Introduction to the Automated Geospatial Watershed Assessment Tool

Using Internal Gage Locations During the Watershed Discretization and Developing Distributed Precipitation Input for SWAT

Introduction: In this exercise you will investigate the manner in which AGWA utilizes Thiessen weighting to create the precipitation files for SWAT over a watershed with no internal precipitation gages. AGWA's utilization of internal stream gages in the delineation process will also be demonstrated.

Goal: To familiarize yourself with 2 of AGWA's more advanced features for hydrologic modeling and landscape assessment.

Assignment: Run the SWAT model on a large watershed near Eugene, Oregon using MRLC landcover data and daily precipitation data from 1993.

Keywords: Watershed assessment, Hydrologic model, Rainfall interpolation, Continuous vs. event-based modeling

---

Introduction

Often times the spatial distribution of rain gages in a particular study area is not ideal for quantifying precipitation depths. In such circumstances, many different methods can be used to derive precipitation over a watershed. Examples of these include: taking a simple arithmetic average, using isohyets, and using Thiessen polygons. The latter two of these can account for some of the spatial variability, or rainfall distribution over the watershed, but perhaps the most widely accepted and well-known method is the Thiessen polygon method. As the name implies, it utilizes the creation of polygons based on gage locations to compute area-weighted rainfall depths over the entire watershed. This method is advantageous in that gages do not necessarily have to be contained within the watershed, and areas are often much easier to calculate than using the isohyetal method.

Flow measurements can be particularly useful in calibrating and validating hydrologic models. To take advantage of this data, however, it is necessary to develop the model in such a way that model output locations coincide with the locations of flow measurement stations. AGWA has thus been designed to enable point locations of flow gaging stations to be used in the subdivision or discretization of the watershed. USGS flow gaging stations represent the most convenient source of gage data in the U.S.; the data they collect and GIS data layers of gage point locations are easily obtainable via the Internet. AGWA can use a user-defined selection of these point locations as it subdivides the watershed.

The Study Area

The Eugene watershed that we have particular interest in contains no rain gages within its boundary but does contain a fair amount of USGS gaging stations. The area is approximately 9,172 km^2 and is primarily dominated by forestland, though the outlet of the watershed is subject to agricultural use and moderate urbanization. The area provides a prime opportunity to utilize AGWA's Thiessen weighting and and delineation capabilities in a forested environment subject to significantly more precipitation than previous areas that AGWA has been applied to.

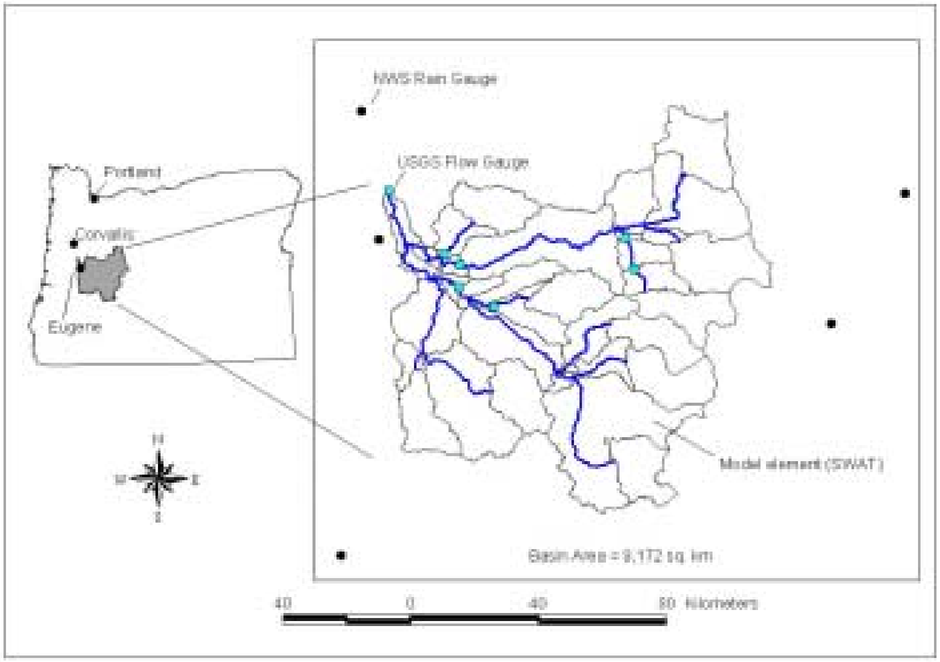
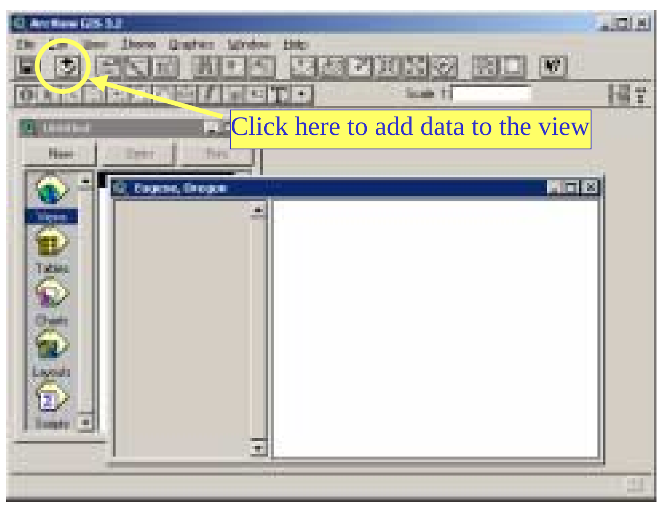


