1.4 WATERSHEDS MODULE

This module offers a wide variety of tools specifically designed to analyse and visualize watersheds. These tools take advantage of the hydrologic relationships between watersheds and use these relationships to identify which watersheds are upstream, which are downstream, and which make up the overall flow regime and/or megabasin. In addition to watersheds, users can also use this module to visualize and possibly analyse data based on any polygonal data type, including administrative boundaries, simple watershed delineations, or surface water bodies. The Watersheds Module is opened or started by clicking on the WS button on the AWRD Interface, or by clicking the "*Open Watershed Viewer…*" menu option in the AWRD Modules menu (Figure 1.28 and Table 1.19).

FIGURE 1.28
Starting the Watersheds Module

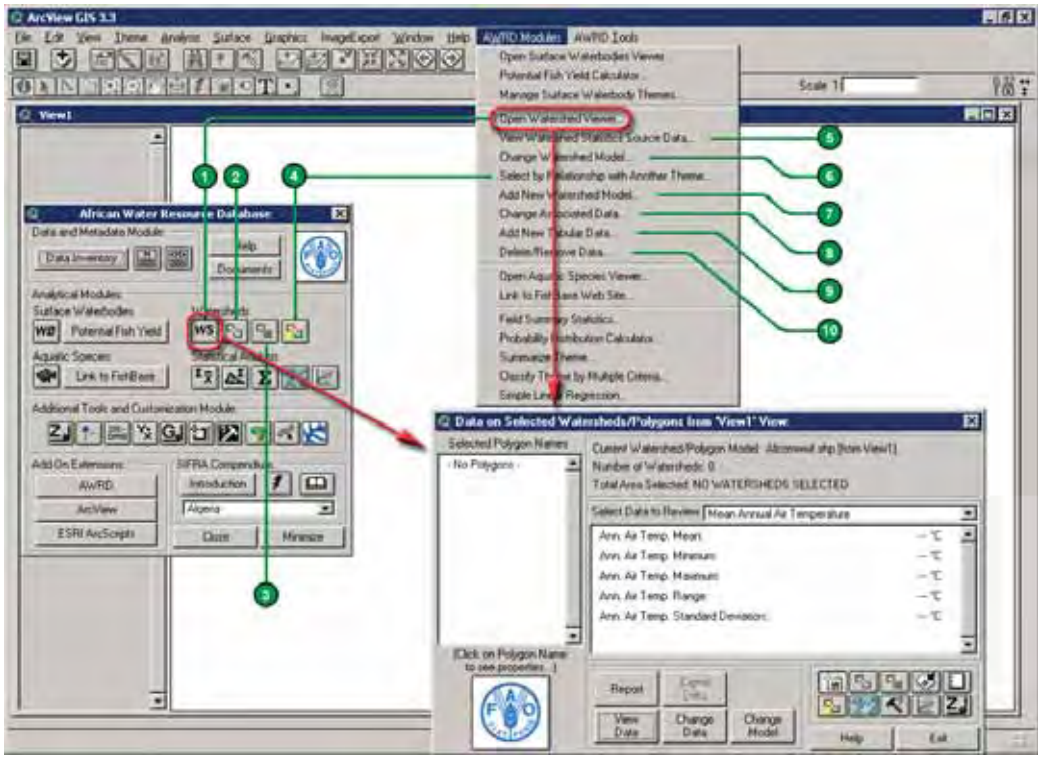
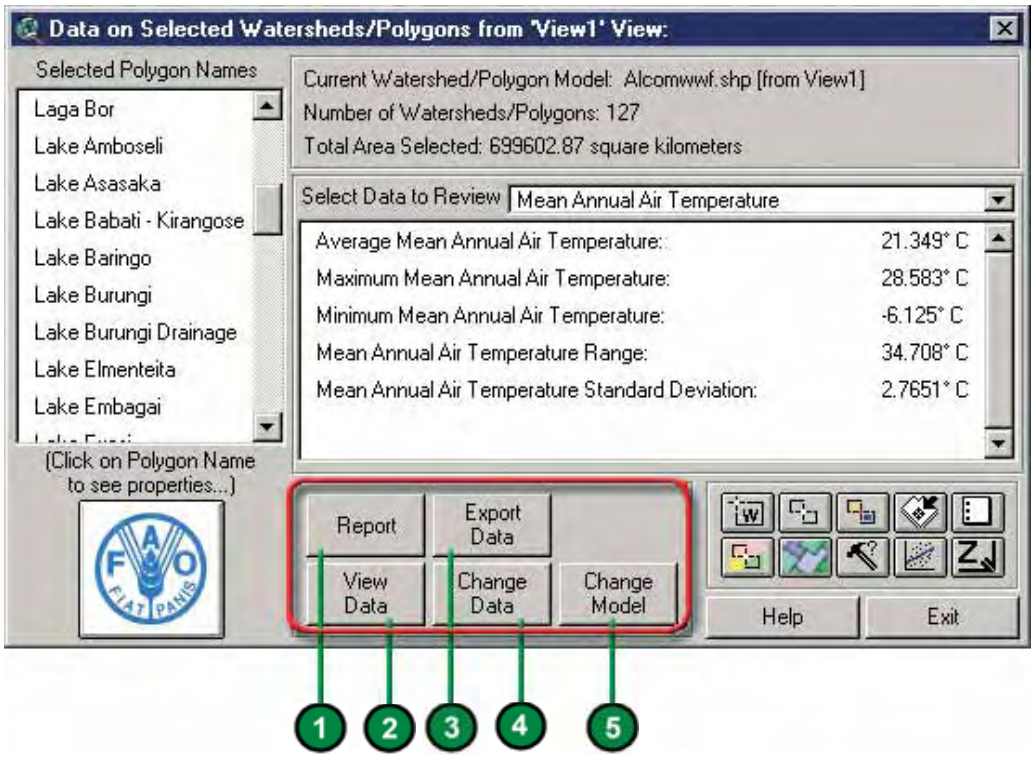


TABLE 1.19
Watersheds Module buttons and menu items

Label (Fig. 1.28)	AWRD button	AWRD Modules menu option	Action executed
1	WS	"*Open Watershed Viewer...*"	*Open Watershed Viewer*: Opens the Watershed Statistics Viewer dialog, allowing you to conduct a wide variety of analyses on watershed themes
2		N/A	*Select Upstream and Downstream Watersheds*: clicking this tool opens the Watershed Selection Criteria tool dialog, allowing users to select watersheds based on their hydrological relationship to a particular watershed selected by the user.

3		N/A	***Identify Upstream and Downstream Watersheds***: this tool opens the "Watershed Visualization Tools" dialog to produce a clear visual map of all the watersheds that are hydrologically related to any particular watershed, i.e. watersheds that are upstream, downstream, or within the same megabasin, plus toools to zoom to the extents of any of these components, to flash the borders of any region, to move upstream or downstream from the base watershed, and to save the flow regime.
4		"Select Watersheds by Relationship with Another Theme…"	***Select by Relationship with Another Theme***: clicking this tool opens the "Select Watersheds by Other Themes" dialog, allowing users to select watersheds based on their hydrological and/or spatial relationship to selected features in another theme.
5	View Data	"View Watershed Statistics Source Data…"	***View Source Data:*** this function shows you the background data used to generate the watershed statistics for a particular watershed theme. If Spatial Analyst is installed, the background data will be added as grids. Otherwise the data will be added as greyscale images.
6	Change Model	"Change Watershed Model…"	***Change Model***: this function is used to change or switch analyses between watershed models. This extension comes with several options (see discussion of Watershed Models) and provides users the ability to customize the AWRD by adding their own data.
7	N/A	"Add New Watershed Model…"	***Add New Watershed Model:*** this function allows users to register new custom watershed models or other polygonal themes so they can be used with the tool-sets of the AWRD Watersheds Module. This tool comes with a Simple and an Advanced version.
8	Change Data	"Change Associated Data…"	***Change Data***: this function allows the user to customize which data themes (e.g. elevation, precipitation, population densities, etc.) the AWRD should calculate statistics for.
9	N/A	"Add New Tabular Data…"	***Add New Tabular Data:*** this function allows a user to generate new data from grid themes.
10	N/A	"Delete/Remove Data…"	***Delete/Remove Data:*** this function allows users to delete and/or unregister watershed models, grid themes and specific data tables.

FIGURE 1.29
The watershed maintenance tools



Watersheds maintenance tools

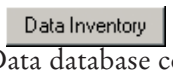
The watershed maintenance tools dialog contains five buttons for exporting and viewing data, and for changing watershed model preferences (Figure 1.29 and Table 1.20).

Table 1.20 provides a summary of the buttons available in the watershed maintenance tools.

TABLE 1.20
Watersheds maintenance tools buttons

Label (Fig.1.29)	AWRD button	AWRD Modules menu option	Action executed
1	Report	N/A	Report: The Report button produces a text report summarizing all the data currently presented on the watershed statistics module. The report is saved as a text file on the hard drive and also appears in a text report on the screen.
2	Export Data	N/A	Export Data: The Export Data button allows users to save the current set of selected watersheds, plus the summary statistics, to a new dBASE table where it can be used with many other software packages.
3	View Data	*"View Watershed Statistics Source Data..."*	*View Source Data:* This function shows you the background data used to generate the watershed statistics for a particular watershed theme. If Spatial Analyst is installed, the background data will be added as grids. Otherwise the data will be added as greyscale images.
4	Change Data	*"Change Associated Data..."*	*Change Data*: This function allows the user to customize which data themes (e.g. elevation, precipitation, population densities, etc.) the AWRD should calculate statistics for.
5	Change Model	*"Change Watershed Model..."*	*Change Model*: This function is used to change or switch analyses between watershed models. This extension comes with several options (see 4.2 Watershed Models) and provides users the ability to customize the AWRD by adding their own data.

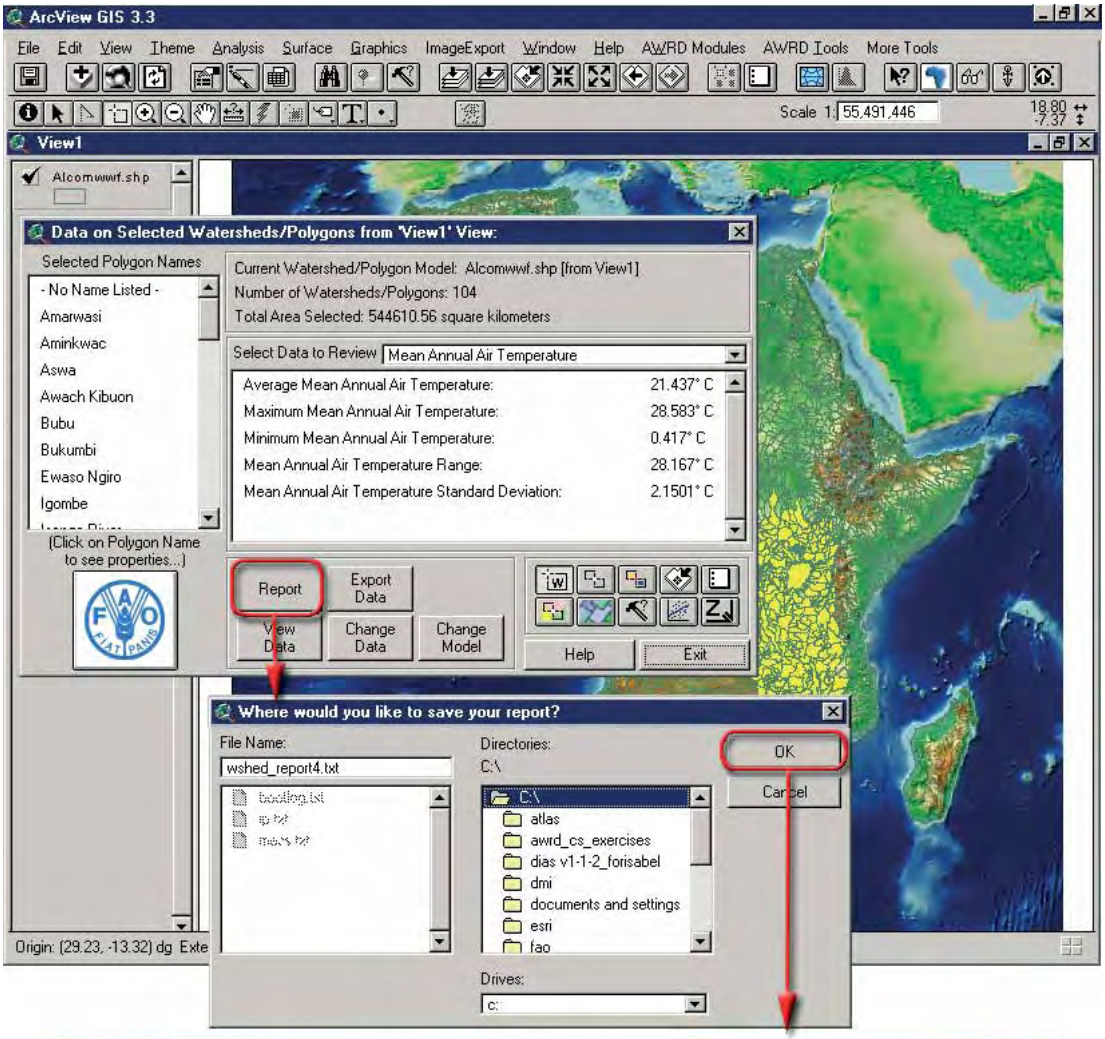
In the following illustrations, the ALCOM watershed model (i.e. Alcomwwwf.shp) was selected to demonstrate the use of AWRD watersheds maintenance tools.

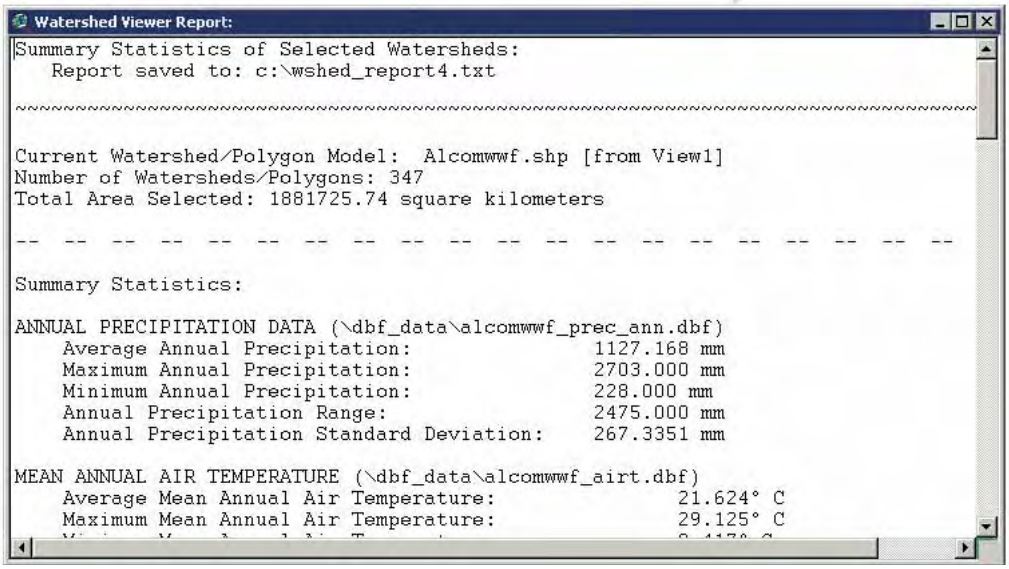
1. Click on the "Add Basemap Image to View" tool  to load one of the image backgrounds (e.g. "Africa_background_2.tif") from the image database component folder. This background image is not necessary for proper functioning of the SWB Viewer, but it makes it easier to locate your area of interest in the view.
2. Click on the "Data Inventory" button  to add the ALCOMWWF watershed model from the Watersheds Data database component.
3. Open the Watersheds Viewer by clicking on the  button on the AWRD interface or by choosing "Open Watersheds Viewer" from AWRD Modules menu.
4. You may be notified that your preferred watershed theme is not present in your view. If you see this message, you will need to set "ALCOMWWF.shp" as your default watershed model. Click the "Specify a new preferred watershed theme" option, and then pick "ALCOMWWF.shp" in the next dialog.
5. Click on the Upstream and Downstream Watersheds button  and the click on any desired location on the watersheds map (i.e. you can select a single watersheds or a group of watersheds). The watersheds selected will be displayed in the "Selected Polygons Names" list and are highlighted in yellow on the watersheds map.

Clicking the "Report Button" 

generates a text report summarizing the statistics for the selected watersheds, saving it as a text file on the hard drive and displaying it in a text report on the screen. In this example a group of watersheds surrounding Lake Tanganyika were selected and are highlighted in yellow (Figure 1.30).

FIGURE 1.30
Saving the information regarding the selected watershed as a text file on the hard drive and viewing the report produced by the Report button on the screen

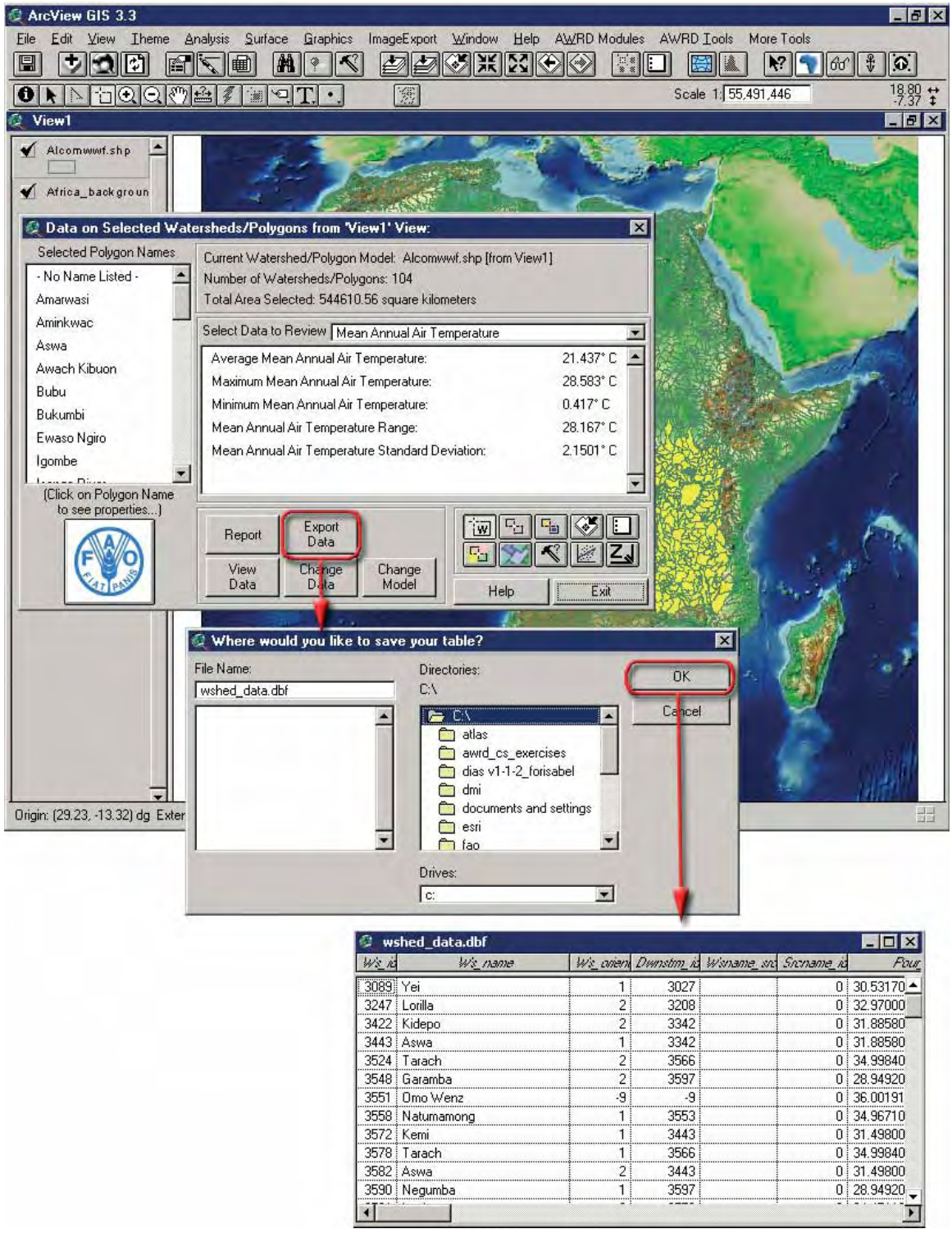




After clicking the "Export Data" button 

the user will be prompted to specify the location to save the table. After clicking the "OK" button, the table will be exported to a dBASE table and then opened in the ArcView project (Figure 1.31). This file that is generated for export is a "dbf" file that can opened in Excel for review and analysis.

