
MapWindow Interface for SWAT (MWSWAT)

Prepared by: Luis F. Leon

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This guide describes both the original MWSWAT, which uses the 2005 version of the SWAT model, as well as MWSWAT 2009 and MWSWAT 2012, which use the 2009 and 2012 versions of SWAT. Any individual or combination of these three versions may be installed and used.

Version 2 applies to MapWindow 4.8.

MWSWAT (MapWindow SWAT)

Step by Step Setup for the San Juan and Linthipe Watersheds

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1 Environment and Tools Required

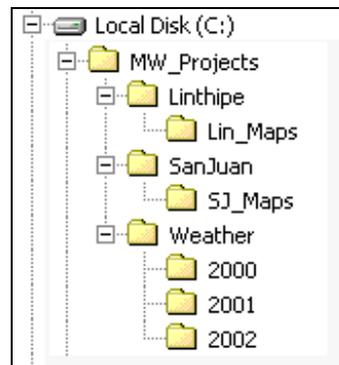
1. Microsoft Windows (any version, as far as we are aware)
2. Microsoft Access, as the interface uses an Access database
3. A tool like WordPad or NotePad that enables you to read ASCII text files.
4. A tool like WinZip that can uncompressed .zip files

2 Installation

- Install MapWindow by running **MapWindowFull-v488SR-installer.exe** (which is stable release version 4.8.8) or a later stable release if available from www.mapwindow.org¹. Use the default folder *C:\Program Files\MapWindow* as the installation folder, or *C:\Program Files(x86)\MapWindow* on a 64-bit machine. Currently we advise you to use the 32-bit version on 64-bit machines. From now on we will use *Program Files* as a folder name, even though it will be *Program Files(x86)* on a 64-bit machine.

- Install MWSWAT by running **MWSWAT.exe**. It will create a folder *C:\Program Files\MapWindow\Plugins\MWSWAT* containing

- **createHRU.dll** and **MWSWAT.dll** - these constitute the MWSWAT plugin
- **mwswat.mdb** - a database that will be copied for new projects
- **crop.dat**, **fert.dat**, **pest.dat**, **till.dat**, **urban.dat** - SWAT data files, in a subfolder *Databases*
- **swat2005.exe** - SWAT executable
- **runswat.bat** – a script to run SWAT
- **SWAT2005.mdb** - SWAT parameter data, in the subfolder *Databases*
- A collection of weather generator (.wgn) files in the subfolder *Databases\USWeather*



- You can instead (or in addition) install MWSWAT 2009 and/or MWSWAT 2012 by running **MWSWAT2009.exe** or **MWSWAT2012.exe**. These are very similar to the above 2005 version except that

- The installation folder is called *MWSWAT2009* or *MWSWAT2012*
- The project database template is called **mwswat2009.mdb** or **mwswat2012.mdb**
- There is an additional data file **septwq.dat**
- There are *Debug* and *Release* versions of the SWAT executables
- The SWAT parameter database is **SWAT2009.mdb** or **SWAT2012.mdb**
- For 2012, **crop.dat** is replaced by **plant.dat**

¹ Please use stable rather than **RC** (Release Candidate) versions of MapWindow as the latter may not have been tested against MWSWAT.

- From the folder *Global_Weather_Data*, 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.

- For the 2005 version, unzip the installation archive SwatEditor_Install_2.1.5.zip (or a later version if available from <http://swat.tamu.edu/software/arcswat/swateditor/>) and run **Setup.exe** to install. Use the default folder *C:\Program Files\SWAT\SWAT 2005 Editor* as the installation folder.

- For the 2009 version, unzip the installation archive SwatEditor_Install_2009.93.7a.zip (or a later version if available from <http://swat.tamu.edu/software/arcswat/swateditor/>) and run **Setup.exe** to install. Use the default folder *C:\SWAT\SWAEditor* as the installation folder.

- For the 2012 version, if you have the 2009 editor already installed and want to keep it, first rename *C:\SWAT\SWAEditor* to *C:\SWAT\SWAEditor2009*. If you want to keep using MWSWAT 2009 you should install version 2.1 or later so that it can find the moved 2009 editor. Then unzip the installation archive SwatEditor_Install_201210_011.zip (or a later version if available from <http://swat.tamu.edu/software/arcswat/swateditor/>) and run **Setup.exe** to install. Use the default folder *C:\SWAT\SWAEditor* as the installation folder.

- Create a folder to store the digital source data (e.g. *SJ_Maps*) 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 (MapWindow 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.tif*, *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.tif*, *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\Scenarios\Default\TablesIn* that may be used by the SWAT editor.
4. A folder *F\Proj\Scenarios\Default\TablesOut* that may be used by the SWAT editor and is used to hold results files from visualisation.
5. A folder *F\Proj\Source* that will contain copies of our input maps and a number of intermediate maps generated during watershed delineation.
6. If we choose to save a SWAT run as *Run1*, say, then a folder *F\Proj\Scenarios\Run1* will be created (a copy of *F\Proj\Scenarios\Default*, including its sub-folders).

5 Setup for Mexico: San Juan River Watershed

This example uses the original MWSWAT. The MWSWAT 2009 or 2012 plugin may be used instead.

1. Start **MapWindow** and check that you have plugins "**Watershed Delineation**", "**Shapefile Editor**", and "**MWSWAT**" available. All 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 labelled *File name* (under the *SanJuan* folder) See Figure 1.

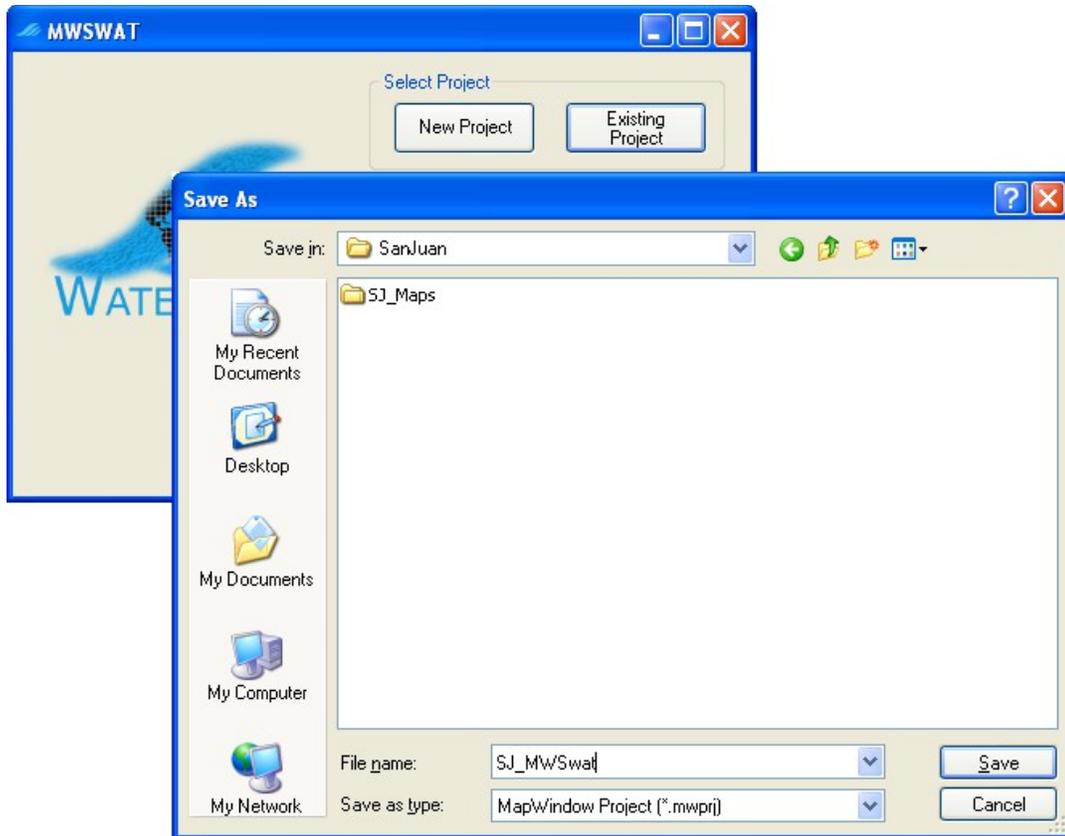


Figure 1: Naming a project

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, UTM²); you also need to make sure that the maps units of measure are meters, (2) that the Watershed Delineation plugin is selected. If some of your maps need re-projecting you can use the *MapWindow Toolbox* to do it. You should also (3) check that Project/Settings/Application Settings is set to **Automatic** or **LoadAsGrid**; you will not be able to process some of your maps if this is set to **LoadAsImage**.

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*.

² UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds.

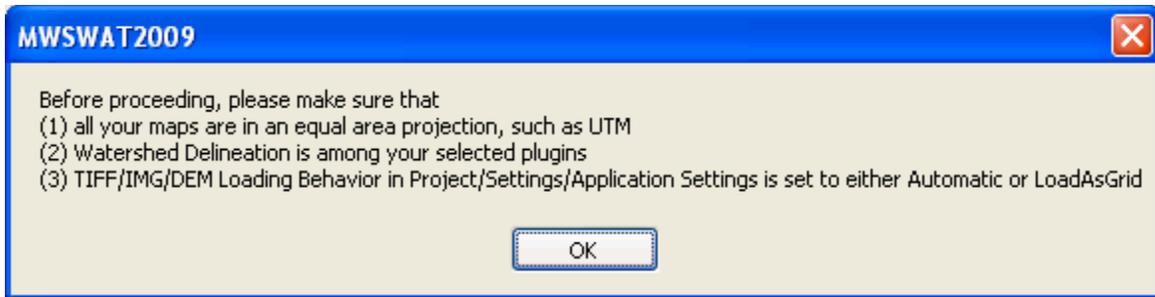


Figure 2: Reminders

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).

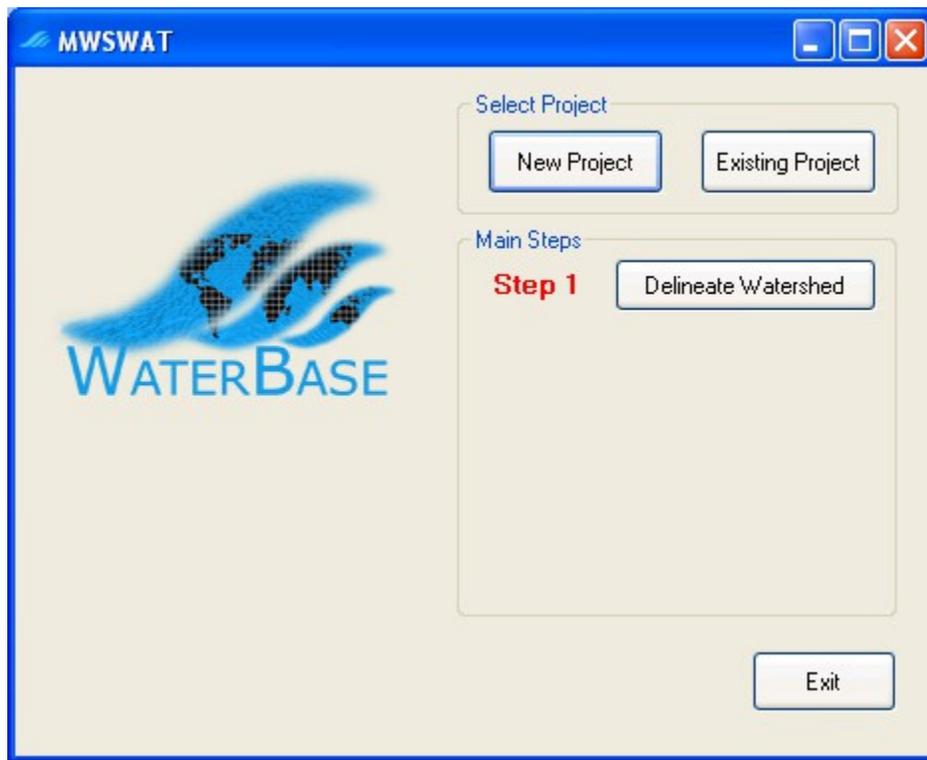


Figure 3: About to do step 1

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 *SJ_MWSwat* folder. See section 9 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.tif* (Figure 4). Leave the *Use predefined watershed and streams* check box unchecked. Refer to section 9.3 to see how to use the predefined option.
8. Click the *Process DEM* button to load the DEM file and activate the *Automatic Watershed Delineation* plug-in.

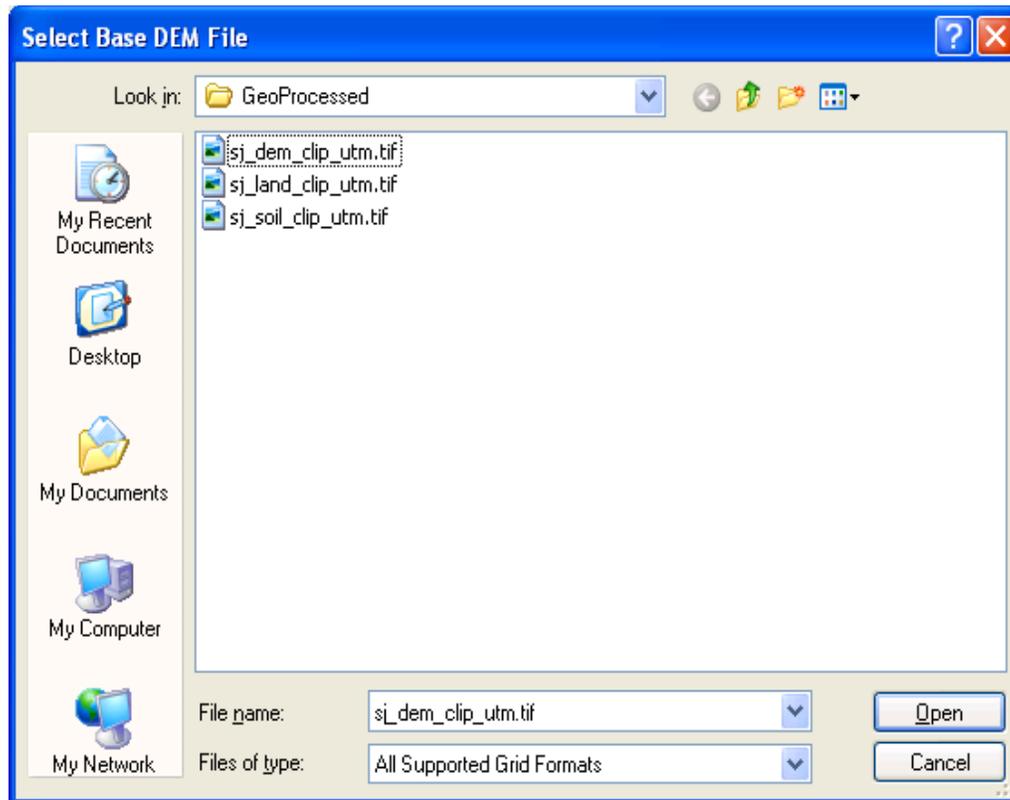


Figure 4: Selecting the DEM

9. The name of the elevation map grid will be displayed in the *DEM* text box on the *Automatic Watershed Delineation (AWD)* dialogue 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.

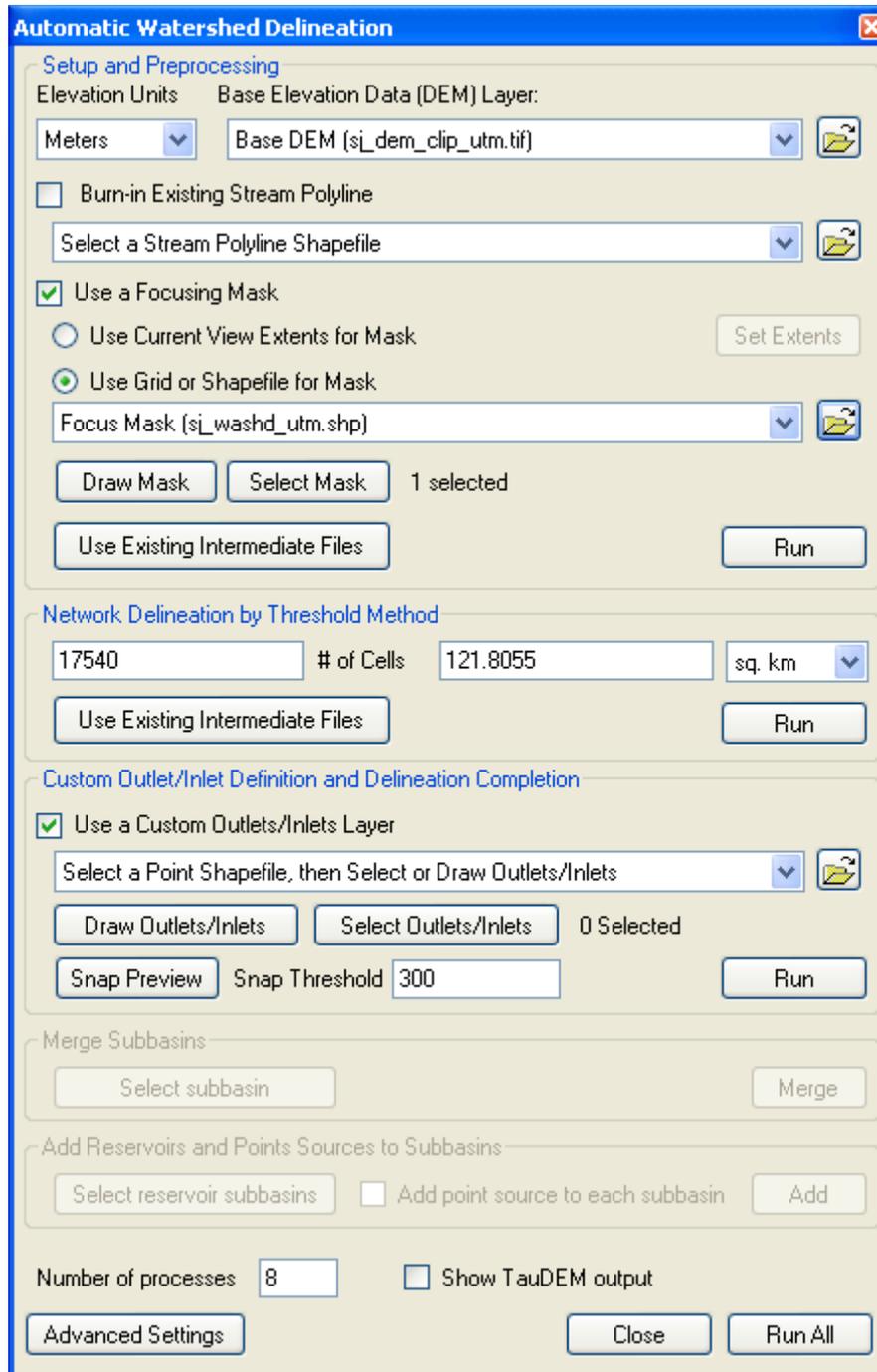


Figure 5: Preprocessing the DEM

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. If necessary, 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.

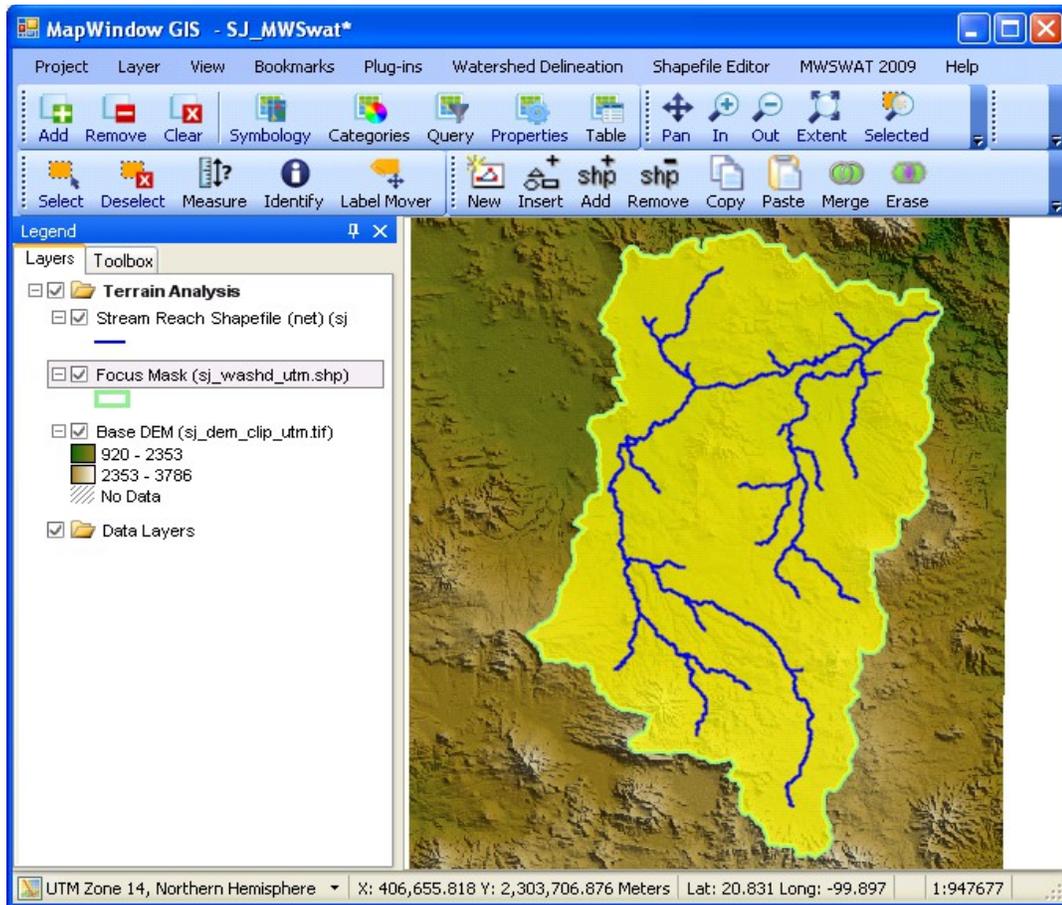


Figure 6: Stream networks displayed

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). For details on defining additional outlets (monitoring points), reservoirs, inlets, and point sources, see Section 9.8.
12. 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. Check that the form reports that 1 point was “snapped”, i.e. it was close enough to a stream reach. If the outlet was placed too far from a stream reach (beyond the snap threshold of 300 metres) you need to move it or increase the threshold and run the final step again. The AWD part is now completed. There are two additional options available in the AWD form, to *Merge Subbasins* and *Add Reservoirs and Point Sources*, but we are not using these in

this example. You can find out about them in section ??? *Close* the AWD form (Figure 8).

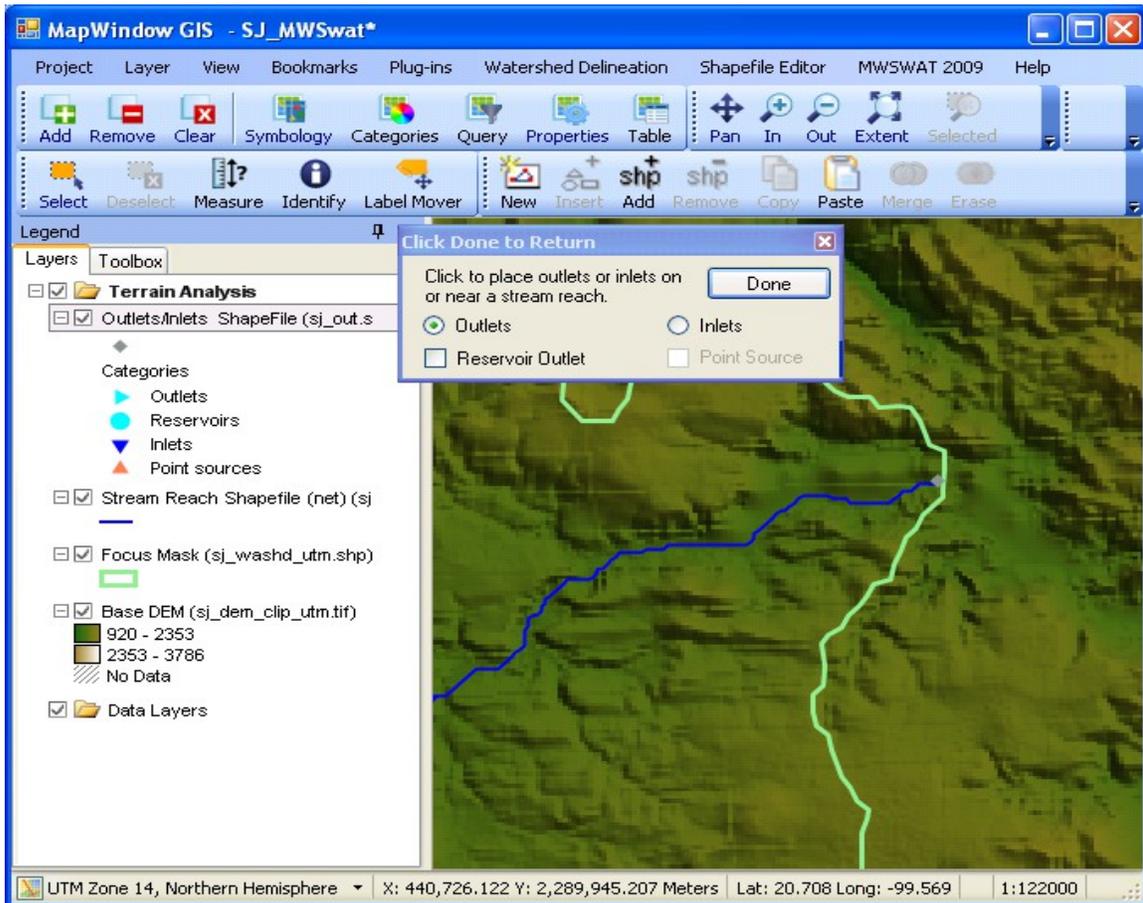


Figure 7: Defining the outlet point

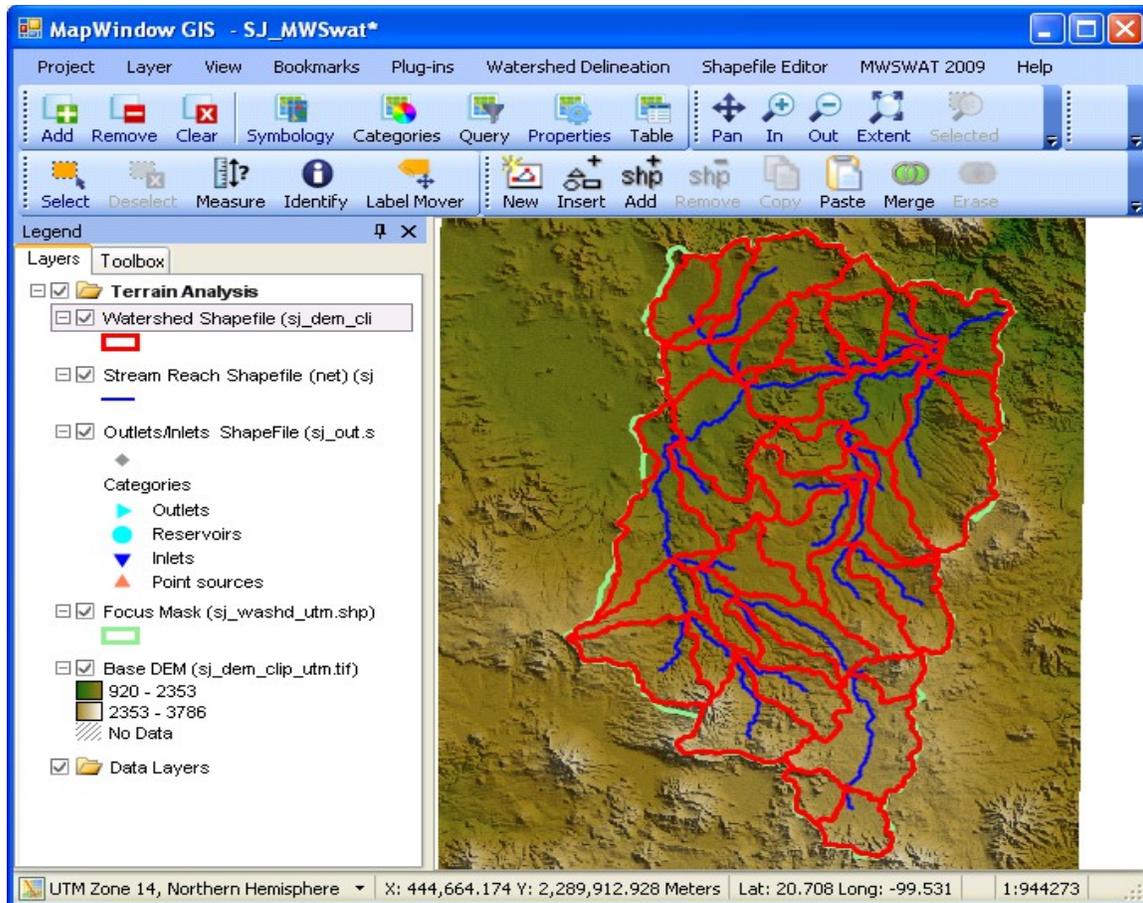


Figure 8: Watershed delineation complete

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

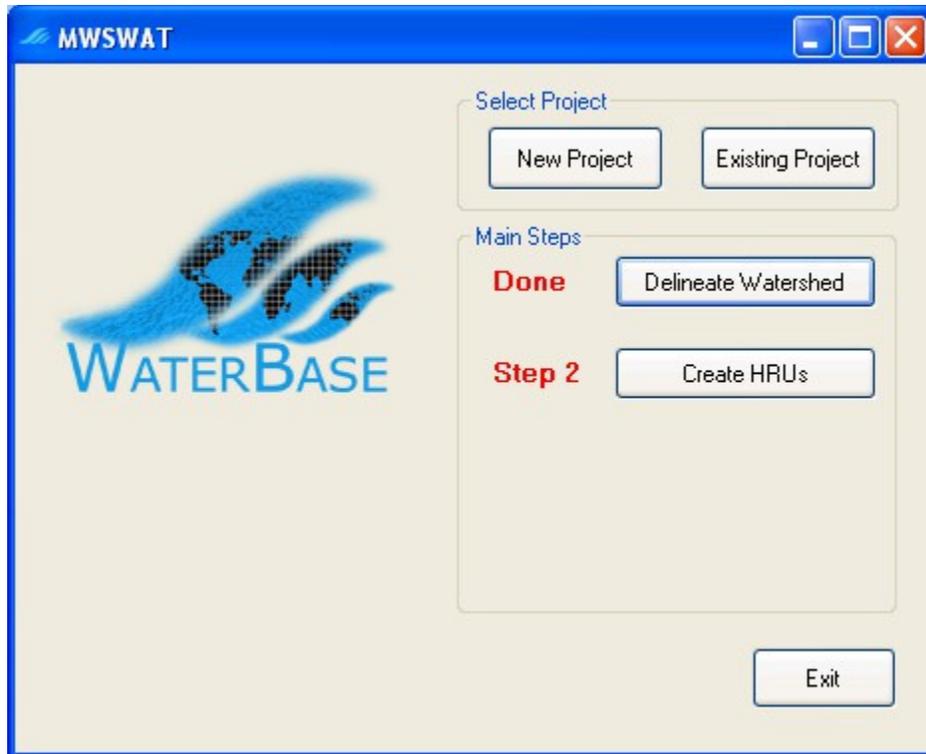


Figure 9: About to do step 2

5.2 Step 2. Create HRUs

15. 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.
16. To do this we click *Create HRUs*, select *sj_land_clip_utm.tif* as the *Landuse Map*, select *sj_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.
17. 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. To generate the *FullHRUs* shapefile, click in the check box.
18. 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.