Figure 1. Diagram showing the location of the watershed under this study.

Getting Started

If the 'eugene_proj' directory does not already exist, copy it into your main AGWA directory from the CD or network drive. Within this directory you will find an ArcView project file called 'eugene_proj.apr' – double click on this file to open the project.

Open up the "Eugene, Oregon" View by double-clicking on its name in the Project Views window. You will be presented with the following screen →



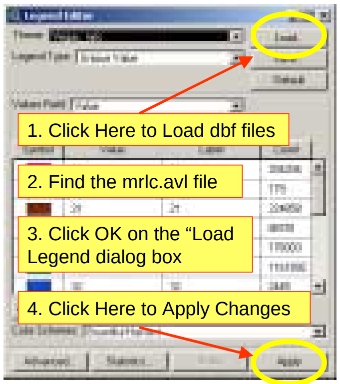
Add data to the view by clicking on the "+" button at the top. You will need to add the following shapefiles (Feature Data Sources) from the agwa\gisdata\Oregon\Eugene directory:

NWS_gages.shp – Five rain gages located near our watershed.
USGS_gages.shp – Coverage of USGS gage locations within our watershed
Statsgo.shp – STATSGO soils

Helpful hint: You can add multiple themes to the view by holding down the 'Shift' key while making your selection.

Click on the "+" button again, and add the following grids to the view (*make sure you change the "Data Source Type" to "Grid data source"*):

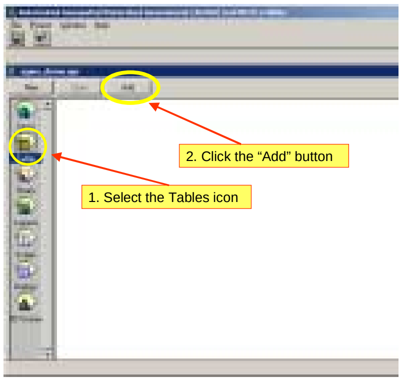
nlcd - National Land Cover Data classified into MRLC cover categories.
flowacc - flow accumulation grid
dem - Digital elevation model
flowdir - Flow direction grid
bnd_eug - Pre-processed watershed outline



To make the MRLC data look a little better, double-click on its legend. You will get a pop-up window like →
Click on the "Load.." button and navigate to select the "**mrlc.avl**" file that is located in your "agwa\datafiles" subdirectory. This will load in a legend with pre-defined colors and names that make looking at the land cover data a little easier. Keep the default "Value" field in the pop-up and *be sure to click the "Apply" button to set the changes*.

Although it is not a necessary step, it is illustrative to add rainfall data to the project that will be used during the watershed assessment. To do so, activate the project window by clicking on it once, and then click on the "Tables" icon in the project window.

Click on the "Add" button and navigate through the agwa\datafiles subdirectory to add in the following database (*.dbf) files:



93rainfall.dbf – Eugene, Oregon daily rainfall data in 1993 for all the NWS gages in the watershed
Wgnfiles.dbf - database table of weather generator stations for SWAT

After loading these files into the project, you can open and view them to familiarize yourself with data they contain. These tables remain in the project (whether open or closed) until deleted by you.

At this point we have all the data necessary to start modeling:
topography, soils, land cover, and rainfall.

