
MapWindow Interface for SWAT (MWSWAT)

**Prepared by: Luis F. Leon
June, 2007**

MWSWAT (MapWindows SWAT)

Step by Step Setup for the San Juan and Linthipe Watersheds

Contents:

1	Environment and Tools Required	4
2	Installation.....	4
3	Structure and Location of Source Data.....	4
4	Structure and Location of Output Data.....	5
5	Setup for Mexico: San Juan River Watershed	5
5.1	Step 1. Process DEM (Watershed Delineation)	7
5.2	Step 2. Create HRUs	13
5.3	Step 3. SWAT Setup and Run.....	21
6	Setup for Malawi: Linthipe Watershed.....	26
6.1	Step 1. Process DEM (Watershed Delineation)	27
6.2	Step 2. Create HRUs	30
6.3	Step 3. SWAT Setup and Run.....	34
7	Rerunning MWSWAT	40
8	Using Your Own Data	41
8.1	DEM.....	41
8.2	Landuse and Soil Maps.....	42
8.3	Weather Sources	43

Figures:

Figure 1: Naming a project	6
Figure 2: Reminders.....	6
Figure 3: About to do step 1	7
Figure 4: Selecting the DEM	8
Figure 5: Preprocessing the DEM.....	9
Figure 6: Stream networks displayed.....	10
Figure 7: Defining the outlet point.....	11
Figure 8: Watershed delineation complete	12
Figure 9: About to do step 2	13
Figure 10: Ready to read the maps	14
Figure 11: After reading grids.....	15
Figure 12: Viewing a potential HRU	16
Figure 13: Elevation report (start).....	17
Figure 14: Splitting a landuse	18
Figure 15: Exempting a landuse	18
Figure 16: Creating multiple HRUs by percentage.....	19
Figure 17: About to do step 3	20
Figure 18: Basin report (fragment)	20
Figure 19: HRUs report (fragment)	20
Figure 20: SWAT Setup and Run form	21
Figure 21: Choosing weather sources	22
Figure 22: About to write the SWAT input files	23
Figure 23: Running SWAT.....	24
Figure 24: SWAT Editor.....	25
Figure 25: San Juan output plots.....	26
Figure 25: About to do step 1	27
Figure 26: Selecting the DEM	28
Figure 27: Running Automatic Watershed Delineation.....	29
Figure 28: Watershed delineation complete	30
Figure 29: Ready to read the maps	31
Figure 30: After reading grids.....	32
Figure 31: Creating multiple HRUs by percentage.....	33
Figure 32: About to setup SWAT (step 3).....	34
Figure 33: SWAT Setup and Run form	35
Figure 34: Choosing weather sources	36
Figure 35: About to write the SWAT input files	37
Figure 36: Running SWAT.....	37
Figure 37: Linthipe output plots	39

1 Environment and Tools Required

1. Microsoft Windows (any version, as far as we are aware)
2. Microsoft Access, as the interface uses an Access database
3. A tool like WordPad or NotePad that enables you to read ASCII text files.
4. A tool like WinZip that can uncompressed .zip files

2 Installation

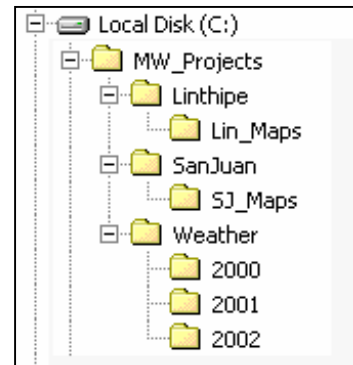
- Install MapWindow from www.mapwindow.org or the distribution CD (the current stable version is 4.4)

- From the CD get **mwswat.zip** located in the *MWSWAT* folder. Place it in *C:\Program Files\MapWindow\Plugins* and unzip it there. It should create a folder *MWSWAT* containing

- o **createHRU.dll** and **MWSWAT.dll** - these constitute the MWSwat plugin
- o **mwswat.mdb** - a database that will be copied for new projects
- o **crop.dat, fert.dat, pest.dat, till.dat, urban.dat** - SWAT data files, in a subfolder *Databases*
- o **swat2005.exe** - this is the SWAT executable
- o **SWAT2005.mdb** - SWAT reference data, in the subfolder *Databases*

- From the CD, folder *Weather*, get **stnlist.txt** and **2000.zip** to **2005.zip**. Place stnlist.txt and the zip files in one folder (e.g. *Weather*) and unzip them. You will get subfolders *2000* to *2005*. The weather data includes precipitation and temperature data.

- From the CD, folder *SwatEditor*, unzip the installation archive and run **Setup.exe** to install the SWAT input file editor. Use the default folder *C:\Program Files\SWAT 2005 Editor* as the installation folder.



- Create a folder to store the digital source data (e.g. *SJ_Maps* sub-folder under each project directory) and refer to the geo-processing document. This is where the DEM, landuse, and soil grids generated according to that document should be placed.

3 Structure and Location of Source Data

The “Step by Step Geo-Processing and Set-up of the Required Watershed Data for MWSWAT (MapWindows SWAT)” document (*Geo-Process.pdf*) describes the pre-

processing of digital map data (DEM, Landuse and Soil). Following that document you can create the required DEM, landuse and soil maps for the two watersheds by clipping and reprojecting the appropriate files from global data. Alternatively you may prefer to skip this step and instead unzip the *Geo_processed.zip* archives in each of the *SJ_Maps* and *Lin_Maps* folders.

After either geo-processing or unzipping the archives you should have at least the following maps available. For the San Juan watershed in *SJ_Maps*: *sj_dem_clip_utm.asc*, *sj_land_clip_utm.tif*, *sj_soil_clip_utm.tif*, and *sj_washd_utm.shp*. For the Linthipe watershed in *Lin_Maps*: *lin_dem_clip_utm.asc*, *lin_land_clip_utm.tif*, *lin_soil_clip_utm.tif* and *lin_out.shp*.

4 Structure and Location of Output Data

We will be establishing a project called *Proj*, say, in a folder *F*. This will create:

1. A folder *F\Proj* containing the project file *proj.mwprj*. If we later want to reopen the project this will be the file we look for. This folder also contains the project database *proj.mdb*.
2. A folder *F\Proj\Scenarios\Default\TxtInOut* that will contain all the SWAT input and output files.
3. A folder *F\Proj\Source* that will contain copies of our input maps and a number of intermediate maps generated during watershed delineation.
4. If we choose to save a SWAT run as *Run1*, say, then a folder *F\Proj\Scenarios\Run1\TxtInOut* will be created (a copy of *F\Proj\Scenarios\Default\TxtInOut*).

5 Setup for Mexico: San Juan River Watershed

1. Start **MapWindow** and check that you have plugins "**Watershed Delineation**" and "**MWSWAT**" available. Both these should be checked in the **Plug-ins** menu.
2. Start **MWSWAT**.
3. The main MWSWAT interface will be displayed. Click the box *New Project*.
4. A browser will be displayed requesting a name for the new project. Type **SJ_MWSwat** in the text box labeled *File name* (under the *SanJuan* folder) See Figure 1.

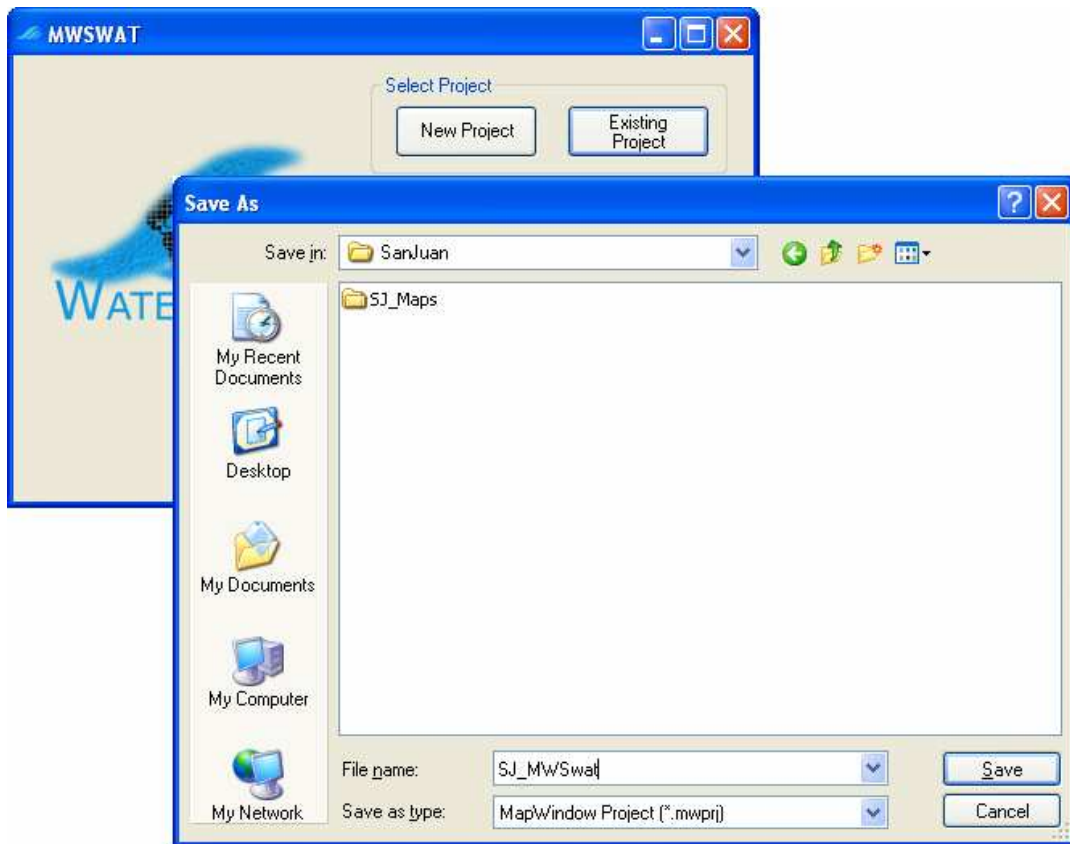


Figure 1: Naming a project

At this point you get a reminder (Figure 2) that (1) all your maps should be in an equal area projection (probably, but not necessarily, UTM); you also need to make sure that the maps units of measure are meters, and (2) that the Watershed Delineation plugin needs to be selected. If some of your maps need re-projecting you can use the MapWindow *GIS Tools* plug-in to do it.

Some of your files may not come with associated projection information, and MapWindow will ask if they have the right projection. If you are sure they have the same projection as your other files you just confirm that they should be loaded and given the same projection as the rest of the project.

If you are ready to proceed with MWSWAT, click *OK*.

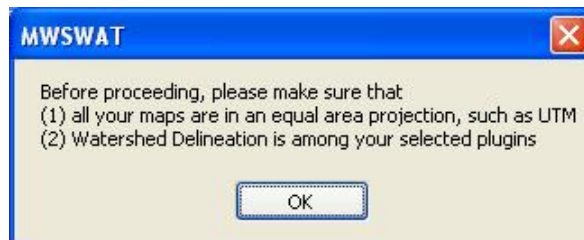


Figure 2: Reminders

The interface now presents a step-by-step configuration to be followed in order to prepare the SWAT simulation, starting with Step 1 (Figure 3).



Figure 3: About to do step 1

5. If you need to set up some database tables for your project, this is a good time to do it, as the database has just been created in the *Proj* folder. See section 8 on *Using Your Own Data*.

5.1 Step 1. Process DEM (Watershed Delineation)

6. To start the automatic watershed delineation click the *Delineate Watershed* button. When the prompt box is opened *Select Base DEM*.
7. Browse to the *SJ_Maps* folder and open the file *sj_dem_clip_utm.asc* (Figure 4)
8. The grid will be loaded and displayed in *MapWindow* (this may take a few minutes). When done, click the *Process DEM* button to activate the *Automatic Watershed Delineation* plug-in.

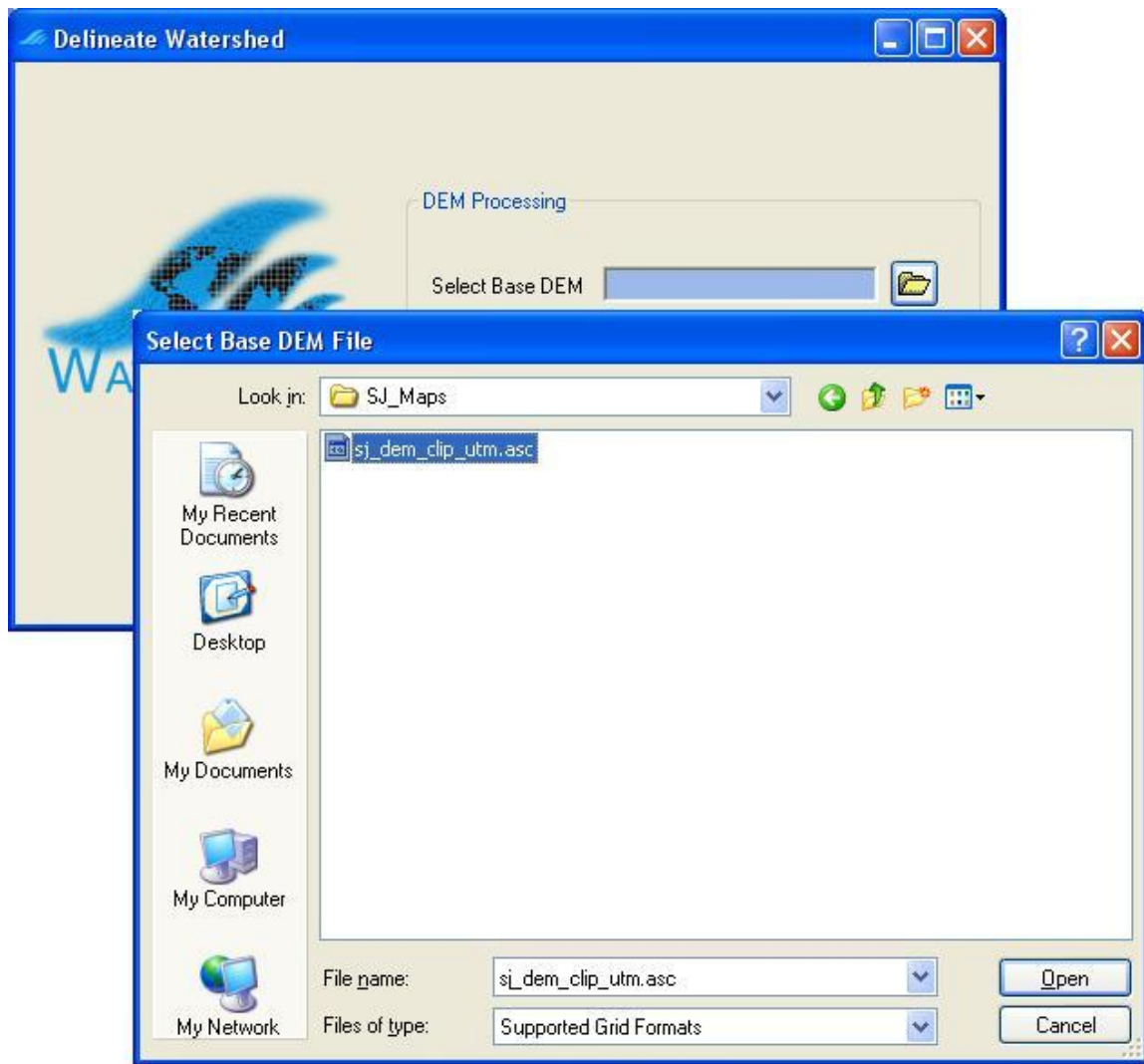


Figure 4: Selecting the DEM

9. The name of the elevation map grid will be displayed in the *DEM* text box on the *Automatic Watershed Delineation (AWD)* dialog box. Make sure the *Elevation Units* are *Meters* (and that this is appropriate for your DEM!) and that the *Burn-in Existing Stream Polyline* option is not checked. For this watershed we have a shape file we will use as a focusing mask; select the *Use a Focusing Mask* option, click the *Use Grid or Shapefile for Mask* option if not already marked, click the file selection icon, and find and open the file *sj_washd_utm.shp* in the *SJ_Maps* folder, and click the first *Run* button (Figure 5). The first part of the watershed delineation tool will be run. This can take a few minutes.

