

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

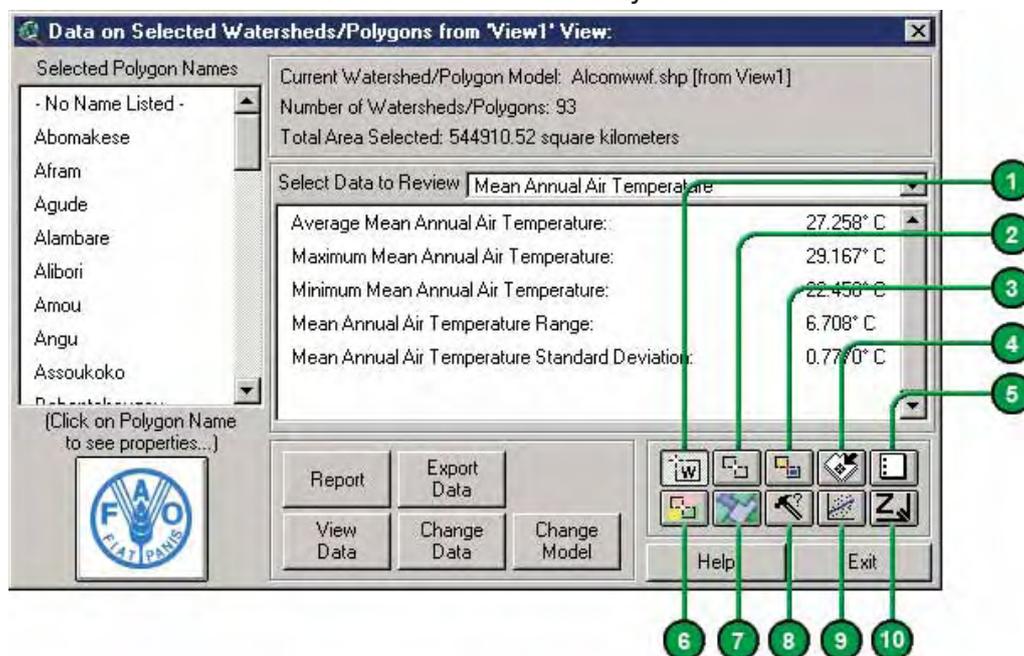


TABLE 1.21
Watershed selection and analysis tools buttons

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:

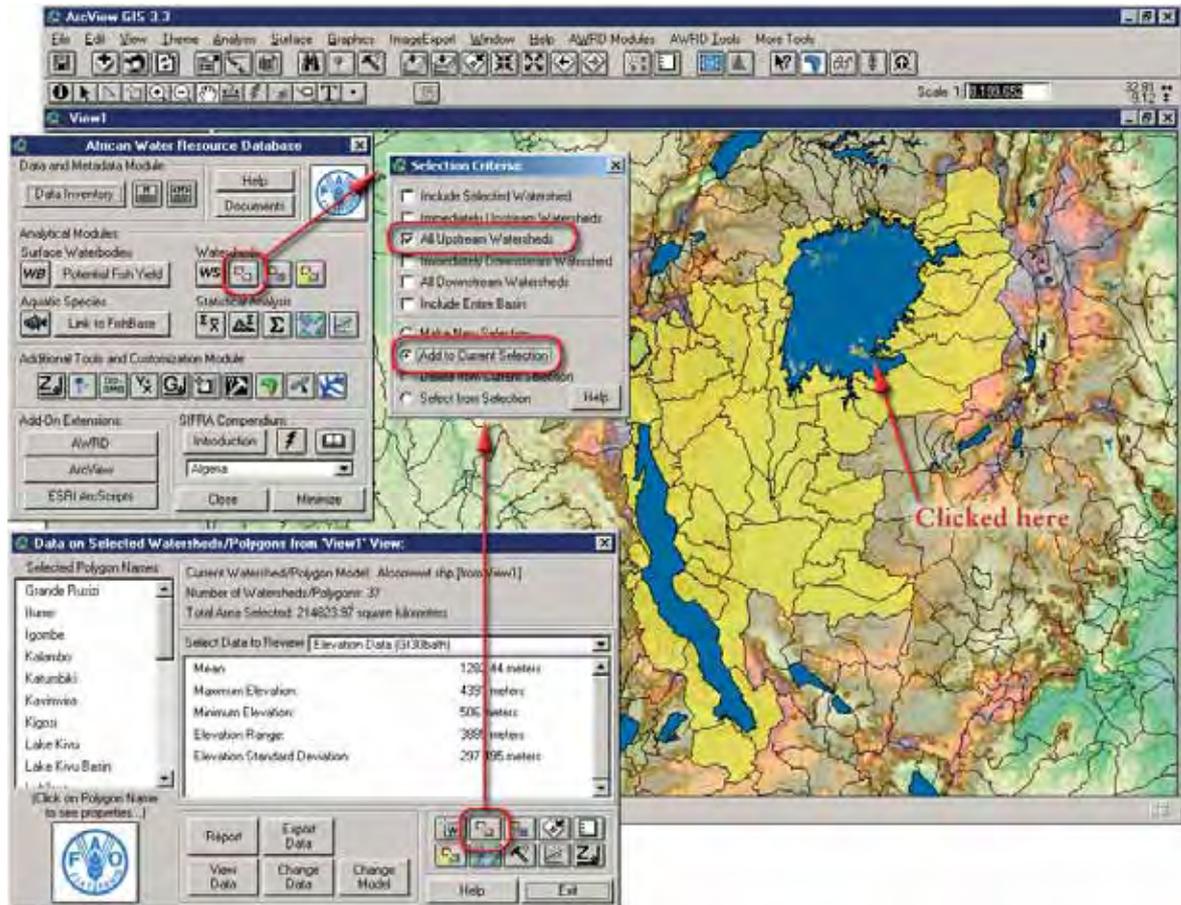
- *Include Selected Watershed:* Selects any watershed specified with a mouse click.
- *Immediately Upstream Watersheds:* Selects the watershed or watersheds lying immediately upstream from the “selected” watershed.
- *All Upstream Watersheds:* Selects the entire drainage basin of that watershed, which 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