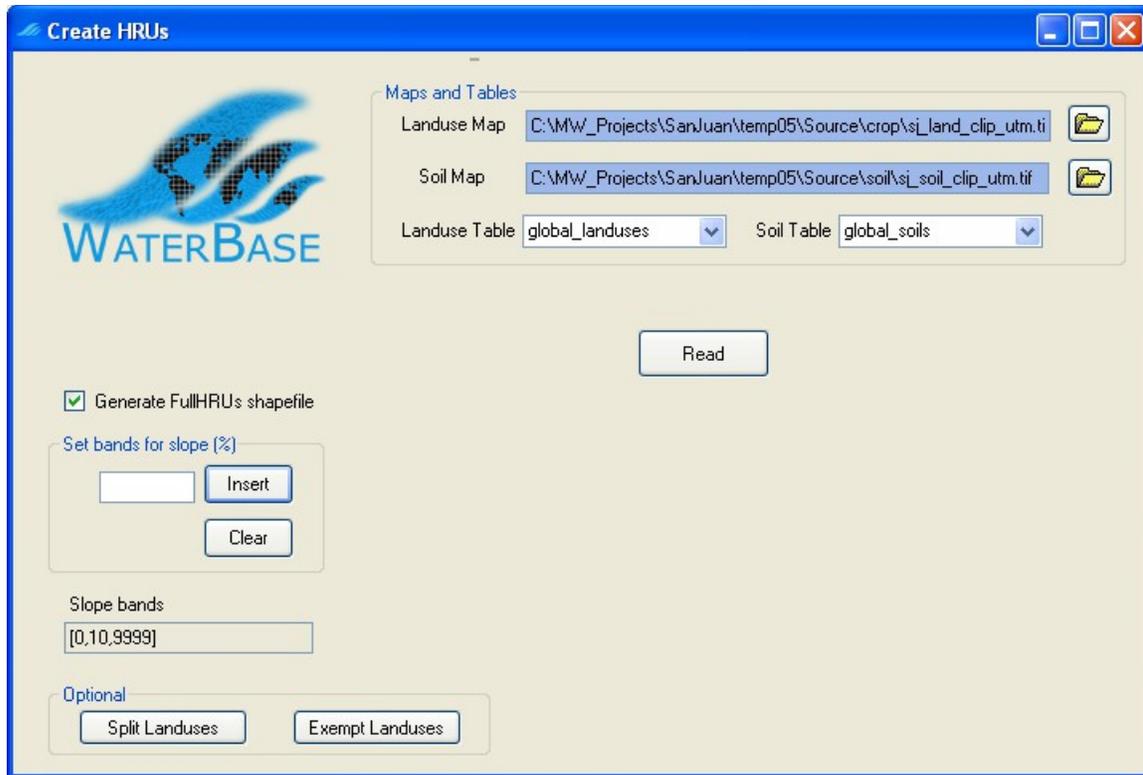


Figure 10: Ready to read the maps

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

- The subbasins have been numbered³.
- 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 15, 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 around the number 15, 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. *Close* the Attribute Table Editor. Generating the FullHRUs shapefile is optional, as it can take some time.

³Numbering of the subbasins may vary.

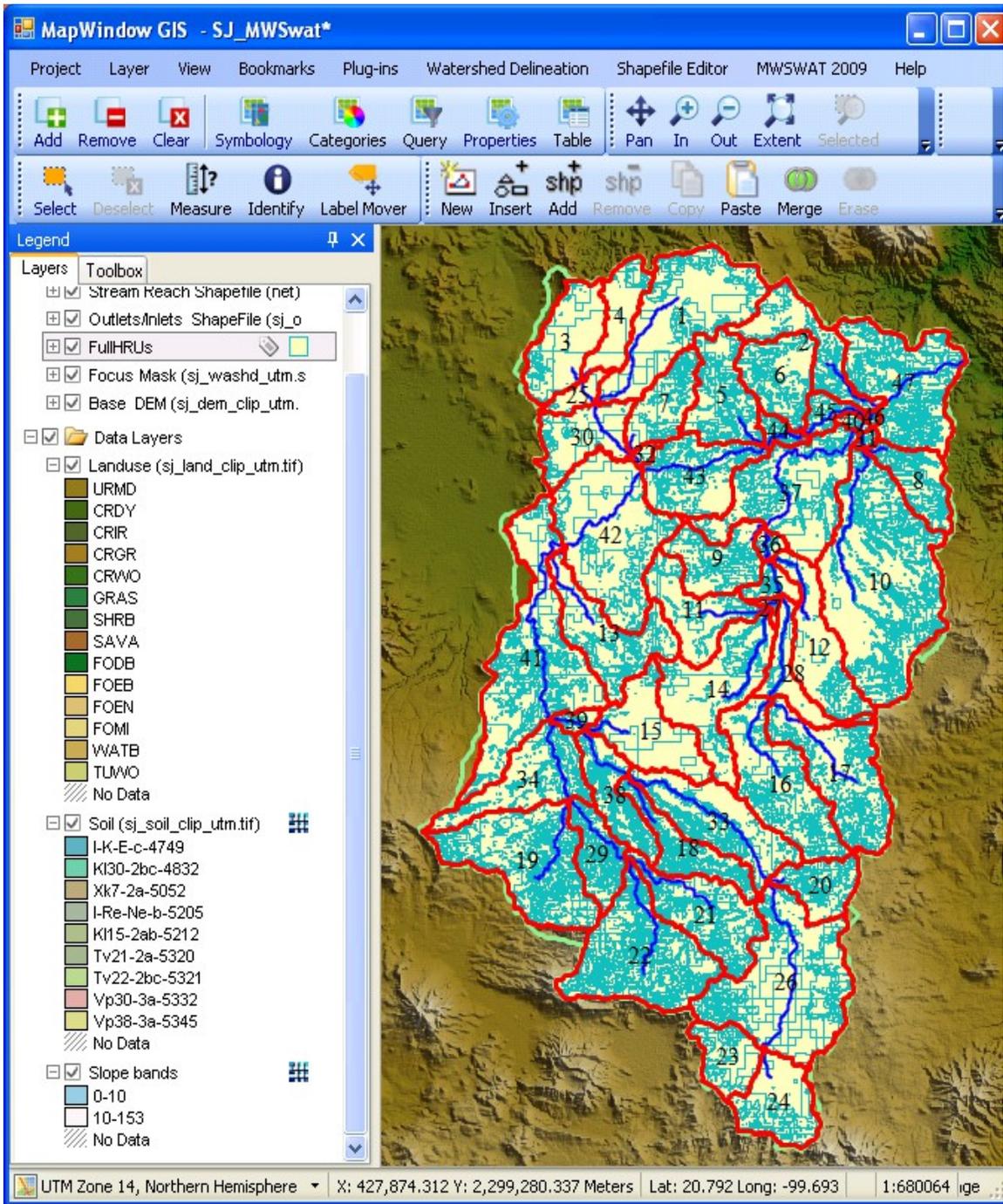


Figure 11: After reading grids

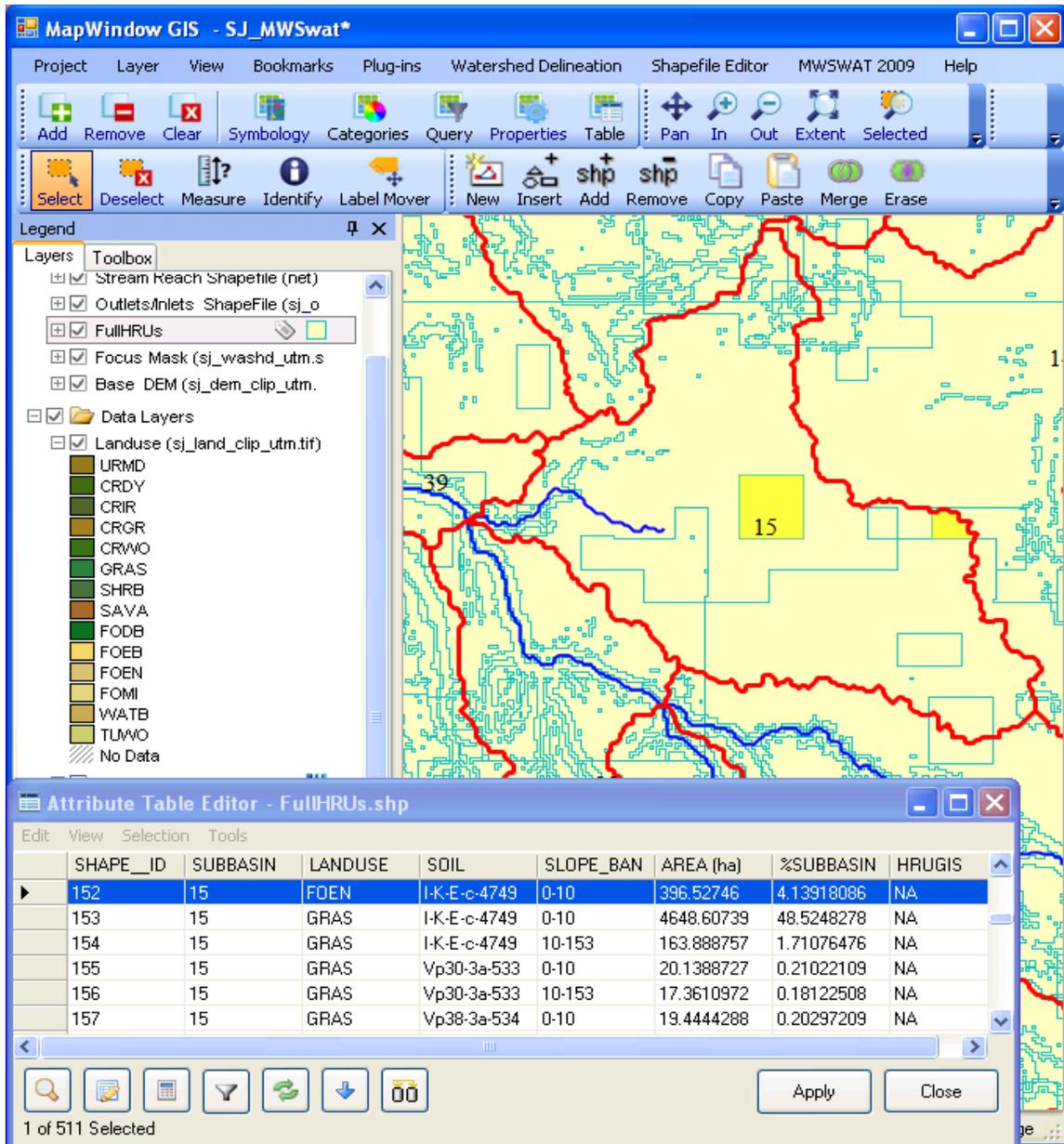


Figure 12: Viewing a potential HRU

20. 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 two reports at this point, which are the *Elevation* and *Basin* reports. The elevation report 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). The basin report lists the landuse, soil and slope-band areas for each subbasin (Figure 14).

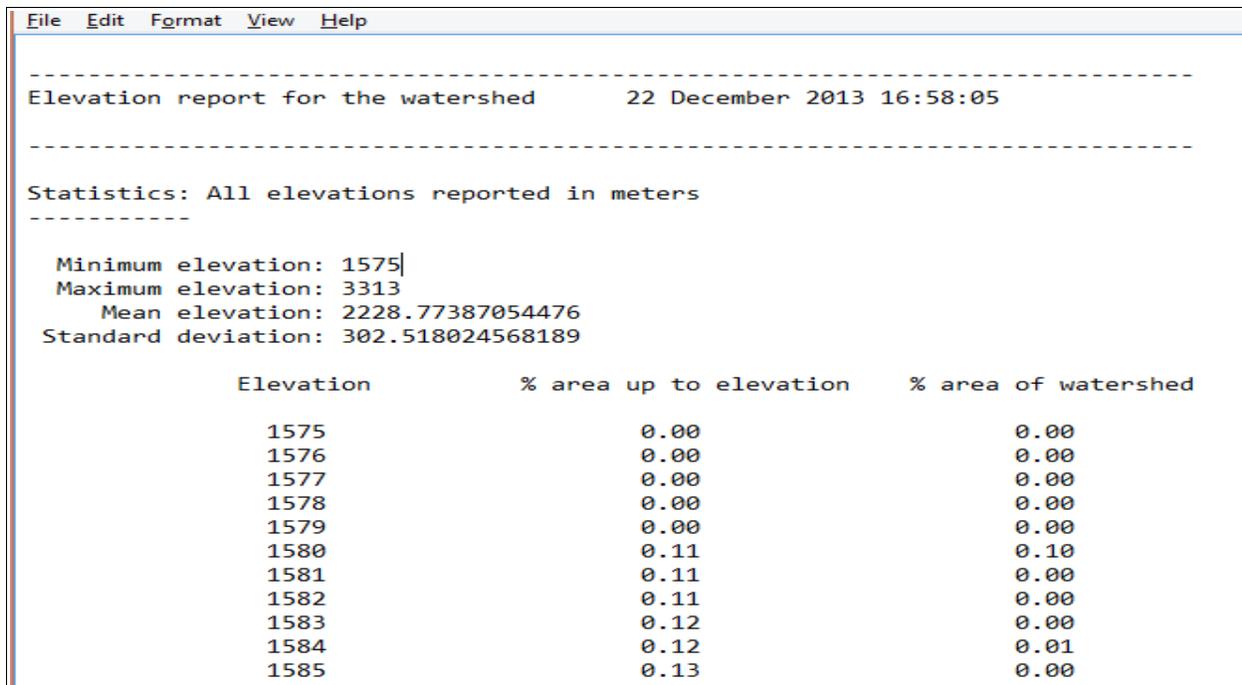


Figure 13: Elevation report (start)

	Area [ha]	%Watershed	%Subbasin
Subbasin 47	15079.15	3.65	
Landuse			
GRAS	8136.10	1.97	53.96
SHRB	6943.05	1.68	46.04
Soil			
K130-2bc-4832	11297.21	2.73	74.92
Xk7-2a-5052	654.17	0.16	4.34
Vp30-3a-5332	3127.78	0.76	20.74
Slope			
0-10	6951.38	1.68	46.10
10-9999	8127.77	1.97	53.90

Figure 14: Basin report (fragment)

21. 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 15).
- 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 16).

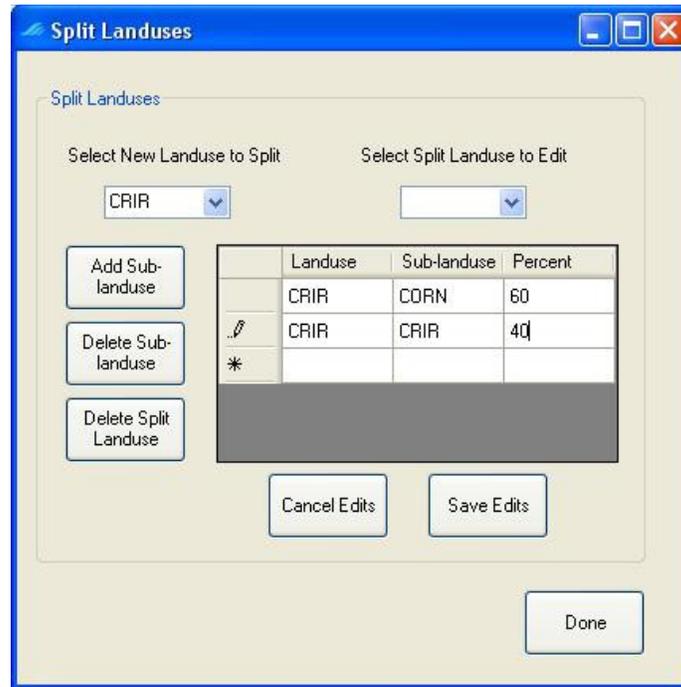


Figure 15: Splitting a landuse

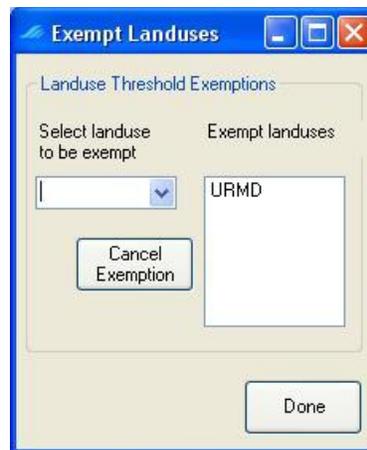


Figure 16: Exempting a landuse

22. In this example we will not split or exempt any landuses. Now we can exclude HRUs that are insignificant by considering percentage thresholds or area thresholds. This is the *Multiple HRUs* option. There are also two options giving just one HRU for each subbasin. *Dominant HRU* selects the largest of the potential HRUs in each subbasin and makes its landuse, soil and slope range the ones chosen for the whole subbasin. *Dominant landuse, soil, slope* chooses the landuse with the biggest area in the subbasin, the soil with the biggest area in the subbasin, and the slope range with the biggest area in the subbasin and uses them for the whole subbasin.

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 maximum 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 minimum across the subbasins of the maximum 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 17). It should report 195 HRUs formed in 47 subbasins. Click *OK*.

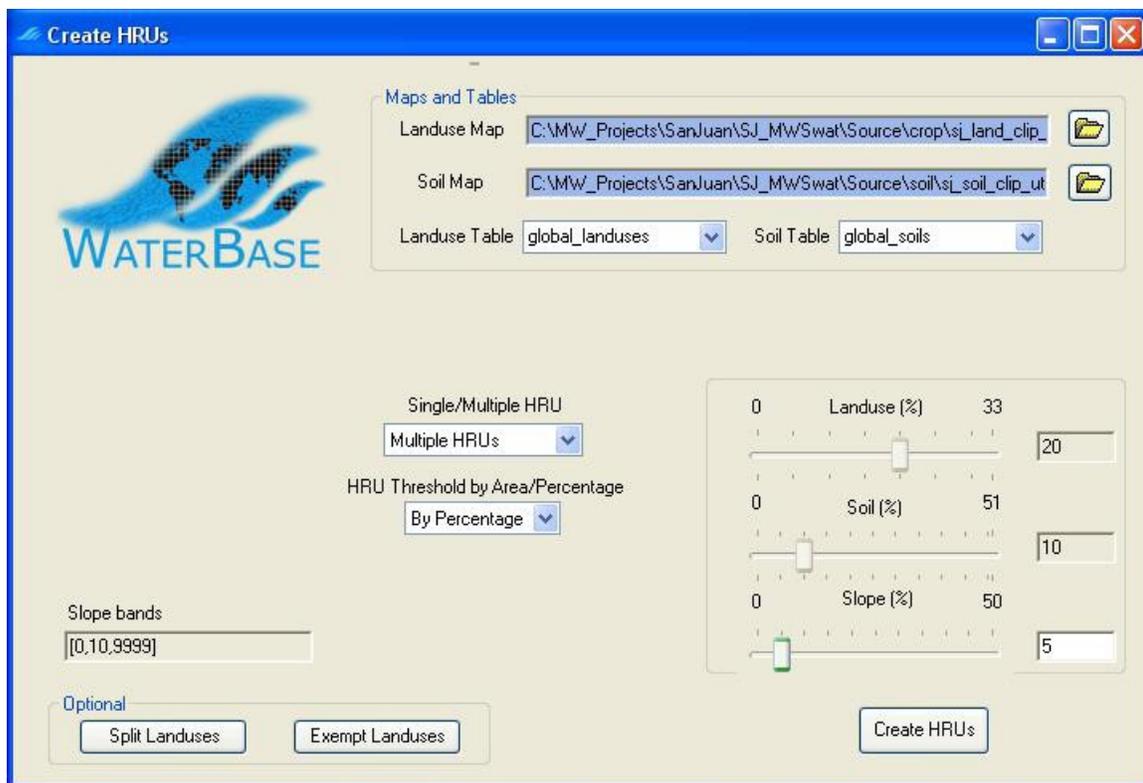


Figure 17: Creating multiple HRUs by percentage

24. *Create HRUs* is now reported as done and the third step is enabled (Figure 18). If you look at the *Reports* now available you will find that there is 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.

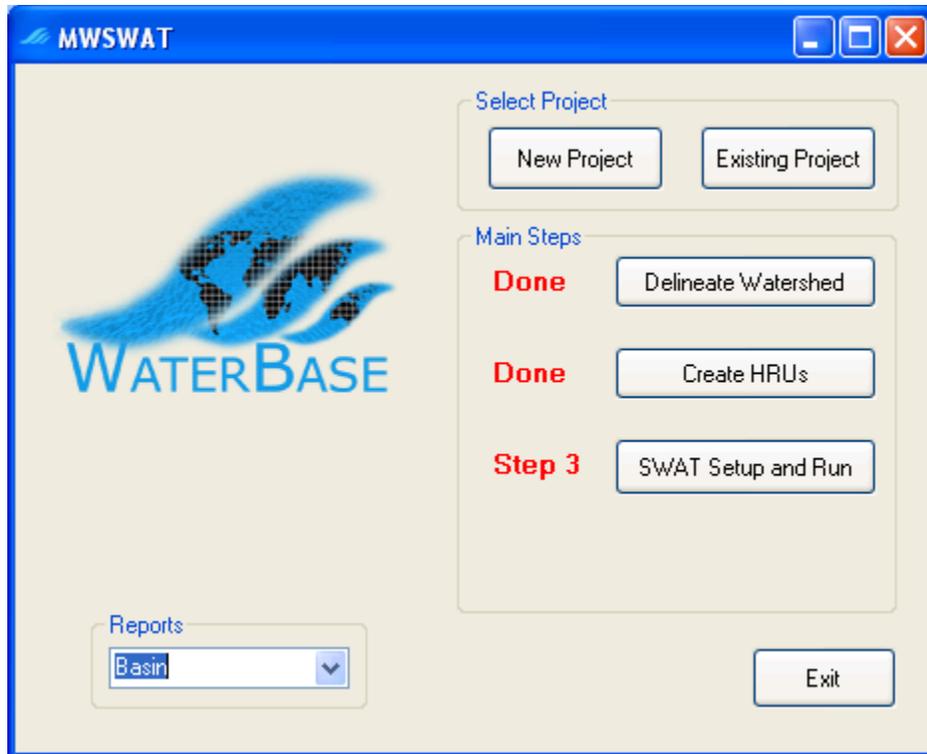


Figure 18: About to do step 3

		Area [ha]	%Watershed	%Subbasin
Subbasin 1		17149.99	4.15	
Landuse				
	GRAS	12617.06	3.05	73.57
	SHRB	4532.93	1.10	26.43
Soil				
	K130-2bc-4832	14110.53	3.41	82.28
	Vp38-3a-5345	3039.46	0.73	17.72
Slope				
	0-10	13424.08	3.25	78.27
	10-9999	3725.91	0.90	21.73
HRUs:				
1	GRAS/K130-2bc-4832/10-9999	2887.93	0.70	16.84
2	GRAS/K130-2bc-4832/0-10	8064.90	1.95	47.03
3	GRAS/Vp38-3a-5345/0-10	1664.23	0.40	9.70
4	SHRB/K130-2bc-4832/10-9999	837.98	0.20	4.89
5	SHRB/K130-2bc-4832/0-10	2319.72	0.56	13.53
6	SHRB/Vp38-3a-5345/0-10	1375.23	0.33	8.02

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' and 'Finish date' fields. The 'Weather Sources' section has a 'Choose' button. The 'Rainfall/Runoff/ROUTING' section has radio buttons for 'Daily/CN/Daily' (selected) and 'Daily/G&A/Daily'. The 'Rainfall distribution' section has radio buttons for 'Skewed normal' (selected) and 'Mixed exponential'. The 'Potential ET method' section has radio buttons for 'Priestley-Taylor', 'Penman-Monteith' (selected), 'Hargreaves', and 'Read in'. The 'Printout frequency' section has radio buttons for 'Daily', 'Monthly' (selected), and 'Yearly', plus a 'NYSKIP:' text box with '0'. At the bottom left is the 'WATERBASE' logo. At the bottom right is a list of file types to select, each with a checkbox: 'Select all files', 'Select weather files', 'Select bsn file', 'Select chm files', 'Select cio file', 'Select fig file', 'Select gw files', 'Select hru files', 'Select mgt files', 'Select pnd files', 'Select pp files', 'Select ppi files', 'Select res files', 'Select rte files', 'Select sol files', 'Select sub files', 'Select swq files', 'Select wgn files', 'Select wus files', and 'Select wwq file'. At the bottom are five buttons: 'Write files', 'Edit files', 'Run SWAT', 'Save run', and 'Close'.

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*. A common mode is 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 *Global_Weather_Data\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 9.7.1.2, have made a local list of stations, *sanjuan1.txt* (containing just one station entry copied from *Global_Weather_Data\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 (and called *pcp1.pcp* and *tmp1.pcp*) 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 global data does not need to be processed. Select *Local files* under *Weather Sources* and then find *sanjuan1.txt* as the *Weather Stations File*.

29. Under *Weather Generator*, select *File*, and find *SJ_Maps\GeoProcessed\sj.wgn* as the *Weather Generator File* (Figure 21). Leave *Sub-daily precipitation* unchecked. Click *Done*.

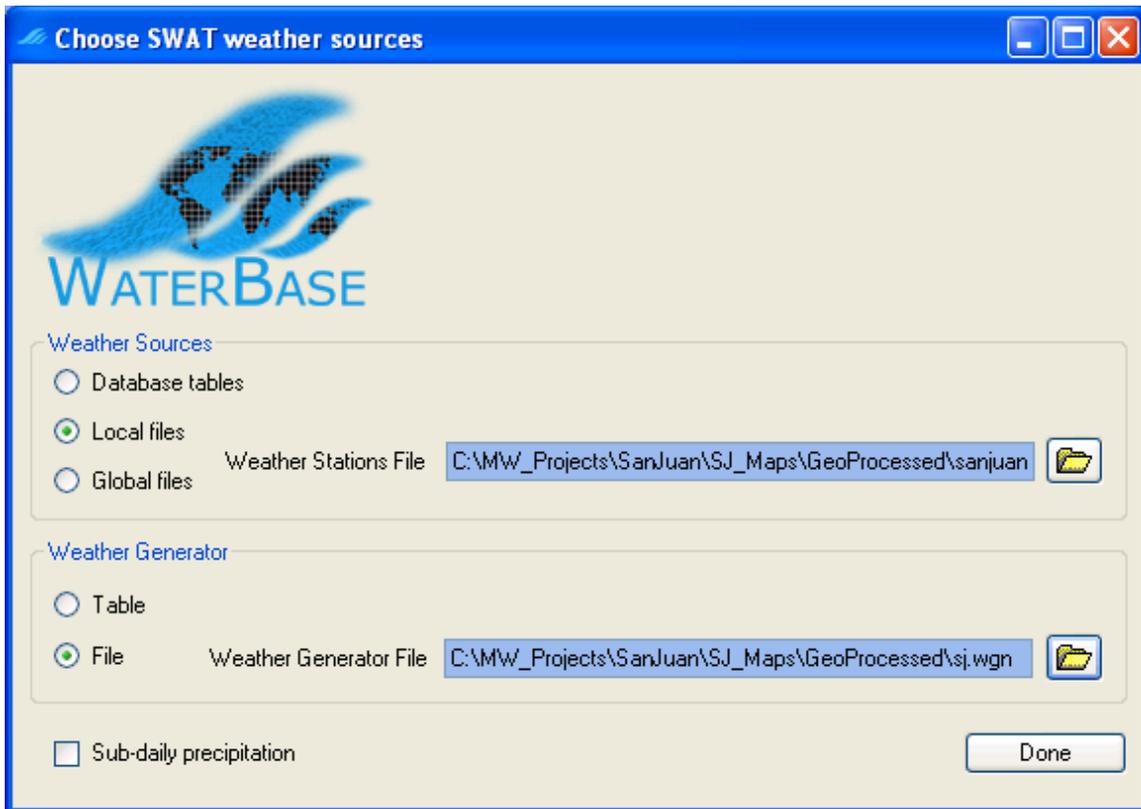


Figure 21: Choosing weather sources

30. Click *Select 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. If all is well you will see a form (Figure 23) showing that all database tables and files have been written successfully. Click *OK*.