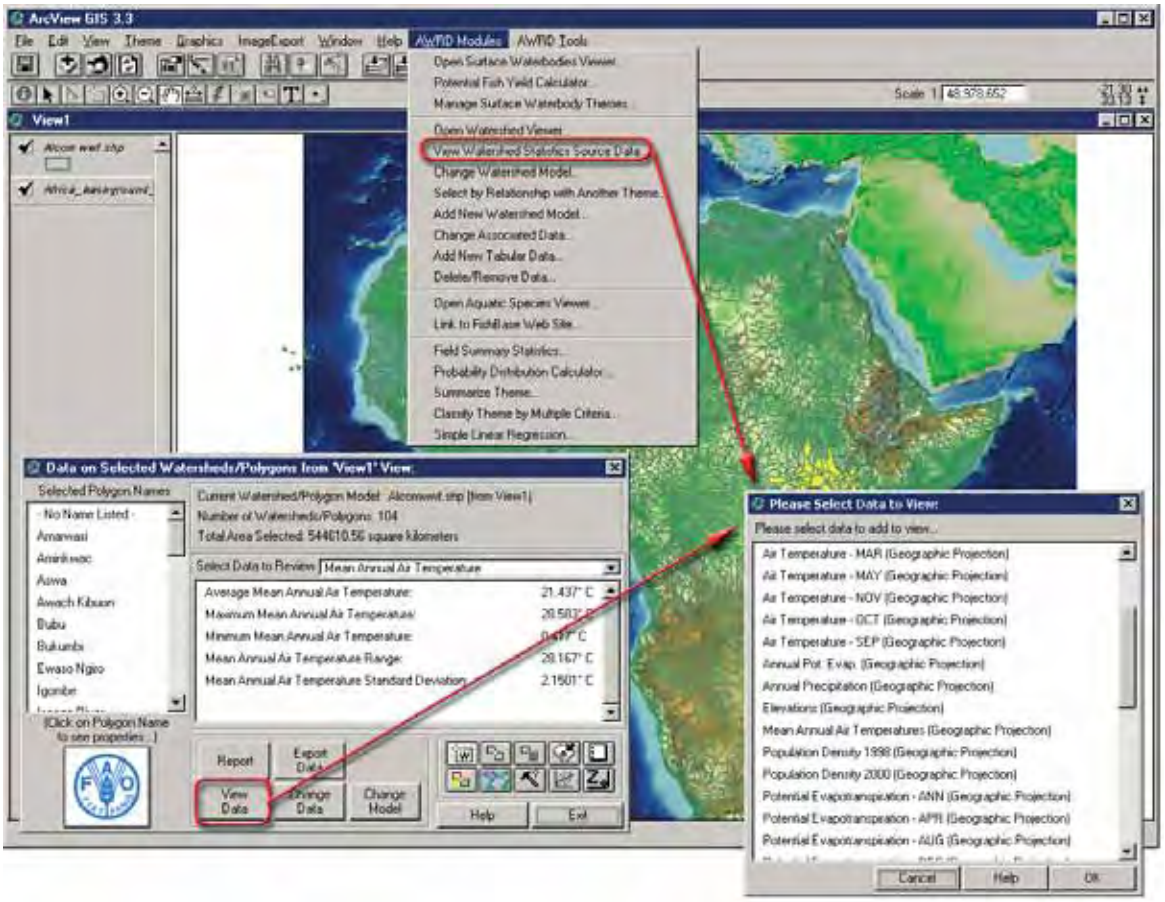
FIGURE 1.31
Saving the new dataset to a new dBASE table and viewing the dBASE table in the ArcView Project



After clicking on the "View Data" button 

or selecting the "*View Watershed Statistics Source Data...*" menu option in the AWRD Modules menu the user is prompted to specify which data layers should be added to the view (Figure 1.32).

FIGURE 1.32
Selection of the data layers



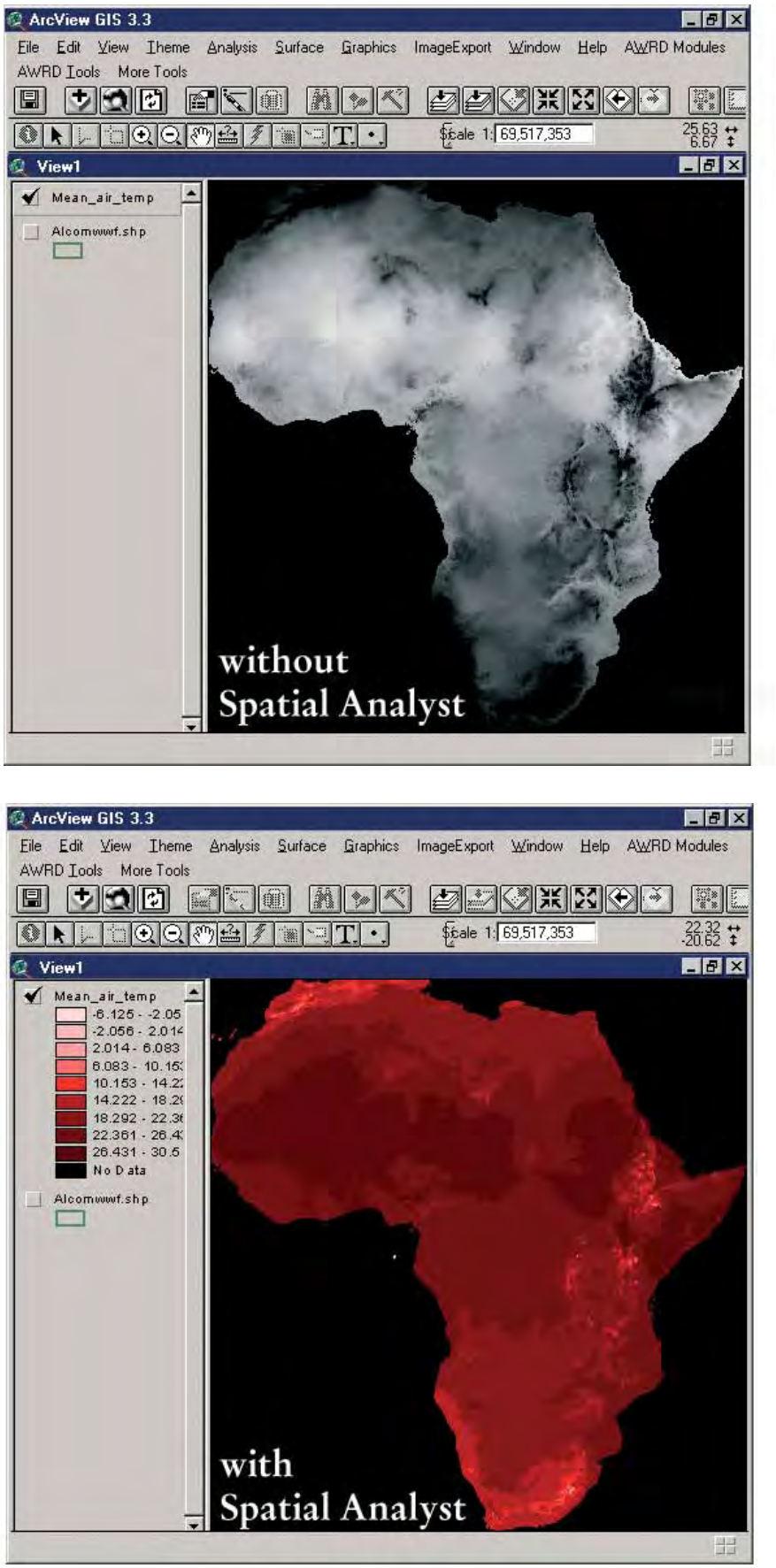
These original data layers are in Grid format so they require Spatial Analyst to be viewed properly. If the user does not have Spatial Analyst, then the "grids" will be added to the view as grey-scale images with the colour ranging from White at the highest values to Black at the lowest values. If the user does have Spatial Analyst, however, then the data layers will appear as Grids and the user can analyse and manipulate them using all the normal grid functions offered by Spatial Analyst. In this example, the "Mean Annual Air Temperature" dataset was selected (Figure 1.33).

The "Change Data" button 

allows the user to customize which data themes (e.g. elevation, precipitation, population densities, etc.) the AWRD should calculate statistics for. This function can also be accessed by selecting the "*Change Associated Data...*" menu option from the main AWRD Modules menu in a View.

Both the button and menu option will open a dialog that allows the user to change which data tables are available for calculating ancillary statistics based on the current selection set of watersheds under the main AWRD Watershed Module dialog. In general–the watershed statistics tool-set will become less responsive and run more slowly with each additional data table a user has selected, so it may be advantageous to avoid including data tables if a user is not interested in them.

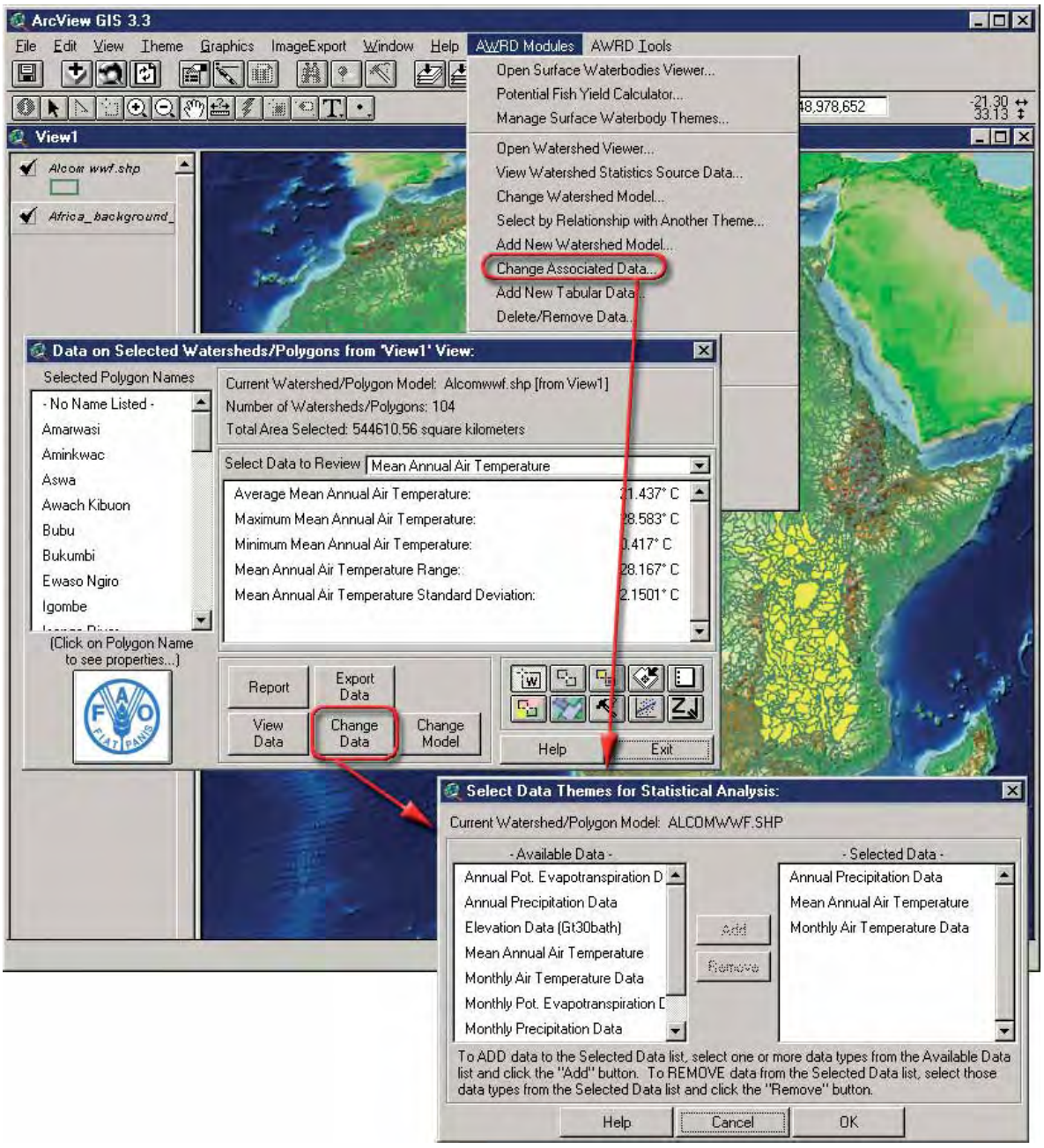
FIGURE 1.33
Viewing watershed statistics source data (e.g. mean annual air temperature) without Spatial Analyst (on the left) and with Spatial Analyst (on the right)



Clicking the button or the menu option opens the "Select Data Themes for Statistical Analysis:" dialog. The list on the left shows all the data tables that are available for the selected watershed model. The list on the right shows which of those data tables the user currently has selected for the generation of statistics (Figure 1.34).

FIGURE 1.34

Changing data for calculating statistics on the selected watersheds



The user may add to the data tables selected by clicking on any or all of the items in the "–Available Data–" list and clicking the "Add" button. These items will immediately appear in the "–Selected Data–" list.

Similarly, a user may remove any selected data tables by selecting any or all of them from the "–Selected Data–" list and clicking the "Remove" button. Hitting the "Remove" button here does not delete the data, but rather simply tells the Watershed Statistics Module not to calculate statistics for those data. If the user wants to truly delete any of these data, then the "*Delete/Remove Data…*" menu option must be used. The user must hit the "OK" button to apply any changes.

The "Change Model" button 

allows the user to change or switch analyses between watershed models. The AWRD currently has three complex watershed models and two simple watershed delineations "registered" with the interface. This extension comes with several options and provides users the ability to customize the AWRD by adding their own data.

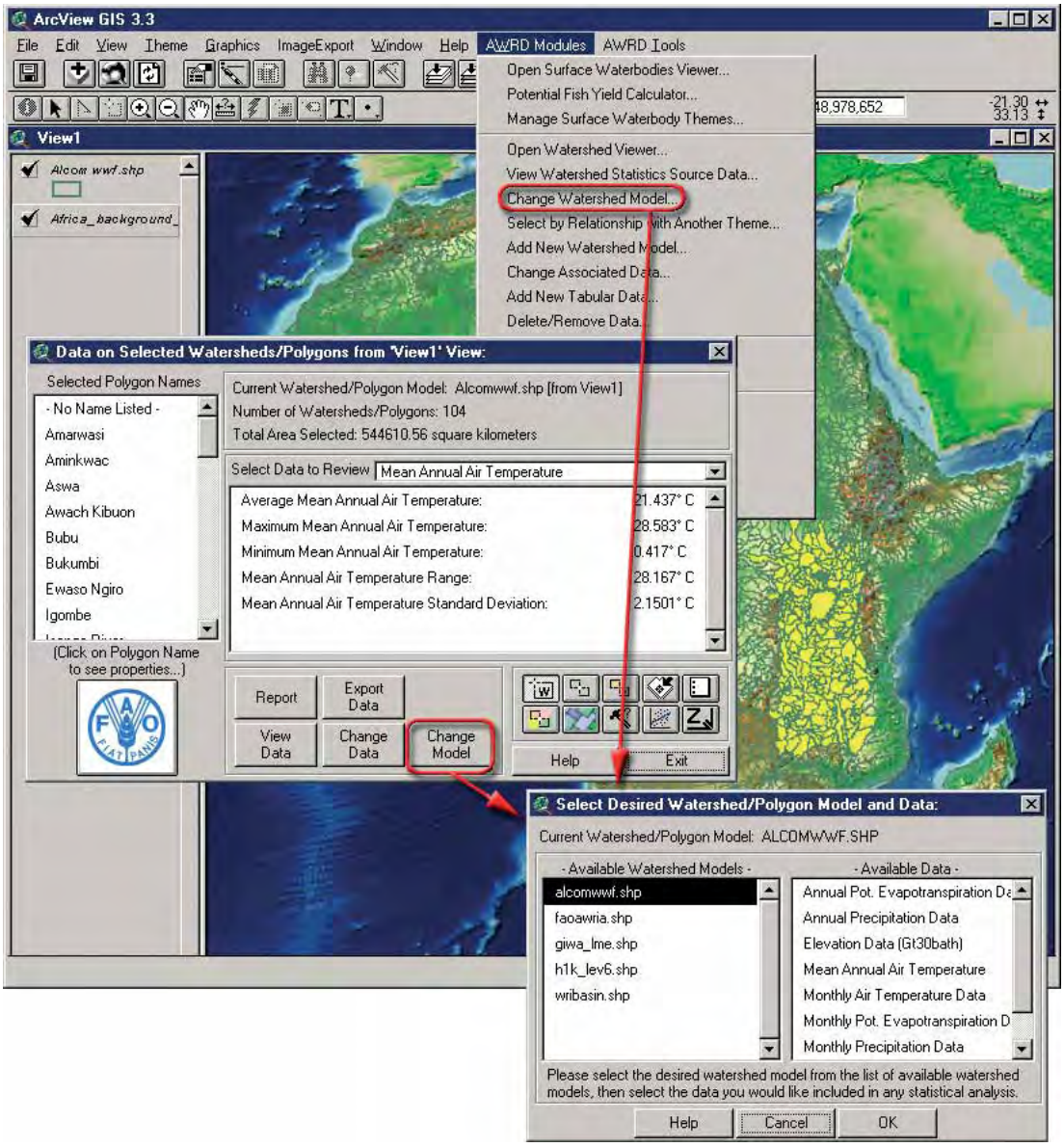
The custom menus and dialogs associated with the Change WS Model function provide the means whereby watershed or other data layers can be "registered" for analysis using the AWRD. Many of the watershed and data analysis tools available in the AWRD are designed to function only if a properly encoded WS model is available. Three such models are provided with the AWRD, along with a default set of core elevation and sample climatological data layers so that the base statistical functions are enabled. However, only one WS model may be analysed at a time, and these Watershed Model Maintenance Tools provide users with the means to change the default WS model, add new watershed models, add new data layers, change processing preferences and modify which analytical layers are examined, and lastly, to remove data from consideration.

The statistical data for the watersheds (e.g. elevation, precipitation, air temperature, water temperature and population densities) are derived from Grid datasets. In order for a particular grid of data to be useful for a particular watershed model, we must conduct statistical analyses on the grid to determine the relevant statistics for each watershed in the model. These statistics are then saved to a table, and this table is joined to the watershed model when the Watershed Statistics Viewer is opened. The Watershed Statistics Viewer works by checking the current selection of watersheds and then looking up the associated statistical data from the data tables, then calculating overall statistics based on the data for each watershed and the sizes of those watersheds.

This extension is designed to enable users to switch among a variety of watershed models or to add additional watershed models and then generate statistical data. Because the statistical data are drawn from Grid themes, users must have ESRI's Spatial Analyst extension in order to revise or generate new statistical data. However, because the relevant summary tables have already been generated from the GTopo30 baseline elevation layer and the sample climatological data layers for each of the three WS models currently registered in the AWRD, even users lacking access to Spatial Analyst will be able to fully utilize the AWRD tool-sets.

This function can be also accessed selecting the "*Change Watershed Model…*" menu option from the main AWRD Modules menu, which opens the "Select Desired Watershed/Polygon Model and Data:" dialog (Figure 1.35).

FIGURE 1.35
Changing the watershed model to analyse



At the left of the opened dialog there is an illustrative list of watershed models currently recognized by the interface. If the user would like to switch to a custom watershed model that is not in this list, then the model must first be registered with the interface via the "*Add New Watershed Model...*" menu option. Otherwise the user needs only select one of the existing models by clicking on it.

At the right of the dialog there is a list of available data tables. These are statistical data that have already been generated from the respective grids for this watershed model.

If a user wishes to add new data to this list, the "*Add New Tabular Data…*" menu option should be clicked; the user must have Spatial Analyst installed or this option will not be available. Otherwise, the user needs only to select any or all of the data tables required. Users may find that the Watershed Statistics Viewer runs faster when fewer of these data sets are selected, so it may be advantageous to limit selections of ancillary data. The watershed and ancillary data selections made by the user are applied when the "OK" button is clicked. After this, the chosen watershed model will become the new default model utilized by the AWRD each time it is opened, until such time as a new model is chosen.

Registering new custom watershed models or other polygonal themes

Add new watershed model

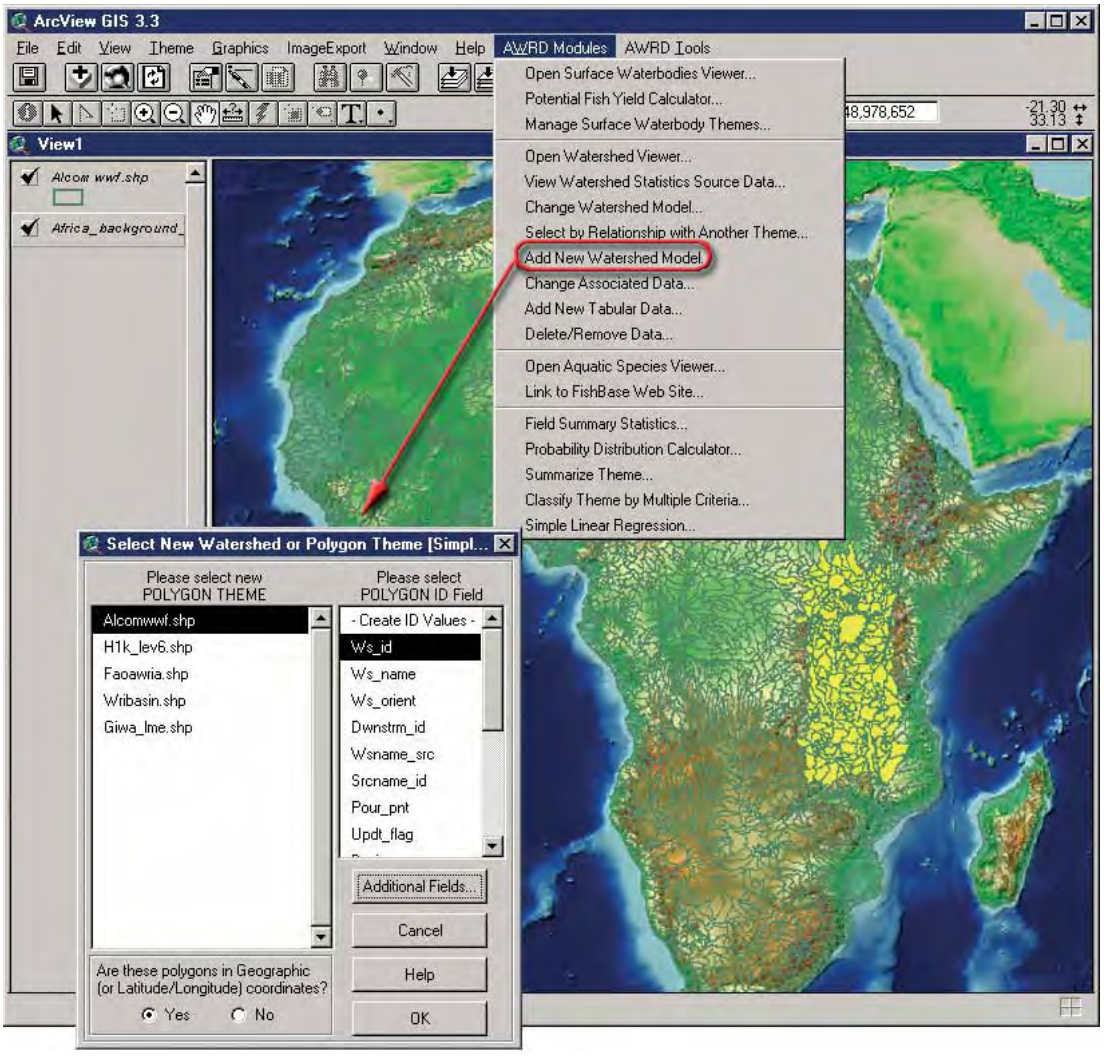
The "*Add New Watershed Model...* " option on the AWRD Modules menu allows users to register new custom watershed models or other polygonal themes so they can be used with the tool-sets of the AWRD Watersheds Module. Although users can in fact register any type of polygon theme, certain watershed functions will only work on "true" watershed models containing unique ID values that identify watersheds immediately downstream.