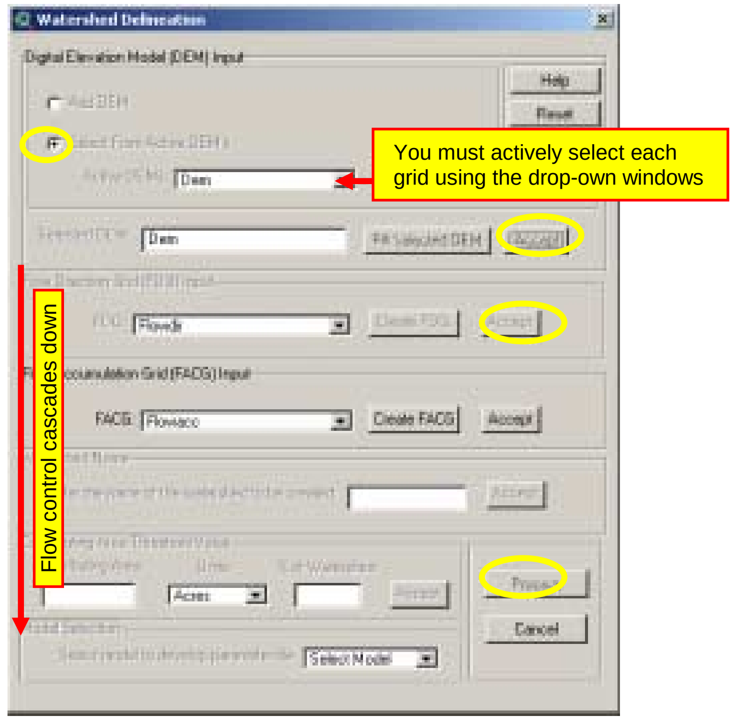
Part I: Modeling Runoff at the Basin Scale Using SWAT

At this point, it would be a good idea to **save your work**. ArcView is a little temperamental, so saving often is highly recommended.

Step 1: Subdividing the watershed

Open up the "Eugene, Oregon" view again. From the "AGWA Tools" menu, select "delineate watershed". This will bring up the 'Watershed Delineation" dialog (window) as shown below …

Fill in the dialog so that it looks like this picture →



If you have previously loaded the GIS data into the view, you should have the appropriate DEM, flow direction and flow accumulation maps available.

Once complete, click the last "Accept" button and you will be prompted to generate a watershed outline.

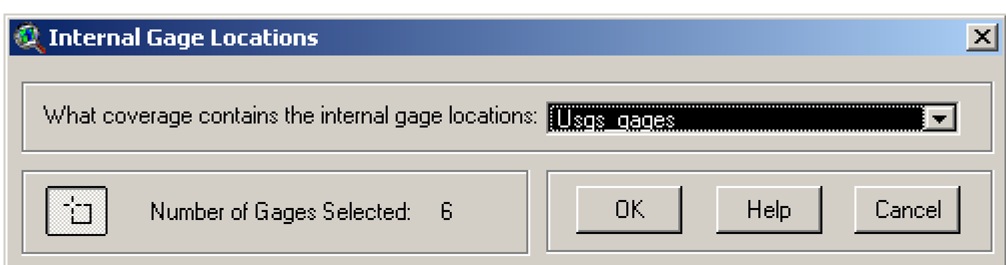
Typically during the first time through, a watershed outline will not exist. However, in the interest of saving time, we have provided a watershed boundary for use in this exercise: bnd_eug. Therefore, click "Yes" when asked, "Does a Watershed Outline Grid Exist?"

A Brief Note on AGWA Speed
The 1st time through this step, AGWA creates a stream network (stream2500) to act as a visual guide for watershed delineation. This can be time-consuming, but it only happens once per DEM.

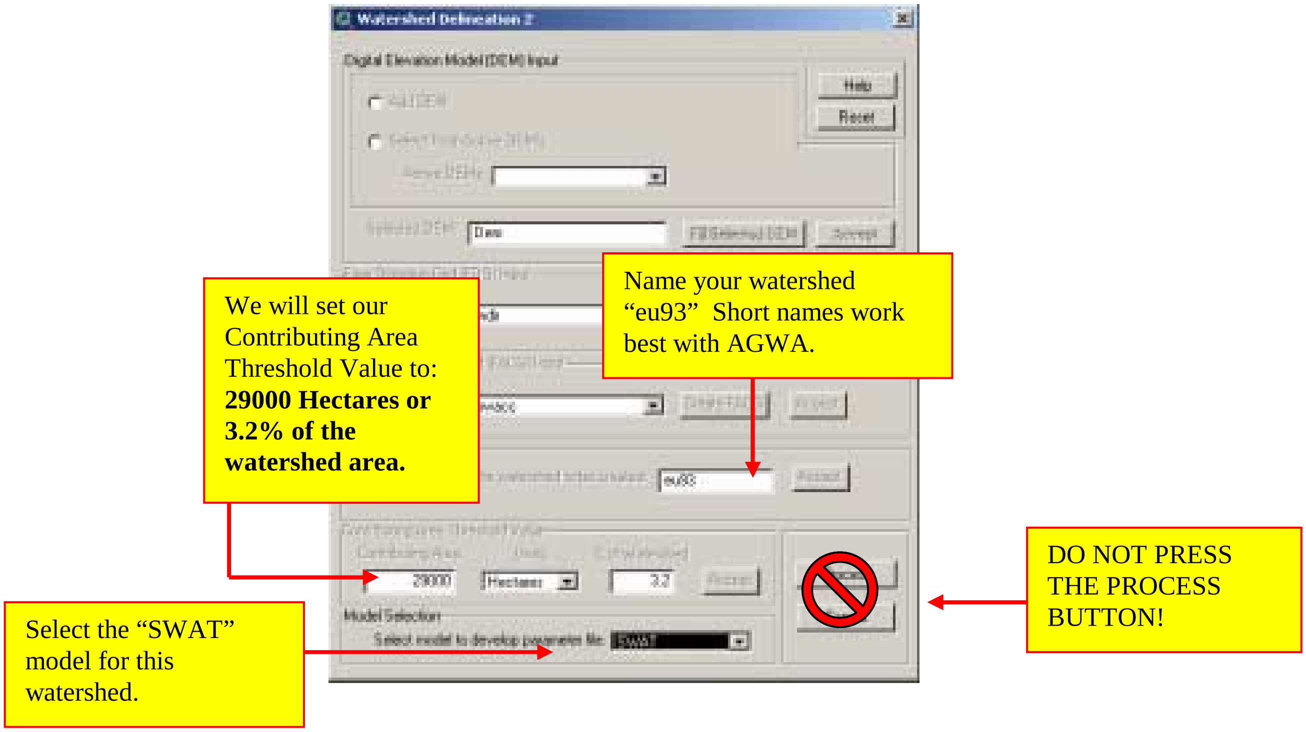
You will then be asked, "Do you want to use internal gages in the watershed subdivision?". Again, click "Yes".