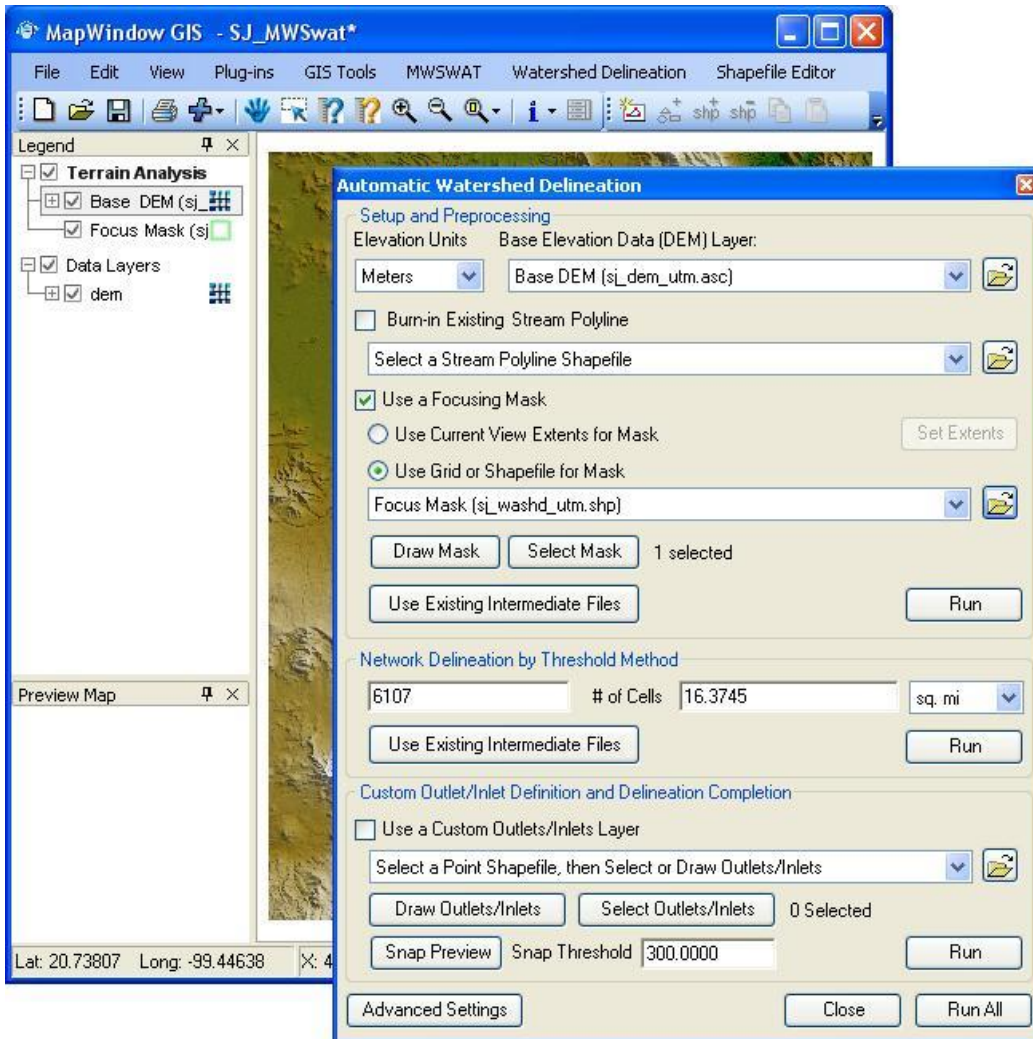


Figure 5: Preprocessing the DEM

10. The threshold size for subbasins is set next. It can be set by area, in various units such as sq km or hectares, or by number (#) of cells. Change the threshold method to use sq km, change the number of sq km to 50, and press *Enter*: the number of cells will be adjusted to the corresponding value (7200). Now click the second *Run* button to delineate the stream network. This can take a few minutes, and when complete the MapWindow display will be as illustrated in Figure 6. (You may have to move the Focus Mask entry above the Base DEM entry in the Legend panel to get exactly this view.)

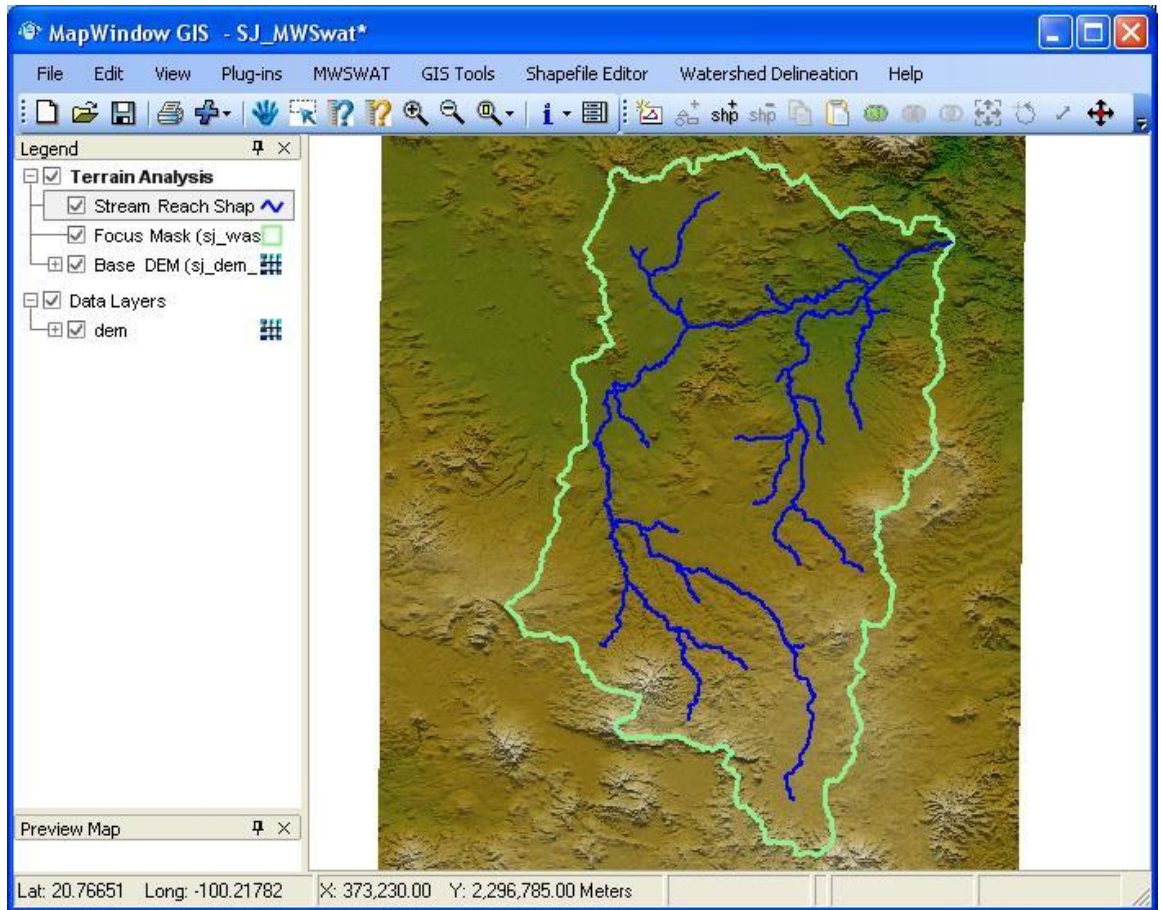


Figure 6: Stream networks displayed

11. To complete the watershed delineation we need to select an outlet point, which will be in the form of a shapefile. In the AWD form make sure that *Use a Custom Outlets/Inlets Layer* is checked, and use MapWindow to zoom into the area of the map where you want to locate the outlet. Click *Draw Outlets/Inlets*. Confirm in the new window that pops up that you want to create a new outlets/inlets shapefile, and in the next dialogue give it the name sj_out. Use the mouse to mark the outlet point on the MapWindow display (where the stream network meets the mask boundary), and click *Done* (Figure 7).
12. *In version 4.4 of AWD there is a bug which causes the network delineation parameters to be reset when the Outlets/Inlets shapefile is selected. If this happens, reset the number of cells to 7200 and press Enter.*
13. Then in the AWD form click the third *Run*. The outlets and subbasin delineation will be performed, which can take a few minutes, and the MapWindow display will show the river network draining to the outlet point and the subbasin boundaries. The AWD part is now completed and you can *Close* the AWD form (Figure 8).

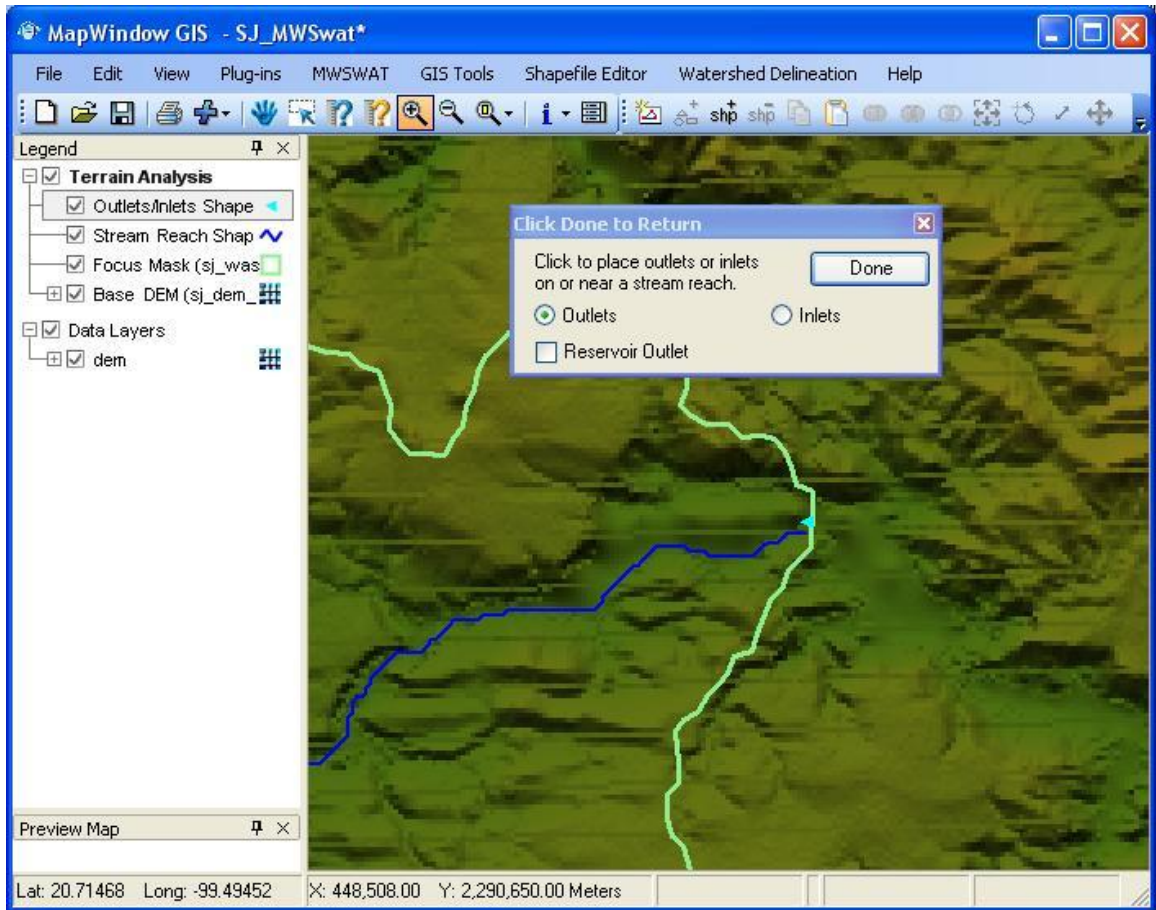


Figure 7: Defining the outlet point

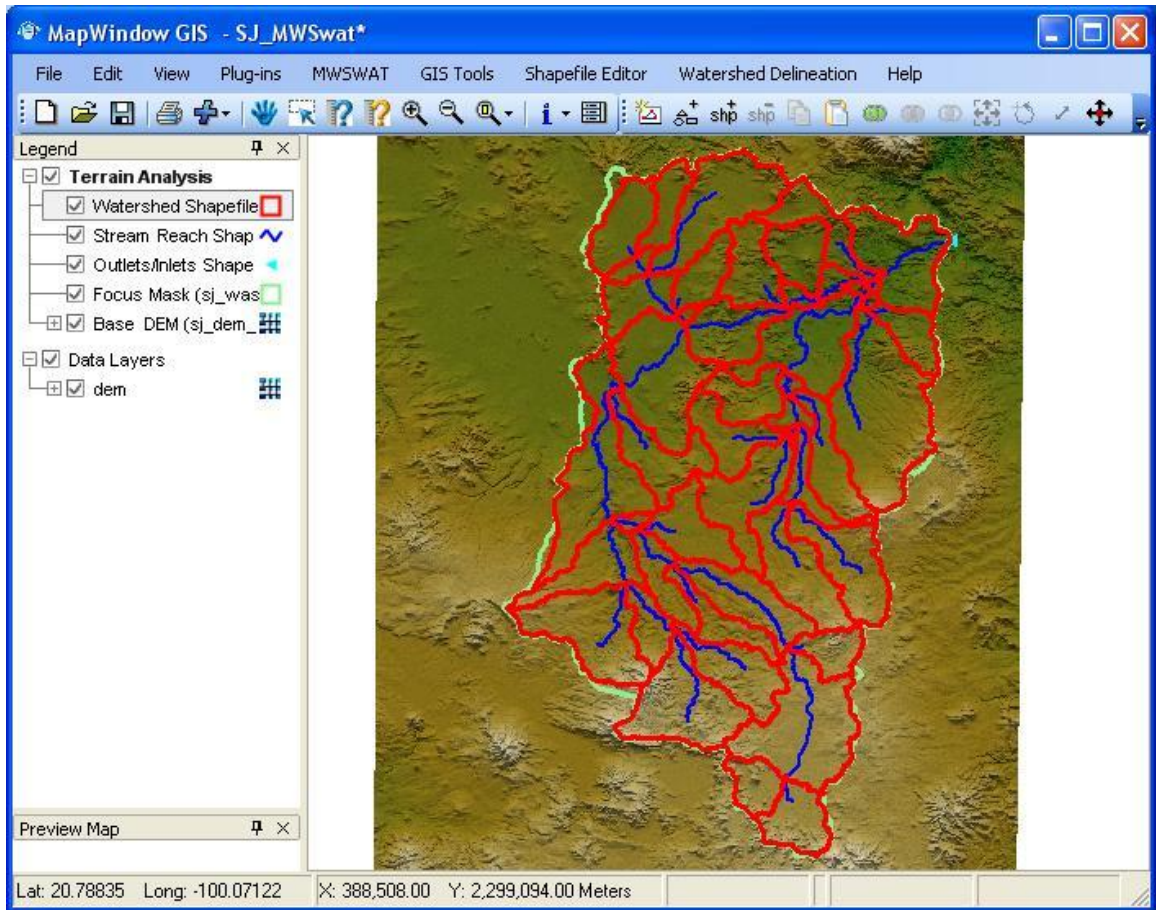


Figure 8: Watershed delineation complete

14. The MWSWAT interface will mark the *Process DEM* as done and enable the second step (Figure 9).
15. It is strongly recommended to save the project (via the menu of MapWindow) at this stage.