Using the dialogs described below, users can also modify some of the settings associated with any of the current watershed models such as which field contains the name or megabasin characterization, and which fields contain the unique ID and/or Downstream ID values. Currently these ID values must be numeric.

Simple version

Selecting the "*Add New Watershed Model...* " menu option will open the *Simple* version of the "Select New Watershed or Polygon Theme:" dialog. This tool version will be sufficient to register watershed delineations and general polygon themes, but is not sufficient to register properly encoded watershed models. The Simple version shows a list of all the polygon themes in the current view, as well as a list of all the currently registered polygon themes (Figure 1.36).

FIGURE 1.36
Registering new custom watershed model (simple version)



The "POLYGON ID Field" list on the right contains all the fields in the watershed model feature attribute table. As different polygon themes are selected from the "POLYGON THEME" list on the left, the list on the right will refill with the fields from each new polygon theme. Select a polygon theme from the list on the left, and then pick a field that contains unique ID values for each of the watersheds from the list on the right. These are values that uniquely identify each watershed in the theme, and are necessary for calculating and reporting statistics. If there is no such ID field, click the "– Create ID Values –" option at the top of the list and the tool will add a new field to the theme. This field will be filled with record numbers, such that the first watershed will have a value of zero and the numbers will increase until the last watershed. In this example the "H1k_lev6" watershed model was selected with "Level6" ID (Figure 1.37).

In general the AWRD will work most efficiently if the watershed and grid data are in geographic coordinates (i.e. in latitude/longitude values). However, the interface will also work with watershed models in other projections, although users may not be able to visually review the grid data layers unless the source grids are in the same projection. In cases where a WS model is in projected units, then the projection of the watershed model must be specified.

Because this "simple" version of the tool does not allow users to specify Downstream ID values, the best use for this version of this tool is to register polygonal themes such as watershed delineations, administrative areas, ecological zones, etc. and not true watershed models. If a user needs to register a true watershed model, then the "Additional Fields…" button must be used to switch over to the *Advanced* version of the tool.

Advanced version

The advanced version of the dialog includes choices for Watershed (or Polygon) Name, Downstream ID, Megabasin ID and Area. All of these choices include an option for "-No Such Field–", if there is no such field available.

POLYGON NAME Field: This field should contain names for each watershed, based on the field the user wishes to use as a basis for selections and reporting. As depicted in the Watershed Viewer illustration (Figure 1.37), the attributes in the polygon name field will be the ones that show up on the main Watershed Statistics Module dialog in the "Selected Polygon Names" list box (i.e. in this example H1k_lev6 watershed model is used).

In the event that there are no names for the watersheds (i.e. there is no "POLYGON NAME" field), then the extension will use the values from the unique ID field specified by the user. This is in fact the case for the USGS-H1k watershed model of Africa that was modified for the AWRD, where the Pfafstetter code is also used as a name.

DOWNSTREAM ID Field: this field is necessary for the watershed model tools to work. It should contain the ID value for the watershed immediately downstream from each watershed, and the ID values should correspond with those in the ID field. For example, if Watershed #1 drains into Watershed #2, then the ID value for Watershed #1 should be "1" and the Downstream ID value should be "2". The ID value for Watershed #2 should be "2", and the downstream ID value should be the ID value of whatever watershed lies immediately downstream from Watershed #2. If this field is not specified, or if it is specified incorrectly, then the watershed modelling tools will not function properly.

MEGABASIN ID Field*:* this field should contain the ID value for the megabasin.

POLYGON AREA Field: if the user does not specify an area field, the extension will calculate areas when it needs to and report the values based on units in square

kilometres. If an area field is specified, however, then the extension will report area values from that field. In this case the measurement units will be those originally defined for the calculation (for example, hectares or square metres), and will not be assumed to be in square kilometres (Figure 1.37).

FIGURE 1.37
Calculation of area in the originally defined measurement units

Users can calculate or update the area values for any polygon theme using the "*Calculate/Update GeoStats in Polygon Theme Tables…*" menu option in the AWRD Tools menu. This tool will calculate/update the area for each polygon in square kilometres, hectares, square miles and/or acres, and/or the perimeter in metres, based on the Lambert Equal Area Azimuthal projection centred at 20° longitude and 5° latitude.

Add new tabular data

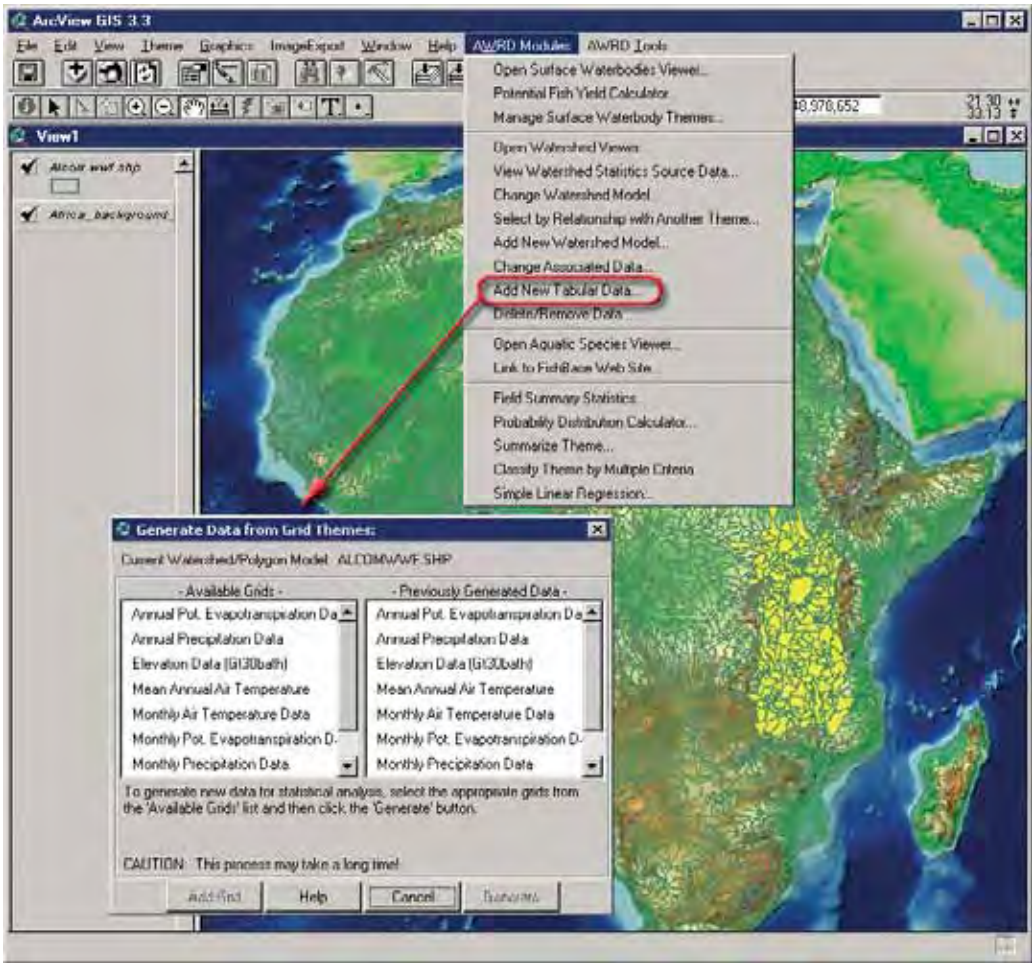
This option, accessed by selecting the "*Add New Tabular Data...*" menu option in the AWRD Modules menu, allows a user to generate new data from grid themes. For example, if a user wishes to add a new custom watershed model and then wants to review statistics on elevation, precipitation, air temperatures, etc. for watersheds in the new model, then this option must be used to generate the data tables for those grids.

This option generates the elevation, precipitation, etc. grid statistics for each watershed and then registers that data so the watershed tools will recognize that the data is associated with the WS model.

Note Because this tool works with grid data, it is only available if Spatial Analyst is installed.

Clicking this option opens the "Generate Data from Grid Themes:" dialog depicted in Figure 1.38.

FIGURE 1.38
Generating new data from grid themes



In this dialog the list on the left contains all the grid themes that are currently registered in the extension. The list on the right contains all the data tables that have already been generated from the grids for this particular watershed model. Simply click on the grid data from the list on the left and then click the "Generate" button. Users may also regenerate a table that already exists (but which has perhaps become corrupted, or perhaps the polygon boundaries have changed) by clicking the grid name for that table and then clicking the "Generate" button. In this case, the tool will warn the user that the table already exists and then ask for confirmation before regenerating it. If the user clicks "Yes" then the data will be regenerated and the existing data tables will be replaced.

Registering new grid themes

Users will also need to use the above dialog to register new grid themes. If the user has any grid themes in the current view, then the "Add Grid" button will be enabled and data for these grids can be registered. Once that grid has been registered, the user can now generate watershed tables for it.

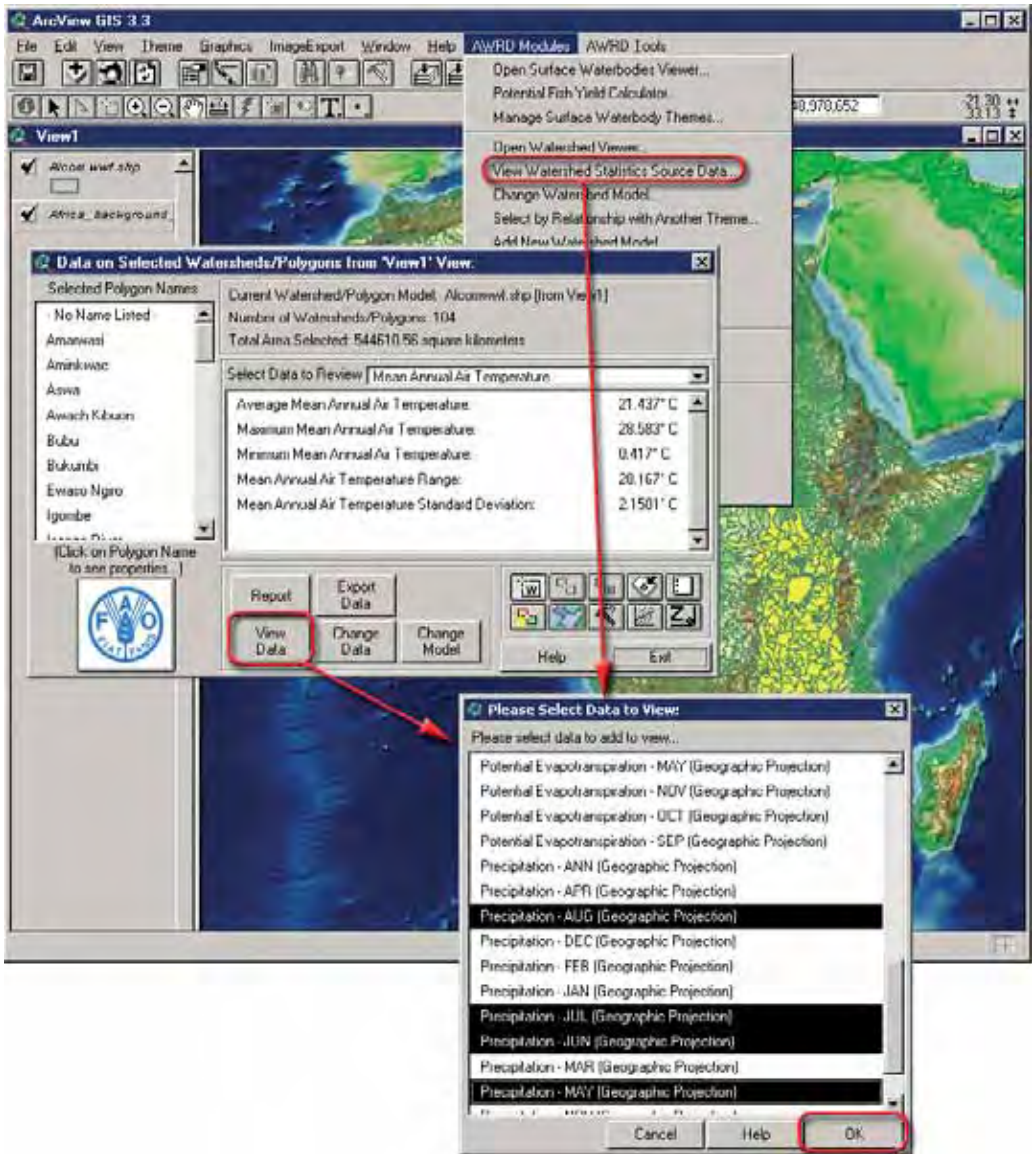
Note This tool is intended to be used with grids that represent a continuous range of data, such as elevation values or population densities. It is not intended to be used with classification grids where grid cell values represent some categorical classification such as forest cover types or political regions. The Watershed Statistics Viewer generates statistics such as mean, minimum, maximum, range and standard deviation, and none of these are valid statistics for categorical data. What,

for example, would the "standard deviation" represent for a watershed that was overlaying the boundary of the Republic of Namibia and the Republic of Botswane on a grid of political regions? The combined set of "the Republic of Namibia" values and "the Republic of Botswana" values cannot be evaluated as a continuous range of numerical values. The Watershed Statistics Viewer will do its best to derive statistics from these data, but the statistics will be meaningless.

To register a new grid theme, the user must first identify or create the grid theme. For example, suppose a user was interested in reviewing average total precipitation for the summer months of May through August (north of the equator, at least!). Values for these grids would need to be generated as follows:

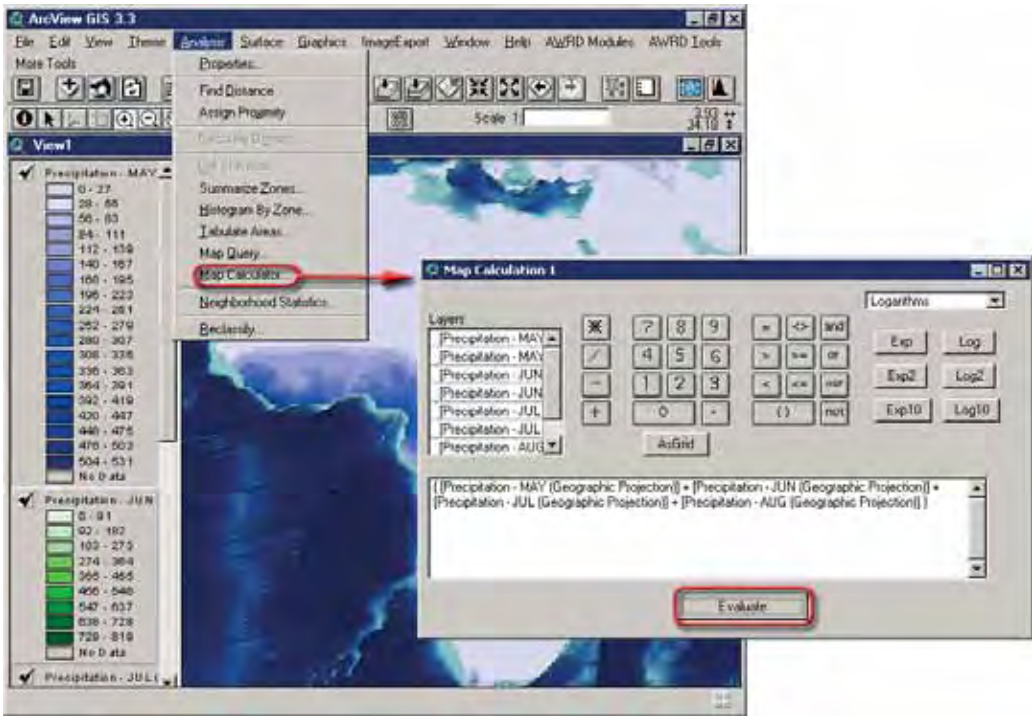
1. Add the relevant grids to the view. Use the "*View Watershed Statistics Source Data…*" option on the AWRD Modules menu or the "View Data" button on the Watershed Module to see a list of grid themes (a user could also simply use the standard ArcView "Add Theme" tool  if the location of the relevant grids is known (e.g. "c:\wrd\data\aras_dbc\precip"). From the list, choose the grids representing precipitation for the months of May, June, July and August. Click "OK" and these grids will be added to the current view (Figure 1.39).

FIGURE 1.39
Selecting and adding the grids of interest to the view from the AWRD Modules menu option or by clicking the View Data button on the Watersheds Module



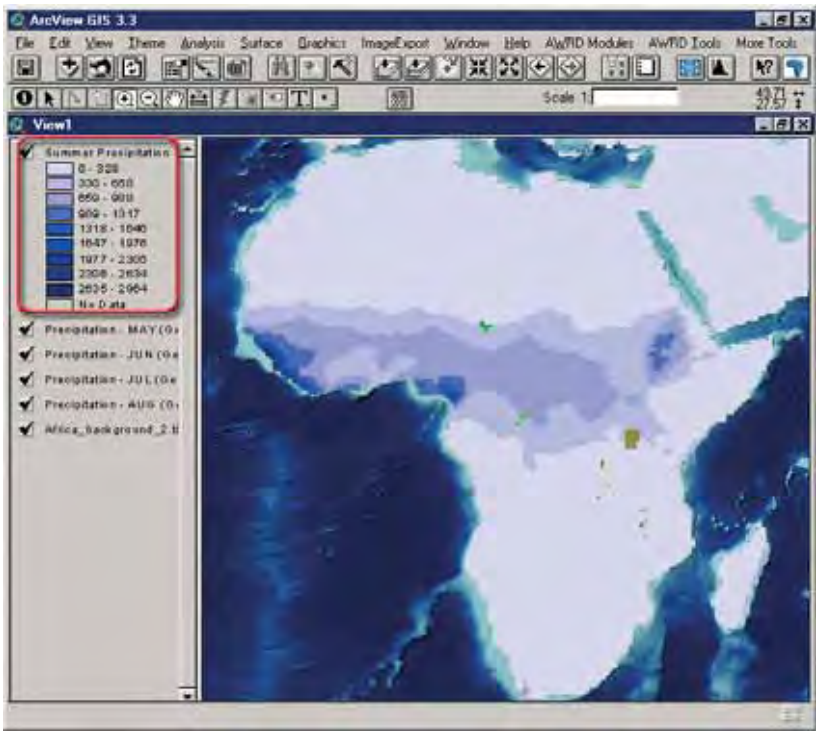
2. Combine the four grids into a single grid. Use Spatial Analyst functions to calculate the total precipitation for these four months by adding these four grids together (Figure 1.40).

FIGURE 1.40
Combining the four grids into a single grid



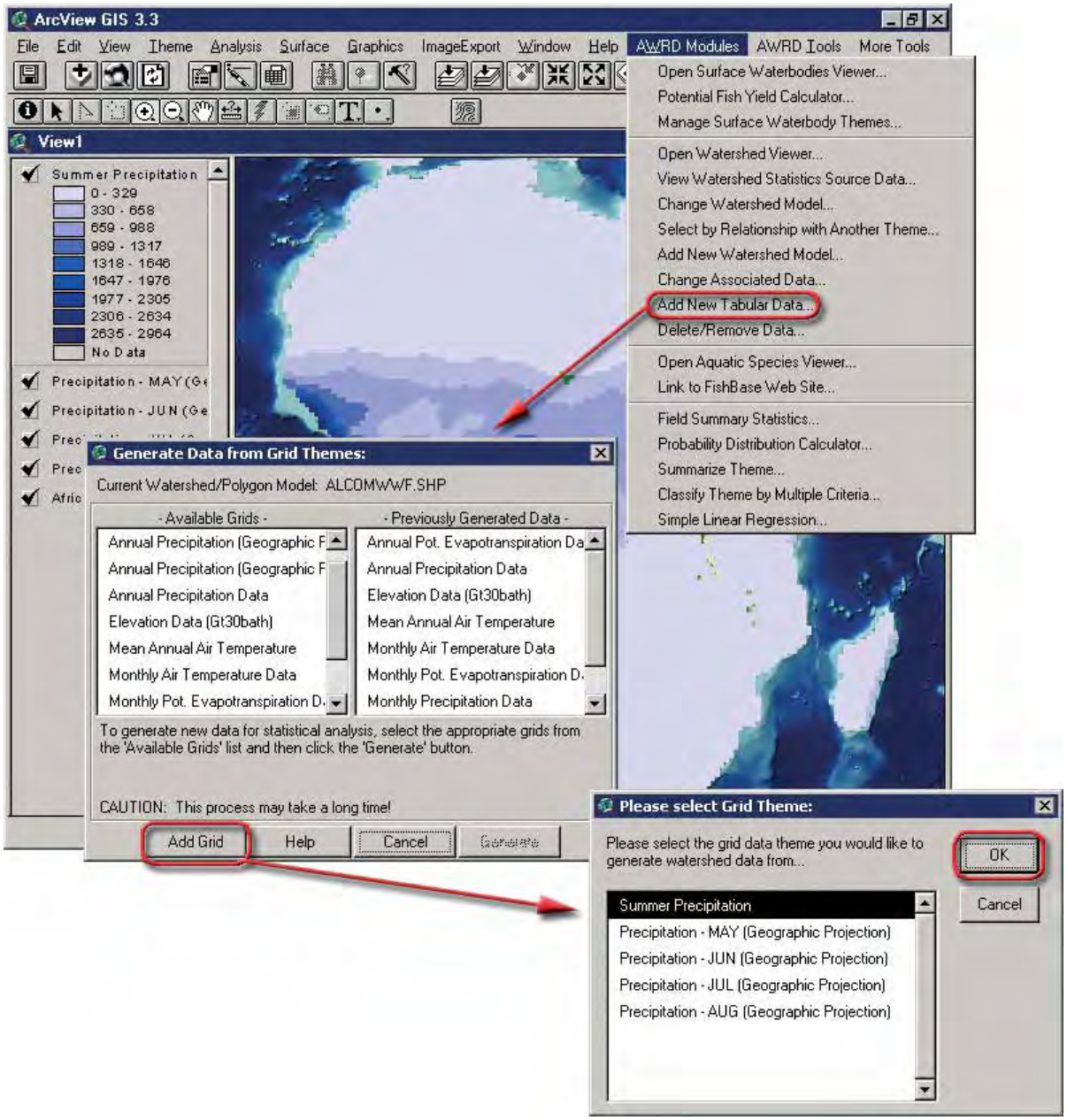
3. Rename the new grid to something like "Summer Precipitation" (or "Winter Precipitation" in cases south of the Equator) through the "Theme" menu option "*Properties…*" (Figure 1.41).

