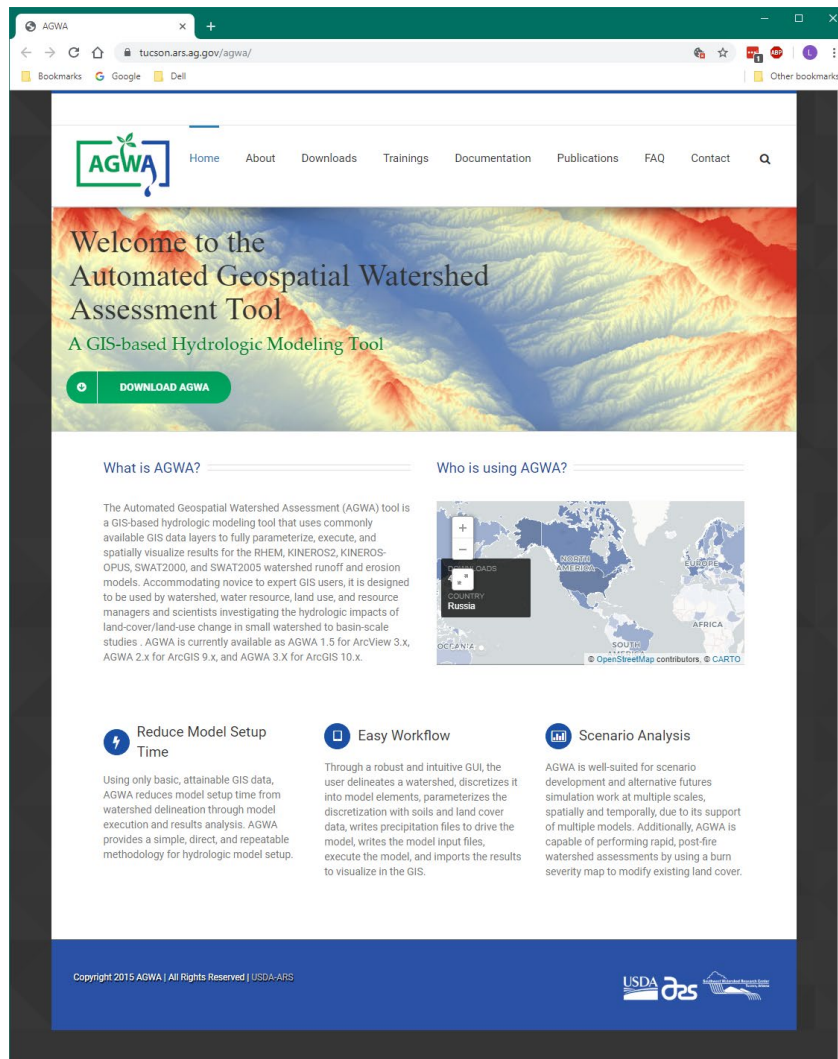
This AGWA Tool Guidance Document demonstrated how to perform a watershed based analysis using the SWAT and KINEROS2 hydrologic models in AGWA. In addition, it showed how to create precipitation files for both models using the various methods available within AGWA. Although the example used here was for the Fort Bliss Army Base, Texas, the methods and techniques can be applied to any location or land cover change scenario. In this example, the Land Cover Modification Tool was used to illustrate how land cover change from military training activities affects local hydrology at Range 88 at Fort Bliss. The AGWA-Facilitator Export Tool will be used next to export the peak flow and sediment yield results to a Facilitator input file for decision support.

Note that this example analysis was limited to just land cover change, and did not modify the soil properties or topography, which would be required to provide a more realistic result. Applying the AGWA Military Disturbance Tool that modifies soil and land surface roughness properties



based on the disturbance level could improve these results. In addition, a more current DEM (i.e. LiDAR) that includes road culverts, other water control structures, and current topography, and a more current land cover map, are recommended for more realistic modeling. The Land Cover Modification Tool can be applied to any land cover change scenario, including revegetation efforts, fire effects, urbanization, grazing impacts, and so on, while the Military Disturbance Tool is intended to be applied to effects from military maneuvers.

Additional tutorials that demonstrate other tools available in AGWA can be found on the AGWA website (<https://www.tucson.ars.ag.gov/agwa>) in the Downloads section. These tutorials, with their datasets, include guidance on using the Burn Severity Tool for analysis of fire impacts, using the Storage Tool to evaluate constructed ponds for flood and sediment control in a watershed, and data preparation for use in AGWA. Free AGWA trainings in Tucson, Arizona, are available during the year that include additional tutorials demonstrating AGWA’s other capabilities, such as the Urban Tool for evaluating best management practices like rainwater harvesting, rain gardens, or buffer strips. The Trainings section of the AGWA website provides the current schedule and a sign up option for notifications of free training opportunities.



## AGWA Glossary and Acronyms

For more complete descriptions of these and other terms, see the AGWA Documentation at <https://www.tucson.ars.ag.gov/agwa/>

AOI, Area of Interest – a polygon representing the study location

Channel initiation points – one of the options for the Stream Definition Methodology during discretization, requires a point theme that is used to define the starting point of channels for a point of interest such as a stream gage

Channel Type - The *Default* Channel Type, unless edited, is equivalent to the *Natural* channel type, which reflects a sandy channel bottom with high infiltration and a winding but clean channel with roughness set to 0.035 Manning's n. The *Developed* channel type reflects a concrete channel with zero infiltrability, very low roughness set to 0.010 Manning's n, and fraction of channel armored against erosion equal to 1.

CSA, Contributing or Channel Source Area - a threshold value that defines first order channel initiation, or the upland area required for channelized flow to begin, as a percent of the watershed area or as an area (acres or hectares), determines the complexity of the watershed discretization. Smaller CSA values result in a more complex watershed, and larger CSA values result in a less complex watershed. The default CSA in AGWA is set to 2.5% of the total watershed area. Enforcing the CSA will cause all subwatersheds to be approximately the same area as the upland areas.

DEM, Digital Elevation Model – a raster where the value of each cell represents an elevation. Used in AGWA to determine the topography for routing surface flow in the hydrologic models; can be a USGS 10m or 30m raster, or LiDAR data

Discretization – The process of subdividing the watershed into smaller elements to capture the variability in topography, soils, and land cover, within the landscape. The discretization process creates a subwatersheds layer with the name subwatersheds\_d1s1 (for SWAT; different models have different prefixes- planes for KINEROS2, rhem for RHEM, and swat2005 for SWAT2005) and a streams layer named streams\_d1s1. In AGWA, discretizations are referred to with their geodatabase name as a prefix followed by the discretization name given in the Discretizer form, e.g. d1\d1s1.

Elements – the planes or stream channels in the watershed discretization

FA, Flow Accumulation – a raster where the value of each cell represents the total of all cells flowing into it, based on the Flow Direction raster. Used in AGWA to identify watershed features such as the outlet.

FD, Flow Direction – a raster where the value of each cell represents the direction of surface flow, based on the digital elevation model (DEM). There are 8 flow directions: N, NE, E, SE, S, SW, W, and NW. Used in AGWA to create the flow accumulation raster.

Fill – a process used to create a hydrologically correct surface by locating and filling sinks or low areas. A sink is a cell or set of spatially connected cells whose flow direction cannot be assigned one of the eight valid values in a flow direction raster, such as when all

neighboring cells are higher than the processing cell or when two cells flow into each other, creating a two-cell loop.)

Flow length options - Flow length is the length of the path from a source to a channel, as indicated by flow direction. AGWA offers two methods for calculating flow length of lateral planes in KINEROS. The default method assumes a geometric abstraction, where the plane is considered a rectangle with a length equal to the channel length of the associated stream and the width (or flow length) equal to the plane area divided by the channel length. The second method calculates the mean flow length of the plane element.

Hydraulic Geometry relationships, HGR – defines bankfull channel width and depth based on watershed size, for very specific physiographic regions. AGWA uses the HGR as part of the watershed parameterization. There are three channel types available: Default, Natural, and Developed. The **Default** Option, unless edited, is equivalent to the *Walnut Gulch Watershed, AZ* relationship.

Internal Pour Points Methodology – a part of the watershed discretization that incorporates important hydrologic features into the watershed representation, such as erosion control dams or stream gages to further subdivide the the watershed and split elements and channels. The user may use an existing point theme or can select a point in the map. Options are: 1) Default, pour points are determined by the discretizer; 2) Default, Enforce CSA, element sizes are equal to or less than the CSA threshold; 3) User-defined, pour points are added manually by clicking on the map; and 4) Point Theme, use an existing point theme to select pour points.

lc\_lut, land cover look up table - a dbf containing the land cover types available to determine percent land cover, interception, surface roughness, percent impervious surface, and hydrologic soil group. These tables are used in the AGWA parameterization.

NLCD, National Land Cover Dataset - Landsat-based, 30-meter resolution, land cover database for the Nation. NLCD provides spatial reference and descriptive data for characteristics of the land surface such as thematic class (for example, urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover. Available from <https://www.mrlc.gov/index.php>. Used in AGWA to identify the land cover type for each watershed element for the look up table.

Slope options – AGWA can model hillslopes as a uniform or a complex slope (important for erosion, best used with LiDAR)

Stream Definition Methodology - defines at which point flow becomes channelized. The three options for stream definition are Threshold-based, Existing stream network, and Channel initiation points.

Threshold-based – One of the options in AGWA for the stream definition methodology during discretization. Represents the number of cells at which point flow becomes channelized. May be based on CSA (acres, hectares or flow accumulation), or on flow length.

Workspace – a folder in the AGWA directory that contains project geodatabases



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## SECTION 2: AGWA-FACILITATOR EXPORT TOOL

AGWA is linked to the Facilitator Decision Support Tool via the AGWA-Facilitator Export Tool. This tool in AGWA allows the transfer of AGWA model results, decision maker experience, and expert opinion to construct a Facilitator decision analysis document. This includes the results for peak flow and sediment yield from the AGWA simulations. Start this section where the previous section ended, with the ArcMap project open.

### Step 1: Opening an existing Facilitator DSS file

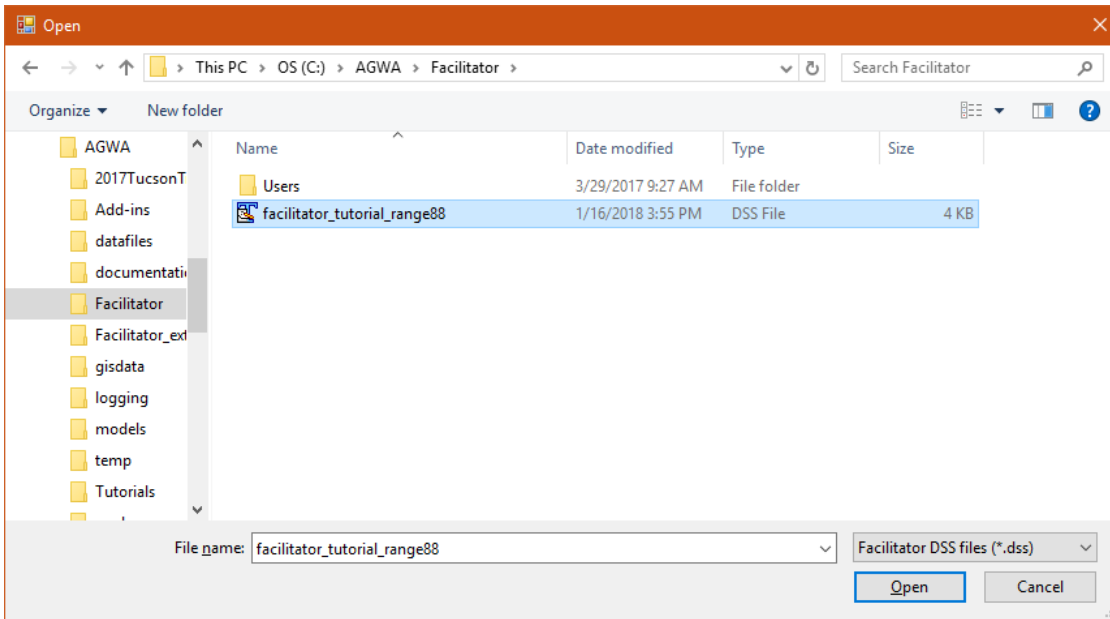
22. Open the *AGWA-Facilitator Export Tool* by selecting *AGWA Tools > Other Options > AGWA-Facilitator Export Tool*.

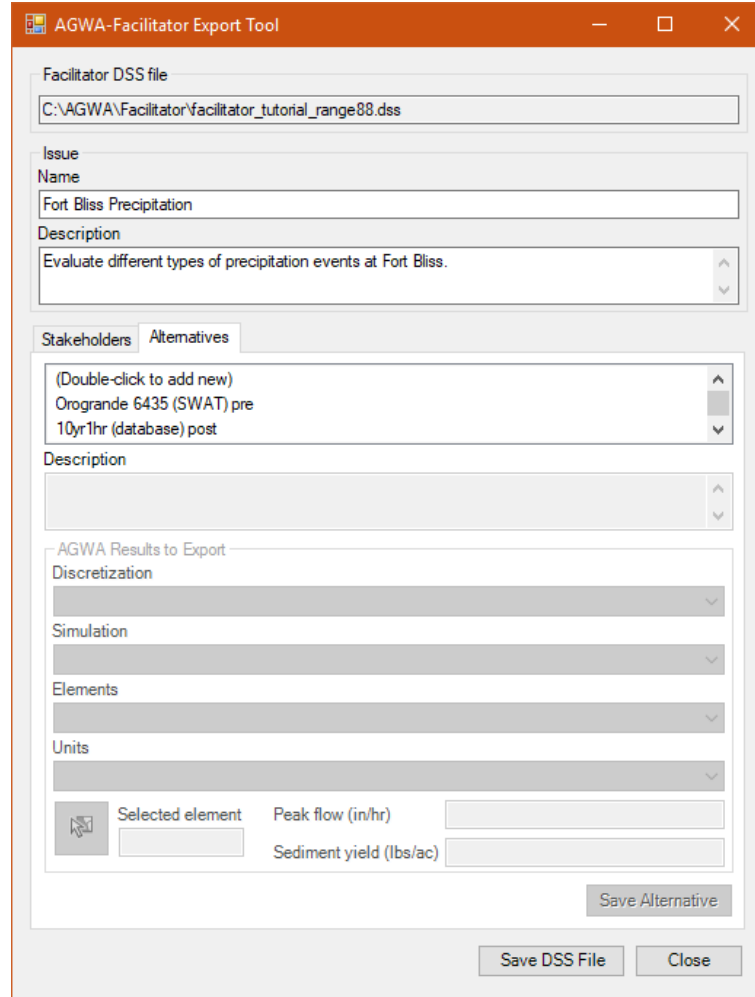
22.1. Open an existing DSS file by first clicking the *Open* button at the top of the form.