Figure 22: About to write the SWAT input files



Figure 23: Progress writing tables and input files

31. If your project is calculated to possibly lie within the USA, then you will see a form like Figure 24. There is a program for estimating the heat units needed for plant growth, using climate data, but it is currently available only for the USA. If your project is within the USA, and you want to use this estimation program, then accept the default setting on the form and just click *Done*. If you want instead to use a fixed, default value, then click on that option, change the numeric value if you wish, and click *Done*.

Project outside the USA are automatically given the fixed default value of 1800. So in the San Juan example you will not see Figure 24.

The heat units value appears in the .mgt files, and you can later if you wish edit these using the SWAT Editor.



Figure 24: Heat unit estimation form

32. The interface reports that the SWAT input files are written. They can be found in the *TxtInOut* folder. Click *OK*.
33. Click *Run SWAT* to launch the SWAT executable in a DOS prompt window (Figure 25).

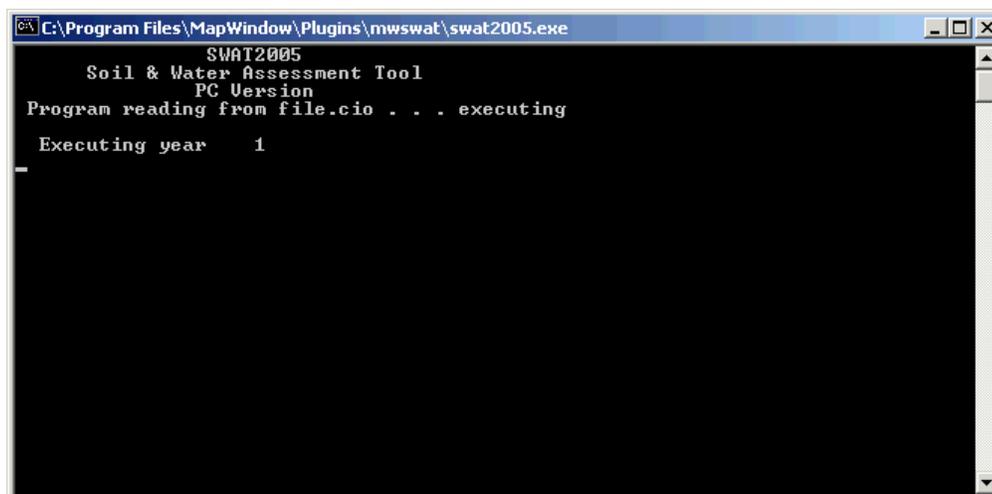


Figure 25: Running SWAT

34. If the run is successful the DOS window will close and a message box will say that SWAT was run successfully. Click *OK*.
35. If the run is not successful the DOS Window will stay open with a message telling you to *Hit Enter to exit*. In MWSWAT 2009 or 2012, if you did not check the *Run SWAT in debug mode* box in the *SWAT Setup and Run* form (which is normally what you do, since the release version is faster) you won't get much information about what went wrong. So check this box and run SWAT again. This allows you to see what went wrong, what error SWAT reported. 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 the SWAT team. Go to the SWAT support page <http://swat.tamu.edu/support/> for advice.
36. You can save the SWAT run if you wish using the *Save run* button. This in fact copies *F\Proj\Scenarios\Default* to *F\Proj\Scenarios\Save1* 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.)
37. 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 26. 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*⁴

- SWAT US soils database (new in SWAT 2012):

C:\Swat\SwatEditor\Databases\SWAT_US_Soils.mdb

- SWAT Executable folder:

C:\Program Files\MapWindow\Plugins\MWSWAT

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

The 2012 SWAT Editor has an additional parameter for the SWAT Soils Database, set to *C:\SWAT\SWATEditor\Databases\SWAT_US_Soils.mdb*. It also has an additional button *Connect to Databases* which must be clicked before editing.

See the SWAT documentation for information on using the SWAT Editor, but also see section 7 about its use with MWSWAT.

⁴ or *SWAT2009.mdb* or *SWAT2012.mdb* if you are using MWSWAT 2009 or 2012.

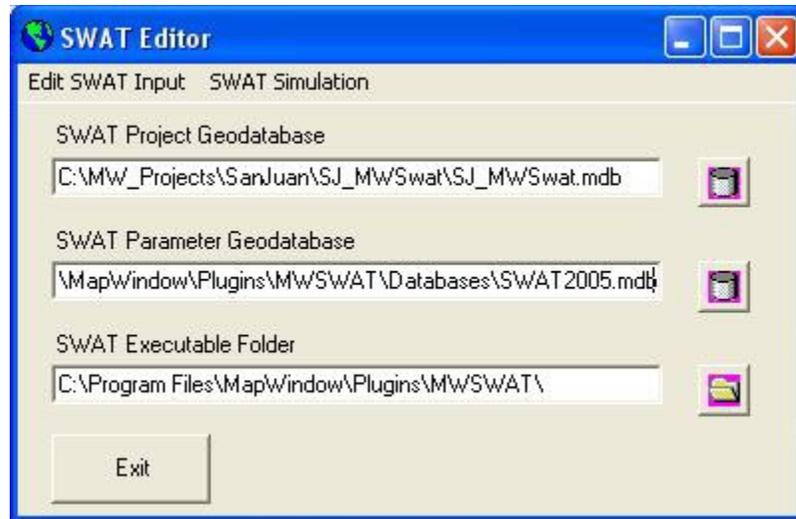


Figure 26: SWAT Editor

38. Graphs of the results such as those in Figure 27 can be created using the SWATPlot and SWATGraph tools (available from WaterBase <http://www.waterbase.org>).

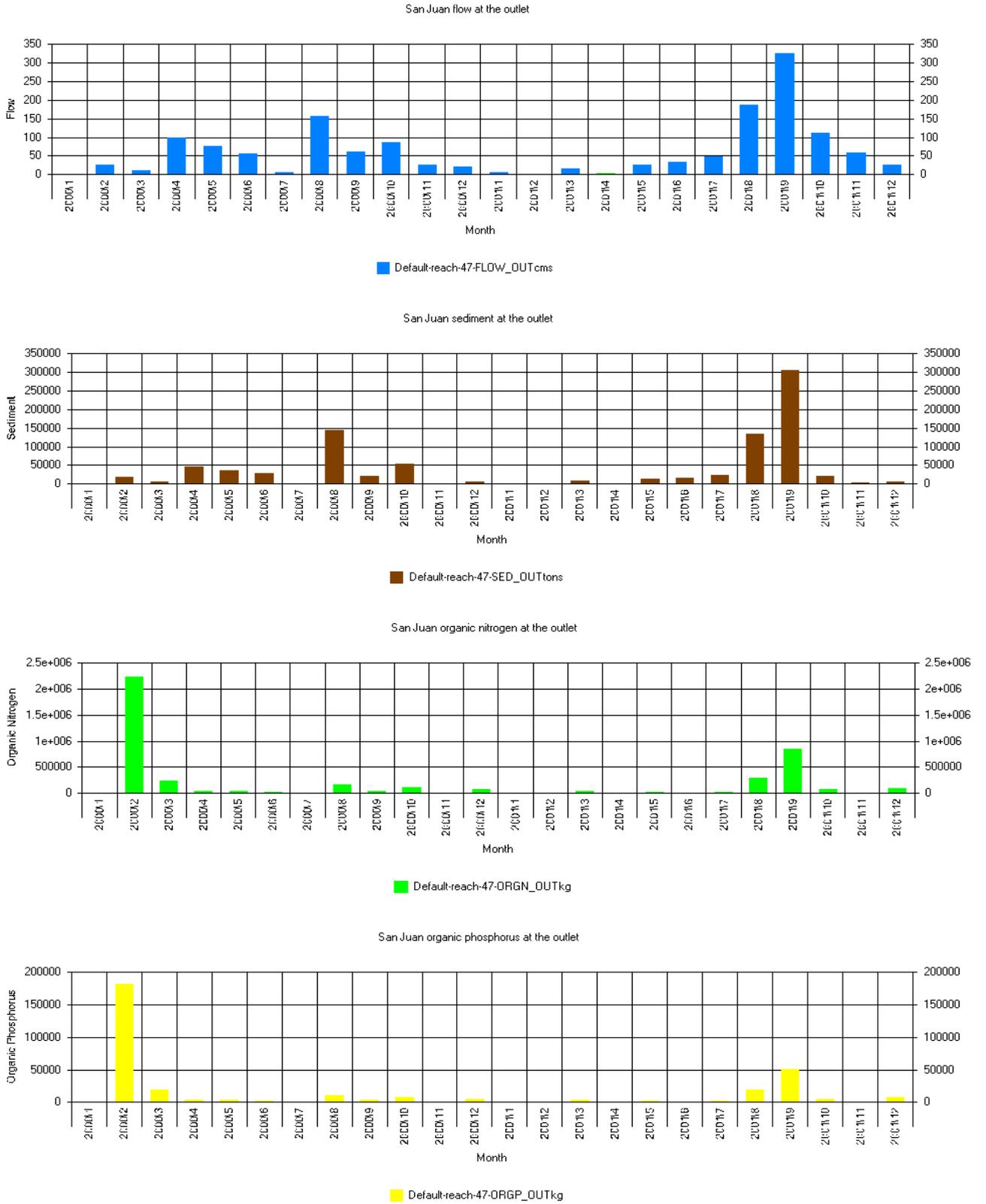


Figure 27: San Juan output plots

39. Close the *SWAT Setup and Run* form. You will see in the main *MWSWAT* form that the Step 3 is marked as *Done* and Step 4 *Visualise* is now available (Figure 28).

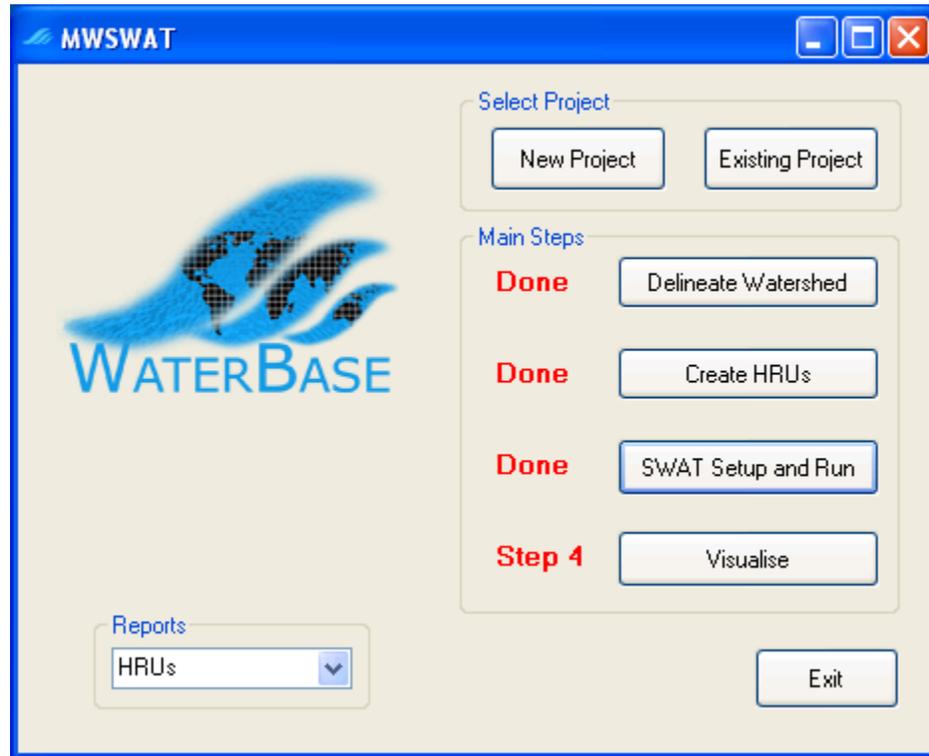


Figure 28: About to do step 4

5.4 Step 4. Visualise results

You can visualise SWAT outputs by using the *Visualise* button. Click on it to get the form in Figure 29. The idea is to make a *results shapefile* showing the subbasins of the watershed, and then to display one of the SWAT outputs by colouring the subbasins according to the value of the output. This involves making the output values an attribute of the shapefile. The outputs can be visualized either statically or dynamically, and we will explain each of these in turn.

5.4.1 Static results.

40. In the static case we can add many outputs if we wish, which allows us to make several displays from one shapefile.

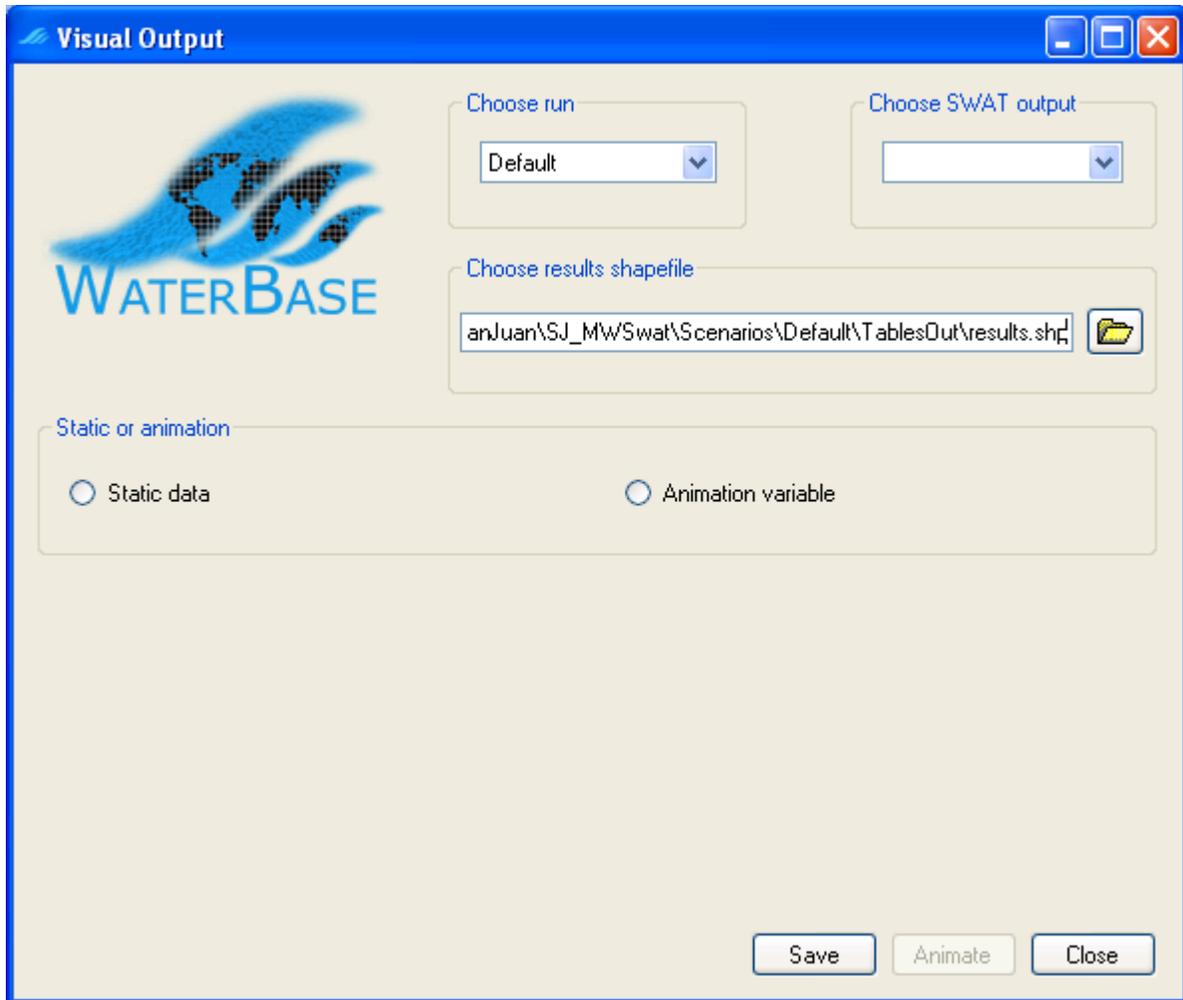


Figure 29: Visual output form

41. We first *Choose run*. In our case there is only one option, *Default*, since we haven't saved any earlier runs.

Note that you can only create the results shapefile for an earlier run if it had the same watershed delineation parameters as the current run, since the results shapefile is created from the current watershed shapefile, and depends in particular on the division into subbasins. So if you may change the watershed parameters it is a good idea to create the results shapefile as soon as you have completed the SWAT run. When you save the run the results shapefile will also be saved, if you created it in the default folder.

42. The shapefile we are going to create has been given a name, which is *F\Scenarios\Default\TablesOut\results.shp*. *Default* is the folder for files for the run *Default*. If we had chosen a saved run its folder would have been used. *TablesOut* is the folder used by the SWAT Editor for saving outputs in a database, and already exists. You can change the name of the results shapefile and/or its location by editing the name manually or by using the file selection button.

43. Note that if we change the run then, provided the file name is rooted in the *F\Scenarios* folder and contains *TablesOut*, this file name is automatically changed accordingly, so that the outputs saved correspond to the run that generated them.
44. Now *Choose SWAT output*, where you will see the options are *reach* and *subbasin*. If we had used the *Single HRU* option when creating the HRUs, *hru* would also have been included, since HRU boundaries would correspond to subbasin boundaries and so could be displayed by colouring subbasins. Select *reach*.
45. Select the *Static data* option. The combo box in *Choose variables* now contains the variables defined in the SWAT output file *output.rch*, from *FLOW_INcms* to *CMETAL#3kg*⁵. We can select and *Add* these one at a time to the results file, or we can select *All*. Click *All*.
46. The variables are added to the list box. You can select and delete (*Del*) variables, select and move *Up* or *Down*, or *Clear* the complete list. You can also go back to the *Choose SWAT output* box and select *subbasin* (or *hru* if available) and add more variables from *output.sub* (or *output.hru*). Variables from different output files may be mixed. We will just use the whole collection of *reach* variables.
47. We need to choose one of the variables in the list for display. Click to select *reach\SEDCONCmg/kg*.
48. Now we need to choose a summary. Select *Maxima*. This means that we will store in the results shapefile, and show in the MapWindow display, the maximum sediment concentration for each reach during the SWAT run.
49. Click the *Save* button .
50. If the results shapefile already exists you have to confirm you want to overwrite it. (If you don't, click *No*, select a new results shapefile and click *Save* again.)
51. The results shapefile is created and added to the MapWindow display as a layer. Initially it has a default colouring (Figure 30) and we get a message that we need to create a colouring scheme for it.

⁵NO3ConcMg/l for SWAT 2012.

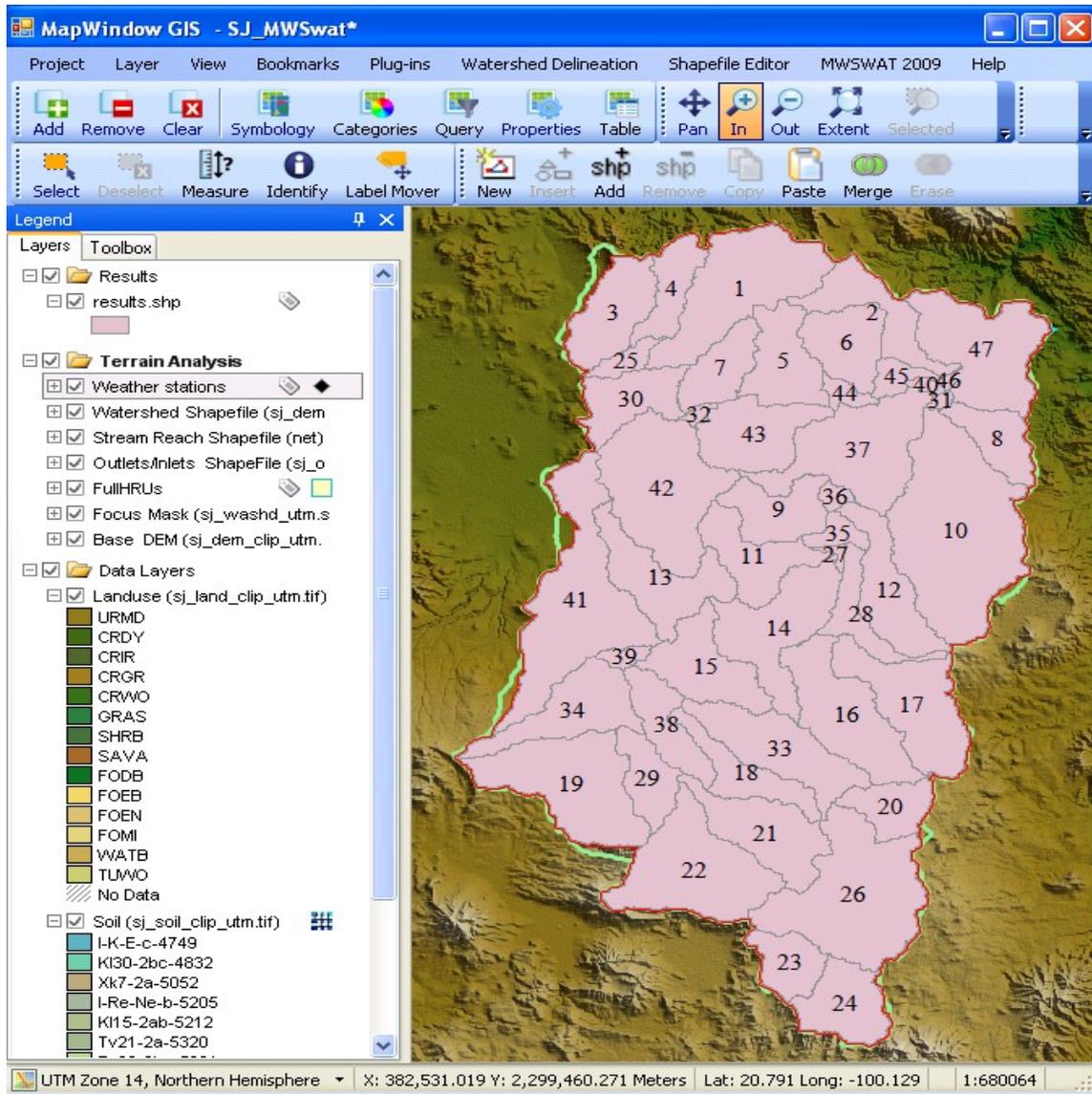


Figure 30: Initial load of results shapefile

52. We can first look at the attribute values that have been included in the results shapefile. Right click on the entry for *results.shp* in the legend, and select *Attribute Table Editor* (Figure 31). We see that there is a *SHAPE_ID*, generated by MapWindow internally, then the subbasin number, and then the area of the subbasin in square km. Note that although we are using reach variables, the area in this table is always the area of the subbasin, not of the area draining into the reach. The remaining attributes are the variables we selected. *Close* this table.

SHAPE_ID	Subbasin	AREAckm2	FLOW_INcms	FLOW_OUTc	EVAPcms	TLOSScms	SED_INtons
0	1	171.5	13.71	13.68	0.04004	0	455900
1	4	53.646	4.147	4.145	0.001861	0	60650
2	2	78.368	6.497	6.488	0.01265	0	396300
3	3	87.389	6.675	6.672	0.003007	0	67720
4	47	150.81	328.1	328	0.1698	0	7996000
5	5	85.486	6.89	6.885	0.007033	0	340200

Figure 31: Results shapefile attributes

53. To select a colouring scheme, click on the entry for the results shapefile in the legend, and click the *Categories* button in the toolbar. In the *Shapefile categories* form click the *Generate categories* button to bring up the *Category generation* form. Set the *Classification type* to *Equal intervals*, the *Number of categories* to, say, 5 and the *Classification field* to the attribute we decided to display, *SEDCONCmg/kg* (Figure 32).
54. We need to choose a colour scheme. There are a number available in the combo box, or we can use the button  to open the *Colour schemes list* (Figure 33).

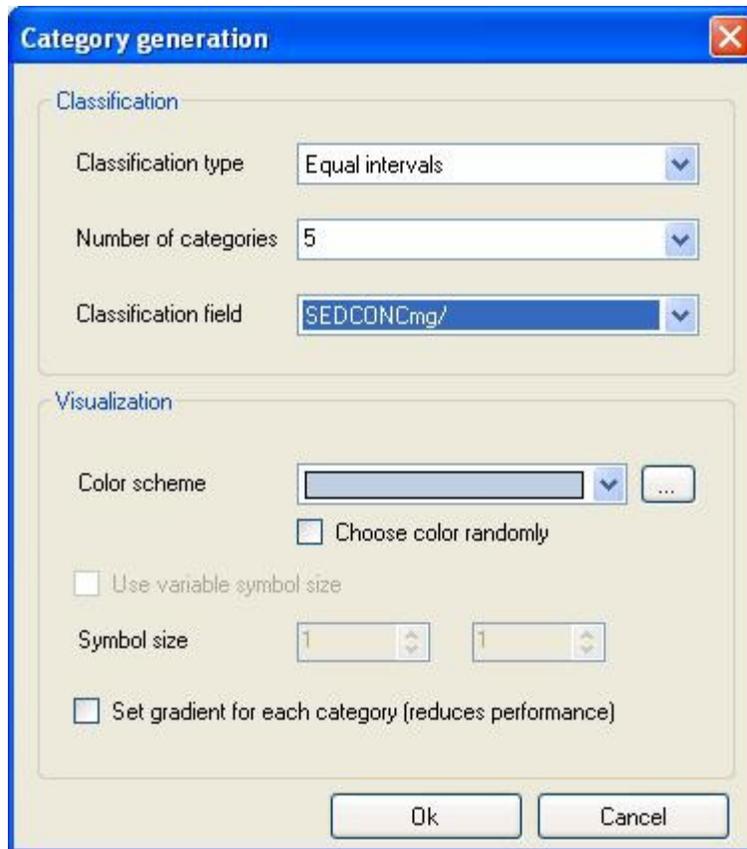


Figure 32: Category generation

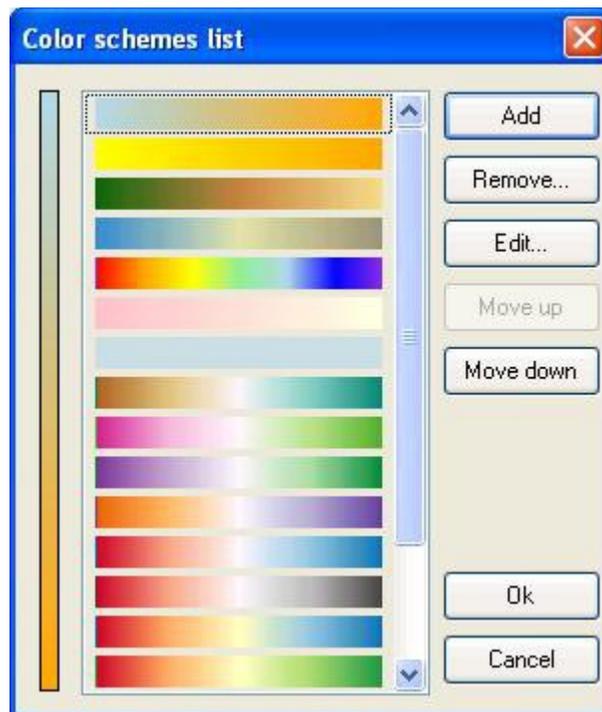


Figure 33: Colour schemes list

56. To make a new colour scheme, click *Add* to start *Colour scheme editing*. To get a simple scheme, say from yellow (low values) to red (high) select yellow as *Color1* and red as *Color2*, leaving the rest unchecked (Figure 34). Click *Ok*. The new scheme appears at the bottom of the *Colour schemes list* and you may want to move it to the top: select it with the mouse and use the *Move up* button repeatedly. Click *Ok* when finished. Now the new scheme appears conveniently in the combo box in the *Category generation* form and we select it (Figure 35). Click *Ok* to return to the *Shapefile categories* form and see the categories created (Figure 36). Click on *More options* to check that *Show fill* is checked, then click *Ok*. Click *Apply* to see the resulting map display. If you are content, click *Ok* to exit the *Shapefile categories* form. Otherwise you can click the *Generate categories* button (+) and change the number of categories and/or the colour scheme.