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

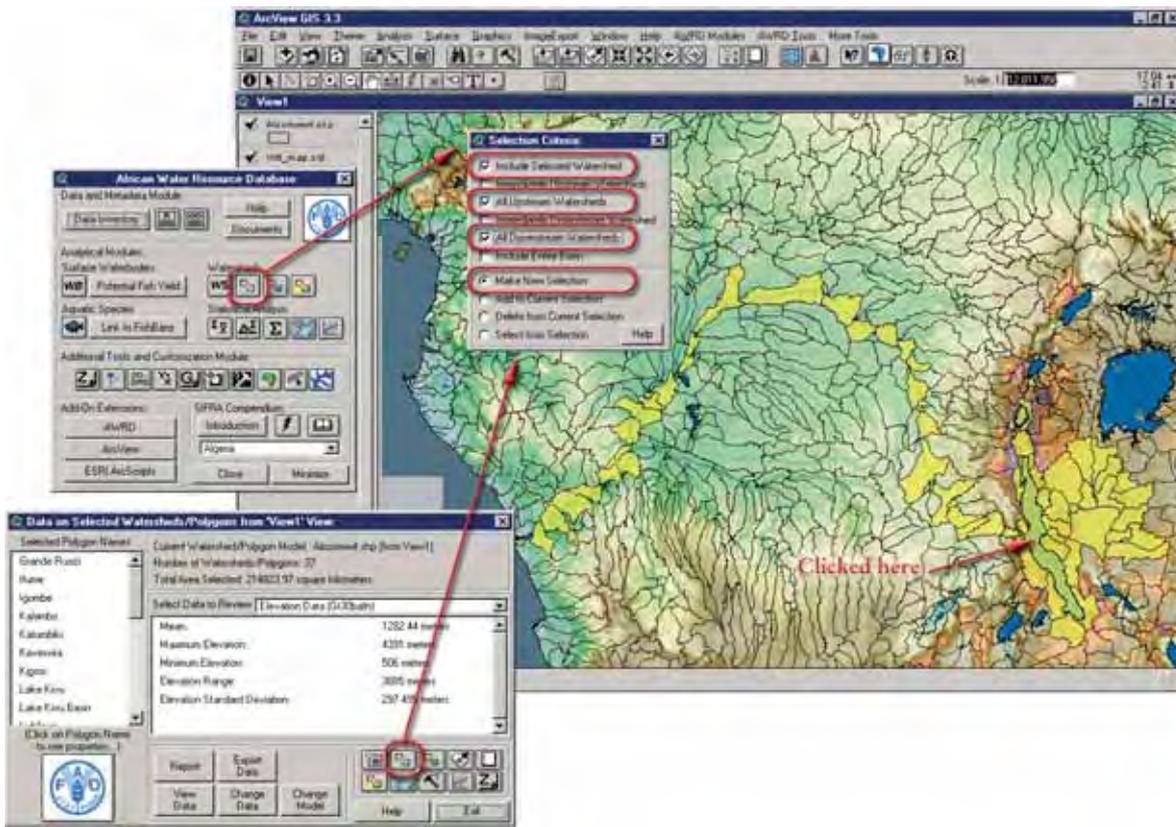
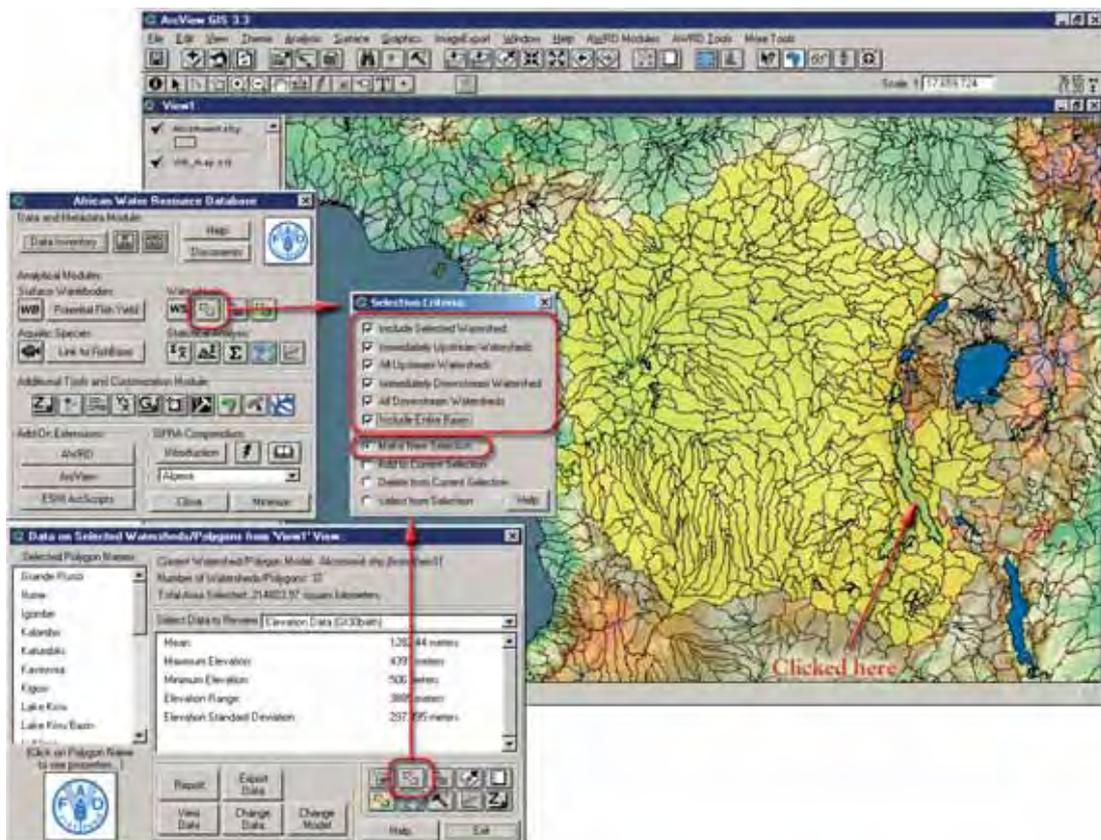