FIGURE 1.41
Viewing the new grid "Summer Precipitation"



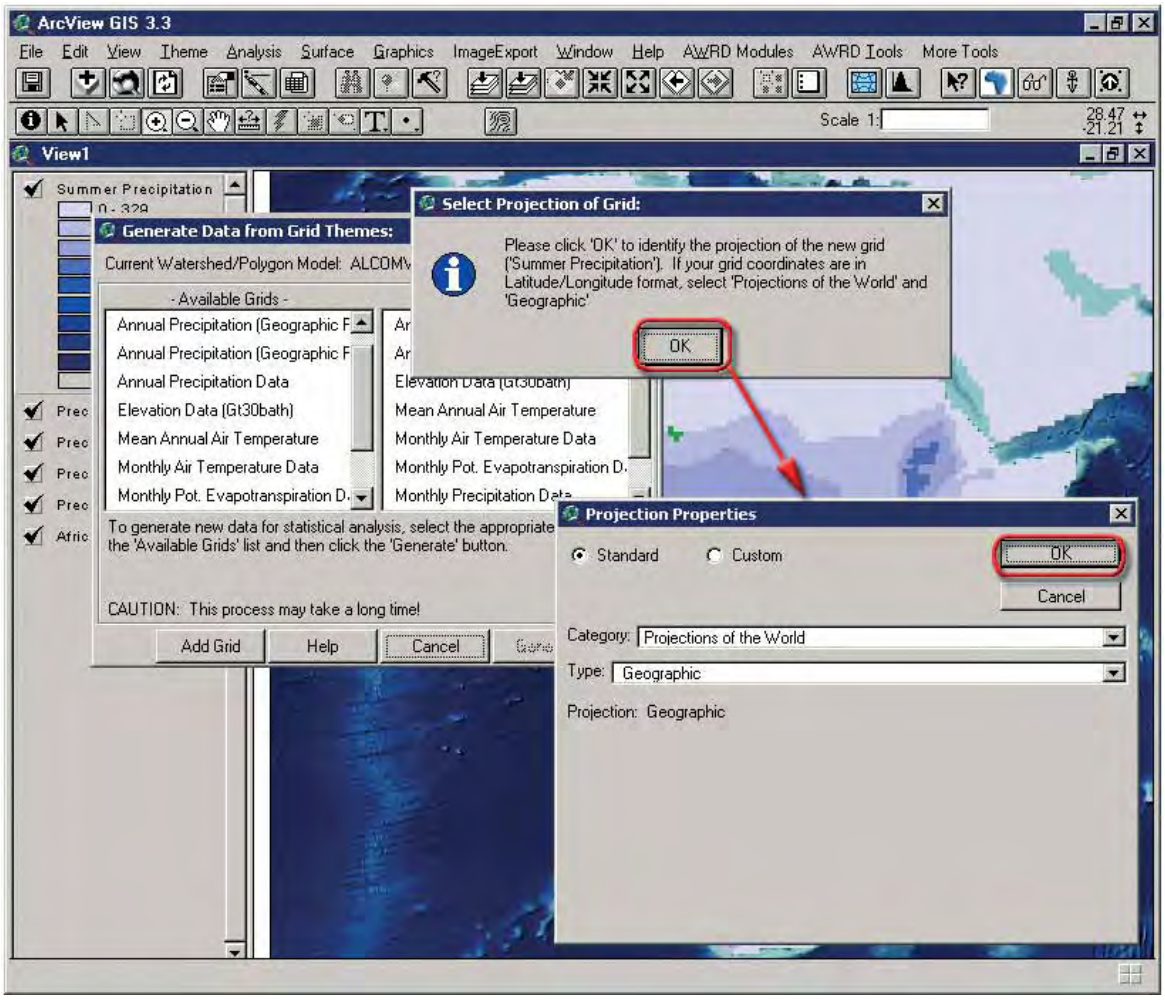
4. Register the new Summer Precipitation grid with AWRD. Click the "*Add New Tabular Data…*" menu option to open the "Generate Data from Grid Themes:" dialog, then click the "Add Grid" button to open the "Please Select Grid Theme:" dialog (Figure 1.42).

FIGURE 1.42
Adding the new grid (Summer Precipitation) into the AWRD



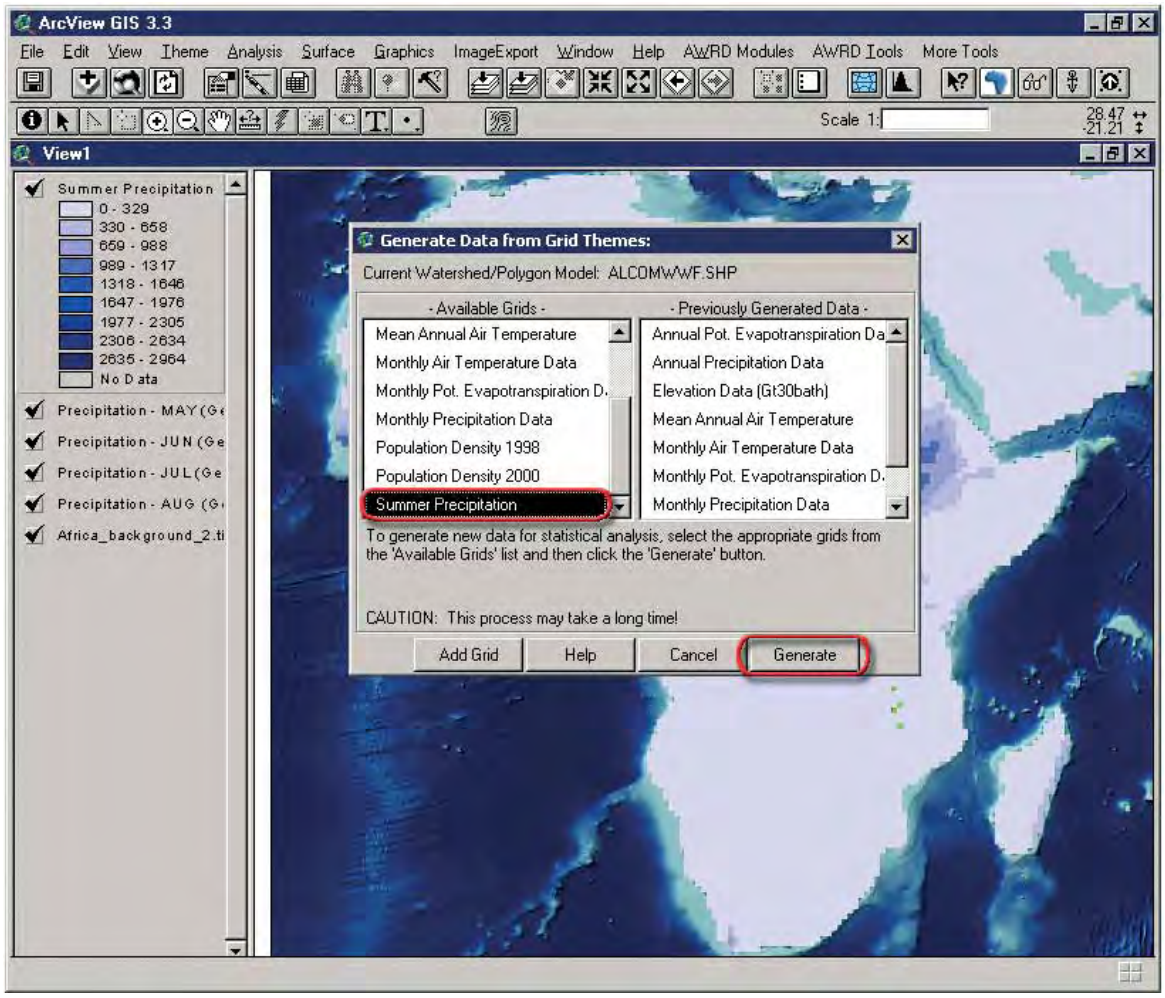
5. Pick the "Summer Precipitation" grid from the list and click "OK".
6. Specify the projection of the Summer Precipitation grid. In this case, because the monthly precipitation grids were in the Geographic projection, the Summer Precipitation grid is also in the Geographic projection (Figure 1.43).

FIGURE 1.43
Specifying the projection of the new grid



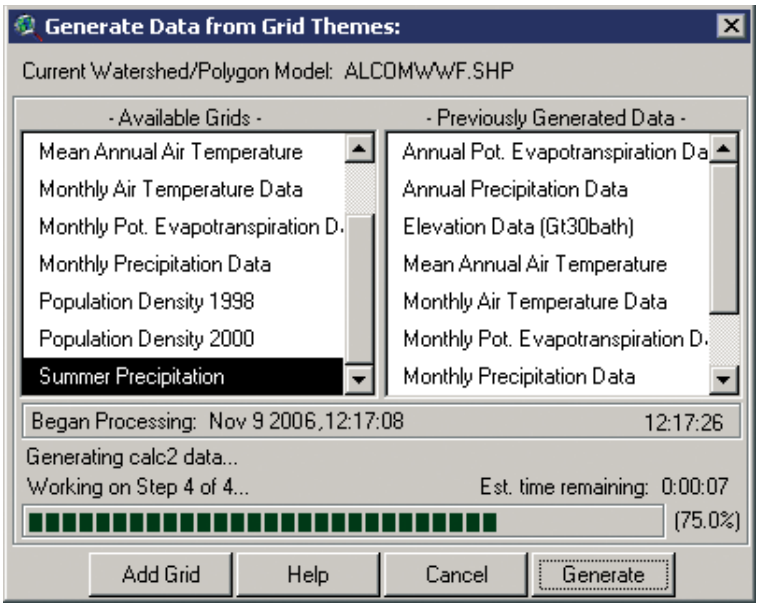
7. After clicking "OK" on the "Projection Properties" dialog, the user is returned to the "Generate Data from Grid Themes:" dialog. Notice that the Summer Precipitation grid has been added to the list of available grids (Figure 1.44).

FIGURE 1.44
Registering the new grid



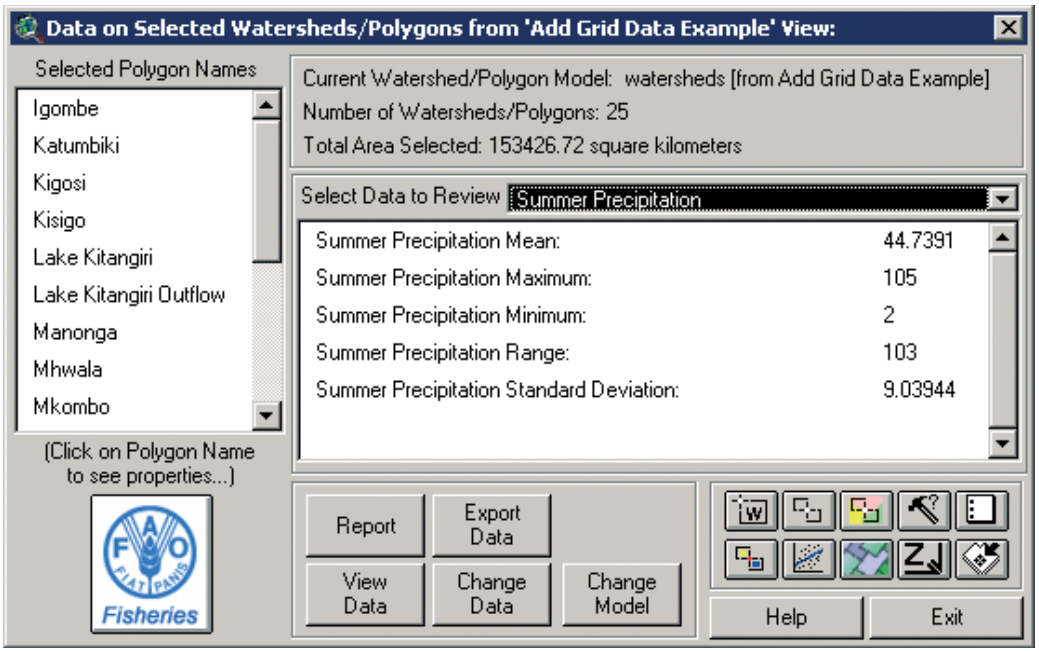
8. Select “Summer Precipitation” from the list and click “Generate”. Because the current default watershed model is “Alcomwwwf.shp”, this tool will generate a table of summer precipitation statistics for the Alcomwwwf watershed model (Figure 1.45).

FIGURE 1.45
Visualization of the new registered grid



Now that the Summer Precipitation grid has been registered and a table of data generated for it, this tool automatically adds the Summer Precipitation data to the default list of selected data, and summary data will automatically be calculated for the selected set of watersheds in the main Watershed Statistics Module dialog (Figure 1.46).

FIGURE 1.46
Calculation of summary data for the new grid



Delete/Remove Data

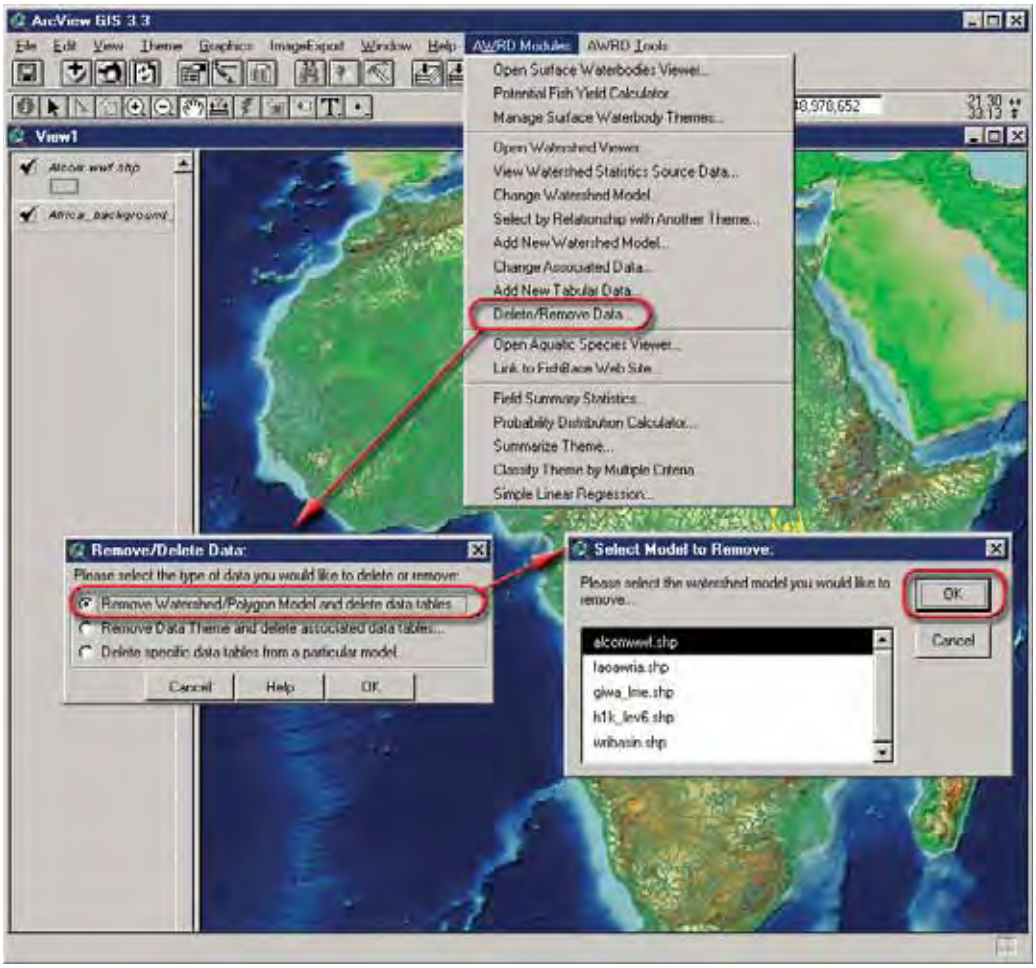
The "*Delete/Remove Data...*" menu option on the AWRD Modules menu allows users to delete and/or unregister watershed models, grid themes and specific data tables. Clicking on this option opens the "Remove/Delete Data:" dialog where the following three options can be found:

Remove Watershed/Polygon Model and delete data table: this option will completely remove a particular watershed model and delete all the associated data tables. This option will not delete the actual watershed model, but it will unregister it so that the AWRD interface will no longer recognize the theme as a watershed model. Clicking this option opens a dialog that will prompt the user to identify a WS model from the list of registered models (Figure 1.47).

1. Select a watershed model and click "OK" and the tool will then prompt the user to confirm the removal. Click "OK" again and the tool will unregister that watershed model and delete all its associated data tables.

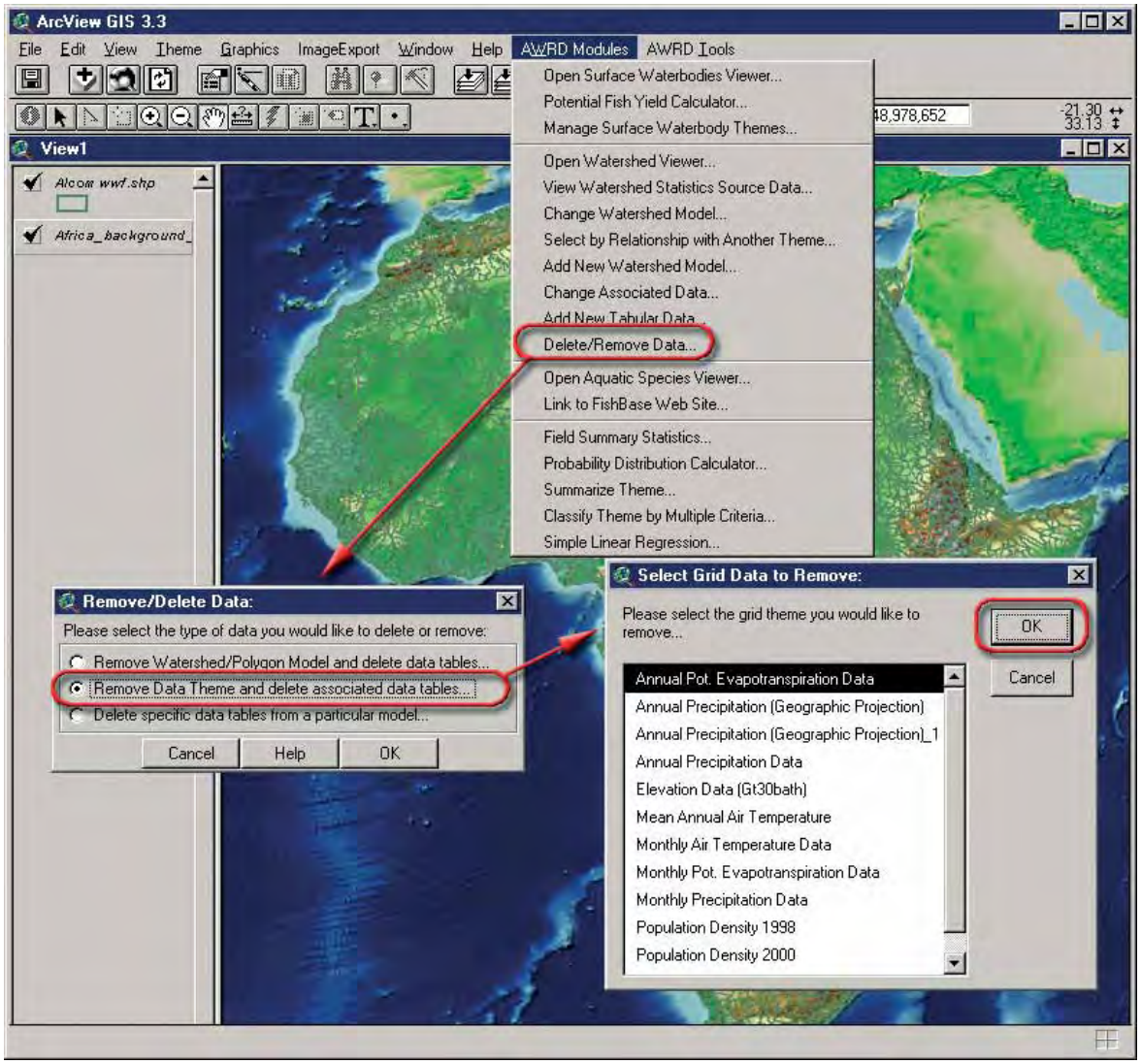
Note Using this function will NOT delete the actual watershed feature dataset from the hard disk.

FIGURE 1.47
Selecting the watershed model to remove



Remove Data Theme and delete associated data tables: this option allows users to completely remove a particular grid data theme and delete all the associated data tables. In this case, several watershed models may have data tables that were derived from that grid. All such data tables will be deleted, but the grid itself will only be unregistered. Although the grid will not be deleted, this extension will no longer recognize it as a data theme. Clicking this option opens a dialog prompting the user to pick the grid theme from a list (Figure 1.48).