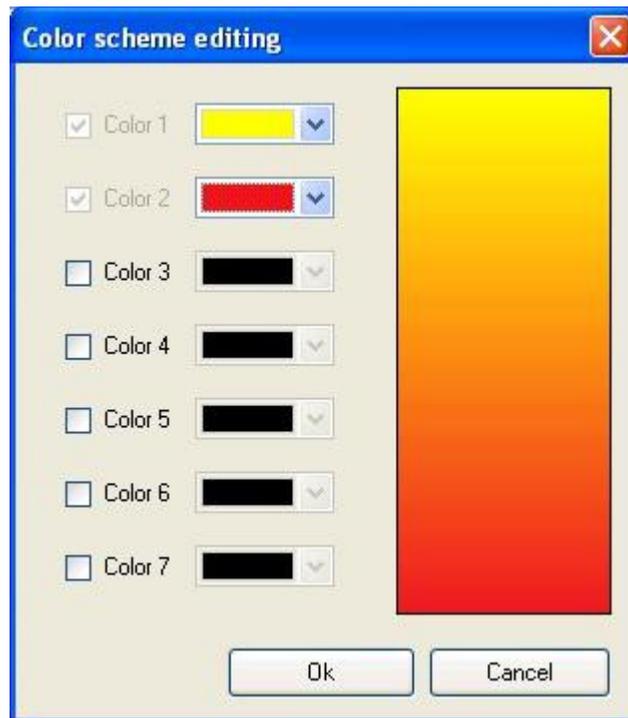


Figure 34: Colour scheme editing

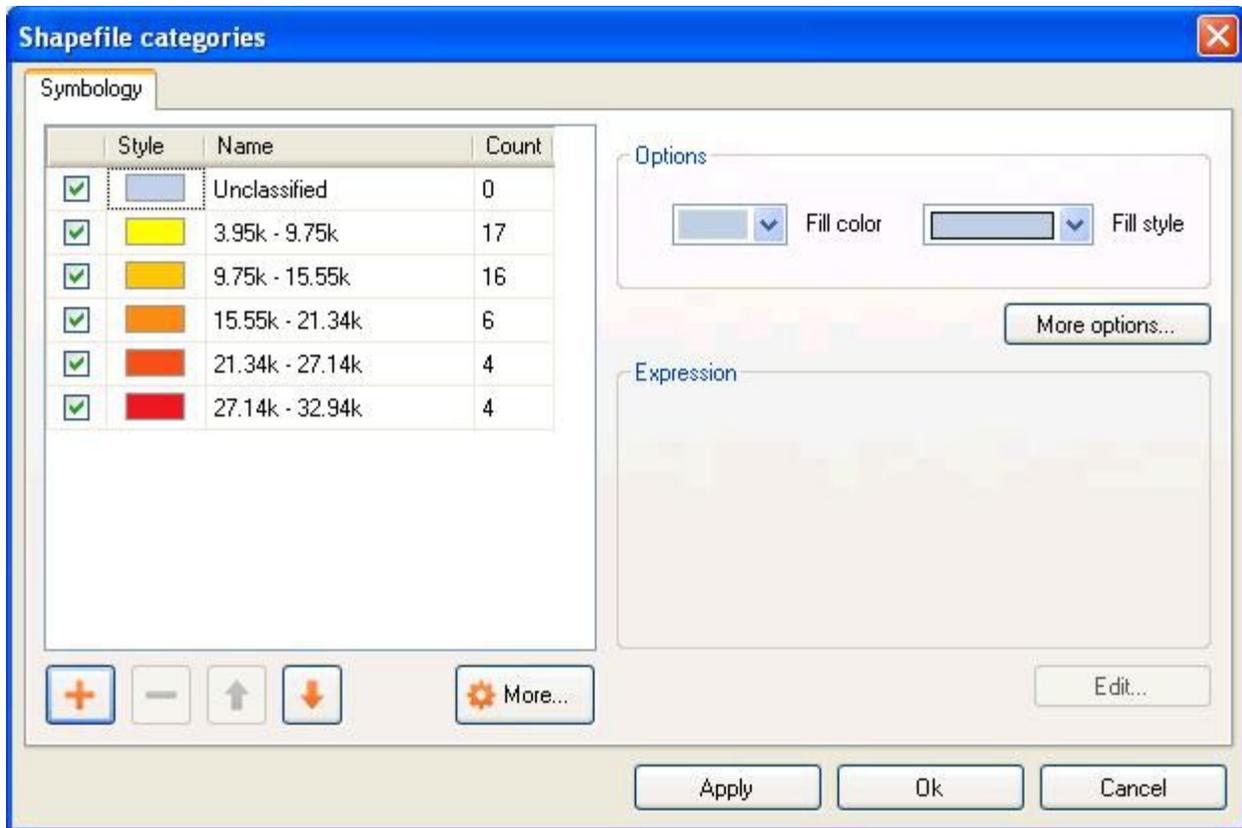


Figure 36: Categories created

57. We get the view in Figure 37 showing the different maximum concentrations of sediment in the various reaches

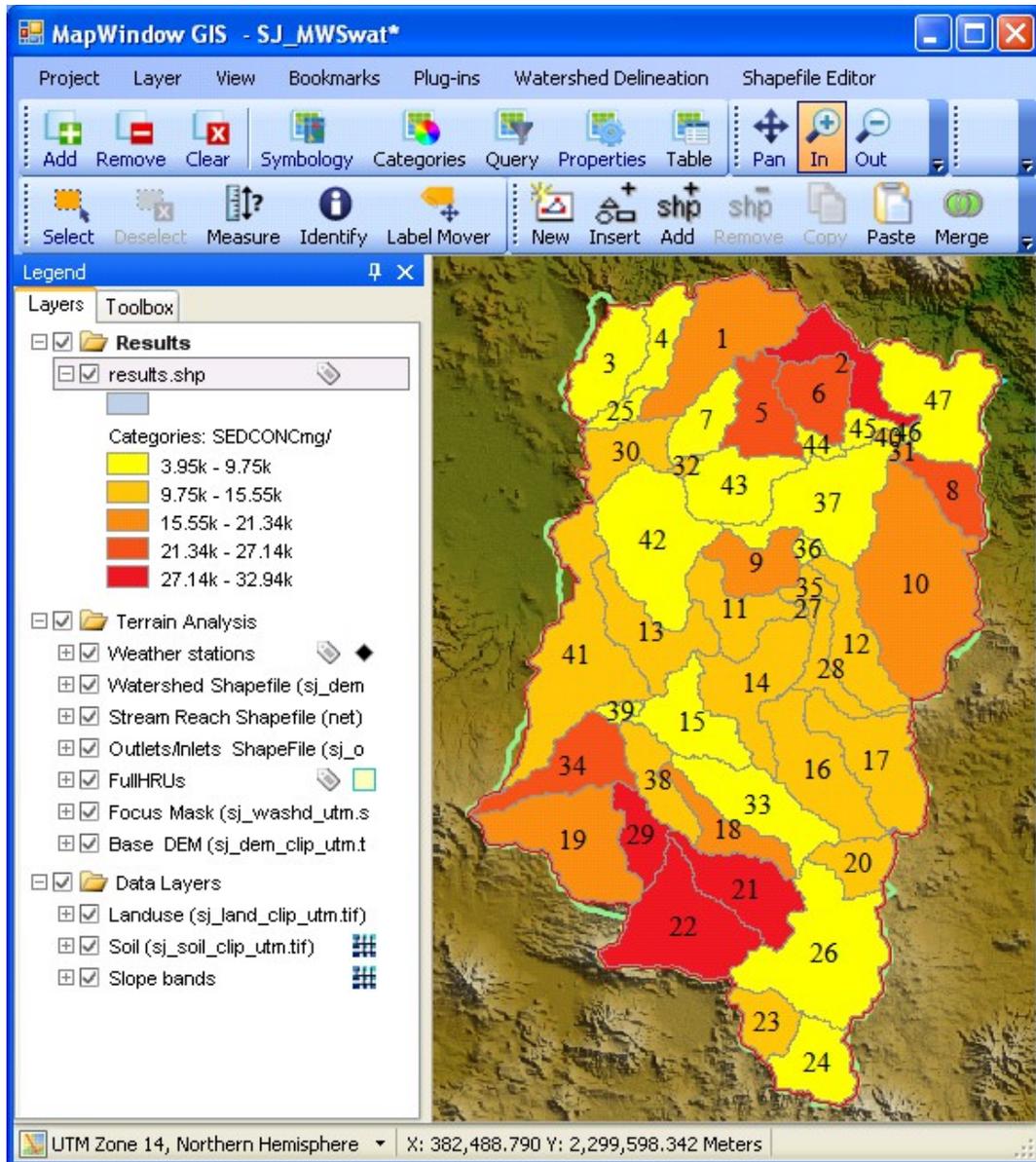


Figure 37: Graphical view of sediment concentration

58. It is possible to display a different variable from the same results shapefile for display. For example, select *reachFLOW_OUTcms* from the list and click *Save*. You are first asked to confirm that you want to overwrite the existing results shapefile. Click *Yes*, or if you want to preserve it, click *No*, change the results shapefile name, and *Save* again. The legend entry changes to show the new variable, and the colouring scheme is adjusted for the new range of values. The colouring scheme can of course be changed to use different colours and/or a different number of categories using the same procedure we used earlier to create one.

5.4.1 Animated results

59. To obtain an animation we start as in the static case, choosing a run, an output (reach, subbasin, or hru if they coincide with subbasins), and a results shapefile. In our case we have to accept Default for the run, as it is the only run we have, and we will accept the proposed shapefile, *results.shp* in the *TablesOut* folder. Select *subbasin* as the SWAT output, and select *Animation variable*. This opens a combo box in which we can select a variable from *outputs.sub*. Animation only allows one variable in the results shapefile: it could be difficult to make animation fast if we had a large number of variables to maintain. Select *ETmm*, and click *Save*.
60. Since we are using the same shapefile as we used earlier for the static display, we have to confirm we are willing to overwrite it.
61. The MapWindow display is updated for the new results shapefile, but no colours are yet shown. If you want to change the colouring scheme now is the time to do it (right click on the legend entry, and select *Properties* as before).
62. The *Visual Output* form has a new button enable: *Animate*. Click it to get the form shown in Figure 38.

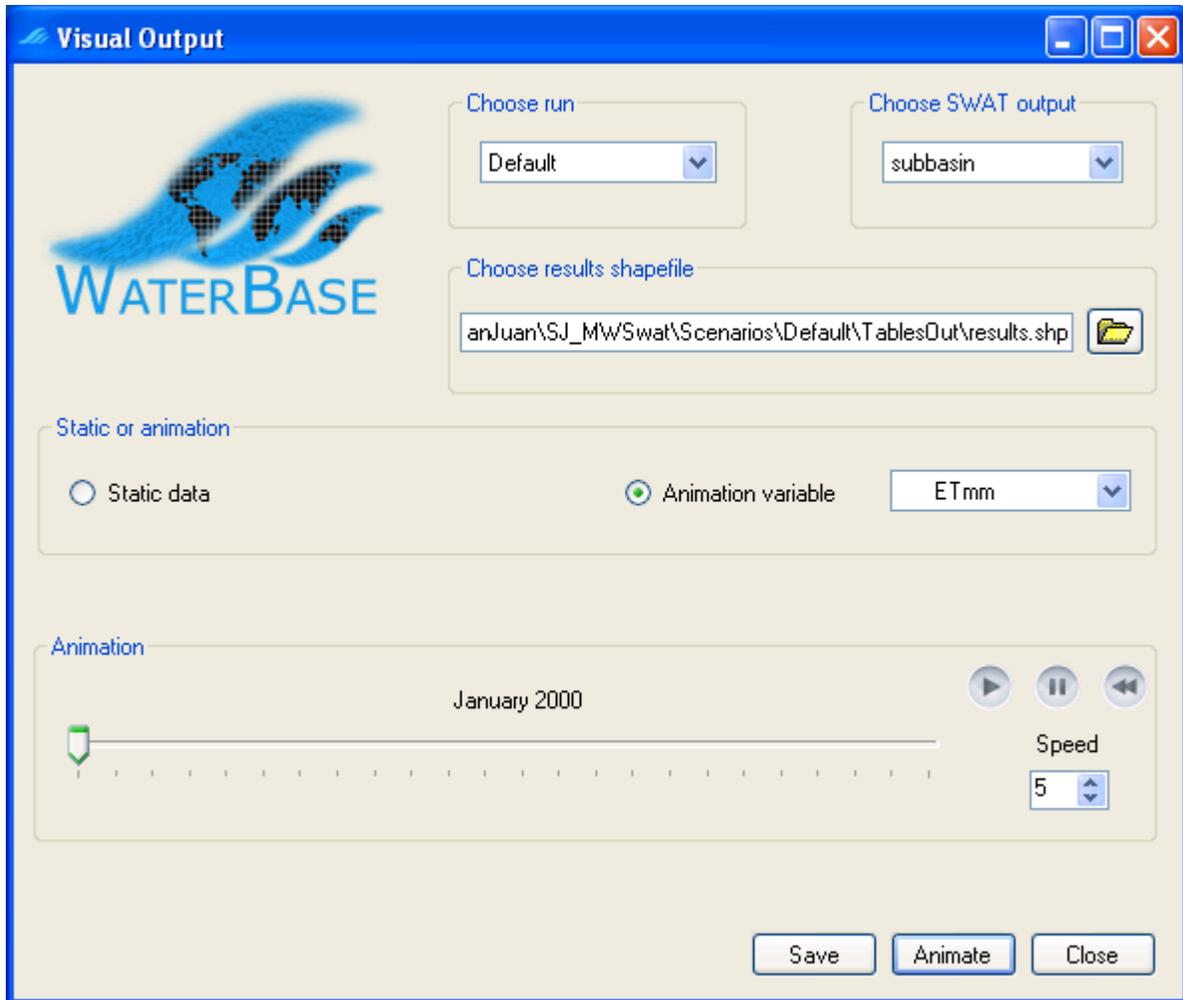


Figure 38: Ready to run animation

63. The MapWindow display now reflects the ET values for January 2000. The animation can be run by clicking on the run button . There is also a pause button  and a rewind button . The animation can also be done manually by shifting the slider  with the mouse. The speed for automatic animation can be increased or decreased with the *Speed* control.
64. As the slider moves the date above the track bar is updated, and so is the MapWindow display, according to the variable values for the date and the colouring scheme.
65. The values in the shapefile are updated as the MapWindow display values are. So when you finally *Close* the form, the values in the shapefile will correspond to the current position of the slider. This enables you to save a particular state of the animation. Note that clicking again on the *Save* button does not do this: it resets to the start of the animation. So you can use *Save* in preparation for changing the colouring scheme for the animation.
66. If you do want to save the results shapefile you may want to rename it, for example to reflect the date it represents. If you do this, remember that a shapefile is formed from a

number of files: .shp, .dbf, plus probably .prj, .mwsr, and .shx. All the files should be consistently renamed.

67. Close the *Visual Output* form, *Exit* from MWSWAT, and use *Exit* from the MapWindow *Project* menu to finish your session.

6 Setup for Malawi: Linthipe Watershed

This example uses the original MWSWAT. The MWSWAT 2009 or MWSWAT 2012 plugin may be used instead.

1. Start **MapWindow** and check that you have plugins "**Watershed Delineation**", "**Shapefile Editor**", and "**MWSWAT**" available. All these should be checked in the **Plug-ins** menu.
2. Start **MWSWAT**.
3. The main interface will be displayed. Click *New Project*.
4. A browser will be displayed requesting a name for the new project. Type **Lin_MWSwat** in the text box labelled *File Name* (under the *Linthipe* folder) and click *Save*.

At this point you get a reminder that (1) all your maps should be in an equal area projection (probably, but not necessarily, UTM⁶); you also need to make sure that the maps units of measure are meters, and (2) that the Watershed Delineation plugin is selected. If some of your maps need re-projecting you can use the MapWindow *Toolbox* to do it. You should also (3) check that Project/Settings/Application Settings is set to **Automatic** or **LoadAsGrid**; you will not be able to process some of your maps if this is set to **LoadAsImage**.

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 39).

⁶ UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds.

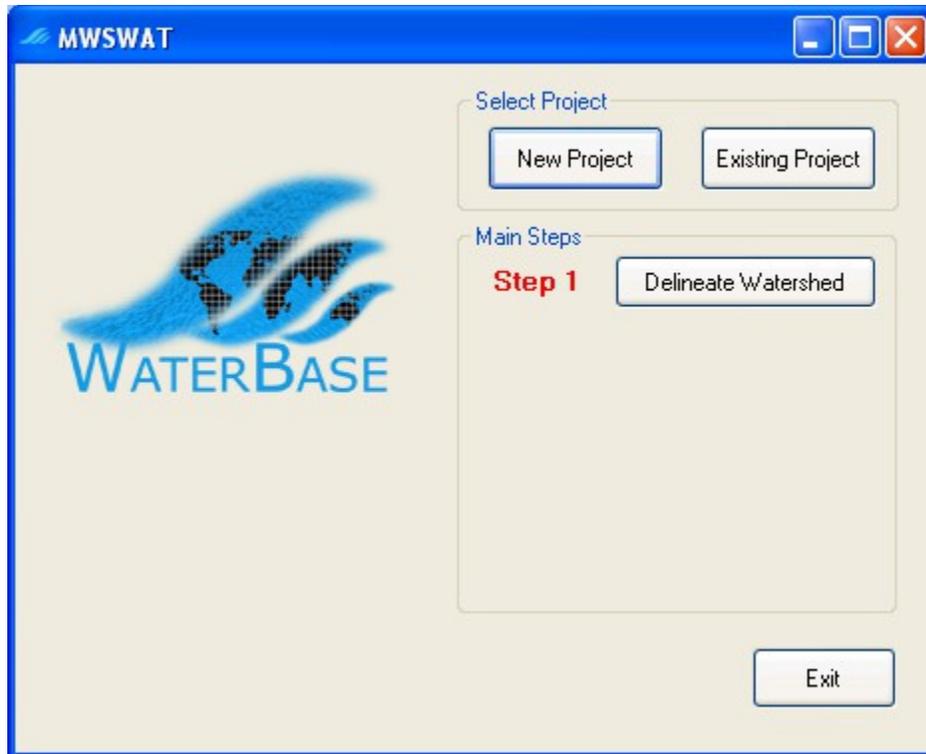


Figure 39: About to do step 1

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 *Lin_MWSwat* folder. See section 9 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/Geo_processed* folder and open the file *lin_dem_clip_utm.tif* (Figure 40). Leave the *Use predefined watershed and streams* check box unchecked. Refer to section ??? to see how to use the predefined option.
8. Click the *Process DEM* button to activate the *Automatic Watershed Delineation* plug-in. This will also load the DEM grid.

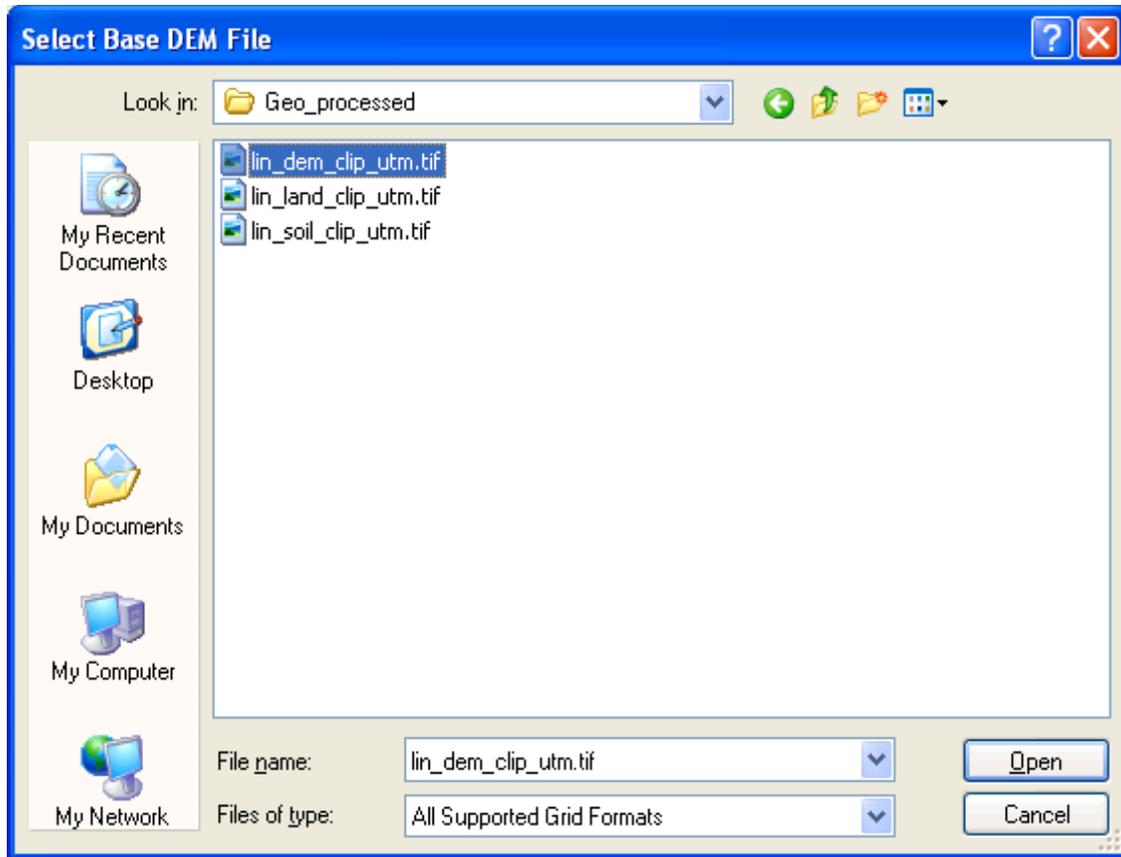


Figure 40: Selecting the DEM

9. The name of the elevation map grid will be displayed in the *DEM* text box on the *Automatic Watershed Delineation (AWD)* dialogue form. 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* is checked and browse for the file *lin_out.shp*.
11. In version 4.7 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 41).

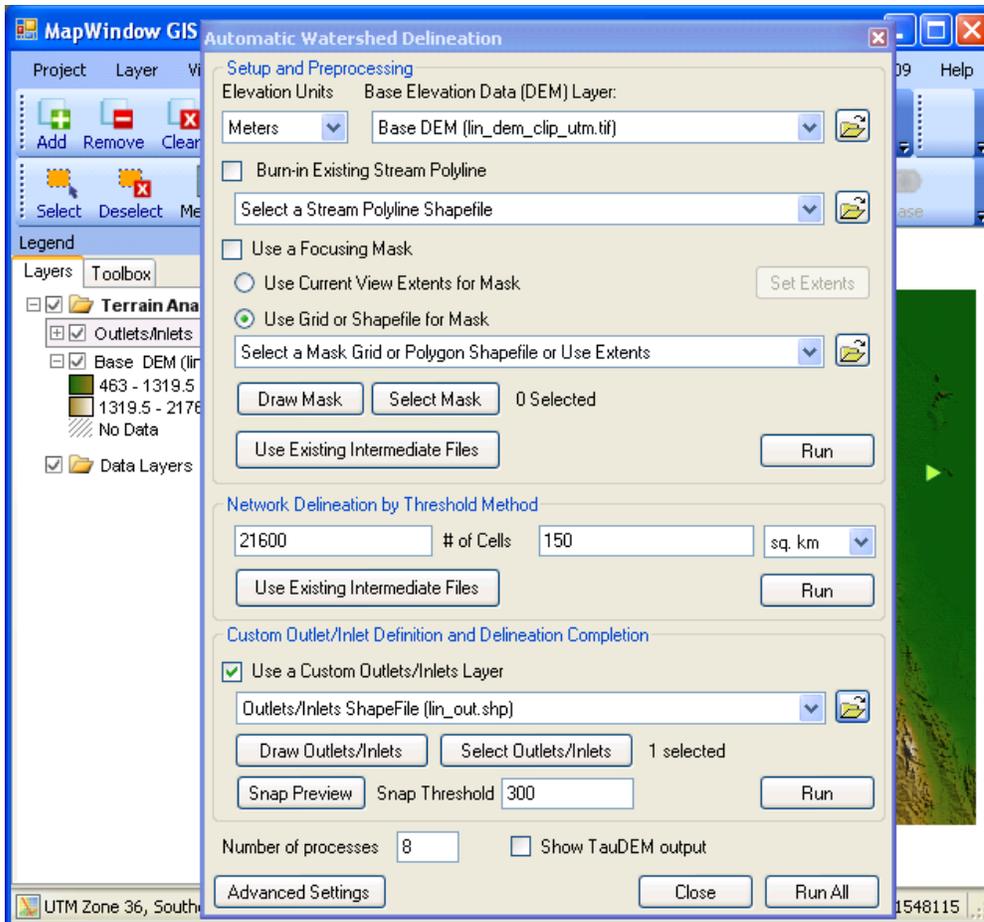


Figure 41: Running Automatic Watershed Delineation

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 42).
13. The MWSWAT interface will mark the *Process DEM* step as done and enable the second step. It's strongly recommended to save your project at this point.

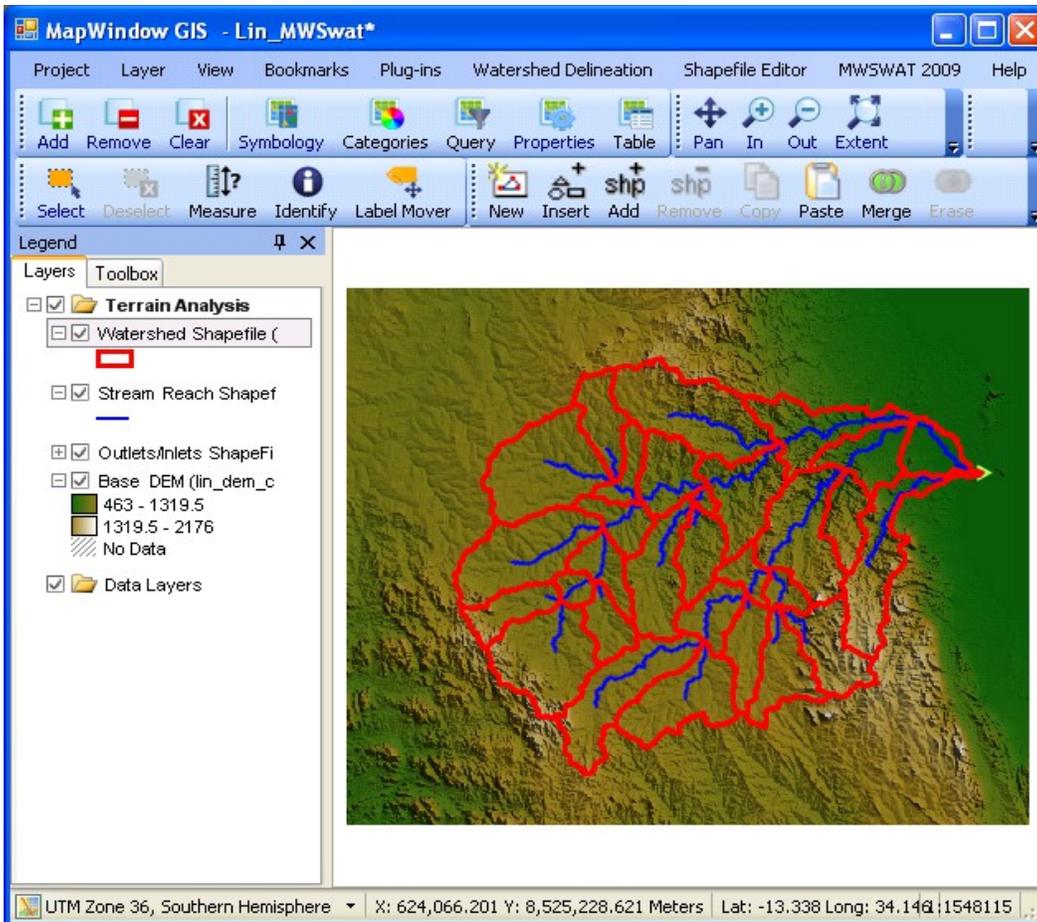


Figure 42: Watershed delineation complete

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. To generate the *FullHRUs* shapefile, click in the check box.
17. To read in the data from the DEM, landuse, soil and slope maps and prepare to calculate HRUs, click *Read* (Figure 43). This may take a few minutes.

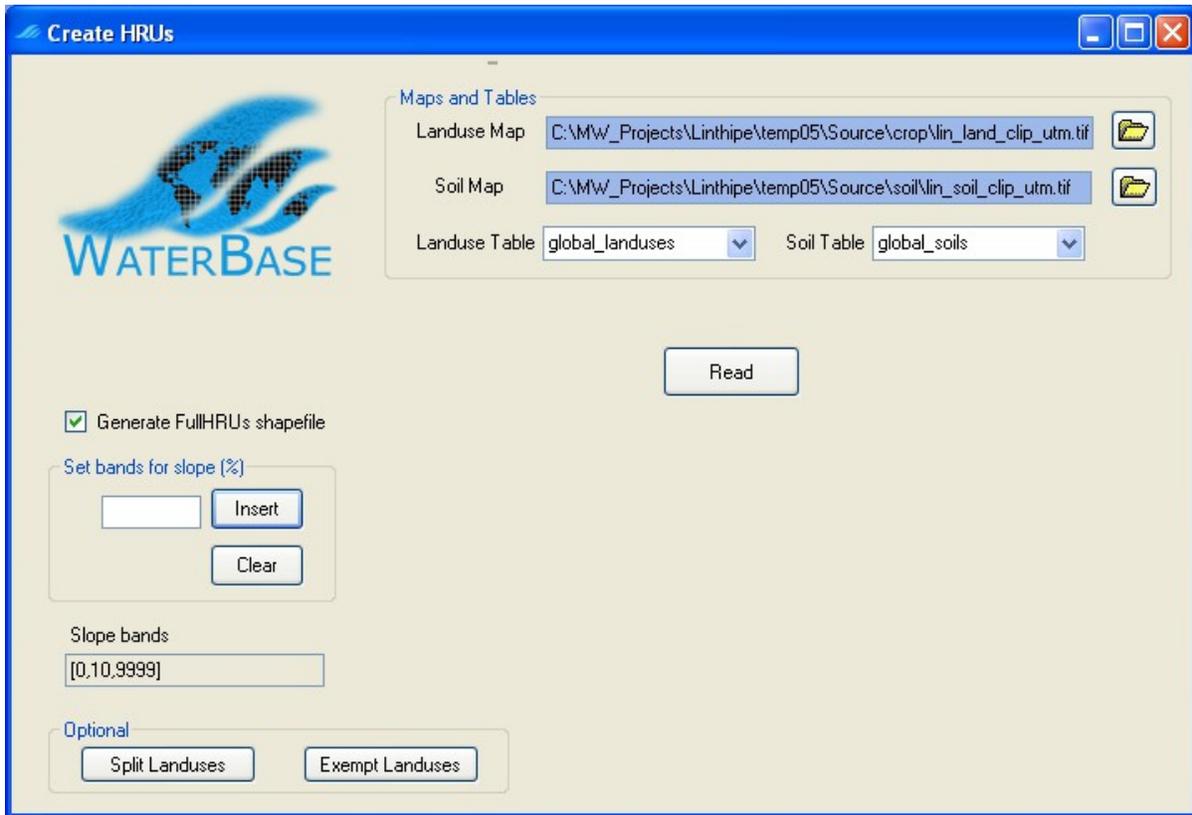


Figure 43: Ready to read the maps

18. After reading the grids you will notice a number of changes to the MapWindow display (Figure 44):
 - a. The subbasins have been numbered.⁷
 - b. 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.
 - c. 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.
 - d. 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. Generating the FullHRUs shapefile is optional, as it can take some time.
19. At this point we have the options to split landuses, and to exempt landuses, both of which will affect how HRUs are defined.
 - a. Splitting landuses allows us to define more precise landuses than our landuse map provides.