Figure 9: About to do step 2

5.2 Step 2. Create HRUs

16. Having calculated the basins we want to calculate the details of the Hydrological Response Units (HRUs) that are used by SWAT. We can divide basins into smaller pieces each of which has a particular soil/landuse(crop)/slope range combination.
17. To do this we click *Create HRUs*, select *sj_land_utm.tif* as the *Landuse Map*, select *sj_soil_utm.tif* as the *Soil Map*, select *global_landuses* as the *Landuse Table*, and select *global_soils* as the *Soil Table*. . The last two will take a few seconds as the relevant database tables are read.
18. We will form HRUs based on slope as well as landuse and soil. We add an intermediate point for slopes (e.g. 10) to divide HRUs into those with average slopes for 0-10% and those with average slopes in the range 10% to the top limit. Type 10 in the box and click *Insert*. The *Slope bands* box shows the intermediate limit is inserted.
19. To read in the data from the DEM, landuse, soil and slope maps and prepare to calculate HRUs, click *Read* (Figure 10). This may take a few minutes.

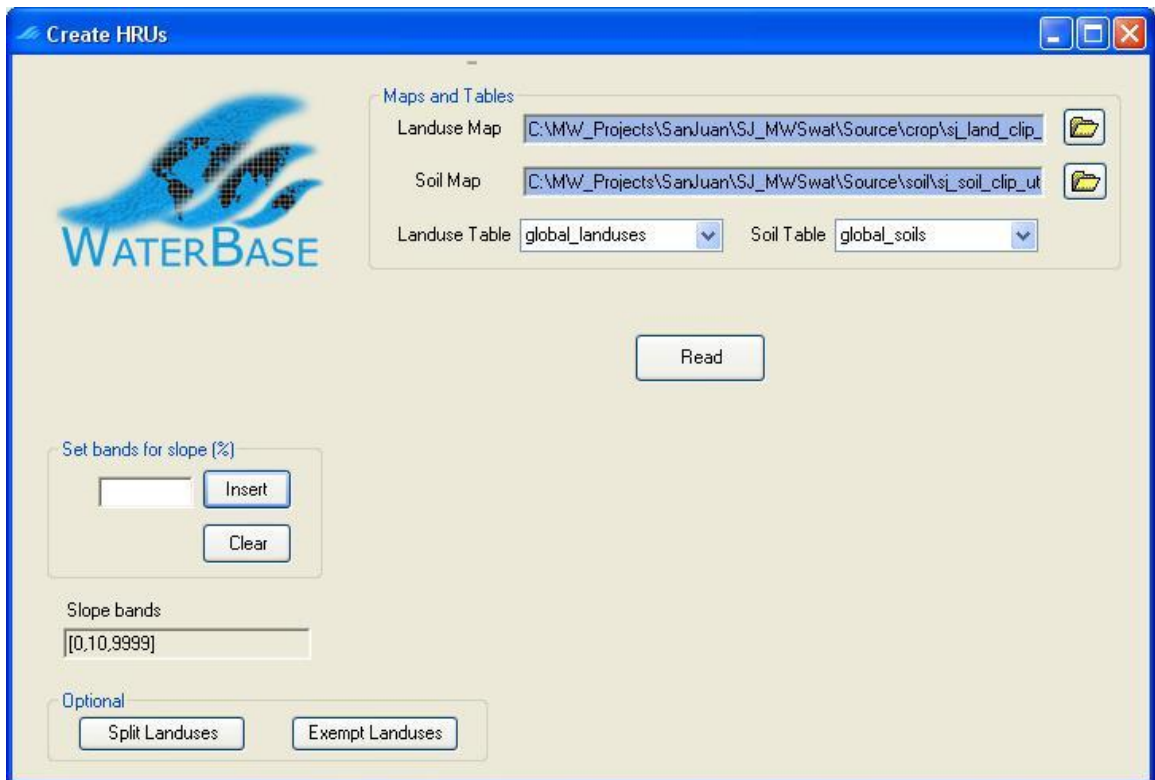



Figure 10: Ready to read the maps

20. After reading the grids you will notice a number of changes to the MapWindow display (Figure 11):

- The subbasins have been numbered
- A *Slope bands* map has been created and added. This allows you to see where the areas of the two slope bands selected for this project are located. If no intermediate slope limits are chosen this map is not created.
- The legends for the landuse map *sj_land_utm* and the soil map *sj_soil_utm* include the landuse and soil categories from the SWAT database.
- A shapefile *FullHRUs* has been created and added. This allows you to see where in each subbasin the potential Hydrological Response Units (HRUs) are physically located. If, for example, we zoom in on subbasin 36, in the Legend panel select (left button) FullHRUs, open its attribute table (right button), set the mouse to *Select* (MapWindow toolbar ) and click on the box just above the number 36, then we get a view like Figure 12. We see that this potential HRU is composed of two parts, has the landuse *FOEN*, the soil *I-K-E-c-4749*, and the slope band *0-10*. Its area of 396.5ha is only 4.1% of the subbasin.

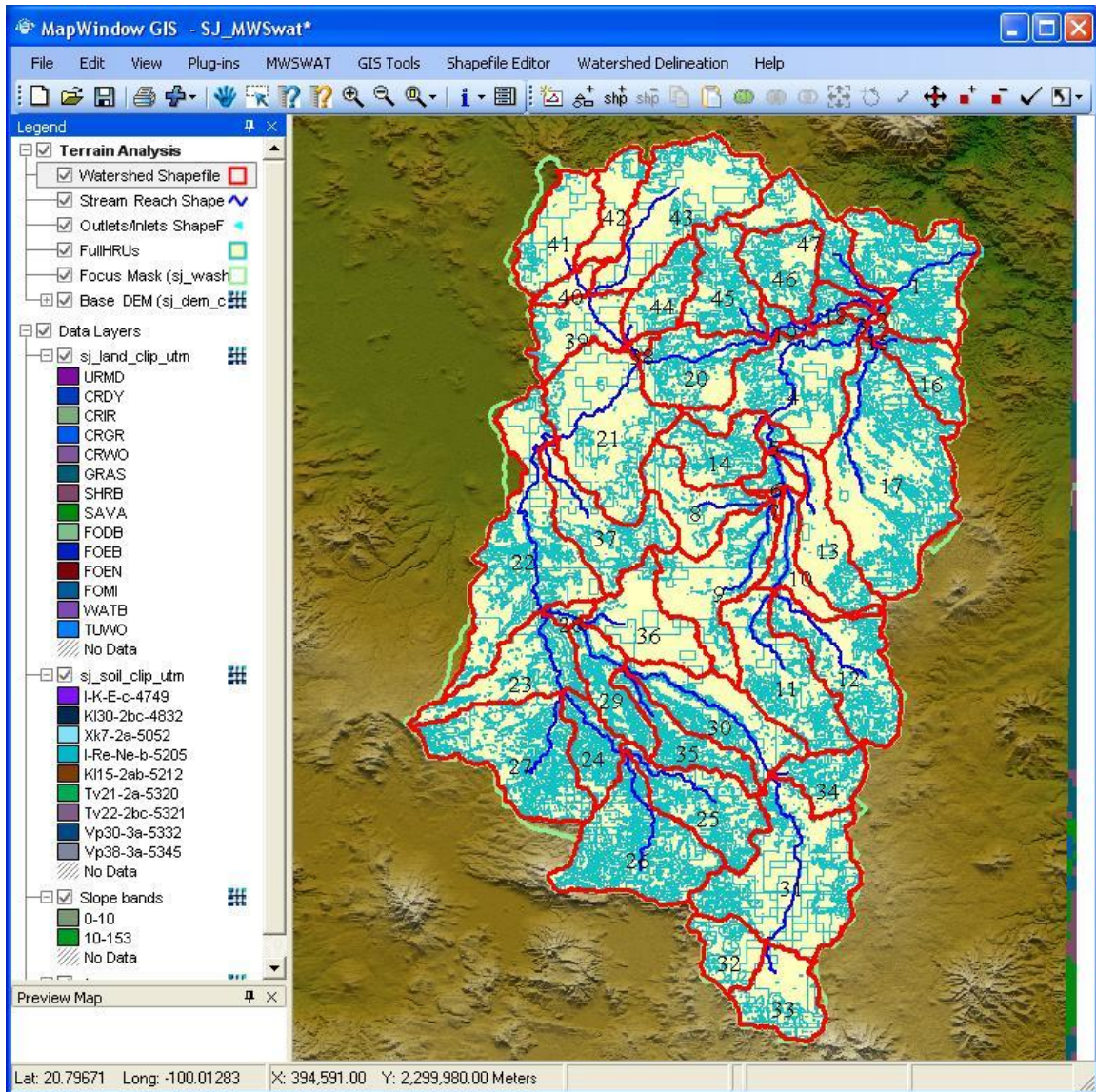


Figure 11: After reading grids

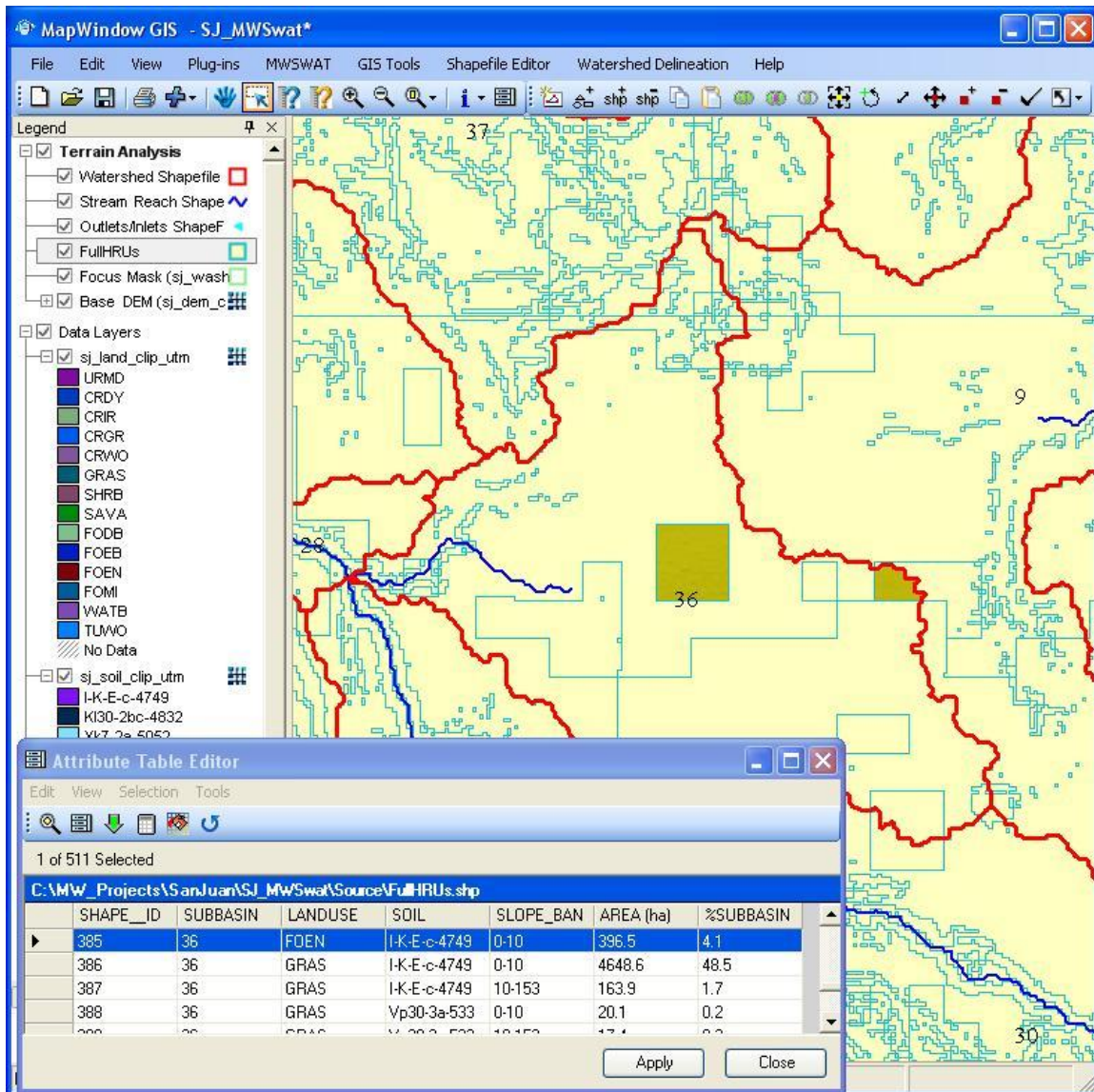


Figure 12: Viewing a potential HRU

21. Before we continue with HRU definition, if we look at the main MWSWAT window we see that a new item *Reports* is available and we can choose to view just one report at this point, which is the *Elevation* report. This gives information about how much land is at each elevation from the lowest to the highest, both for the watershed as a whole and for each subbasin (Figure 13).

Elevation report for the watershed			Thursday, December 13, 2007 12:08:48 AM
Statistics: All elevations reported in meters			
Minimum elevation:	1575		
Maximum elevation:	3313		
Mean elevation:	2228.76787366251		
Standard deviation:	302.515630179528		
Elevation	% area up to elevation	% area of watershed	
1575	0.00	0.00	
1576	0.00	0.00	
1577	0.00	0.00	
1578	0.00	0.00	
1579	0.00	0.00	
1580	0.11	0.10	
1581	0.11	0.00	
1582	0.11	0.00	
1583	0.12	0.00	
1584	0.12	0.01	
1585	0.13	0.00	
1586	0.13	0.00	
1587	0.13	0.00	

Figure 13: Elevation report (start)

22. At this point we have the options to split landuses, and to exempt landuses, both of which will affect how HRUs are defined.

- Splitting landuses allows us to define more precise landuses than our landuse map provides. If, say, we know that in this basin 60% of the CRIR (Irrigated cropland and pasture) is used for corn, we could split CRIR into 60% CORN and 40% CRIR (Figure 14).
- Exempting landuses allows us to ensure that a landuse is retained in the HRU calculation even if it falls below the thresholds we will define later. For example, we might decide to exempt the urban landuse URMD (Figure 15).

