Department of Water Affairs and Forestry

WaterMarque: A system for presenting water quality on maps

Archived information about 1990s software - no longer functional

WaterMarque is a water quality data query system built on ESRI's Arc/Info GIS.

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Technical Specifications

Introduction

WaterMarque is a system designed for use by water quality specialists. It allows the user to assess, query, display, report on water quality data and to create graphics files. The data is collected throughout the country by the Department of Water Affairs and Forestry and resides in WaterMarque in a digital format.

WaterMarque is a set of tools performing the tasks mentioned above on a closed set of data. The user cannot edit this data in the WaterMarque environment.

The following agencies designed WaterMarque as a collaborative project: the Institute for Water Quality Studies of the Department of Water Affairs and Forestry, Stewart Scott Incorporated, GisLAB of the University of Pretoria, and GIMS (Pty) Ltd. of Midrand.

Various datasets were used in the creation of this tool. For full details regarding the copyright, ownership and limitations on use please consult the copyright section of the Users Manual.

This Guide

This guide operates as an independent reference guide for experienced system administrators who need to assess the full operational environment of WaterMarque. It is not designed for technically inexperienced users.

The guide consists of various elements pieced together to create a working document from which to assess the full operational parameters of WaterMarque. These elements are to some degree reflections of the material found elsewhere in the WaterMarque documentation. A system overview, a modular description, a discussion of the system requirements, the operating system environments, technology and the inclusion of peripherals to the basic system are to be discussed.

System Description

WaterMarque is designed to perform various assesment, analysis, query and display functions. Each of these functions is operated by a separate part of the software which deals independently and interactively with the others.

Please refer to the system flow diagrams at the start of each chapter in the User Manual.

Basic Interface Functionality

Within WaterMarque all menus can be open simultaneously, allowing you to cross-reference sections and choices within one session. The menu structure is not hierarchical, because this would increasingly isolate you in one specialised field of inquiry. The freedom to enter various functions freely in any order must be treated with caution lest you miss selecting vital data or coverages and have to start again. For example, the dataset must be selected or recalled from memory before a time series data query can be processed.

Major WaterMarque Modules

The WaterMarque system is best understood in terms of functionality modules, where sets of similar functions are grouped together.

These modules are accessed in the main menu bar, and constitute the primary interface procedure.

In WaterMarque there are five main functionality modules.

Catchment Selection
- Spatial Feature Selection and Display
- Monitoring Point Selection
- Data Query
- Output

Each of these modules consists of a number of menus which are designed to have a consistent appearance, although they perform different functions.

Catchments Selection

This module has allows you to select an area of interest on the basis of prenamed and determined catchments as hydrological units. The catchments are defined at primary, secondary and tertiary levels.

Spatial Feature Selection and Display

A range of geographic features is available to provide vital background information for the process of water quality assessment. The features are grouped according to natural environment (elevation, geology, vegetation) and man-made environment (infrastructure, towns, landuse). The features are displayed as shaded areas (polygons), lines or point symbols. A number of different features may be simultaneously selected and displayed.

Monitoring Point Selection and Display

Inspect the data from the different water quality monitoring networks recognised by DWAF.

Monitoring points can be interrogated here in three different ways according to:

Monitoring Network

Selects and displays the monitoring network of your choice within a catchment or catchments, for the purposes of analysing and processing such data.

Data Record

Selects and locates monitoring stations according to the water quality records and then performs a monitoring network audit, among other tasks. The data required can be displayed in rapid on screen interrogation. The result is that monitoring activity can be readily visualised throughout the area.

Provincial Boundary

Selects monitoring points within provincial boundaries.

The module further allows you to initiate a query session on the data record for the monitoring points you selected.

Data Query Module

Selects the water quality variables of interest, the recommended guidelines for use and the time period of data to be assessed. A number of graphs and symbols are available for display of the data - including standard time series graphs, box and whisker plots, pie charts and some non-standard symbols specially developed for WaterMarque e.g. radial time series.

This module allows you to recall previously saved data and dispense with the tedious process of monitoring point reselection.

Output

Converts the selections made within the session into a graphics file, which you can then plot. The paper size can be selected, as well as various map features. The program only allows you to print in landscape.

A Further Note

Several submodules within WaterMarque are very useful for manipulating various aspects of data representation. These are discussed in more detail within the module chapters.

Each functionality module is a system which can be accessed on its own or in conjunction with other modules. Each module performs a selected function. Usually, functions are not performed by more than one module, although the *point selection and display* and the *data query* module do share some functions. These are discussed in the Users Manual.

Support

Should you have any problem in operating WaterMarque, or have questions regarding the use of this product, please do not hesitate to call us by E-mail or at the telephone or fax numbers provided below. In addition should you have any problems concerning installation, set up or maintenance of hardware or software involved in constituting the WaterMarque system, please contact GIMS at:

Support Division
P O BOX 652
Halfway House
1685
Gauteng, South Africa

Telephone us and ask for the HOTLINE service which will place you in contact with the hotline staff .

Tel: + 27 12 345 2243

Fax: + 27 12 345 6625

Email support@gims.com

Further Support

Problems you may encounter in WaterMarque will not always be of an operational nature. They may be related to some aspect of the software, or software documentation. Please use the forms described below to send error reports and suggestions to us at the above address.

Bugs

Software often contains bugs. Bugs may occur in any form, from a typographical error to an incorrect shading. Many annoying irregularities are also bugs. Should you detect any bugs, minor or major, please fill in the attached BUG REGISTRATION FORM.

The registration of bugs will help us help you, the user. As other users log their bugs and they are corrected so the next versions of WaterMarque will be improved - and so will your efficiency.

Documentation Bugs

Writing technical manuals occurs hand in hand with software development. As the software progresses so does the documentation. Sometimes, due to circumstance the software and the documentation procedure get out of phase.

Should you detect a documentation bug please fill in the Documentation Bug Registration Form. This will allow the manual to be updated and remain consistent with software development.

Software Enhancements

As a user of WaterMarque you are continually in contact with the software. As a result you will probably have some recommendations or suggestions as to how this product may be improved to fulfil the tasks required in a more appropriate way. Should you have any enhancement suggestions of any nature please do not hesitate to use the ENHANCEMENT REGISTRATION FORM enclosed below.

In order to maintain the integrity and usability of WaterMarque and its support structure please return the attached registration forms.

Operating Environment

The platform on which WaterMarque runs is a Unix workstation. Sun Unix workstations running either the SunOS 4.1.3 or Solaris 2.4 / 2.5 (or later) operating systems are able to support full ARC/INFO licenses. It can operate in the Open Windows and Common Desktop Environments. The system requires that a ARC/INFO version 7.0.4. (or later) license be accessible and present on the platform. WaterMarque is activated at the `arc` prompt.

Because of incompatible naming conventions and file hierarchies, WaterMarque is not supported on Open VMS or NT.

From the Unix environment WaterMarque can be accessed by PCs networked to workstations using X-terminal emulators. The X-terminal emulators on which WaterMarque has been successfully supported are Exceed™ and X-Vision™. Other emulators may also work, we have only tested these two.

Emulators running under the PC environments Microsoft Windows 3.x, Windows 95 and Windows NT have supported WaterMarque successfully. If you purchase an X-terminal emulator, ensure that it is compatible with your operating system.

Compilers

Within the WaterMarque statistical data analysis module, or tool, are a number of "C" compiled applications which interpret time period data into statistical data. Examples of these would be the *maucha* and *star* diagrams produced in the Data Query module.

Originally these applications were produced on the SunOS 4.1 C compiler. On later operating systems, a separate C compiler was necessary. Some problems have been experienced when running the statistical analysis functions on workstations which contain the SunOS 4.1 compiler. It is recommended that this compiler be renamed before installation of WaterMarque. This should ensure that the analytical structures function smoothly.

The problems lie in the naming and searching functions of the various compilers. Certain executables become 'unlocatable' or the software may search for files which do not exist.

WaterMarque Copyright

The "WaterMarque" software and manual have been prepared with the appropriate degree of skill, expertise and care using data obtained from a variety of technical and research sources. While every effort has been made to ensure that the figures reflect the most reliable and up-to-date data available, the Institute for Water Quality Studies accepts no responsibility for any damage that may be claimed by any user whatsoever, for the specifications, errors or omissions in the use of these figures, or in the modeling thereof in the "WaterMarque" program, all of which may be examined by the user prior to acquisition or purchase.

Disclaimer: Application of Scale, Time and Depth

The analysis of water samples is used to monitor changes in South African water resources with time. Water samples are taken at specific points on river reaches or water storage areas, comprise a very small amount of the total water present at that time and represent the conditions pertaining only at that time. Should the data indicate reason for concern, then the program user should seek supporting data to confirm this evidence.

Copyright for Data used in WaterMarque

WaterMarque's data sets consist of digital data from various sources. While some datasets such as the DWAF monitoring points and the USGS digital elevation data are in the public domain and freely available to the public from a variety of sources, other datasets such as the Digital Chart of the World are protected by copyright and are only available from the owners. A third type are derived from public domain data but must be obtained from the owners or distributors who wish to retain control over the quality of the data and its eventual end use.

The table below summarises sources and copyrights for data used in WaterMarque. Please be aware that contact information, particularly E-mail addresses, is ephemeral.

Table of Copyrights for data used in WaterMarque.

Title	Copyright	Owner	Contact/Phone/Fax/E-mail
Acocks Veld Types	Protected, contact owner	National Botanical Institute Private Bag X1011 PRETORIA 0001	Dr M. C. Rutherford (012) 804 3200 (012) 804 3211
World 0.5x0.5' Elevation Data	Public domain	EROS Data Centre Mundt Federal Building Sioux Falls, SD 57198, USA	Customer Services + 1 605 594 6151 + 1 605 594 6589 klarson@dglCr.usgs.gov
Geology map of South Africa, Lesotho and Swaziland	Protected, contact owner	Council for Geoscience Private Bag X112 PRETORIA 0001	The Director (012) 841 1912 (012) 841 1203 postmaster@geoscience.org.za
Monitoring Points of the Department of Water Affairs & Forestry	Public domain, but may not be redistributed. Frequently updated.	Hydrology Directorate Department of Water Affairs & Forestry Private Bag X313 PRETORIA 0001	The Director (012) 388 8077 (012) 326 1488 scc@dwaf.pwv.gov.za
Monitoring Points of the Institute for Water Quality Studies, Department of Water Affairs & Forestry	Public domain, but may not be redistributed. Frequently updated.	Institute for Water Quality Studies Department of Water Affairs & Forestry Private Bag X313 PRETORIA 0001	The Director (012) 808 0374 (012) 808 0338 eca@dwaf.pwv.gov.za

Management Regions of the Department of Water Affairs & Forestry	Public domain, but may not be redistributed. Frequently updated.	Strategic Planning Directorate Department of Water Affairs & Forestry Private Bag X313 PRETORIA 0001	The Chief Engineer (012) 388 8047 (012) 323 2123 apa@dwaf.pwv.gov.za
Regional Pollution Monitoring Points of the Department of Water Affairs & Forestry	Public domain, but may not be redistributed. Frequently updated.	Water Quality Management Directorate Department of Water Affairs & Forestry Private Bag X313 PRETORIA 0001	The Chief Engineer (012) 388 8691 (012) 323 0321 tbf@dwaf.pwv.gov.za
"Natural" Drainage Regions	Public domain, but may not be redistributed. Frequently updated.	Hydrology Directorate (see above) Alternative source: WR90, Water Research Commision: hugo@wrc.ccwr.ac.za	The Director (012) 388 8077 (012) 326 1488 scc@dwaf.pwv.gov.za
Gauging Weir Drainage Regions	Public domain, but may not be redistributed. Frequently updated.	Hydrology Directorate (see above)	The Director (012) 388 8077 (012) 326 1488 scc@dwaf.pwv.gov.za
Problem Aquatic Macrophytes in South Africa (1993)	Public domain, but may not be redistributed. Not updated.	Environment Studies Directorate Department of Water Affairs & Forestry Private Bag X313 PRETORIA 0001	The Director (012) 388 8221 (012) 338 8678 dig@dwaf.pta.gov.za
South Africa 712 Climate Zones	Protected, contact owner.	Agricultural Engineering Department University of Natal P.O. Box 375 PIETERMARITZBURG 3201	Director, CCWR (0331) 260 5177 (0331) 6 1896 dent@aqua.ccwr.ac.za
South African 1'x1' Mean Annual Precipitation Grid	Protected, contact owner.	Agricultural Engineering Department University of Natal P.O. Box 375 PIETERMARITZBURG 3201	Director, CCWR (0331) 260 5177 (0331) 6 1896 dent@aqua.ccwr.ac.za
South African Dams and Rivers	Protected, contact owner. (NB: highly modified for WaterMarque.)	Surveys & Land Information Chief Directorate Department of Land Affairs Private Bag MOWBRAY 7705	The Chief Director (021) 685 4070 (021) 689 9721
South African International Borders	Protected, contact owner. (NB: highly modified for WaterMarque.)	Surveys & Land Information Chief Directorate Department of Land	The Chief Director (021) 685 4070 (021) 689 9721

		Affairs Private Bag MOWBRAY 7705	
South AfricanUrban Areas	Protected, contact owner. (NB: highly modified for WaterMarque.)	Surveys & Land Information Chief Directorate Department of Land Affairs Private Bag MOWBRAY 7705	The Chief Director (021) 685 4070 (021) 689 9721

WaterMarque System Bug Report Form

Please send this information to GIMS Hotline

by E-mail (support@gims.com) or fax (011) 315 0395

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Customer number	
Site	
Arc/Info version number	
WaterMarque version number	
Platform (computer type)	
Operating system (e.g. Solaris 2.5)	
Menu where bug emerged	
Action which produced the problem	
AML or system error message	
AML line number, if known	

WaterMarque Document Bug Report Form

Please send this information to GIMS Hotline

by E-mail (support@gims.com) or fax (011) 315 0395

Name of user	

Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Customer number	
Site	
Document version number	
Module where bug found	
Page number(s)	
What has been incorrectly described?	
What changes do you suggest?	
Other comments	

WaterMarque Quality Data Bug Report Form

(Hydrological Information System Data -- not POLMON)

Please send this information to Johan Wentzel

by E-mail (sdj@dwaf.pwv.gov.za) or fax (012) 326 1488

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Postal Address	
WaterMarque version number	
Station code (e.g. A2H027Q01)	
Station type (stream, dam, etc.)	
Type of error (location of point, anomalous concentration, etc.)	

Suggested correction	

WaterMarque POLMON Data Bug Report Form

Please send this information to Geert Grobler

by E-mail (tdb@dwaf.pwv.gov.za) or fax (012) 323 0321

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Postal Address	
WaterMarque version number	
Station code	
Province or region	
Type of error (location of point, anomalous concentration, etc.)	
Suggested correction	

WaterMarque Coverage Bug Report Form

Please send this information to Michael Silberbauer

by E-mail (SilberbauerM@dwaf.gov.za) or fax (012) 808 0338

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Postal Address	

WaterMarque version number	
Coverage (e.g. Evaporation)	
Type of error (geographic location, shape, anomalous value, etc.)	
Suggested correction	

WaterMarque Enhancement Request Form

Please send this information to GIMS Hotline

by E-mail (support@gims.com) or fax (011) 315 0395

Name of user			
Date			
Contact phone number			
Contact fax number			
Contact E-mail address			
Customer number			
Site			
Arc/Info version number			
WaterMarque version number			
Platform (computer type)			
Operating system (e.g. Solaris 2.5)			
Is this a data enhancement?	Y	N	
What type of data?	Y	N	
Spatial data	Y	N	
Time series data	Y	N	
Other data type			
Is this a functionality enhancement?	Y	N	
What type of functionality?	Y	N	
	Y	N	
User interface	Y	N	

Statistics Symbol or icon Output	Y	N	
Describe the suggested enhancement (attach a detailed description if necessary)			

Introduction

WaterMarque is a menu driven set of tools developed using GIS technology for the assessment, query, display and reporting of water quality information. It is based on water quality data collected throughout the country together with a range of geographical data sets for available background information.