FIGURE 1.54
Entire Congo-Zaire megabasin

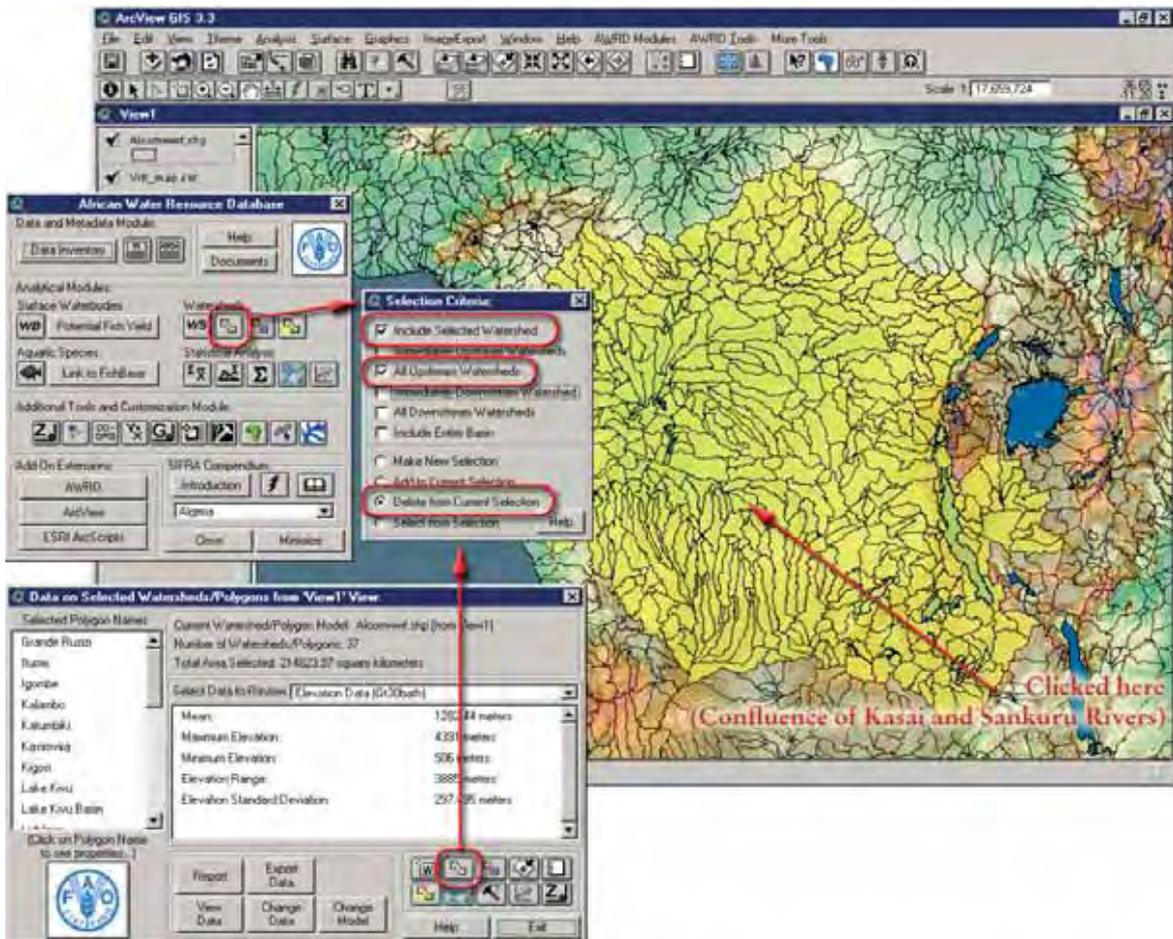


The “Include Entire Basin” option will select the entire megabasin irrespective of where the user clicks within that megabasin. For example, clicking on Lake Tanganyika will cause the entire Congo–Zaire megabasin to be selected (Figure 1.54).

Users may also unselect currently selected watersheds by clicking on the “Delete from Current Selection” option.

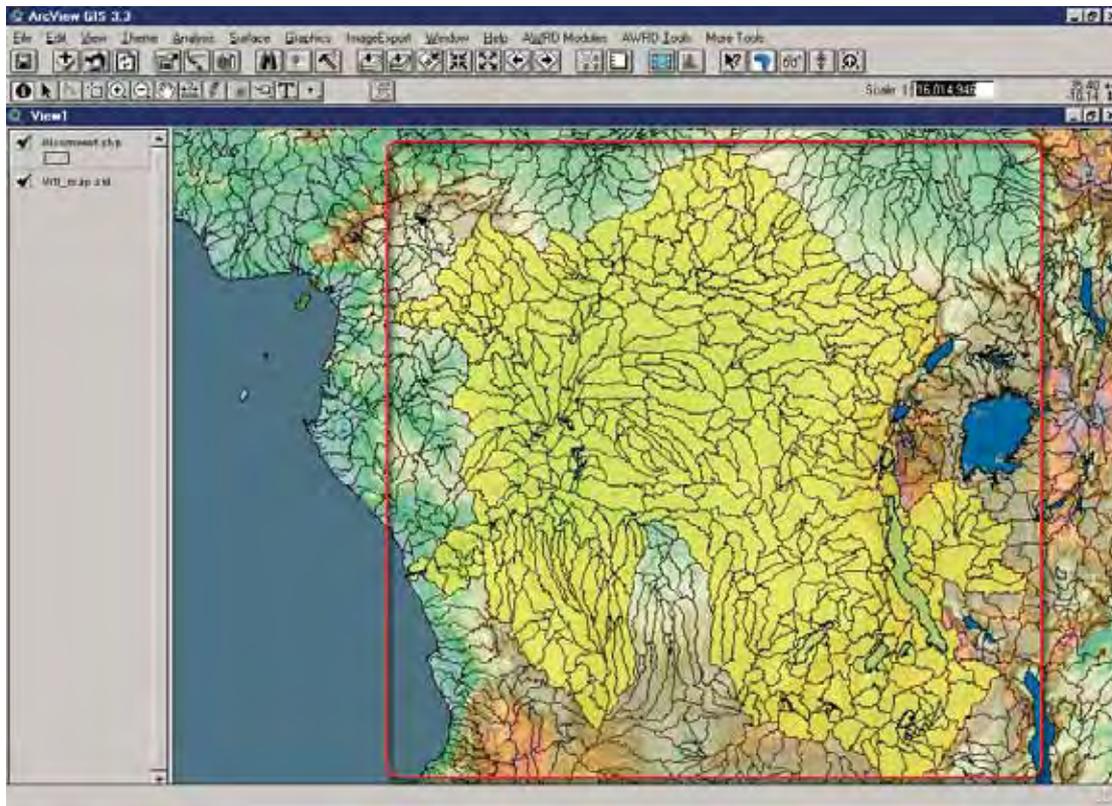
For example, if for some reason a user was interested in the entire Congo–Zaire megabasin, except that portion lying upstream of the confluence of the Kasai and Sankuru rivers, they would first select the Congo–Zaire megabasin as described above, and then select the “Delete from Current Selection” option 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