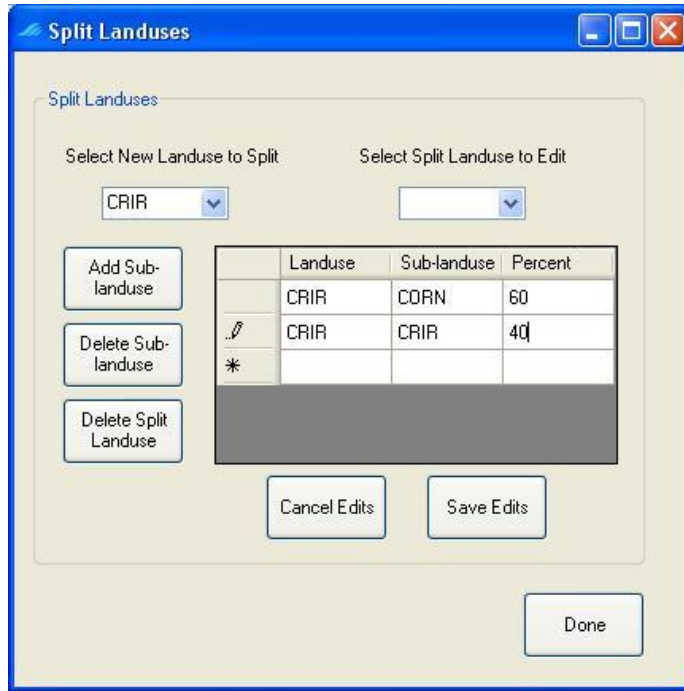


Figure 14: Splitting a landuse

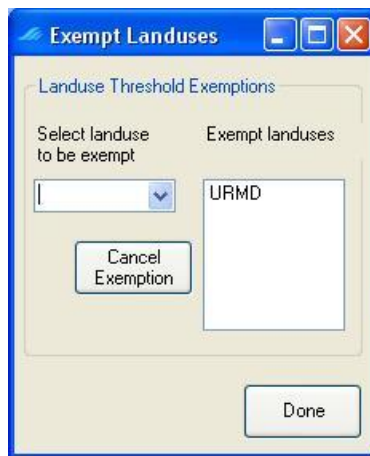


Figure 15: Exempting a landuse

In this example we will not split or exempt any landuses. Now we need to exclude HRUs that are insignificant by considering percentage thresholds or area thresholds. This is the "multiple" HRU option. The "single" option just uses each basin as one HRU, giving it the dominant soil, landuse and slope range for that basin.

23. Once all the data has been read in and stored, the *Single/Multiple HRU* choice is enabled. Select *Multiple HRUs*, and then select *By Percentage*. Now select thresholds for landuse, soil and slope. The idea of this option is that we will ignore any potential HRUs for which the landuse, soil or slope is less than the selected threshold, which is its percentage in the subbasin. The areas of HRUs

that are ignored are redistributed proportionately amongst those that are retained. The value of 33 as the maximum we can choose for landuse indicates that there is a subbasin where the max value for a landuse is 33%: if we chose a higher value than 33% we would be trying to ignore all the landuse categories in that subbasin. Hence 33% is the min across the subbasins of the max landuse percentage in each subbasin. Select 20% for landuse, by using the slider or by typing in the box, and click *Go*. The interface then computes the min-max percentage for a soil as 51%. Select 10 for Soil, click *Go*, 5 for slope, and click *Create HRUs* (Figure 16). It should report 195 HRUs formed in 47 subbasins. Click *OK*.

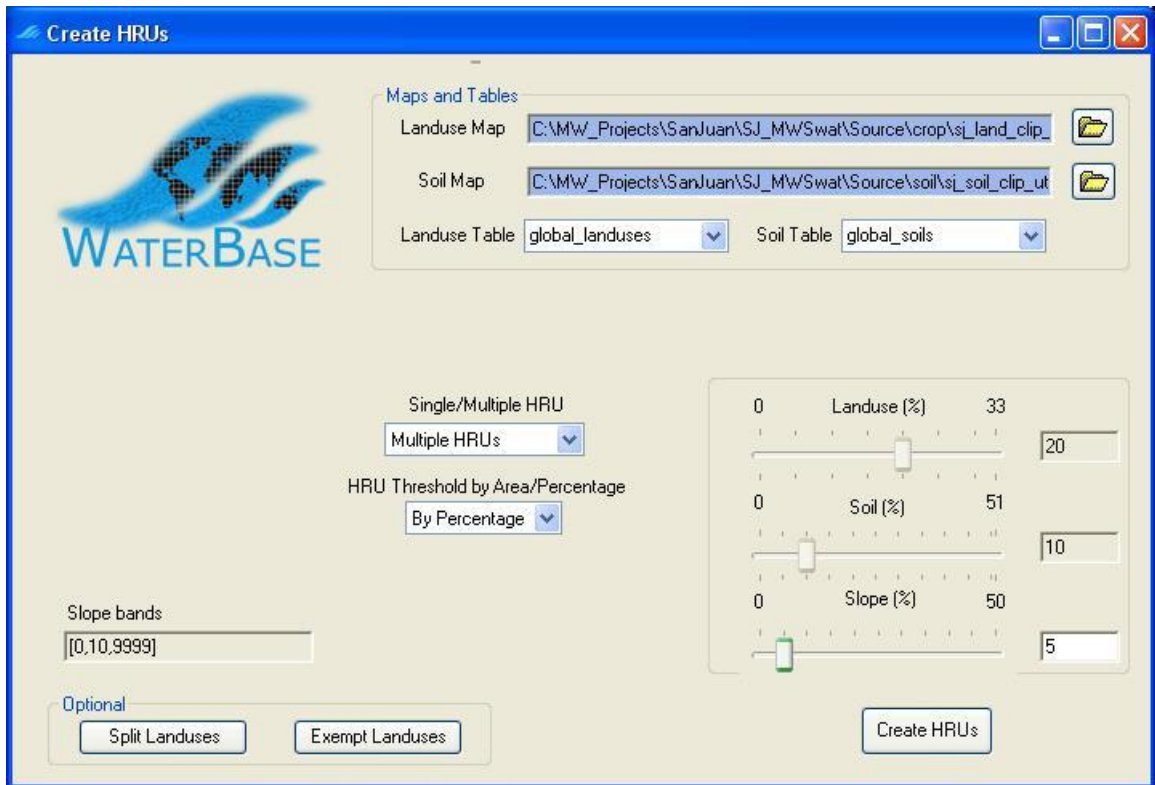


Figure 16: Creating multiple HRUs by percentage

24. *Create HRUs* is now reported as done and the third step is enabled (Figure 17). If you look at the *Reports* now available you will find that there is a *Basin* report that lists the landuse, soil and slope-band areas for each subbasin (Figure 18) and also an *HRUs* report that only includes the landuses, soils and slope bands left after HRU selection, and also gives details of the HRUs that have been formed (Figure 19). If you wish to change the HRU thresholds then you can click the *Create HRUs* button again, change the thresholds and/or the landuses to be split or exempted, and rerun the *Create HRUs* step.



Figure 17: About to do step 3

		Area [ha]	%watershed	%Subbasin
Subbasin 1		15079.15	3.65	
Landuse	SHRB	6943.05	1.68	46.04
	GRAS	8136.10	1.97	53.96
Soil	Vp30-3a-5332	3127.78	0.76	20.74
	K130-2bc-4832	11297.21	2.73	74.92
	Xk7-2a-5052	654.17	0.16	4.34
Slope	0-10	6951.38	1.68	46.10
	10-153	8127.77	1.97	53.90

Figure 18: Basin report (fragment)

		Area [ha]	%watershed	%Subbasin
Subbasin 1		15079.15	3.65	
Landuse	SHRB	6943.05	1.68	46.04
	GRAS	8136.10	1.97	53.96
Soil	Vp30-3a-5332	3210.23	0.78	21.29
	K130-2bc-4832	11868.93	2.87	78.71
Slope	0-10	7010.74	1.69	46.49
	10-153	8068.41	1.95	53.51
HRUs:				
1	SHRB/Vp30-3a-5332/10-153	800.00	0.19	5.31
2	SHRB/Vp30-3a-5332/0-10	1384.72	0.33	9.18
3	SHRB/K130-2bc-4832/10-153	2366.66	0.57	15.69
4	SHRB/K130-2bc-4832/0-10	2391.66	0.58	15.86
5	GRAS/Vp30-3a-5332/10-153	381.36	0.09	2.53
6	GRAS/Vp30-3a-5332/0-10	644.15	0.16	4.27
7	GRAS/K130-2bc-4832/10-153	4520.39	1.09	29.98
8	GRAS/K130-2bc-4832/0-10	2590.20	0.63	17.18

Figure 19: HRUs report (fragment)

25. It is strongly recommended to save the project (via the menu of MapWindow) at this stage.

5.3 Step 3. SWAT Setup and Run

26. At this point almost everything is ready to write the SWAT input files and run SWAT. Click *SWAT Setup and Run* (Figure 20).

The screenshot shows the 'SWAT Setup and Run' dialog box. The 'Period of simulation' section has 'Start date' set to 1 January 2000 and 'Finish date' set to 31 December 2001. The 'Weather Sources' section has the 'Choose' button selected. The 'Rainfall/Runoff/ Routing' section has 'Daily rain/CN/Daily' selected. The 'Rainfall distribution' section has 'Skewed normal' selected. The 'Potential ET method' section has 'Penman-Monteith' selected. The 'Crack Flow' section has 'Not active' selected. The 'Channel water routing method' section has 'Variable storage' selected. The 'Channel dimensions' section has 'Not active' selected. The 'Stream water quality processes' section has 'Active' selected. The 'Printout frequency' section has 'Monthly' selected. The 'Write files' section has several checkboxes, with 'Write all files' and 'Write bsn file' checked. The 'Run SWAT' button is highlighted.

Figure 20: SWAT Setup and Run form

27. The first thing to do on this form is to set the period for the SWAT run. Select 1 January 2000 as the *Start date* and 31 December 2001 as the *Finish date*.
28. Next we have to choose the source of weather data. Click the *Choose* button for *Weather Sources*. MWSWAT is set up to use actual weather data for maximum and minimum temperature and precipitation, and a weather generator file that will simulate other weather factors (solar radiation, wind speed, and relative humidity). So you need to provide a weather generator file for your basin, and data for precipitation and temperature. Normally for the first run you would choose the option *Global files*, and choose *Weather\stnlist.txt* as the *Weather Stations File*. Then MWSWAT looks for the nearest 6 weather stations in that file, generates the temperature and precipitation data for them, and then associates each subbasin with the nearest weather station from amongst those six. We have in this case decided to use just one of those six as the weather station for the

whole watershed, and adopting the procedure described in Section 7.8, have made a local list of stations, *sanjuan1.txt* (containing just one station entry copied from *Weather\stnlist.txt*) in the *SJ_Maps* folder, and copied the two files *765850.pcp* and *765850.tmp*, made in the *TxtInOut* folder in an earlier run using the global files option, to the *SJ_Maps* folder. 765850 is the station identifier of the weather station with an entry in *sanjuan1.txt*. The local files option allows us to control more precisely what weather stations are used, and also means that the setup is much faster as the .pcp and .tmp files do not need to be created.

29. Choose *SJ_Maps\sj.wgn* as the *Weather Generator File* (Figure 21). Click *Done*.

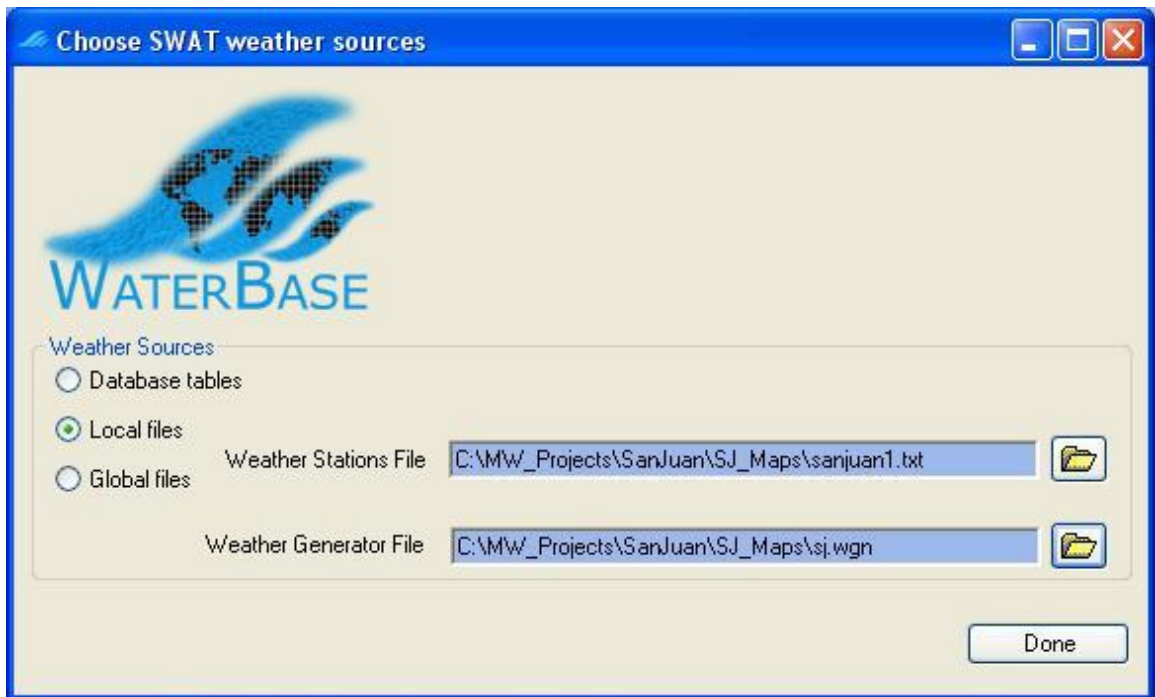


Figure 21: Choosing weather sources

30. Click *Write all files* in the list box (Figure 22) and click the *Write files* button. This can take a few minutes, especially if your simulation covers several years, but is fast in this case as the weather data is prepared already.