WaterMarque consists of a set of menus that will allow users trained in water quality evaluation to access water quality and associated information, analyse that information and produce output maps.

WaterMarque was developed as a collaborative project between the following agencies: Institute for Water Quality Studies of the Department of Water Affairs and Forestry, the CSIR Division of Water, Environment and Forestry Technology (Environmentek), Stewart Scott Incorporated, GisLAB (formerly of the University of Pretoria), and GIMS (Pty) Ltd. of Midrand.

The system was prototyped by the Institute for Water Quality Studies and stabilised by GIMS under contract to the Institute. Installation and a hotline support service are provided by GIMS.

WaterMarque uses various datasets obtained from the following agencies: Department of Water Affairs and Forestry, National Botanical Institute, the Chief Director of Surveys and Land Information, the CSIR, the Water Research Commission and the University of Natal. A more detailed description of the datasets, copyright notices and usage limitations with respect to the system data dictionary are in the appendix.

WaterMarque main screen and initial menus

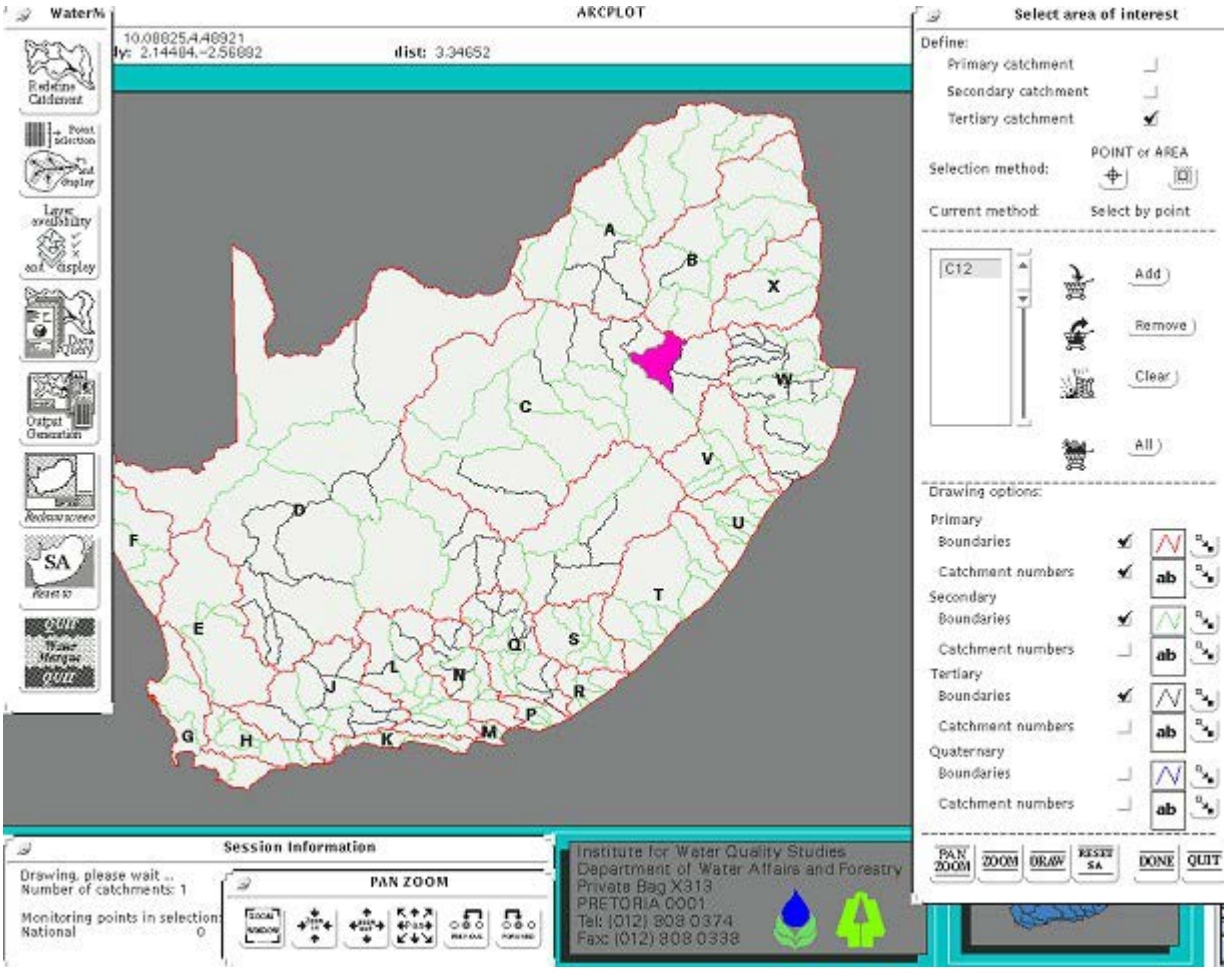


Figure 1a The WaterMarque main screen and menus

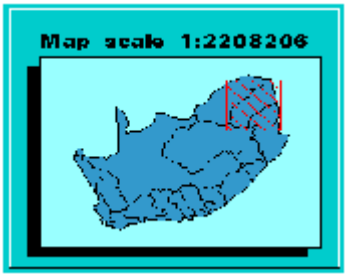
The WaterMarque main screen has a number of elements that are visible throughout the session.

The main elements, some of which are shown above, are:

- The **main screen** which consists of:
  - the mapping area which shows the primary catchment areas of South Africa
  - blank area to the right which is used to display diagrams and map legends when required
- The locational inset map in the bottom right-hand corner
- The *Main menu* bar on the left
- The message dialogue box in the bottom left-hand corner
- The *Panzoom* menu at the centre bottom of the screen.

Main mapping area

- The **main mapping area**, which fills most of the monitor screen, consists of a large map area on the left-hand side of the monitor, where spatial data are displayed, such as:
  - monitoring point data
  - cities and towns
  - symbols representing water quality data
  - other spatial data such as veld types
- An area to the right of the map, which is blank at start up, is used to display
  - legends
  - diagrams, when required



1b The Locational Inset Map

Locational inset map

In the lower right-hand corner of the main screen is the locational inset map. This map indicates the extent that the map being drawn on the main screen occupies relative to the whole of South Africa. This is particularly useful as you zoom in or pan across catchments.

The extent of the large main map is indicated on the locational map of South Africa by a red hatched box.

 ***Panzoom*** menu

The *Panzoom* menu provides access to generic facilities for changing the extent of the area displayed on the main map.

The facilities include :

- **Zoom in / zoom out** on a point location
- **Pan** about the map in any direction
- **Previous / Forward** allows you to return to previous areas viewed

Main menu bar

The *Main menu* bar is always located at the left of the screen.

The menu icons or buttons are as follows :

- Redefine catchment:

Provides access to the on-screen catchment selection routines

- Monitoring point selection and display:
  - Provides access to the monitoring point data and display routines. It also provides access to the various analysis and statistical routines available within WaterMarque.
- Feature selection and display:
  - Provides access to routines allowing the addition of coverages to the map, e.g. roads, railways, towns, rivers and features such as the geology and veld types within the area.
- Data query:
  - Provides access to the query and tabular reporting routines.
- Output generation:
  - Provides access to the output generation and plotting routines incorporated within WaterMarque.
- Quit:
  - To exit WaterMarque completely.

Other onscreen features

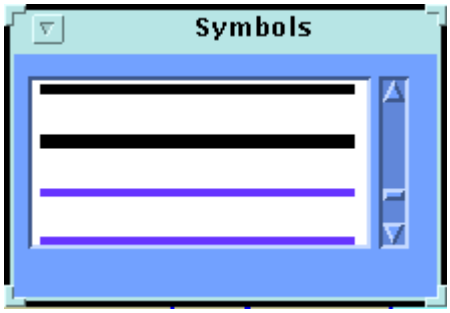
In addition to the primary features which are to be found on screen there are a number of smaller features. These smaller features are building blocks of the larger features.

- A check box
  - A menu option with a check box beside it.
  - This is the square box usually to the right of an option.
  - If it has not been selected, the box is empty. Conversely if it has been selected, then it contains a tick.
  - To select the option (switch it on) centre the cursor arrow on the empty box and click the left mouse button once. A tick will appear in the centre of the box.
  - To deselect the option (switch it off), centre the cursor arrow on the tick within the check box and click the left mouse button once. The tick will disappear leaving the check box empty.
- An icon
  - To select an option or to start a variety of actions. Centre the cursor arrow on the icon and click the left mouse button once to activate a specific aspect of WaterMarque.
- Session Information
  - The session information menu has the primary purpose of informing you of the functions and processes being run by the computer. It appears and remains (unless dismissed by the user) in the lower left-hand corner of the screen.
- Scroll box
  - On the right-hand side of the scroll box there is a scroll bar. On smaller scroll bars an elevator consisting of two arrows separated by a box can be moved up and down the scroll bar. This is done by centring the cursor arrow on one of the arrows and depressing the left-hand mouse button. To move down, place the cursor on the lower arrow. To move up, place the cursor on the upper arrow. In addition a quick scrolling action is also available. Hold down the mouse button on the centre of the arrowed handlebar to drag the box up or down.

- An Input Field
  - This is an underlined area in which the user is required to type in data - perhaps a name or password as in the opening menu.
  - To type in your password, move the cursor to the start of the line. Click the left mouse button once. Type in your password. Then press <Enter>on the keyboard.

    
    You do not always have to press <Enter> on the keyboard to ensure that the information entered in that field is accepted by WaterMarque. It is only required on this first menu in WaterMarque.

- Popup menus
  - Menus contain submenus which flash onto the screen, referred to as *popup menus*. Make a selection by clicking on the option of choice. The other menus on the screen will remain inactive until you respond to the popup menu. When you have made a choice by clicking on the popup menu option, then the popup menu will disappear.
  - For example, a popup menu allowing you to select a colour has a scrollbar on the right which allows you scroll through and select the colour that you want. Place the cursor arrow on the downward facing



arrow and depress the left mouse button. The scrollbar elevator will slowly descend, exposing colours within the box as it does so.
- Release the left mouse button when you find a colour you like, centre the cursor arrow on the colour, click the left mouse button once. The popup menu will disappear.

Basic Interface Functionality

Within WaterMarque all menus can be accessed simultaneously, allowing you to cross-reference sections and choices within one session. The menu structure is not hierarchical, in which you become increasingly isolated in one specialised field of inquiry. This freedom to enter various functions, in any order, must be used carefully lest you miss selecting vital data or coverages and have to start again. For example, the dataset must be selected or recalled from memory before a time series data query can be processed.

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These modules are accessed in the *Main menu* bar, and constitute the primary interface procedure.

In WaterMarque there are five main functionality modules.

- Catchment Selection
- Spatial Feature Selection and Display
- Monitoring Point Selection
- Data Query
- Output

Each of these modules consists of a number of menus which are constructed similarly as they perform similar but different functions. (e.g. the layers module menus).

- **Catchment Selection**

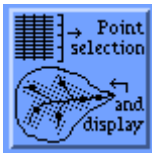
  This module allows you to select an area of interest on the basis of prenamed and determined catchments. The catchments are defined at primary, secondary and tertiary catchment levels. You can display quaternary catchment boundaries, but cannot use them for selection.

- **Spatial Feature Selection and Display**

  This module presents a range of geographic features which are vital background information for the process of water quality assessment. The features have been grouped according to natural environmental features (elevation, geology, vegetation) and man-made environmental features (infrastructure, towns, landuse). The features are displayed as shaded areas (polygons), linear or point symbols. A number of different features may be simultaneously selected and displayed.

- **Monitoring Point Selection and Display**

  This module allows you to inspect the data from the different water quality monitoring networks recognised by the DWAF.

  Monitoring points can be interrogated in three ways:

  - *Monitoring Network* allows you to select and display the monitoring network of your choice within a catchment or catchments, in order to analyse and process such data

- *Data Record* this option allows you to select and locate monitoring stations according to the water quality records and to then perform a monitoring network audit, among other tasks. The data required can be displayed in a rapid on screen interrogation session. The result is that monitoring activity can be readily visualised throughout the area.
- *Provincial Boundary* this option allows you to select monitoring points within provincial boundaries.

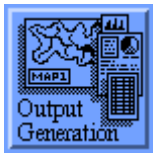
The module extends further in allowing you to initiate a query session on the record of data collected at the monitoring points you selected.

- **Data Query Module**

This module allows you to select the water quality variables of interest, the recommended guidelines for use and the time period of data to be assessed. A number of graphs and symbols are available for display of the data, including standard time series graphs, box and whisker plots, pie charts and some non-standard symbols specially adapted for WaterMarque e.g. radial time series and maucha diagrams.

The Data Query Module module also allows you to recall previously saved data and dispense with the tedious process of monitoring point reselection.

- **Output**



The Output module allows the selections you made within the session to be converted into a graphics file format, from which you will be able to plot. The paper size can be selected, as well as various map features. It is important to note that this version of WaterMarque only allows you to print in landscape orientation.

- **Reset to SA**

Switches off current catchment selection and resets map display to show the full extent of South Africa.

A Note on Module Interaction

Several submodules within WaterMarque are very useful for manipulating various aspects of data representation. These will be discussed in more detail within the module chapters.

Each functionality module is a system which can be accessed on its own or in conjunction with other modules. Each module performs a selected function, within the analysis of water quality data, usually not performed by the other modules. However, the Point Selection and the Data Query module do share, for convenience, some of the same functions. These will be discussed in greater detail later.

General Information

Conventions Specific to WaterMarque

Menus in WaterMarque share various conventions and similarities. Certain symbols and icons occur repeatedly in menus of many different functions.

Quit icon

Common to all menus in WaterMarque is the *Quit* icon. The purpose of the *Quit* icon is to allow you to exit a menu or module quickly without having to enter information into a field and to avoid having to make selections.

For example, you have mistakenly entered into the *Administrative Boundaries* menu when you really wanted to be in the *International Boundaries* menu. Without having to select unwanted data from the datasets in the *Administrative Boundaries* menu, you can simply click on the *Quit*icon found at the bottom of all menus. The exceptions are those menus that form the backbone of the system's functionality, such as the session information, the *Main menu* bar and

the *Pan Zoom* menu.