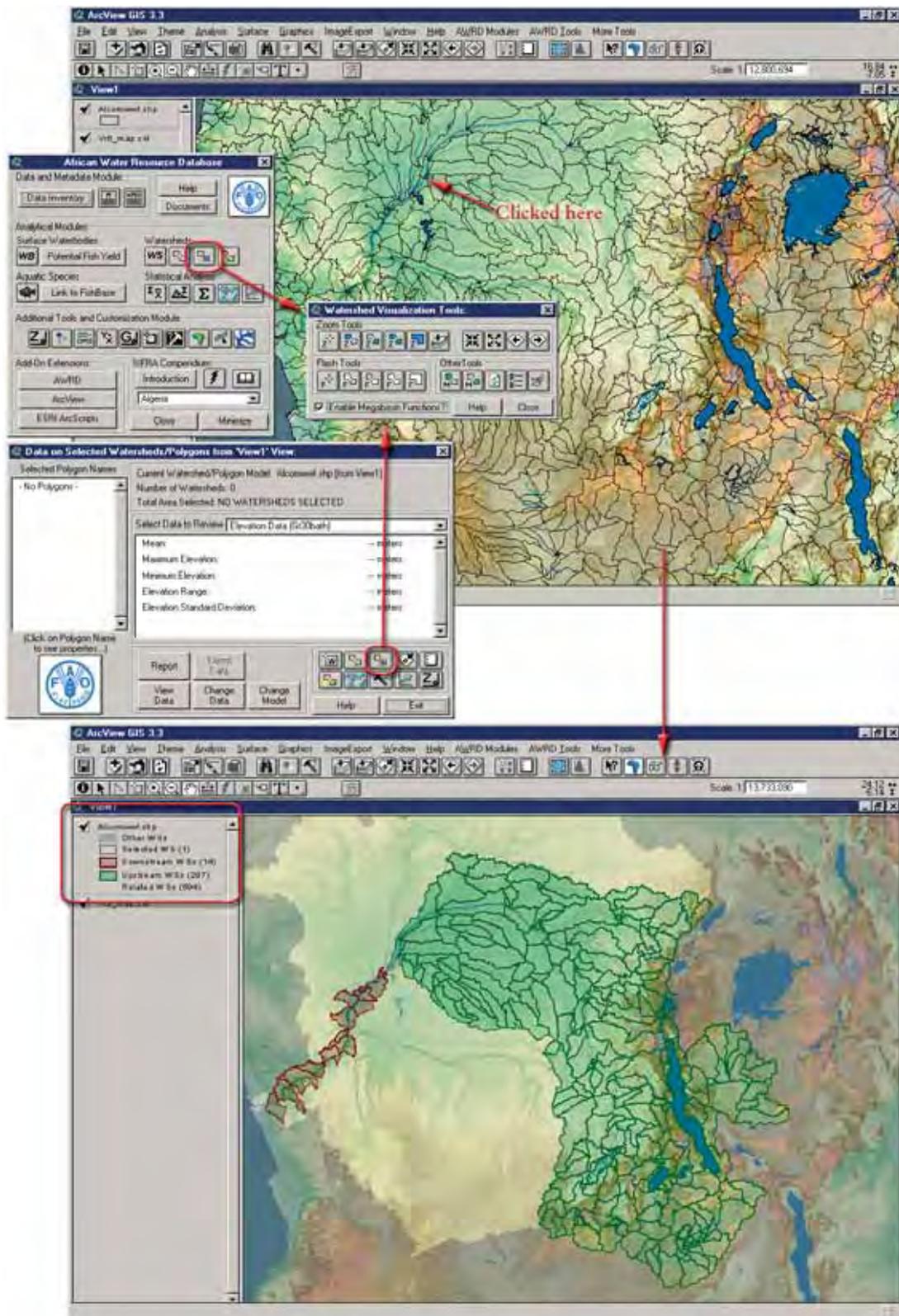
The “Identify Up/Down Tools” dialog is opened by clicking on the  button on either the AWRD Interface or the Watershed Module. Clicking on this button changes the cursor to a “+” symbol and allows users to identify all upstream, downstream and megabasin watersheds and colour them in such a way that they 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.

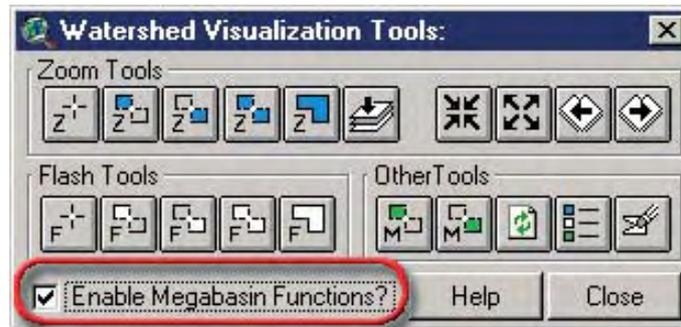
FIGURE 1.56
Identifying all upstream, downstream and megabasin watersheds by clicking on any watershed in the theme



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/downstream 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