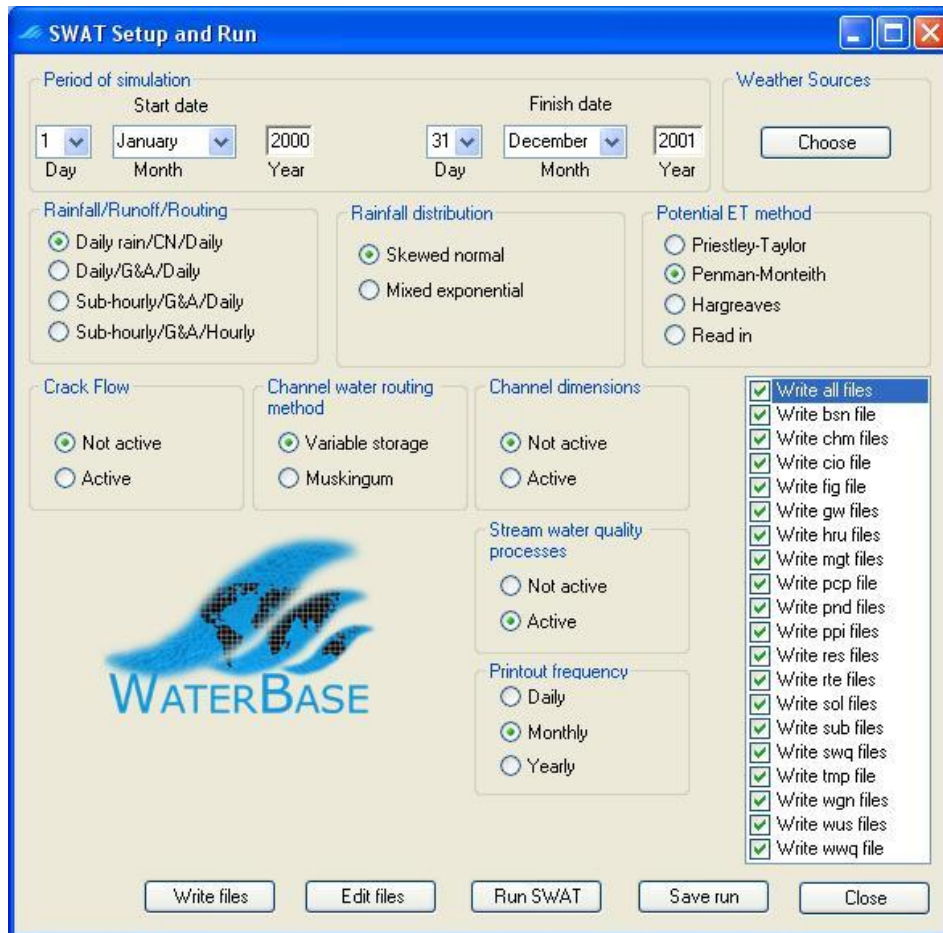


Figure 22: About to write the SWAT input files

31. The interface reports that the SWAT input files are written. They can be found in the *TxtInOut* folder.
32. Click *Run SWAT* to launch the SWAT executable in a DOS prompt window (Figure 23).

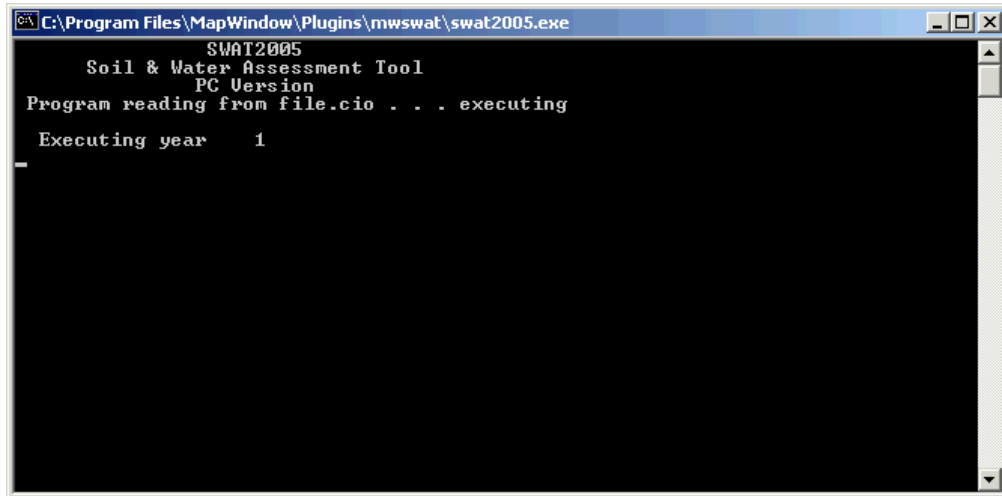


Figure 23: Running SWAT

33. When done a message box will say that SWAT was run successfully, or that it failed. Click *OK*.
34. To see what happened if it failed you need to rerun in a DOS command window. To do this:
 - Copy the file
`C:\Program Files\MapWindow\Plugins\MWSWAT\swat2005.exe`
 to the project's *TxtInOut* folder.
 - Start a DOS command window (use start menu -> *Run...* , type *cmd* and click *OK*, or use start menu -> *All Programs* -> *Accessories* -> *Command Prompt*).
 - Use the *CD* command to change to the project's *TxtInOut* folder.
 - Use the command *swat2005* to run SWAT in this window. The error message will remain visible and will specify the line of SWAT code where the error occurred. The error message may suggest which SWAT input file needs to be checked, or you may be able to get more information from examining the SWAT source code, but probably you will need to report the problem to WaterBase technical assistance.
35. You can save the SWAT run if you wish using the *Save run* button. This in fact copies *F\Proj\Scenarios\Default\TxtInOut* to *F\Proj\Scenarios\Save\TxtInOut* if you choose to save as *Save1*. If *Save1* already exists it is overwritten. This button is live as soon as the *SWAT Setup and Run* form is opened, so you can if you wish use the form to save an earlier run before you start writing the files for this one. (But note that if you changed the watershed delineation or the HRU parameters the report files will be wrong, so in this case you should do the save manually before starting the interface.)

36. You can use the *Edit files* button to run the SWAT Editor to edit any of the input files and database files if you wish. See Figure 24. Note that the parameters for the editor should be set as follows:

- SWAT Project Geodatabase: *F\Proj\Proj.mdb*
- SWAT Parameter Geodatabase:

C:\Program Files\MapWindow\Plugins\MWSWAT\Databases\SWAT2005.mdb

- SWAT Executable folder:

C:\Program Files\MapWindow\Plugins\MWSWAT

(Note the final “\”, which must not be omitted.)

See the SWAT documentation for information on using the SWAT Editor.

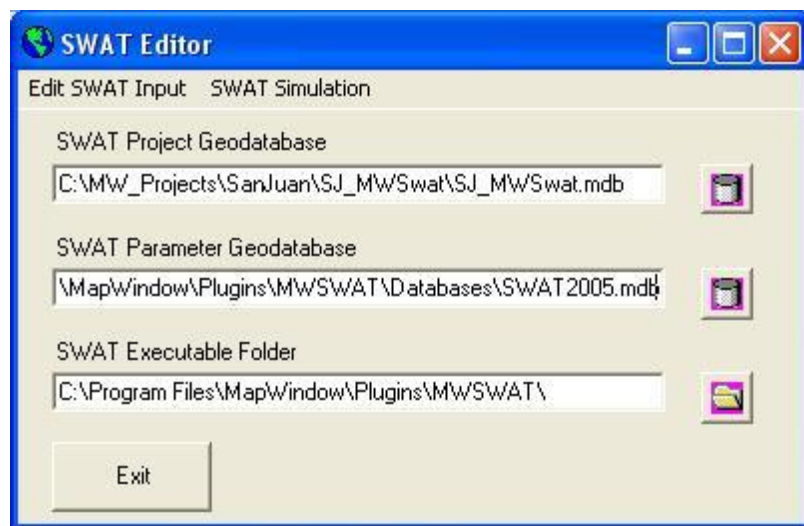


Figure 24: SWAT Editor

From the reach output file, the monthly values for the outlet were extracted and the following plots (Figure 25) created (note: precipitation values for San Juan are for the two nearest rain gauges).

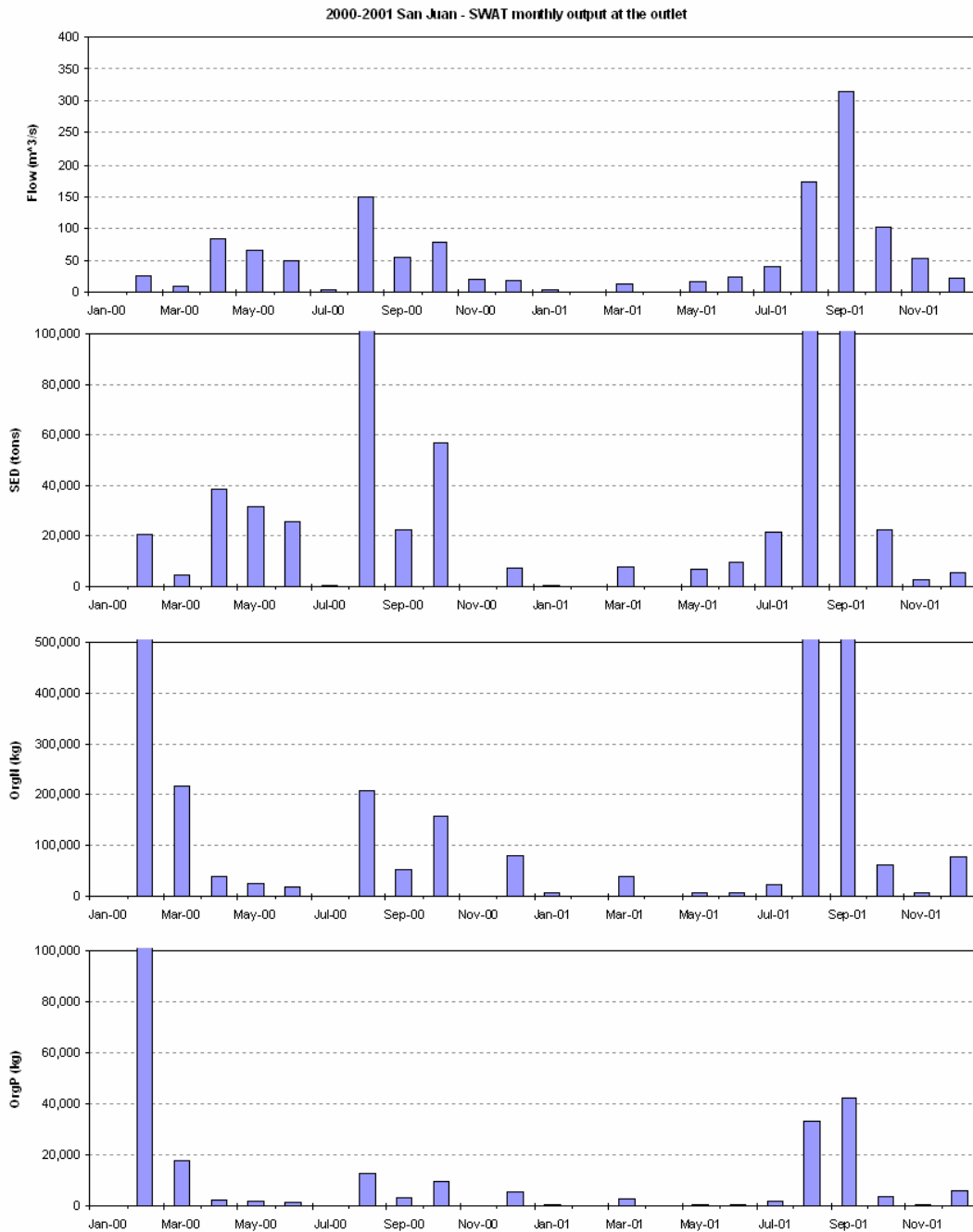


Figure 25: San Juan output plots

6 Setup for Malawi: Linthipe Watershed

1. Start **MapWindow** and check that you have plugins "**Watershed Delineation**" and "**MWSWAT**" available. Both these should be checked.
2. Start **MWSWAT**.

3. The main interface will be displayed. Click the box beside *New Project*.
4. A browser will be displayed requesting a name for the new project. Type **Lin_MWSwat** in the text box labeled *File Name* (under the *Linthipe* folder).

At this point you get a reminder that (1) all your maps should be in an equal area projection (probably, but not necessarily, UTM); you also need to make sure that the maps units of measure are meters, and (2) that the Watershed Delineation plugin needs to be selected. If some of your maps need re-projecting you can use the MapWindow *GIS Tools* plug-in to do it.

Some of your files may not come with associated projection information, and MapWindow will ask if they have the right projection. If you are sure they have the same projection as your other files you just confirm that they should be loaded and given the same projection as the rest of the project.

If you are ready to proceed with MWSWAT, click *OK*.

The interface now presents a step-by-step configuration to be followed in order to prepare the SWAT simulation, starting with Step 1 (Figure 26).



Figure 26: About to do step 1

5. If you need to set up some database tables for your project, this is a good time to do it, as the database has just been created in the *Proj* folder. See section 8 on *Using Your Own Data*.

6.1 Step 1. Process DEM (Watershed Delineation)

6. To start the automatic watershed delineation click the *Delineate Watershed* button. When the prompt box is opened *Select Base DEM*.

7. Browse to the *Lin_Maps* folder and open the file *lin_dem_utm.asc* (Figure 27).
8. The grid will be loaded and displayed in *MapWindow* (this may take a few minutes). When done, click the *Process DEM* button to activate the *Automatic Watershed Delineation* plug-in.

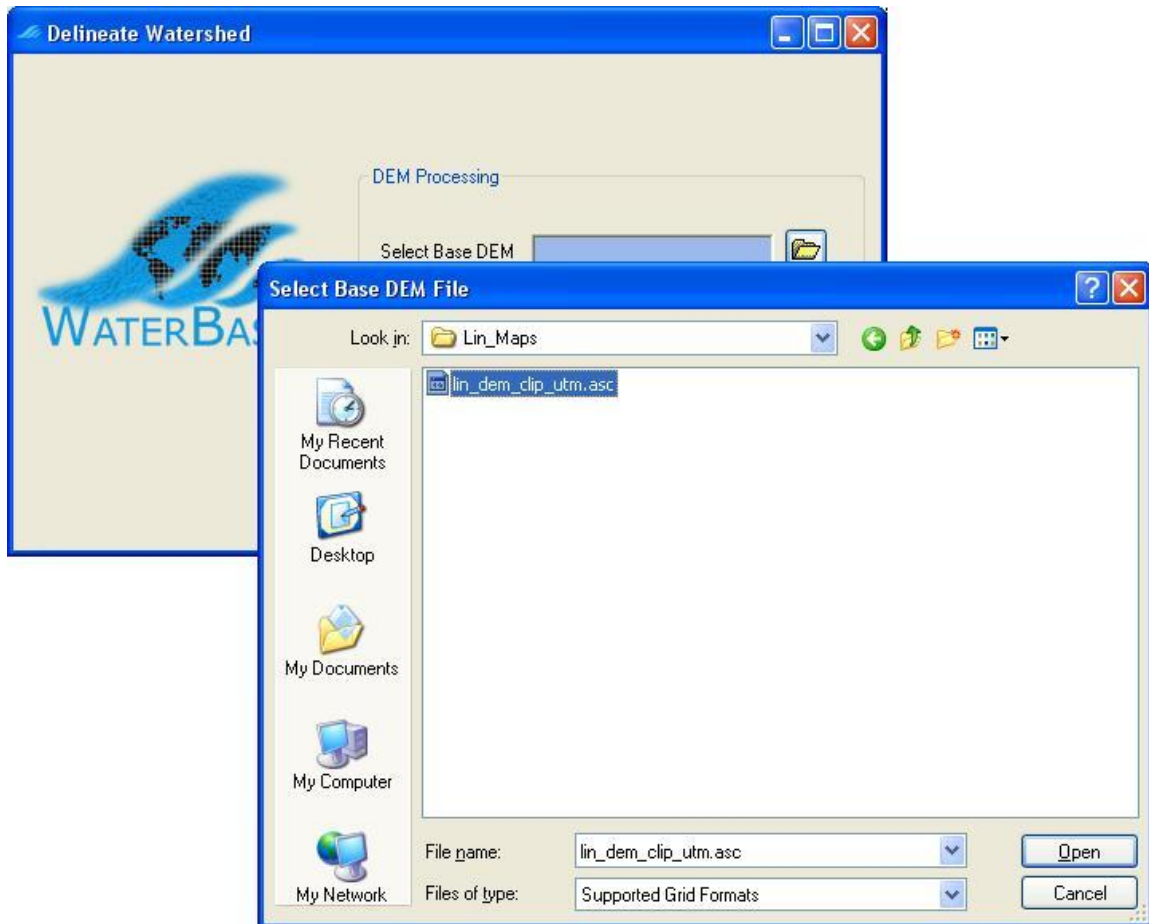


Figure 27: Selecting the DEM

9. The name of the elevation map grid will be displayed in the *DEM* text box on the *Automatic Watershed Delineation* (AWD) dialog box. Make sure the *Elevation Units* are *Meters* (and that this is appropriate for your DEM!) and that the *Burn-in Existing Stream Polyline* and *Use Focusing Mask* options are not checked. The threshold size for subbasins is set next. It can be set by area, in various units such as sq km or hectares, or by number (#) of cells. Change the threshold method to use sq km, change the number of sq km to 150, and press Enter: the number of cells will be adjusted to the corresponding value (21600).
10. To complete the watershed delineation we need to select an outlet point, which will be in the form of a shapefile. In the AWD form make sure that *Use a Custom Outlets/Inlets Layer* and browse for the file *lin_out.shp*.
11. In version 4.4 of AWD there is a bug which causes the network delineation parameters to be reset when the *Outlets/Inlets* shapefile is selected. If this happens, reset the number of cells to 21600 and press Enter (Figure 28).