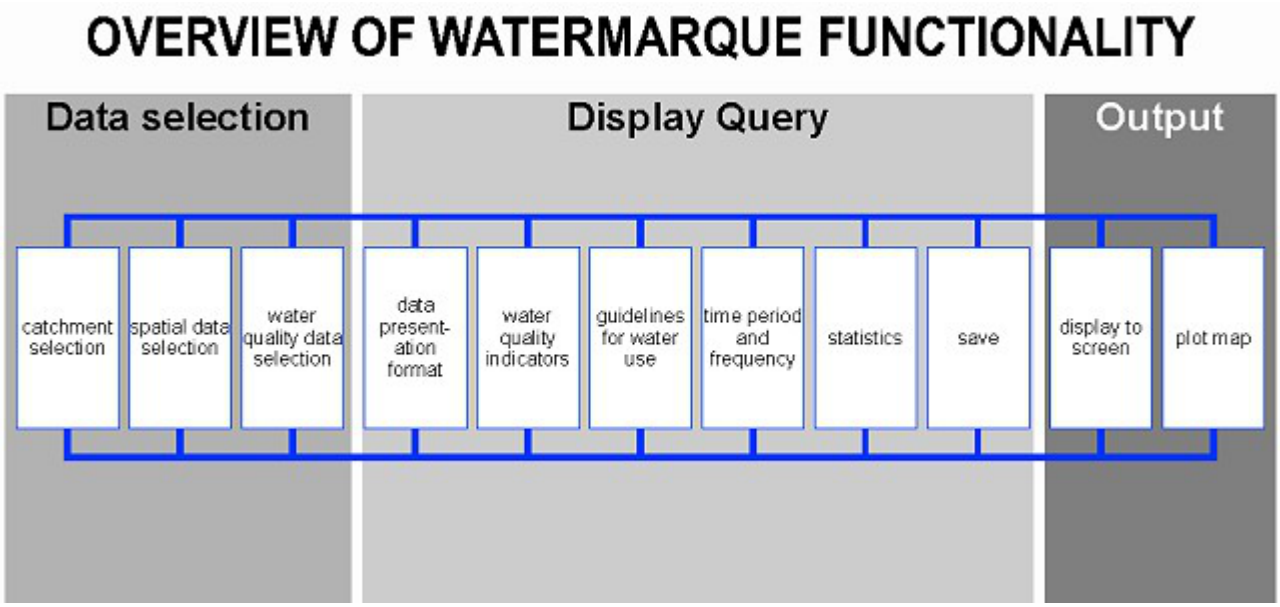
Draw icon

The *Draw* icon is found on almost all menus and serves the purpose of allowing you to draw your selections from various selections to screen.

Change Symbols Icon

The *Change Symbols* icon occurs on menus which provide you with the ability to display data to the screen and maps as layers of colour or symbols representing certain values or occurrences, e.g. waterweed symbol. These symbols are set up within WaterMarque as defaults. These can be reset by simply clicking on *Reset* icons on selected menus.

The *Change Symbols* icon allows you to change a symbol for a value or occurrence on the map with a choice from a predetermined characterset. To see how it works click on the *Change Symbols* icon.



Return to index page
Proceed to Catchment Selection

Department of Water Affairs and Forestry

WaterMarque

A system for presenting water quality on maps

Disclaimer

The Watermarque software and manual have been prepared with the appropriate degree of skill, expertise and care using data obtained from a variety of technical and research sources. While every effort has been made to ensure that the figures reflect the most reliable and up-to-date data available, the Institute for Water Quality Studies, GIMS and CSIR accept no responsibility for any damage which may be claimed by any user whatsoever for the specifications, errors or omissions in the use of these figures, or in the modeling thereof in the Watermarque program, all of which may be examined by the user prior to acquisition or purchase.

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IWQS home page.

Department of Water Affairs and Forestry

WaterMarque

A system for presenting water quality on maps

Typographical Conventions

This manual uses the following conventions: *Italic type* indicates names of the options available, menu and icon names .

Note icon means that the adjacent paragraph contains information of interest.

Information icon means that the adjacent paragraph contains useful hints and short cuts.

This manual is an elementary guide to the workings of WaterMarque. The manual provides guidance in two ways:

- through pictures of menus taken directly from the screen, so you will encounter menus in the manual as they are seen on screen.
- through textual information providing assistance on the requirements and purpose of each menu

Etymological convention

In this manual, the word “data” is a singular noun referring to information, usually stored in a computer file. Language purists must console themselves with the saying “data is not all they used to be.”

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What is new in version 1.3?

1. Data sets

Updated Hydrological Monitoring Stations

The attribute information for hydrological monitoring stations were updated. The data was exported from the (HIS) database at DWAF Head Office. The INFO is called INORGANIC.DAT in the $WMSYS/wmdata/wq directory

Updated Landcover data set

The complete landcover data set available from the CSIR were incorporated into the *Layer Availability* and *Output* modules. This data set was derived from 1:250000 LandsatTM images during the National Landcover database project done by the CSIR.

Incorporated 1:50 000 Rivers for South Africa

A map library was created for the 1:50 000 rivers for the whole of South Africa and has been incorporated in the *Layer Availability* module in the *Hydrological Features Layers* menu. Click on the checkbox next to *1:50 000 rivers* to draw the rivers. Use the *more...* button next to each option to access the menu that display more classifications available for the data.

Y2K compliancy

WaterMarque has been updated to be Y2K compliant - where needed.

2. Functionality

Monitoring station selection

The *Select station number* menu has been updated to allow the user to 'build' a list of station numbers to be selected - it previously only allowed for selecting one station number from the list.

Metadata

The option to display the metadata of all the datasets that are used in *WaterMarque* has been added to the help menu

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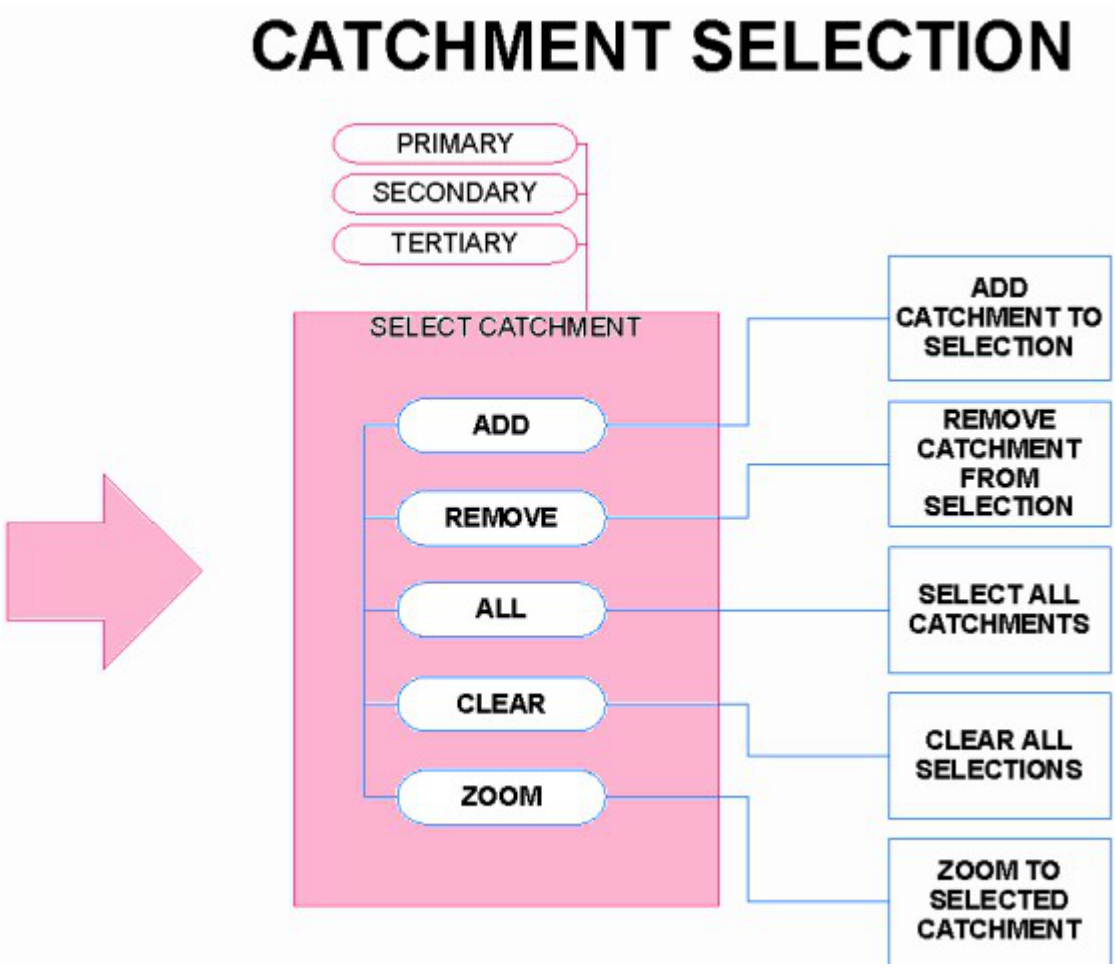
Return to index page

Catchment Selection



WaterMarque is primarily designed to provide information on water quality data at the catchment level. The catchments can be selected at either tertiary or primary level.

Generally, the first task in WaterMarque is to identify the catchment or catchments of interest for the remainder of the session. But remember that the modules can be strung together in any order, and you need not restrict yourself to a logical, sequential order. During the session you may return to the catchment selection menu, and redefine the area of interest once the data has been assessed.

Selecting a catchment

Click on the Redefine catchment icon on the *Main menu bar*. After clicking on the *Redefine catchment* icon, the *Select Area of Interest* menu appears in the upper right-hand corner of the screen. This contains a menu split into four sections :

- Selection settings
- Select, de-select catchments
- Drawing options
- Work icons

Selection settings allow you to define the selection method (point or area) and the selection feature (primary, secondary or tertiary catchments). In general, it is easier to select tertiary catchments immediately and then zoom in on them using the *Zoom* icon. This is found at the base of the menu. Point selection is often easier than area selection. Because of this, point selection is the default option.

The centre section of the menu allows you to select or remove catchments. The following icons are used here:

 allows you to select one or **add** further catchments to your map, the cursor arrow becomes a pair of crosshairs.

 allows you to **remove** catchment numbers from the scrollable list box.

 clears all the catchment numbers from the list box.

 selects all the catchments in the Republic of South Africa

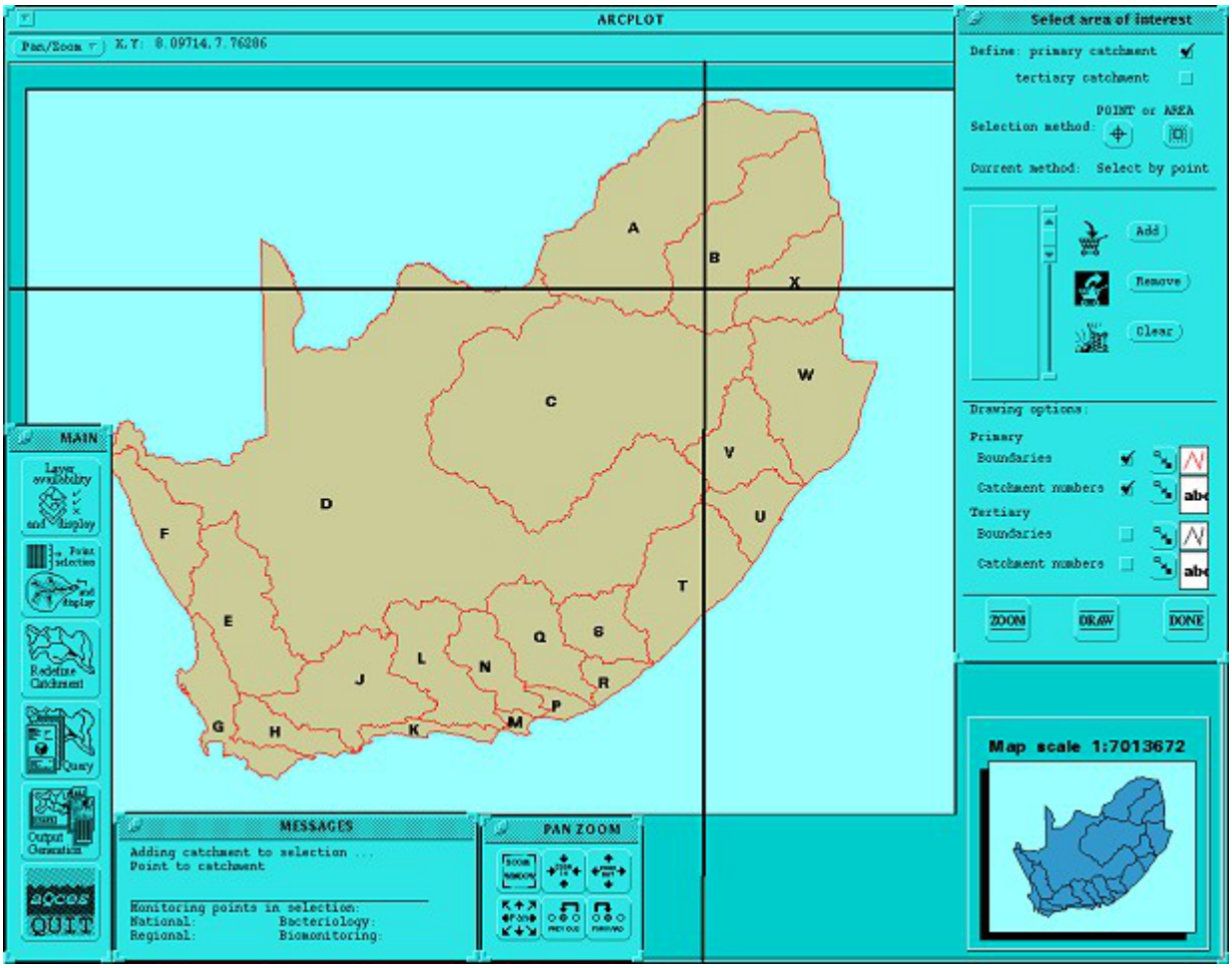
Selecting to display tertiary catchments before you have zoomed in on the primary catchment you would like to work in, may clutter your screen. This also makes the selection of the tertiary catchment more difficult. It is, therefore, recommended that you not do this until you have properly zoomed into the primary catchment.

To select a catchment After clicking on the *Redefine catchment* icon on the *Main menu bar*, the *Select Area of Interest* menu appears and the procedure is as follows :

Click on the primary catchment check box. Whether you choose to work on the primary, secondary or tertiary catchment areas depends entirely on you and the tasks you wish to perform. Whether you wish to select by point or area again depends on whether you want to work solely within a catchment or not.

Click on the *Point Selection Method* icon.

Click on the *Add* icon.



2a The main map showing the primary catchments and crosshairs centred over the B catchment.

Move your cursor over the *Main Mapping Area*. Cross-hairs will appear as the cursor moves into the main mapping area. Click on the catchment you wish to select . The scroll box now contains the catchment number that you selected. During the selection stage the main screen will appear as follows :

Once the selection is complete and the catchment number appears in the selection list on the menu, click on the *Zoom* icon to zoom into the highlighted catchment.

You can now display other catchment boundaries and catchment numbers within the primary catchment. This is done by clicking on the check box to the right-hand side of the required catchment boundaries check box at the bottom of the menu.

Secondary and tertiary catchments are added in the same manner as primary catchments. Click on the *Add* icon and then onto the relevant catchment using the cross-hairs. To add multiple catchments merely repeat the process a number of times.

Alternatively, the *area* option may be used. Click on the *Add by Area* option on the menu and then click on the *Add* icon. When you move your pointer onto the *Main Mapping area* you will be expected to describe an area. This may include as many catchments as you wish.


Should you select two or catchments that are far apart, you may encounter difficulties later on in your session. All monitoring points and attribute data will be selected in accordance with the catchments selected.


Once you have indicated that you wish to select an area or a catchment you **must** do so. There is no option allowing you to exit or escape from the selection procedure. However, you may click on the sea and select nothing. Should you find that you have selected an unwanted catchment, either click on the**Reset to SA** icon on the *Main menu bar*, or use the *Remove* icon.


Clicking on the border between two adjacent catchments or tertiary catchments selects them both.

As you select additional catchments to the scroll box, the catchment most recently selected is highlighted. This display allows you to pick up any mistakes immediately.

Of course, you can select a tertiary catchment straight away by clicking on the tertiary options in the *Select area of interest* menu.