22.2. Navigate to and open: [C:\AGWA\Facilitator\facilitator\\_tutorial\\_rang88.dss](#).

This file already includes the Issue Name and Description, the Alternatives (the precipitation events), and Stakeholders, and those boxes will be automatically populated. The results from the AGWA KINEROS2 simulations for each precipitation event will now be added as Alternatives. Notice that there is an

Alternative for the SWAT precipitation simulation; we will add that information manually in the Facilitator (the next Tutorial).





## Step 2: Adding AGWA KINEROS2 Results for the 10yr 1hr database Alternative

23. Select **10yr1hr (database) post** from the selection box in the *Alternatives* tab. This is the alternative representing the precipitation event created from the AGWA database, for the post-development condition at Range 88.

23.1. The *Description* box in the Alternatives tab will be automatically populated when you select an alternative.

23.2. *AGWA Results to Export* box:

23.2.1. *Discretization*: select **d2/d2k1**


23.2.2. *Simulation*: select **10yr1hr\_post**

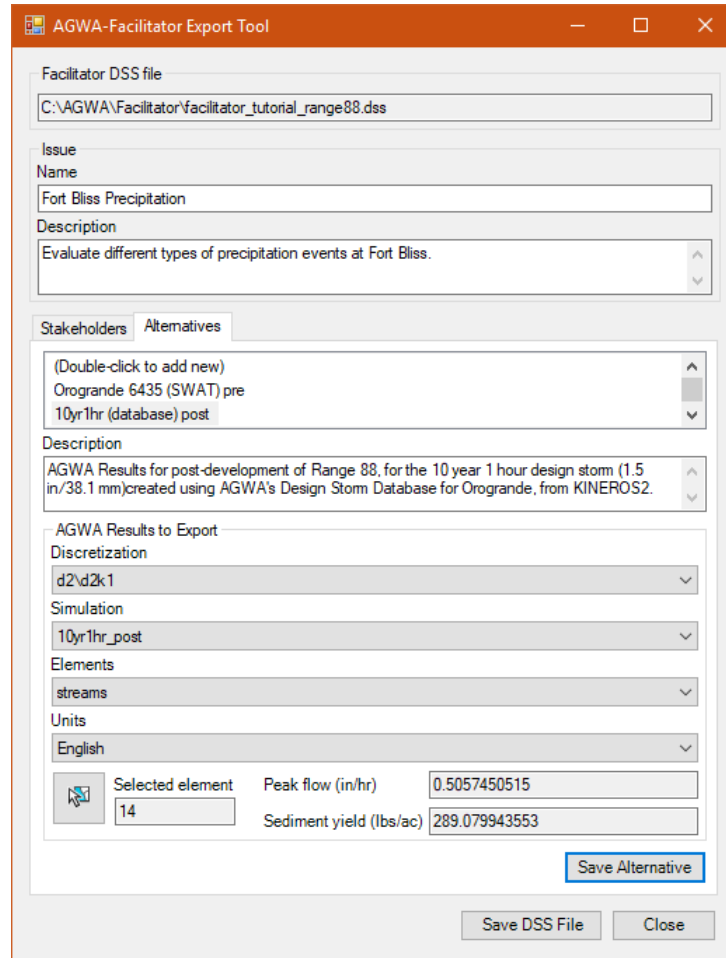
23.2.3. *Elements*: select **streams**

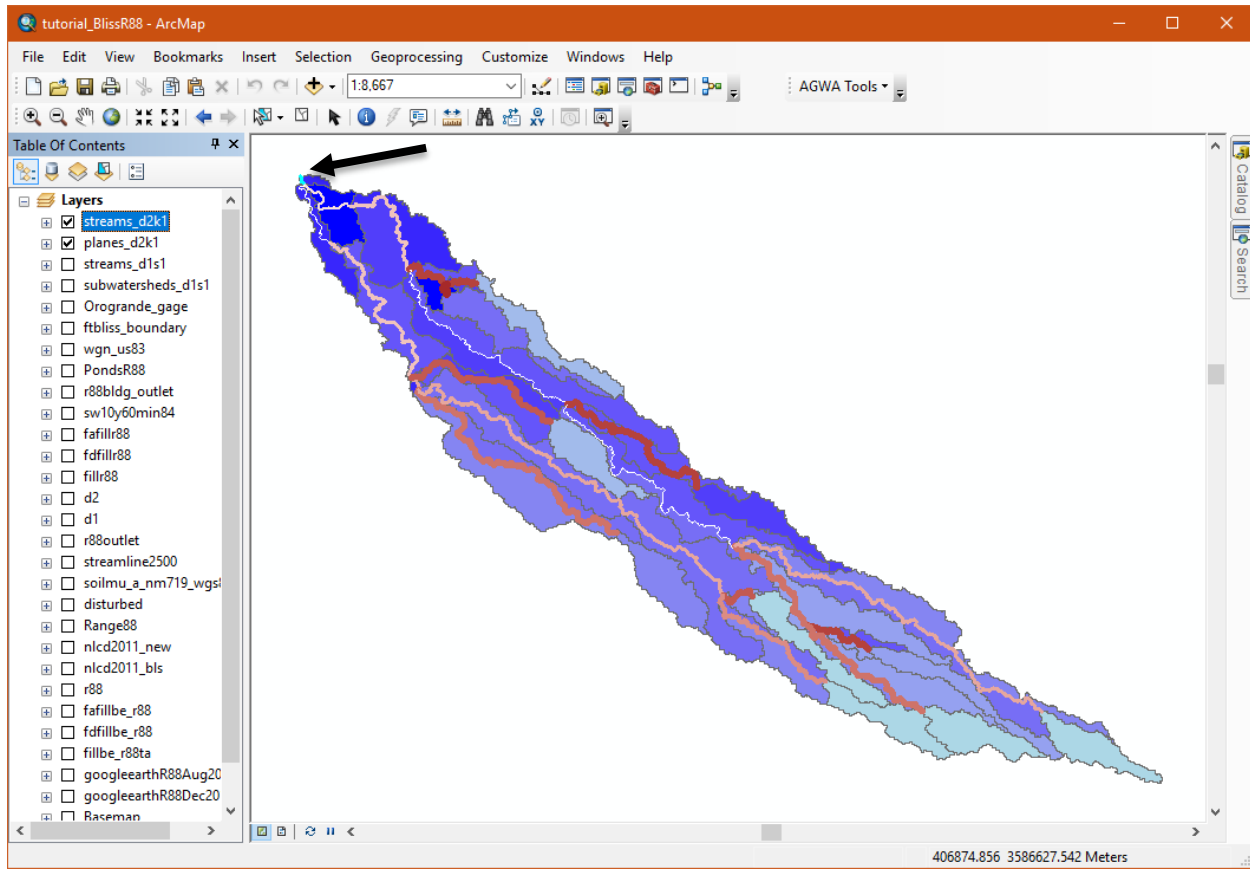
23.2.4. *Units*: select **English**

23.2.5. Select the stream segment at the outlet of the watershed:

23.2.5.1. Click and drag the *streams\_d2k1* layer to the top of the Table Of Contents so the stream can be located.

- 23.2.5.2. Click the **Select Features** tool  to select stream segment 14 at the watershed outlet. See the figure below. Select the Units again to see the peak flow and sediment yield results in the form if they don't automatically appear.
- 23.2.6. Click the **Save Alternative** button. Do not click **Save DSS File** yet!





### Step 3: Adding AGWA KINEROS2 Results for the Precipitation Frequency Alternative

Repeat the above steps to add the AGWA simulation results for the **PrecipFreq 10y1h post** alternative.

24. Select **PrecipFreq 10y1h post** from the selection box in the *Alternatives* tab. Read the description.

24.1. The *Description* box in the Alternatives tab will be automatically updated.

24.2. *AGWA Results to Export* box:

24.2.1. *Discretization*: select **d2/d2k1**

24.2.2. *Simulation*: select **pf10y1hpost**

24.2.3. *Elements*: select **streams**

24.2.4. *Units*: select **English**

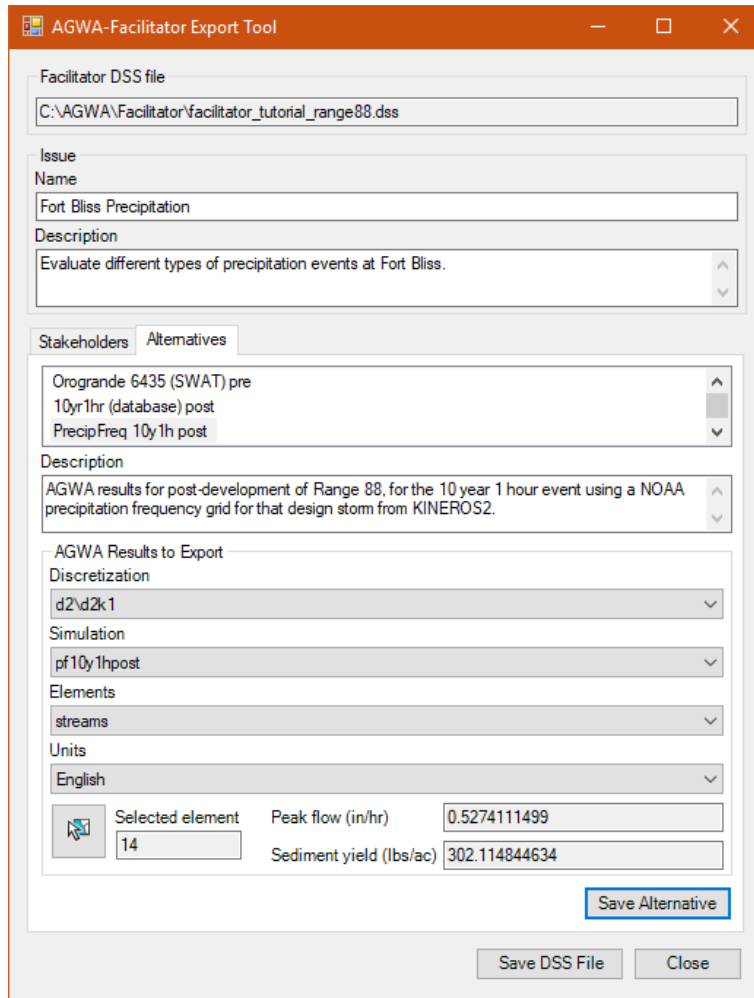
24.2.5. Select the same stream segment at the outlet of the watershed, as you did in the previous step:

24.2.5.1. Click and drag the *streams\_d2k1* layer to the top of the Table of Contents if it is not already there.

24.2.5.2. Click the *Select Features* tool  to select stream segment 14. See the figure above.

Click the *Save Alternative* button. Do not click *Save DSS File* yet!





#### Step 4: Adding AGWA KINEROS2 Results for the 20140918 post Alternative

Repeat the above steps to add the AGWA simulation results for the Sept. 9, 2014 storm post-development of Range 88.

25. Select **20140918 post** from the selection box in the *Alternatives* tab.

25.1. The *Description* box in the Alternatives tab will be automatically updated.

25.2. *AGWA Results to Export* box:

25.2.1. *Discretization*: select **d2\d2k1**


25.2.2. *Simulation*: select **20140918post**

25.2.3. *Elements*: select **streams**

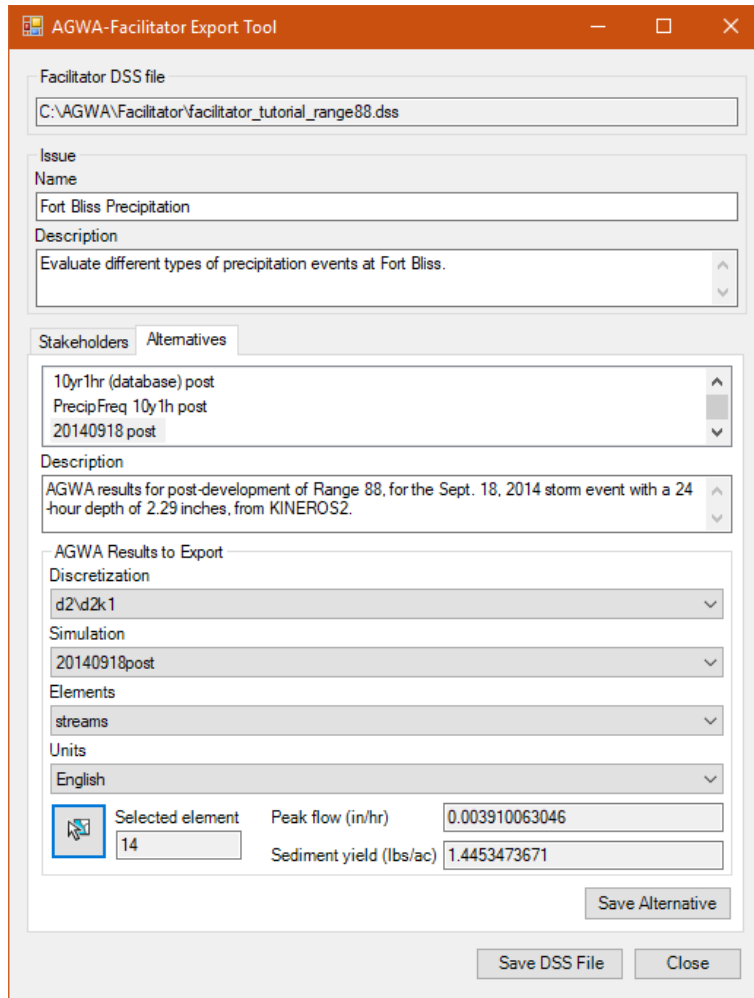
25.2.4. *Units*: select **English**

25.2.5. Select the stream segment at the outlet of the watershed, as you did previously:

25.2.5.1. Click and drag the *streams\_d2k1* layer to the top of the Table of Contents if it is not visible.


25.2.5.2. Click the *Select Features* tool  to select stream segment 14.

25.2.6. Click the *Save Alternative* button. Do not click *Save DSS File* yet!



### Step 5: Adding AGWA KINEROS2 Results for the 20140918 pre Alternative

Repeat the above steps to add the AGWA simulation results for the Sept. 9, 2014 storm pre-development of Range 88. This will enable us to view the results pre- and post-development in the Facilitator report.