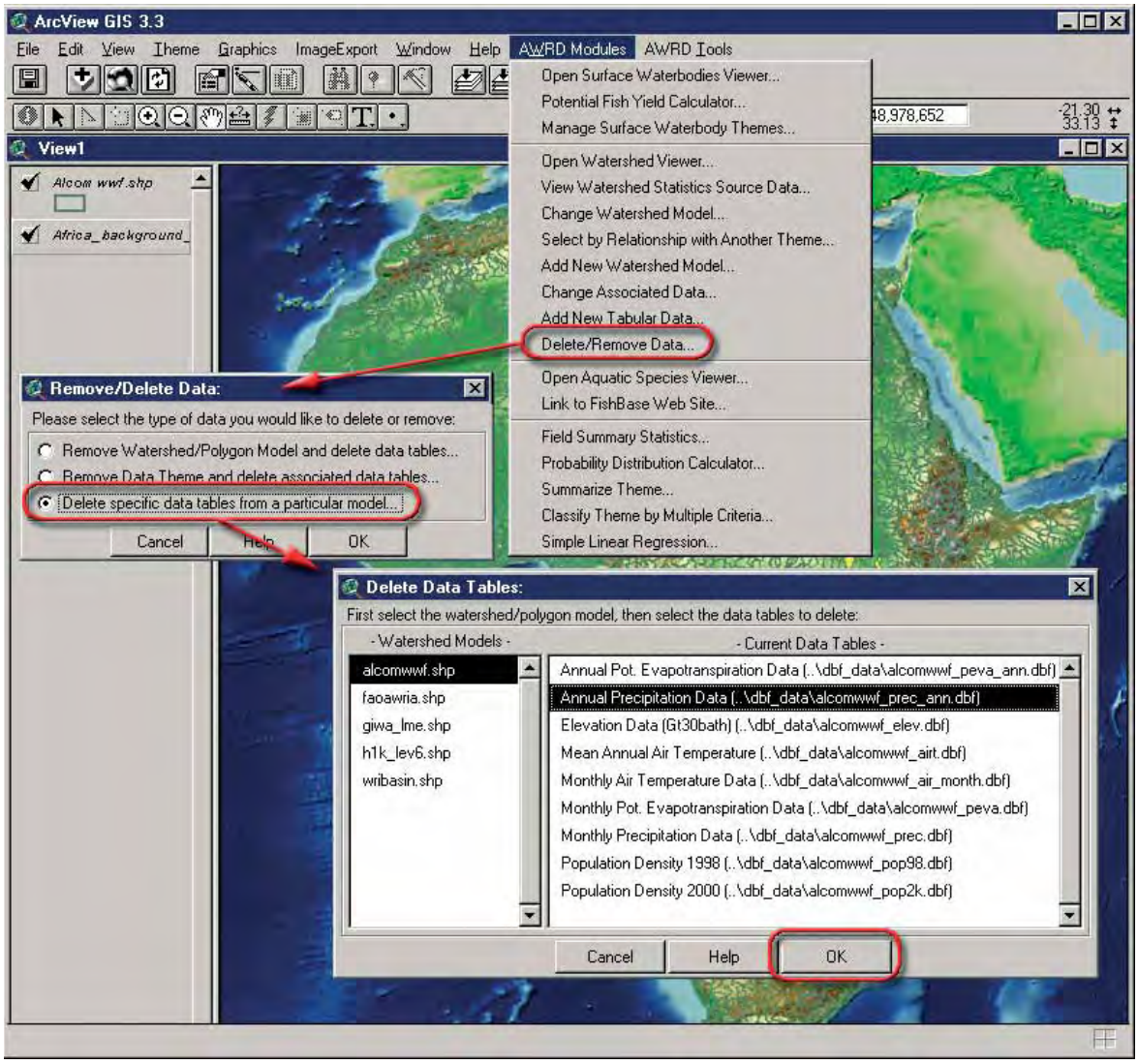
FIGURE 1.48
Selecting the grid theme to remove



1. Select a grid theme (e.g. Annual Potential Evpotranspiration Data) and click "OK" and the tool will then prompt for confirmation of the deletion. Click "OK" and the tool will unregister that grid theme and delete all data tables derived from it.

Delete specific data tables from a particular model: this option provides users with greater control over deleting specific data tables. Clicking this option opens the "Delete Data Tables" dialog (Figure 1.49).

FIGURE 1.49
Deleting specific data tables



1. The list on the left contains all the currently registered watershed models. Click on one of these and a list of all the current data tables for that particular model appears in the list on the right. Pick any or all of the themes selected for deletion (e.g. Annual precipitation) and click "OK". The tool will again prompt for confirmation before the associated data tables are deleted. Click "OK" and the data files will be deleted.

Watershed selection and analysis tools

The watersheds selection and analysis tools contains ten buttons for selecting and analysing watersheds (Figure 1.50 and Table 1.21).

FIGURE 1.50
Watershed selection and analysis tools

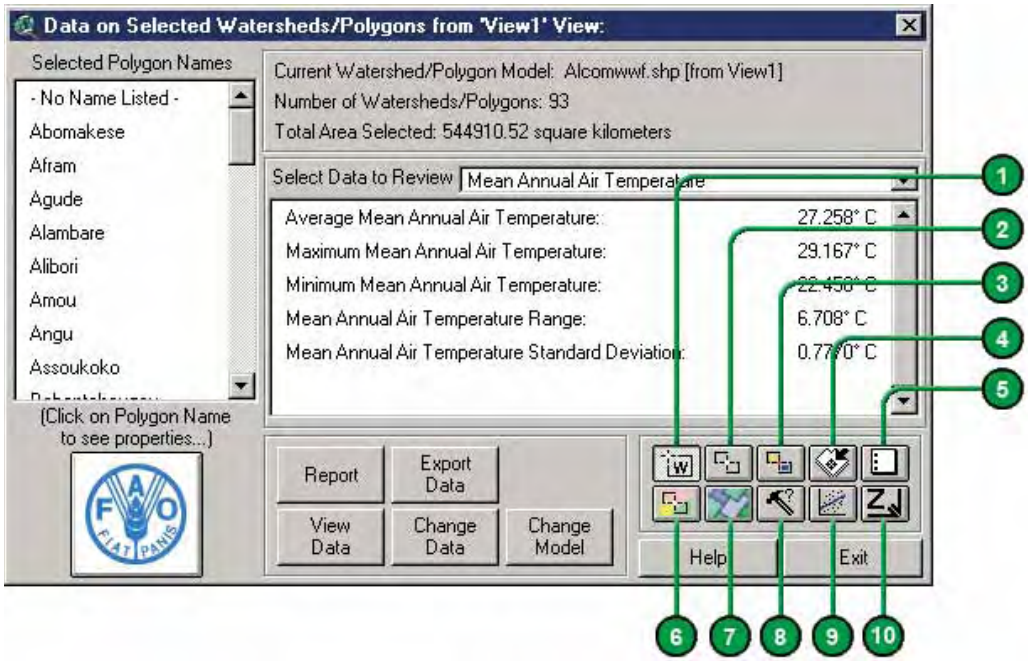


TABLE 1.21
Watershed selection and analysis tools buttons

Label (Fig.1.50)	AWRD button	AWRD menu option	Action executed
1		N/A	*Select Features*: clicking this tool allows the user to select watersheds directly from a view by clicking on them. The user can also hold the mouse button down to draw a rectangle and select several watersheds simultaneously, or can hold the Shift key down to unselect currently selected watersheds.
2		N/A	*Select Upstream and Downstream Watersheds*: clicking this tool opens the "Watershed Selection Tool" dialog, allowing users to select watersheds based on their hydrological relationship to a particular watershed selected by the user.
3		N/A	*Identify Upstream and Downstream Watersheds*: this tool opens the "Watershed Visualization Tools" dialog to produce a clear visual map of all the watersheds that are hydrologically related to any particular watershed, i.e. watersheds that are upstream, downstream, or within the same megabasin, plus to zoom to the extents of any of these component, to flash their borders of any region, and to move upstream or downstream from the base watershed, and to save the flow regime.
4		N/A	*Zoom to Selected Watersheds*: clicking this tool zooms into the full extent of all the selected watersheds within the user's current view.
5		N/A	*Clear Selection*: clicking this tool clears the selection set so that no watersheds are selected. The Watershed Statistics Viewer updates itself to show that no watersheds are selected.
6		AWRD Modules *"Select by Relationship with Another Theme..."*	*Select by Relationship with Another Theme*: clicking this tool opens the "Select by Relationship with Another Theme" dialog, allowing users to select watersheds based on their hydrological and/or spatial relationship to selected features in another theme.
7		AWRD Modules *"Classify Theme by Multiple Criteria..."*	*Classify Watershed/Polygon Model by Multiple Criteria*: the classification and ranking tools provide users with the means to classify features according to a wide variety of simple and complex functions. With these tools, users can rank features based on either single or multiple criteria, as well as identify features that do not meet any selection criteria at all. This function is described in detail in Section 1.6.

8		AWRD Tools ***"Query Builder..."***	***Model Query Builder:*** this tool gives the user the ability to apply complex queries to the data to either select features or to apply a theme definition. This function is described in detail in Section 1.7.
9		AWRD Modules ***"Simple Linear Regression..."***	***Watershed Model Regression***: this tool provides a method for analysing linear relationships between data in watersheds, letting the user identify whether a dependent variable varies in a predictable way over different levels of the independent variable. This function is described in detail in Section 1.6.
10		AWRD Tools ***"Find Location by Theme..."***	***Find Location by Theme***: this tool offers several methods for locating particular features. This function is described in detail in Section 1.7.

Many of the analytical functions within the AWRD are designed to work on only a subset of features out of the overall dataset. For example, if the users had a dataset of all countries and provinces in Africa, and they wished to analyse socioeconomic trends within the provinces of a single country, it would not make sense to include data on all the other countries of Africa when calculating their statistics.

As with any thematic mapping system, ArcView allows users to "select" the provinces of a single country and thereby restrict an analysis to only those provinces. While these provinces are selected, then any analyses conducted on the overall dataset will only reflect those few provinces. Calculations of such things as mean annual income, life expectancy, and birth rates will only reflect conditions in those few provinces and will not be skewed by conditions outside the country. Therefore, in order to refine a user's analysis, it is in general necessary to first select those watersheds that lie within the user's area of interest.

Watershed selection tool

The watershed selection tool provides users with a powerful method to select watersheds from a watershed model based on the spatial relationships of the hydrological network. Because of these hydrological relationships, this tool is able to identify all the component areas of a flow regime, i.e. those watersheds that are either upstream, downstream or within the same megabasin as any particular watershed. This tool also allows a user to modify the current set of selected watersheds by adding to it, subtracting from it, or selecting from it.

The Watershed Selection tool is opened by clicking the  icon on either the AWRD Interface or on the Watershed Module dialog. Because this tool operates directly on a "registered" watershed model, the tool will only be enabled if such a model is present in the view and if valid hydrological relationships are defined for it. The "Selection Criteria:" dialog opens when this icon is clicked, and the tool is used by simply clicking on any watershed within the active view.

This tool provides six selection criteria, including:

- *Include Selected Watershed*: Selects any watershed specified with a mouse click.
- Immediately Upstream Watersheds: Selects the watershed or watersheds lying immediately upstream from the "selected" watershed.
- *All Upstream Watersheds*: Selects the entire drainage basin of that watershed, which represents all watersheds lying upstream. This area is often considered a "River basin".
- *Immediately Downstream Watershed*: Selects the single watershed immediately downstream of the "selected" watershed.
- *All Downstream Watersheds*: Selects all watersheds lying downstream from the "selected" watershed.
- *Include Entire Basin*: Selects the broadest river basin, i.e. the megabasin that includes the 'selected' watershed.

In hydrological terms, only the "Include Entire Basin" is all encompassing and in

general, the other criteria can be used in conjunction with each other to create varied selection sets.

There are four selection options relating to how the user wishes to incorporate the new selection with any existing selection:

- *Make New Selection*: Clears out any previous selection and makes a new one based on the specified criteria.
- *Add to Current Selection*: Makes a selection based on the specified criteria and combines it with the previous selection.
- *Delete from Current Selection*: Makes a selection based on the specified criteria, and then subtracts this selection from the previous selection. The resulting selection represents the entire previous selection except those watersheds which met the current selection criteria.
- *Select from Selection*: Only selects those watersheds that were previously selected and which meet the current selection criteria.

For example, if a user was interested in identifying all those areas that drained into Lake Tanganyika:

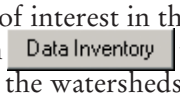
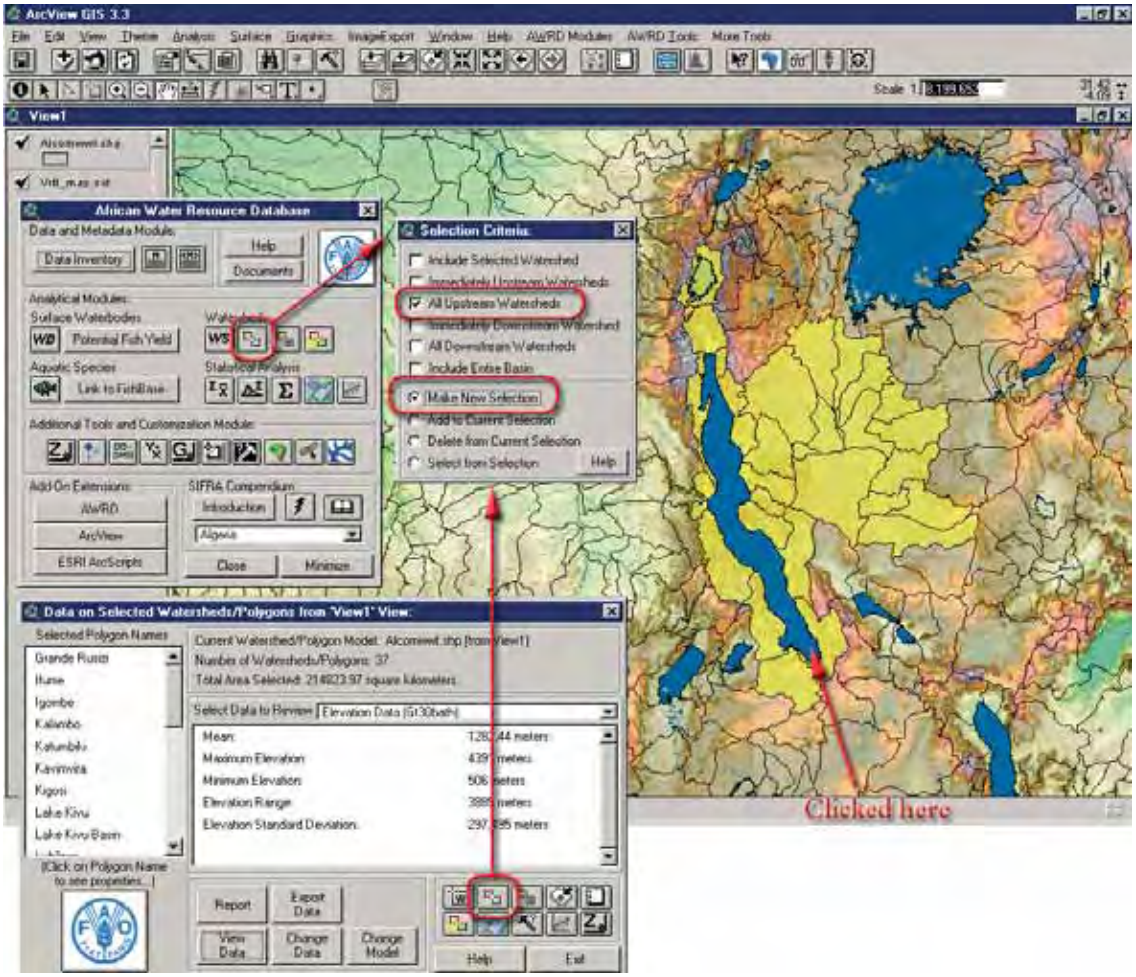
1. Click on the "Add Basemap Image to View" tool  to load one of the image backgrounds (e.g. "Vrtl_map.sid") from the image database component folder. This background image is not necessary for proper functioning of this tool, but it makes it easier to locate your area of interest in the view.
2. Click on the "Data Inventory" button  to load one of the watershed models (e.g. "Alcomwwf.shp") from the watersheds database component.
3. Click the  button, check the "All Upstream Watersheds" and "Make New Selection" selection criteria, and then click on Lake Tanganyika in the view (Figure 1.51).

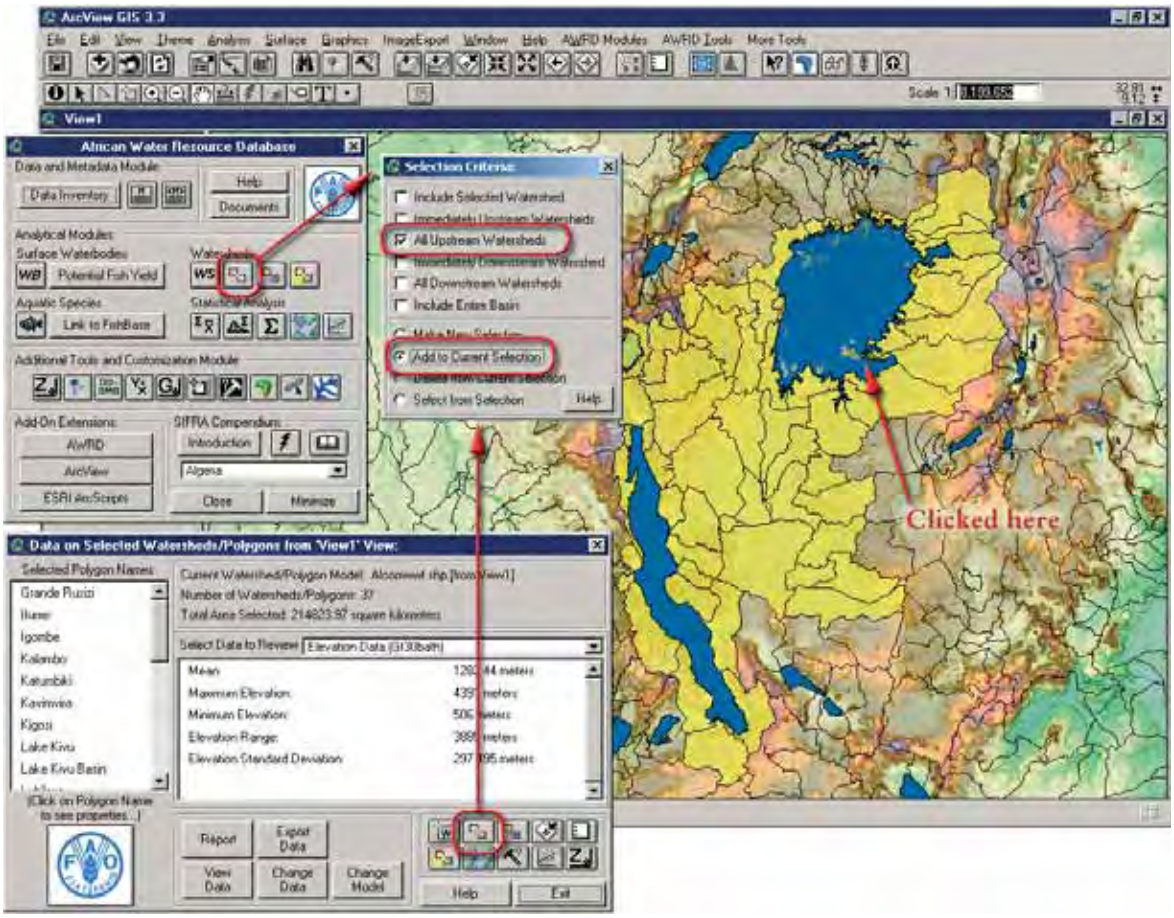
FIGURE 1.51
Upstream drainage basins for Lake Tanganyika



The selected watersheds now show up highlighted in yellow and illustrate the drainage basin for Lake Tanganyika. Any statistical calculations conducted on the watershed model will now be limited to the upstream watersheds around Lake Tanganyika.

If the user also wanted to include all the areas that drained into Lake Victoria, they could use this tool to add those watersheds to the current selection. In this case, they would leave the "All Upstream Watersheds" option selected, choose "Add to Current Selection", and then click on Lake Victoria (Figure 1.52).

FIGURE 1.52
Upstream drainage basins for Lake Tanganyika and drainage basins for Lake Victoria



Multiple selection options can also be considered, and if a user was interested in Lake Tanganyika, its drainage basin and all the watersheds it drained into, they would need to check: "All Upstream Watersheds"; "All Downstream Watersheds" and "Include Selected Watershed" as well, while also choosing the "Make New Selection" option (Figure 1.53).