The removal of a catchment is much the same process, except that you click on the *Remove* icon and then on the catchment to be removed. WaterMarque redraws the main display to reflect the current catchment selection.

On completion of the selection procedure, zoom in on the current selection.

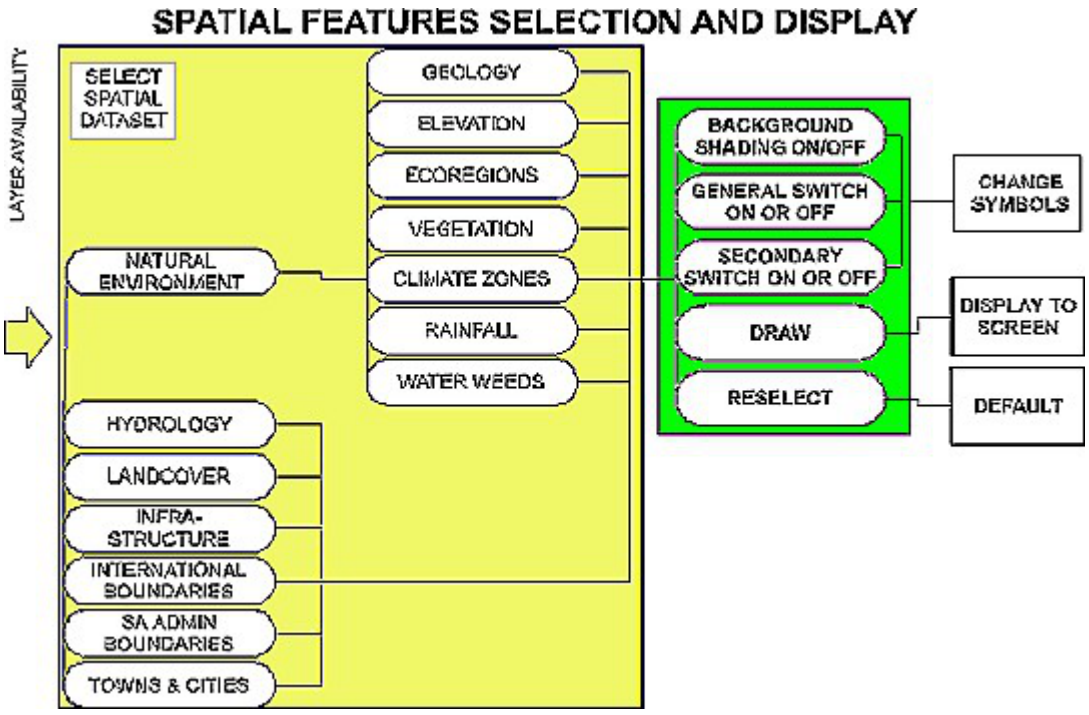
Redraw the screen if you want to select a different area.

or ,

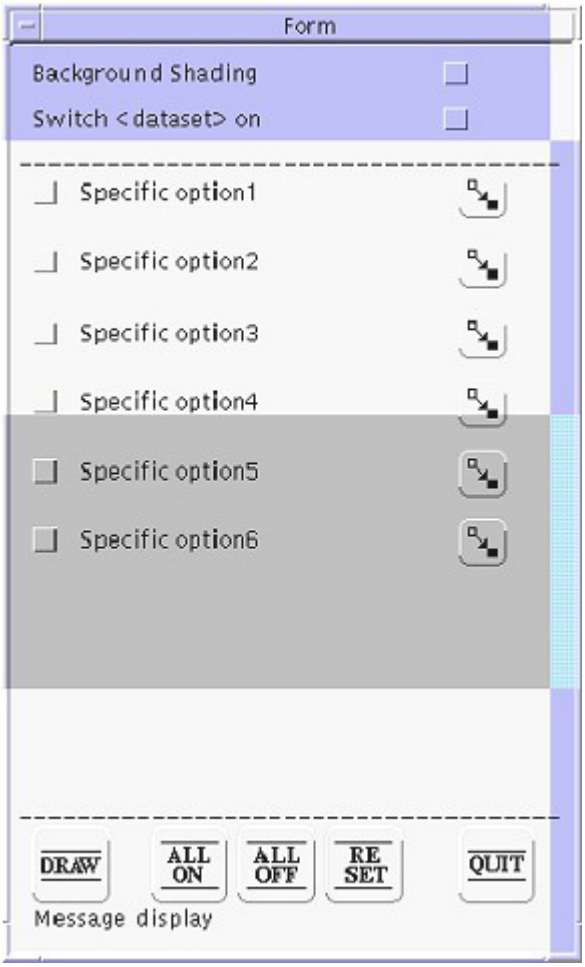
Quit the menu and carry on to monitoring point selection and water quality data display via the *main menu* options.

Return to index page
Proceed to Feature Selection

Spatial Feature Selection and Display



To display additional geographical features on your catchment map, use this module. Each of the menus belonging to this module is structured similarly. All menus in this Spatial Feature Selection display module contain **two general selection switches** which, if inactivated, limit the display of the layers in some way.



3a A model menu of the Spatial Feature Selection Module

The first general selection switch on the menu is the *background shading switch*. It is activated and deactivated by clicking the mouse pointer over the check box situated immediately below the menu title. This switch controls and determines the extent to which the layers chosen are displayed; either all over the display area (not activated) or only to the catchment which you have selected in the Catchment Selection module (activated).

The second general selection switches determine whether or not any of the selections you will make via the specific control switches will be displayed on the screen.

At the base of the module's menus are five icons:

- **DRAW** to draw selections made via the various menu control switches on the screen. If you are not satisfied with a previous draw, either because you selected the wrong coverages or aspects thereof, then selecting this option will remove the old selections and replace them with the new selections that you make.
- **ALL ON** to select all the options at the specific control switch level
- **ALL OFF** to deselect all the options made at the specific control switch level
- **RESET** to reset any changes you have made in the symbols used to represent data visually, to the defaults.
- **QUIT** to leave that menu, and remove it from the screen. This icon does not kick you out of the module, merely returns you to the menu from which you came.


The number of polygon datasets that can be plotted at once is limited. Complete solid fill coverages such as rainfall or landuse obscure background information so only one such layer can be plotted.

Exceptions to this rule include Dams and Urban areas, which can be displayed on top of other layers. The program will automatically place them on top of all other polygon data, whatever the order of selection.

To select spatial features

Click on the Layer availability and display icon in the *Main menu* bar. The*Geographical Features* menu appears. Should the *Geographical Features* menu not be on screen, activate it from the *Main menu* bar. The sub-options are:

- Natural environment
- Hydrology
- Landcover
- Infra-structure
- International Borders
- Administrative boundaries
- Towns and cities

Adding background geographical features to the map areas allows easy recognition of the area. This allows potential impacts on water quality by environmental phenomena to be identified and considered. As the purpose of WaterMarque is to monitor the water quality in South Africa, we will start by selecting hydrological features. Note that you can access the layers either before or after selecting the catchment or monitoring points, depending on your requirements.

In this manual the layers that are accessible directly from this menu are discussed first. Should you click on the *Natural Environment* icon on the *Geographical Features*menu, the *Natural Environment* menu will appear and provide you with a further selection of layers.

To show hydrological features


Click on the *Hydrology* icon on the *Geographical Features* menu. The *Hydrological Features Selection* menu appears onscreen.

There are two main hydrological features datasets:

- S A hydrological features
- DCW features (ESRI Digital Chart of the World)

Commonly, rivers are shown on maps as linear features. In this manual the rivers you can display to screen are drawn from two different data sets. Of these the more useful is the *SA Hydrological Features* menu which allows you to select layers with a scale of 1: 500 000 as opposed to the 1: 1 000 000 DCW. The 1:500 000 river arcs have Strahler order.

To use the SA Hydrological features, click on the check box after the *SA Hydrological features* option. Then click on those features that you wish to select in that sub-directory:

- Weir drainage areas
- DWAF Region Boundaries
- DWAF Region Labels
- 1:500 000 dams
- 1:500 000 rivers
- Stream Order (1 to 7)
- River Names

To select rivers, click on the check box after DCW features, and a tick will appear in the relevant check box. To display International rivers to the screen or map, click on the check box to the left of the *International rivers* option on the menu.


Should you want all the rivers, streams and dams in a uniform colour, use the icons in front of the symbols. Click on the appropriate icon. *A change symbols popup* menu appears. Use the scrollbar to scroll down through the colours until you find a suitable one, then click on the colour you want to use. The colour of the representative symbol will appear in the new colour. Simply click on the *Reset* icon in the lower portion of the menu and the default colours will reappear.

When you have made your selection of the available options click on the *Draw* icon at the bottom of the menu.

When you are satisfied with the map, click on the *Quit* icon.


If you do not wish to slow your session down every time you redraw your screen, activate this general control switch only in your output module.

To show landcover


Click on the *Landcover* icon in the *Geographic Features* menu. Should the *Geographical Features* menu not be on screen, activate it from the *Main menu*bar and the *Geographical Features* menu.

The *Landcover* menu appears.

Click on the check box to the right of the *Switch landuse on* option.

Click on the check boxes to the left of the options you select.

Once you have selected the landcover you wish to display, click on the *Draw* icon to present them to screen.


If you do not wish to slow your session down every you redraw your screen, activate this general control switch only in your output module.

To show infrastructure bridges, roads, railway and utility lines


Click on the *Infrastructure* icon on the *Geographical Features* menu. Should the *Geographical Features* menu not be on screen, activate it from the *Main menu*bar and the *Geographical Features* menu. Click on the *Infrastructure* icon.

The four main options are:

- Bridges
- Roads
- Railways
- Utility lines

To select all of the sub-directory options click on the check box following the main option. For example, if you click on the box following **Roads**, all four types of roads will be selected as shown by the ticks which appear in the check boxes in front of them, tracks, trails and footpaths included.

If tracks, trails and footpaths are not of interest and only clutter up your map, switch off this option by clicking on the tick on the box in front of it. The tick will disappear and this option will not appear on the map.

Select the features you want to appear on the map.

Click on the check box following the *Bridges* option, should you want to have bridges indicated on your map. If not, ignore this option.

Click on the check box to the right of the *Roads* option, only if you want to include all the road options. Otherwise click on the check boxes of the more significant road options such as dual lane highways and primary and secondary roads.

Click on the check box to the right of the *Railways* option if you want to include all the available railway options including light duty and urban area connectors. If you want to indicate only the larger, more important railway lines, click on the check boxes in front of the *Multiple track* and *Single track* options.

Click on the check box to the right of the Utility line option if you want to indicate all the *Utility line* options on your map. If not, ignore the main *Utility lines* option and click on the check boxes to the right of each option you select.

To show international boundaries

Click on the *Political Boundaries* icon on the *Geographical Features* menu. Should the *Geographical Features* menu not be on screen, activate it from the *Main menu*bar and the *Geographical Features* menu. Click on the *Political Boundaries* icon.

The *Southern African Countries* menu will appear in the upper right-hand corner of the screen.

This is one occasion where the *Background shading* option is useful, so start by clicking on the check box after this option.

Click on the check box after the *Switch countries on* option.

Here you do not have the option of choosing the countries individually. You do however have the option to change the colours in which the countries are shaded. To make the states you do not wish to display invisible, and maintain those that are required, use the *change symbol* icon and the popup menu to shade the unnecessary states the same colour as the ocean or your background.

Click on the *Draw* icon. When you are finished, click on the *Quit* icon at the base of the menu.

To show towns and cities

Click on the *Towns and cities* icon on the *Geographical Features* menu. You can activate the *Geographical Features* menu through the *Main menu bar*.

The *Urban Areas* menu will appear in the upper right-hand corner of the screen.

The menu contains the following selections:

Urban Points: Location.
This option allows you to select between:

- major cities
- minor cities

This selection is derived from the DCW data and is not suited for the viewing of data over the whole country. It is best suited to viewing in the localised catchments, as it is highly detailed. The major cities can be viewed at any scale.

Urban Points: Annotation

The minor cities option provides annotation of city and town names to the points on the display in the Urban Points location selection. Again the minor cities are best selected after one has selected and zoomed into a catchment.

Urban Areas:

This option allows you to select urban settlement polygon data. This shades the land area covered by urban settlement. It can be used together with the point annotation option, or, each polygon can be individually annotated if you chose annotation with urban areas.


You can indicate the position of a feature by clicking on the check box to the right of the *Location* option. If you want to name the feature click also on the check box to the right of the *Annotation (name!)* option.


It is better to use rather too few landmarks than too many and to name only those provinces, towns, cities and landmarks that are important to orientating the map user. The final map size will also influence the number of features that can be easily seen on a map.

When you have selected the options you wish to see on your map, click on the *Draw* icon at the base of the menu.

When you are satisfied with your choices, click on the *Quit* icon at the base of the menu.


If you do not wish to slow down your session every time you redraw your screen, activate the general control switch only in your output module.

To show administrative boundaries

To add administrative boundaries to the map click on the *Administrative Boundaries* icon on the *Geographical Features* menu. Should the *Geographical Features* menu not be onscreen, activate it through the *Main menu*bar. Click on the *Administrative Boundaries* icon.

The menu is divided into two main sections :

- Administrative boundaries: location,
- Administrative boundaries: annotation.


The Location Facility is fully functional. But you can only name the South African provinces using the Annotation facility and not the farms or magisterial districts. This data may be incorporated into later versions of WaterMarque.

To show natural environment features

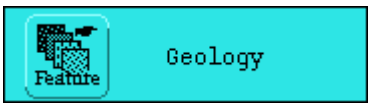
To add natural environment features to your map, click on the *Natural Environment* icon on the *Geographical Features* menu. Should the *Geographical Features* menu not be present, activate it through the *Main menu bar* .

The *Natural Environment* menu will appear in the upper right-hand corner of the screen.

The features which are listed and may be chosen to appear on your map include:

- Geology
- Elevation
- Ecoregions
- Vegetation
- Climatic zones
- Rainfall
- Water weeds

To show geological features



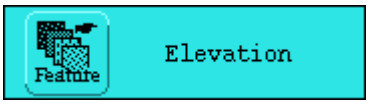
Click on the *Geology* icon in the *Geographical Features* menu to activate this menu. Should it not be present onscreen activate it through the *Main menu* bar.

The *Geological groups* menu consists of sixteen check boxes. Each check box displays a rock layer or rock type e.g. compact arenaceous and argillaceous strata. These are hydrogeological classifications. The full geology coverage will be available in a later version of WaterMarque.

When you have made your choice, by selecting the secondary control switches relevant to the layers you wish to display, click on the check box at the top of the menu where it says *Switch geology on*. Then click on *Draw* icon at the base of the menu.

If you do not wish to slow your session down every time you redraw your screen, activate this primary control switch only in your output module.

To show elevation



Click on the *Elevation* icon on the *Natural Environment* menu. This is activated through the *Main menu* bar and the *Geographical Features* menu. Elevation is displayed and manipulated through the *Hypsographic Features* menu. The display selections you have access to are:

- Contour lines
- Contour heights
- Elevation

Select any or all of these options by clicking on the check boxes in front of the individual options.

Contour lines are linear features joining points of equal heights.

Contour Heights are Point Features which are displayed to the map as points associated with heights given in metres on the screen. Selecting this option is best done after one has zoomed into the catchment one would like to work in as the data is very detailed. The points and numbers associated with this function are not autoscaled.

Elevation is indicated onscreen by means of shading. The elevation range of the country is divided into separate bands (0, 200, 400, 1000, 1500, 2000, 3000, 4000 metres above mean sea level) each having its own colour.

To show ecoregions

To display these to your map click on the *Ecoregions Feature* icon on the *Natural Environment* menu.