26. Select **20140918 pre** from the selection box in the *Alternatives* tab.
  - 26.1. The *Description* box in the Alternatives tab will be automatically updated.
  - 26.2. *AGWA Results to Export* box:
    - 26.2.1. *Discretization*: select **d2\d2k1**
    - 26.2.2. *Simulation*: select **20140918pre**
    - 26.2.3. *Elements*: select **streams**
    - 26.2.4. *Units*: select **English**
    - 26.2.5. Select the stream segment at the outlet of the watershed, as you did previously:
      - 26.2.5.1. Click and drag the *streams\_d2k1* layer to the top of the Table of Contents if it is not already there.
      - 26.2.5.2. Click the *Select Features* tool  to select stream segment 14.

26.2.6. Click the *Save Alternative* button.

**Step 6: Saving the Facilitator DSS file**

27. Click the *Save DSS File* button

27.1. Click *OK*, close the form, and continue to the analysis with the Facilitator DSS.

### **SECTION 3: FACILITATOR DECISION SUPPORT SYSTEM**

The Facilitator software helps individuals and groups of people in making decisions.

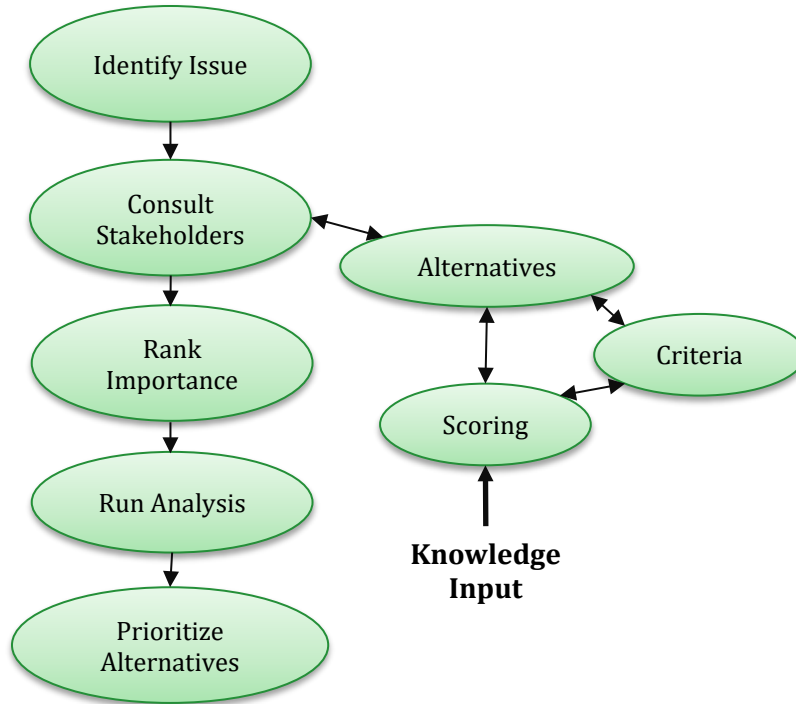
One of the original intents in writing the software was to help facilitate group decision making and problem solving in natural resource management. A requirement in the group decision making process was to appoint or provide a *facilitator*, hence the name for the software.

A couple of the fascinating aspects of this software are the way in which it channels groups toward working out what are the real issues at hand and the way in which it brings groups of people into a common problem mind-share.

The Facilitator software uses decision rules, a hierarchical system for ranking criteria, score functions, and linear programming (for terminology definitions, see Appendix A) to identify a preferred management option consistent with the technical information relating alternatives to their effects and the users' ranking of the decision criteria. Assigning an importance order to the decision criteria overcomes in part the difficult task of assigning individual weights to each criterion. The matrix framework of management options and decision criteria is generic and open, encouraging participation by all stakeholders, and can accommodate measured data, simulation model results, and expert opinions in the decision making process. The results can be viewed in one of two formats: bar or polar. Results in the bar format are displayed as horizontal bars with best and worst composite scores; the length of the bars representing the sensitivity of the resource management option to the individual ordering of the criteria. The polar format highlights and groups differences between best and worst composite scores. "What if" scenarios can be generated by reordering the decision criteria, selecting a different score function or by including additional options and criteria. The entire process can be exported to HTML, allowing scenarios to be viewed from anywhere on the web.

#### **The Decision-Making Process: What is Multi-Criteria Analysis?**

Making a decision can be complicated. There can be many factors to take into account and there may be different people involved with various views of what is important. Multi-criteria analysis (MCA) is a technique that has been developed to help with this situation. It involves working out what your choices are, and identifying factors that should be considered in the process. There are tools that can then help in analyzing which of your alternatives (to solve an issue) might be better and which are less promising. The Facilitator is one of these tools. The Facilitator is a computer-based system, which can be used with a group while they work through a decision. It captures the information and issues as they arise, and helps to show the relative merits of the alternatives. A simplified workflow for the Facilitator is shown in Figure 1.



**Figure 18. Workflow used by Facilitator for a multi-objective decision support session**

### Facilitator Installation

The *Facilitator* software was written to run on any platform which supports the Java runtime environment (Java is a programming language and environment which allows code to run on multiple platforms).

If you do not have a Java runtime environment installed on your machine, you will need to install one before you can use the *Facilitator* software. To get the Java runtime environment for your platform, visit <https://www.java.com/en/download/>

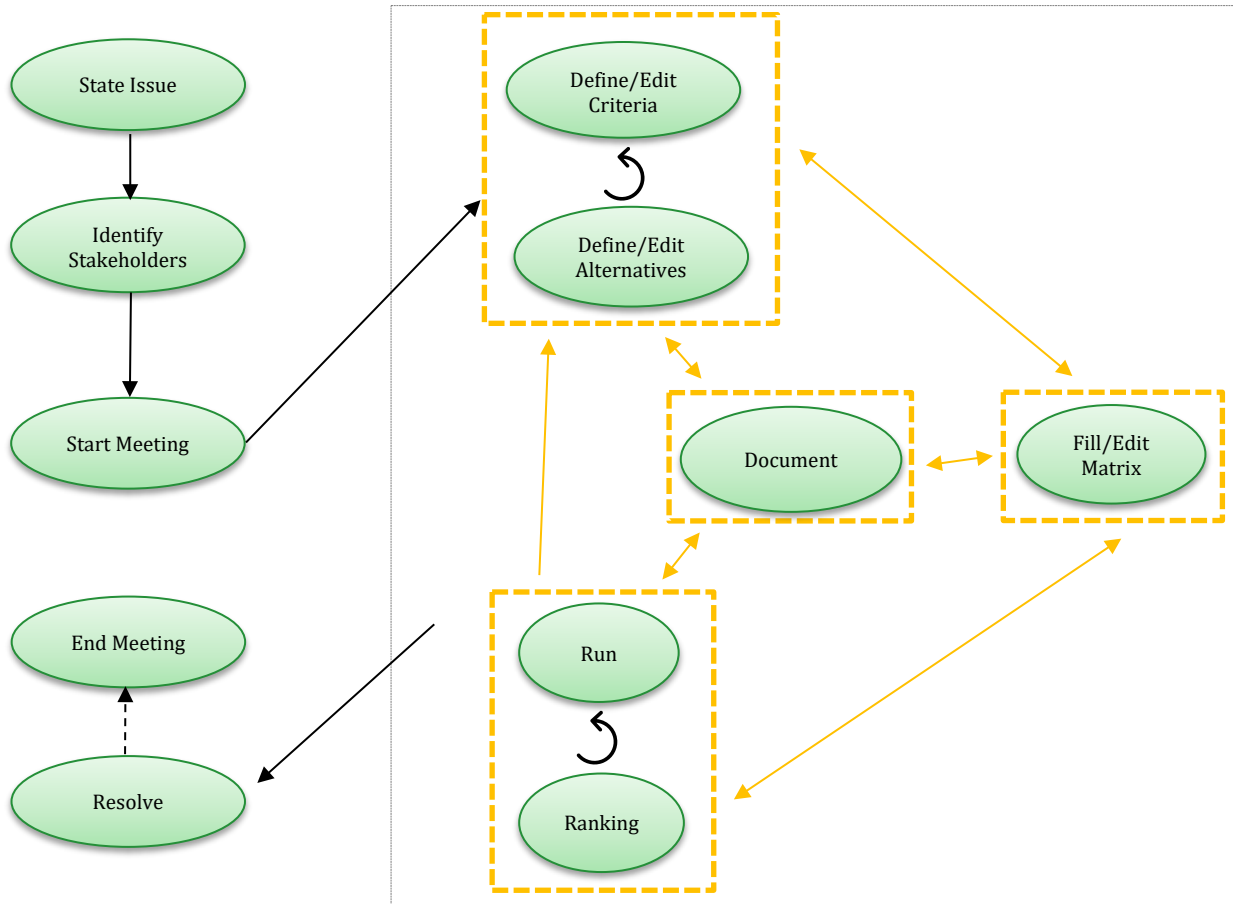
The Facilitator software can be downloaded from <https://sourceforge.net/projects/facilitator/>.

After downloading and installing Java, the Facilitator software can be run by clicking on the .jar file.

### Getting Started

There is no specific recipe for using the Facilitator software except that you should use it in a way which makes sense for your decision making process(es). Having said that, there are a number of stages you will tend to go through in a particular *analysis*.

The following diagram captures the stages in using this software. This diagram was drawn up in the early stages of requirements analysis, which is still quite relevant today.



### 3 Major Stages

The 3 major stages to run a Facilitator analysis include:

1. Defining alternatives and criteria.

Alternatives form the rows of the matrix, and criteria form the columns. The facilitator (person) plays an important role here in group scenarios, where he/she is responsible for helping extract, question, and collate responses from members of the group.

This stage will probably be revisited as more knowledge becomes available about the problem.

2. Populating the matrix formed by the alternatives and criteria.

Once a matrix has been defined, experimental values need to be provided for all cells in the matrix. Values can be obtained by a variety of methods (which are not dictated by the software). These methods include measured data, results from a simulation model such as from AGWA, and technical experts.

3. Ranking the criteria, performing runs, and analysing the result sets.



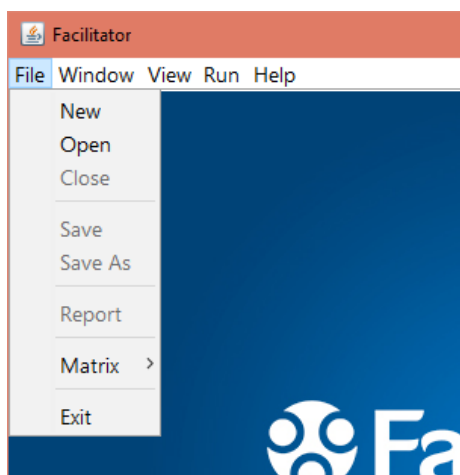
Once the matrix has been defined, criteria are ranked and a result set is produced by performing a run. A run requires a matrix, its cells, alternatives, criteria, and a ranking of its inputs in order to produce a result set.

The software provides views of the result set which enable the user to make decisions about alternatives.

Only a single analysis can ever be open at one time.

## Overview of Menu Options

### File menu

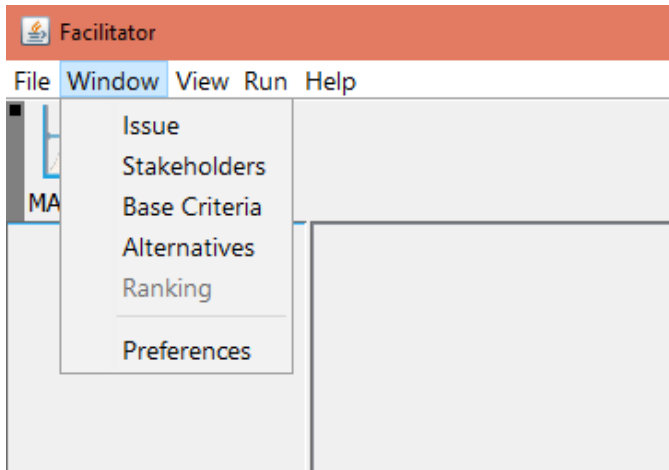


File menu options in the Facilitator

The options in the File menu revolve around *analysis* management. There are options for creating a new analysis, opening an existing analysis, and closing an analysis. Each analysis is stored in a file (which you name) which has a .dss extension.

It also contains options for reporting and importing/exporting matrices.

### Window menu

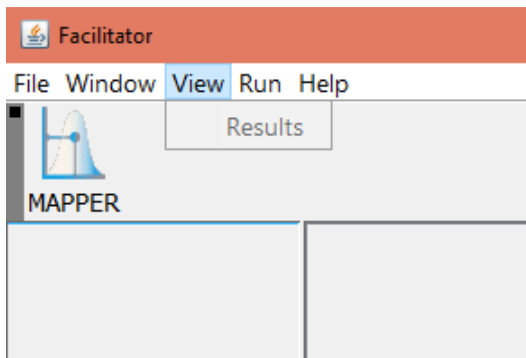


Window menu options in the Facilitator

The options in the Window menu revolve around window control for the main parts of the application. This includes defining the issue, consulting the stakeholders, defining the base criteria, and defining the alternatives. Each analysis is stored in a file (which you name) which has a .dss extension.

The Windows menu also contains a Preferences management option. Preferences within the Facilitator software act like preferences in any application; they provide a mechanism for you to tailor application behavior to suit your needs. This tailoring is saved across application sessions so when you start up the software a week later the preferences are as you left them.