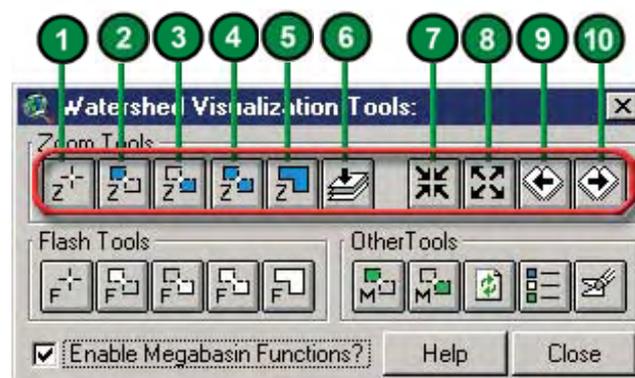
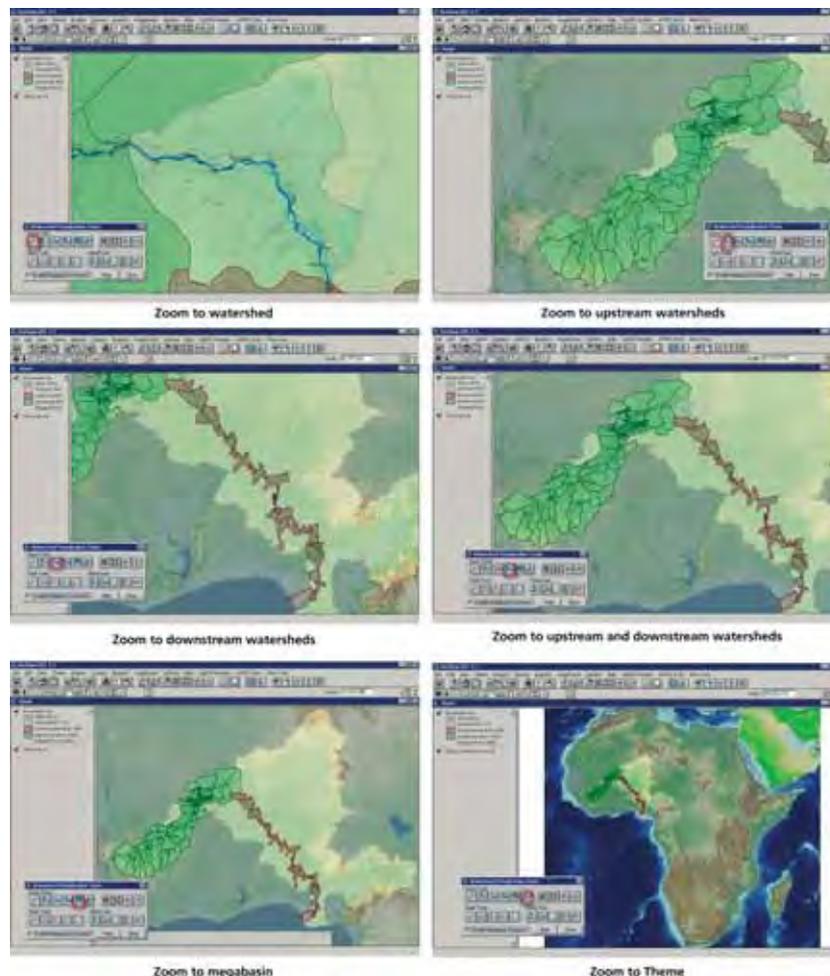


TABLE 1.22
Watershed zooming tools buttons

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

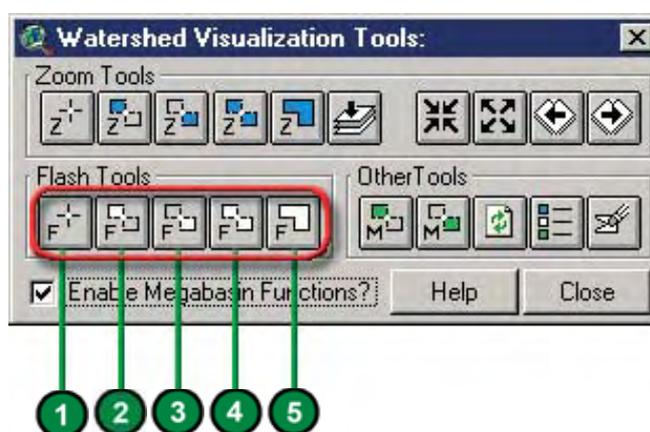


TABLE 1.23
Watershed flashing tools buttons

Label (Fig.1.60)	AWRD button	Action executed
1		<i>Flash Boundary of Selected Polygon</i> : flashes the boundary of the base watershed, leaving a temporary graphic boundary around it using a white colour.
2		<i>Flash Upstream Boundary</i> : flashes the boundaries of <i>any</i> upstream component watersheds of a flow regime related to the base watershed, leaving temporary green graphic boundaries around them.
3		<i>Flash Downstream Boundary</i> : flashes the boundaries of <i>any</i> downstream component watersheds of a flow regime, leaving temporary red graphic boundaries around them.
4		<i>Flash Upstream and Downstream Boundary</i> : flashes the boundaries of both upstream and downstream watersheds leaving temporary green and red graphic boundaries respectively.
5		<i>Flash Megabasin Boundary</i> : 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