⁷ Numbering of the subbasins may vary.

- b. 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 can exclude HRUs that are insignificant by considering percentage thresholds or area thresholds. This is the *Multiple HRUs* option. There are also two options giving just one HRU for each subbasin. *Dominant HRU* selects the largest of the potential HRUs in each subbasin and makes its landuse, soil and slope range the ones chosen for the whole subbasin. *Dominant landuse, soil, slope* chooses the landuse with the biggest area in the subbasin, the soil with the biggest area in the subbasin, and the slope range with the biggest area in the subbasin and uses them for the whole subbasin.

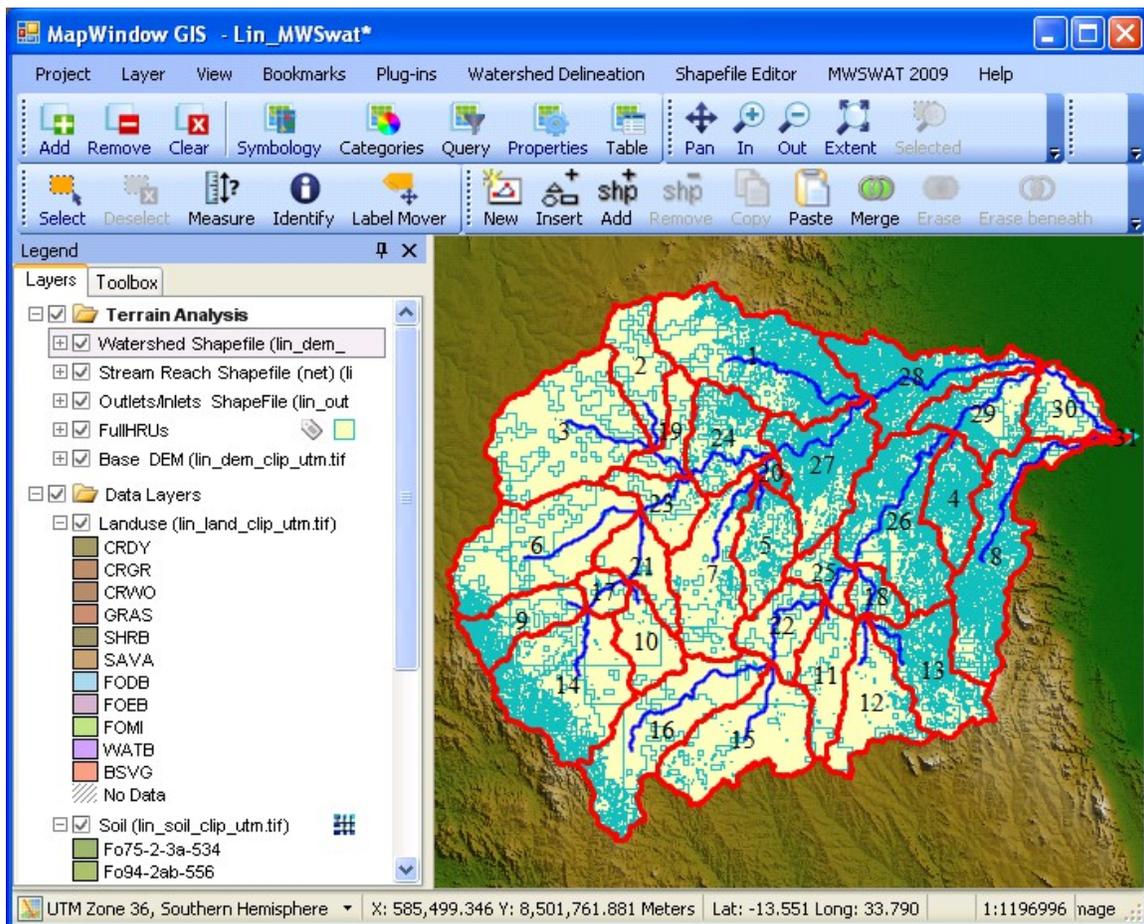


Figure 44: After reading grids

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 maximum 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 minimum across the subbasins of the maximum 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 45). It should report 127 HRUs formed in 31 subbasins. Click *OK*.

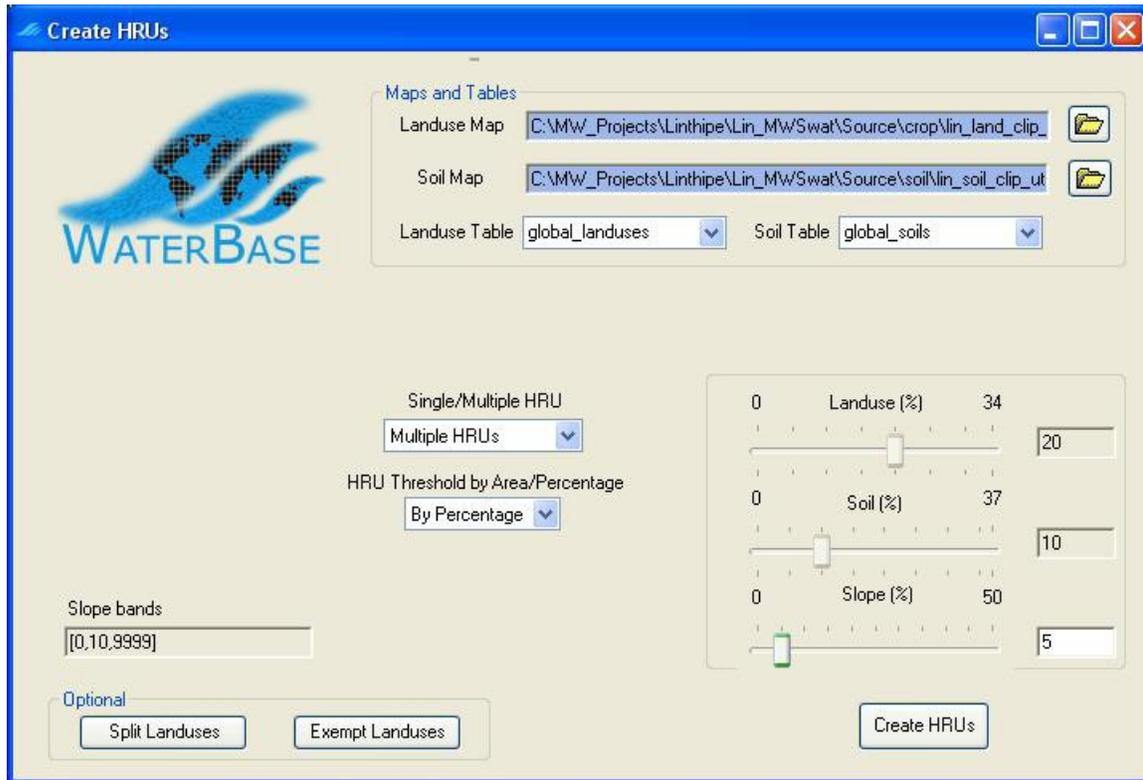


Figure 45: Creating multiple HRUs by percentage

Create HRUs is now reported as done and the third step is enabled (Figure 46). If you look at the *Reports* now available you will find that there is an *Elevation* report that gives information on the elevation profile of the basin and each subbasin, 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.

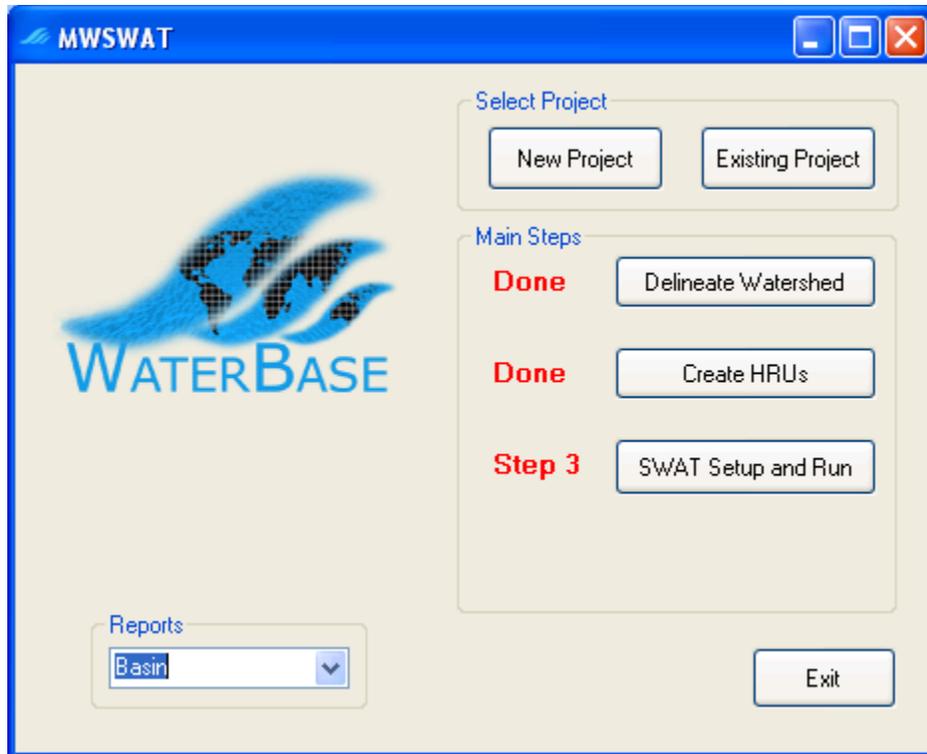


Figure 46: About to do step 3

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 47).

Figure 47: 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*. A common mode is 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* for *Weather Sources*, and choose *Global_Weather_Data\stnlist.txt* as the *Weather Stations File*. Then choose *File* for *Weather Generator* and *Lin_Maps\lin.wgn* as the *Weather Generator File* (Figure 48). Click *Done*.

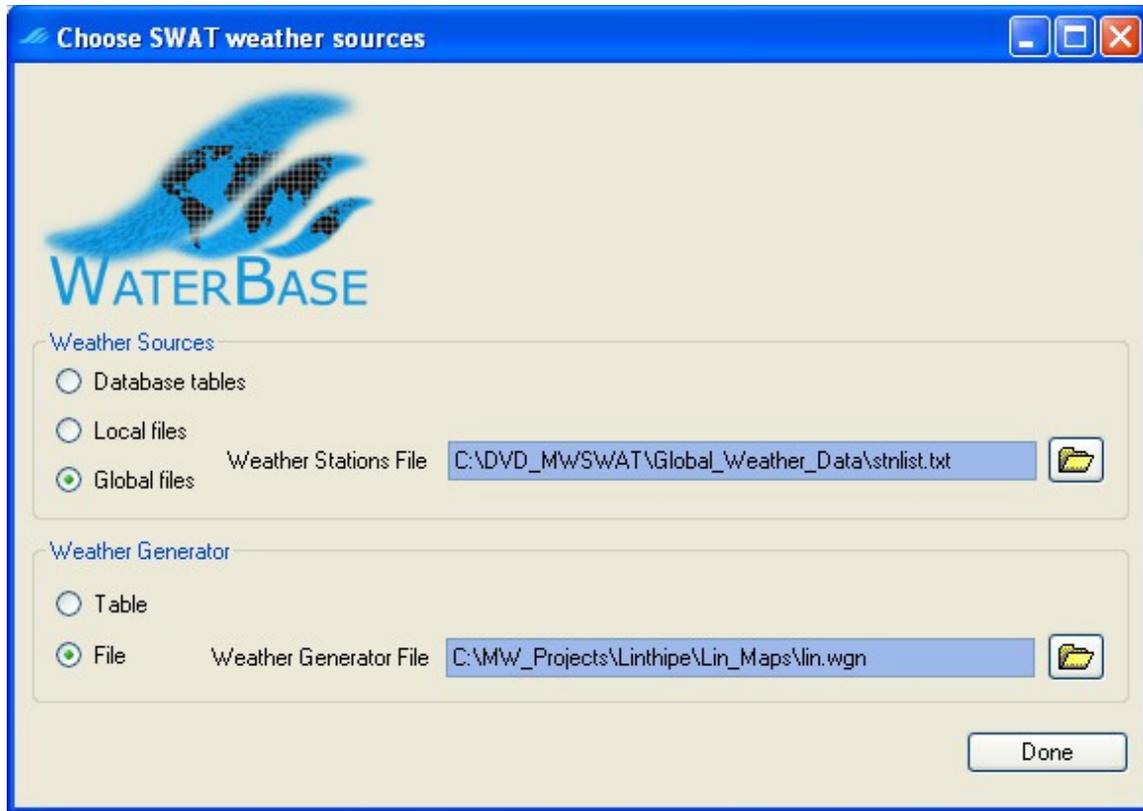


Figure 48: Choosing weather sources

25. Click *Select all files* in the list box (Figure 49) and click the *Write files* button. This may take a few minutes, especially if your simulation covers several years. If all is well you will see a form (Figure 50) showing that all database tables and files have been written successfully. Click *OK*.



Figure 49: About to write SWAT input files



Figure 50: Progress writing tables and files

26. If your project is calculated to possibly lie within the USA, then you will see a form like Figure 51. There is a program for estimating the heat units needed for plant growth, using climate data, but it is currently available only for the USA. If your project is within the USA, and you want to use this estimation program, then accept the default setting on the form and just click *Done*. If you want instead to use a fixed, default value, then click on that option, change the numeric value if you wish, and click *Done*.

Project outside the USA are automatically given the fixed default value of 1800. So in the Linthipe example you will not see Figure 51.

The heat units value appears in the .mgt files, and you can later if you wish edit these using the SWAT Editor.



Figure 51: Heat unit estimation form

27. The interface reports that the SWAT input files are written. They can be found in the *TxtInOut* folder. Click *OK*.
28. Click *Run SWAT* to launch the SWAT executable in a DOS prompt window (Figure 52).

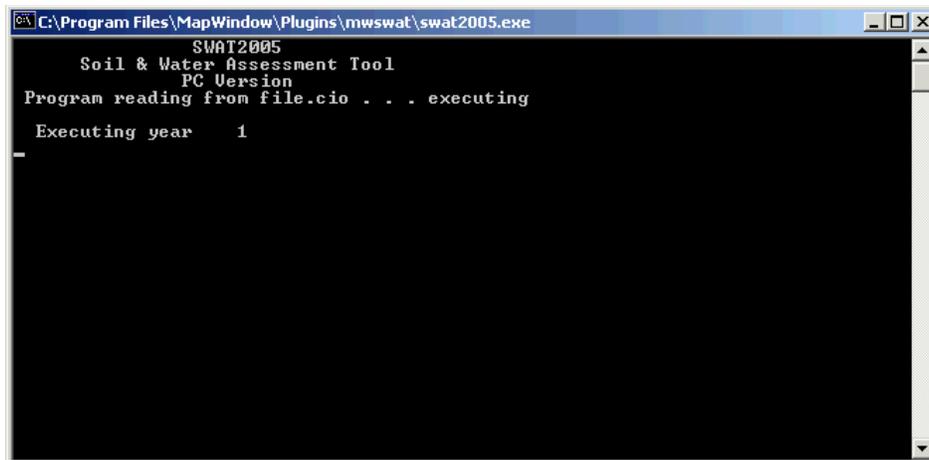


Figure 52: Running SWAT

29. If the run is successful the DOS window will close and a message box will say that SWAT was run successfully. Click *OK*.

30. If the run is not successful the DOS Window will stay open with a message telling you to *Hit Enter to exit*. In MWSWAT 2009 or 2012, if you did not check the *Run SWAT in debug mode* box in the *SWAT Setup and Run* form (which is normally what you do, since release version is faster) you won't get much information about what went wrong. So check this box and run SWAT again. This allows you to see what went wrong, what error SWAT reported. 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 the SWAT team. Go to the SWAT support page <http://swat.tamu.edu/support/> for advice.
31. You can save the SWAT run if you wish using the *Save run* button. This in fact copies *F\Proj\Scenarios\Default* to *F\Proj\Scenarios\Save1* 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.)
32. Graphs of the results such as those in Figure 53 can be created using the SWATPlot and SWATGraph tools (available from WaterBase <http://www.waterbase.org>).

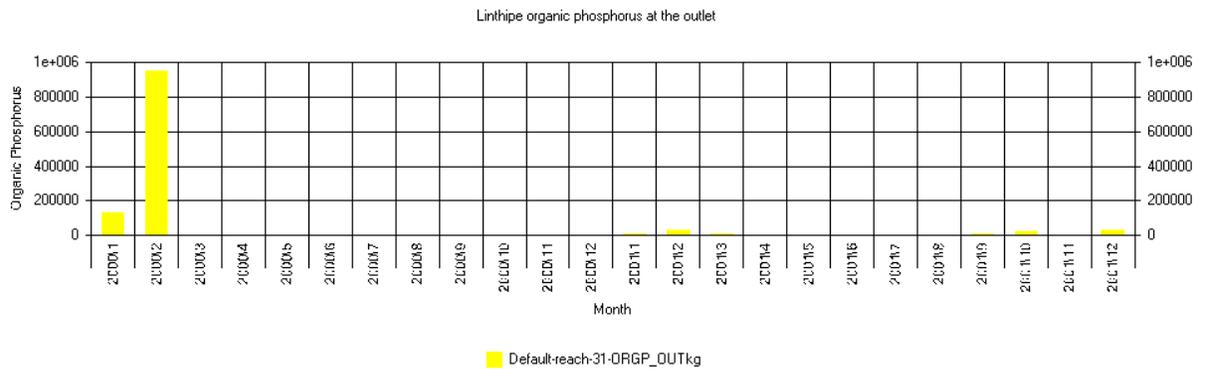
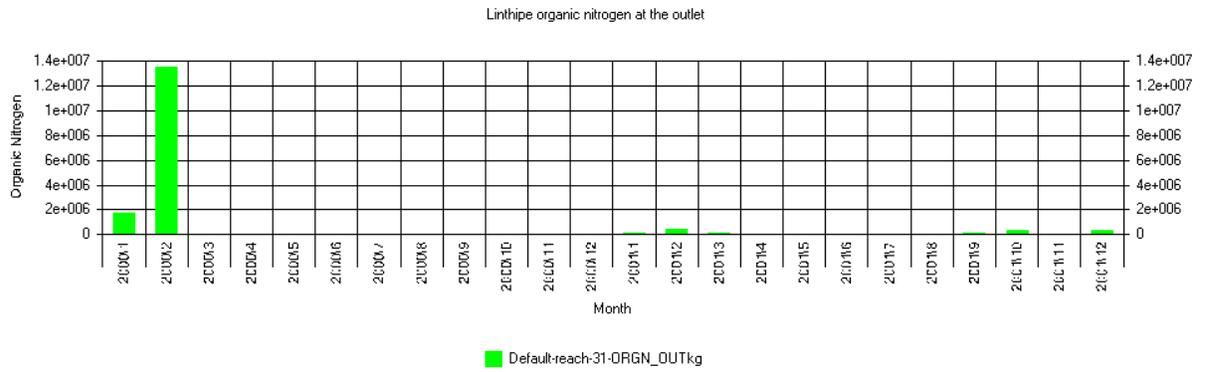
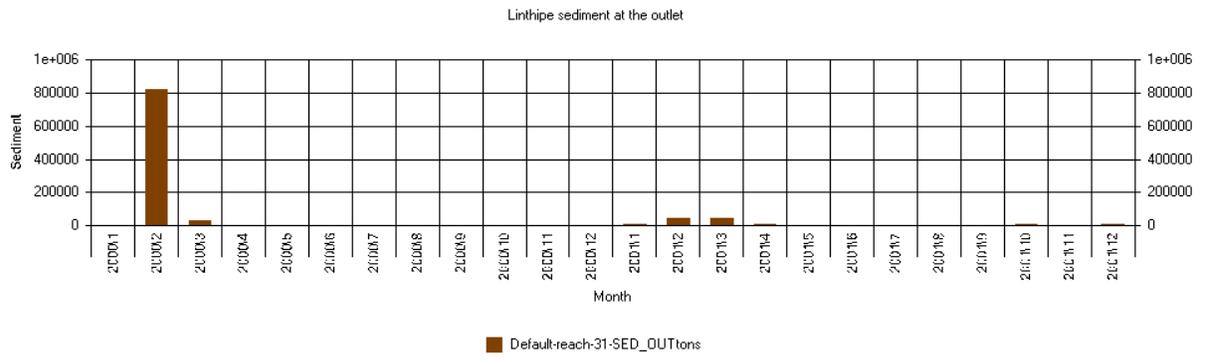
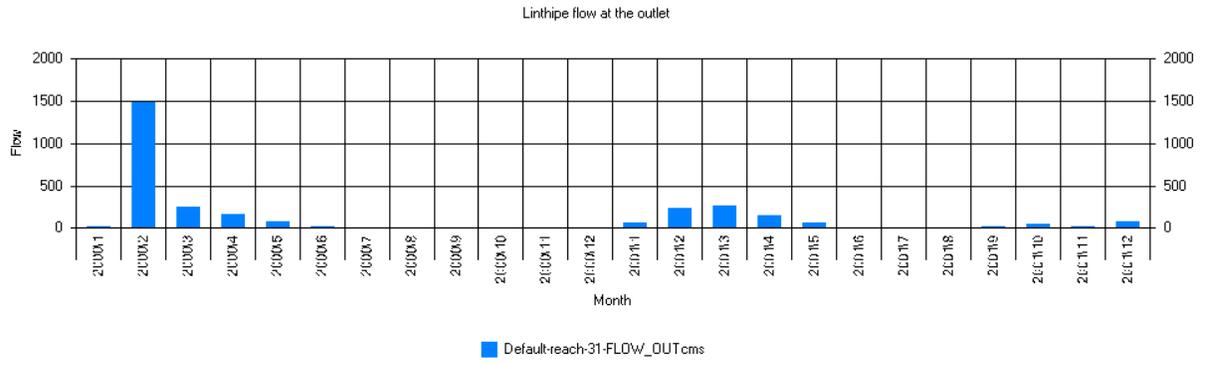


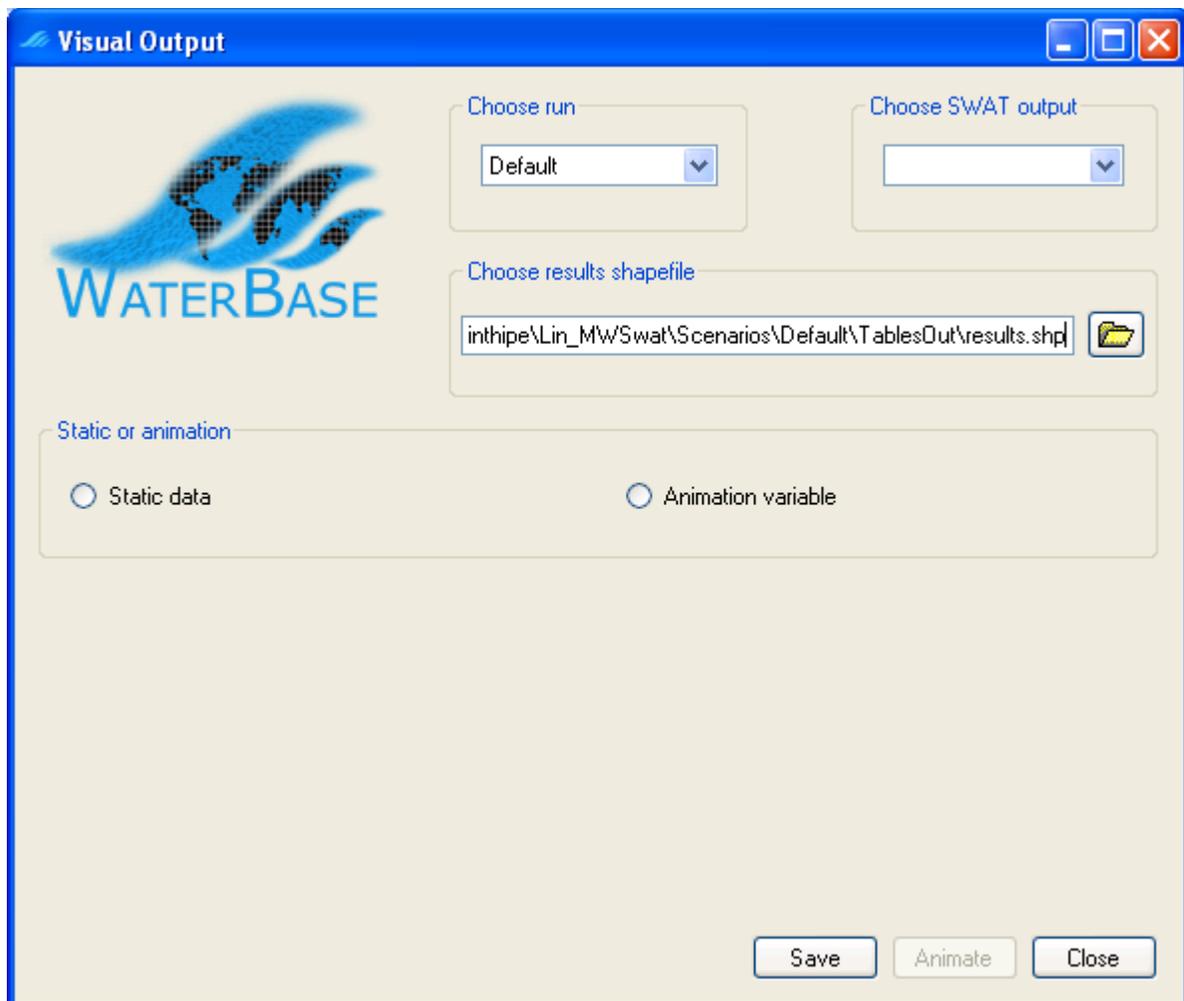
Figure 53: Linthipe output plots

6.4 Step 4. Visualise results

You can visualise SWAT outputs by using the *Visualise* button. Click on it to get the form in Figure 54. The idea is to make a *results shapefile* showing the subbasins of the watershed, and then to display one of the SWAT outputs by colouring the subbasins according to the value of the output. This involves making the output values an attribute of the shapefile. The outputs can be visualized either statically or dynamically, and we will explain each of these in turn.

6.4.1 Static results.

33. In the static case we can add many outputs if we wish, which allows us to make several displays from one shapefile.



The image shows a software dialog box titled "Visual Output" with a blue header bar. On the left side, there is a logo for "WATERBASE" featuring a stylized blue globe with a grid pattern. The main area of the dialog is light beige and contains several controls:

- Choose run:** A dropdown menu with "Default" selected.
- Choose SWAT output:** An empty dropdown menu.
- Choose results shapefile:** A text input field containing the path "in\hipe\Lin_M\W\Swat\Scenarios\Default\TablesOut\results.shp" and a folder selection icon to its right.
- Static or animation:** A section with two radio buttons: "Static data" (which is selected) and "Animation variable".
- Buttons:** At the bottom right, there are three buttons: "Save", "Animate", and "Close".

Figure 54: Visual output form

34. We first *Choose run*. In our case there is only one option, *Default*, since we haven't saved any earlier runs.

Note that you can only create the results shapefile for an earlier run if it had the same watershed delineation parameters as the current run, since the results shapefile is created from the current watershed shapefile, and depends in particular on the division into subbasins. So if you may change the watershed parameters it is a good idea to create the results shapefile as soon as you have completed the SWAT run. When you save the run the results shapefile will also be saved, if you created it in the default folder.

35. The shapefile we are going to create has been given a name, which is *F\Scenarios\Default\TablesOut\results.shp*. *Default* is the folder for files for the run *Default*. If we had chosen a saved run its folder would have been used. *TablesOut* is the folder used by the SWAT Editor for saving outputs in a database, and already exists. You can change the name of the results shapefile and/or its location by editing the name manually or by using the file selection button.

Note that if we change the run then, provided the file name is rooted in the *F\Scenarios* folder and contains *TablesOut*, this file name is automatically changed accordingly, so that the outputs saved correspond to the run that generated them.

36. Now *Choose SWAT output*, where you will see the options are *reach* and *subbasin*. If we had used the *Single HRU* option when creating the HRUs, *hru* would also have been included, since HRU boundaries would correspond to subbasin boundaries and so could be displayed by colouring subbasins. Select *reach*.

37. Select the *Static data* option. The combo box in *Choose variables* now contains the variables defined in the SWAT output file *output.rch*, from FLOW_INcms to CMETAL#3kg⁸. We can select and *Add* these one at a time to the results file, or we can select *All*. Click *All*.

38. The variables are added to the list box. You can select and delete (*Del*) variables, select and move *Up* or *Down*, or *Clear* the complete list. You can also go back to the *Choose SWAT output* box and select *subbasin* (or *hru* if available) and add more variables from *output.sub* (or *output.hru*). Variables from different output files may be mixed. We will just use the whole collection of *reach* variables.

39. We need to choose one of the variables in the list for display. Click to select *reach\SEDCONCmg/kg*.

40. Now we need to choose a summary. Select *Maxima*. This means that we will store in the results shapefile, and show in the MapWindow display, the maximum sediment concentration for each reach during the SWAT run.