AGWA will now ask you to identify the watershed outline, which is the aforementioned "Bnd_eug."

AGWA will then bring up the 'Internal Gage Locations' window. Select the theme containing the internal gages – the 'usgs_gages' theme.

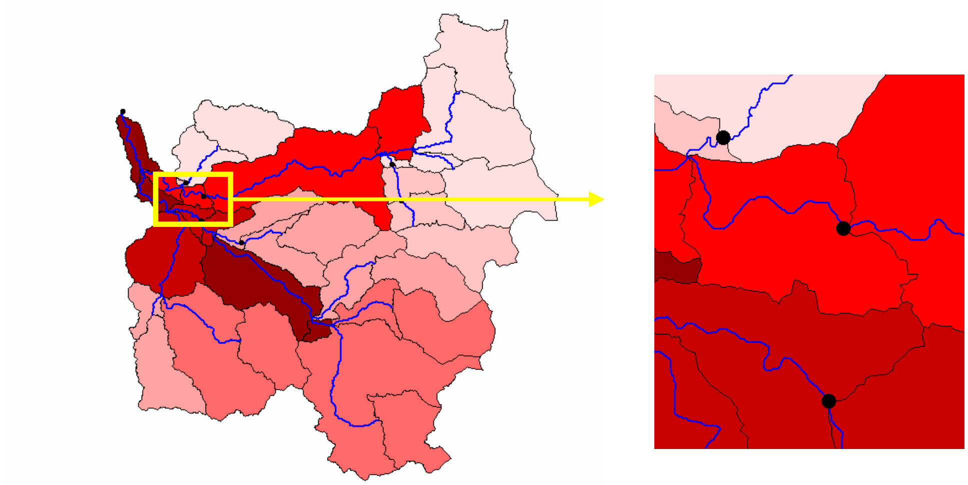


AGWA does not assume that you will be using all the points in the internal gages theme, so you will have to select the gages where you want the subwatersheds split. To do this click on the selction tool (the button in the lower left of the window), and then click on or drag a box around the gages you would like to use. When the gages are selected click "OK". This will return you to the watershed delineation window to complete the remaining information. Enter the information as shown in the following figure:



Typically, you would press the "Process" button at this point and allow AGWA to subdivide your watershed according to your specifications. Unfortunately, this process can take some time depending on watershed size, contributing area threshold value (geometric complexity), and gage divisions. So, in the interest of time we have supplied you with the resultant watershed and stream themes, and they should already be in the view (weug.shp and seug.shp). Had this been a typical run, AGWA would have created these for you and saved them to the av_cwd directory.

Notice how AGWA has subdivided the watershed such that subwatersheds break at the specified gage locations and how the main stream channel follows the original "stream 2500" theme originally created by AGWA (pictured below). Decreasing the contributing source area (CSA) can make more, smaller, subwatersheds, while increasing the CSA can create fewer, larger subwatersheds.