FIGURE 1.53
Upstream and downstream drainage basins for Lake Tanganyika

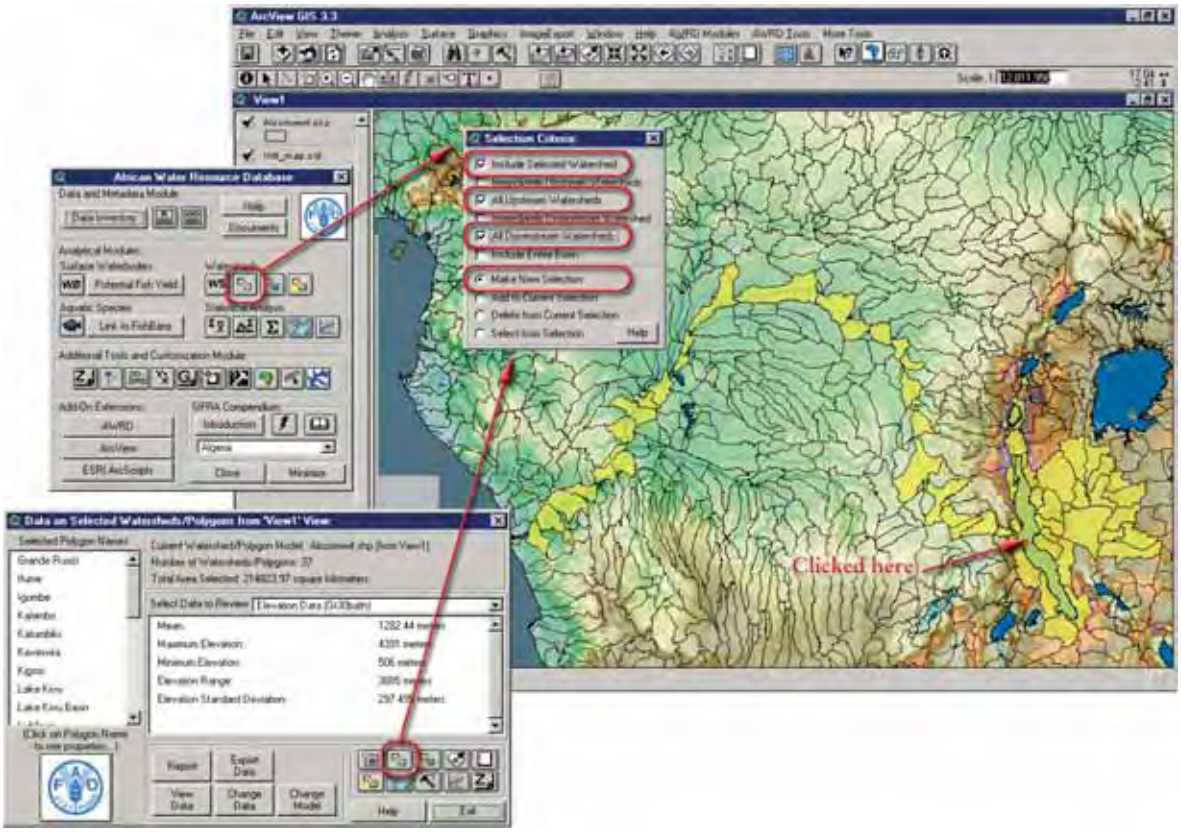
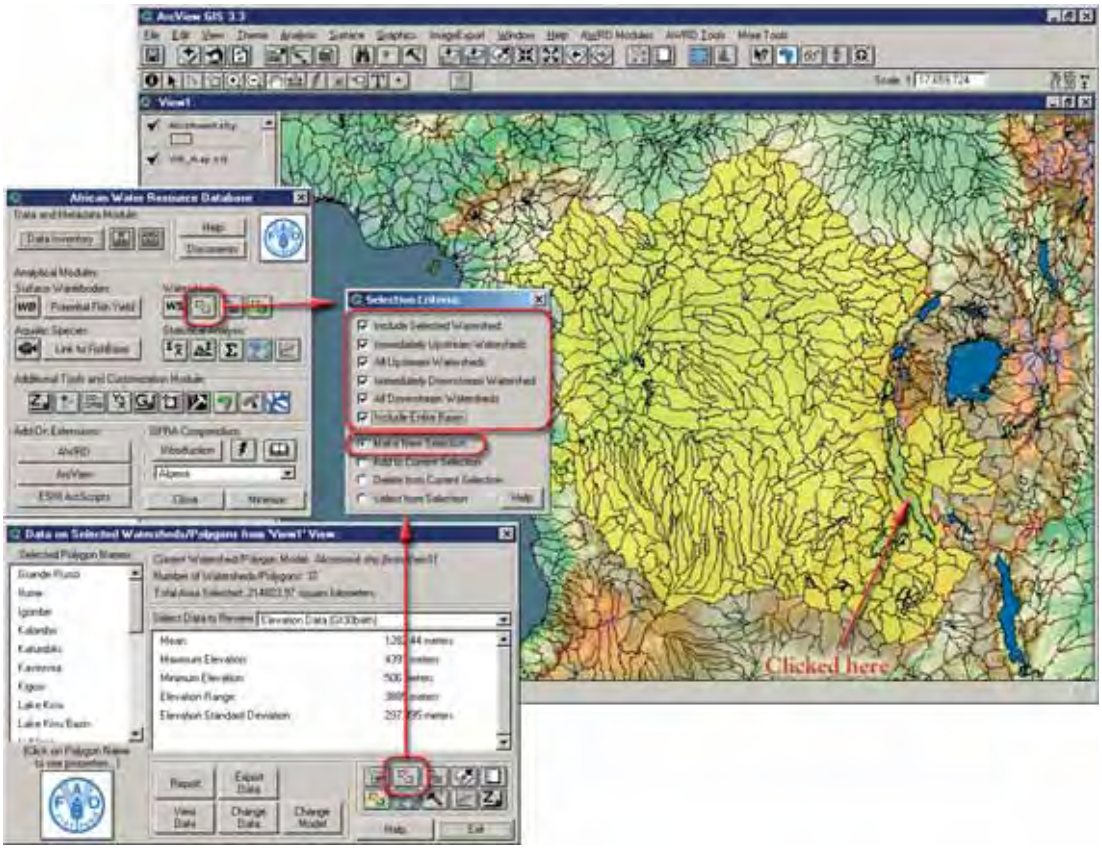


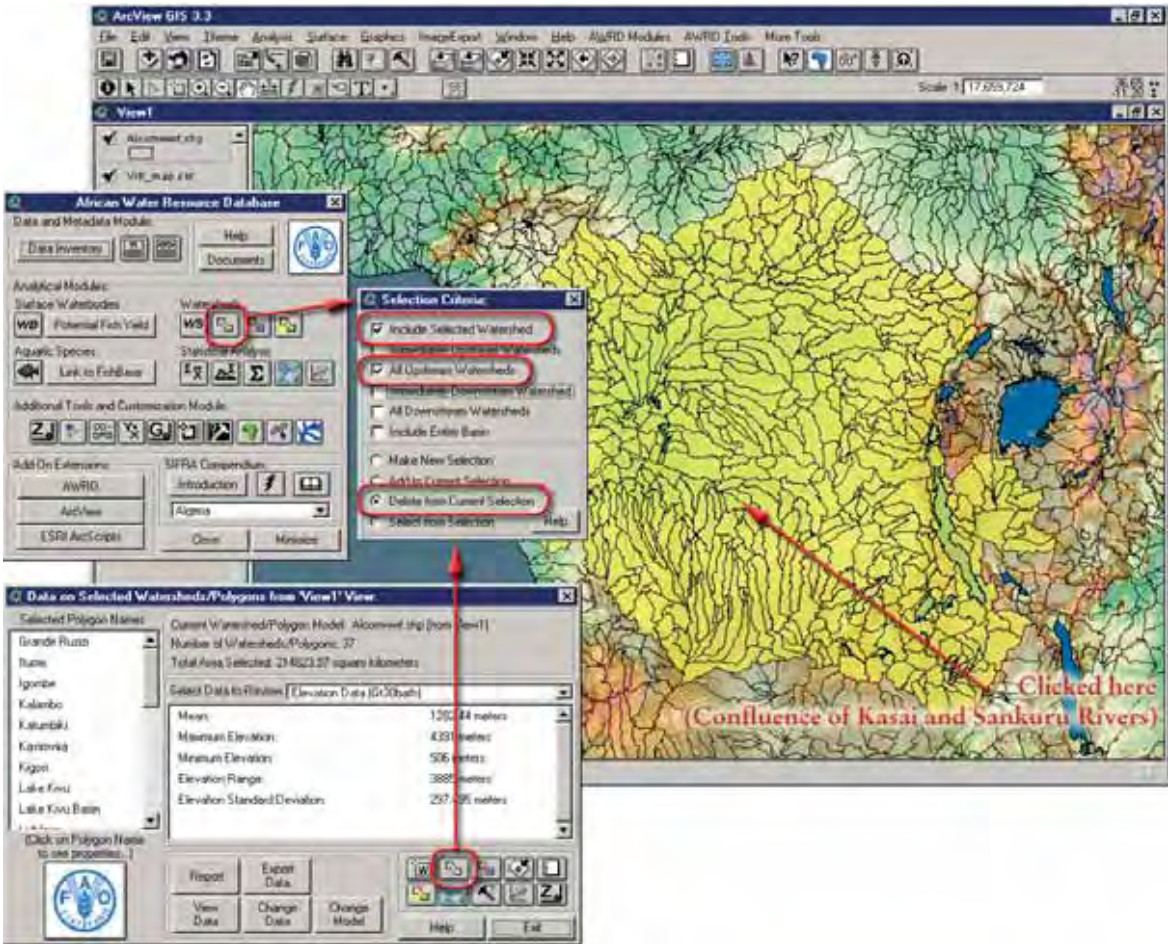
FIGURE 1.54
Entire Congo-Zaire megabasin



The "Include Entire Basin" option will select the entire megabasin irrespective of where the user clicks within that megabasin. For example, clicking on Lake Tanganyika will cause the entire Congo–Zaire megabasin to be selected (Figure 1.54).
Users may also unselect currently selected watersheds by clicking on the "Delete from Current Selection" option.

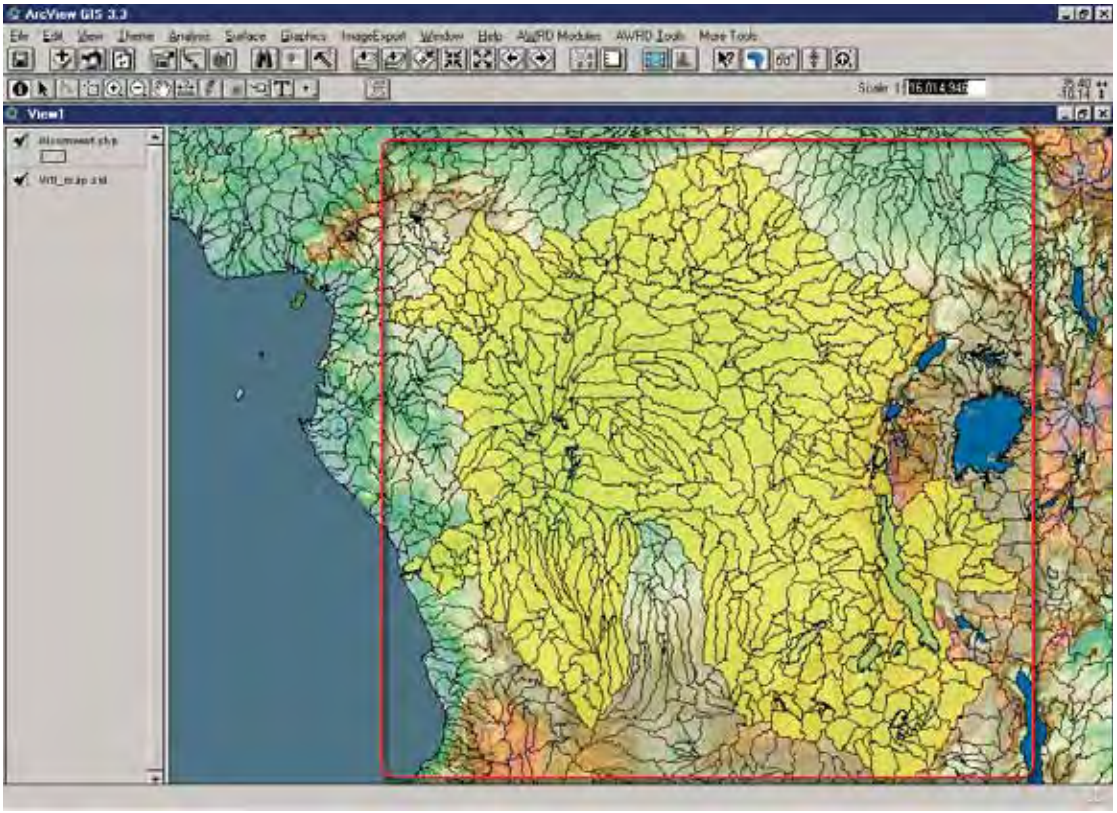
For example, if for some reason a user was interested in the entire Congo-Zaire megabasin, except that portion lying upstream of the confluence of the Kasai and Sankuru rivers, they would first select the Congo–Zaire megabasin as described above, and then select the "Delete from Current Selection" option and click on the Kasai/ Sankuru confluence (Figure 1.55a).

FIGURE 1.55A
Selection of the portion lying upstream of the confluence of the Kasai and Sankuru rivers, in the Congo-Zaire megabasin



Clicking on the confluence point would cause all the watersheds associated with the upstream flow regime above this confluence to be removed from the selection set, as depicted in Figure 1.55b.

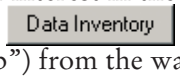
FIGURE 1.55B
Entire Congo-Zaire megabasin except the portion lying upstream of the confluence of the Kasai and Sankuru rivers



Watershed visualization tools

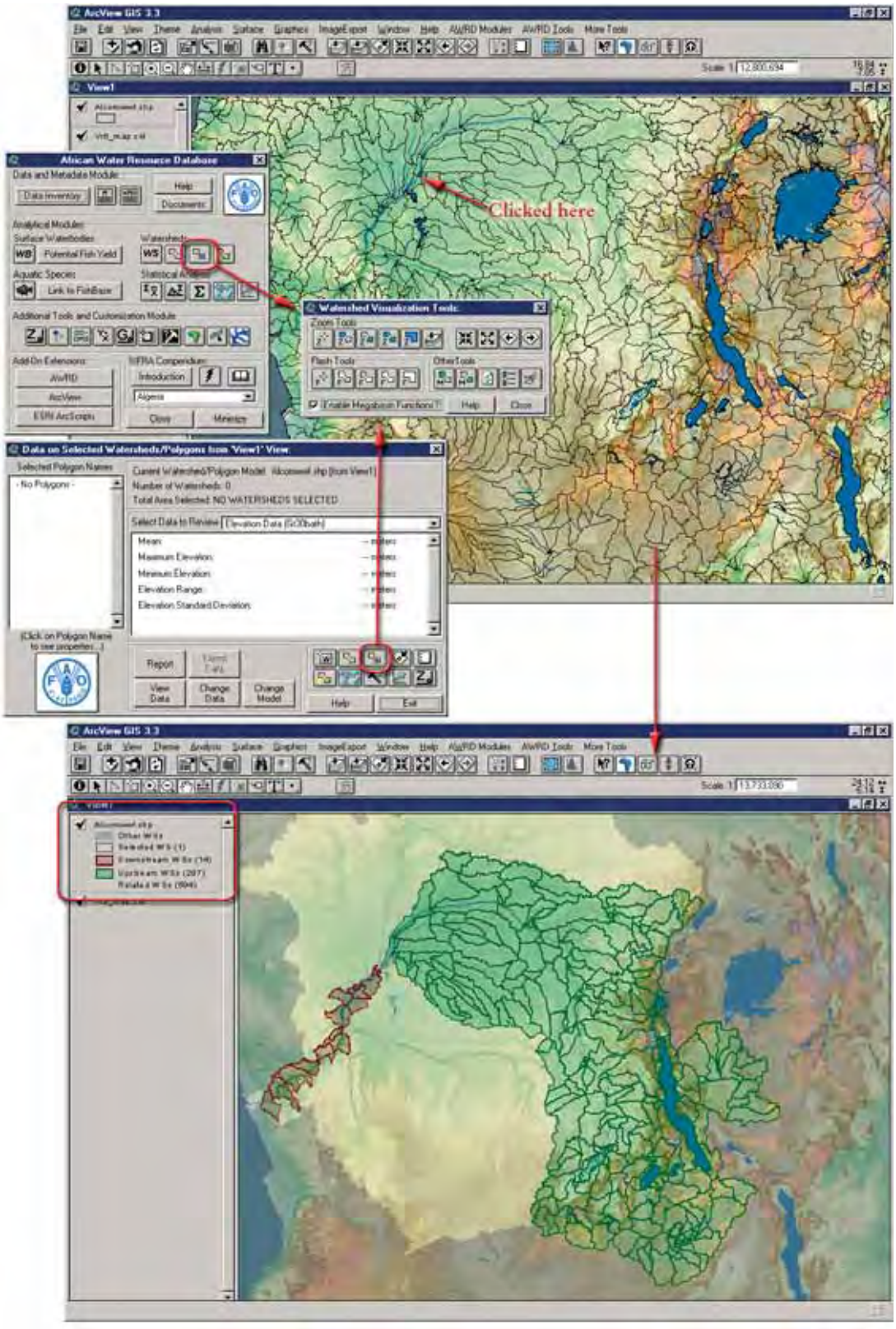
The "Identify Up/Down Tools" dialog is opened by clicking on the  button on either the AWRD Interface or the Watershed Module. Clicking on this button changes the cursor to a "+" symbol and allows users to identify all upstream, downstream and megabasin watersheds and colour them in such a way that they are easy to identify. The legend of the theme contains counts of how many watersheds are upstream, downstream, etc. The tool also gives the user a wide variety of zooming and moving functions to move around to different portions of the hydrological network, as well as flashing the boundaries of the upstream, downstream or megabasin watersheds. This tool works on the currently selected watershed model and therefore is only enabled if this watershed model is present in the active view.

These tools provide users with a variety of ways to visualize their watersheds and to explore the hydrological network.

1. Click on the "Add Basemap Image to View" tool  to load one of the image backgrounds (e.g. "Vrtl_map.sid") from the image database component folder. This background image is not necessary for proper functioning of this tool, but it makes it easier to locate your area of interest in the view.
2. Click on the "Data Inventory" button  to load one of the watershed models (e.g. "alcomwwf.shp") from the watersheds database component.
3. Click the  tool to open the "Identify Up/Down Tools" dialog, and then simply click on any watershed in the theme and the tool will identify all upstream, downstream and megabasin watersheds, and colour them according to their location relative to the selected watershed.

In Figure 1.56, all upstream watersheds are coloured transparent green, downstream watersheds are coloured transparent red, other megabasin watersheds are coloured a transparent yellow, and external watersheds outside the megabasin are coloured a transparent grey. The external watersheds and the other megabasin watersheds have had their borders removed so they are less distracting.

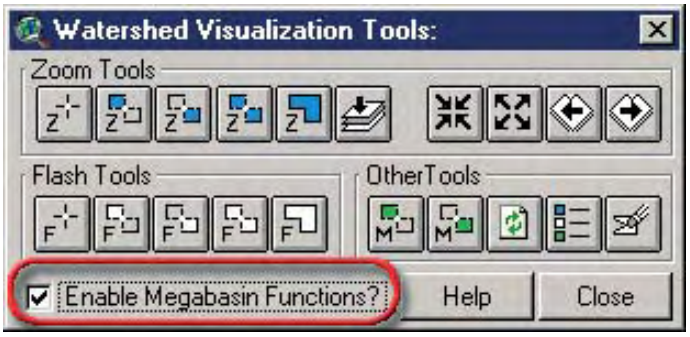
FIGURE 1.56
Identifying all upstream, downstream and megabasin watersheds by clicking on any watershed in the theme



Megabasin functions

This tool is also designed to take advantage of megabasin data stored in the Watershed Model, if any such megabasin data are available. Whenever a "Megabasin ID" field is specified with the model, this checkbox will automatically be checked and the tools will automatically be enabled (Figure 1.57).

FIGURE 1.57
The megabasin functions



This tool can also calculate the entire megabasin if the user has only specified a "Downstream ID" field, but it can potentially take a lot of processing time. Therefore, to save time, users can disable the megabasin calculations by unchecking this check box. In this case, all megabasin-related buttons on this tool will be disabled and the tool will not spend time identifying all watersheds in a megabasin.

If the user has not designated either a "Downstream ID" field or a "Megabasin ID" field for their model, then this tool will not be available to the user because the tool would have no way to identify megabasins or upstream/downstram components. There are three validated WS models currently in the AWRD archive. For each of these models, the "Downstream ID" and "Megabasin ID" fields have been "registered" such that the various tools and function of the AWRD are fully enabled if one is chosen by a user. However, it would be impossible to use this tool with the two WS delineations that are also archived in the AWRD, and therefore the button that opens this tool will be disabled if either of these watershed delineations are set as the current watershed model.

Watershed zooming tools

These tools let users quickly zoom to regions of a view based on a watershed's position in a hydrological network (Figure 1.58 and Table 1.22).