The summaries are calculated as follows. For each variable there is a set of daily, monthly, or annual (according to the printout frequency used for the SWAT run) output values. *Totals* are the sums of these values; *Daily means* are the sums divided by the number of days in the run; *Monthly means* are the sums divided by the number of months in the run (which may be fractional); *Annual means* are the sums divided by the number

⁸NO3ConcMg/l for SWAT 2012.

of years in the run (which may also be fractional); *Maxima* are the maxima of the values; *Minima* are the minima of the values.

For variables which are already given output values which are effectively means, such as rates of flow, only some of the summaries make physical sense, namely the *mean* for the chosen printout frequency, *Maxima* and *Minima*. Users should therefore exercise caution in choosing summaries for results files including such variables.

41. Click the *Save* button .
42. If the results shapefile already exists you have to confirm you want to overwrite it. (If you don't, click *No*, select a new results shapefile and click *Save* again.)
43. The results shapefile is created and added to the MapWindow display as a layer. Initially it has a default colouring and we get a message that we need to create a colouring scheme for it.
44. We can first look at the attribute values that have been included in the results shapefile. Right click on the entry for *results.shp* in the legend, and select *Attribute Table Editor* (Figure 55). We see that there is a *SHAPE__ID*, generated by MapWindow internally, then the subbasin number, and then the area of the subbasin in square km. Note that although we are using reach variables, the area in this table is always the area of the subbasin, not of the area draining into the reach. The remaining attributes are the variables we selected. *Close* this table.

SHAPE_ID	Subbasin	AREAk2	FLOW_INcms	FLOW_OUTc	EVAPcms	TLOSScms	SE
0	1	618.38	0.07811	0	0.0478	0	2E-
1	2	223.49	0.01197	0.003214	0.006828	0	4E-
2	28	355.7	0.183	0	0.183	0	4.7I
3	3	601.33	0.02255	0.001579	0.02016	0	4E-
4	30	179.36	0.2254	0	0.1616	0	0.0'
5	19	130.87	0.01305	0	0.009913	0	5E-
6	29	251.35	0.1662	0.0006481	0.08266	0	3.3I
7	24	255.41	0.02727	0	0.02727	0	1.4I
8	27	370.39	0.04158	0	0.04158	0	0.0I
9	26	501.74	0.06063	0	0.06063	0	0.0.
10	8	464.53	0.05304	0	0.05244	0	1E-
11	4	198.35	0.01816	0.01162	0.001984	0	1.1I
12	31	0.38194	0.000863	0	0.000863	0	4E-
13	20	29.417	0.01286	0.0001543	0.008344	0	5E-
14	23	164.06	0.01734	0	0.01734	0	5E-
15	7	375.23	0.01526	7.536E-05	0.01497	0	4E-
16	5	214.36	0.01994	0.009367	0.004924	0	1.1I
17	6	537.54	0.05368	0	0.03014	0	1.6I
18	21	172.06	0.02827	0	0.0266	0	0.0I

Figure 55: Results shapefile attributes

45. To select a colouring scheme, click on the entry for the results shapefile in the legend, and click the *Categories* button in the toolbar. In the *Shapefile categories* form click the *Generate categories* button to bring up the *Category generation* form. Set the *Classification type* to *Equal intervals*, the *Number of categories* to, say, 5 and the *Classification field* to the attribute we decided to display, *SEDCONCmg/kg* (Figure 56).
46. We need to choose a colour scheme. There are a number available in the combo box, or we can use the button  to open the *Colour schemes list* (Figure 57).
47. To make a new colour scheme, click *Add* to start *Colour scheme editing*. To get a simple scheme, say from yellow (low values) to red (high) select yellow as *Color1* and red as *Color2*, leaving the rest unchecked (Figure 58). Click *Ok*. The new scheme appears at the bottom of the *Colour schemes list* and you may want to move it to the top: select it with the mouse and use the *Move up* button repeatedly. Click *Ok* when finished. Now the new scheme appears conveniently in the combo box in the *Category generation* form and we select it (Figure 59). Click *Ok* to return to the *Shapefile categories* form and see the categories created. Click on *More options* to check that *Show fill* is checked, then click *Ok*. Click *Apply* to see the resulting map display. If you are content, click *Ok* to exit the *Shapefile categories* form. Otherwise you can click the *Generate categories* button (+) and change the number of categories and/or the colour scheme.

48. We get the view in Figure 60 showing the different maximum concentrations of sediment in the various reaches.

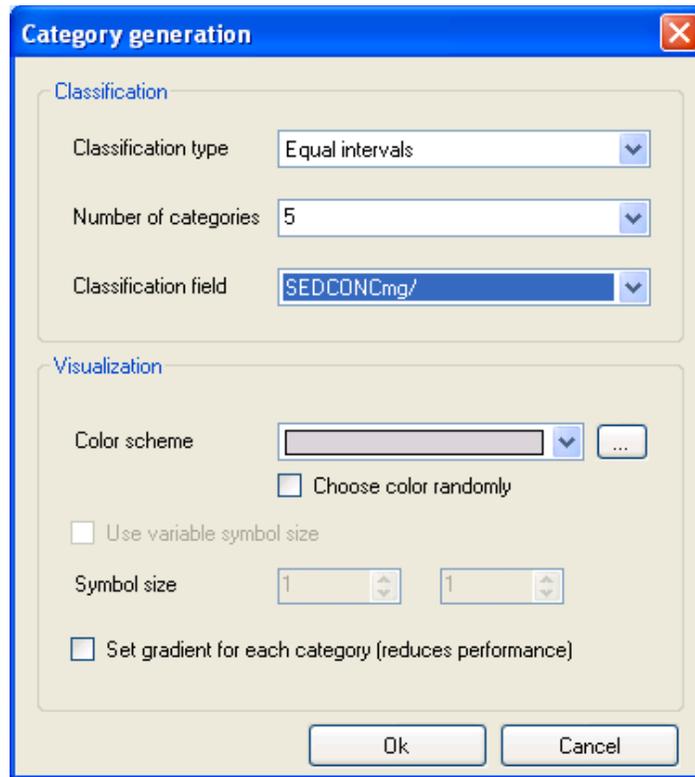


Figure 56: Category generation

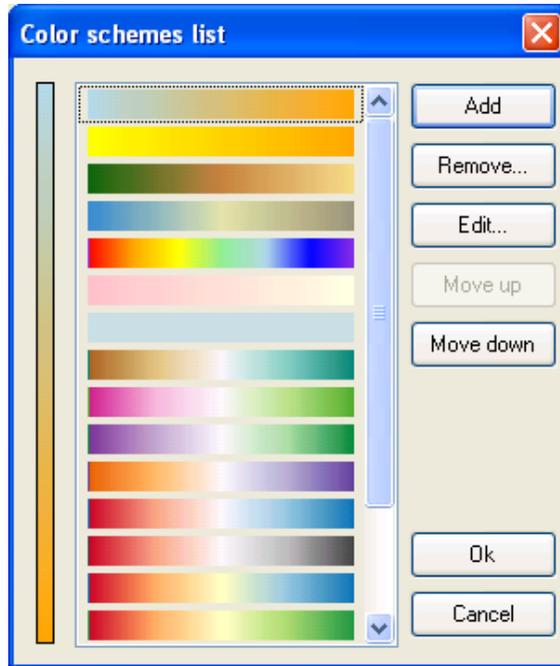


Figure 57: Colour schemes list

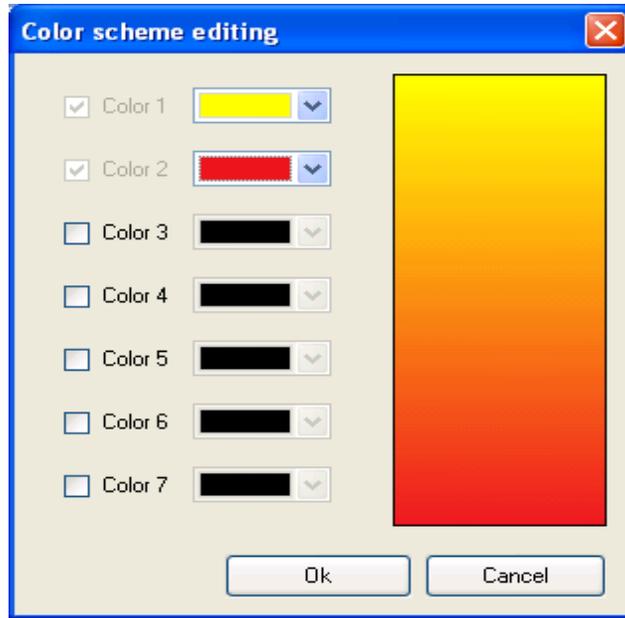


Figure 58: Colour scheme editing

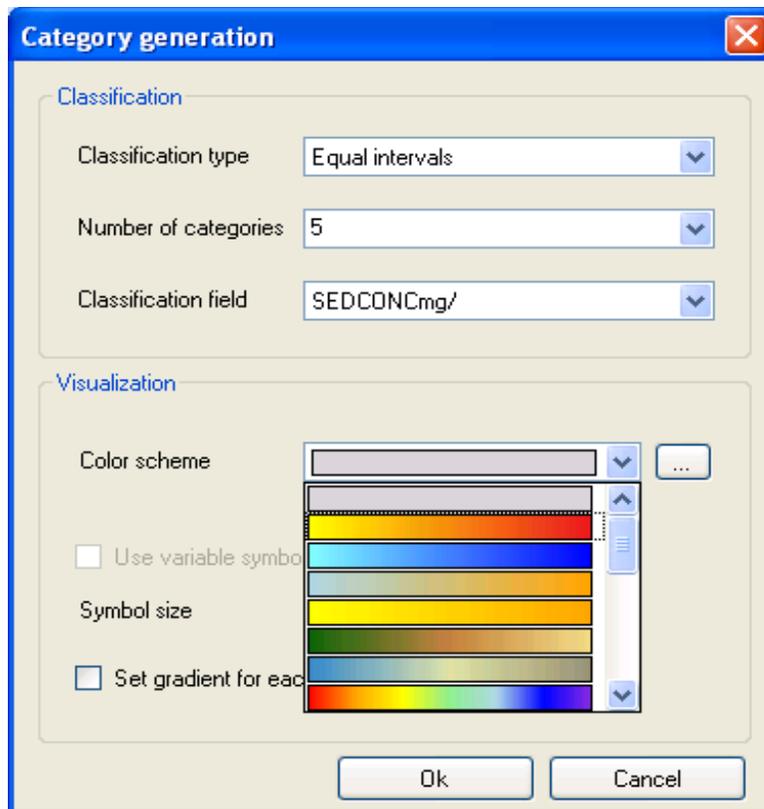


Figure 59: Selecting the colour scheme

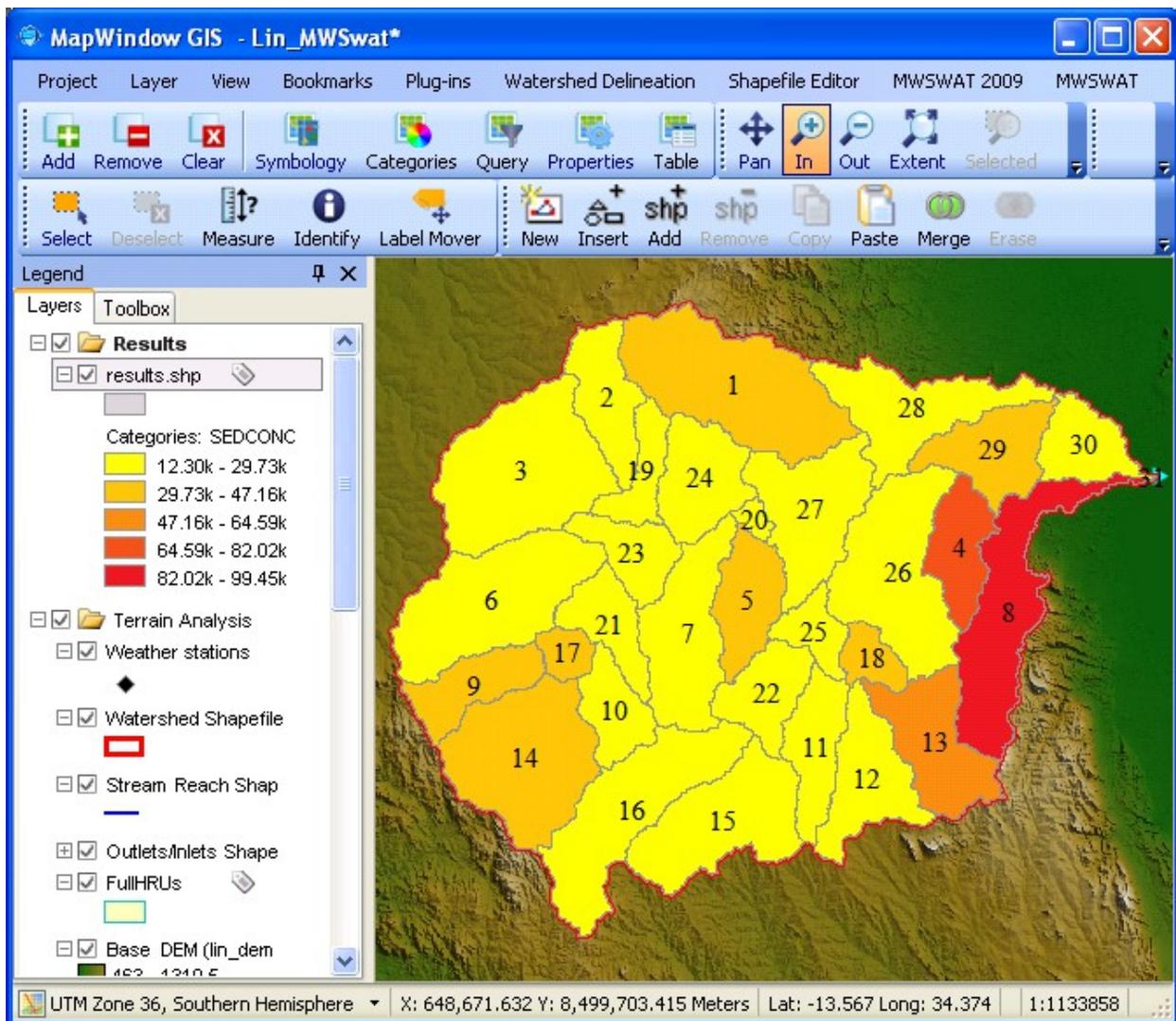


Figure 60: Graphical view of sediment concentration

49. It is possible to display a different variable from the same results shapefile for display. For example, select *reach\FLOW_OUTcms* from the list and click *Save*. The legend entry changes to show the new variable, and the colouring scheme is adjusted for the new range of values. The colouring scheme can of course be changed to use different colours and/or a different number of breaks using the same procedure we used earlier to create one.

6.4.1 Animated results

50. To obtain an animation we start as in the static case, choosing a run, an output (reach, subbasin, or hru if they coincide with subbasins), and a results shapefile. In our case we have to accept *Default* for the run, as it is the only run we have, and we will accept the proposed shapefile, *results.shp* in the *TablesOut* folder. Select *subbasin* as the SWAT

output, and select *Animation variable*. This opens a combo box in which we can select a variable from *outputs.sub*. Animation only allows one variable in the results shapefile: it could be difficult to make animation fast if we had a large number of variables to maintain. Select *ETmm*, and click *Save*.

51. Since we are using the same shapefile as we used earlier for the static display, we have to confirm we are willing to overwrite it.
52. The MapWindow display is updated for the new results shapefile, but no colours are yet shown. If you want to change the colouring scheme now is the time to do it (right click on the legend entry, and select *Properties* as before).
53. The *Visual Output* form has a new button enable: *Animate*. Click it to get the form shown in Figure 61.

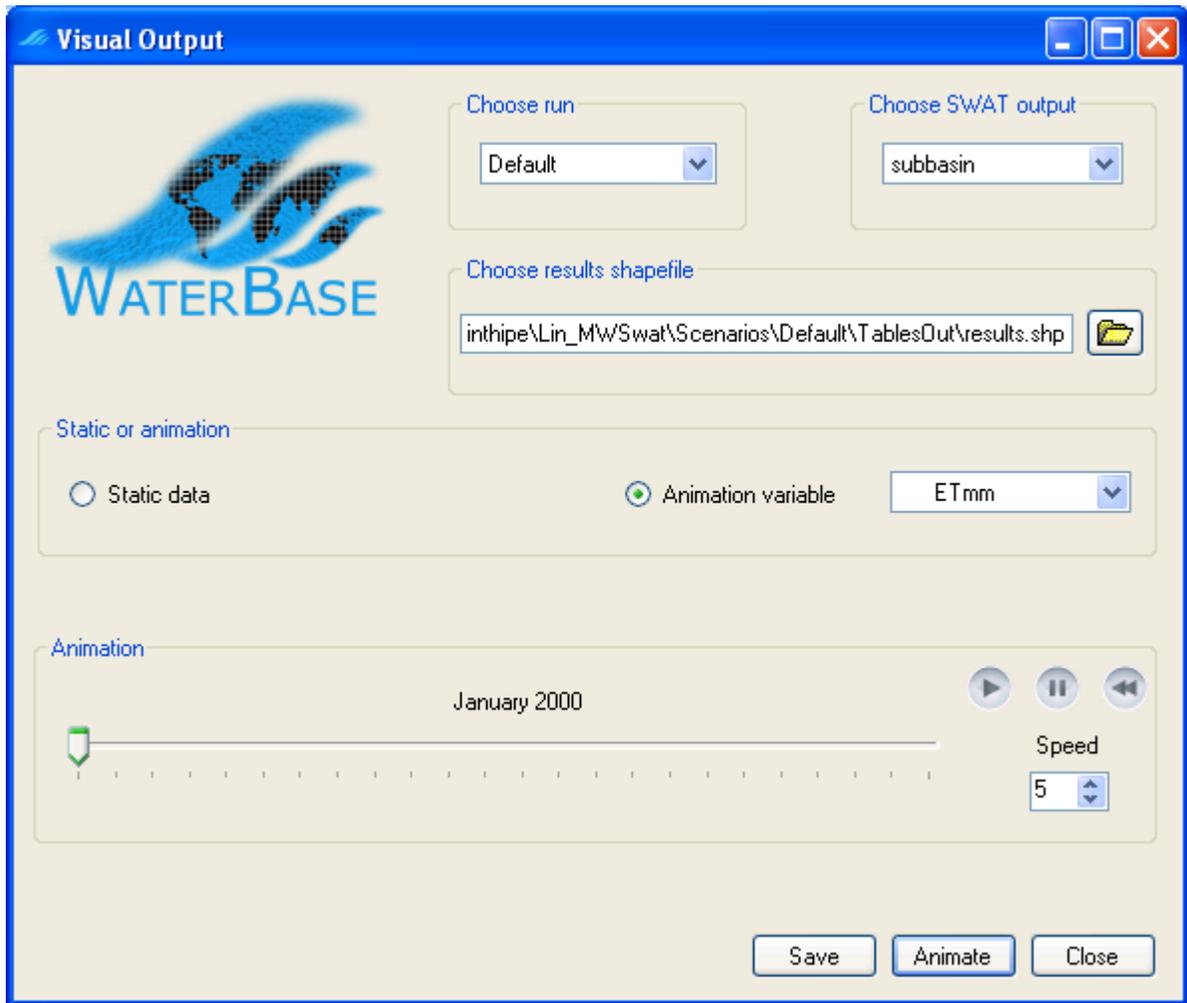


Figure 61: Ready to run animation

54. The MapWindow display now reflects the ET values for January 2000. The animation can be run by clicking on the run button . There is also a pause button  and a

rewind button . The animation can also be done manually by shifting the slider  with the mouse. The speed for automatic animation can be increased or decreased with the *Speed* control.

55. As the slider moves the date above the track bar is updated, and so is the MapWindow display, according to the variable values for the date and the colouring scheme.
56. The values in the shapefile are updated as the MapWindow display values are. So when you finally *Close* the form, the values in the shapefile will correspond to the current position of the slider. This enables you to save a particular state of the animation. Note that clicking again on the *Save* button does not do this: it resets to the start of the animation. So you can use *Save* in preparation for changing the colouring scheme for the animation.
57. If you do want to save the results shapefile you may want to rename it, for example to reflect the date it represents. If you do this, remember that a shapefile is formed from a number of files: .shp, .dbf, plus probably .prj, .mwsr, and .shx. All the files should be consistently renamed.
58. *Close* the *Visual Output* form, *Exit* from MWSWAT, and use *Exit* from the MapWindow *File* menu to finish your session.

7 The SWAT Editor

You can run the SWAT Editor from the *SWAT Setup and Run* form. It is used for three main purposes:

1. Editing SWAT database data.
2. Editing the SWAT inputs for the current project.
3. Calibrating the current project.

The second and third functions of the SWAT Editor function well with MWSWAT, but the first, changing database data, needs some explanation, which you will find in section 7.1 below.

There are also some details on using the SWAT Editor to set up the data for reservoirs, inlets and point sources in section 9.8.

The SWAT Editor comes with its own documentation which you should refer to for detailed instructions on its use.

7.1 Editing Databases

The databases that may be edited are listed as

1. User Soils
2. Land Cover/Plant Growth
3. Fertilizers
4. Pesticides
5. Tillage
6. Urban
7. User Weather Stations
8. Septic WQ (2009 and 2012 only)

Numbers 2 to 6 and 8 in this list have the effect, when you make a change and save it, of changing a table in the SWAT parameter database **SWAT2005.mdb** (or **SWAT2009.mdb** or **SWAT2012.mdb**) in the MWSWAT *Databases* folder, and of generating one of the files **crop.dat** (**plant.dat** for 2012), **fert.dat**, **pest.dat**, **till.dat** and **urban.dat** (and **septwq.dat** for 2009 and 2012) both in the MWSWAT *Databases* folder and also in the current project's default *TxtInOut* folder. This means the changes will apply not only to future SWAT runs in the current project but also to future projects: a new project copies these files from the MWSWAT *Databases* folder. If you want to change one of these files just for this project you should be careful to change the database back again after your SWAT run (which unfortunately means you cannot run again without making the change again) The alternative is to edit the relevant file(s) in the *TxtInOut* folder directly – they can be edited with a text editor. Be careful to maintain the layout as SWAT can be quite sensitive to the structure of its input files.

For the other two databases, soils and weather stations, MWSWAT and the SWAT Editor take a different approach. MWSWAT was designed to be used all over the world, with people developing their own local weather station and soil information. So the data is collected not in one table in the SWAT parameter database, but in a table in the project database, so that different projects may use different tables. The SWAT Editor does not, unfortunately, offer a choice of tables to edit. So if you want to edit the soil table you are using, or the weather generator stations, you should edit the tables in the project database directly using Access, and make sure you write the SWAT input files after doing so. If you want the changes to apply to other future projects, then change the MWSWAT database *C:\Program Files\MapWindow\Plugins\MWSWAT\mwswat.mdb*, (or *C:\Program Files\MapWindow\Plugins\MWSWAT2009\mwswat2009.mdb* or *C:\Program Files\MapWindow\Plugins\MWSWAT2012\mwswat2012.mdb*) which is copied to make the initial project database when you start a new project. But remember to preserve and then redo your changes if you reinstall or upgrade MWSWAT!

8 Rerunning MWSWAT

This section describes restarting an MWSWAT project. Exactly the same method is used for restarting an MWSWAT 2009 or 2012 project, except that the MWSWAT 2009 or 2012 plugin is used.

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 point sources, inlets, reservoirs, or outlets.

4. The *Create HRUs* step is initially marked as *Step 2*, but the tool tries to recreate the HRUs (see the message *Recreating HRUs ...* in the main MapWindow display) and if it is successful will mark this step as *Done*.
5. If the tool finds the SWAT output file *output.rch* and the SWAT input file *file.cio*, and the last write time of the former is not earlier than the latter, it marks the *SWAT Setup and Run* step as *Done*, else it marks it as *Step 3*.
6. If the tool finds *output.rch* it makes step 4, *Visualise*, available. Note that it does not check if the output is recent, so you can visualise earlier runs before making a new one.
7. Any step marked as *Done* can be rerun by clicking on its button, in which case later steps will also have to be rerun.
8. If you rerun 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.
9. 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.
10. 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 single and multiple HRUs, for multiple ones between area and percentage, you can change the threshold values, and you can change landuse splits and exemptions, or you can just immediately click *Create HRUs*, keeping the old settings.
11. You can then 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.
12. There are three ways to select the weather sources:
 - You can use the global weather data that is supplied on the WaterBase web site. This provides a worldwide list of weather stations *stnlist.txt*. In the folder *Global_Weather_Data* 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, making your own set of local files, as follows. In the *TxtInOut* folder you will find files of the form *pcp1.pcp* and *tmp1.tmp*. If you have more than 300 precipitation or more than 150 temperature stations there will be additional files *pcp2.pcp* and/or *tmp2.tmp*, etc. The body of these files consists of a Julian date (4 digit year followed by 3 digit day of the year) followed, for pcp, by one or more precipitation values, each a number in the form xxx.x. These are precipitation values for that day for the weather station whose latitude, longitude, and elevation appear above them at the start of the file. For tmp there are one or more pairs of values in each line, each

pair being the maximum and minimum temperature for that day, each again a number in the form xxx.x. To make local weather files first 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. The lines you need are those for the stations whose coordinates appear in your *pcpn.pcp* and *tmpn.tmp* files. Now you have to make files *nnnnnn.pcp* and *nnnnnn.tmp* for each column in the *pcpn.pcp* and *tmpn.tmp* files, by removing all columns except the date column and the column for the weather station *nnnnnn*. If there is only one weather station involved, as for the San Juan and Linthipe examples, this is nothing more than renaming the *pcp1.pcp* and *tmp1.tmp* files and storing the renamed files in the same folder as the station list file. If there are multiple columns it is much easier to use database tables: see below. The option of using files is really intended as a convenience for users who have other sources of local data, from which they can prepare the necessary files.

- 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*, plus tables *pcpnnnnnn*, and *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 or end dates in later runs you must ensure 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 *Global_Weather_Data* folder has sub-folders for all the years required.

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

8.1 Converting from earlier versions of MWSWAT

If you have a SWAT 2005 project you can convert it to 2009 or 2012, or an MWSWAT 2009 project may be converted to 2012, simply by using the MWSWAT 2009 or 2012 plugin and opening the project as an existing project. You will then be warned that you will be converting the project and asked if you want to continue. You should **NOT** do this if you have edited or calibrated your model: see below. If you answer “No” the MWSWAT 2009 or 2012 form is closed and you can start the original plugin instead, or do the update with the SWAT Editor instead. If you answer “Yes” the MWSWAT 2009 or 2012 plugin will continue and the project will be converted. Note that you must be careful to use **Write all files** in Step 3, or you will get an inconsistent set of SWAT input files and SWAT will probably fail to run.

It is possible in an exactly analogous manner to convert a later project to an earlier one.

Converting a project to a different version in this way means that your files and project database are overwritten completely. So if you have edited them by hand, or calibrated the model, you should instead use the SWAT Editor to do the update. The SWAT Editor can add the additional

fields to the database and rewrite the SWAT input files without overwriting your existing input values.

9 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.

9.1 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” projection⁹ (and you can use MapWindow’s *Toolbox* to do any reprojection) and (b) the elevations must be in metres.

9.2 Outlets/Inlets Shapefile

The outlets/inlets shapefile can be prepared interactively during watershed delineation as described in the San Juan example, or it may be prepared separately in advance. This section describes the requirements. First, it must be a point shapefile. Second, it must have at least the fields in the table below:

Name	Type
ID	Integer
RES	Integer
INLET	Integer
PTSOURCE	Integer

ID values must be unique in the file. These values are used in the DSNODEID field of the Stream Network to link stream reaches with the relevant outlet or inlet. When TauDEM creates the streams it tries to “snap” points in the outlets/inlets file to the nearest stream reach, and this will succeed if the point is within the *Snap Threshold* of a stream reach, which defaults to 300 metres. The number of points successfully snapped is shown on the AWD form. If this is less than you expect you can see which have been successfully snapped by using the *Snap Preview* button, which loads another shapefile showing the new positions of the successfully snapped points.

The other three fields are used to distinguish outlets (which are called monitoring points if they are upstream of another outlet), reservoirs, inlets, and point sources by using values 0 or 1 as shown in the following table:

⁹ UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds.

Kind of point	RES	INLET	PTSOURCE
Outlet	0	0	0
Reservoir	1	0	0
Inlet	0	0	0
Point source	0	1	1

9.3 Predefined Watershed and Stream Network

The form used to select the DEM also allows you to opt for a predefined watershed and stream network (Figure 62). You need to check the *Use predefined* box before clicking on *Process DEM*.

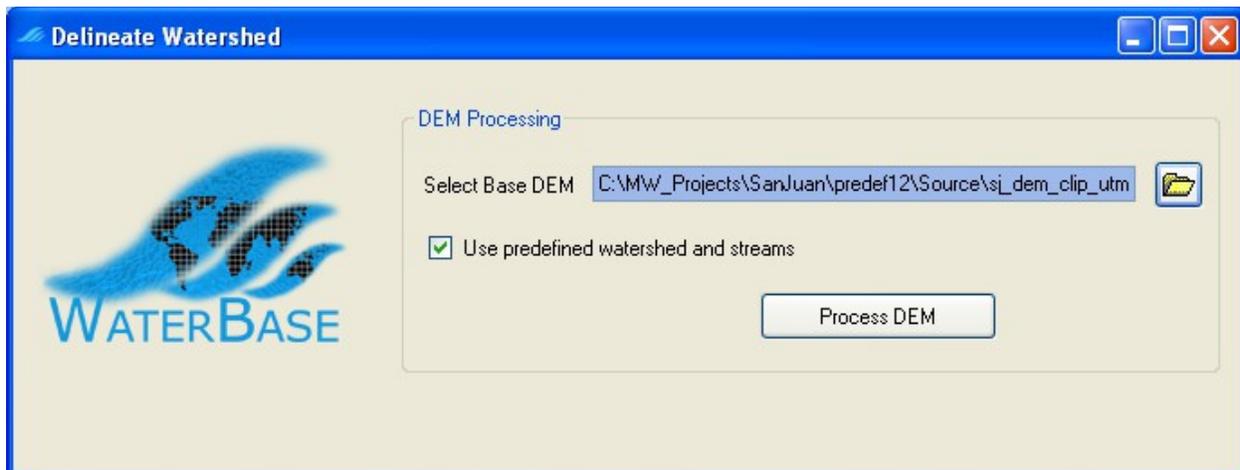


Figure 62: Use predefined watershed and stream network

This produces a new form (Figure 63) allowing you to select the shapefiles containing the watershed and its subbasins (the *Watershed shapefile*) and the stream network (the *Streams shapefile*). These files need to have the same projection as the DEM. If you want to use files generated by TauDEM in a previous project, then such files can be found in the *Sources* subfolder of that project, with names ending *w.shp* and *net.shp* respectively.