The *Ecoregions* menu appears on screen. The 26 Ecoregions are homogenous ecological units having a relatively uniform impact on water resources under pristine conditions. Ecoregions are determined by geology, elevation, rainfall and vegetation. The large number of Ecoregions means that only half the menu appears at a time. Notice the *More* icon located at the bottom of the menu. This icon enables you to activate the *second Ecoregions* menu. Similarly on the *Final Ecoregions* menu there is also a *More* icon which enables you to activate the *First Ecoregions* menu.

There are five label options to accompany your choice of ecoregion layers. You can use only one at a time on your map:

- Ecoregion numbers
- Ecoregion vegetation types
- Ecoregion geology groups
- Ecoregion altitude numbers
- Ecoregion rainfall numbers

The labels will occur as area attributes within each region, naming different areas according to their characteristics.

If you do not wish to slow your session down every time you have to redraw your screen activate this primary control switch only in your output module.

You might find that the labels you have chosen through the label attributes section of the menu may not occur within your catchment map. This is especially likely to occur when the ecoregion is large and covers many primary catchments. This is not to say that there is no attribute data to accompany the layer but that it falls outside the map. To rectify this, zoom out slightly to include the label in your map presentation.

You can also overcome this by zooming out using the *Zoom Out* icon (top right-hand icon on the *Panzoom* menu) until the label occurs on your map. Click on the *Zoom Out* icon. Repeat these steps until the label appears.

To show vegetation types

Click on the Vegetation icon on the *Natural Environment* menu. This is activated through the *Main menu*bar and the *Geographical Features* menu.

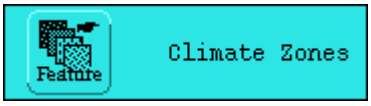
The *Vegetation Types* menu will appear.

The 12 vegetation types listed in the menu are those defined on the 1982 J.P.H. Acocks *Veld Types of South Africa* map.

The default colours selected to represent the vegetation types are approximately those used by Acocks.

When you have made your selection, click on the *Draw* icon at the base of the menu. If you are satisfied with the map, click on the *Quit* icon at the base of the menu. If dissatisfied, select new options and click on *Draw* once more.

To show climatic zones



Click on the *Climatic Zones* icon on the *Natural Environment* menu. This is activated through the *Main menu*bar and the *Geographical Features* menu.

These zones were developed by the Department Engineering, University of Natal (see copyright section) and include rainfall, slope and aspect. There are 712 Climatic zones in South Africa. None of the climatic data is available in this version of WaterMarque. The zones have, however, been classified into 15 groups: 1-50, 51-100, 101-150,151-200, 201-250, 251-300 and so on to 701-712.

To display the climatic zones on your map, click on the check box following the *Display climatic zones* option at the top of the menu.

When you have made your selection, click on the *Draw* icon at the base of the menu. If you are satisfied with the map, click on the *Quit* icon at the base of the menu. If dissatisfied, select new options and click on *Draw* once more.

To show rainfall data

Click on the *Rainfall* icon on the *Natural Environment* menu. This is activated through the *Main menu*bar and the *Geographical Features* menu. The *Rainfall* menu will appear.

The intervals chosen here are 100 mm, which may be too coarse for water monitoring purposes at the catchment scale.

Once again the default colours selected are those that are used as standard indicators of varying rainfall values.

When you have made your selection, by selecting the specific control switches relevant to the layers you wish to display, click on the *Draw* icon at the base of the menu.

If you are satisfied with the map, click on the *Quit* icon at the base of the menu. If dissatisfied, select new options and *Draw* once again.

To show water weeds

As water weeds can cause problems in both waterbodies and waterways, a database indicating their presence or absence is being compiled and is included in WaterMarque. The database supplied is a digital copy of a once off survey in 1991. This is now out of date, and not spatially verified.

To include this data on your map, click on the *Water Weeds* icon on the *Natural environment* menu. The *Water weeds* menu will appear.

The water weeds monitored here include:

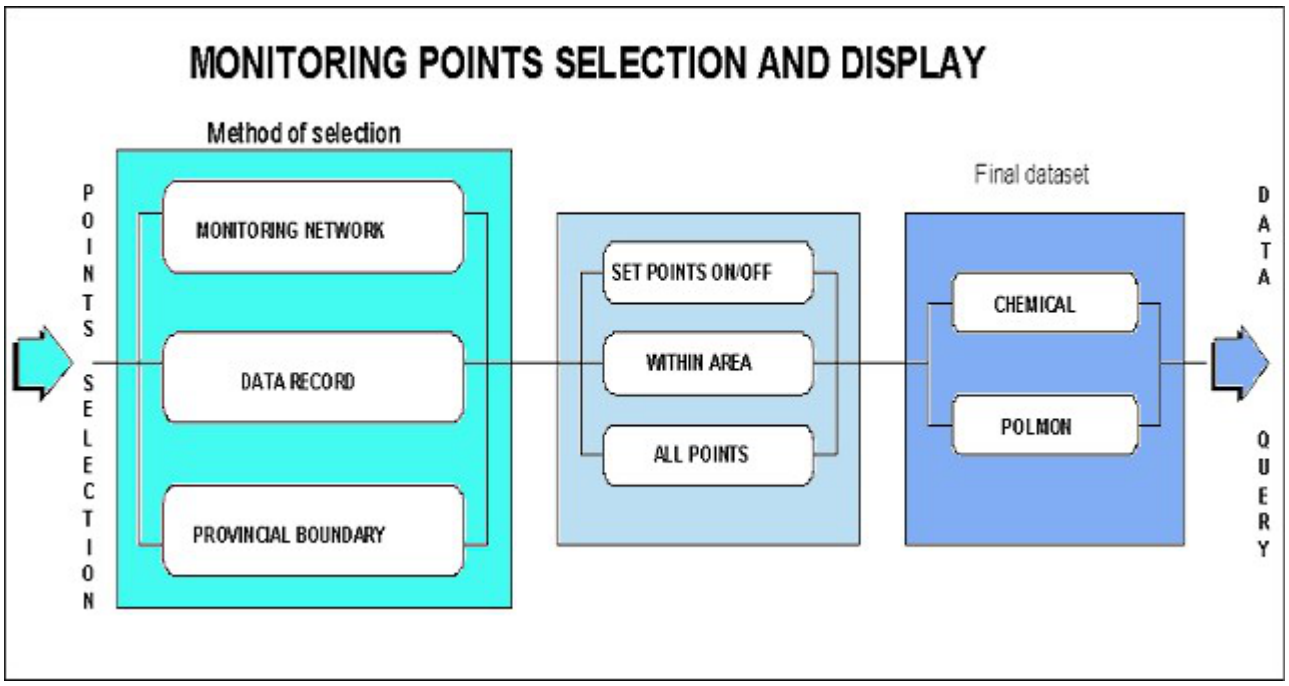
- *Salvinia molesta* (Kariba weed)
- *Pistia stratiotes* (water lettuce)
- *Azolla filiculoides* (red water fern)
- *Myriophyllum aquaticum* (parrot's feather)
- *Eichhornia crassipes* (water hyacinth)

The colours representing them on the chart are arbitrary, but the marker symbols represent the actual plants.

When you have made your selection, by selecting the secondary control switches relevant to the layers you wish to display, click on the *Draw* icon at the base of the menu. If you are satisfied with the map, click on the *Quit* icon at the base of the menu. If dissatisfied, select new options and click on *Draw* once more.

Return to index page
Go to Monitoring Point Selection and Display

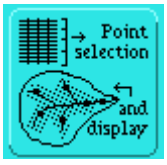
Monitoring Point Selection and Display



Water quality monitoring points can be selected in four ways :

- by monitoring network (either National or POLMON.)
- by data record
- by provincial boundary

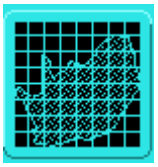
To select monitoring points



To select monitoring points, click on the *Point selection and display* icon on the *Main menu bar*.

The *Method of selection* menu appears in the upper right-hand corner of the screen...

To select points by Monitoring Network



Click on the top button to the right-hand side of the *Monitoring Network* option. The *Monitoring points* menu will appear.

Click on the *Switch Monitoring Points On* check box at the top of the menu. You can now choose if you want to display the points :

- within your selected catchments only
- over the whole country

Below this section of the menu are the numerous monitoring networks from which you can choose. Monitoring networks are stored as point features and are displayed as small square features on the screen. Their colour is dependent on the monitoring network they belong to and the colours for these are not fixed. If you attempt to select more than one monitoring network or more than one aspect of the monitoring network, your previous choices will be deselected. WaterMarque changes the points on screen as you select networks. For example, clicking first on the *All* option under the *National Monitoring Network* option will bring a large number of monitoring network points to screen. Should you now select the stream monitoring points (i.e. a subset within National), the points on screen will disappear. Those points from your first selection that are *National Stream Monitoring points*, will be represented by red points, as the default colour.

The monitoring networks available are:

National :

- All
- Rivers
- Reservoirs

Regional (POLMON):

- All
- Highveld
- Transvaal
- Natal
- Free State
- Eastern Cape
- SW Cape

Some other possible monitoring networks are:

- Ground Water
- Estuaries
- Springs / Eyes
- Canals
- Flow Data

but these monitoring networks are not implemented in this version of WaterMarque.

To further refine your selection use the following buttons:

One -allows the user to select one monitoring station from the dis play screen
Many -allows the user to select many monitoring stations from the dis play screen. Press 9 to quit.
Box -allows the user to select monitoring stations within an extent b y indicating the corners of a box on the display screen
Station number -allows the user to pick a station number from a scrol ling list in a menu
Reset -resets the selection set to the setting on the menu

The *Selected stations* scrolling list contains the station numbers of the currently selected monitoring stations.

Once you have selected the monitoring network you wish to assess, click on the *Done* icon at the bottom of the screen. A single monitoring station, particularly a National monitoring station, is often used to monitor several different characteristics of water quality. Thus, if you select the different options in turn in this menu, you will see the same point on the map change colour to indicate that the different characteristics are being monitored at the same point.

The next menu to appear to screen is the *Final Dataset* menu.

Selecting monitoring points by Data Record

Click on the *Data Record* icon on the *Method of Selection* menu. Activate the *Method of Selection* menu through the *Point selection and display* icon on the *Main menu bar*.

Then click on the *Data Record* icon. The *Data Record* menu will appear in the upper right-hand corner. To select monitoring points based on data records:

Click on the check box to the right of the *Set monitoring points on* option.

Select either :

- Within area, or
- All points,

by clicking on the relevant check box following your choice.

Select your points by data type.

In this you have a choice of:

- Inorganic
- Trace Metals
- Organic
- Trihalomethanes
- Biomonitoring
- Habitat Diversity
- Algal Identification
- Invertebrates
- Bacteriology
- Flow
- Polmon

Table 1. Substances or characteristics monitored (shaded items not available in WaterMarque)

Categories of substances or characteristics monitored	Examples of some of the water quality variables measured in each category
Inorganic chemicals	Ammonia Boron Calcium Chloride
Trace metals	Aluminium Antimony Arsenic Barium
Organic substances	Biomass mg/l Chlorophyll *a* microgram/l Phaeophytin microgram/l
Trihalomethanes	Bromoform Chloroform Dibromochloromethane
Biomonitoring	ASPT - Average score per taxon DO - Dissolved oxygen HQI - Habitat quality index
Habitat diversity	Bank erosion potential Bank vegetative stability Bottom scouring and depth
Algal identification	Chlorophyta - Actinastrum Chlorophyta - Ankistrodesmus Chlorophyta - Carteria
Invertebrates	Annelida - Hirudinea Annelida - Oligochaeta Coelenterata - *Hydra* spp
Bacteriology	Enteric coliforms Faecal coliforms

	Faecal streptococci
Flow	Daily flow in cumecs Maximum monthly flow Mean monthly flow
POLMON	Alkalinity - total Aluminium - dissolved Aluminium - suspended Aluminium - total

Your selection of the dataset will be determined by your purposes and tasks. As you select the points by data type you will notice that the scroll box at the bottom of the screen is continually updated.

Look at the *Set data record per point* options section of the the menu. Do you want :

- data for all the points extracted regardless of the number of records for
- data extracted only where the number of records exceeds one?
- to select monitoring points for which no data exists?
- to select a range of data available for each point where especially large data sets exist, giving the range minimum and maximum.

To further refine your selection use the following buttons:

One -allows the user to select one monitoring station from the dis play screen
Many -allows the user to select many monitoring stations from the dis play screen. Press 9 to quit.
Box -allows the user to select monitoring stations within an extent b y indicating the corners of a box on the display screen
Station number -allows the user to pick a station number from a scrol ling list in a menu
Reset -resets the selection set to the setting on the menu

The *Selected stations* scrolling list contains the station numbers of the currently selected monitoring stations.

In the present version of WaterMarque, only one monitoring network dataset can be assessed with at once, although several variables within a particular dataset category may be processed simultaneously.

If you wish to interrogate the regional (POLMON) monitoring networks further, select the *POLMON in more detail* menu. Different menus will appear with a similar format to the data record menu, which you can switch between.

Finally, if you are satisfied with your selection, click on the *Done* icon. The *Final Dataset* menu will appear.

POLMON figures are available for all regions.

If you are dissatisfied with your selection, click on the *Draw* icon which will clear all data selected here and you can start again.

Selecting Monitoring Points by Provincial Boundary

Click on the *Provincial Boundaries* icon on the *Method of Selection* menu. Activate the *Method of Selection* menu through the *Point selection and display* icon on the *Main menu bar*.

The *Provincial Boundaries* menu appears on the screen.

To select monitoring points within Provincial Boundaries:

Click on the check box to the right of the *Set Monitoring Points on* option.

Select either :

- Within area, or
- All points,

by clicking on the relevant check box following your choice.

Select the Province for which you want data displayed, either:

- Northern Province
- Mpumalanga
- North West
- Northern Cape
- Gauteng
- Free State
- Kwazulu Natal
- Eastern Cape
- Western Cape

To further refine your selection use the following buttons:

One -allows the user to select one monitoring station from the dis play screen
Many -allows the user to select many monitoring stations from the dis play screen. Press 9 to quit.
Box -allows the user to select monitoring stations within an extent b y indicating the corners of a box on the display screen
Station number -allows the user to pick a station number from a scrol ling list in a menu
Reset -resets the selection set to the setting on the menu

The *Selected stations* scrolling list contains the station numbers of the currently selected monitoring stations.

In the present version of WaterMarque, only one dataset category can be dealt with at once, although several variables within a particular dataset category may be processed simultaneously.

Selecting Monitoring Points by DWAF Regions

Not implemented (restructuring of DWAF was taking place) - 1997-03-01 -

Selecting Your Final Dataset

The process of selecting your final dataset can be seen as a confirmation procedure. It allows you to check that the selections that you have made in the previous menu are correct and provides you with an intermediary step before beginning to analyse and later plot your data. Should you wish at this point to :

- reselect the data, or,
- add additional datasets,

go back to the relevant monitoring networks to do so.

To select the current selection for any of these datasets, click on the check box following the *current selection* option in the relevant dataset. You cannot select more than one dataset.

If satisfied with your selection, click on the *Done* icon

If dissatisfied, click on the *Resel(*reselect) icon and start again.