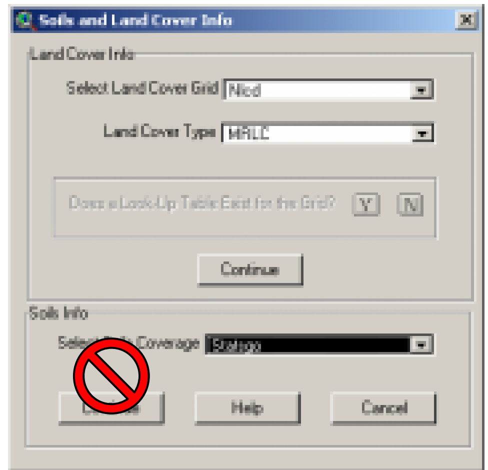
Step 2: Characterize the watershed elements for SWAT model runs

1. Each of the model elements (subwatersheds and stream channels) needs to be characterized according to its unique land cover and soil properties. These properties are used by AGWA to generate input hydrologic parameters for SWAT. To start this process, select on ***"AGWA Tools… Run Landcover and Soils Parameterization***"

2. Select the watershed theme, and then fill in the landcover & soils dialog box as shown here →

Normally, you would then press the Continue button and AGWA would run through some machinations to prep the weu93 watershed for running SWAT using MRLC land cover and STATSGO soils.

Again, in the interest of time, do NOT press the "Continue" button. The landcover and soils parameterization has already been run for the provided watershed.



3. At this point the watershed has been subdivided into model elements and these elements have been characterized according to their land cover and soil properties. AGWA has added a few items to the watershed's data table that will be used to provide input to the SWAT model. You can see this data by selecting on the legend for weu93 and then clicking on the *Table* icon that looks like: 

Step 3: Prepare rainfall files

1. AGWA provides a means for preparing rainfall files in SWAT- or KINEROS-ready format. The key is that the user has previously prepared a database file containing daily estimates of rainfall for the rain gauges within the study area. Rainfall data for gages near the Oregon study area are provided for you in the 'datafiles' directory as "***93rainfall.dbf***".

> *Note on rainfall input:* In a normal hydrologic study, multiple years of rainfall data and perhaps more than five gages will be utilized. The process of creating area-weighted files is very time-consuming (it can take several hours to characterize a complex watershed for many years and gages with rainfall data) and we will not be performing an extensive characterization in this exercise. Instead, we will only use one year of rainfall data to demonstrate the Thiessen weighting capabilities of AGWA and how gages without data are processed within AGWA. This process will typically take 5 to 10 minutes, so please be patient.

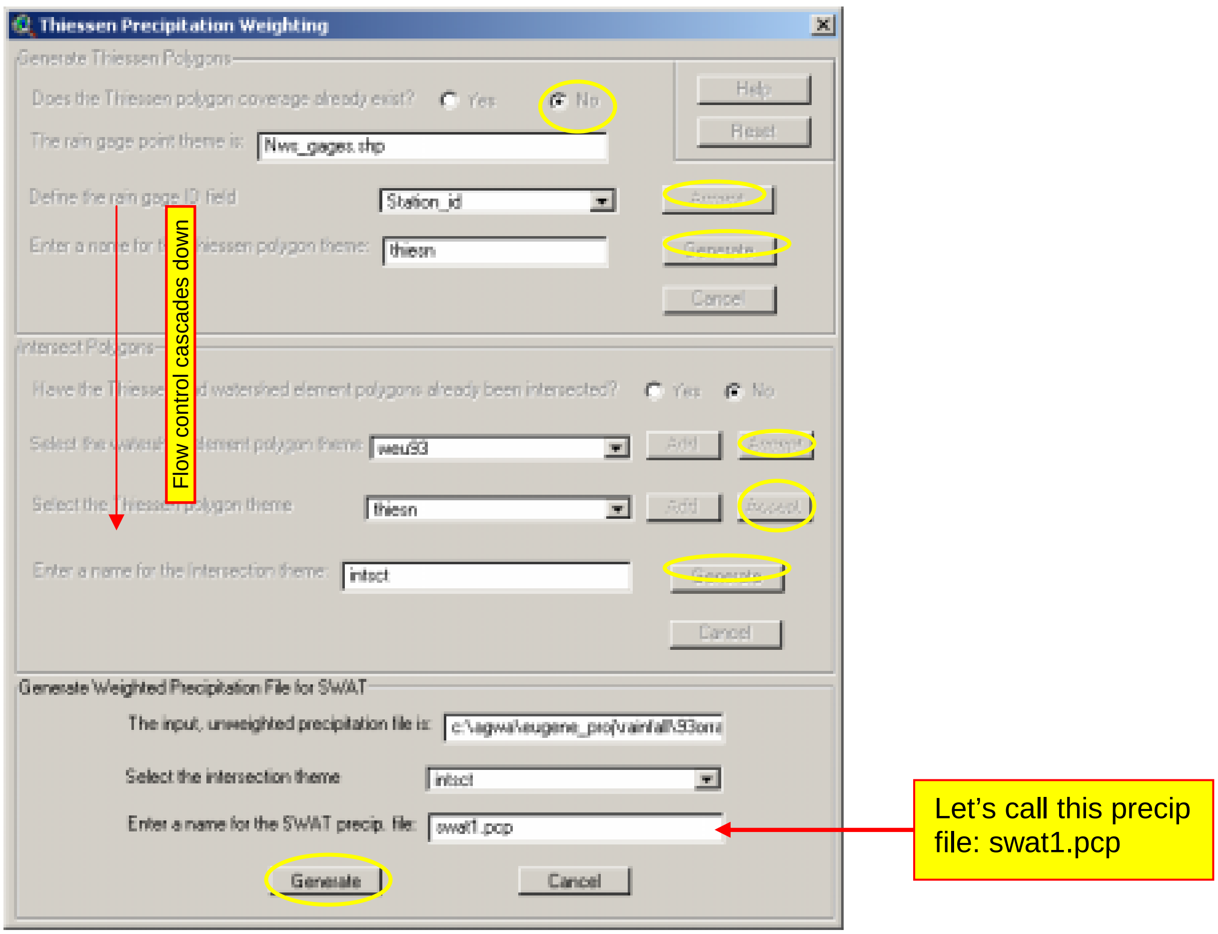
2. When AGWA is used expressly as a hydrologic modeling tool it is critical that the rainfall data be spatially distributed across the watershed. A large body of literature exists regarding the crucial nature of spatially distributed rainfall data. Given a number of rain gauges scattered throughout the study area (see the nws_gages