It is also possible, but not necessary, to specify an *Outlets/Inlets shapefile*, and again a file from the previous project may be used. If such a file is not specified, only main outlet(s) from the watershed will be used as main outlets in the new project, and no internal outlets, reservoirs, point sources, or inlets will be used.

The *watershed shapefile* must be a polygon shapefile (each polygon representing a subbasin) with the following fields:

Necessary/Optional	Name	Type
Necessary	PolygonID	Integer
Optional	Area	Double
Optional	Subbasin	Integer

The *streams shapefile* must be a line shapefile (each line representing a stream reach) with the following fields:

Necessary/Optional	Name	Type
Necessary	WSNO	Integer
Necessary	LINKNO	Integer
Necessary	DSLINKNO	Integer
Optional	USLINKNO1	Integer
Optional	USLINKNO2	Integer
Optional	DSNODEID	Integer
Optional	Length	Double
Optional	Drop	Double

An *outlets/inlets shapefile* must be a point shapefile with the following fields:

Necessary/Optional	Name	Type
Necessary	ID	Integer
Necessary	RES	Integer
Necessary	INLET	Integer
Necessary	PTSOURCE	Integer

Necessary fields must be defined in the original files. *Optional* fields may or may not be defined originally. With two exceptions defined below, if optional fields are defined, and if the *Reuse* button is checked then their values will be assumed to be correct and reused. If optional fields are not defined originally, or if the *Recalculate* button is checked, then they will be defined if necessary, calculated, and the calculated values inserted¹⁰. Any file may have other fields defined: these will be ignored. The fields may be in any order.

The first exception is the DSNODEID field. This is *necessary* if an outlets/inlets shapefile is specified, in which case it is assumed to be correct and its non-negative values must refer to ID values in that file. DSNODEID values are never recalculated.

¹⁰Changes to these files are only made to the copies of the originals in the *Source* folder of the project.

The second exception is the Subbasin field in the watershed shapefile. Even if present and *Reuse* is selected it is checked to have suitable values for the SWAT basin numbers. These must be strictly positive and form a consecutive ascending sequence starting from 1, except for basins which are either empty or upstream from inlets, when the Subbasin values must be zero. If the Subbasin values do not meet these requirements they are recalculated.

There are some conditions imposed on the fields. The PolygonID values in the watershed shapefile must be unique, non-negative, and must equal the corresponding WSNO values in the streams shapefile: each subbasin must have exactly one stream reach, and each stream reach must have exactly one subbasin. These two fields provide the connection between the subbasins and the stream reaches. The LINKNO values must also be unique and non-negative (and will typically but not necessarily be the same as the WSNO numbers.) The DSLINKNO (downstream link) values must each be another LINKNO value or -1, where -1 indicates a watershed outlet. At most two reaches may share a non-negative DSLINKNO value. Files previously generated by TauDEM will meet all these conditions, and their values may be safely reused.

There is also an assumption made about the order of the points stored in the stream reach shapefile. Each stream reach is a single line, represented as a sequence of points. The first point in the sequence may represent the upstream (source) end and the last represent the downstream (outlet) end, or vice versa. TauDEM creates stream reaches with the first point at the outlet end, but either orientation is accepted by MWSWAT. The assumption is that the orientation is the same for all the reaches. The orientation is checked by finding a reach with an upstream or downstream reach where the ends of the reaches are within one dem cell of each other: normally such ends will exactly coincide.

The optional fields are (if necessary) calculated as follows:

Field	Calculation
Area	The area of the subbasin in square metres.
Subbasin	For subbasins which are not empty and not upstream of an inlet, a unique number from the contiguous sequence 1 .. n, where n is the number of such subbasins. These will be the subbasin numbers for use by SWAT. For subbasins which are empty or upstream of an inlet, 0.
USLINKNO1	For stream reach with LINKNO k, if there are stream reaches with LINKNO values i and j which have DSLINKNO values k, then either i or j, else -1.
USLINKNO2	In the case above, either j or i, whichever has not been used for USLINKNO1, else -1.
Length	The total length in metres of the straight line segments forming the reach.
Drop	The absolute difference in metres between the elevations of the end points of the reach.

Note that if a predefined watershed and stream network is chosen then the length of the stream reach in each subbasin will be used for the maximum flow length in that subbasin.

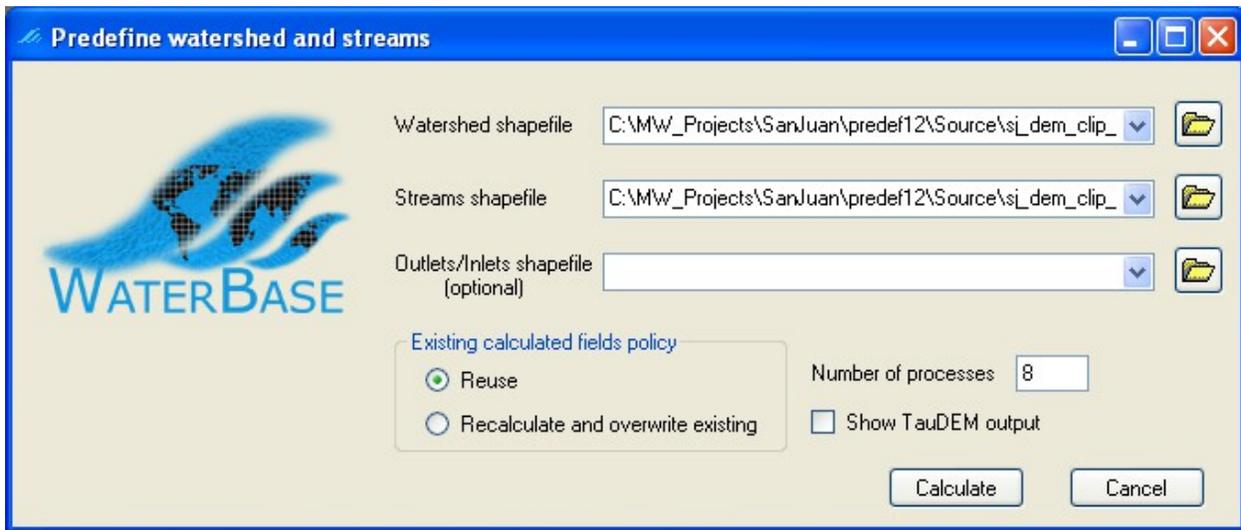


Figure 63: Predefining watershed and streams

9.4 Reducing the Number of Subbasins

After running watershed delineation two new options become available in the Automate Watershed Delineation form (Figure 64)

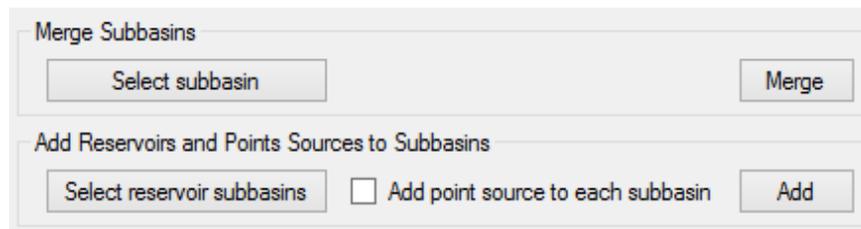


Figure 64: Options following watershed delineation

In this section we explain how you can merge subbasins: adding reservoirs and point sources is discussed in the following section 9.5.

Merging subbasins may be done to reduce the number of subbasins. You might want to do this if you selected a low delineation threshold to obtain streams where you had gauges, but in other parts of the watershed would be happy with fewer subbasins. You can only merge a subbasin whose stream reach is a “leaf” in the stream network, i.e. it has no upstream reaches. You can also not merge a subbasin that has a reservoir, point source, inlet or outlet associated with it.

To merge a subbasin, click *Select subbasin* to bring up the subbasin selection form (Figure 65)

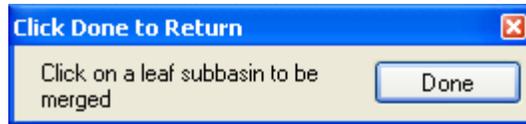


Figure 65: Subbasin selection

and put the MapWindow display in selection mode. Click on the subbasin you wish to merge (Figure 66, left) and click *Done* in the subbasin selection form. Then click *Merge* in the watershed delineation form. The reach in the subbasin you selected is removed, and the subbasin is merged into the one downstream of it and with the other subbasin that was upstream of that downstream one (Figure 66, right).

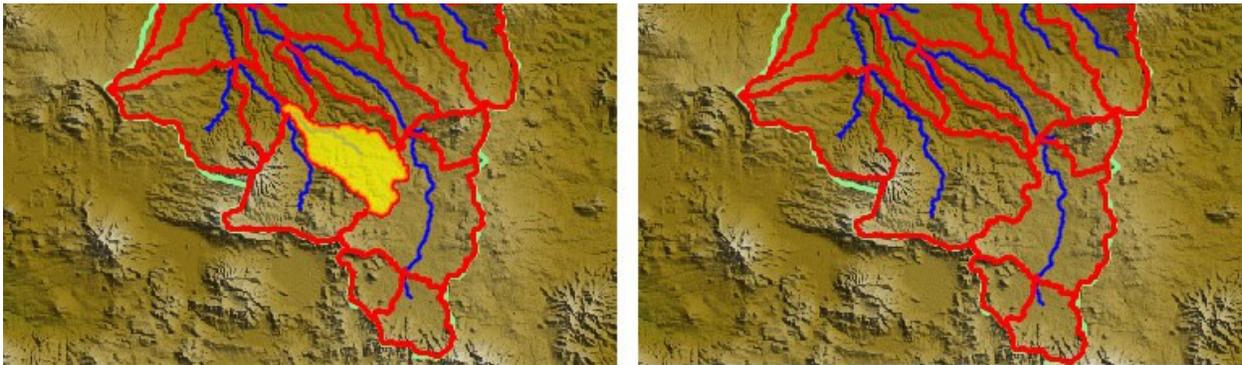


Figure 66: Merging a subbasin

You can only merge one subbasin at a time, but you can repeat the procedure as many times as you wish.

Merging subbasins cannot be undone, except by repeating the final delineation step, by clicking the third *Run* button.

9.5 Adding Reservoirs and Point Sources

The other option available after completing delineation, and possibly after merging subbasins, is to add reservoirs and point sources (Figure 64). Adding a reservoir or point source to the Outlets/Inlets shapefile before the final delineation step will make a new subbasin boundary at the location of the reservoir or point source. Adding them by this mechanism will place them at existing subbasin outlets, and does not create new subbasins. It is possible to add reservoirs to selected subbasins, and to add point sources to all subbasins. The default point source data provides no input and so does not change the SWAT run. If you have a number of point sources it is therefore convenient to add them to all subbasins and then provide data only for those that actually exist.

To add reservoirs to selected subbasins, first click on *Select reservoir subbasins* to bring up the reservoir subbasin selection form (Figure 67) and put the MapWindow display in selection mode.



Figure 67: Reservoir subbasin selection form

Hold the *Ctrl* key and select as many subbasins as you wish (Figure 68). You may clear the existing selection by clicking outside the watershed shapefile boundary. When you have selected the subbasins you want, click *Done* in the selection form, and then *Add* in the delineation form (Figure 69).

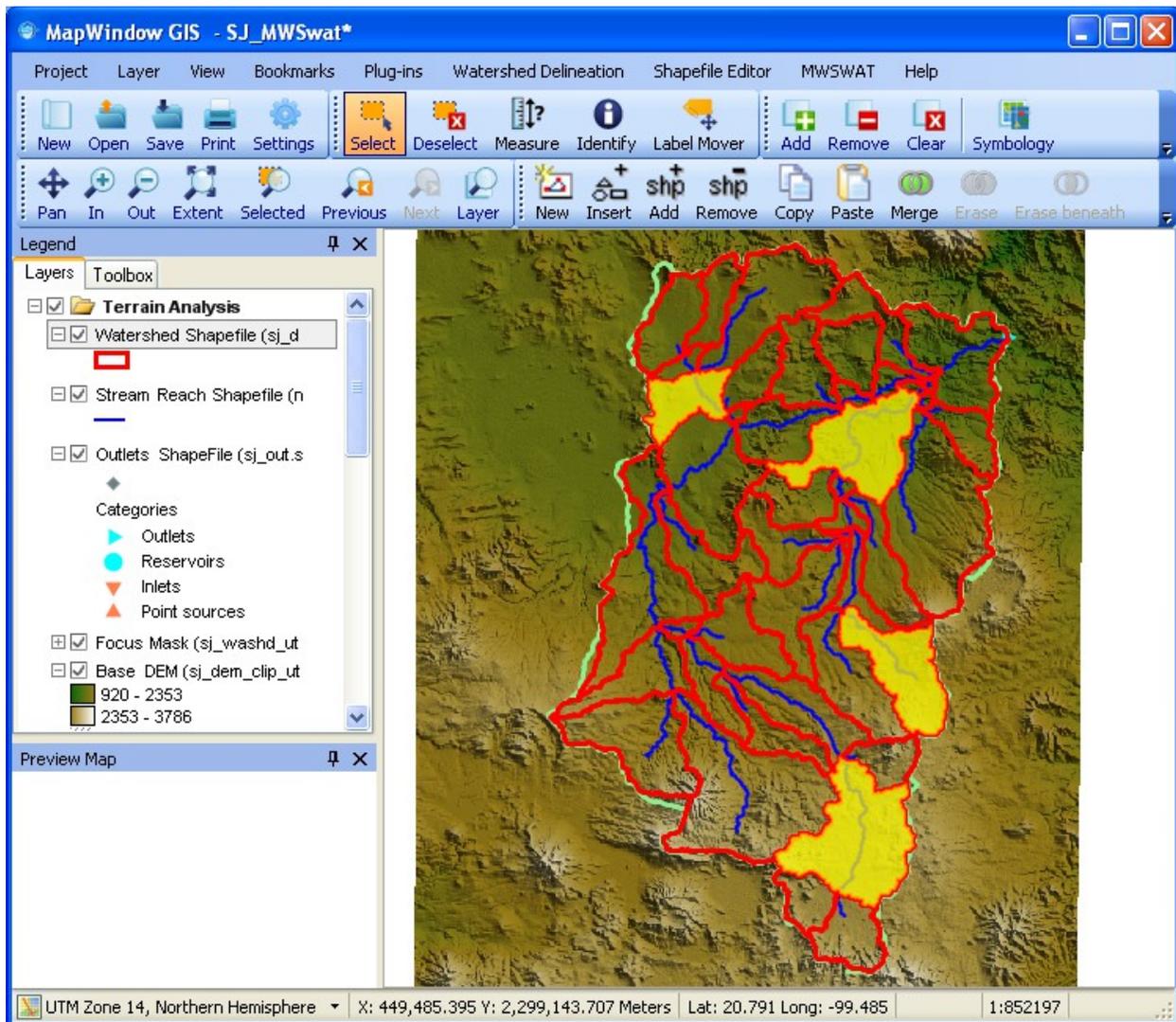


Figure 68: Selecting reservoir subbasins

You can also add point sources to all subbasins (except any that already have them) before clicking *Add* by checking the box. Such new point sources are placed slightly upstream from reservoirs in the subbasins where they both occur.

You will notice that an extra shapefile is added to the MapWindow display, the *Extra Outlets/Inlets Shapefile*.

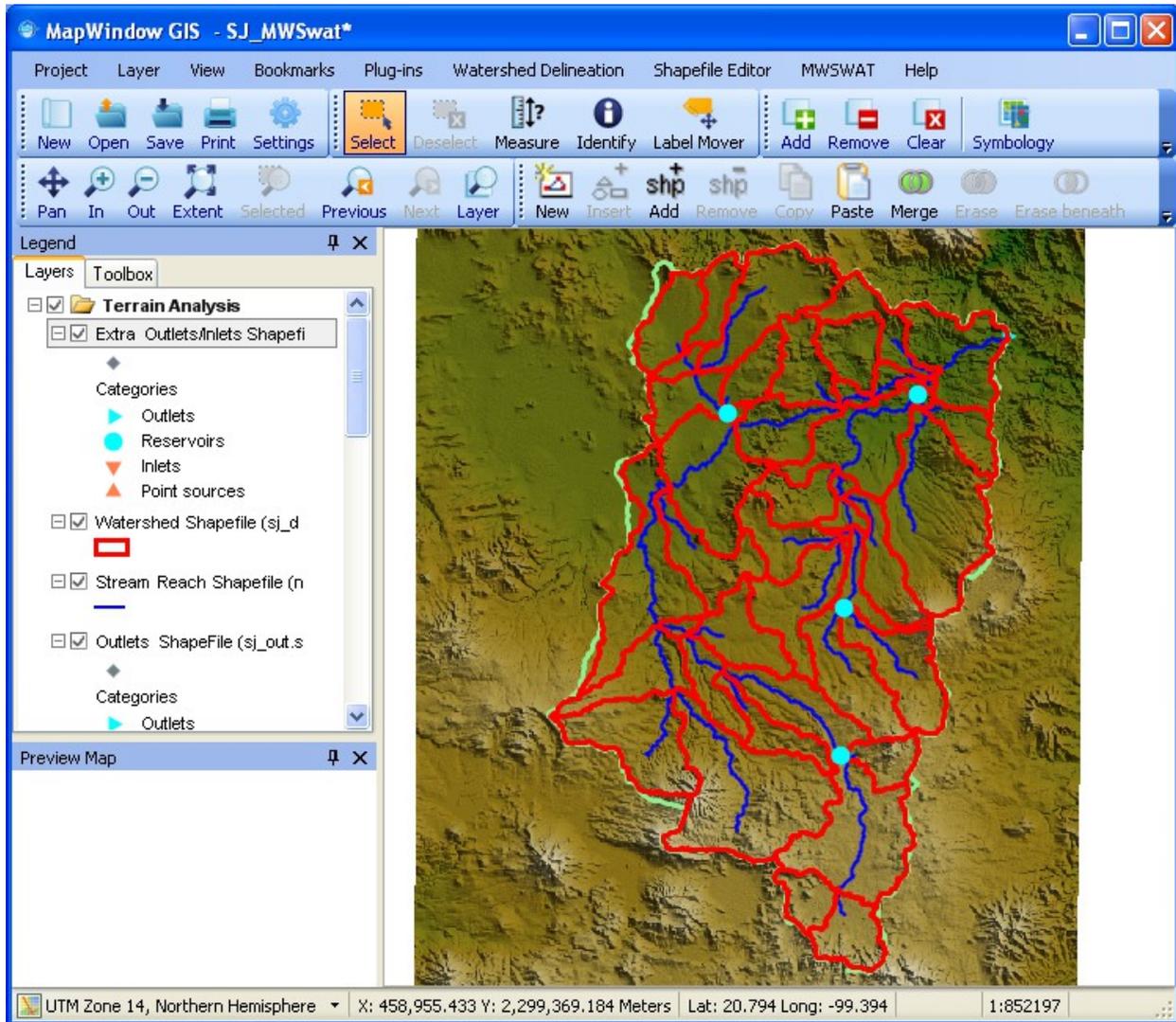


Figure 69: Reservoirs added

If you click again on *Select reservoir subbasins* the subbasins already selected for reservoirs are already selected. So you can add more, or remove them by clicking outside the watershed boundary. So you can if you wish remove all the reservoirs. If the checkbox for adding point sources is not checked then clicking *Add* will remove all reservoirs and point sources, and delete the extra outlets/inlets shapefile.

9.6 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 *C:\Program Files\MapWindow\Plugins\MWSWAT2009\mwswat2009.mdb* or *C:\Program Files\MapWindow\Plugins\MWSWAT2012\mwswat2012.mdb*) or the project database *Proj.mdb* in the *Proj* 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_IDs 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 databaseThese 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 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 can copy the structure of *usersoil* in the project database to another table with a name containing the string *usersoil*, such as *my_usersoil*, and then enter your soil data in it. On the first run of your project MWSWAT will discover that your soil names are not in *usersoil* and will look for other tables with *usersoil* in their names that contain the required soil names. Each such will be offered to the user to accept or reject, so there may be more than one. Once one is accepted it is stored in the configuration file and used in subsequent runs. If you want to use the table in more than one project you should add it to *C:\Program Files\MapWindow\Plugins\MWSWAT\mwswat.mdb* (or the corresponding 2009 or 2012 database), which is copied to make the project database of new projects. But remember to save this database somewhere if you reinstall MWSWAT, or it will be lost.

An alternative is simply to add your soils to the *usersoil* table, provided they have new names.

9.7 Weather Sources

9.7.1 Daily precipitation

We deal first with daily precipitation, and later with the changes needed for sub-daily precipitation.

9.7.1.1 Using the database

You can use the database option in *Choose weather sources* to use your own weather 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 can be tables called *pcpid*, *tmpid*, *slrid*, *hmdid*, and *wndid*. 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 or Date/Time, 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, but all the tables you use must start and finish with the same dates.

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.
5. The tables called *slrid* must have a column SLR of type Double giving the solar radiation in MJ/m² on that day. The value -99 indicates missing data.

6. The tables called *hmdid* must have a column HMD of type Double giving the relative humidity as a decimal fraction on that day. The value -99 indicates missing data.
7. The tables called *wndid* must have a column WND of type Double giving the wind speed in m/s on that day. The value -99 indicates missing data.

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

Any of these tables can be present or absent for each of the weather stations listed in the first table. The algorithm used by MWSWAT is as follows:

For each of the 5 categories precipitation, temperature, solar radiation, relative humidity, and wind speed:

1. If there are no tables in that category, the category is simulated using a weather generator.
2. Otherwise each subbasin will use measured data from the table whose weather station is the closest amongst those stations having tables in that category.

For example, suppose there are weather stations with identifiers A, B and C, and tables Apcp, Bpcp, Atmp, Btmp, and Cslr. Then the result will be:

- For precipitation: subbasins will use measured data from Apcp or Bpcp, according to whether station A or B is nearer.
- For temperature: subbasins will use measured data from Atmp or Btmp, according to whether station A or B is nearer.
- For solar radiation: all subbasins will use measured data from Cslr.
- For relative humidity: all subbasins will use simulated data.
- For wind speed: all subbasins will use simulated data.

This makes it easy for users to vary climate data if they wish, and to combine measured data from a number of sources. It is even possible to combine simulated and measured data for different subbasins: in the example above, for example, if all the values in Apcp are -99 (unknown, missing data), while Bpcp is measured data, then subbasins nearer to station A will use simulated precipitation data and those nearer to B will use measured data.

9.7.1.2 Using local files

An alternative to using database tables is to prepare some files containing the data.

1. First make a .txt file called any name you choose, e.g. *stations.txt*. This is structured like the *stnlist.txt* supplied in the *Global_Weather_Sources* folder. It may have any number of header lines followed by one or more station lines. The first 6 characters of a station line must be

decimal digits (and the first 6 characters of a header line must not be all decimal digits). These six digits form the station identifier. Each station line must also have (numbering the first, leftmost position as 1):

- A latitude in positions 38-42 inclusive, starting with a + or – sign in position 38, followed by 4 decimal digits representing a latitude in hundredths of a degree.
- A longitude in positions 44-49 inclusive, starting with a + or – sign in position 44, followed by 5 decimal digits representing a longitude in hundredths of a degree.
- An elevation in positions 51-55 inclusive, starting with a + or – sign in position 51, followed by 4 decimal digits representing an elevation in metres.

The station lines may contain other data, but it is ignored. Such lines may be copied directly from *stnlist.txt*.

2. In the same folder as *stations.txt* may be placed files *nnnnnn.pcp*, *nnnnnn.tmp*, *nnnnnn.slr*, *nnnnnn.hmd*, *nnnnnn.wnd* with precipitation, temperature, solar radiation, relative humidity and wind speed data respectively, where *nnnnnn* is the identifier of a station in *stations.txt*. These files are used to create the table *weather_sources* and for each file a table called *pcpnnnnnn*, *tmpnnnnnn*, *slrnnnnnn*, *hmdnnnnnn* or *wndnnnnnn*. The rules for tables described in the previous section are then used to determine how the weather for each subbasin is measured or simulated. The structure of each of these five file types is as follows:

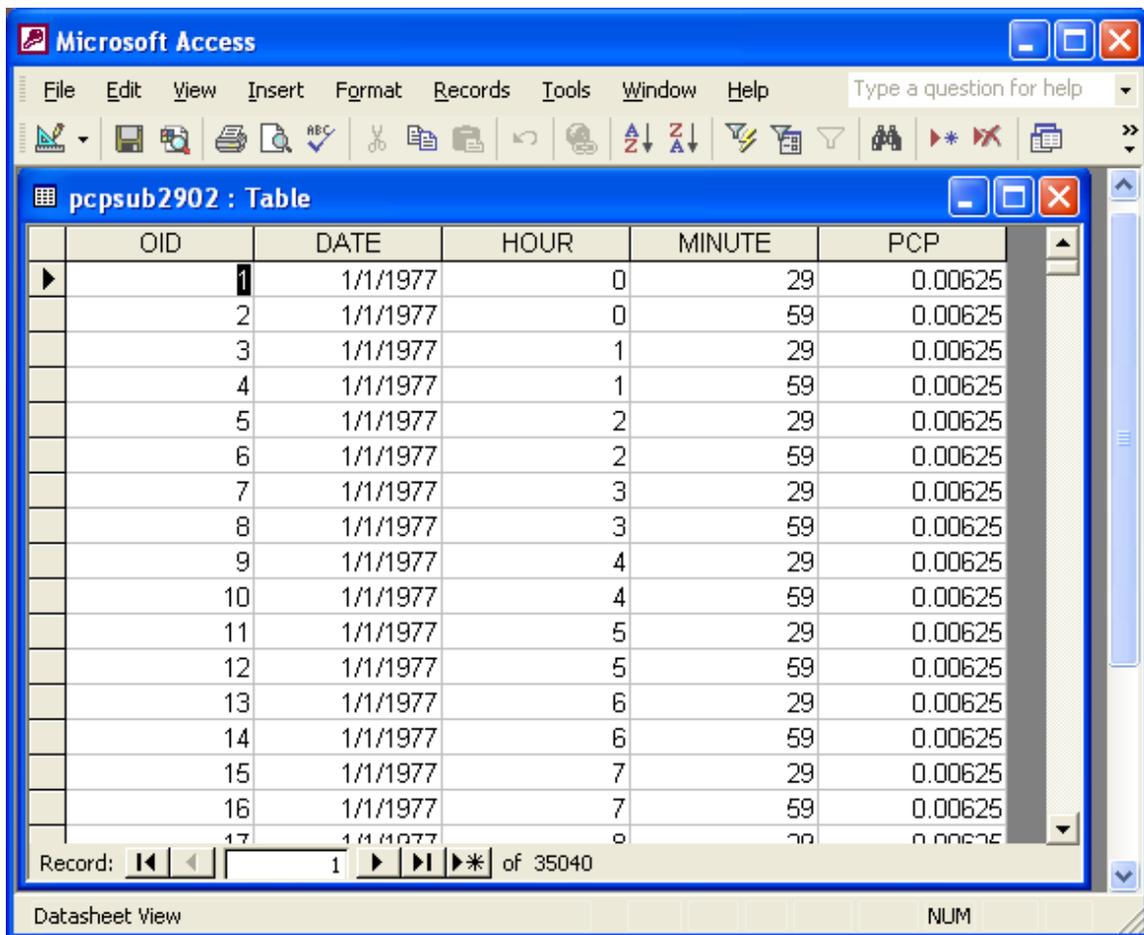
- The first line can contain any text: it is ignored.
- For *.pcp* and *.tmp* only:
 - i. The second line has the string “Lati” in positions 0-3 and a latitude in degrees expressed as a decimal number, optionally starting with a – sign, in positions 8-12 for *.pcp*, 13-17 for *.tmp*.
 - ii. The third line has the string “Long” in positions 0-3 and a longitude in degrees expressed as a decimal number, optionally starting with a – sign, in positions 8-12 for *.pcp*, 13-17 for *.tmp*.
 - iii. The fourth line has the string “Elev” in positions 0-3 and an elevation in degrees expressed as a decimal number, optionally starting with a – sign, in positions 8-12 for *.pcp*, 13-17 for *.tmp*.
- The following lines all have the date in Julian form (4-digit year followed by 3-digit zero-filled day) in columns 1-7. The date is followed by one or two numbers as follows
 - i. For *.pcp*: the precipitation for that day in mm in the form xxx.x in positions 8-12
 - ii. For *.tmp*: the maximum and minimum temperatures for the day in °C, each in the form xxx.x, in positions 8-12 and 13-17 respectively.
 - iii. For *.slr*: the solar radiation for that day in MJ/m² in the form xxxx.xxx in positions 8-15.
 - iv. For *.hmd*: the relative humidity for that day as a fraction in the form xxxx.xxx in positions 8-15.
 - v. For *.wnd*: the wind speed for that day in m/s for in the form xxxx.xxx in positions 8-15.
- The dates in all files must be the same, and within each file must be sequential days.