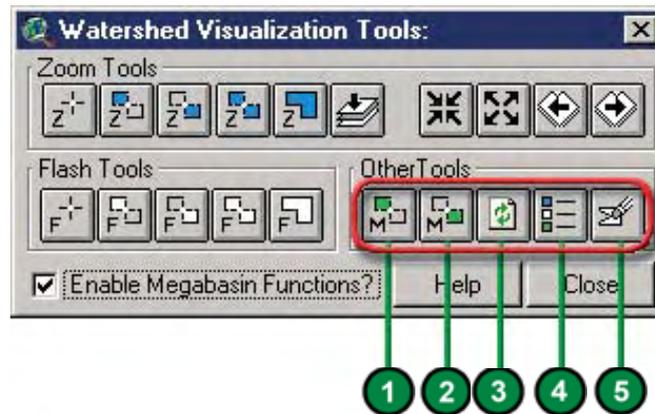


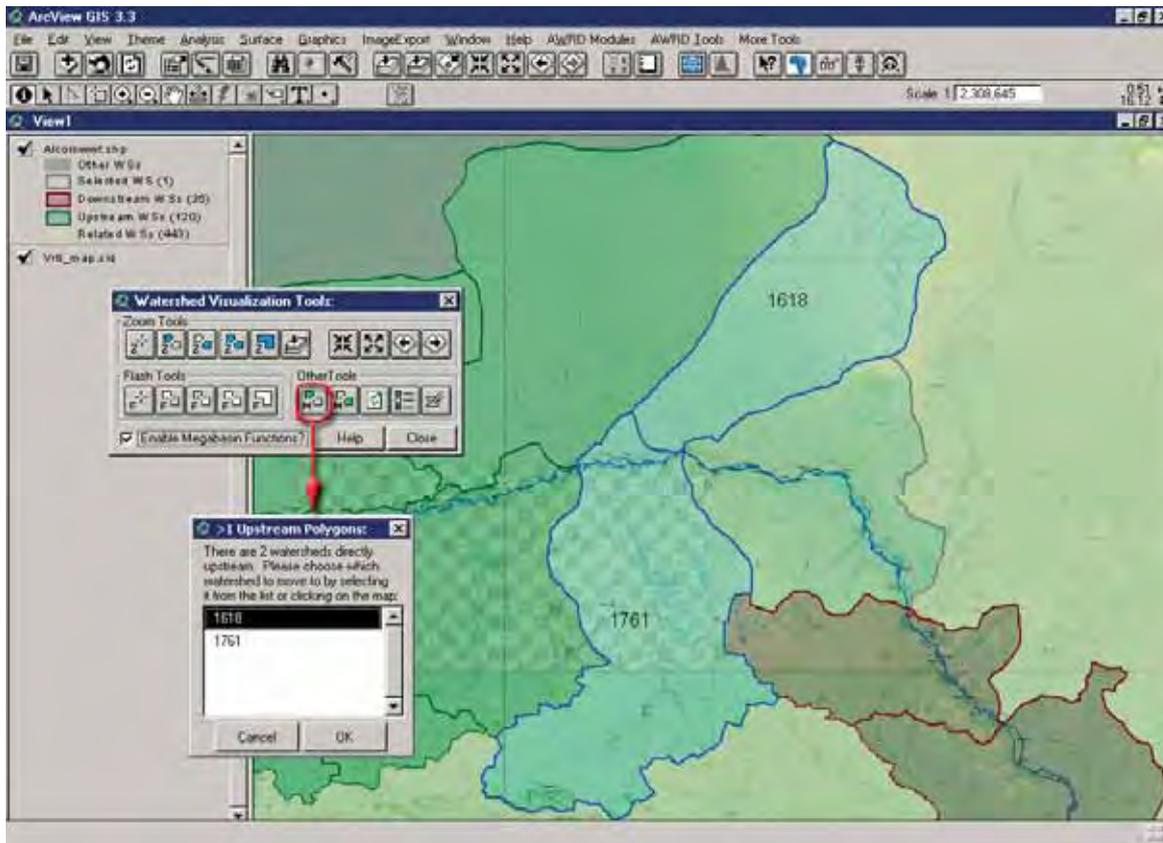
TABLE 1.24
Other watershed visualization tools buttons

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 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

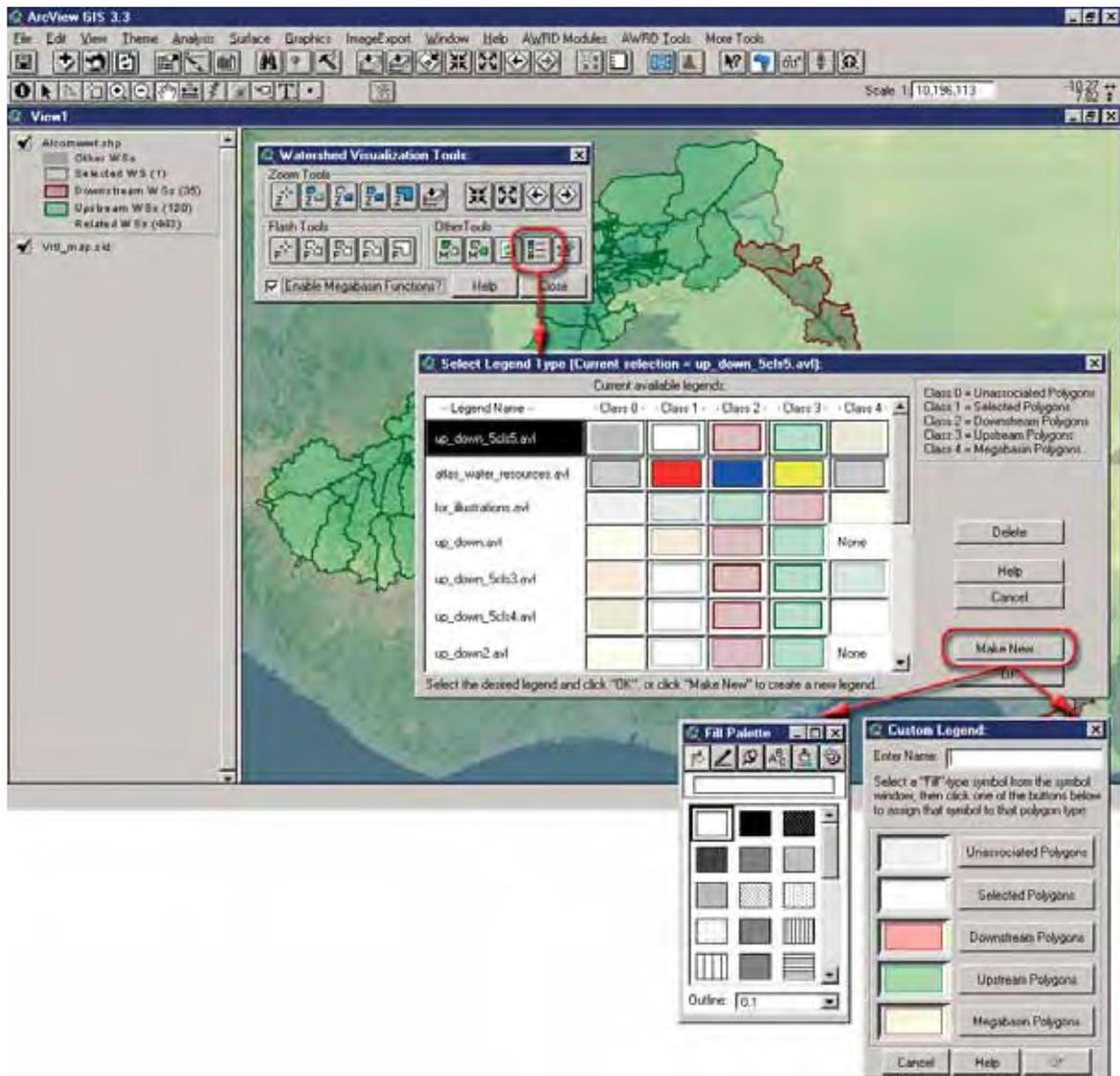


Legend type tool

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).