data layer), AGWA will generate a Thiessen rainfall map and distribute observed rainfall on the various watershed elements using an area-weighting scheme.

3. To generate the distributed rainfall input, select on "AGWA Tools… Write SWAT Precipitation file". You will be prompted to select the rain gage point theme as shown to the right. Select NWS_gages.shp – note that since the selected shapefile has multiple points, AGWA automatically routes you the dialog for creating an area-weighted precipitation file rather than the dialog for creating a homogeneous or uniform rainfall file (which it does if 2 or less points are present).

After selecting the rain gage point theme, you will be prompted to select the unweighted precipitation file. This is the previously seen, "93rainfall.dbf" and it is located in the c:\agwa\datafiles directory.

You will then see the Thiessen Precipitation Weighting dialog window. It should be filled out as shown in the following figure:

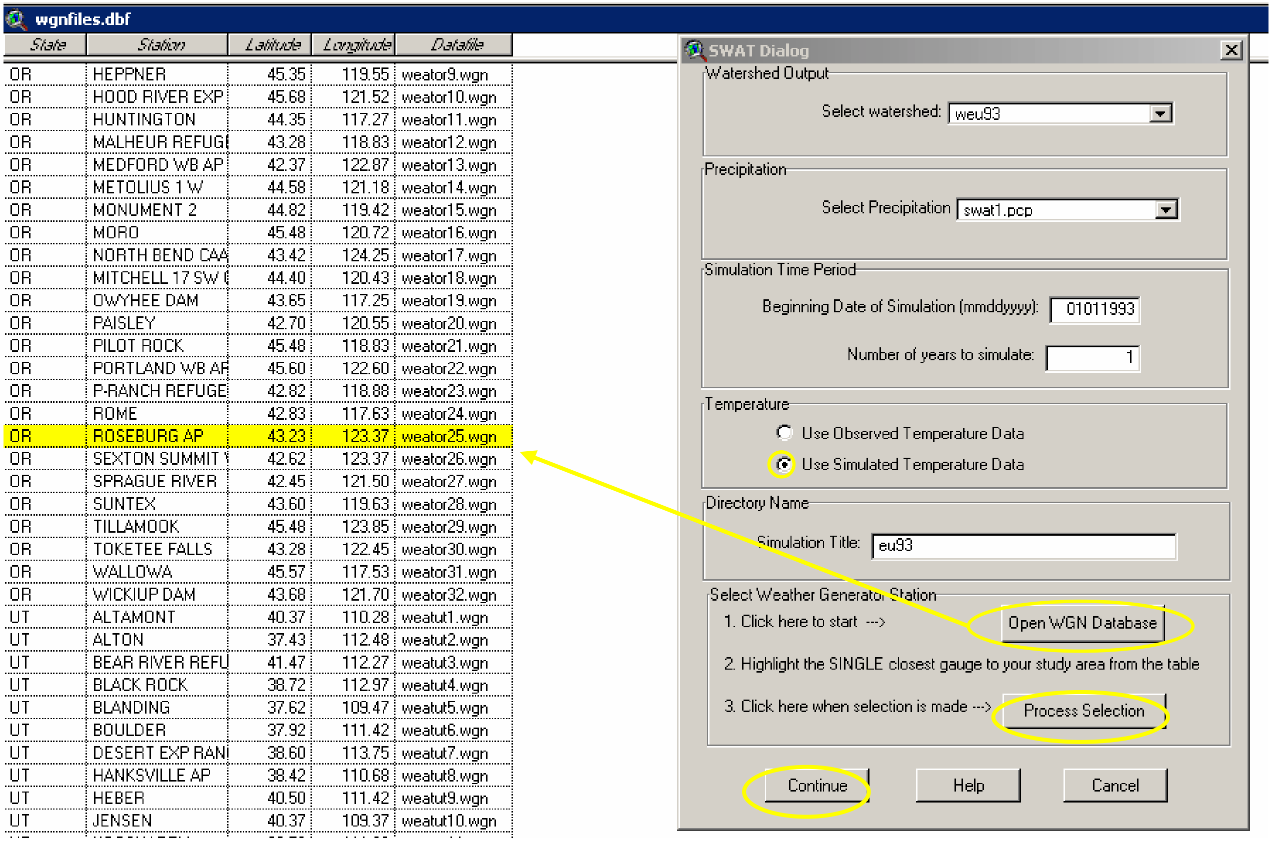


Click the "Generate" button and AGWA will warn you that this could take a while. We are only going to do one year, so the wait should not be too long, but this should give you some idea of the amount of time involved if you were processing multiple years.

*** Thought Provoking Topic *** You can try using two different sources of rainfall data for SWAT: uniform and distributed rainfall. In this example, we used multiple gages, but you could also try running SWAT with a shapefile containing only one of the provided gages for the same time period. In this way you can investigate the impacts of rainfall input on computed water yield.

Step 4: Write output and run SWAT

1. At this point all the pieces are in place to run SWAT. The last step is to click on "AGWA tools… Write Output and Run Swat." You will be prompted with the following dialog:

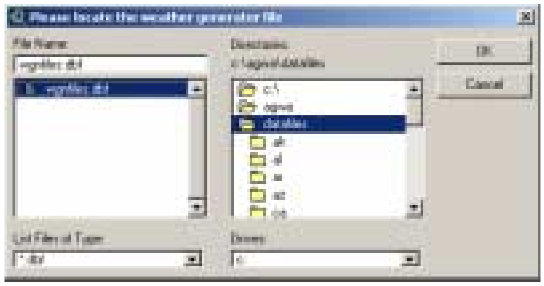