FIGURE 1.58
Watershed zooming tools

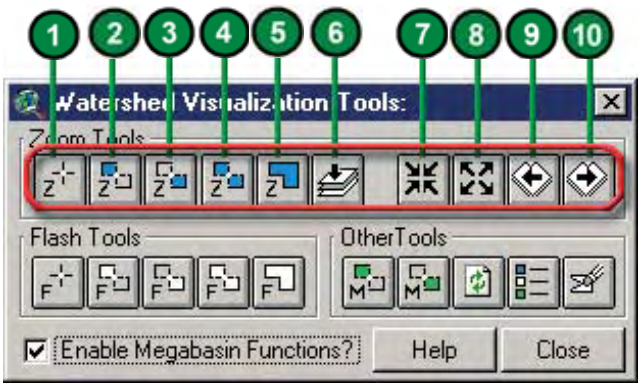
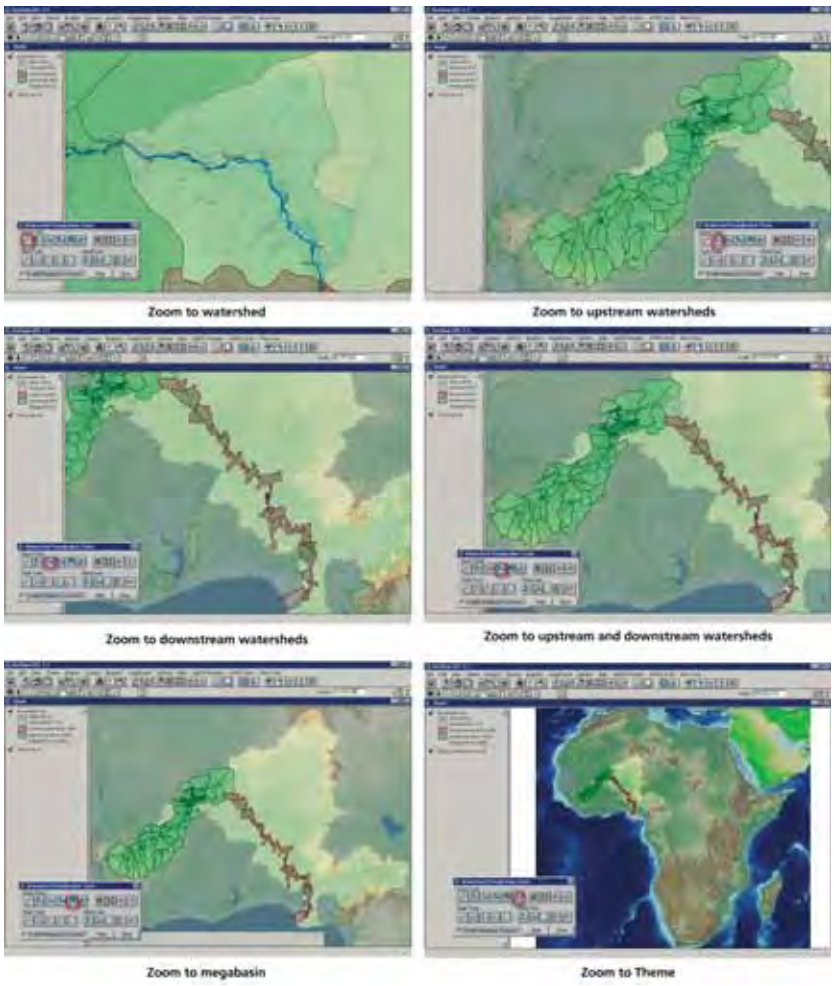


TABLE 1.22
Watershed zooming tools buttons

Label (Fig.1.58)	AWRD button	Action executed
1		*Zoom to Extent of Selected Polygon*: zooms to the extent of the "selected" watershed/polygon.
2		*Zoom to Extent of Upstream Polygons*: zooms to upstream watersheds. This button is disabled if there are no upstream watersheds.
3		*Zoom to Extent of Downstream Polygons*: zooms to downstream watersheds. This button is disabled if there are no downstream watersheds.
4		*Zoom to Extent of Upstream and Downstream Polygons*: zooms to the total extent of the upstream, downstream and selected watersheds.
5		*Zoom to Extent of Megabasin*: zooms to the entire megabasin. This button will only be enabled if the "Enable Megabasin Functions?" checkbox is checked.
6		*Zoom to Extent of Model Theme*: zooms to the full extent of the entire model.
7		*Zoom In*: zooms into the centre of the view by 150%.
8		*Zoom Out*: zooms out from the centre of the view by 150%.
9		*Zoom to Previous Extent*: returns the view display to the last zoom scale, similar to the "back" button on an internet browser.
10		*Zoom to Next Extent*: returns the view display to the next zoom scale if one exists, similar to the "forward" button on an internet browser

An example on the use of the watersheds visualization tools is illustrated by selecting the Niger megabasin in Figure 1.59.

FIGURE 1.59
Using the watershed zooming tools in the Niger megabasin



Watershed flashing tools

These tools are intended to draw users' attention to either a particular watershed or the components comprising the flow regime related to this watershed by generating and "flashing" temporary graphic images of the flow regime boundaries on the screen (Figure 1.60 and Table 1.23). Because these graphics are only temporary, they will remain on a view only until it is refreshed. This tool is especially useful for identifying components of the flow regime when the user has chosen to zoom in, zoom out, pan, or "walk" up or down stream. It is also useful for identifying hydrologically related watersheds which are not directly upstream or downstream of the focal watershed (i.e. those lying within the megabasin), when the default legend does not depict the watershed boundaries.

FIGURE 1.60
The watershed flashing tools

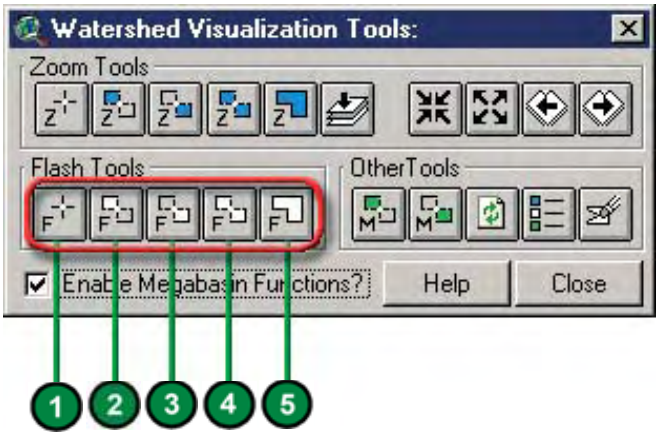


TABLE 1.23
Watershed flashing tools buttons

Label (Fig.1.60)	AWRD button	Action executed
1		*Flash Boundary of Selected Polygon*: flashes the boundary of the base watershed, leaving a temporary graphic boundary around it using a white colour.
2		*Flash Upstream Boundary*: flashes the boundaries of ***any*** upstream component watersheds of a flow regime related to the base watershed, leaving temporary green graphic boundaries around them.
3		*Flash Downstream Boundary*: flashes the boundaries of ***any*** downstream component watersheds of a flow regime, leaving temporary red graphic boundaries around them.
4		*Flash Upstream and Downstream Boundary*: flashes the boundaries of both upstream and downstream watersheds leaving temporary green and red graphic boundaries respectively.
5		*Flash Megabasin Boundary*: flashes the boundaries of the megabasin watersheds, leaving grey boundaries around them; enabled only if the "Enable Megabasin Functions?" checkbox is checked.

Other watershed visualization tools

The "Identify up/Down Tools" dialog includes two tools that enable users to effectively "walk" iteratively either upstream or downstream from any watershed within a watershed model, and another tool to customize and save the default legends associated with the visualization tools (Figure 1.61 and Table 1.24).

FIGURE 1.61
Other watershed visualization tools

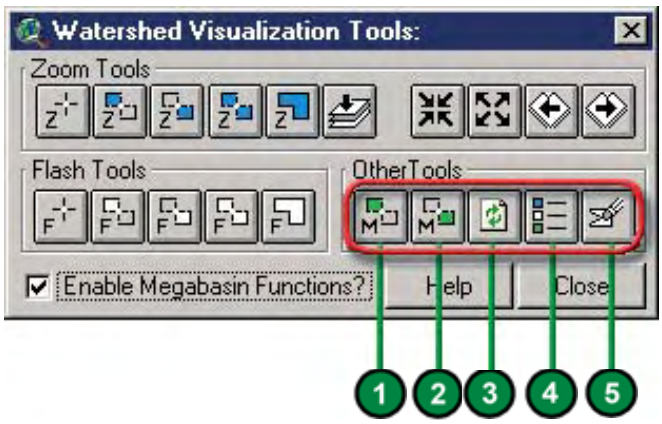


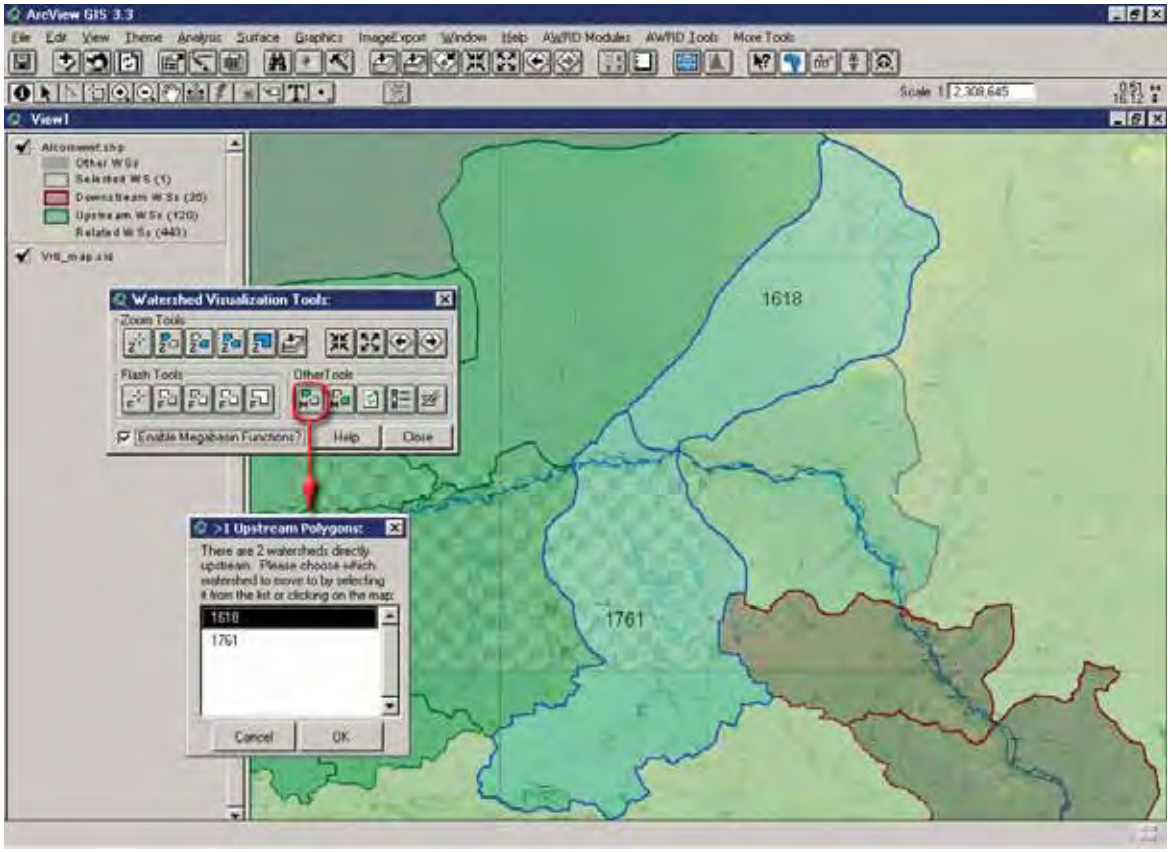
TABLE 1.24
Other watershed visualization tools buttons

Label (Fig.1.61)	AWRD button	Action executed
1		*Move Upstream*: this tool identifies the watershed(s) immediately upstream from the focal watershed and regenerates the display. Because multiple watersheds may exist upstream, the user is prompted to select which upstream branch to go to; tool enabled only if there is a watershed upstream.
2		*Move Downstream*: This tool identifies the watershed immediately downstream from the focal watershed and regenerates the display; tool is enabled only if there is a downstream watershed.
3		*Refresh Screen*: this redraws the screen. Any temporary graphics produced by the "Flash" tools or other watershed visualization tools are removed from the display of the View.
4		*Change Legend Shading Preference*: this button allows users to change the default semi-transparent legend used by the "Identify Up/Down Tools" to alternative AWRD or custom legends designed by the user.
5		*Export or Create Outline of Up/Down Flow regime*: this tool provides users with a means to save and possibly aggregate the results of any specific watershed visualization.

Example of visualization tool in the Niger megabasin (Figure 1.62).

1. Click on the "Add Basemap Image to View" tool to load one of the image backgrounds (e.g. "Vrtl_map.sid") from the image database component folder. This background image is not necessary for proper functioning of this tool, but it makes it easier to locate your area of interest in the view.
2. Click on the "Data Inventory" button Data Inventory to load one of the watershed models (e.g. "alcomwwf.shp") from the watersheds database component.
3. Click on the button to open the watersheds visualization tool.
4. Mouse click on any desired location on the map.
5. If necessary, select the ArcView zoom icon to zoom to in to the area.
6. Select the "Move upstream" icon (Figure 1.62).

FIGURE 1.62
Visualization of the watersheds directly upstream with the "Move Upstream" tool

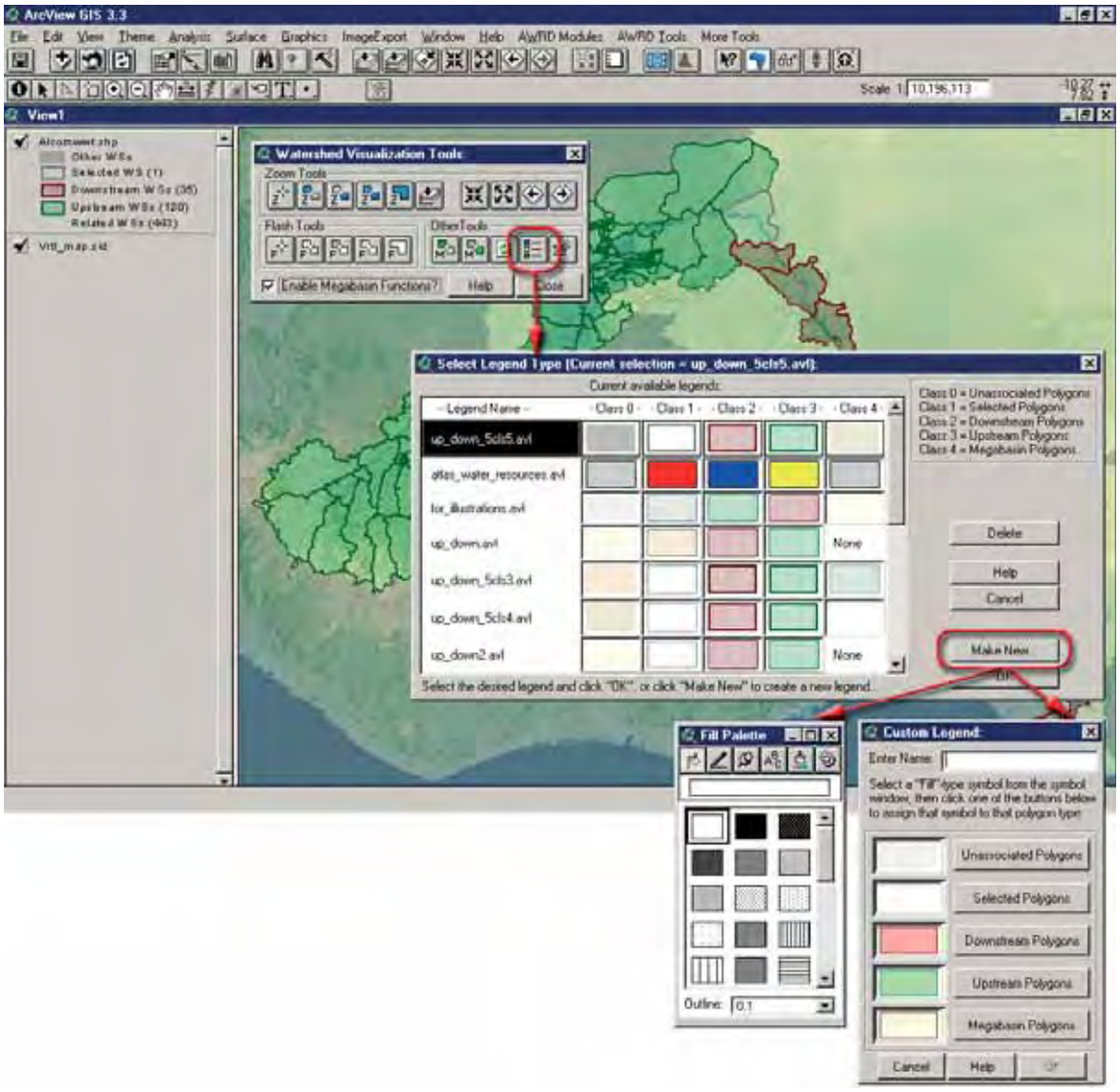


Legend type tool

Users can select a new default legend type by clicking on one of the legend names from the "Select Legend Type" tool dialog and then clicking the "OK" button, after which it will always be used when the "Identify Up/Down Tools" dialog is used. Users can also choose to either delete any of these custom legends from this dialog, and/or create new ones meeting their own criteria by clicking the "Make New…" button available in the "Select Legend Type" tool dialog (Figure 1.63).

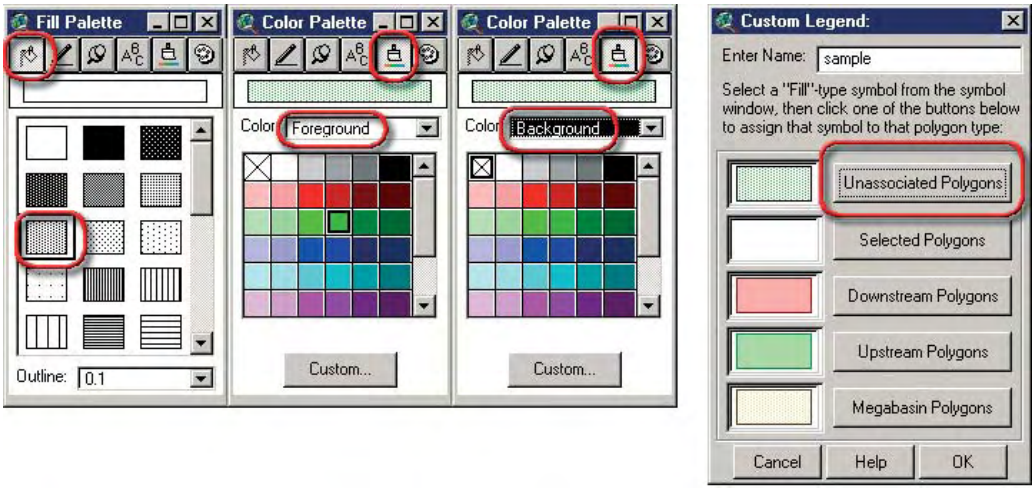
1. Click on the "Make New…" button to open the *Custom Legend* tool.
2. Enter a name for the new legend. The name can be composed of letters and/or numbers, and can be of any length, but users are recommended to keep the length below approximately 25 characters so that the full name can appear in the "Select Legend" dialog.
3. Select the various fill options to apply to the clicked-on watershed, upstream watersheds, downstream watersheds, megabasin watersheds and unassociated watersheds. The standard ArcView Symbol dialog opens at the same time, and can be used to select the specific fill and symbol types desired.

FIGURE 1.63
The custom legend tool



The easiest way to do this is to first generate the fill pattern using the Fill Palette, then click one of the buttons in the "Custom Legend" to apply that fill pattern to the respective watershed class. For example, if the user wanted to apply a semi-transparent green colour to the Unassociated watersheds, then they would do the following (Figure 1.64).

FIGURE 1.64
Applying a semi-transparent green colour to the unassociated watershed



1. On the Symbol dialog, first click the Fill button to show the list of available Fill patterns.
2. Select one of the fills with dots, stripes or a pattern in it (any fill other than the white box at the top left or the black box at the top centre. The white box will show only the polygon boundary and the black box will produce a non-transparent fill pattern).
3. Click the Colour button on the Symbol dialog to show the list of available colours.
4. Choose "Foreground" from the Colour dropdown box, then click one of the Green colours to set the foreground colour.
5. Choose "Background" from the Colour dropdown box, then click the "X" box in the top left corner. This sets the Background colour to be transparent.
6. Now that you have created the fill pattern, go back to the Custom Legend dialog and click the "Unassociated Polygons" button to apply that pattern to the unassociated polygons.

When finished, click "OK" and the new legend will become the default legend for the "Identify Up/Down Tools:" dialog.

Saving graphics and themes of a flow regime

Due to the dynamic visual nature of the functions available through this tool-set, the user is not left with any "current" selection set as they would with the Watershed Selection tools, from which they could save the results of their visualization exercise as a new shapefile theme. For a similar reason, the graphic shape outlines defining the various selected, upstream, downstream, associated, and unassociated watershed components of a particular flow regime are not added to the users reference view. Rather, instead of leaving users with potentially distracting selection or graphic sets, the watershed visualization tools depend on a temporary tabular join of a scratch database containing a field named "UpDown". Unfortunately, because both this database and its join are only temporary, subsequent execution calls to this tool-set will re-initialize or write over the information in this field for the purposes of legend classification.

The "Save Flow Regime" button provides users with a means to save the results of any specific visualization. This button will become enabled as soon as a user uses the "Identify Up/Down Tools" dialog to identify the various components in the flow regime. The tool can be used to save individual components of the flow regime

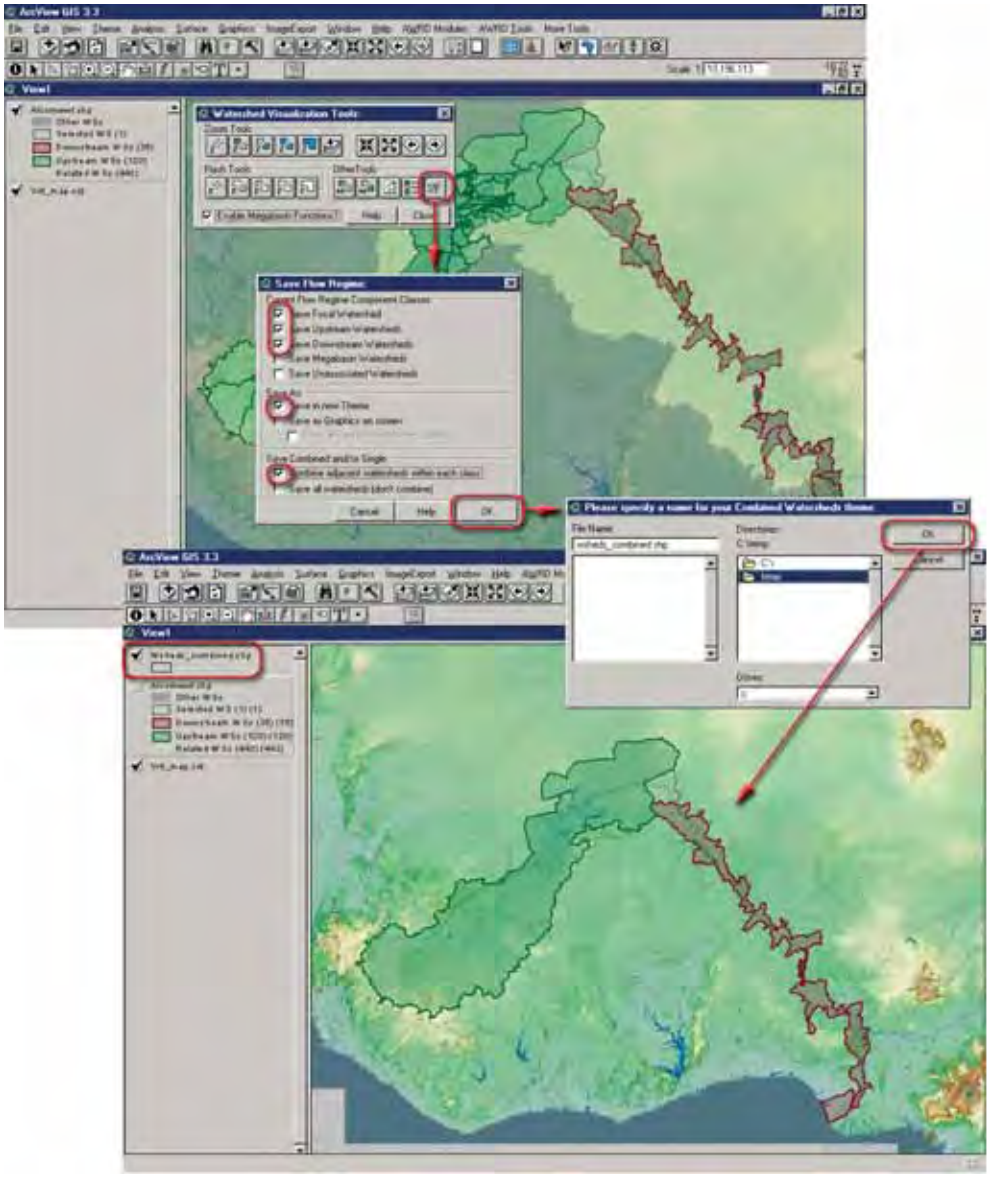
separately, to combine watersheds within each component, and to save the data as either graphics on the screen or as new themes.