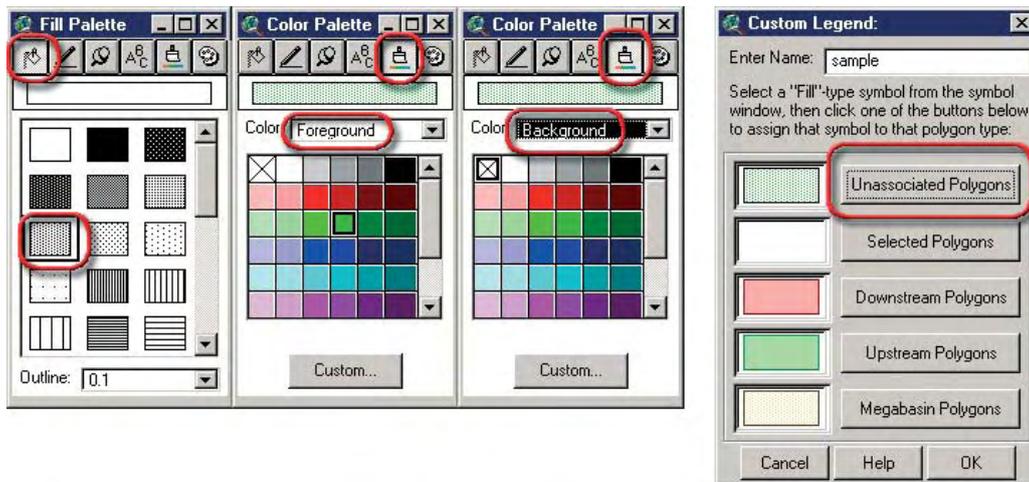
1. Click on the “Make New...” button  to open the *Custom Legend* tool.
2. Enter a name for the new legend. The name can be composed of letters and/or numbers, and can be of any length, but users are recommended to keep the length below approximately 25 characters so that the full name can appear in 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

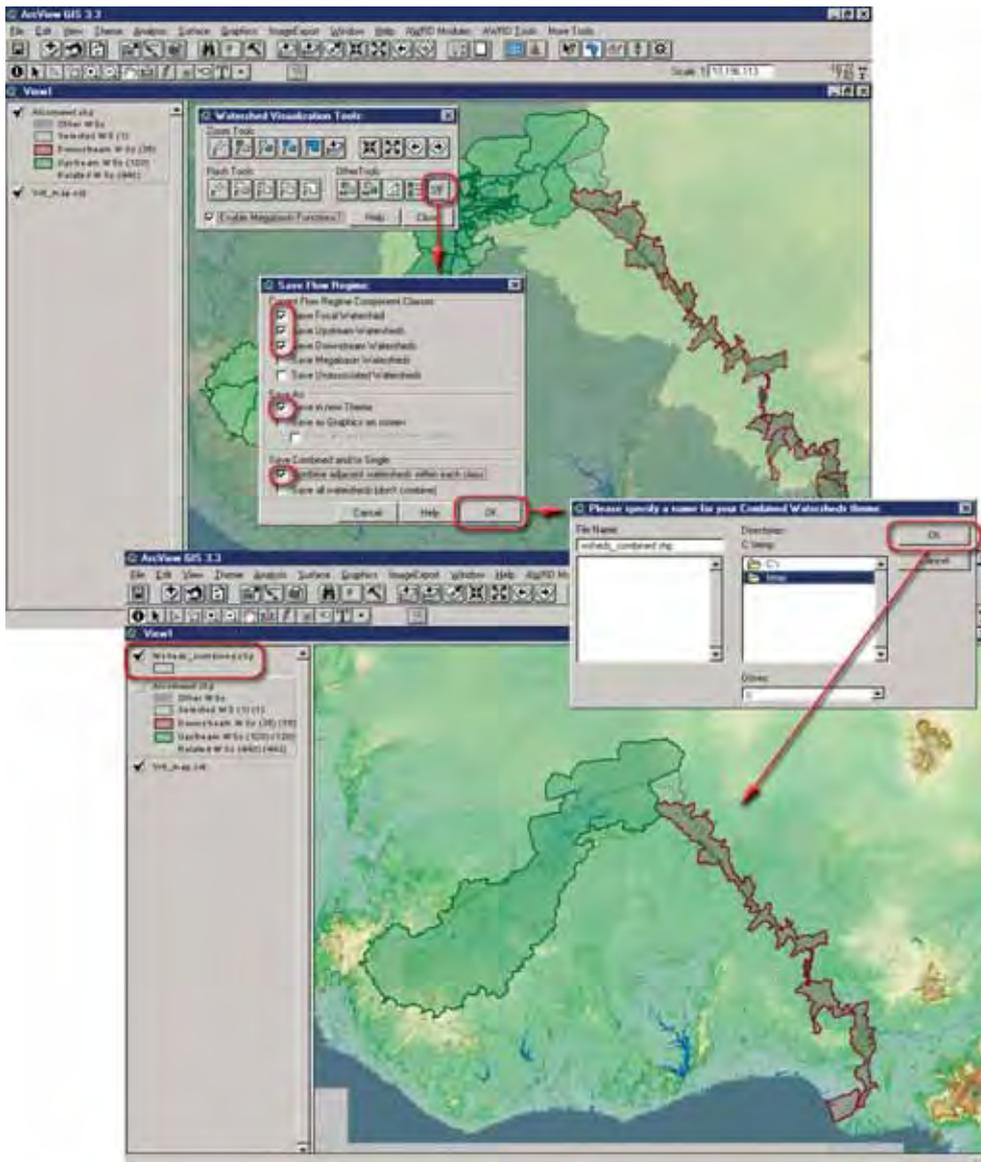
separately, to combine watersheds within each component, and to save the data as either graphics on the screen or as new themes.

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.