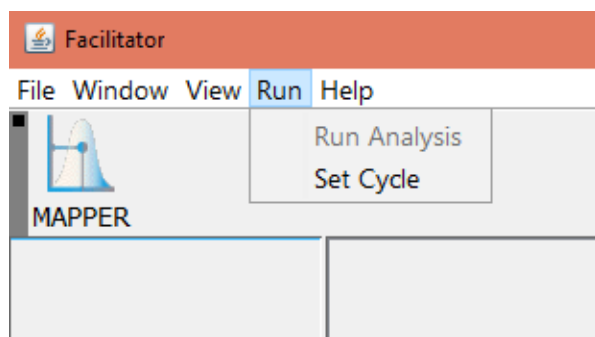
### View menu



View/Results menu options in the Facilitator

The View menu Results option opens a window that contains a list of runs (*result sets* in the current analysis).

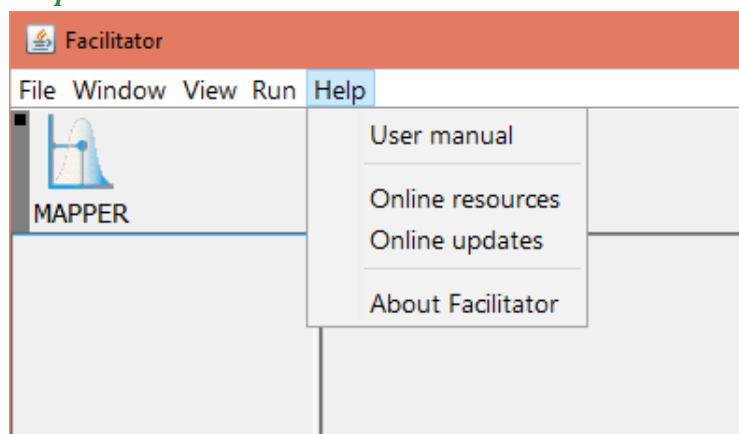
### Run menu



Run menu in the Facilitator

The Run menu includes a Run Analysis option, and the Set Cycle option. Selecting the Run Analysis option will initiate the generation of a result set using current values. The Set Cycle option can be used to reset the current analysis, including base criteria, alternatives, and matrix values.

### Help menu



Help menu in the Facilitator

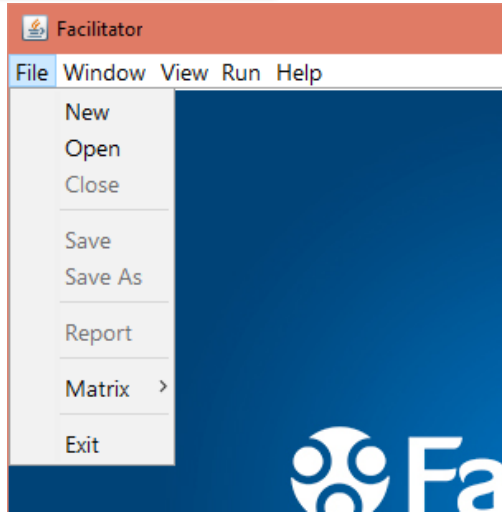
The Help menu contains various Facilitator help resources and historic information about the tool, including a User manual.

## Running the Facilitator

This section will give an example for using the software and will use a predefined analysis document (.dss) which, again, is used by the Facilitator to store all the required information to perform its workflow. For this Guidance Document, this predefined .dss file will include model outputs from the AGWA analysis at the Taylor Arroyo Watershed at Piñon Canyon Maneuver Site, Colorado, from the AGWA Tool Guidance Document. In this analysis, 3 different locations have been disturbed and a priority has to be determined for which location is to be treated first, assuming funds are limited and only one site can be recovered at this time. The user will explore

the issue, stakeholders, base criteria, and alternatives, and run the Facilitator for three different criteria ranking orders and compare the results.

## USING THE SOFTWARE



**Step 1.1** Open the Facilitator application by double clicking on the **facilitator-1.3.8.jar** file. To open the Facilitator analysis document, click on **Open** from the **File** menu and select the *pcms\_facilitator\_tutorial.dss* from the **C:\AGWA\Facilitator** directory (or the directory selected by the user).

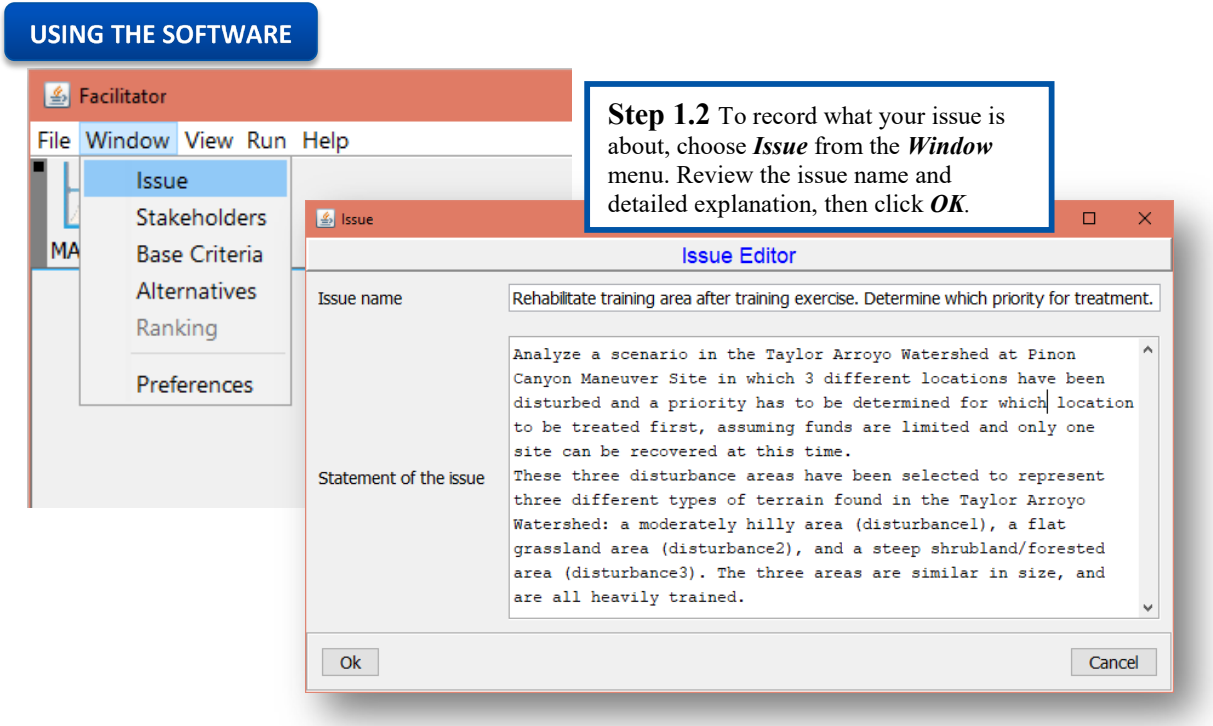
### Step 1: Identify the Issue

The first stage in the decision making process is to develop a clear definition of the issue at hand.

When defining the issue, it is useful to consider the scale at which you are operating. What is the physical scope of the project? Do you only want to consider impacts in the project area, or are broader implications to be factored in (e.g., downstream effects, wildlife concerns, and broader social or economic impacts beyond the project area)?

When identifying the alternatives, it may be beneficial to consult with other parties with an interest in the issue (the stakeholders). If there is support for tackling the problem and involvement in making the decision, it is much more likely there will be “buy in” to the final decision.

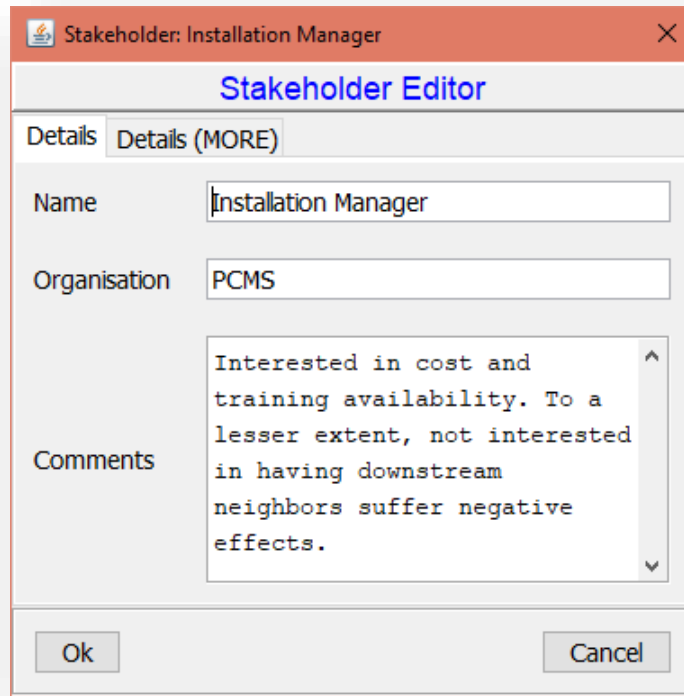
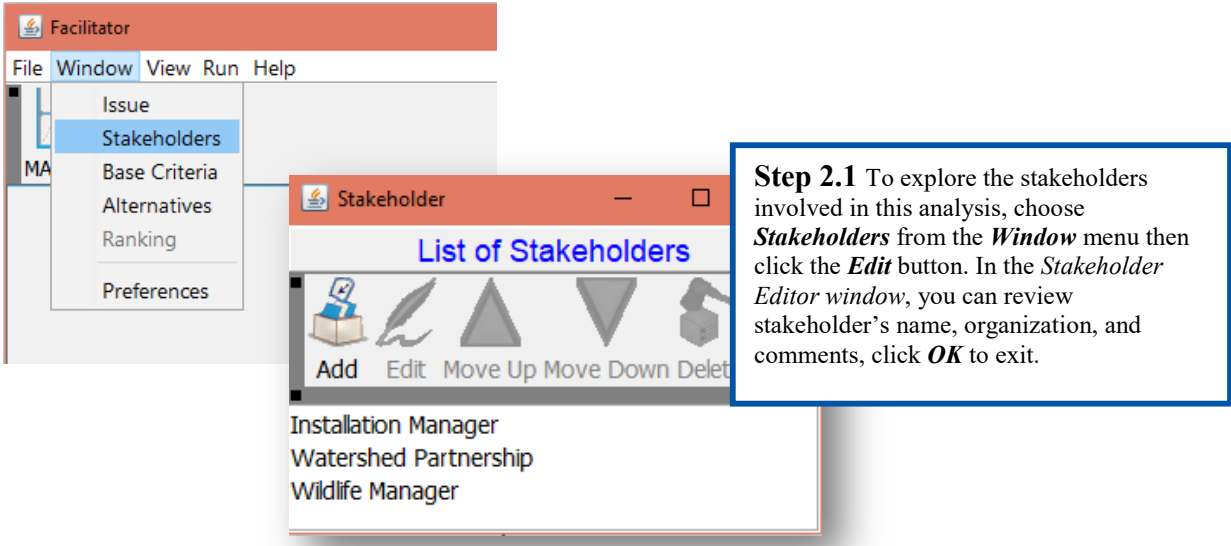
Open the **Issue Editor** from the **Window** menu and read the Statement of the issue that has already been defined, but may be modified by the user. This issue is to rehabilitate a training area after a training exercise, and determine which area to prioritize for treatment.



### Step 2: Consult Stakeholders

One way to identify stakeholders is to get the people involved together and brainstorm who else might be interested. This might include affected landholders, local community organizations and environmental groups, industry representatives, or government representatives at local and state levels. Group size may be limited by the dynamics of the number of individuals involved, but all significant interests should be represented.

For this example, our stakeholders will include the Installation Manager, a Watershed Partnership group, and a Wildlife Manager. The user is able to edit the descriptions for each stakeholder, or add others.



### Step 3: Defining Your Alternatives

To be able to make progress with the decision, you need to have some possible courses of action to choose from. These will become the “alternatives” in the decision-making process.

**Identifying alternatives:** The people involved in initially identifying the issue may have some ideas, and the stakeholders may also be able to contribute some alternatives. If you have a



meeting with stakeholders, one way of collecting ideas might be to brainstorm all the possibilities.

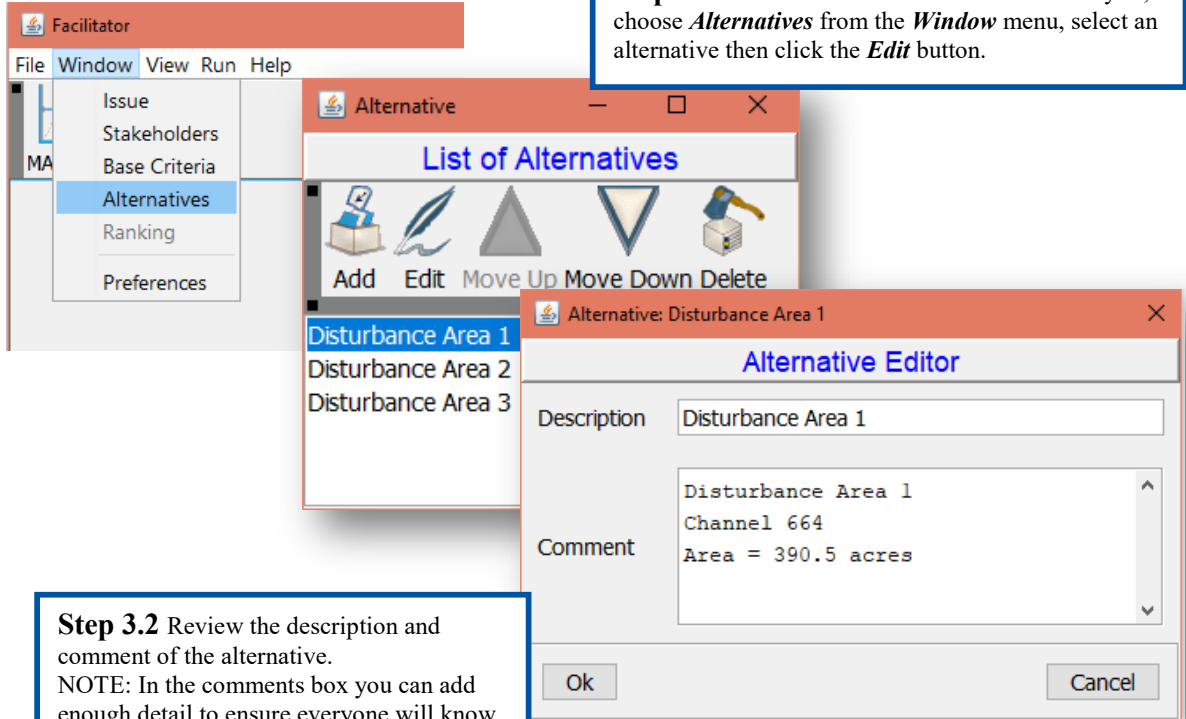
**Not too many:** There will be constraints such as time, money or other resources, which will limit the combinations of alternatives it will be possible to pursue. Also, if you have too many alternatives, it takes a long time to evaluate them all, so you might want to decide roughly how many possible alternatives you have the resources to consider. If you have too many, you can make a checklist of factors with practical considerations such as cost or feasibility which might rule them out altogether. Using this, it might be possible to eliminate some alternatives from the beginning. One suggestion to simplify the overall decision is to ensure that alternatives are defined such that there are significant differences between them.