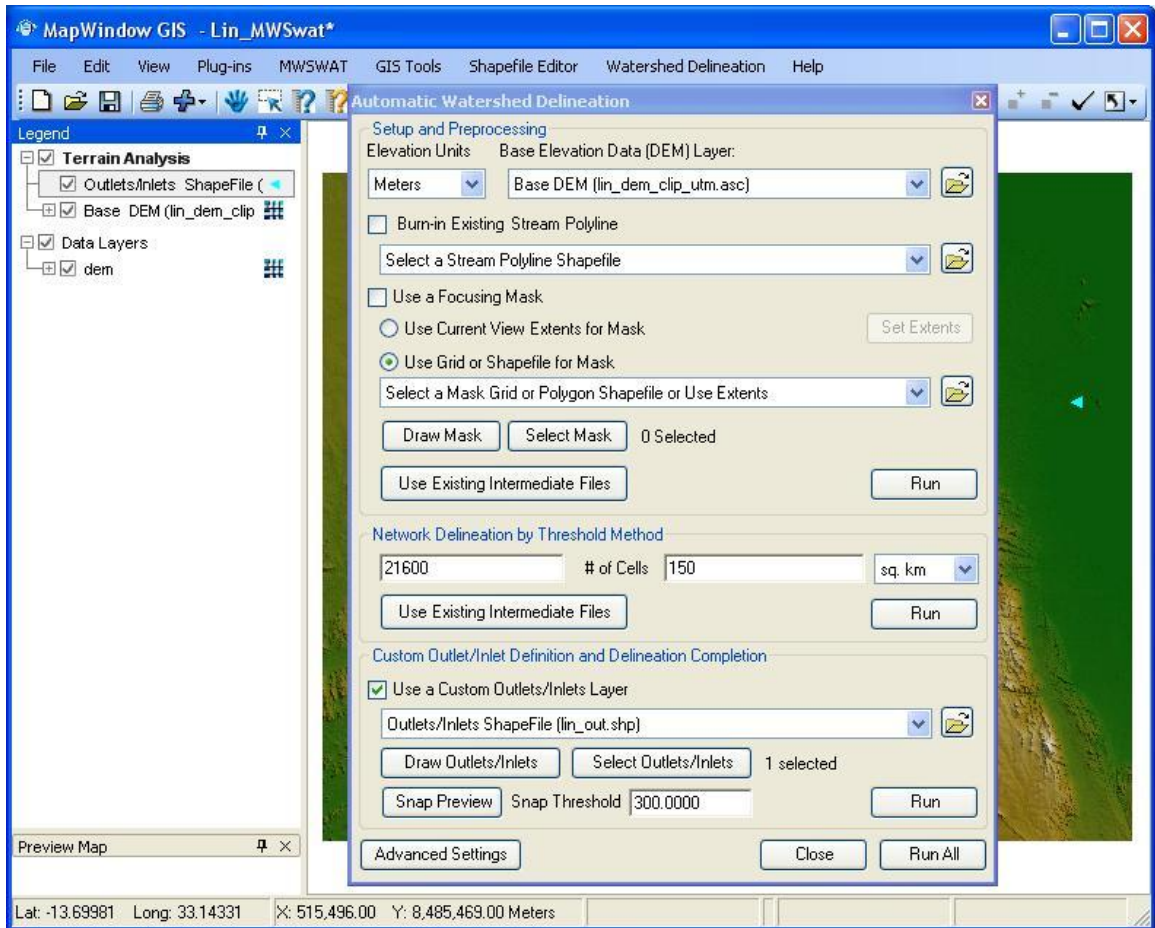


Figure 28: Running Automatic Watershed Delineation

12. Click *Run All*. All the watershed delineation steps will be performed, which can take a few minutes, and the MapWindow display will show the river network draining to the outlet point and the subbasin boundaries. The AWD part is now completed and the AWD form will be closed automatically. (Figure 29).
13. The MWSWAT interface will mark the *Process DEM* as done and enable the second step. It's strongly recommended to save your project at this point.

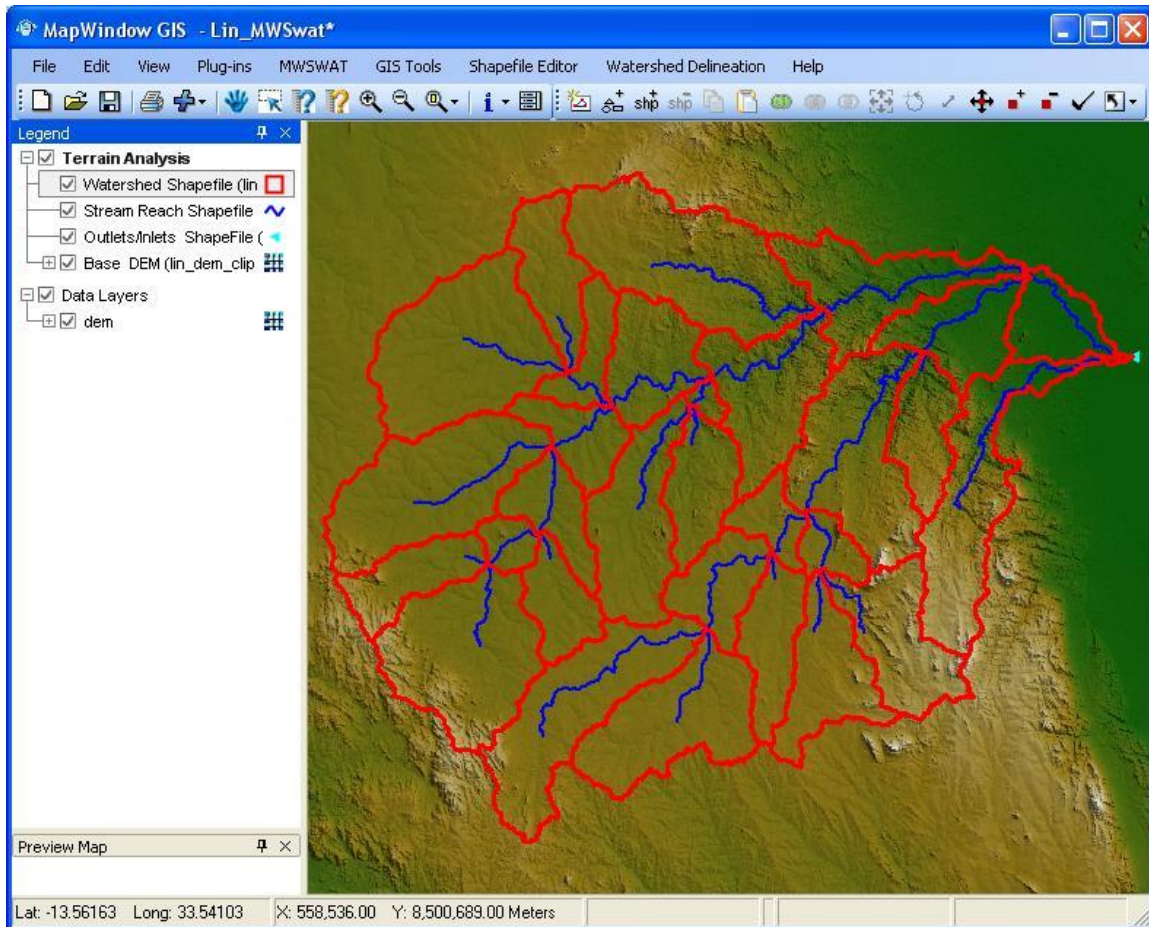


Figure 29: Watershed delineation complete

6.2 Step 2. Create HRUs

14. Having calculated the basins we want to calculate the details of the Hydrological Response Units (HRUs) that are used by SWAT. We can divide basins into smaller pieces each of which has a particular soil/landuse(crop)/slope range combination.
15. To do this we click *Create HRUs*, select *lin_land_clip_utm.tif* as the *Landuse Map*, select *lin_soil_clip_utm.tif* as the *Soil Map*, select *global_landuses* as the *Landuse Table*, and select *global_soils* as the *Soil Table*. The last two will take a few seconds as the relevant database tables are read.
16. We will form HRUs based on slope as well as landuse and soil. We add an intermediate point for slopes (e.g. 10) to divide HRUs into those with average slopes for 0-10% and those with average slopes in the range 10% to the top limit. Type 10 in the box and click *Insert*. The *Slope bands* box shows the intermediate limit is inserted.

17. To read in the data from the DEM, landuse, soil and slope maps and prepare to calculate HRUs, click *Read* (Figure 30). This may take a few minutes.

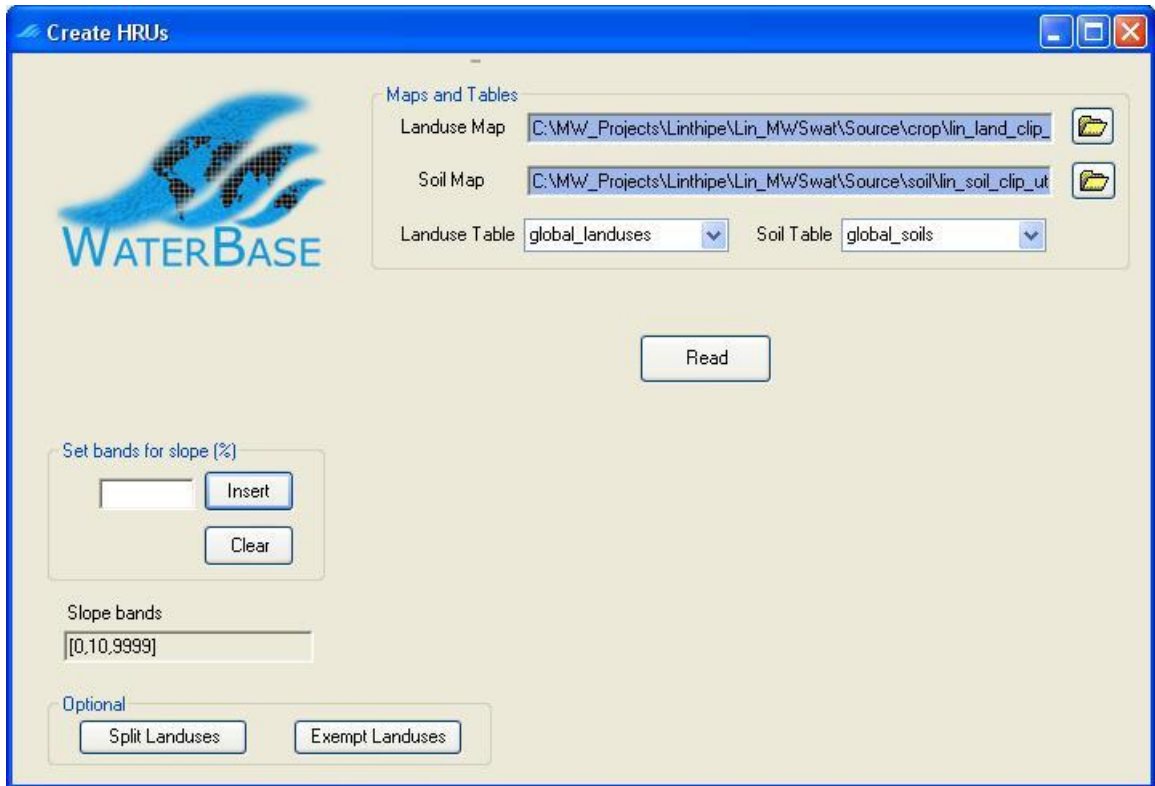


Figure 30: Ready to read the maps

18. After reading the grids you will notice a number of changes to the MapWindow display (Figure 31):
- The subbasins have been numbered
 - A *Slope bands* map has been created and added. This allows you to see where the areas of the two slope bands selected for this project are located. If no intermediate slope limits are chosen this map is not created.
 - The legends for the landuse map *lin_land_clip_utm* and the soil map *lin_soil_clip_utm* include the landuse and soil categories from the SWAT database.
 - A shapefile *FullHRUs* has been created and added. This allows you to see where in each subbasin the potential Hydrological Response Units (HRUs) are physically located.
19. At this point we have the options to split landuses, and to exempt landuses, both of which will affect how HRUs are defined.
- Splitting landuses allows us to define more precise landuses than our landuse map provides.
 - Exempting landuses allows us to ensure that a landuse is retained in the HRU calculation even if it falls below the thresholds we will define later.

20. In this example we will not split or exempt any landuses. Now we need to exclude HRUs that are insignificant by considering percentage thresholds or area thresholds. This is the "multiple" HRU option. The "single" option just uses each basin as one HRU, giving it the dominant soil, landuse and slope range for that basin.