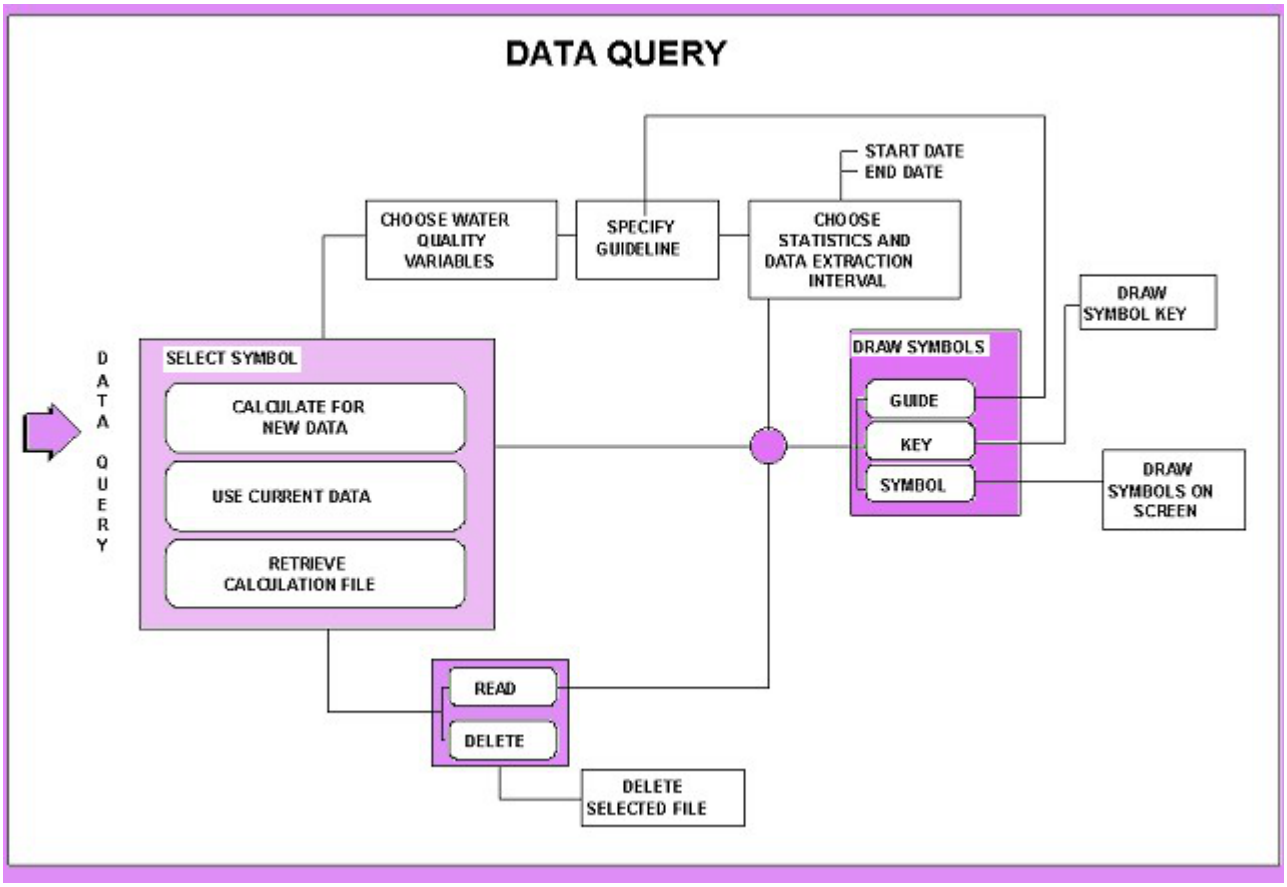
The selection sets created from one method of selection will not be kept when switching to another method of selection.

If you click on the *Done* icon, the *Final Dataset* menu will appear. The user can now verify to either use the inorganic selection set or POLMON selection set to continue.

The following menu is the first menu of the Data Query module. All following menus will be discussed fully in the next chapter even though they can be accessed through the Monitoring Points selection and display module, as well as the selection of *Data query* icon on the *Main menu bar*.

Return to index page
Go to Data Query

Data Query



The modules previously discussed are fairly straightforward and explanatory. The Data Query module is more complex. It includes the selection of water quality variables, guidelines, and statistical analysis methods.

Should you have no data subset saved you may still enter the Data Query Module and select the data that you would need in order to produce a map. Should you not save sessions or point selections which you often use, you may never have need of this module as its functionality is incorporated into the Point Selection And Display Module.

The menu to select the symbols for analysis of water quality variables is the *Symbols* menu, either POLMON or Inorganic. To activate it:

- Click on the *Data Query* icon on the *Main menu* bar.The *inorganic symbols* menu appears.

You can also reach it from the point selection and display module. Select a symbol from the *Symbols* menu, one which best suits your purposes. Click on the icon to the right-hand side of the graph or diagram you want to use.

Eleven options are available for data presentation, roughly divided into two groups:

- Single water quality variable symbols
- Multiple water quality variable symbols

These different symbols are best used to display different segments or statistics of the recorded data. The symbols to be used must be selected now, as it is essential to know what you want to extract from WaterMarque. Afterwards, as your inquiry deepens, you can go back to this menu and reselect another diagram type for specific purposes. As we shall see, the use of the symbols iterative process. The symbols indicated initially on the *Symbols* menu are the spot and pie diagrams. These are excellent screening tools enabling you to determine the quality of the data record for each monitoring station.

Single water quality variable Symbols

Spot Diagrams

Spot diagrams display one water quality variable statistically summarised over a user determined period of time. For example, we could display calcium concentrations over a six month period against a certain user defined guideline. The guideline selected may be either the default or a user defined guide.

The diagram appears as a coloured circle on the map at the position of the monitoring station or in a space next to the map, as defined by the user. The colour of the diagram shows the exceedance or compliance of the data to the set guideline.

The size of the diagram depends on the magnitude of the statistic. For example, a monitoring station has records for calcium water quality variables which for 75 per cent of the record exceed the guidelines. It will appear **red**. Let's say it has in the 75th percentile of the data a reading of 4000 mg/l. Another monitoring station has in the 75th percentile a reading of 400 mg/l. This happens to be well within the required guideline, so it appears on the screen in **blue**. The first station will appear onscreen as a circle which is ten times the area of the second, because the units measured there at the set statistic exceed that of the second by a factor of ten. The spot areas (not diameters) increase linearly with concentration.

Click on a check box in the *select colours* menu to display the numerical value of the 75th percentile (i.e. 400 or 4000) on the symbol. You can also display the water quality statistic on top of the spot symbol, if the exact number is of concern to the report.

Pie Diagrams

Pie diagrams display information about one water quality variable over a user determined period of time. The greater the number of records for that water quality variable, the greater in size will be the pie diagram. As such the pie diagrams are essentially a counter mechanism. The colours of the diagram are determined by the exceedance or adherence to a user defined guideline. Pie diagrams differ from the spot symbols in that they are not affected by any selection of statistic.

The slices within the pie indicate what proportion of the data at that monitoring point is in exceedance or compliance with the data. The exceedance and compliance are indicated by the colours of the slices.

The user can decide to display the actual number of data records at a particular station through the *Change Colours for Symbols* menu. The number will appear on the surface of the pie. The use of this facility is not recommended for output purposes as the number being displayed to screen may obscure the diagram, especially small slices within the diagram.

For a few monitoring stations within a small catchment, pie diagrams are a useful facility.

Water Use Symbols

The Water Use symbols are an IWQS specific markerset, mostly designed to display the exceedance or adherence to user defined guidelines. The symbols are of different colours depending on the position of the statistic chosen, as compared against the guidelines set.

Should you select an industrial or agricultural guideline the symbols will correspond to that selection. For example, a selection of agricultural guidelines produces plant and animal symbols on the screen.

Box Plots

Box plots used in WaterMarque correspond to the standard box and whisker plot used in graphics packages. Box plots display one variable over a user defined period of time. The main body of the Box Plot corresponds to the 25th percentile and the 75th percentile of the data record at that point. The whiskers indicate the position of the 5 th and the 95th percentiles.

The colours displayed within the boxes are user defined and show compliance with the guidelines. For example, if the 30th percentile in the data exceeds the maximum set by the guideline, the box will be shaded **red** from that point

upwards.

Box Plot Graphs

Box Plot Graphs are time-series graphs composed of annual box plots. The graphs display one variable over a number of years. Each box plot displays the data record for that monitoring point over a period of a year. This option allows the user to find trends in the data over a period of years. The data can then be re-evaluated in a time series graph. The relative sizes of the box plots in the graph represent variability in the data.

Radial Box Plot Graphs

Radial box plot graphs display data for one variable over a period of several years. Colours and proportions of the box plots are similar to the box plots discussed above. The resultant diagram is a circular box plot with each year indicated on the diagram. Radial box plots are more compact than ordinary box plot graphs.

Time Series

Time Series Graphs display one variable for a user defined period of time. It is a standard line graph with *x* and *y* axes. The *x* axis represents time and the *y* axis the water quality variable selected by the user. Guidelines can be displayed as horizontal lines, in a different colour to the rest of the diagram. The use of the diagram can lead to some clutter on the map but it is a useful tool in the analysis of 'raw data'. After initial assessments have been made using this tool, more concise and specific symbols can be used to output the results. Time Series are best displayed in the separate area off the main body of the map, with connecting lines to the monitoring points.

Multiple water quality variable symbols

WaterMarque uses three kinds of multiple water quality variable presentation symbols:

- Maucha diagrams
- Rose diagrams
- Star diagrams

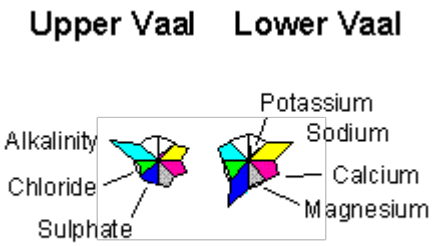
These diagrams are used to display at least two and as many as twelve different water quality variables.

Maucha Diagrams

The Maucha diagram is a very specific symbol designed to display a set number and a set group of water quality variables. It displays three anions and four cations. A proper understanding of this symbol is required before use. The most important feature of the Maucha symbol that differs from the other symbols is the way that it uses the time period selection. The Maucha module **takes only the *first* valid sample** in the selected time period for plotting. To ensure that you have data comparable between, monitoring points, therefore, choose a short time interval in the data selection fields.

The Hungarian geochemist, Rezso Maucha, used this symbol in the 1920s and 1930s to summarise the major ions in water. It allows rapid comparison of the major solutes in different water samples. The diagram is ingenious but tedious to construct manually, and consists of an eight-pointed star symbol with the anions (negatively charged ions) on the left and the cations (positively charged ions) on the right. Concentrations are represented in milli-equivalents per litre (meq L^{-1}) so that the balance of cations and anions can be seen at a glance--no stable water sample should have a surplus of positive or negative charge. The background circle shows what a sample would look like with precisely the same number of equivalents for each major ion.

In the 1960s, limnologists modified the symbol so that its size is proportional to the total dissolved salt (TDS) concentration. In WaterMarque, the carbonate and bicarbonate ions have been combined into a single total alkalinity spike, because of problems distinguishing between the two in a preserved sample. The Maucha diagram is now a powerful method for summarising TDS and ionic composition in one symbol. The interpretation of the symbol is illustrated in the following two diagrams from the Vaal River:



Rose Diagrams

Rose diagrams are used to display more than one water quality variable simultaneously. A minimum of two variables must be selected. Up to twelve water quality variables can be displayed at one time.

A circle represents the guidelines for each water quality variable selected and the data is normalised to the circle. Any exceedances are indicated as **red** petals.

Star Diagrams

Star diagrams are used to display more than one water quality variable simultaneously. A minimum of two must be selected. Up to twelve water quality variables can be displayed at one time. The star diagram is based on a circle representing the guidelines for each water quality variable selected and the data is normalised to the limit. Any exceedances are indicated as **red** blades outside the circle.

Using multiple water quality variable symbols

In most scenarios, the water quality variables and the ranges differ. For this reason, the symbols normalise the data to allow for comparative visualisations of different water quality variables on the same symbol.

As a result, neither the absolute values nor any indication of the actual data can be determined from Rose and Star symbols. The size of the blade or petal is not proportional to water constituent concentrations, which is the basis of all the single water quality variable symbols (spot, pie, etc.).

The Maucha symbol represents ionic rather than molar or mg/L concentrations.

Note that the name of your choice now appears beside the *current* prompt below the presentation symbols, to confirm your choice.

Now you must either choose *new data* or *reuse data* chosen previously.
Always select *new data* for Maucha symbols!

- To select new data, click on the check box following the *Calculate for new data* option:
- To use your current data selection, click on the check box following this option.
- To retrieve a calculation file click the check box.

Click on the *Done* icon.

If you have chosen to select new data

If you choose to select new data, and you have chosen the Inorganic dataset, the *Inorganic Symbols* menu will appear.

If you have chosen to use the current data selection option

If chemical datasets and *Use Current Data Selection* options were selected, then the next menu to appear is the *Choose statistic to draw symbol* menu discussed in conjunction with the diagram or graph type in the following sections.

If you have chosen to retrieve a calculation file

In certain circumstances you will find it necessary to save your session selections and either:

- exit your session, or,
- work elsewhere within it


In order for you to retrieve saved data it is necessary for you to have previously saved a session!

The data saved by the *save* function comprises the catchment selection, the monitoring point data type and the water quality variables chosen. Click on the appropriate check box.

- Retrieve Calculation file

The *Data for symbols* menu will appear on screen. The menu consists of: a scrollable list box, a file description and some functionality icons, which are found at the bases of most of the WaterMarque menus.

The scrollable list box contains all the files in the directory to which you have saved such session information. If you have no information saved to these directories, the scroll box appears empty.

Below this you will find the description defining aspects of the saved data such as

- Which Catchments were selected
- Number of Points
- Start Date
- End Date
- Pointset
- Increment
- Sampleset
- Extra Percentile
- the Guideline, and
- Owner.

Select the file that you wish to work in. You can now choose either to delete the file or read it into your current session.

- Deleting the file will instruct the system to do just that.

The file will be removed from the working directories.

- Should you choose the second option you will be returned to the *Inorganic symbols* menu. You will notice in the lower portion of the menu that a tick has been placed by WaterMarque over the check box corresponding with the *Use Current Data selection* check box.

Click on the *Done* icon.

Select water quality variables

To select water quality variables, click on the check boxes of the members of the *Water Quality Variables* menu. You may wish to select only a few in which case selecting by pointer is most suited.


If you become involved in an in depth inquiry and wish to investigate the concentrations of many water quality variables, select them all now to prevent having to come back later and selecting them. There is no obligation for you to plot all water quality variables selected. Select all the water quality variable you might need now. If you need them all click on the *All On* icon. Change your mind or want to clear your present choices, click on the *All Off* icon. When satisfied with your selection, click on the *Done* icon.

Define water quality guidelines

The *Define Water Quality Guidelines* menu appears.

The water quality variables that you selected *in Inorganic Water Quality Variables* menu, are already listed in this menu.

It is necessary to define the minimum and maximum guidelines for use of these water quality variables. Maximum and minimum concentrations of different variables are the guidelines against which the water monitoring data is compared and assessed. The guidelines are necessary as points of reference. Different standards exist for the five recognised water uses e.g. Domestic.

To select the guideline against which the data will be compared, click on the *Guide* icon near the upper left-hand corner of the menu (centre the cursor arrow on the *Guide* icon and press the left mouse button once).

A popup menu called the *Guideline selection* menu appears with five options:

- agriculture
- domestic
- industry
- recreation
- (environment - not yet available)

Click on any one of these options, e.g. agriculture.

A second popup menu now detailing uses within that section appears.

Note that the selection has been listed on this popup menu as

Use 1: Agriculture,
so that you cannot become confused. Further Use labels will appear should you select aquaculture as an additional class requiring guidelines.

Click on the appropriate menu item . It will become highlighted. It will also appear next to Use 2: on the *Guidelines for water quality* menu. Numbers will now start appearing next to the water quality variable listed in that menu.