**Describe the alternatives:** Once you have a list of alternatives, it is useful to include a fairly detailed description of what each alternative will entail. This will help others who have not been involved in the discussions to follow how the decisions were made. It will also provide the people involved in assessing the alternatives with the information they need to do the assessment. You might want to include information such as the location of the alternative, relevant dates and times, and descriptions of model results such as from AGWA.

**Additional alternatives:** As new people become involved, more information is gathered and additional factors are taken into account, new alternatives may come to light. These can be added as you go along with the decision making process.

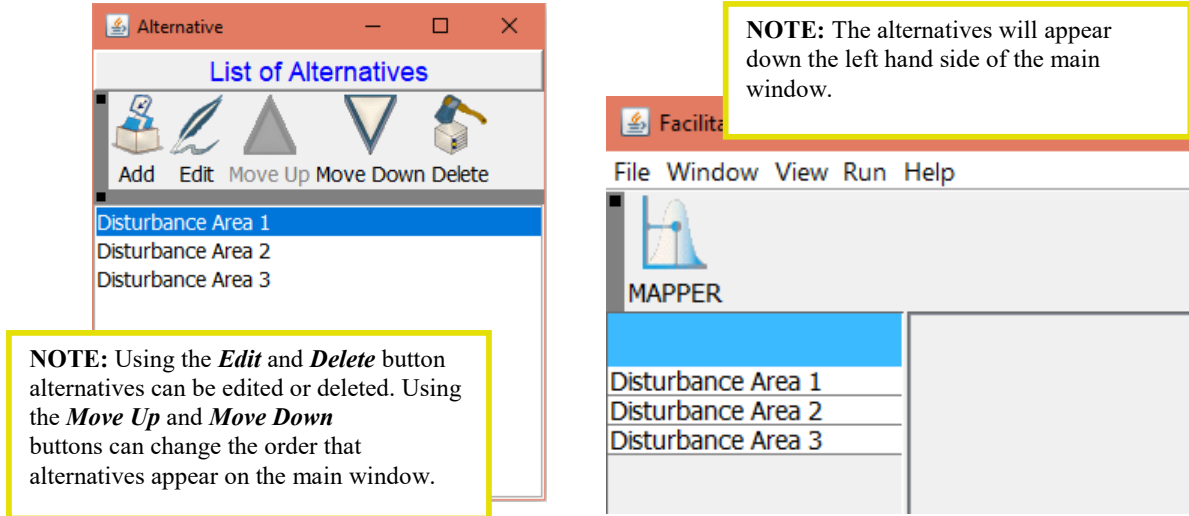
**Do nothing:** One alternative which is usually a good idea to include is the alternative to “do nothing”. Some people call it “the status quo”, “current situation”, “no action”, or “business as usual”. The “do nothing” alternative doesn’t mean you actually do nothing. It just means you carry on doing whatever you would do without this planning project. This provides a useful comparison for the rest of your alternatives against the alternative of not planning for change.

**Step 3.1** To review the alternatives for the analysis, choose *Alternatives* from the *Window* menu, select an alternative then click the *Edit* button.



**Step 3.2** Review the description and comment of the alternative.  
 NOTE: In the comments box you can add enough detail to ensure everyone will know what is meant by that alternative. Click **OK** to exit.

**NOTE:** The alternatives will appear down the left hand side of the main window.



**NOTE:** Using the *Edit* and *Delete* button alternatives can be edited or deleted. Using the *Move Up* and *Move Down* buttons can change the order that alternatives appear on the main window.

### Step 4: Identifying Your Criteria

Next, you need a way of assessing your alternatives. It is best if the stakeholders can get together to work this out. You need to think of which factors make some of your alternatives better or worse than others. Often people will identify such factors as cost, effectiveness at addressing the issues, and offsite effects. A brainstorming session can be a good way to get criteria on the table. It can be useful to use the headings *social*, *environmental*, and *economic* to elicit criteria. This can help to ensure that a balanced approach is taken which does not just favor particular interest groups. The brainstorming will give you a useful starting list, which might need some refining and can be added to as new issues emerge. To be useful, a criterion should:

- Distinguish between your alternatives. For example, if they all cost the same, there is no point having cost as a criterion - it will not make any difference.
- Be possible to be assessed. If no one can think of a way to assess a criterion, it is probably not practical to use it. For example, while it might sound nice to include "maximize happiness" as a criterion, it would probably be a challenge to assess in a way acceptable to everyone.
- Be important to at least one person included in the process.

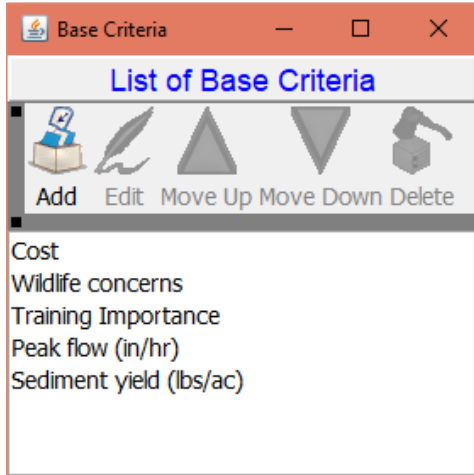
#### USING THE SOFTWARE

The screenshot shows the Facilitator software interface. The main window has a menu bar with File, Window, View, Run, and Help. The Window menu is open, showing options like Issue, Stakeholders, Base Criteria, Alternatives, Ranking, and Preferences. The Base Criteria window is open, displaying a list of criteria: Cost, Wildlife concerns, Training Importance, Peak flow (in/hr), and Sediment yield (lbs/ac). The Base Criteria Editor window is also open, showing the Properties tab for the 'Cost' criterion. The Properties tab includes fields for Measurement, Quantity, Units (dollars), Criteria limits (Minimum 0.0, Maximum 120000.0), and a Score Graph dropdown menu set to 'More Is Worse (linear)'. A yellow arrow points from a note box to the Score Graph dropdown.

**Step 4.1** To review the *Base Criteria* for this analysis, choose *Base Criteria* from the *Window* menu, select one of the base criteria then click the *Edit* button. Read the description and comment for the criterion. Note that the comment should have enough detail to show how the criteria will be assessed.

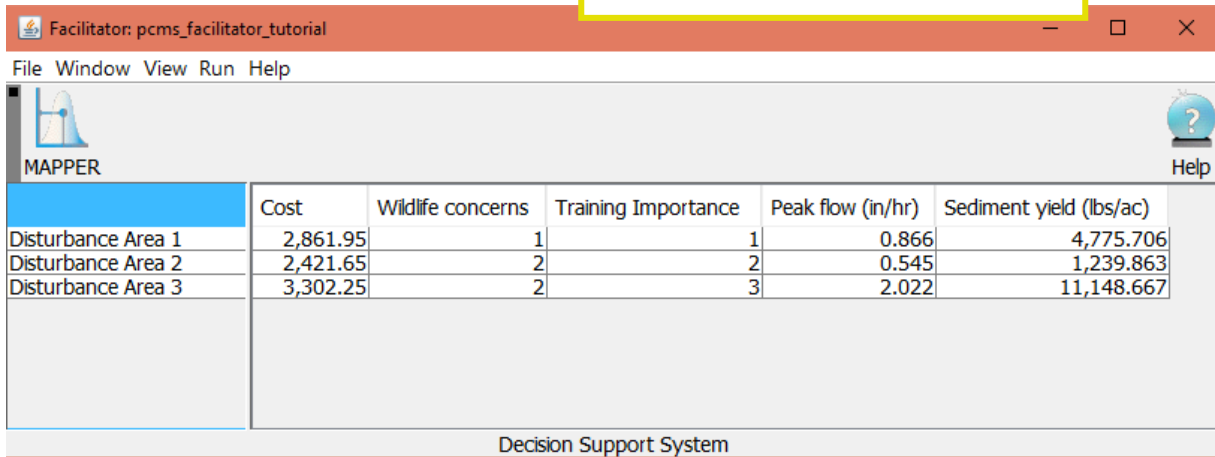
**Step 4.2** Click on the *Properties* tab and review the minimum and maximum limits and the score function for the criterion, then click **OK**.

**NOTE:** These are score graphs, which tell Facilitator how to interpret the score for this criterion. If the highest score is the best score, choose 'More is Better'. Or the highest score might be worse (e.g. cost), in which case you might want to choose 'More is Worse'.



**NOTE:** Using the *Edit* and *Delete* button, criteria can be edited or deleted. Using the *Move Up* and *Move Down* buttons, criteria can be reordered. This will affect the criteria order (column order) that appears in the main window.

**NOTE:** The criteria will appear across the top of the main window, and will form the table for the scores to go in.



### Step 5: Scoring the Alternatives

**Where to put scores:** The next step is to assess your alternatives by the criteria you have defined. In the Facilitator, a table is formed with the criteria along the top and the alternatives down the left hand side. The table of criteria, alternatives and values is called the matrix. When you make your assessments, these become scores in the body of the table (the matrix).

**Data sources:** Sometimes you might have additional information that can be added to the table. For example, quotes for different projects could be added as cost information. For other criteria you might have to use people’s opinions regarding which are the best alternatives. For example, if you want to prevent soil erosion you might get someone with experience to assess which alternatives would score well and which ones would not be as good.

**Scoring precision:** If you have detailed knowledge, you might want to score them out of 10. If you have very little information you might want to score them out of 3 so that you are in effect saying they are good, medium or bad. If you have absolute values, such as cost or the output from model runs (such as AGWA) these can be added here as well. These scores can be refined as you gain more information.

**How to score:** When scoring by rating the alternatives, it is best to score one criterion at a time. Give the best alternative the highest score and the worst alternative the lowest score. Then try to work out how well the others do relative to the best and worst and score them in relation to those best and worst scores. You might want to leave some room at the ends of the range of scores for alternatives to be added later. If there are higher or lower scoring alternatives the full range of scores might not be used.

It can be useful to have a quick go at scoring everything roughly to get a feel for whether you have the most important factors. You will find out from that what additional information you need to have more confidence in the results. Eventually the results will become robust and more information will be unlikely to change the results. Then you can feel confident you have enough information.

USING THE SOFTWARE

**Step 5.1:** Review the values in the matrix. Note that the values for the last 2 criteria (columns) are from the AGWA simulation results.

	Cost	Wildlife concerns	Training Importance	Peak flow (in/hr)	Sediment yield (lbs/ac)
Disturbance Area 1	2,861.95	1	1	0.866	4,775.706
Disturbance Area 2	2,421.65	2	2	0.545	1,239.863
Disturbance Area 3	3,302.25	2	3	2.022	11,148.667

**NOTE:** The scores for each alternative against each criterion are added into the score table or matrix. It is possible to navigate this matrix using the mouse or the cursor keys, in the same way as a spreadsheet. It is not possible to enter a score outside the range (minimum and maximum) entered for that criterion.

### Step 6: Knowledge Input

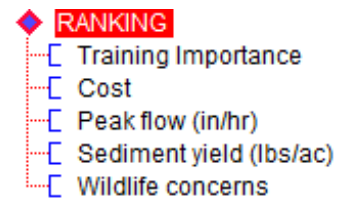
If you want people to have confidence in the results you produce, and not be open to criticism that they are biased, then you will need to be able to provide reasonable justification for the scoring of your matrix. It might help to delegate the scoring of the matrix to people with little emotional attachment to particular alternatives, and people who can be reasonably accountable

such as professionals with reputations to defend. Actual facts and figures can be used where possible. Government agencies might be able to supply information, you can go out and take measurements, or you can use simulation results (as with AGWA). However the scoring is done, it is useful to record the reasons why each alternative received a particular score. This information can be recorded in a table similar to the matrix, termed the score matrix.

### Step 7: Creating a Hierarchy of Criteria

The criteria can be ranked and built into a hierarchy. This means that you can also have criteria under headings such as *social*, *environmental*, and *economic* if you like. It is useful to group together related ideas.

**Reducing duplication:** If there is overlap between criteria, it is useful to put them under a heading. This prevents the overlapping concepts from being measured twice. For example, suppose you want to include employment and growth in enterprises as criteria. You could put them both under a heading such as regional impacts.



Example of a ranking tree

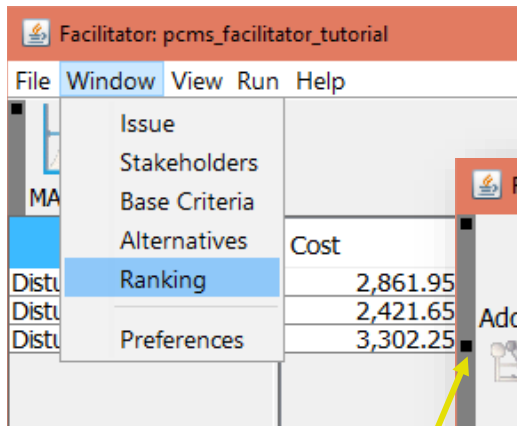
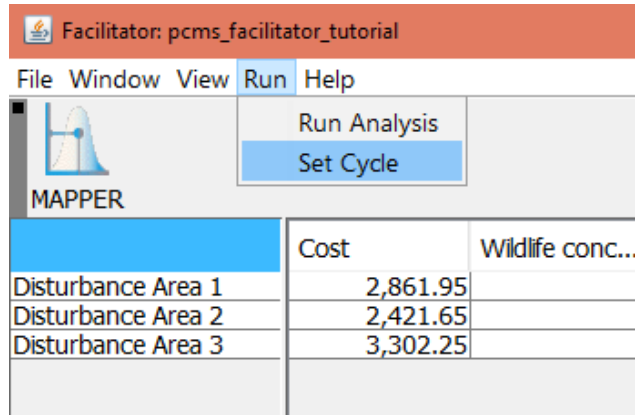
**Under multiple headings:** You can put the same criterion under more than one heading if it fits in more than one place. For example, employment might fit in as both a social and an economic factor and could go under both headings. If the impacts are different from the two perspectives they could be assessed differently.