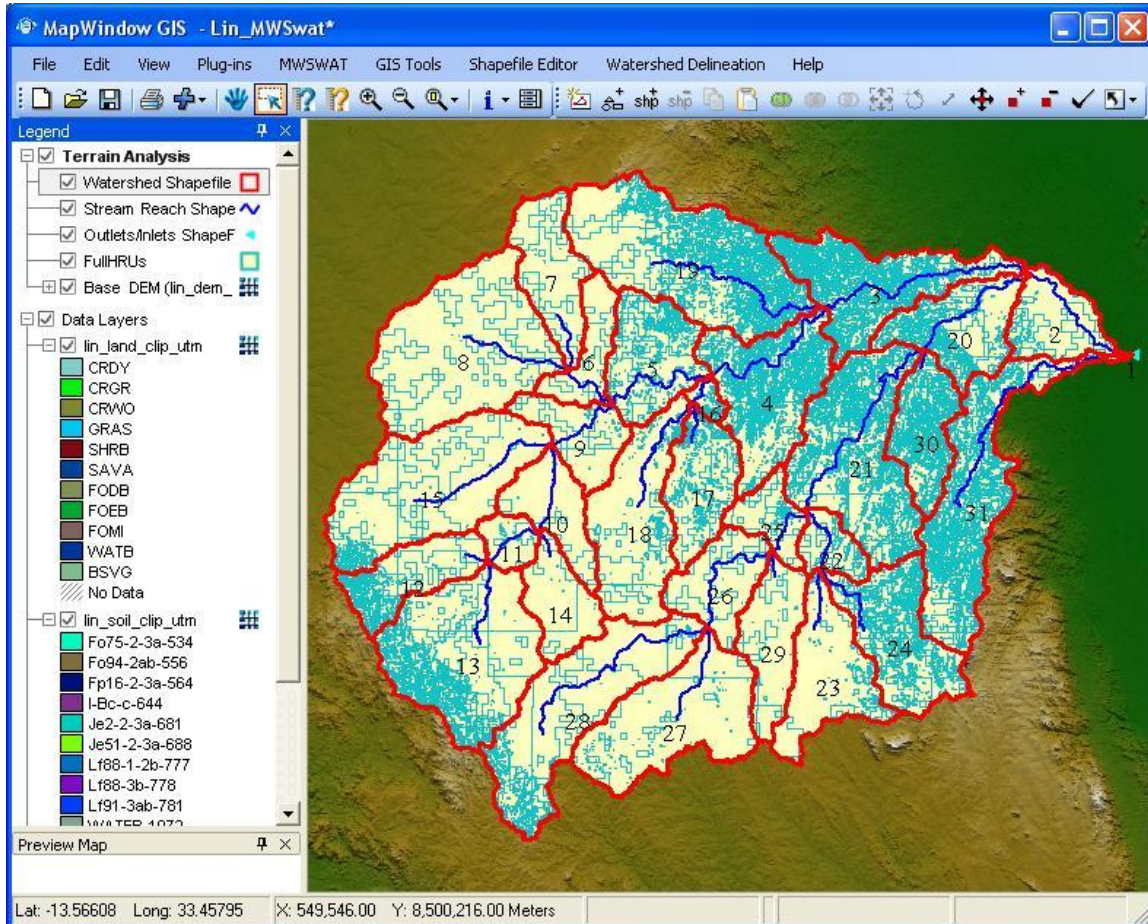


Figure 31: After reading grids

21. Once all the data has been read in and stored, the *Single/Multiple HRU* choice is enabled. Select *Multiple HRUs*, and then select *By Percentage*. Now select thresholds for landuse, soil and slope. The idea of this option is that we will ignore any potential HRUs for which the landuse, soil or slope is less than the selected threshold, which is its percentage in the subbasin. The areas of HRUs that are ignored are redistributed proportionately amongst those that are retained. The value of 34 as the maximum we can choose for landuse indicates that there is a subbasin where the max value for a landuse is 34%: if we chose a higher value than 34% we would be trying to ignore all the landuse categories in that subbasin. Hence 34% is the min across the subbasins of the max landuse percentage in each subbasin. Select 20% for landuse, by using the slider or by typing in the box, and click *Go*. The interface then computes the min-max percentage for a soil as 37%. Select 10 for Soil, click *Go*, 5 for slope, and click *Create HRUs* (Figure 32). It should report 127 HRUs formed in 31 subbasins. Click *OK*.

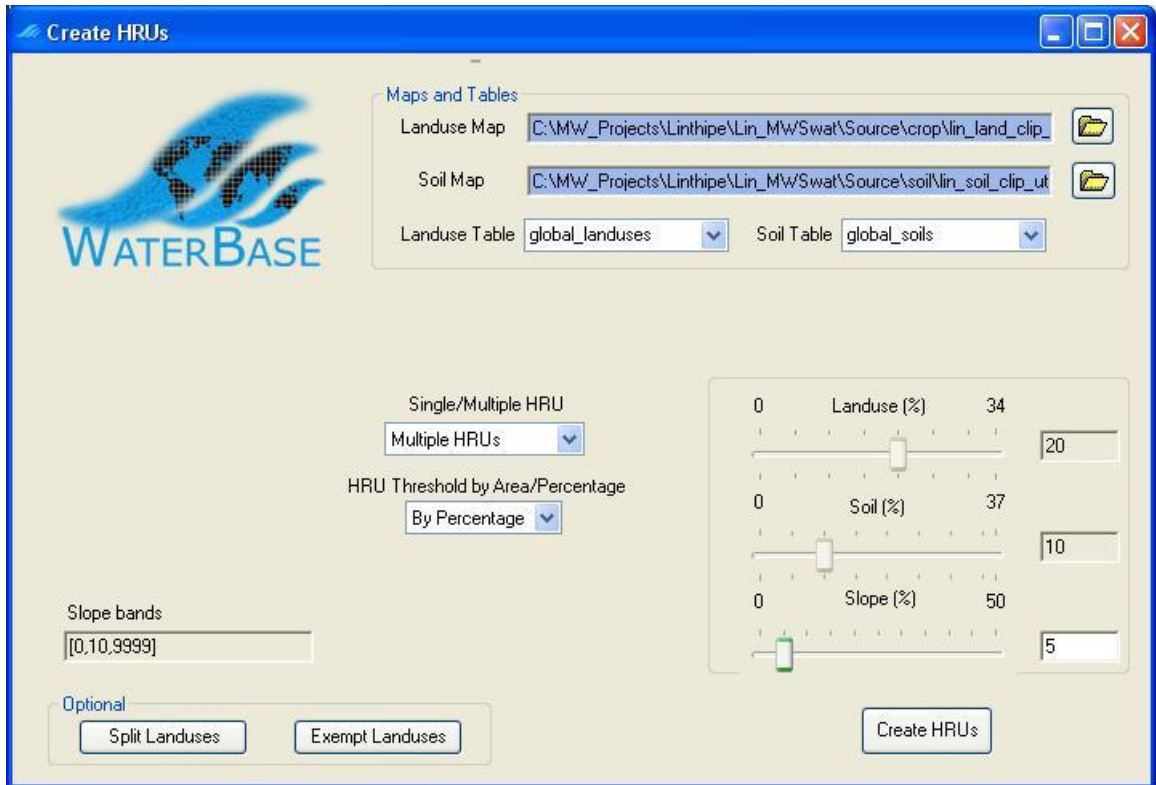


Figure 32: Creating multiple HRUs by percentage

Create HRUs is now reported as done and the third step is enabled (Figure 33). If you look at the *Reports* now available you will find that there is a *Basins* report that lists the landuse, soil and slope-band areas for each subbasin and also an *HRUs* report that only includes the landuses, soils and slope bands left after HRU selection, and also gives details of the HRUs that have been formed. If you wish to change the HRU thresholds then you can click the *Create HRUs* button again, change the thresholds and/or the landuses to be split or exempted, and rerun the *Create HRUs* step.

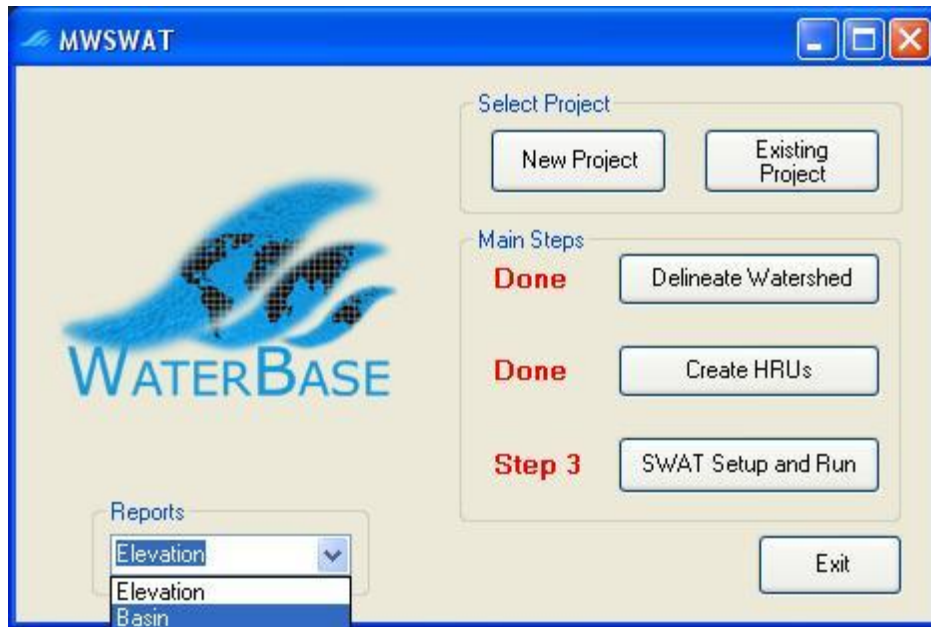


Figure 33: About to setup SWAT (step 3)

6.3 Step 3. SWAT Setup and Run

22. At this point almost everything is ready to write the SWAT input files and run SWAT. Click *SWAT Setup and Run* (Figure 33).

Figure 34: SWAT Setup and Run form

23. The first thing to do on this form is to set the period for the SWAT run. Select 1 January 2000 as the *Start date* and 31 December 2001 as the *Finish date*.
24. Next we have to choose the source of weather data. Click the *Choose* button for *Weather Sources*. MWSWAT is set up to use actual weather data for maximum and minimum temperature and precipitation, and a weather generator file that will simulate other weather factors (solar radiation, wind speed, and relative humidity). So you need to provide a weather generator file for your basin, and data for precipitation and temperature. Choose the option *Global files*, choose *Weather\stnlist.txt* as the *Weather Stations File* and *Lin_Maps\lin.wgn* as the *Weather Generator File* (Figure 35). Click *Done*.

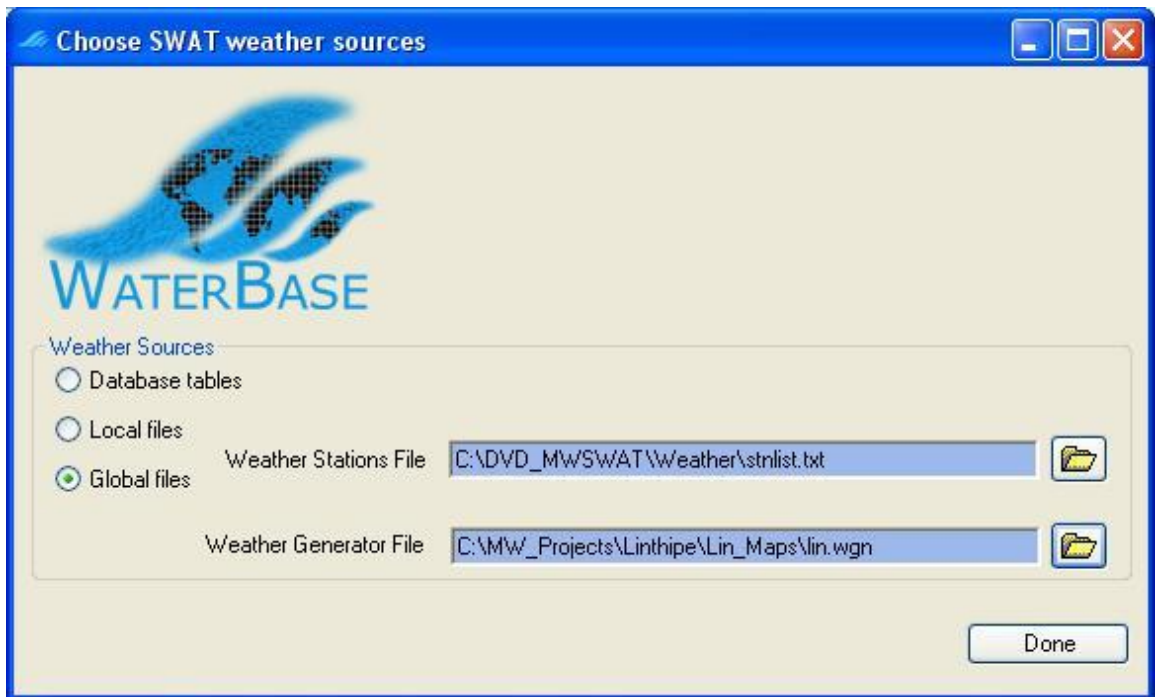


Figure 35: Choosing weather sources

25. Click *Write all files* in the list box (Figure 36) and click the *Write files* button. This may take a few minutes, especially if your simulation covers several years.

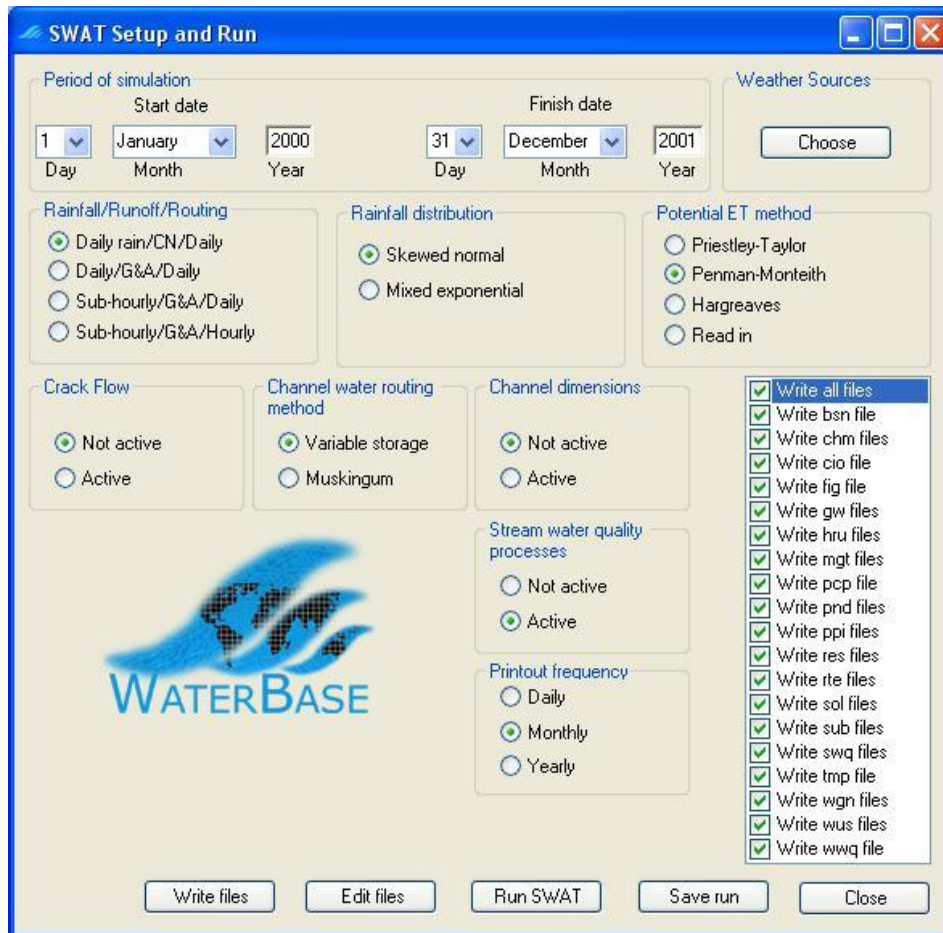


Figure 36: About to write the SWAT input files

26. The interface reports that the SWAT input files are written. They can be found in the *TxtInOut* folder.
27. Click *Run SWAT* to launch the SWAT executable in a DOS prompt window (Figure 37).