2. Once you select the watershed, AGWA will provide you with the available precipitation files that you have created for the watershed. If you generate multiple rainfall events, AGWA will keep track of them for you.

   There is only one year of data in the rainfall record you created earlier, so we will only simulate one year. You can change the start and end dates so long as they fall between the start and end dates of your precipitation file. The default start date is the beginning date of your precipitation file.

   Since we do not, as yet, have processed temperature data for our watershed area, we will be using simulated temperature data for this run. Had we used observed temperature data, AGWA would have asked you to locate the file containing the temperature data.

   Once you have clicked on "Open WGN Database" you will be prompted to select a weather generator file. If the master database file containing weather record locations (wgnfiles.dbf) has not been added to the project, you must do so here. It can be found in the "datafiles" folder under "agwa," which is shown below.



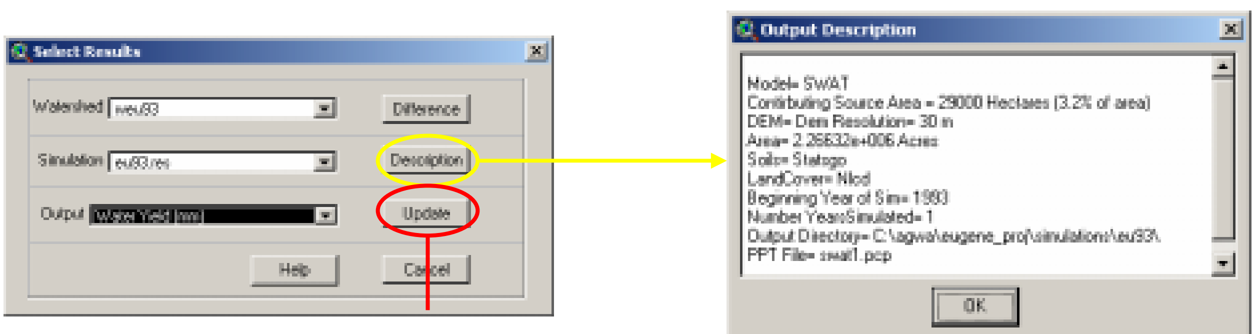
After the wgnfiles.dbf file is added to the project, you will need to select on the weather station closest to your study area. You will be shown a list of the available stations. Make sure the  button is depressed in the top center of the screen when selecting a location. **NOTE:** *AGWA will show the name, latitude and longitude of the available stations, but it is the responsibility of the user to choose an appropriate station. In the Eugene, Oregon basin, choose the* **ROSEBURG AP** *station.*

3. If you have not set up an environmental variable for AGWA, then the first time you run SWAT, you will be prompted for the location of the SWAT executable. It can be found in "agwa\models" directory and is called **swat2000.exe**.