**How many?** There is no limit to the number of criteria that can go under any heading, but if there are too many then people may have difficulty in grasping what the heading is about. If you have five criteria under a heading, people will be able to think about it fairly easily. If there are more than seven criteria under a heading, it will be too many for most people to deal with. Also, with more than seven criteria the contribution of low ranking criteria is negligible, so you will have to weigh the benefits of including everyone's ideas against the time it will all take.

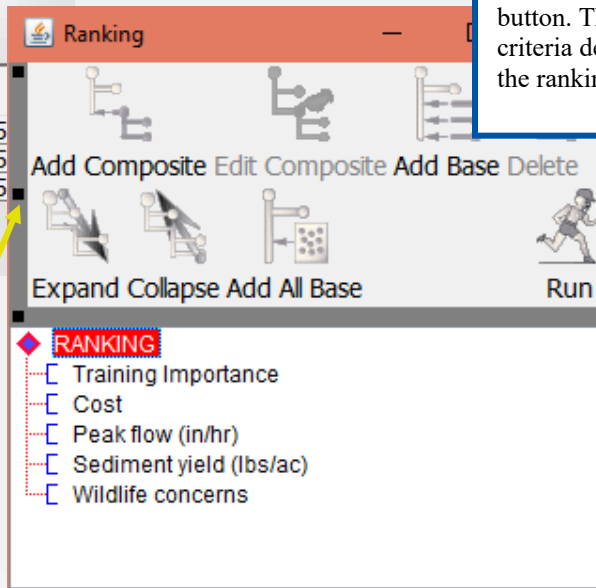
**Defining criteria:** The criteria you choose will need to be carefully defined. This may include instructions on how they will be assessed. There needs to be enough information so that different people with access to the same data would be likely to assess the criteria the same way.

**USING THE SOFTWARE**

**IMPORTANT NOTE:** If the data have changed (such as the alternatives, base criteria, or matrix values), it will be necessary to *Set Cycle* before ranking or running the analysis. This deletes any old runs and prevents confusion over which dataset goes with which run.



**Step 7.1** To create the hierarchy of criteria for an analysis, choose **Ranking** from the **Window** menu, then click the **Add All Base** button. This will add all the base criteria defined for this analysis to the ranking tree.



**NOTE:** If the second row of options is not displayed (row with the *All Base Criteria* option), click here to expand the toolbar.

**Step 8: Define Relative Importance of Criteria**

The stakeholders have the opportunity to express which factors they think are more important than others by ranking the criteria. This assigns weights to the criteria, where those ranked higher are given more weight than the lower ranked criteria. Criteria can also be grouped as equally important.

**Rank each level in the hierarchy:** Criteria are ranked under their headings, so social criteria are ranked separately from economic criteria, for instance. Then the heading criteria themselves can also be ranked. So if there are several headings under “economic”, for instance, (e.g., risk, financial viability), they can also be ranked. If criteria only appear under the root (RANKING) there is no hierarchy and all criteria will be considered together.

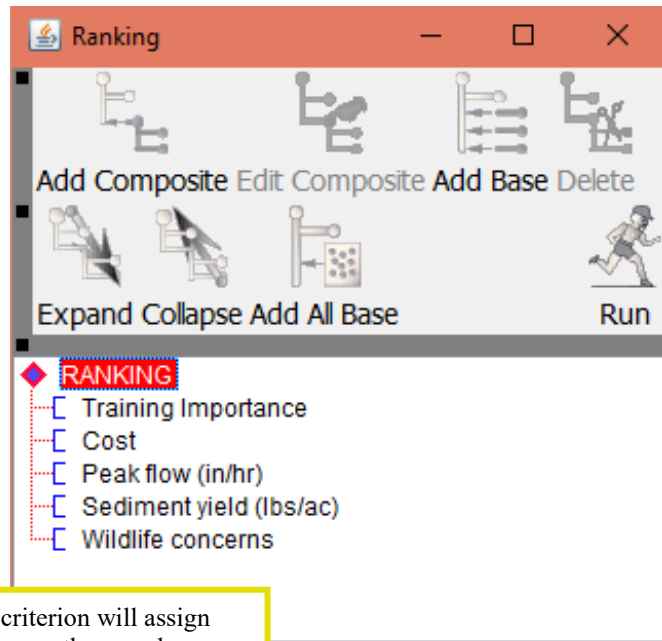


**Conflict over ranking:** If people disagree over which are the most important criteria, it is possible to create several different rankings and compare them. Often, it will not make much difference to the results, and it is useful for people to be able to see this. There may also be different interest groups within the stakeholder group (e.g., there are often conservationists and developers). One approach is for the identifiable interest groups to be able to produce their own rankings. Developers will be more concerned about the economic criteria, and the conservationists will be relatively more concerned about environmental criteria. This can promote collaboration and the recognition of each other's contribution to the solution.

**USING THE SOFTWARE**

**Step 8.1** To reorder criteria nodes to reflect the most important criteria in the ranking tree, click on a criteria node, drag it and drop it on top of where you would like to position the node. Reposition the other nodes as shown in the following ranking tree. This ranking, for example, is from the Installation Manager's perspective where training availability and cost are of major concern.

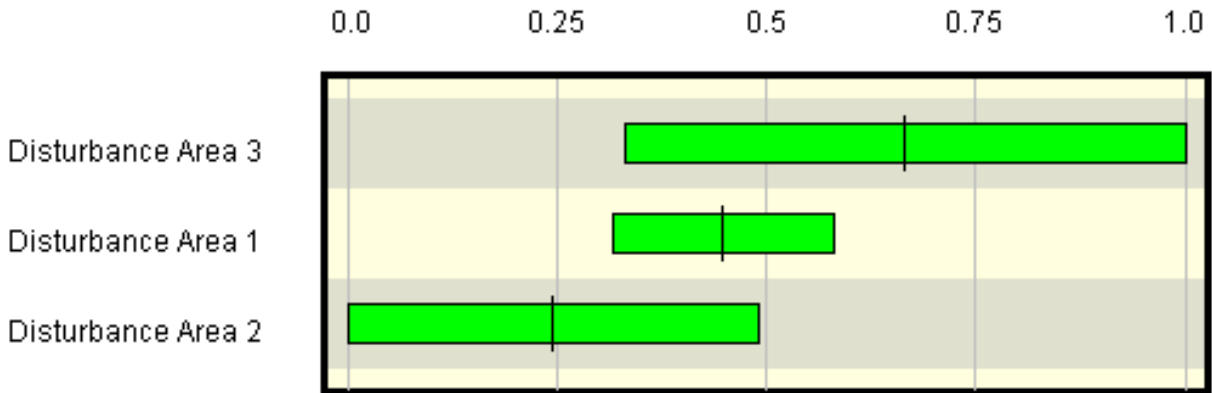
**Note:** You will create other ranking trees for other runs later in this example.



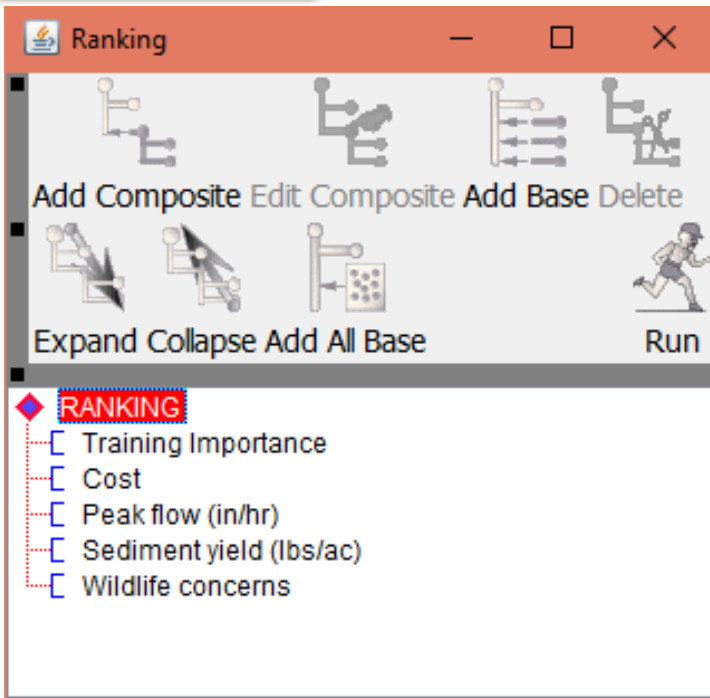
**NOTE:** Double clicking on a criterion will assign equal importance to the criterion as the one above. Double clicking again will break this assignment and assign greater importance to the criterion above.

**Step 9: Analysis**

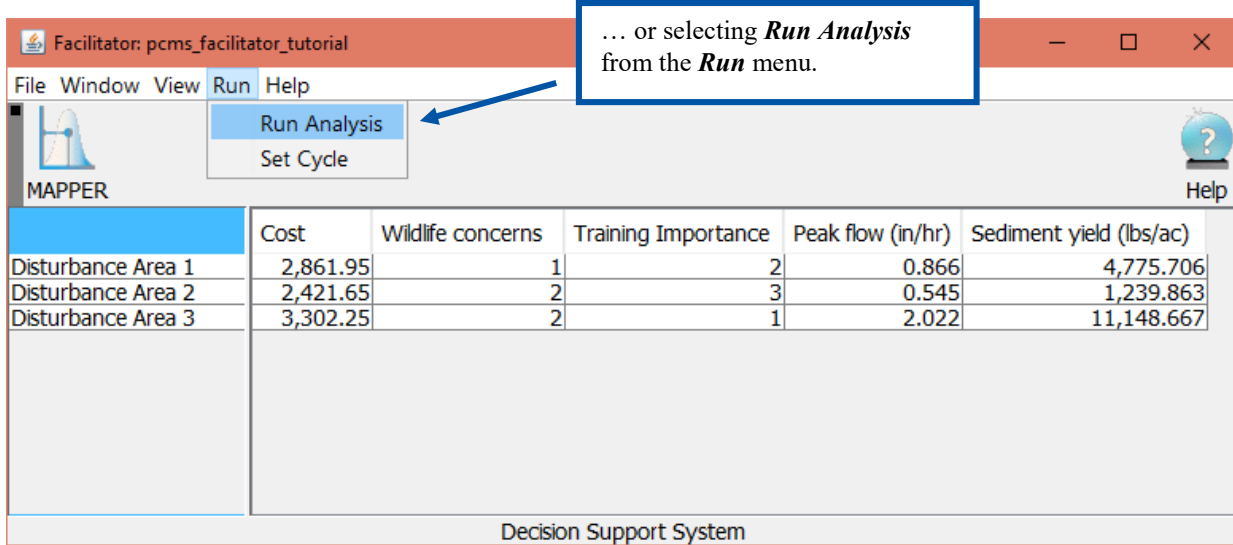
The Facilitator allows you to analyze the alternatives by producing graphs, which give a visual representation of the alternatives' relative merits. Each alternative is represented by a green bar, which shows the range of overall scores for that alternative. The further to the right in the graph (the closer to 1.0), the better the alternative. It is only clear that an alternative is better than another if there is no overlap between the green bars.



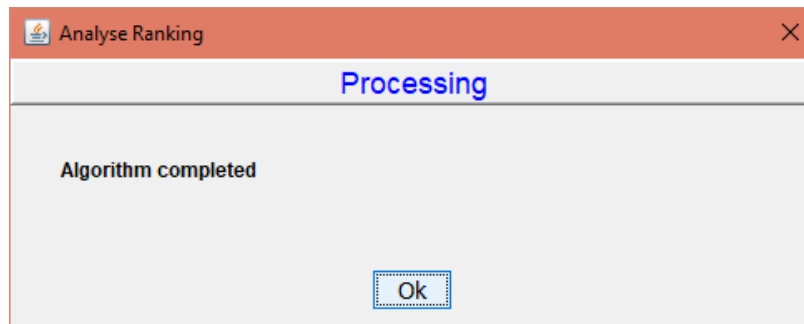
USING THE SOFTWARE



**Step 9.1** Everything is now in place to run the analysis. This can be done from two locations, either by clicking on the **Run** button in the **Ranking** toolbar...



Then click **OK** and the results will be displayed.



**Step 9.2** Once you are done running the above scenario, perform a second and third run using the following ranking trees. Be sure to name the runs so you can tell which one is which.