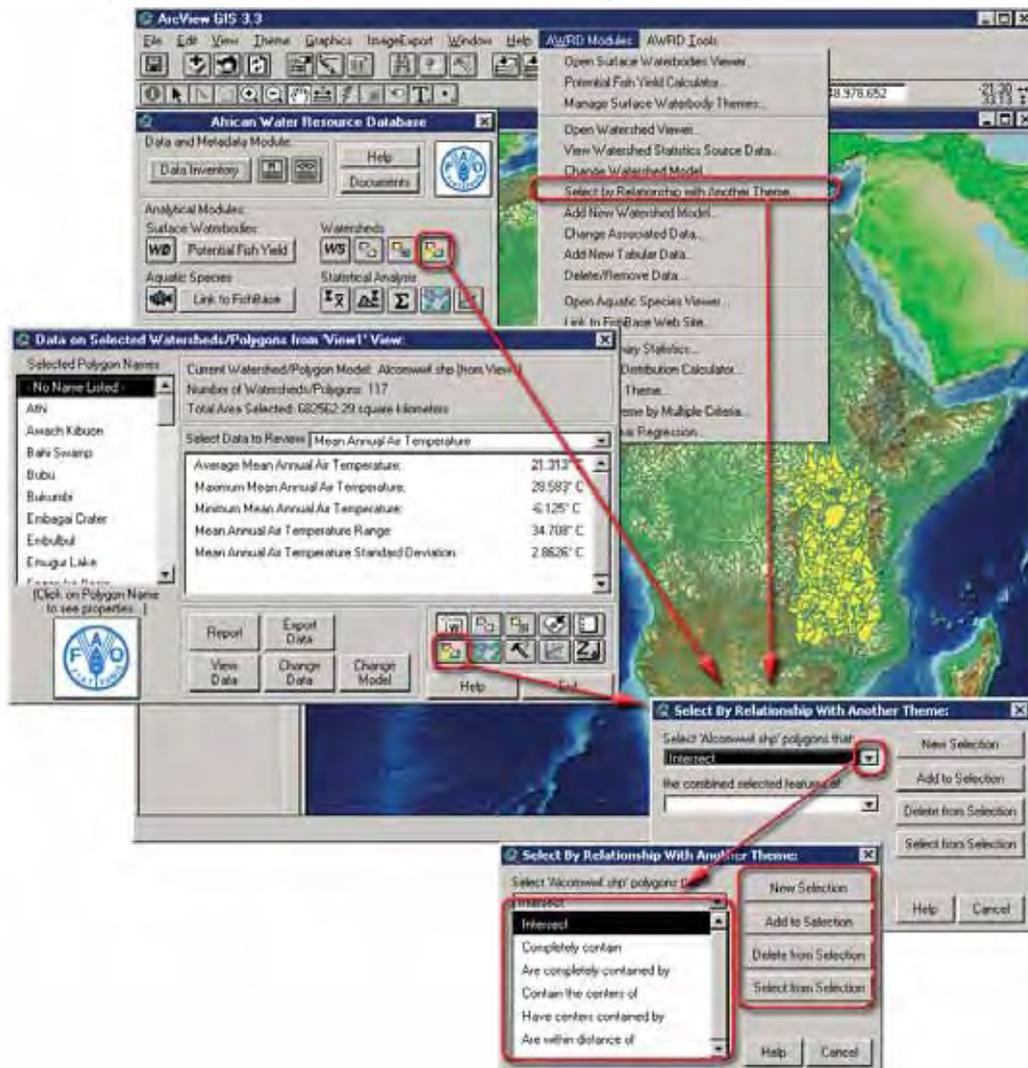
Select by Relationship with Another Theme Tool

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).

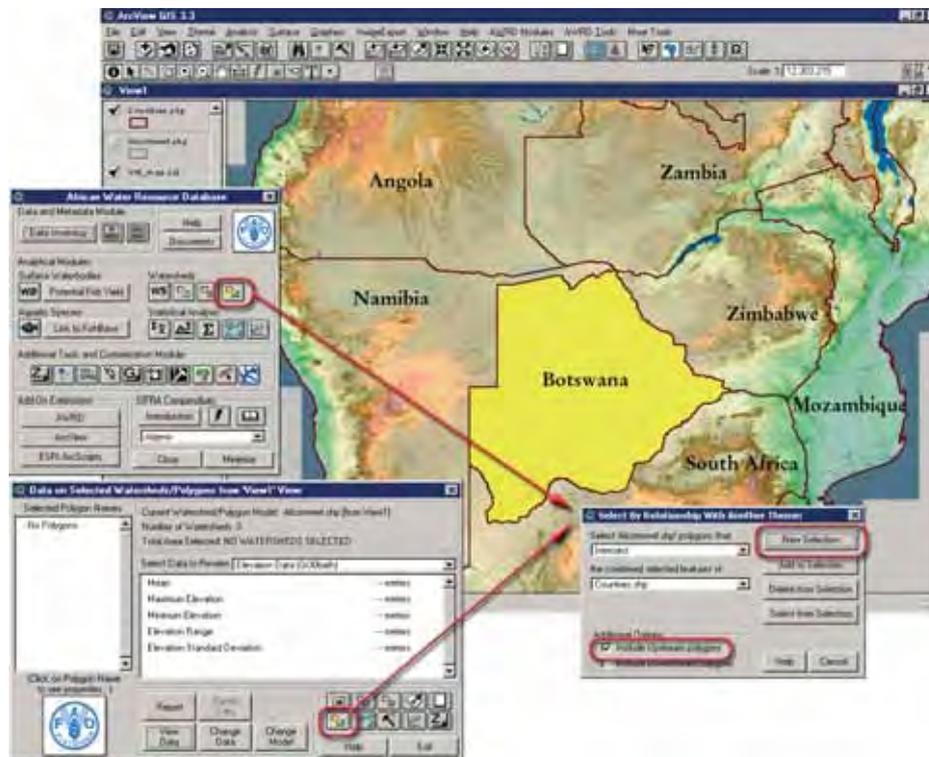
TABLE 1.25
Select by relationship with another theme tool buttons

Label (Fig1.66)	AWRD button	Action executed
		Clears out any previous selection of watersheds and makes a new one based on the specified spatial relationship.
		Selects watersheds based on the specified spatial relationship and combines the selection with the previous selection of watersheds.
		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.
		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 Botswana (this selection will highlight this country in yellow).
5. Open the Select Watersheds by Relationship with Another Theme tool dialog by clicking on the , 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