9.7.2 Sub-daily precipitation

The *Choose SWAT weather sources* form has, when the database or local files option is chosen for the Weather Source, an additional option to select *Sub-daily precipitation*.

9.7.2.1 Using the database

When sub-daily precipitation is chosen with *Database tables* MWSWAT will look for tables named *pcpsubid* for each weather station *id*, instead of *pcpid*. These tables are like the *pcpid* tables but have two additional columns, HOUR and MINUTE of type Integer. Hour values are in the range 0-23, and minute values in the range 0-59. Part of such a table is shown in Figure 70, which illustrates a time step of 30 minutes. Date/times must be ordered sequentially, the difference between successive minutes (the time step) must be 1, 2, 3, 4, 5, 6, 10, 15, 20 or 30 minutes, and constant through all the *pcpsubid* tables, all days must be complete, and the total range of days must be the same as any *tmpid*, *slrid*, *hmdid* and *wndid* tables.



OID	DATE	HOUR	MINUTE	PCP
1	1/1/1977	0	29	0.00625
2	1/1/1977	0	59	0.00625
3	1/1/1977	1	29	0.00625
4	1/1/1977	1	59	0.00625
5	1/1/1977	2	29	0.00625
6	1/1/1977	2	59	0.00625
7	1/1/1977	3	29	0.00625
8	1/1/1977	3	59	0.00625
9	1/1/1977	4	29	0.00625
10	1/1/1977	4	59	0.00625
11	1/1/1977	5	29	0.00625
12	1/1/1977	5	59	0.00625
13	1/1/1977	6	29	0.00625
14	1/1/1977	6	59	0.00625
15	1/1/1977	7	29	0.00625
16	1/1/1977	7	59	0.00625
17	1/1/1977	0	00	0.00625

Figure 70: Table for sub-daily precipitation

9.7.2.2 Using local files

When the *Local files* option is chosen with sub-daily precipitation, the behaviour is like the use of local files with daily precipitation, except that the precipitation data files that are looked for are those ending *.pcpsub*. The structure of such files is like that of the *.pcp* files, except:

- The latitude, longitude and elevation values are in positions 13-17.
- Each data line has a two-digit hour in positions 8-9, a colon “:” in position 10, a two-digit minute in positions 11-12, and the precipitation in mm is a number in the form xxx.x in positions 13-17.

Date/times must be ordered sequentially, the difference between successive minutes (the time step) must be 1, 2, 3, 4, 5, 6, 10, 15, 20 or 30 minutes, and constant through all the *.pcpsub* files, all days must be complete, and the total range of days must be the same as any *.tmp*, *.slr*, *.hmd* and *.wnd* files.

It is also possible in *.pcpsub* files to use an abbreviated system for days in which there is zero precipitation. Such a day can be represented by a single line, with the date in positions 1-7 and a space instead of the colon in position 10: the rest of the line is ignored. It is not possible to have a *.pcpsub* file in which every day has this abbreviation (as there would be no way to calculate the time step).

9.7.3 Weather generation

When measured data is not available SWAT uses data simulated by a weather generator program which uses parameters supplied in weather generator files. MWSWAT supports the use of one weather generator file, which is then used for all subbasins, or a weather generator table, which can contain the parameters for a number of weather stations, each represented by one line in the table. A table for the USA is supplied with MWSWAT. For MWSWAT 2005 and 2009 it is the table *wgn_US* in the *mwswat.mdb* or *mwswat2009.mdb* database. For SWAT 2012 it is *WGEN_US_FirstOrder* in the *mwswat2012.mdb* database. The appropriate one of these databases is used as the initial project database for each new project. It can be used directly if your watershed is in the USA. In the *Choose SWAT weather sources* form, under *Weather Generator*, select *Table* and then find *wgn_US* or *WGEN_US_FirstOrder* in the pull-down menu. If you make your own such table, add it to the project database with a name including the string *wgn* (MWSWAT 2005 or 2009, but not just *wgn*, which is the name of another table used by MWSWAT) or including the string *WGEN* (MWSWAT 2012). It will then appear in this menu. MWSWAT will then allocate to each subbasin the nearest weather generation station from the selected table. For MWSWAT 2012, if the database *ArcSWAT_WeatherDatabase.mdb*, supplied with the SWAT Editor, is found as expected in *C:\SWAT\SWATEditor\Databases*, its tables with names starting *WGEN* are also offered in the menu.

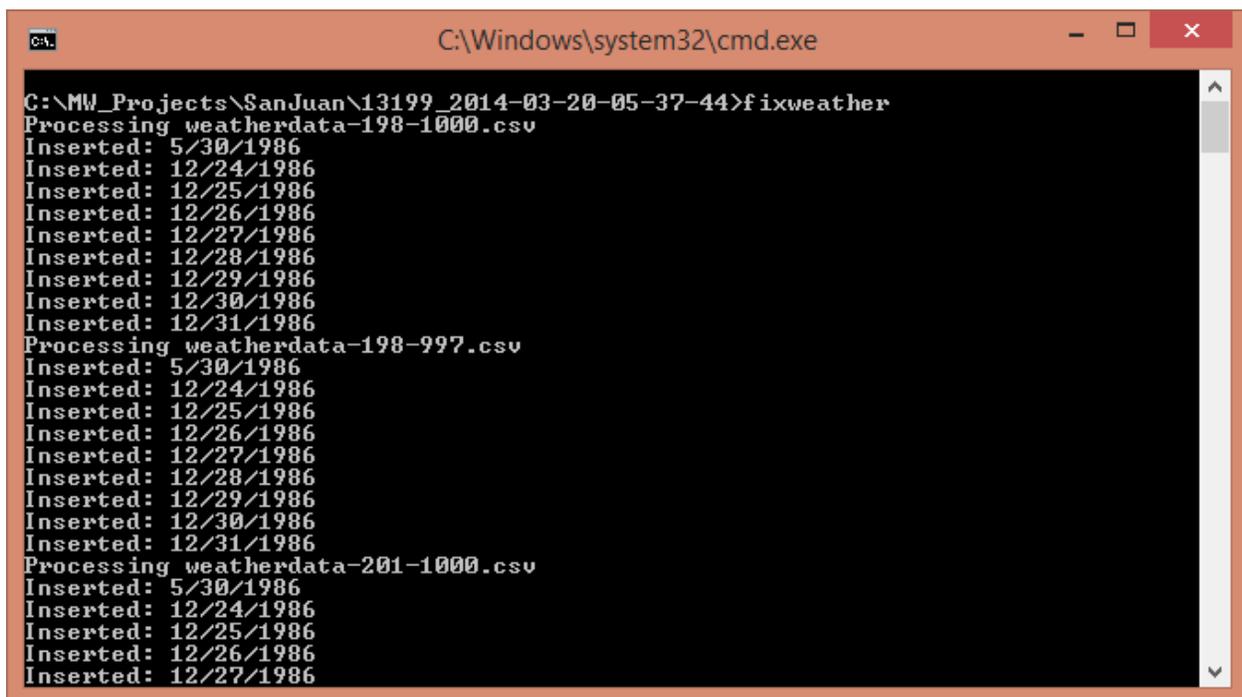
9.7.4 Using global data from the SWAT web site

The SWAT web site offers global weather data (<http://globalweather.tamu.edu/>). In this section we explain how to use such data with MWSWAT.

At the web site, input the latitude and longitude bounds of your watershed. (You can obtain these from the MapWindow display after loading, for example, your DEM.) You may want to adjust your bounds to get a reasonable number of weather stations, which are displayed on the site as you change the bounds. We obtained 8 weather stations for the San Juan watershed with bounds of -100.3 to -99.4 longitude, 19.7 to 20.9 latitude. You will need to request both SWAT and CSV data.

After receiving the zip archive and extracting the files you will find, amongst others, *pcp.txt*, (assuming you asked for precipitation data, else *tmp.txt*, *rh.txt*, *solar.txt*, or *wind.txt* – any of these can be used, but we refer to *pcp.txt* below). We will use this file to make a weather stations table. You will also find, for each weather station, a file of the form *weatherdata-m-n.csv*, where *m* and *n* are numbers, or of the form *weatherdata--n.csv*, where *n* is a number. These contain the actual weather data and each will be used to make a table in the project database.

The *weatherdata...csv* files may have some records missing. We have found 30 May 1986, and 24-31 December 1986 to be absent. Records for such dates should be inserted, using the “missing data” value of -99.0. There is a program *fixweather* available from the MWSWAT website (<ftp://anonymous@ftp.iist.unu.edu/pub/waterbase/fixweather.exe>). To run this, download the program and place it in the folder containing the *weatherdata...csv* files. Then open a command prompt and use the command *fixweather*. The program looks for files with names matching *weatherdata-*.csv* and within them looks for missing dates. You will see output like Figure 71.



```
C:\Windows\system32\cmd.exe
C:\MW_Projects\SanJuan\13199_2014-03-20-05-37-44>fixweather
Processing weatherdata-198-1000.csv
Inserted: 5/30/1986
Inserted: 12/24/1986
Inserted: 12/25/1986
Inserted: 12/26/1986
Inserted: 12/27/1986
Inserted: 12/28/1986
Inserted: 12/29/1986
Inserted: 12/30/1986
Inserted: 12/31/1986
Processing weatherdata-198-997.csv
Inserted: 5/30/1986
Inserted: 12/24/1986
Inserted: 12/25/1986
Inserted: 12/26/1986
Inserted: 12/27/1986
Inserted: 12/28/1986
Inserted: 12/29/1986
Inserted: 12/30/1986
Inserted: 12/31/1986
Processing weatherdata-201-1000.csv
Inserted: 5/30/1986
Inserted: 12/24/1986
Inserted: 12/25/1986
Inserted: 12/26/1986
Inserted: 12/27/1986
```

Figure 71: Running *fixweather*

You can import the data into a project database, or create a database with just the weather tables and import this into the project database. We do the latter.

Use Access to create a new database, which we call *sj_weather.mdb*. Discard the default *Table1* which appears. Select *External Data, Import, Text File*, and browse to *pcp.txt* (Figure 72).

Click *OK*, and in the Import Text Wizard that appears, select *Delimited*, click *Next*, choose *Comma* as the delimiter, check *First Row Contains Field Names*, click *Next*, click *Next* again (we can leave the field definitions as they are), and select *Choose my own primary key*. It should select *ID*, but if it doesn't make that the selection. Click *Next*, and change the table name to *sj_weather*, or any other name containing the *weather* (but don't choose *weather_sources*, which is reserved for use by MWSWAT). Click *Finish* and then *Close* the next form.

If you open the resulting table you will see something like Figure 73. This is close to, but not the same as the standard MWSWAT format for a weather stations table. Do not attempt to make the format the same as the standard: the differences are used by MWSWAT to detect that global data from the SWAT web site is being used.

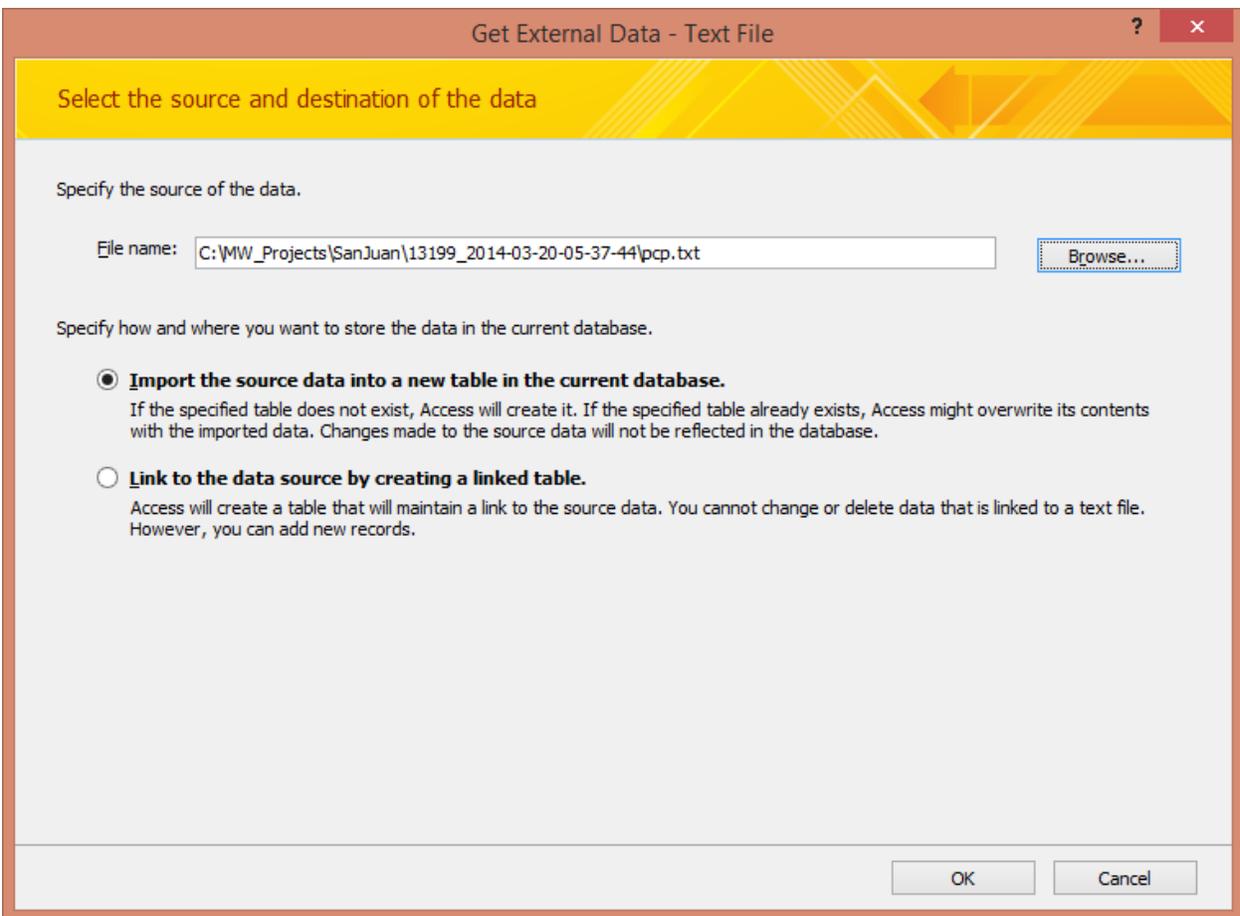


Figure 72: Selecting the weather stations file

We are now ready to import the data files. Select *External Data, Import, and Text File*, and browse to the first *weatherdata-m-n.csv* or *weatherdata--n.csv* file. Make sure that you are importing into a new table (first of the three radio buttons) and click *OK*. Select *Delimited*, click *Next*, choose *Comma* as the delimiter, check *First Row Contains Field Names*, click *Next*, click *Next* again (we can leave the field definitions as they are), and select this time the first radio button *Let Access add primary key*. This is important as it prevents Access arbitrarily reordering the entries. A new column *ID* has been added. Click *Next*, and change the name to *wthr* before clicking *Finish*. This time, before closing the next form, check *Save import steps*: we intend to make importing the other 7 files much easier. Change the *Save as* name to, say, *Import-weatherdata*, add a description if you wish, and click *Save Import*.

We see that a new table *wthr* has been created. We chose a generic name because we are going to repeat the import steps on each csv file, and while it is possible to change the name of the file being read, it does not seem possible to change the resulting table name. So the procedure is to set the csv file name, run the import, and rename the resulting table.

Right click on the table name in the *All Tables* panel, select *Rename*, and change the name to *wthrm_n*, if the file imported was *weatherdata-m-n.csv* (Figure 74) or to *wthr_n* if the file was *weatherdata--n.csv*. Note in particular that the first hyphen (the one following *weatherdata*) is lost and the second hyphen (the one preceding *n*) is replaced by an underscore: SQL commands do not work with hyphens in table names. MWSWAT will relate a *NAME* value in the stations table to a data table name by removing the leading character (*p* if the source was *pcp.txt*, *t* if it was *tmp.txt*, etc.) replacing the hyphen with an underscore, and prefixing with *wthr*. It is easier for MWSWAT to do than asking you to edit the names in the stations table.

We are now ready to import the next csv file. Select *External Data, Import, Saved Imports* and we see our saved operation *Import-weatherdata* is available to be run. We need first to change the csv file that will be imported. Click twice on the file name to make it editable (Figure 75), edit it to the next file name, and hit *Enter* to finish editing. Then Click *Run*. You should get a

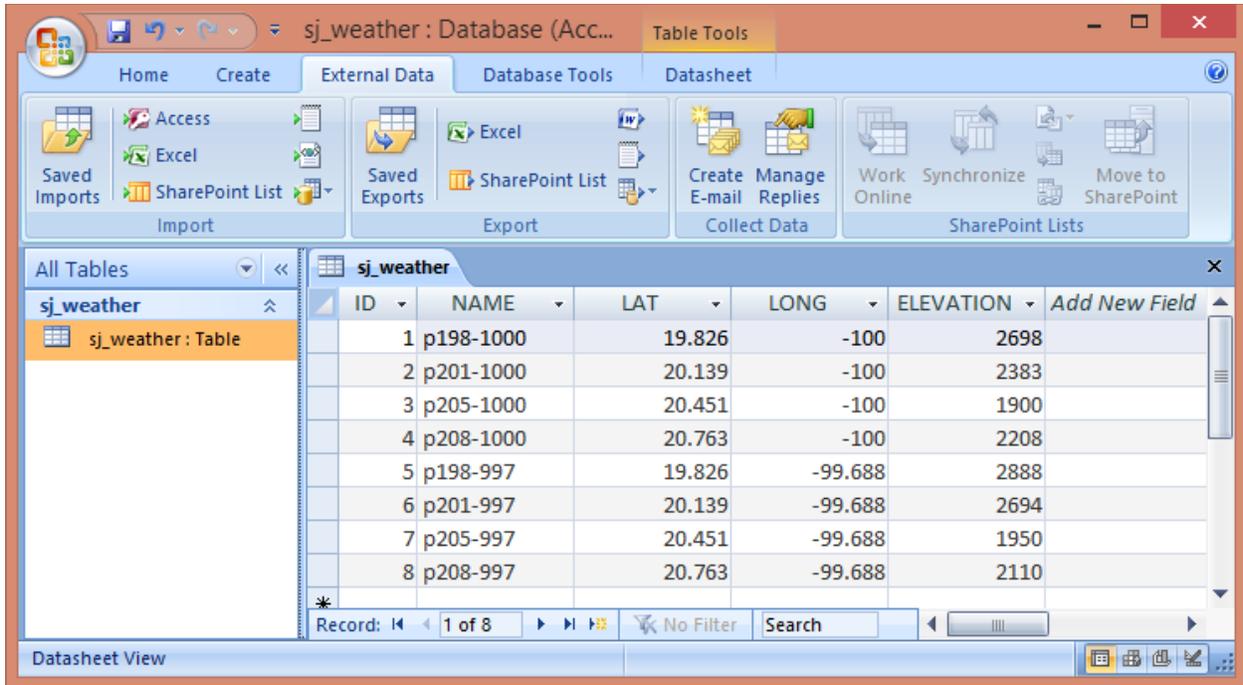


Figure 73: Stations table completed

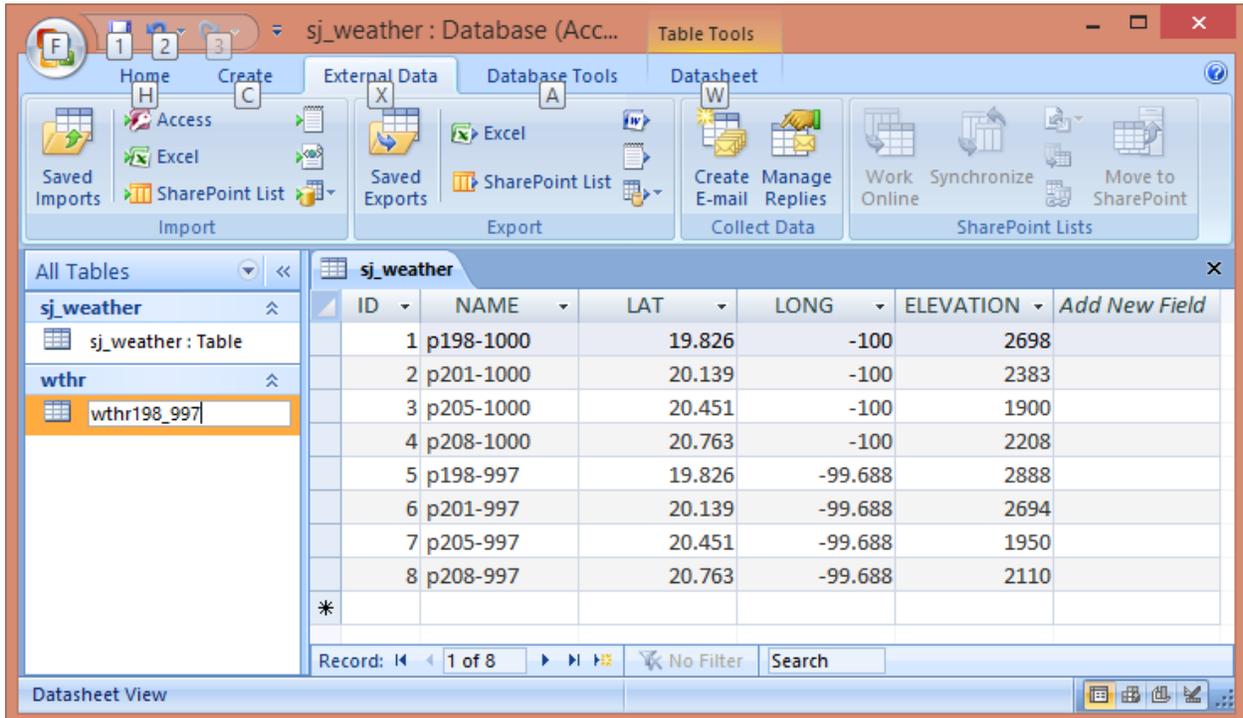


Figure 74: Renaming the data table

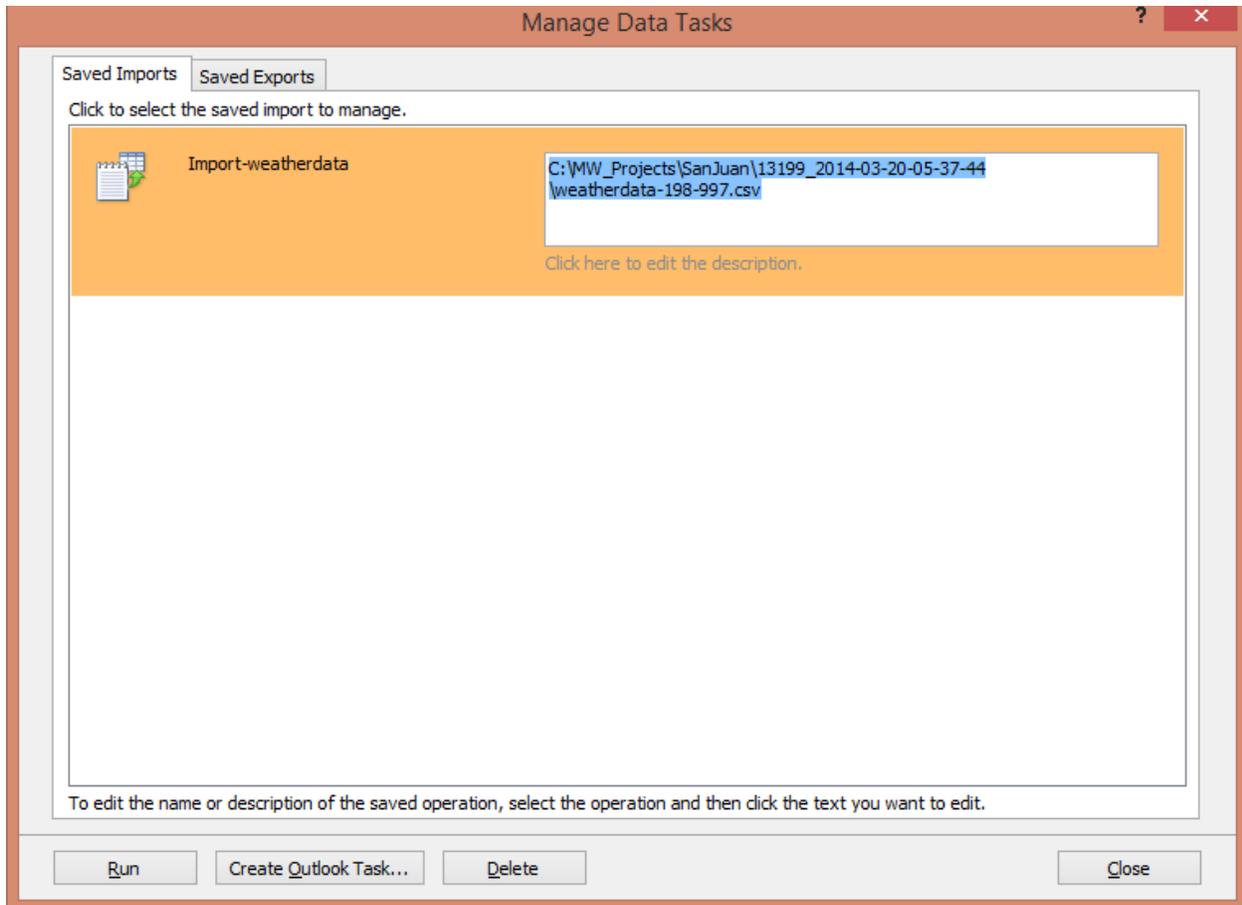


Figure 75: Editing the import file name

message that *All objects were imported successfully*. Click *OK*, and then *Close*. The new table *wthr* appears in the database. We proceed as before, right-clicking the table name, changing it according to the file name we imported, and then selecting *External Data, Import*, and *Saved Imports* to import the next csv file. We repeat until all the csv files have been imported.

If, like us, you made a separate .mdb file for the weather data, you need to import it into your project database. This is easily done by opening the project database, and selecting *External Data, Import*, and *Access*. Browse to the weather data .mdb file, click *OK*, select *sj_weather* and all the *wthr...* tables (you can use *Select All*, unless some system tables are also visible), and click *OK*.

You are now ready to use this data in MWSWAT. In the *Choose SWAT weather sources* form, select *Database tables* for *Weather Source*, and select *sj_weather* as the *Weather Stations Table*. Note that this data allows simulations for up to 32 years, and if you select long periods and especially if there are a number of weather stations involved, it takes some time for the weather files to be written.

9.8 Monitoring Points, Reservoirs, Inlets, and Point Sources

The form shown in Figure 7 can also be used to insert outlets, reservoirs, inlets, and point sources. In this section we describe how to provide the data for these.

Note that when you place any of these on a stream reach a subbasin boundary is generated at that point. That means that each is associated with an upstream and (apart from a main outlet) a downstream subbasin.

9.8.1 Monitoring Points

An outlet upstream from a main outlet is called a monitoring point. Such an outlet, because it will be at the outlet of its upstream subbasin, causes SWAT to produce output data for the upstream subbasin. So it is appropriate for the user to place outlet points where there are gauges, so that SWAT output can be compared to measured data.

9.8.2 Reservoirs

A reservoir is regarded as an outlet, so it is associated with its upstream subbasin. *.res* and *.lwq* files are created by MWSWAT for that subbasin, and referenced in the *fig.fig* file so that SWAT reads them. MWSWAT just creates default constant values for uncontrolled simulated reservoir outputs. It is possible for the user to change these values, or to use instead measured monthly or daily outflow, or controlled simulated outflow. To make such changes the SWAT Editor is used, first using *Edit SWAT Input → Reservoirs* to edit the *.res* and *.lwq* data in the database, and then *Edit SWAT Input → Re-Write SWAT Input Files* to actually rewrite the *.res* and *.lwq* files. For measured monthly or daily outputs it is necessary to prepare an appropriate text file: details of file formats are in the SWAT INPUT/OUTPUT FILE DOCUMENTATION. After saving the data, SWAT must be run via the SWAT Editor (*SWAT Simulation → Run SWAT*) as it is the *Setup SWAT Run* command that causes an additional SWAT data file to be written.

9.8.3 Inlets

Inlets are used when it is desired to model the watershed in more than one part. The inlet point for one (lower) part is a main outlet point for another, upper one. Running SWAT on the upper part generates the outputs to be supplied at the inlet when modelling the lower part. When an inlet point is defined in MWSWAT the upstream basins are removed from the model. A file *ni.dat* is generated (with zero input values), where *n* is the downstream subbasin number, and referenced in the *fig.fig* file. This needs to be supplied with data before SWAT is run. To do this the SWAT Editor is used. First, *Edit SWAT Input → Inlet Discharges* gives access to the inlet data. Then *Constant*, or *Annual*, *Monthly*, or *Daily Records* is selected as the inlet data type. For the last three, a text file of data must be supplied: format details are in the SWAT INPUT/OUTPUT FILE DOCUMENTATION. After saving the data, SWAT must be run via the SWAT Editor (*SWAT*

Simulation → *Run SWAT*) as it is the *Setup SWAT Run* command that causes the *ni.dat* file to be written with the data.

9.8.4 Point Sources

Point sources are associated with their upstream subbasins. MWSAT generates a default file *np.dat* (with zero input values), where *n* is the upstream subbasin number, and references it in the *fig.fig* file. This needs to be supplied with data before SWAT is run. To do this the SWAT Editor is used. First, *Edit SWAT Input* → *Point Source Discharges* gives access to the point source data. Then *Constant*, or *Annual*, *Monthly*, or *Daily Records* is selected as the point source data type. For the last three, a text file of data must be supplied: format details are in the SWAT INPUT/OUTPUT FILE DOCUMENTATION. After saving the data, SWAT must be run via the SWAT Editor (*SWAT Simulation* → *Run SWAT*) as it is the *Setup SWAT Run* command that causes the *np.dat* file to be written with the data.