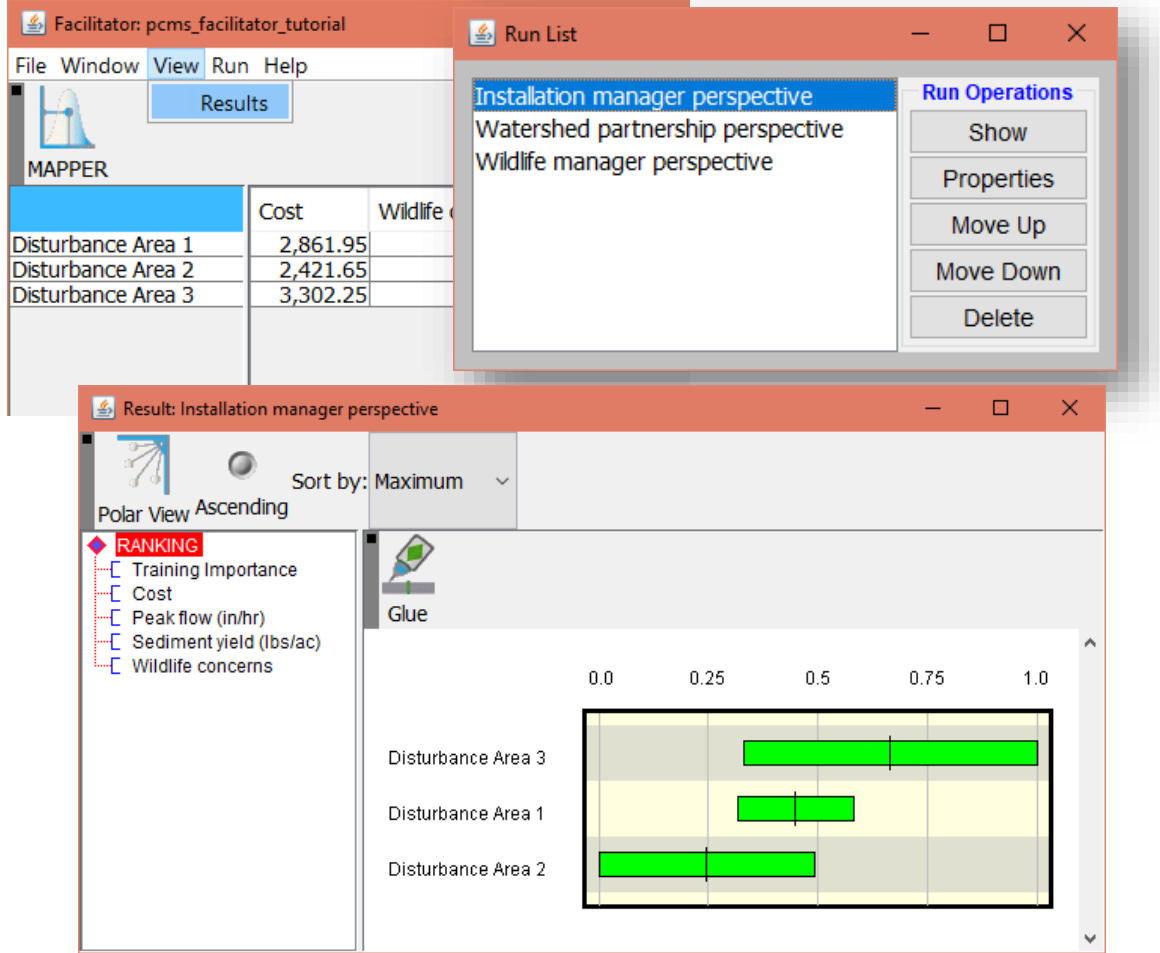
- RANKING**
- Sediment yield (lbs/ac)
- Peak flow (in/hr)
- Wildlife concerns
- Cost
- Training Importance

- RANKING**
- Wildlife concerns
- Peak flow (in/hr)
- Sediment yield (lbs/ac)
- Cost
- Training Importance

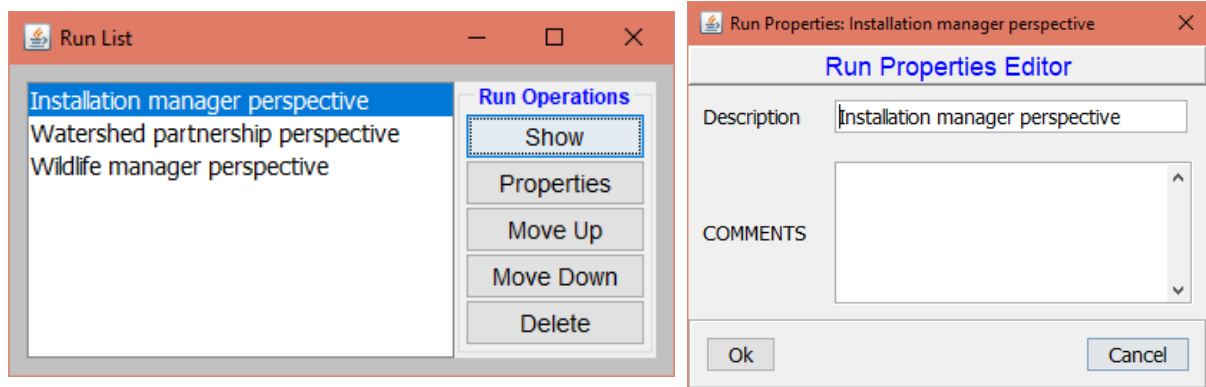
Step 10: Viewing the Results

USING THE SOFTWARE

**NOTE:** Previously run results can be viewed by selecting **Results** from the **View** menu. Select a run from the list then click **Show** in the dialog box.



**NOTE:** The **Properties** option allows the user to change the name of the run and add comments describing the current run. The order they appear in this list can be changed using **Move Up** and **Move Down** and the **Delete** option can be used to remove unwanted runs.



## Step 11: Ordering the Results

**USING THE SOFTWARE**

**NOTE:** Using the *Sort By* drop down, the display order can be changed. The alternatives can be listed in different orders: e.g. by mean, minimum, maximum, range, and alphabetical. Select the order from the drop down menu.

## Step 12: Prioritizing of Alternatives

With a hierarchy of criteria it is possible to produce result graphs for any point in the hierarchy. For instance, you can look at just the economic aspects of the alternatives. If you have a subheading of risk, then it is possible to compare them on the basis of the risk factors. If you have used the top level headings - social, economic and environmental - then it is better to look at the graph for each of these headings separately and to try to satisfy all of them. Producing an overall analysis averages out the different aspects. So, for instance, if an alternative scores well economically and badly environmentally it would be somewhere in the middle overall. But it could be very environmentally damaging and it is important not to lose that information. For potentially harmful alternatives, looking for alternatives that score well socially, economically and environmentally does least harm.

Once you run the analysis and look at the results, you will start to get a feel for whether you've included all the important factors. Does it produce the sorts of results that people who are really familiar with the situation would expect? If not, what is missing? Are there criteria that should have been included? Are there problems with the hierarchy or the rankings? Do you need to collect additional information to refine the scores? Have additional alternatives emerged which need to be added and assessed? Do additional model simulations need to be run in order to show a different scenario?

**The process is iterative:** The first runs provide useful information on how to refine your matrix to develop a useful decision tool that the people involved will have confidence in. You might

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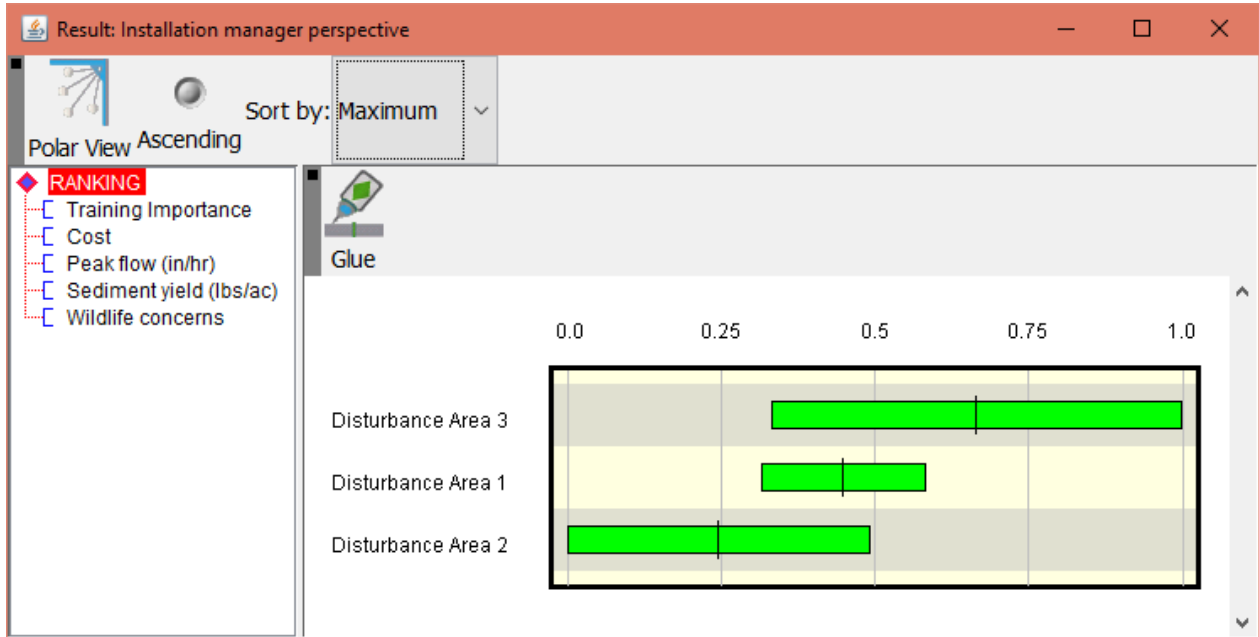
117

expect to revisit criteria, alternatives, scores and rankings several times before feeling sure that you really have a handle on your decision model.

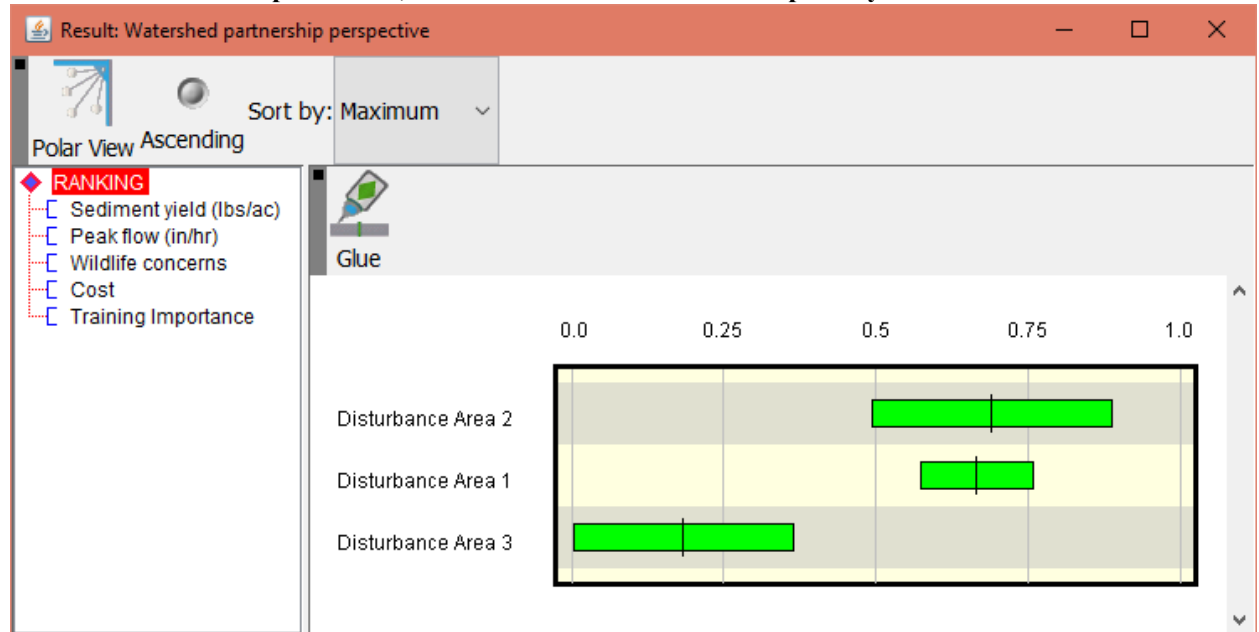
**USING THE SOFTWARE**

**NOTE:** The Results can be viewed from any point within the ranking hierarchy, by clicking on the relevant place.

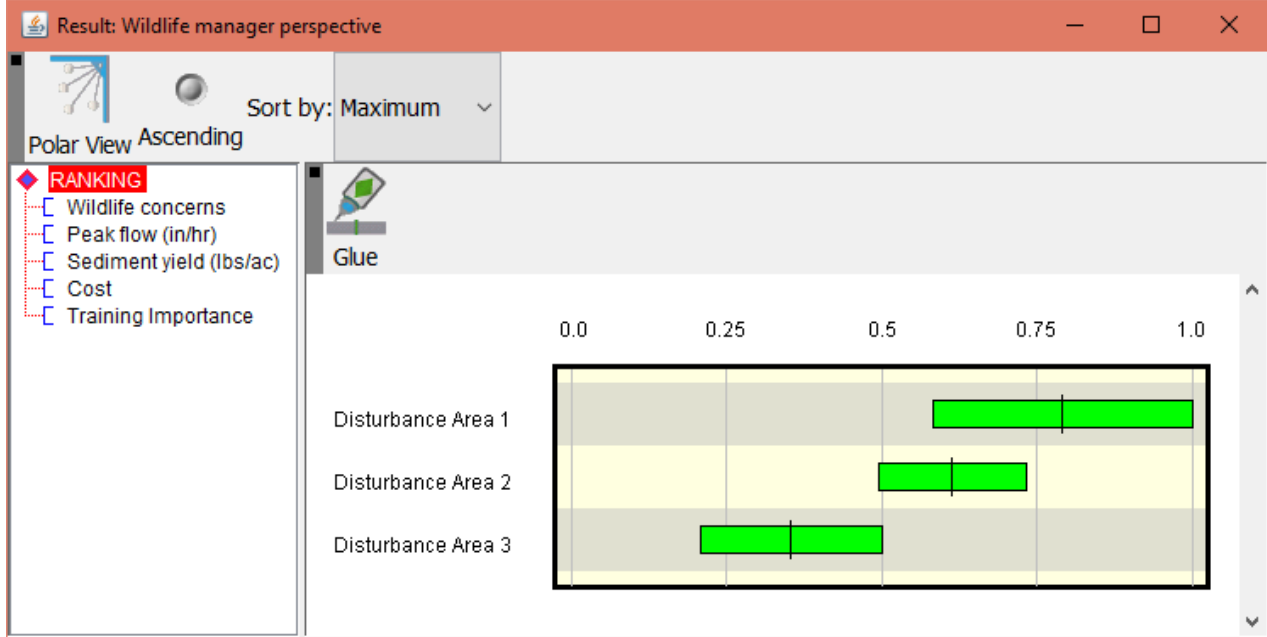
**Results from Installation Manager’s perspective: training availability and cost are most important, and Disturbance Area 3 is prioritized**



**Results from Watershed Partnership perspective: sediment yield and peak flow are most important, and Disturbance Area 2 is prioritized, with Disturbance Area 1 also a priority**



**Results from Wildlife Manager perspective: wildlife concerns and peak flow are most important, and Disturbance Area 1 is prioritized**



**Creating a report**

Once the user has successfully produced an alternative that satisfies the need to solve the issue identified, the user will be able produce a report (in HTML format) which documents the process followed with the Facilitator.