Had your original choice been industry, your second popup menu would have included industry subsets such as:

- iron and steel
- leather and tanning
- petrochemical
- power generation
- pulp and paper.

Numbers start to appear beside the variables selected in the *Inorganic Water Quality Variables* menu, which are already listed in this menu.

Note that not all the variables have guidelines for all water uses as some water quality variables are simply irrelevant to some water uses e.g. conductivity in noncontact recreation. You can type in guidelines if you wish to do so.

The second popup menu to determine the water variable guidelines appears.

Now click on the *Done* icon. The *Data Extraction Intervals* menu appears.

Define data extraction intervals, statistical analysis and sampling level

Please note that there are three sets of information required on the *Data Extraction* menu:

- the date range of collected data be analysed.
- the extraction intervals at which the data should be sub-sampled. This is only important for time-series graphs, box plot graphs and radial box plots. For spot, pie, water use, star, Maucha, rose and box diagrams, the

interval is unimportant so we click on none.
- the sampling level - all the samples or only one sample per month.

Finally click on *Done*.

Choosing the Statistic

The *Choose statistic to draw symbol* menu appears. Select the portion of the data that you wish to analyse. If you selected a single water quality variable symbol then you will have to select the water quality variable on this menu. Do this by clicking on the variable you would like to analyse in the scroll box in the middle of the menu.

If you selected a multiple water quality variable then you will simply have to switch on the variables as you wish to display them. To do this, simply click on the check box next to the correct variable.

The statistics that you can choose to display and use to analyse the data are:

- minimum
- maximum
- arithmetic mean
- geometric mean
- median
- standard deviation
- percentiles (5, 10, 25, 50, 75, 90, 95)

You also have the option of a user-defined percentile, created by simply clicking on the insert point before the field and typing in the value.

In the scroll box below the statistic area, choose the water quality variable you wish to analyse. The selected variable will appear in the menu section below this with the guidelines set.

This menu also requires you to select the position of the symbol to be drawn, either at:

- the monitoring points on the map, or
- in a separate area (to the right of the main mapping area).

WaterMarque can draw a maximum of 14 symbols in this area.

For clarity, you may link the monitoring points to the area to the right of the map where the symbols will be plotted. To link the symbols to the map click on the *link symbols to the map* check box.

Choosing to draw the symbols to the map or the area to the right of it is one thing you will have to consider. The drawing of symbols to the map may obscure the presentation of the final output. On the other hand, should you choose to select the separate area option you are restricted to displaying 14 symbols. Remember that many of the tertiary catchments may have up to 60 points and you will have to find some way to thin out the population, or, simply keep your symbols with the map.

At this point you may wish to exit your session to work on another aspect of selection or you may wish to end your session on WaterMarque.

For these purposes, this menu has been equipped with a *Save* icon on the bottom of the menu.

If you elect to save the session, be aware that the information that you are saving is the following:

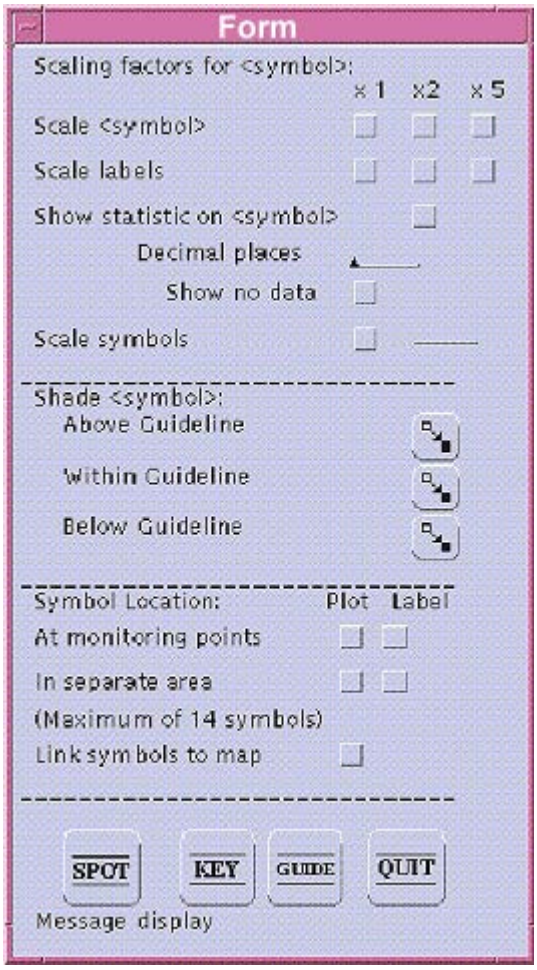
- Catchments Selected
- Number of Points
- Start Date
- End Date
- Pointset
- Increment

Sampleset
- Extra Percentile
- the Guideline
- Owner.

Any other information that you might want to save is not stored by WaterMarque, so please make a note of it.

All the layer information that you would like to display with the stored data must be reselected through the layer availability module.

To plot the selections that you have made, click on the symbol icon. The next menu to appear will be the *Choose colours for symbols* menu.



General diagram for menus that regulate size, position and colour of analysis.

Choose Colours for Symbols Menu

This menu allows you to:

- scale your diagrams and label sizes
- display statistics to the diagram
- show no data at points with no data on a specific water quality variable by drawing an empty circle filled with four nines.
- manipulate the shading of the exceedance and conformance indicated in the diagrams.

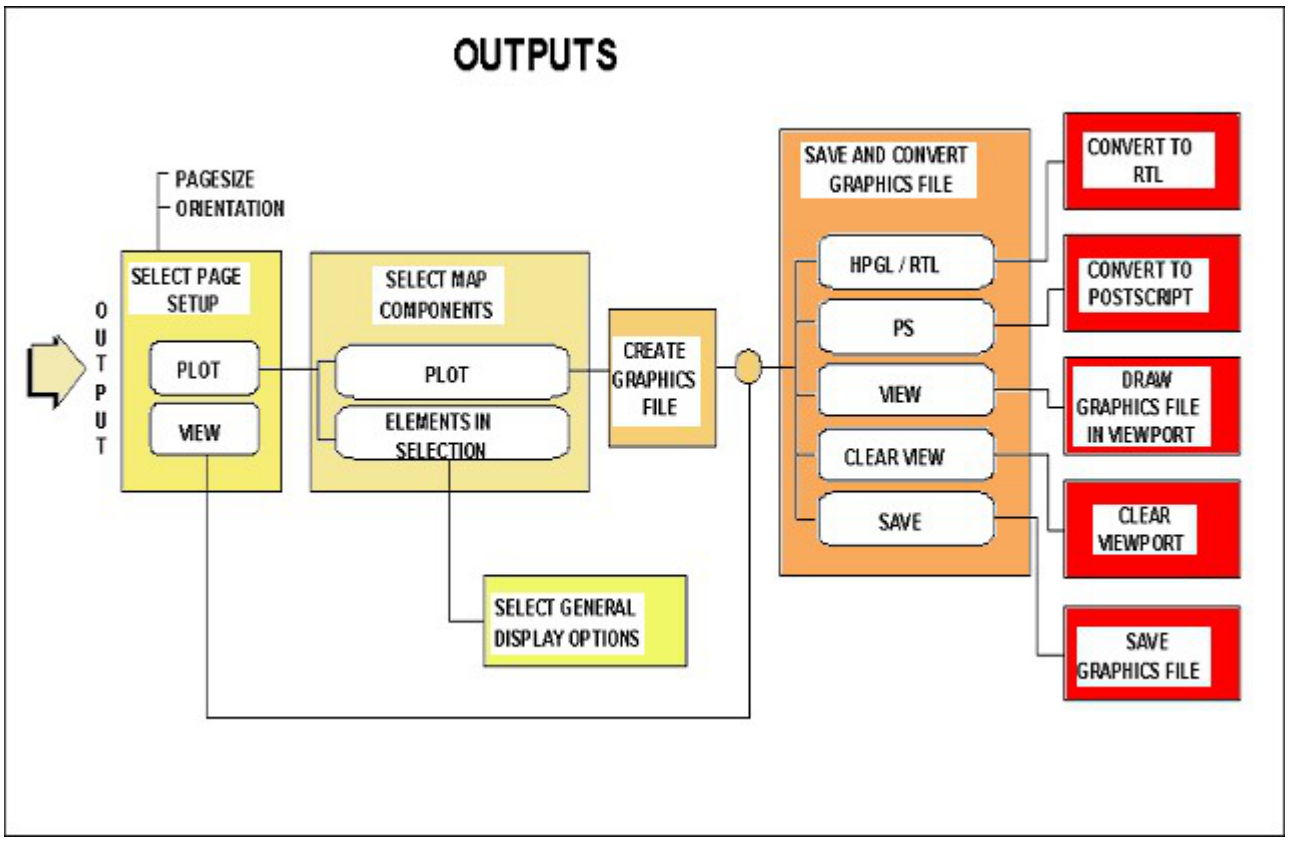
To draw a key explaining the diagram to the map user click on the *Key* icon.

To redefine and reselect your guidelines for a specific water quality variable click on the *Guide* icon.

To draw click on the *Draw* icon.

Return to index page
Go to Output module

Outputs



The output module should be viewed as an accumulation of a whole WaterMarque session. You have located, displayed and analysed various layers of data and perhaps associated the occurrence of one data type with another. The next logical step then is to create a graphics file that can be converted to hardcopy.

The output module is designed specifically to produce a graphics file in a format from which it can be plotted by any ARC/INFO supported device. Selections of feature overlays, attribute points and line features can all be placed into the graphics file. WaterMarque produces a graphics file `(.gra)` which can be converted to either a Raster Transfer Language (RTL) or Postscript format. WaterMarque creates the files in the directory `/wmusr/`*`username`*`/plot`.

The output module menus are designed with some continuity. All menus have a *Quit* icon allowing you to opt out of the menu should you have made a mistake in selecting it. In addition, some of the menus have a Plot icon. This icon takes you to the *Graphics Files to Save/View* menu.

The *View* icon allows you to view a graphics file in the right-hand margin of the map area. If you would like to view one file after the other, simply click on the *View* icon after you have highlighted a new file name in the scroll box. The view of the new graphics file will replace the old view.

The *View* icon is associated with the *Clear View* icon in the *Graphics files to save/view* menu. The *Clear View* allows you to clear the view area of the map on screen once you have finished viewing a single or multiple set of maps.

The *Save* icon allows you to create the graphics file which is a selection of the elements selected in your session, entirely according to your requirements.

To create a graphics file with the output module

Click on the *Output Generation* icon on the *Main menu bar* at the lower left-hand side of the screen. The *Output device, plot size, orientation* menu appears on the screen. This menu allows you to choose the map size for the graphics file to be created. You have the choice of a range of sizes from paper size A0 to A5. Below this menu you will find a line, *Map Orientation*. The map orientation in this version of WaterMarque is always landscape. Any

rotations which you would like to perform must be performed in Arc, outside of the WaterMarque interface.

Having selected the options available click on the *Plot* or *View* icons at the base of the screen. If you wish to view your file then click on the *View* icon and refer to the introduction section of this Module.

If you selected the *Plot* icon, the next menu to appear will be the *Select Elements to plot* menu. This menu is structured to provide you with the final controls on the map production process. The menu consists of a number of check boxes which act as specific control switches. Each of these switches controls a particular feature of the map in the graphics file you are going to create. Should you wish a feature to be present in your graphics file, click on the relevant check box.

- To add a title
- Symbols, Point
- Symbols, Area
- Symbols, Key
- Scale Bar
- Address
- Logo
- Grid
- Positional map
- North Arrow
- Legend
- Graticule Text

The *Symbols Point, Area and Key* options merit extra discussion: these options come from the data query module. The *Symbols Point* allows you to change the position in which the symbols are to be drawn if you have previously chosen to draw the symbols to the area at the side of the map. Similarly, if you have previously chosen to draw your symbols at the monitoring points, you may click on the *Symbols Area* check box and have your symbols drawn to the side of the map in a separate area.

The *Symbols Key* check box allows you to switch the symbols key on and off for the symbols you have chosen. The key is drawn in the space below the map.

The same key is used for both the Box Plots and the Box Plot Graphs. This version of WaterMarque has no keys for either the Time Series or Radial Timeseries symbols. The symbols can be scaled in order to ensure that the textsize and the scale of the symbols remains constant. Should you wish that any of the above items should appear on screen, and in your final graphics file, simply click on the check box to the right of these options.

To alter the scale of the graphics file

Click on the *Scale* icon at the base of the menu.

The menu which will appear to screen will be the *Set scale for Graphics File* menu. The menu has the function of allowing you to select the scale of the map you want to create in the graphics file. You have the choice of selecting either:

- Automatic scaling:
  - e.g. 1 : 7013672

- Set Map Scale
  - 1 : 10 000 000
  - 1 : 5 000 000
  - 1 : 2 500 000
  - 1 : 1 000 000
  - 1 : 500 000
  - 1 : 250 000
  - 1 : 50 000
  - 1 : 10 000

- Other

A field is supplied here to allow you to input a scale which suits you. You do not have to execute a carriage return in order for WaterMarque to 'see' your input. Click on the *Done* icon.

You might not have remembered to click on a relevant general selection control switch check box in the data selection modules earlier on in your session. Going back to reselect or deselect them can become a tedious and time consuming process. To regulate the selection of these switches click on the *Elements in Selection* icon bar at the base of the menu.

The *Elements in Selection* menu will appear. This menu is an accumulation of every general control switch available and some of the more important specific control switches for every features and point selection menu which has them.

It includes an accumulative *background shading* option which selects background shading for the area which is being viewed.

The mechanics of using this menu are relatively easy to understand:

Let us assume that you ran a session and used every module available in WaterMarque to hone and select some core pieces of data. To speed up the selection process in the Features Selection Module you did not select the general control switches on any of the menus, only the relevant specific control switches. If you had, it would have meant waiting every time that you changed some selection or redrew your screen as WaterMarque reselected the data from its libraries and drew it all to screen.

By not switching on the general control switches, the session was much faster. All that had to be done was to select the specific control switches (those switches which regulate exactly what aspects or subsets of a general layer are to be selected e.g. Basaltic Lava) . If no specific control switches were selected in your session, you would be switching no layers of data on by clicking on the general control switch.

When you have completed checking your selection in the*Elements in selection* menu click on the *Done* icon at the base of the menu. You may now choose to view the file you are wanting to create before you save it. Click on the *Plot* icon at the base of the menu. An information box containing "deciding what to plot" messages will appear to screen.

The next menu to appear is the *Graphics files to save/view*.

The menu is constructed of an input field, a scroll box and a number of icons.

The input field , "current map in selection", displays a graphics file name. The default name is `plotmap.gra`. The highlighting in the scroll box below will correspond to the name which appears in the input field. You can choose to change the name by clicking on the field and typing the name you want.

The scroll box contains the names of graphics files which have previously been saved in this menu. You can scroll through the file names and view a saved file before plotting, or you may delete the files by simply clicking on the appropriate icon.

Changing the graphics file format and Deleting

The *HPGL*/*RTL* and *PS* icons to the right of the menu are for selecting the Hewlett Packard Graphics Language Raster Transfer Language or PostScript.

In creating a useful base map or one which will be reproduced a number of times you may wish to save a graphics file. This is simply done by clicking on the *Save* icon at the base of the menu. Be sure that the name you have selected for the file is one that is appropriate and is not duplicated in the *Plot* menu. The formats present are all supported by ARC/INFO.

You also have the option of deleting any of the files in *your* `/plot` directory that you have write access to. To

minimise the risk of accidental file deletion, WaterMarque will query your choice before the file is deleted.