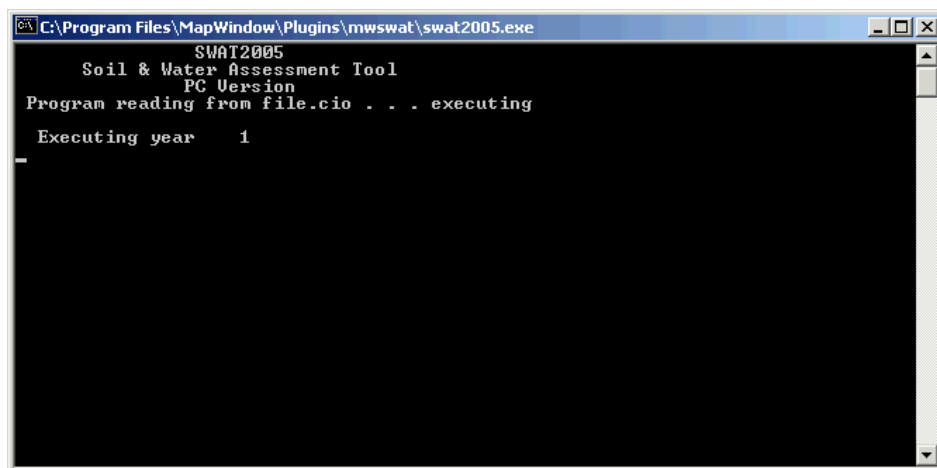


Figure 37: Running SWAT

28. When done a message box will say that SWAT was run successfully, or that it failed. Click *OK*.
29. To see what happened if it failed you need to rerun in a DOS command window:
 - a. Copy the file
C:\Program Files\MapWindow\Plugins\MWSWAT\swat2005.exe
to the project's *TxtInOut* folder.
 - b. Start a DOS command (use start menu -> *Run...*, type *cmd* and click *OK*, or use start menu -> *All Programs* -> *Accessories* -> *Command Prompt*).
 - c. Use the *CD* command to change to the project's *TxtInOut* folder.
 - d. Use the command *swat2005* to run SWAT in this window. The error message will remain visible and will specify the line of SWAT code where the error occurred. The error message may suggest which SWAT input file needs to be checked, or you may be able to get more information from examining the SWAT source code, but probably you will need to report the problem to WaterBase technical assistance.
30. You can save the SWAT run if you wish using the *Save run* button. This in fact copies *F\Proj\Scenarios\Default\TxtInOut* to *F\Proj\Scenarios\Save\TxtInOut* if you choose to save as *Save1*. If *Save1* already exists it is overwritten. This button is live as soon as the *SWAT Setup and Run* form is opened, so you can if you wish use the form to save an earlier run before you start writing the files for this one. (But note that if you changed the watershed delineation or the HRU parameters the report files will be wrong, so in this case you should do the save manually before starting the interface.)

From the reach output file, the monthly values for the outlet were extracted and the following plots created (Figure 38).

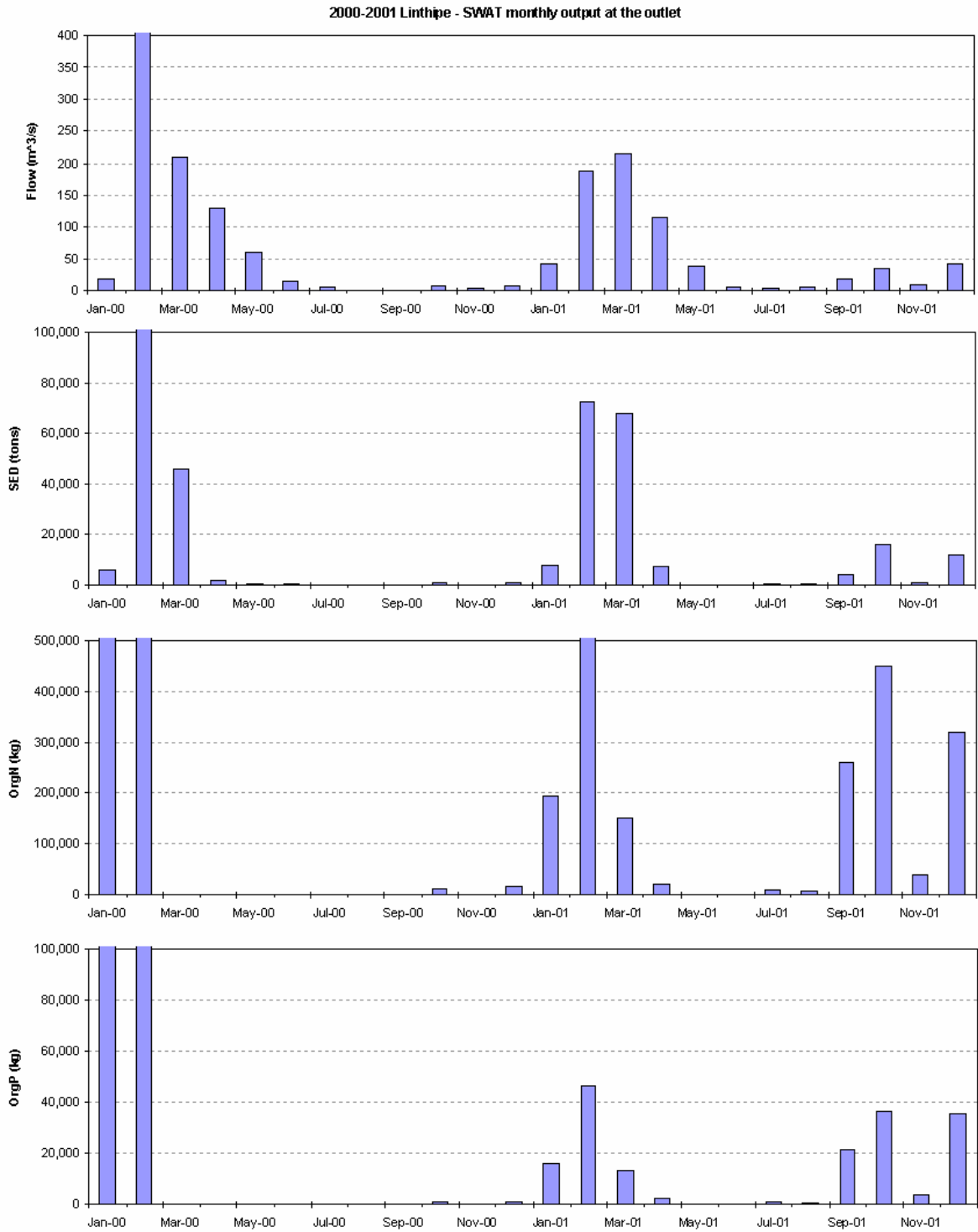


Figure 38: Linthipe output plots

7 Rerunning MWSWAT

You may want to rerun the interface because you want to change some of the parameters. This section explains how to do so.

1. Start MapWindow and make sure that the plugins *MWSWAT* and *Watershed Delineation* are selected. Start *MWSWAT*.
2. Click *Existing Project* and open the project file *F\SJ_MWSwat\SJ_MWSwat.mwprj* (remember that we started the new project *SJ_MWSwat* in folder *F*).
3. The *Process DEM* step is marked as already done. You can rerun it if you want to use a new DEM, change the subbasin threshold, or move the outlet point, or add additional inner inlets, reservoirs, or outlets.
4. In the *Create HRUs* step you will find that the landuse and soil maps are already set to the files you used before (or, rather, the copies that were made of them and stored in the project folder tree) and the database tables are set to *global_landuses* and *global_soils*. These can be changed if you want to use different maps.
5. Assuming you keep the same landuse and soil maps, you are offered the options to *Read from previous run* or *Read from maps*. The former is much faster, and can be used unless you want to change the slope limits. Changing the slope limits requires a re-read of the maps because cells are allocated to potential HRUs by their subbasin number, landuse type, soil type, and slope range.
6. After reading or rereading you are offered the same choice as before between removing insignificant HRUs by percentages or area thresholds, and the values you used last time are preselected. You can switch between area and percentage, you can change the values, and you can change landuse splits and exemptions, or you can just immediately click *Create HRUs*, keeping the old values.
7. You can now start the final form *SWAT Setup and Run*. Here you can change the Start and Finish dates, the weather sources, and any other of the options shown.
8. There are three ways to select the weather sources:
 - You can use the global weather data that is supplied on the CD. This provides a worldwide list of weather stations *stnlist.txt*. In the folder *Weather* containing *stnlist.txt* there are subfolders *2000*, *2001* etc containing data for each year. In the *Choose SWAT weather sources* form choose the option *Global files* and find the *stnlist.txt* file for the *Weather Stations File*. MWSWAT will later select the six weather stations closest to your basin, and then from them select the one nearest to each subbasin. It will also create precipitation and temperature files for each weather station for use by SWAT. This is what we did when we ran for the first time.
 - You can reuse the files generated by using the previous option as follows. In the *TxtInOut* folder you will find files of the form *nnnnnn.pcp* and *nnnnnn.tmp*. *nnnnnn* is a weather station identifier from *stnlist.txt*. Create

a new file, *sj_list.txt*, say, in *SJ_Maps*, and cut and paste the relevant lines from *stnlist.txt* into it. It does not matter if you insert some header lines first: MWSWAT will only start reading at the first line starting with 6 digits. You don't need to use all six weather stations for which *.pcp* and *.tmp* files exist, and you can use different weather stations if you wish (but make sure there is data for them in *yyyy/JAN.txt*, where *yyyy* is your start year). If you have put into your weather stations list only stations for which there are *.pcp* and *.tmp* files in *TxtInOut*, copy these files to *SJ_Maps* and in your next run you can use the *Local files* option in the *Choose SWAT weather sources* form, selecting *sj_list.txt* as your *Weather Stations File*. When this option is chosen only those stations in the weather stations file are used, and the *.pcp* and *.tmp* files are looked for in the same folder as the weather stations file.

If you have in your weather stations list some stations for which you do not have *.pcp* and *.tmp* files in *TxtInOut* then copy *sj_list.txt* to the same folder as *stnlist.txt* and next time use the *Global files* option but with *sj_list.txt* as the weather stations file.

- The third alternative is to use tables in the database *SJ_MWSwat.mdb*, which you will find in the *F\SJ_MWSwat* folder. The first run will generate a table *weather_sources*, six tables *pcpnnnnnn*, and six tables *tmpnnnnnn*. These tables can be reused by selecting *Database tables* as the weather source, and *weather_sources* as the table.

Note that if you use different start of end dates in later runs you must ensure that with the local or database options that your precipitation and temperature files or tables include the whole simulation period, and with the global option that the *Weather* folder has sub-folders for all the years required.

9. You can also use the *SWAT Editor* to edit any of the SWAT input files. The SWAT Editor is described in its own documentation.

8 Using Your Own Data

The data supplied with MWSWAT is obtained from the web, and you may have your own data which you want to use. This section explains how to do so.

8.1 DEM

The digital elevation map (DEM) is selected at the start of the interface. It can be any resolution, but (a) it must be projected to UTM, or another “equal area” projection (and you can use MapWindow's *GIS Tools* plugin to do any reprojection) and (b) the elevations must be in meters.

8.2 Landuse and Soil Maps

You can substitute your own landuse and/or soil maps. This is a little more complicated since you have to provide the information on how the categories of landuse or soil that your maps use are to be interpreted by SWAT. For each differently categorized landuse or soil map that you use you have to prepare a table like *global_landuses* or *global_soils* and put it into either *C:\Program Files\MapWindow\Plugins\MWSWAT\mwswat.mdb* or the project database in the *F\SJ_MWSwat* folder. In the first case it will be copied into every new project database, but you must be careful to keep it and replace it if you ever reinstall MWSWAT. In the second case it will only be used on the particular project. The project database is created (by copying *mwswat.mdb*) by the *New Project* action, so after this, before *Step 1*, is the best time to add any extra tables you need for a particular project.

1. In the case of a landuse map, the table should have the string *landuse* in its name. Then it will be offered as an option for a landuse table. It must have the same structure as the table *global_landuses* in *mwswat.mdb*. So it must contain at least the columns *LANDUSE_ID* (type Long Integer) and *SWAT_CODE* (type Text). The *LANDUSE_ID* corresponds to the values in the landuse grid. It is possible that more than one of your *LANDUSE_ID*s maps to the same *SWAT_CODE*, where your data makes more distinctions than are supported by SWAT. The *SWAT_CODE* strings are 4 letters long and all the ones used in your map must be found in a table *crop* (or a table *urban* if the *SWAT_CODE* starts with a 'U') found in
 - a. The project database, or
 - b. The SWAT reference database

These databases are examined in this order.

2. In the case of a soil map, the table should have the string *soil* in its name. Then it will be offered as an option for a soil table. You should copy the structure of the table *global_soils* in *mwswat.mdb*. So it must contain at least the columns *SOIL_ID* (type Long Integer) and *SNAM* (type Text). The *SOIL_ID* corresponds to the values in the soil grid. You may map more than one of your soil categories to the same SWAT soil, where your data makes more distinctions than are supported by SWAT, but this is much less likely than it is for landuses. All the the *SNAM* strings you use must be found in a table *usersoil* found in
 - a. The project database, or
 - b. The SWAT reference database

MWSWAT uses by default *global_soils* whose characteristics are defined in the table *usersoil* defined in *mwswat.mdb* and hence in your project database. If you need to define your own soils then you need to rename *usersoil* in the project database to something else (when the default will be the *usersoil* table in the SWAT reference database) and, if the SWAT reference table is not appropriate, replace it with another table of the same name and design. Or you can just add your own soils to *usersoil*, provided they have new names.

8.3 Weather Sources

You can also use the database option in *Choose weather sources* to use your own precipitation and temperature data if you have it. You need to prepare and put into your project database:

1. A table containing weather station data like *weather_sources*, with columns (at least) STATIONID, LATITUDE, LONGITUDE and ELEVATION. The first of these is type Text, the other three are type Double. The table should have a name that includes the string *weather* (but should not be called *weather_sources* or it is likely to be overwritten at some point by MWSWAT.)
2. For each STATIONID *id* in the first table there should be a table called *pcpid* and a table called *tmpid*. Each of these must have an column OID of type *Integer* that is marked as an index (with no duplicates) containing 1, 2, 3 etc., a column DATE of type *Text*, and the dates in this column must be consecutive days in one of four formats:
 - a. Julian date *yyyyddd*
 - b. *yyyy/mm/dd*
 - c. *dd/mm/yyyy*
 - d. *mm/dd/yyyy*

MWSWAT decides which format is being used, using the first two dates in the table in the case of non-Julian dates.

These tables can start and end with any date, not necessarily the first or last date of a year.

3. The tables called *pcpid* must have a column PCP of type Double giving the precipitation in mm on that day. The value -99 indicates missing data.
4. The tables called *tmpid* must have columns MAX and MIN of type Double defining the maximum and minimum temperatures on that day in degrees Celsius. -99 indicates missing data.

Text files with comma (or some other character)-separated values, or of fixed format, can be easily imported to make the *pcpid* and *tmpid* tables.