   If the environmental variable has been set, then AGWA will know where to look for these files, and SWAT will run without interruption.

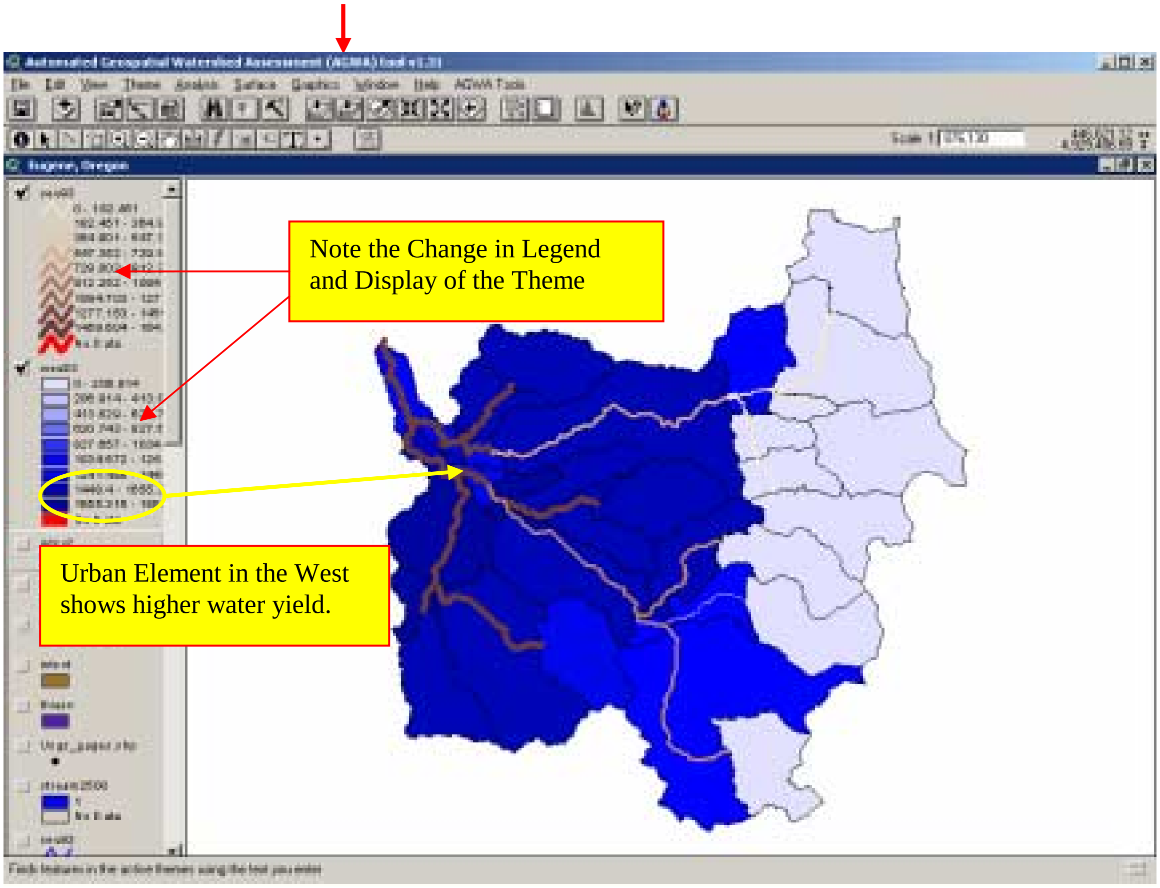
<u>Step 5: View the results</u>

1. After SWAT runs to completion, AGWA retrieves the output data created by SWAT and attaches the results to the watershed and stream themes (in this case, weu93 and seu93). You can display the spatially distributed runoff, infiltration, and other water balance results by clicking on "AGWA Tools… View SWAT Results." You will presented with the following dialog:



Click on the "Description" button to review the choices you made to get to this point. This box provides a summary of the data used to provide input to SWAT. In this case, the watershed size was about 2.26 X 10^6 acres with a CAS of 29000 hectares. National Land Cover Data and STATSGO soils were used to parameterize the watershed for a 1 year model run starting in 1993.

2. Experiment with the visualization tool by choosing different results to display. The results for water yield should look something like this:



Additionally, AGWA can show the difference between simulated runs. This is accomplished by running through the AGWA program using another set of parameters (rainfall duration, gage location, CSA, etc…) and pressing the "Difference" button from the "View Results" dialog.