**USING THE SOFTWARE**

Selecting **Report** in the **File** menu will produce a report for the analysis. The details and content of the report can be defined using the "Report Options" dialog window.

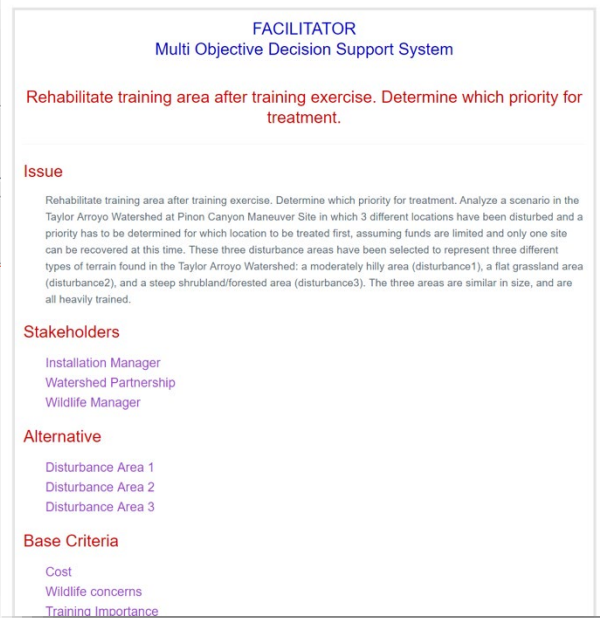
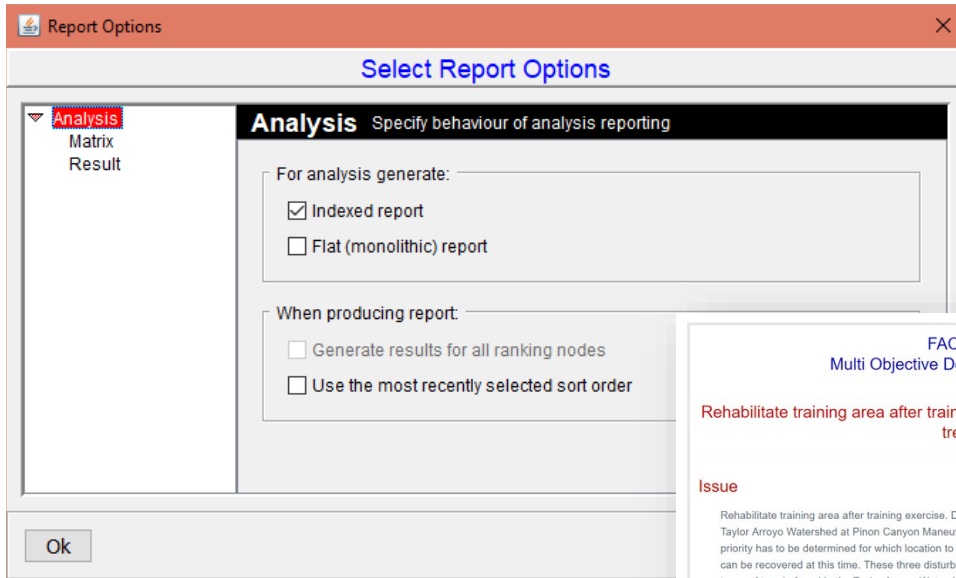
The screenshot shows the "Facilitator: pcms\_facilitator\_tutorial" window. The "File" menu is open, and the "Report" option is highlighted. The background shows a data table with the following content:

	Cost	Wildlife concerns	Training Importance	Peak flow (in/hr)	Sediment yield (lbs/ac)
a 1	2,861.95	1	2	0.866	4,775.706
a 2	2,421.65	2	3	0.545	1,239.863
a 3	3,302.25	2	1	2.022	11,148.667

Decision Support System



**Note:** There are various options available before creating a Facilitator report. These can be changed before producing the report in HTML.



## Follow-up

### Questions to think about

- Have new stakeholders been added to the decision analysis and should be included in this process?
- Are there additional alternatives (other AGWA simulations) to consider?
- Are there additional decision criteria that should be considered in this analysis?
- Should new matrix scores be considered in the analysis?

## Facilitator Use Cases

This section provides a list, by country, of some of the use cases where the Facilitator has been applied.

### Australia

- Development and outcomes from a multiple objective decision support system for water quality in the Queensland watersheds draining toward the Great Barrier Reef.
- Using a multiple criteria decision support system to support natural resource management decision-making for ecologically sustainable development.
- Participatory multiple objective decision making processes: Emerging approaches with new challenges.
- A decision environment: Going beyond a decision framework to improve the effectiveness of decision making in natural resource management.

### India

- Assessment of a multi-objective decision support system generated land use plan on forest fodder dependency in a Himalayan watershed.

### Kenya

- Spatially explicit multiple objective decision support for rural watersheds.

### Mexico

- Planning for increasing irrigation efficiency in Mexico.
- Working smarter: Research and decision support systems in Mexican agriculture.

### United States

- A Decision Support System for Evaluating the Effects of Alternative Farm Management Practices on Water Quality and Economics.
- Targeting Farms to Improve Water Quality.

- Using measured data and expert opinion in a Multiple Objective Decision Support System for semiarid rangelands.

#### World

- Appraising and selecting conservation measures to mitigate desertification and land degradation based on stakeholder participation and global best practices.
- Decision support for selecting SLM technologies with stakeholders.

### References

- Heilman, P., Davis, G., Lawrence, P., Hatfield, J.L., Huddleston, J. 2002. The facilitator - An open source effort to support multiobjective decision making. Proc. 1st Biennial Meeting of the Internat'l. Environ. Modelling and Software Soc. 3:253-258.
- Heilman, P., and Lawrence, P. 2003. Watershed planning with the Facilitator Decision Support System. Proc. 1st Interagency Conf. on Research in the Watersheds, K.G. Renard, S. McElroy, W. Gburek, E. Canfield, and R.L. Scott (eds.)

## Appendix A

Term	Synonymns	Definition				
Issue	Problem	A situation that requires a response through a decision. An unresolved issue is a problem.				
Analysis		The act of trying to solve an issue.				
Stakeholder	Client Customer	A person, group, or agency who has a direct involvement in, or will be affected by, the decisions made on a particular issue and who wishes to exercise a right of involvement in decision making on the particular issue.				
Alternative	Option Management Option Possibility Management Practice	One possible course of action to address the issue.				
Criteria	Indicator Decision Criteria Attribute Evaluation Criteria Basis for Judgement	<p>One possible way of measuring the effect of implementing an alternative.</p> <p>There are two types of criteria:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%; padding: 5px;">Base Criteria</td> <td style="padding: 5px;">A base criteria is a single criterion with an associated score graph. A base criteria also has a value associated with it. This value is converted into a dimensionless value between 0 and 1 by using the score graph associated with the base criteria.</td> </tr> <tr> <td style="width: 20%; padding: 5px;">Composite Criteria</td> <td style="padding: 5px;">A composite criteria is a criteria formed by grouping a mixture of base criteria and composite criteria.</td> </tr> </table> <p>Where the term criteria is used, it refers to both base criteria and composite criteria.</p>	Base Criteria	A base criteria is a single criterion with an associated score graph. A base criteria also has a value associated with it. This value is converted into a dimensionless value between 0 and 1 by using the score graph associated with the base criteria.	Composite Criteria	A composite criteria is a criteria formed by grouping a mixture of base criteria and composite criteria.
Base Criteria	A base criteria is a single criterion with an associated score graph. A base criteria also has a value associated with it. This value is converted into a dimensionless value between 0 and 1 by using the score graph associated with the base criteria.					
Composite Criteria	A composite criteria is a criteria formed by grouping a mixture of base criteria and composite criteria.					
Score Graph	Score Function	<p>A single score graph is associated with each criteria.</p> <p>The score graph is a mechanism for scaling a base criterion from its original units into a score within the range of 0 to 1.</p>				
Meeting		<p>The act of a group of stakeholders getting together to work on a common scenario.</p> <p>In reality, this will most commonly be a group of stakeholders getting together in a room to thrash out an issue, although it is foreseeable that the meeting might be a logical meeting place where people from different physical locations come together.</p>				

## Facilitator Tool Guidance Document - ESTCP Project RC201308

Scenario		<p>A specific instance of where a group of stakeholders are attempting to perform an analysis (i.e., solve an issue).</p> <p>You might be wondering what the difference is between a scenario and an analysis. The difference is that there may be many scenarios that combine to solve an issue. A specific example is when there are three stakeholders in a meeting trying to solve an issue. There could be a disagreement, and they all decide (a consensus decision) to end the meeting, go away and perform their own individual scenario.</p> <p>Perhaps in this case each stakeholder, outside the meeting, thinks they are running their own analysis but in fact they are running another scenario of the same analysis.</p> <p>This process of disagreement and the farming out of the current scenario to each stakeholder to work on independently is referred to as resolution.</p>
Consensus		<p>The position reached when stakeholders agree on a particular stage of the decision process, or where the majority of stakeholders agree and the position of any dissenting stakeholders is noted but for the purposes of progressing the range of scenarios, there is an agreement to proceed. At this stage the user (or group facilitator) moves the process on.</p>
User		<p>Person actually sitting in front of a computer using this application.</p>
Matrix	Consensus Matrix Table	<p>The matrix is defined by using the currently defined base criteria (columns) and active alternatives (rows).</p> <p>There is only one matrix in any instance of a scenario.</p> <p>Each cell of the matrix can only be modified by the user (hopefully this equates to a consensus).</p> <p>If individual stakeholders wish to modify their own matrices, then this is accomplished by activating a resolve action within the application. The resolve action will create a separate scenario for each stakeholder.</p>
Ranking	Importance Order Ranking Rank Order Preferred Order	<p>The ordering (defined by consensus) of importance of criteria.</p> <p>This will most often be done prior to executing a run and is a necessary requirement for executing a run.</p>
Mathematical Engine		<p>An engine which takes as its inputs a matrix and a ranking and produces as its output a result set.</p>
Run	Test	<p>Represents the processing of a matrix and ranking by a mathematical engine to produce a result set. A run can only occur when by consensus all cells which represent the intersection of active alternatives and base criteria have been filled.</p>

Facilitator Tool Guidance Document - ESTCP Project RC201308

Result Set	Results	<p>Output from the mathematical engine as the result of a run.</p> <p>The result set is simply the results produced by the mathematical engine. The result graph is just one view of these results. There is no restriction on the number of views of the result set which may be defined in the future.</p>
Result Graph		<p>One particular, but commonly used, view of the result set.</p>
Resolve	Resolution Phase	<p>In a scenario where there is more than a single stakeholder a point may be reached where the stakeholders dissent.</p> <p>They can resolve this situation by each stakeholder being provided with their own scenario (really this is a sub-scenario as there are restrictions place on it by the scenario to which stakeholder belongs).</p> <p>Each stakeholder takes their scenario away from the meeting and processes it separate to the other stakeholders.</p>

**USDA-ARS Southwest Watershed Research Center, Tucson, AZ**

**ARS MANUSCRIPT PROCEDURES CHECKLIST**

CRIS # 871-2022-10-00-00-00

Peer Reviewers: **Peer Review was conducted by the Department of Defense, Environmental Security Technology Certification Program, see attached.**

Person Submitting Request: **Dave Goodrich**

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**Mark all that apply:**

Peer Reviewer comments addressed (on ARS-533 form or separate sheet of paper)

Cleared by Cooperative Agencies/Institutions

Abstract Only

First Formal Report of Research Other Than Abstracts

Date paper submitted to RL

**Prominent issues**

Potential to Attract Media Interest/Attention

Represents a Significant Scientific Advancement

Significantly affect Existing or Future USDA Policy

Potential Trade Implications

Other (Specify)

Manuscript Title:

**Automated Geospatial Watershed Assessment (AGWA) to Aid in Sustaining Military Mission and Training, Guidance Documents for AGWA Tool, AGWA-Facilitator Export Tool, Facilitator Decision Support Tool**

Journal/Equivalent to which Manuscript is Being Submitted and date submitted:

**Department of Defense, Environmental Security Technology Certification Program, Sept. 25, 2019**

Publication Type (Proceedings, Refereed Journal, Book Chapter, etc).

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Due to Patent Potential, is Retention of Intellectual Property Rights Desired: **No**

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Abstract:

This is the User Guidance Document for the Department of Defense, Environmental Security Technology Certification Program project that describes the use of the Automated Geospatial Watershed Assessment (AGWA) tool coupled with the Facilitator Decision Support System (DSS) to address installation managers concerns of land disturbance from military training and testing, flooding, and erosion. Step-by-step instructions for AGWA, Facilitator, and the AGWA-Facilitator Export Tool are shown for an example analysis of a military training event. This Guidance Document is applicable to the project demonstration sites of Piñon Canyon Maneuver Site and Fort Carson, Colorado, and Fort Bliss, Texas/New Mexico. AGWA is a publicly available Geographic Information Systems (GIS) interface that uses national data to parameterize, execute, and visualize outputs of several watershed models at multiple temporal and spatial scales over a range of environmental conditions. The Facilitator DSS provides a flexible, easy to use, framework to structure and document installation manager experience, expert knowledge, and AGWA simulation model results to select a preferred management action. Tools within AGWA are the military training disturbance tool to evaluate changes in soil and vegetation cover resulting from training events; the erosion control structure tool to design and place these structures for flood and erosion control; the burn severity tool to evaluate prescribed and wildfire effects on site and downstream; the urban tool to evaluate stormwater flooding and green infrastructure practices; and the climate assessment tool. This Guidance Document describes the application of the land cover modification tool. It was presented at one of the 1.5 to 2-day training sessions that were conducted at each installation.

Interpretive Summary

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