Use this dialog to define which components to save, whether to save them as graphics or as a new theme, and whether to combine watersheds that are contained within the same flow regime component.

For example, if the user has already clicked on a focal watershed and identified the various flow regime components related to that watershed, and next wants to save that watershed along with the upstream and downstream components in a new theme, and also wishes to combine watersheds so that there will be a single polygon representing the "upstream" region and a single polygon representing the "Downstream" region, they would use the tool as follows (Figure 1.65).

1. Click the button  to open the "Save Flow Regime" options dialog (Figure 1.65).
2. Select the following options: Save focal watershed; save upstream watershed; Save downstream watershed; Save in new theme; Combine adjacent watersheds within each class.
3. Click "OK.
4. Specify a name for the combined watershed theme, then click OK.

FIGURE 1.65
Saving graphics and themes of a flow regime



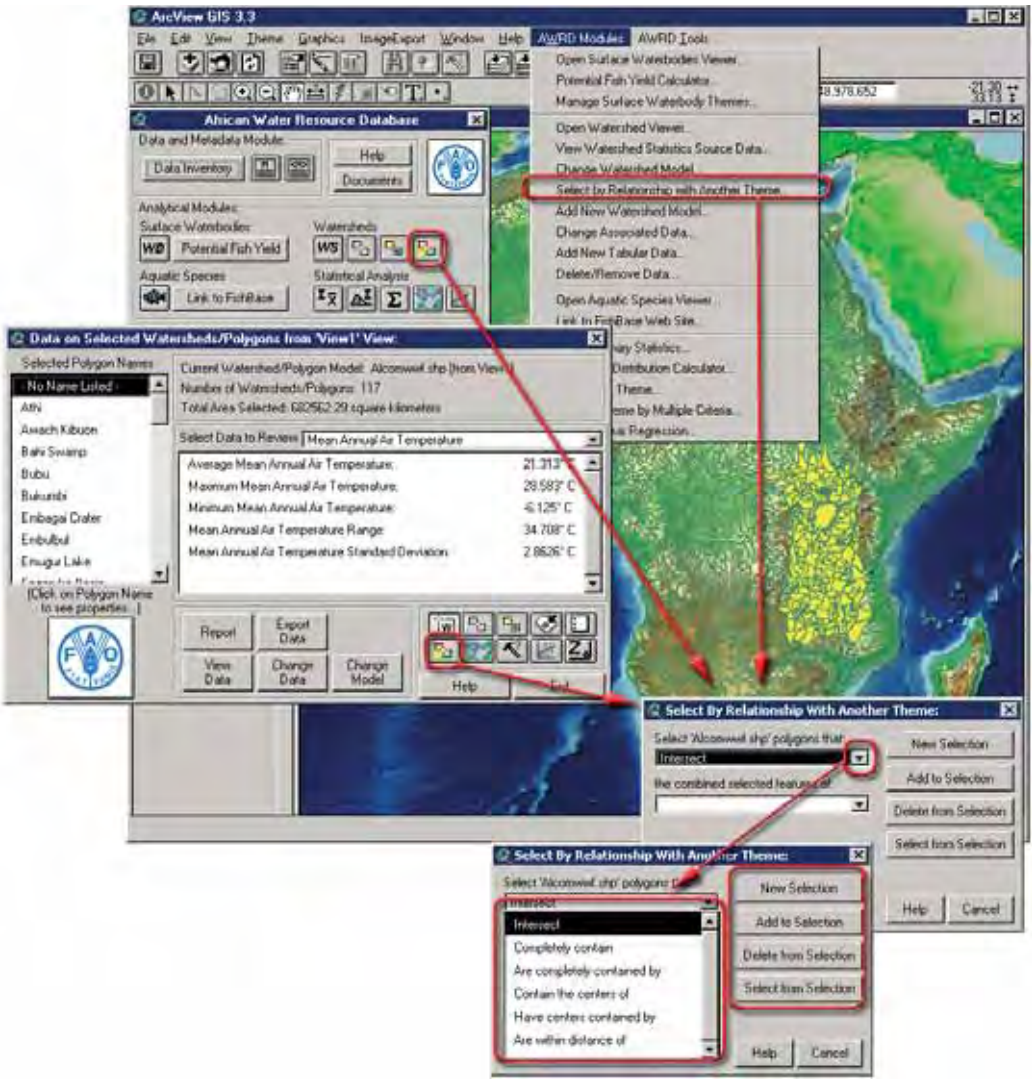
The new theme is saved with the same legend as the current watershed theme. In this example, the new watershed theme only has three polygons; one for the upstream region, another for the downstream region, and a third polygon for the focal watershed. The user could have chosen to save all watersheds rather than combining them, or they could have simply saved a graphic representation of the flow regime components on the screen.

Select by Relationship with Another Theme Tool

Within the AWRD, users are provided with a variety of methods for the selection of watersheds, including selections based on the current selection set for other feature themes. The Select by Another Theme tool allows users to select watersheds based on where they lie in relation to selected features from another theme.

The Select by Relationship with Another Theme tool is opened by clicking on the  button on AWRD Interface or the Watershed Module dialog, or by selecting the option "Select by Relationship with Another Theme…" in the AWRD Modules menu. The dialog automatically assumes the user is going to select watersheds from the current watershed model, based on some type of spatial relationship the watersheds may have with the selected features in another theme. To use this tool, first select those features from that other theme before opening this dialog. To illustrate these functions, the country of the Republic of Botswana has been selected from the theme named "countries.shp". The following examples will identify watersheds that are upstream and downstream from the Republic of Botswana. The first drop down list contains a variety of possible spatial relationships (Figure 1.66).

FIGURE 1.66
Various spatial relationships available with the Select by Relationship with Another Theme Tool



- *Intersect*: Selects all watersheds that touch the Republic of Botswana.
- *Completely contain*: Selects all watersheds that completely contain the country of Botswana. In this example, this option would not select any watersheds because no single watershed is large enough to contain all of the Republic of Botswana.
- *Are completely contained by*: Selects all watersheds that are completely contained within the borders of the Republic of Botswana.
- *Contain the centres of*: Selects the single watershed that contains the centre point of Republic of Botswana.
- *Have centres contained by*: Selects all watersheds whose centres are located within the borders of the Republic of Botswana.
- *Are within distance of*: Selects all watersheds that are within a minimum distance of the Republic of Botswana.

There are four selection options relating to whether the user wishes to make a new selection or not (Table 1.25).

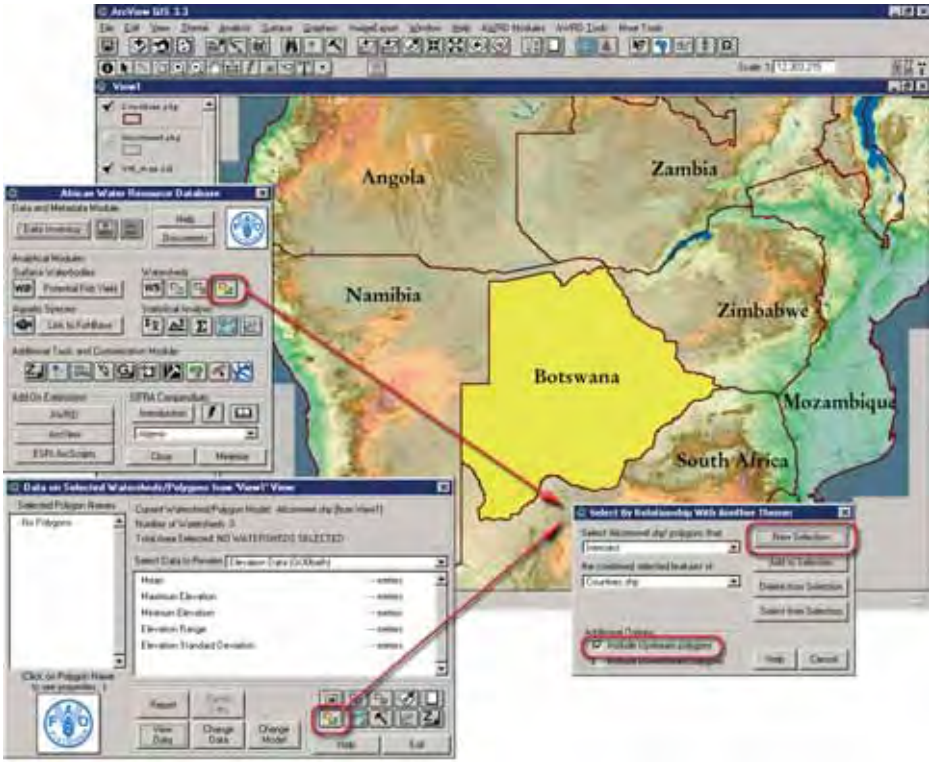
TABLE 1.25
Select by relationship with another theme tool buttons

Label (Fig1.66)	AWRD button	Action executed
1	New Selection	Clears out any previous selection of watersheds and makes a new one based on the specified spatial relationship.
2	Add to Selection	Selects watersheds based on the specified spatial relationship and combines the selection with the previous selection of watersheds.
3	Delete from Selection	Makes a selection based on the specified spatial relationship, and then subtracts this selection from the previous selection. The resulting selection represents the entire previous selection except those watersheds which met the current selection criteria.
4	Select from Selection	Only selects those watersheds that were previously selected and which meet the current selection criteria.

The second drop-down list contains all the vector themes in the user's view (i.e. all themes made up of points, lines or polygons). For example, if a user wanted to identify only those watersheds which drained into the Republic of Botswana, the user would first select Botswana from the "countries.shp" theme.

1. Click on the "Add Basemap Image to View" tool  to load one of the image backgrounds (e.g. "Vrtl_map.sid") from the image database component folder. This background image is not necessary for proper functioning of this tool, but it makes it easier to locate your area of interest in the view.
2. Click on the "Data Inventory" button  to load one of the watershed models (e.g. "alcomwwf.shp") from the watersheds database component.
3. Click on the "Data Inventory" button  to load one of the administrative boundary themes (e.g. "RWDB2 National-Ad1 Polygonal Boundaries", or "RWDB_Ad1-Py.shp") from the watersheds database component.
4. Click on the ArcView "Select feature" icon  from the ArcView menu bar and then mouse click anywhere in Bostwana (this selection will highlight this country in yellow).
5. Open the Select Watersheds by Relationship with Another Theme tool dialog by clicking on the  button, check the option "Include Upstream Polygons", and then click the "New Selection" button.
6. Select the ArcView zoom icon  to zoom to view the result (Figure 1.67a)

FIGURE 1.67A
Selection of the Republic of Botswana and selection of the correct parameters to identify its entire drainage basin



Based on these actions, the user has now identified the entire drainage area for the Republic of Botswana (Figure 1.67b).

FIGURE 1.67B
Entire drainage area for the Republic of Botswana

In a similar manner they could have identified those areas which drain out of the Republic of Botswana, and where they go, by checking the "Include Downstream Polygons" option (Figure 1.67c).

FIGURE 1.67C
Areas which drain out of the Republic of Botswana

Given that the analysis process is a function of the "current" selection state of the watershed theme, a user can conduct iterative queries based on containment or other spatial relationships with numerous themes in a view.

Watershed Statistics Viewer

This tool offers users a wide variety of statistics describing the current set of selected watersheds. The Watershed Statistics Viewer will generate statistics for all the currently selected datasets. These datasets may include such things as: population densities, mean annual air temperatures, precipitation, and potential evapotranspiration. In Figure 1.68, the "Selection Criteria" tool was used to select all the watersheds that drain into Lake Tanganyika. To do this:

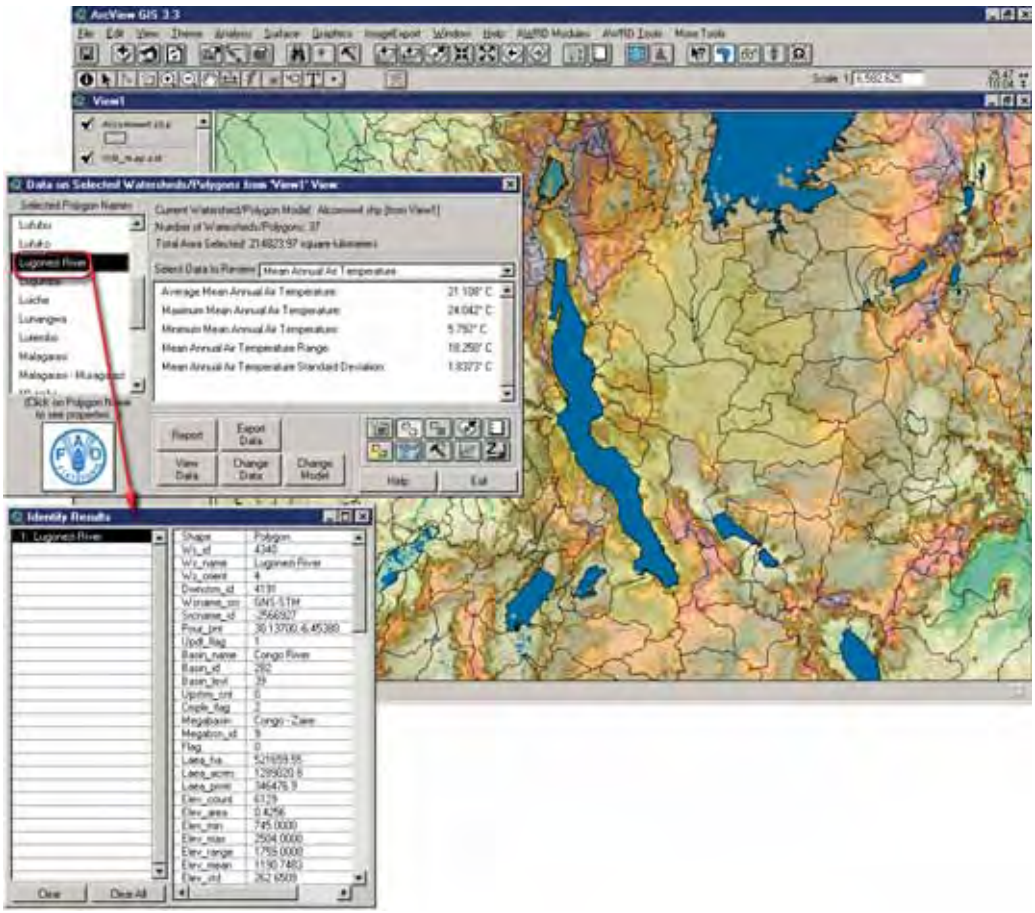
1. Click on the "Add Basemap Image to View" tool  to load one of the image backgrounds (e.g. "Vrtl_map.sid") from the image database component folder. This background image is not necessary for proper functioning of this tool, but it makes it easier to locate your area of interest in the view.
2. Open the Watershed viewer by clicking on the 

icon. This will also make sure that the default watershed model is added to the view.

3. Select the ArcView zoom button  to zoom to the Lake Tanganyika region.
4. Click on the "Select Upstream and Downstream Watersheds" icon  and Select "All Upstream Watersheds" from the selection criteria.
5. Mouse click anywhere in lake Tanganyika.

The Watershed Statistics Viewer then generates a set of statistics for the entire selected area for all the datasets that are currently associated with this watershed model. In this example, the Watershed Viewer is showing the cumulative elevation statistics for the 37 watersheds in the Lake Tanganyika drainage basin (Figure 1.68).

FIGURE 1.68
Attribute data of watersheds



The Watersheds Module presents a variety of data as well as a number of tools to examine, analyse and visualize the data. At the top centre of the "Watersheds Viewer" is basic information about the current selection, including the current watershed model, the current view, the number of watersheds selected, and the total land area selected. The Watersheds Module may also be resized by stretching on one of the corners so that all the data may be viewed at once.

Statistics on any Watershed: on the left side of the Watersheds Viewer is a list of all the currently selected watersheds. The attribute data associated with any of these watersheds can be reviewed by simply clicking on the name of the watershed of interest as shown in Figure 1.68.

If the user selects the 'Mean Annual Air Temperature Data' rather than 'Elevation Data (Gt30bath)' as shown above, then the results would show the monthly and annual

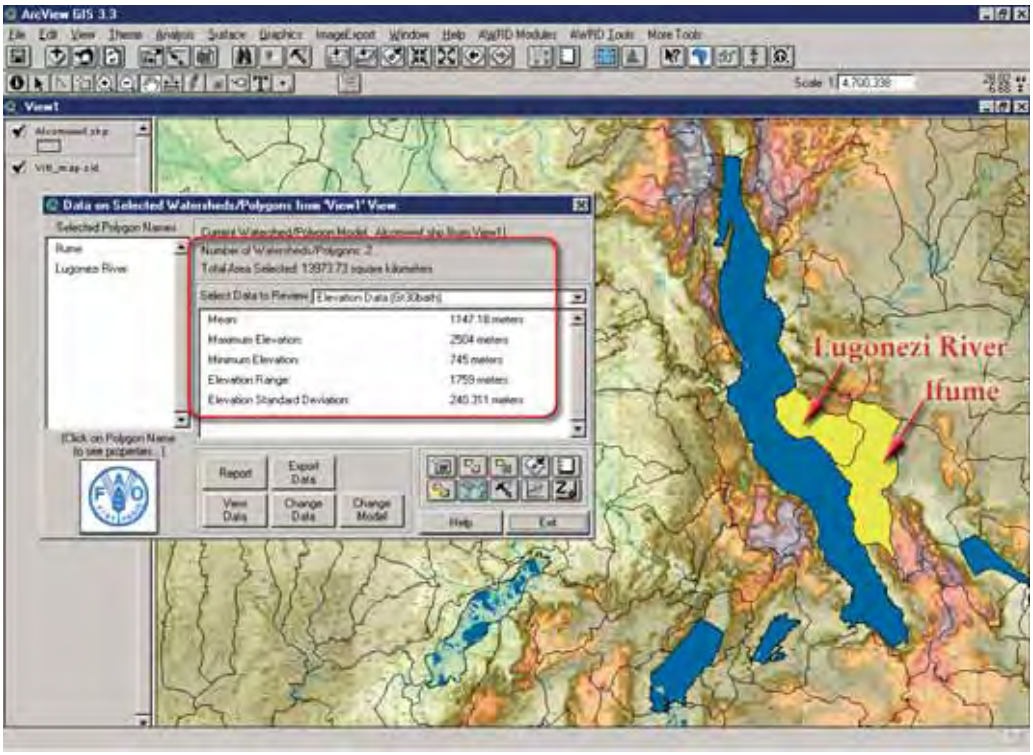
mean air temperatures for the Lake Tanganyika drainage basin.

Also, if the user has access to the ESRI ArcView Spatial Analyst extension, then the AWRD will also provide the ability to generate statistical datasets from the users' own data. Users can also customize this module to generate summary statistics based on any other additional non-categorical raster datasets by "registering" that raster dataset with the Watershed Model Maintenance Tools. Summary statistics can be generated for any "registered" polygonal data layer, and users are not limited to examining WS models alone with this module.

Statistics on the combined set of individual watersheds: can also be derived. In the following example two watersheds were selected at random to illustrate the use of this tool:

1. Click on the "Add Basemap Image to View" tool to load one of the image backgrounds (e.g. "Vrtl_map.sid") from the image database component folder. This background image is not necessary for proper functioning of this tool, but it makes it easier to locate your area of interest in the view.
2. Open the Watershed viewer by clicking on the WS icon. This will also make sure that the default watershed model is added to the view.
3. Select the ArcView zoom button to zoom to the Lake Tanganyika region.
4. Click on the "Select watershed feature" icon, hold down the "Shift" key and then mouse click on the Ifume and Lugonezi River watersheds (this selection will highlight these watersheds in yellow, and the "Shift" key allows you to select multiple watersheds.). The statistics generated for these two watersheds are illustrated in Figure 1.69.

FIGURE 1.69
Statistics on the combined set of selected watersheds



The Mean Elevation value of the combined set of watersheds, shown in the Watershed Statistic Viewer above, is derived from the data of Mean Elevation and Watershed Size of these two selected watersheds. Basically, the Watershed Module weights each watershed based the size of that watershed when computing the various statistics, so that, for example, if two watersheds were selected and if one watershed was twice the size of the other, then the larger watershed would be weighted twice as heavily as the smaller one. In this example, if Watershed A had a mean elevation of 100 m and was 100 square kilometres in size, and if Watershed B had a mean elevation of 200 m and was 50 square kilometres in size, then the mean elevation for the combined areas of Watersheds A and B would be calculated as follows:

$$\text{Mean Elevation} = \frac{(\text{A\_Elev} * \text{A\_size}) + (\text{B\_Elev} * \text{B\_size})}{(\text{A\_size} + \text{B\_size})} = \frac{(100 * 100) + (200 * 50)}{(100 + 50)} = 13$$

where:

A_elev = Watershed A Mean Elevation

A_size = Watershed A Size

B_elev = Watershed B Mean Elevation

B_size = Watershed B Size