Return to index page
Go to System Administration module

Return to index page

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Guidelines

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Return to index page
Last edited 2019-02-20 14:01

System Administration

SystemRequirements

Hardware requirements

The minimum hardware required is a Unix workstation (at least a Sparc2) supported by ESRI's ARC/INFO software, preferably with 64 Mb RAM and 1000 Mb free disk space. This must be linked to a graphics printer or plotter set up to work with ARC/INFO if hardcopy of output is required.

Software requirements

The software required is a current ARC /INFO v.7.x or later user license.

The Watermarque programs and data are supplied on a CD-ROM. The program is installed on a number of subdirectories on the disk, in a directory stipulated by the system administrator. These subdirectories include:

`/wmrq`

`ptool`

- `icons` (the icons required for menu display)
- `aml` (controlling programs written in Arc Macro Language)
- `menu`
- `symbols`
- `templates`

`wmusr`

(subdirectories will be created as each user or project group researcher logs in, to store plot files and working data files)

`wmdata`

(water quality data, water quality guidelines for individual users or project use)

- `general`
- `images`
- `polmon`
- `wq`

`db1m`

- `libraries`
- `access`
- `database`
- `metadata`
- `tiles`

The map library

A map library called `watermarque` must be created by editing the `$ARCHOME/TABLES/LIBRARIES` file. This library must contain the Digital Chart of the World (DCW) data, obtained by the user if outside the Department of Water Affairs & Forestry. The library can be situated anywhere on the system, not necessarily in the same location as the

WaterMarque subdirectories.

Password access to Watermarque

The user password file must be added, to allow different users access to the system. This is not a security device but a way to allow several users to use the program without conflict, saving analyses files and plots to separate directories. It allows the system administrator to monitor the disk space utilised per user or user group, keeps records separate so that they can be effectively archived when a project terminates or can ensure that more heavily used files are backed up more frequently if necessary.

The file :

```
...directory/wmrq/ptool/icons/login
```

will contain individual researcher's names with their chosen passwords, or project names should user groups wish to work within a single set of records.

Unix settings

Before opening an ARC session, the canvas colour must be set to white, to give a screen view that resembles the output, i.e. black text will appear black on screen and in plots. The global `WMSYS` variable must also be set so that WaterMarque knows where to find system files.

The system administrator may edit the global `login` file in Unix to set these variables. If this is not desirable, then:

- Individual users can edit their individual `login` files to contain this command; or
- before each ARC session , the user must type in the following commands at the Unix prompt (using lower and upper case letters as shown):

```
setenv CANVASCOLOR WHITE
setenv WMSYS <path/to/watermarque>

Followed by:

arc

and finally,

wmrq
```

The datasets

- The chemical and flow data supplied with Watermarque is public domain information which has been collected by the Department of Water Affairs and Forestry (DWAF). This data has been included in WaterMarque with the full understanding that some errors may have crept through the data checking process, though flow and water quality data are continuously checked and updated.
- Geographical datasets which are generally **NOT** in the public domain (yet).

WaterMarque has a menu driven interface which does not permit editing of datasets within the program. This is a desirable feature where several users have access to the data. Any editing of data must occur outside the Watermarque interface using ARCEDIT to edit the spatial data (such as rivers or monitoring point locations) and Unix or ARC/INFO to edit data pertaining to time series, water quality or flow data.

Installing WaterMarque

Watermarque may be supplied on CD-ROM . Instructions for loading will be supplied with the media.

Running WaterMarque

To run Watermarque, first start ARC/INFO by entering
arc at the Unix prompt. Once ARC/INFO has started the following ARC prompt will appear:

arc:

At this stage, if an error occurs i.e. ***product not licensed*** or ***command not found*** , or the arc prompt does not appear, contact your system administrator.

Start WaterMarque typing wmrq at the arc prompt, thus:

arc: wmrq

A few seconds will pass while the screen is cleared and the opening window is displayed. This opening window requests a username and password. While the username can be typed in if necessary, by default it will be your Unix login name. The password is *not* your Unix password, and will usually be the same as your name. Moving between the two menu fields (username and password) is accomplished by using the **<Tab>** key or the mouse.

Acceptance of the username and password is indicated by hitting the**<Enter>** key on the keyboard.

To exit the system immediately, click on the **Exit** button.

Proceed to Technical Specifications

Data Updating Procedures

The data sets in WaterMarque containing pollution and hydrological monitoring stations and the water quality attribute information for these stations are constantly being updated by the Department of Water Affairs and Forestry (DWAF). To supply WaterMarque users with current data these data sets will be regularly updated.

The original data sets reside on databases at DWAF head-office and regional offices in different file formats. The data sets had are reformatted to ARC/INFO format, namely coverages and INFO tables to be incorporated and displayed in WaterMarque. In order to simplify the updating of the data within WaterMarque, procedures were developed to automate the reformatting process where possible. These procedures are documented below.

N.B. Because of changes to the structure of the Department of Water Affairs & Forestry, the names of files may not be exactly as specified here.
The data sets that are updated are as follows:

- hydrological monitoring stations coverages for the whole country and each province. The coverages are:
  - HWQ
  - HWQ_MPUM
  - HWQ_FSTATE
  - HWQ_GAUT
  - HWQ_NATAL
  - HWQ_NCAPE
  - HWQ_NPROV
  - HWQ_NWEST
- an INFO table containing water quality attribute data called INORGANIC.DAT
- pollution monitoring station coverages for South Africa and each DWAF region called:
  - POLMON
  - FREESTATE
  - WCAPE
  - ECAPE
  - SWCAPE
  - TRANSVAAL
  - NATAL
  - HIGHVELD
- an INFO table containing water quality data for pollution monitoring stations called POLMON.DAT
- INFO tables containing permit attribute data for pollution monitoring stations for South Africa and each DWAF region called:
  - PERMIT.POLMON
  - PERMIT.FREESTATE
  - PERMIT.ECAPE
  - PERMIT.SWCAPE
  - PERMIT.TRANSVAAL
  - PERMIT.NATAL
  - PERMIT.HIGHVELD

A general diagram of the updating procedures. The new data will be collated by IWQS from DWAF head-office and regional offices. The data formatting procedures will be done by GIMS and the formatted data will be send to each installation site.

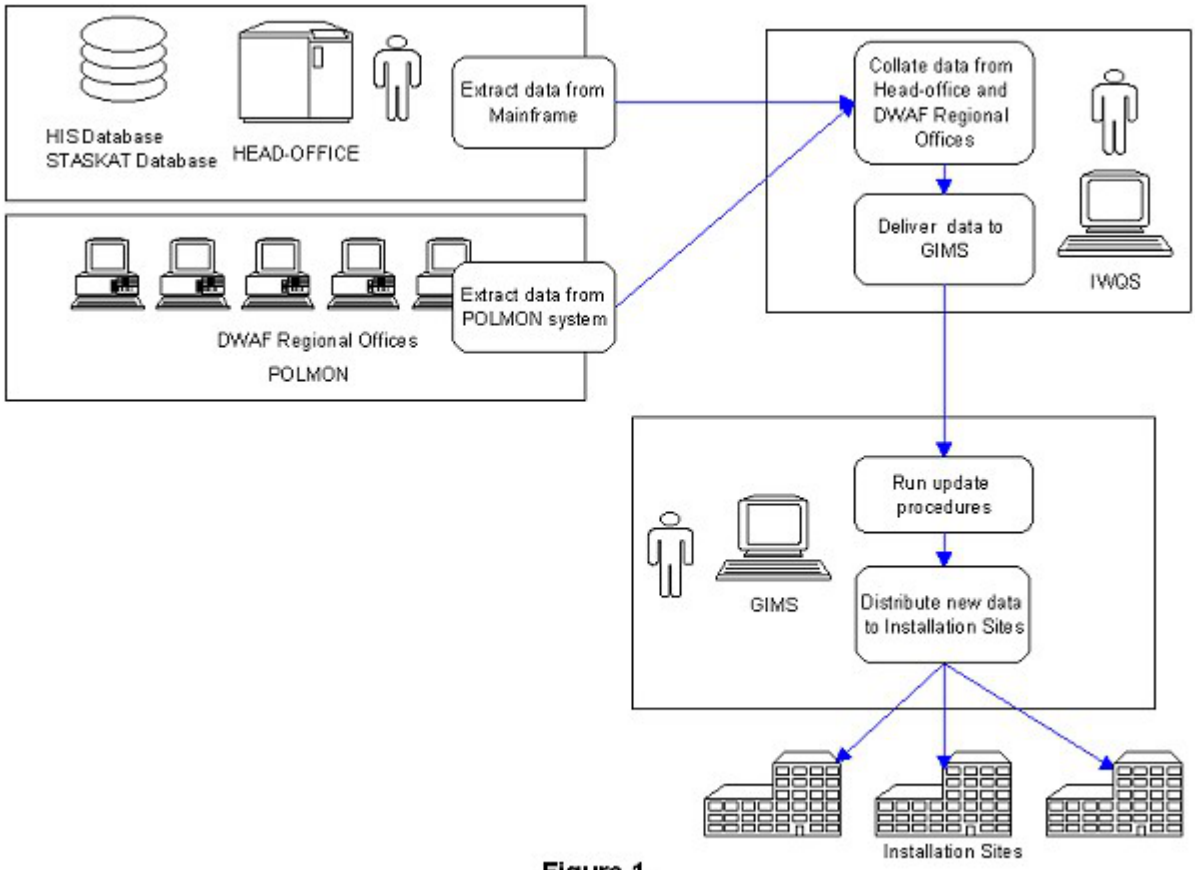

Figure 1.

Data formatting procedure for Hydrological Monitoring Stations

The hydrological monitoring stations are exported in ASCII file format from the Stations Catalog Database(STATKAT) at DWAF Head-office. Follow these steps to convert the ASCII data into point coverages:

1. Load ASCII file:
Create a temporary workspace for loading the data and running the procedures to ensure that existing data is not overwritten immediately:

```
Arc: cw tempwork
Arc: w tempwork
```

2. Run AML to generate point coverage:

```
Arc: &amlpath $WMSYS/ptool/aml
Arc: &r his_pntdef

Usage: &r his_pntdef <directory> <asciiname> <infoname> <coverage name>

Arc: &r his_pntdef $WMSYS/tempwork monpnt.asc stations.dat stations
```

If you have problems with the ADD FROM line, it could be that:

a. You need to remove spurious blanks from the input file.

   In vi Editor, try

```
:1,$s/ *,/,/g
:1,$s/, */,/g
```

   which removes blanks before and after commas.

b. You need to remove quote (") marks from the input file. These occur when exporting fields containing commas from packages such as Excel and Quattro. Remember to remove the offending commas as well (usually a fiendish decimal).

3. Create point coverages for DWAF regions: an AML is run that does an INTERSECT with the monitoring stations and the DWAF regions polygon coverage, and the monitoring stations coverage and the quaternary catchment polygon coverage. The monitoring stations are then split up into the different regions.

```
Arc: &r his_splitstat
Usage: &r his_splitstat.aml <directory> <stations coverage>
{routine}
Arc: &r his_splitstat $WMSYS/tempwork stations
```

4. Kill existing coverages in WaterMarque data directory:

```
Arc: w $WMSYS/wmdata/general
Arc: kill hwq all
Killed hwq with the ALL option
Arc: kill hwq_wcape all
Killed hwq_wcape with the ALL option
Arc: kill hwq_ecape all
Killed hwq_ecape with the ALL option
Arc: kill hwq_mpum all
Killed hwq_mpum with the ALL option
Arc: kill hwq_fstate all
Killed hwq_fstate with the ALL option
Arc: kill hwq_gaut all
Killed hwq_gaut with the ALL option
Arc: kill hwq_natal all
Killed hwq_natal with the ALL option
Arc: kill hwq_nprov all
Killed hwq_nprov with the ALL option
Arc: kill hwq_nwest all
Killed hwq_nwest with the ALL option
Arc: kill hwq_ncape all
Killed hwq_ncape with the ALL option
```

5. Copy new coverages to WaterMarque data directory:

```
Arc: copy hwq $WMSYS/wmdata/general/hwq
Copied hwq to $WMSYS/wmdata/general/hwq
Arc: copy hwq_ecape $WMSYS/wmdata/general/hwq_ecape
Copied hwq_ecape to $WMSYS/wmdata/general/hwq_ecape
Arc: copy hwq_wcape $WMSYS/wmdata/general/hwq_ecape
Copied hwq_wcape to $WMSYS/wmdata/general/hwq_ecape
Arc: copy hwq_mpum $WMSYS/wmdata/general/hwq_mpum
Copied hwq_mpum to $WMSYS/wmdata/general/hwq_mpum
Arc: copy hwq_fstate $WMSYS/wmdata/general/hwq_fstate
Copied hwq_fstate to $WMSYS/wmdata/general/hwq_fstate
Arc: copy hwq_gaut $WMSYS/wmdata/general/hwq_gaut
Copied hwq_gaut to $WMSYS/wmdata/general/hwq_gaut
Arc: copy hwq_natal $WMSYS/wmdata/general/hwq_natal
Copied hwq_natal to $WMSYS/wmdata/general/hwq_natal
Arc: copy hwq_ncape $WMSYS/wmdata/general/hwq_ncape
Copied hwq_ncape to $WMSYS/wmdata/general/hwq_ncape
Arc: copy hwq_nprov $WMSYS/wmdata/general/hwq_nprov
Copied hwq_nprov to $WMSYS/wmdata/general/hwq_nprov
Arc: copy hwq_nwest $WMSYS/wmdata/general/hwq_nwest
Copied hwq_nwest to $WMSYS/wmdata/general/hwq_nwest
```

Data formatting procedure for Water Quality attribute data for Hydrological Monitoring Stations

The water quality data for hydrological monitoring stations are exported as an ASCII file from the (HIS) database at DWAF Head-office. The ASCII file must be in comma delimited format. Follow these steps to convert the ASCII data into point coverages:

1. Load ASCII file:
Create a temporary workspace for loading the data and running the procedures to ensure that existing data is not overwritten immediately:

```
Arc: cw tempwork
Arc: w tempwork
```

2. Run AML to generate INFO table:

```
Arc: &amlpath $WMSYS/ptool/aml
```

```
Arc: &r his2info.aml

Usage: &r his2info.aml <path Name> <Ascii Name> <Info Name> {routine}
Arc: &r his2info $WMSYS/tempwork hisdata.txt inorganic.dat
```

3. Delete old inorganic.dat from WaterMarque data directory:

```
Arc: w $WMSYS/wmdata/wq
Arc: &sv d [delete inorganic.dat -info]
```

4. Copy new INFO table to WaterMarque data directory:

```
Arc:copyinfo inorganic.dat $WMSYS/wmdata/wq/inorganic.dat
```

Data formatting procedure for Pollution Monitoring (POLMON) Stations

The POLMON stations and related water quality information are exported in ASCII file format from the POLMON system at Head-office. The files needed for each DWAF region include: mon_pt.txt, permit.txt, qual_val.txt.

Formatting the POLMON stations:

The exported POLMON stations data for a DWAF region is contained in mon_pt.txt. Follow these steps to convert the ASCII data into a point coverage:

1. Load ASCII file:

Create a temporary workspace for loading the data and running the procedures to ensure that existing data is not overwritten immediately:

```
Arc: cw tempwork
Arc: w tempwork
```

2. Run AML for each DWAF region, to generate point coverage: the AML generates a point coverage and add additional items such as class, type and z-code.

```
Arc: &amlpath $WMSYS/ptool/aml
Arc: &r pol_makepts
Usage: &r pol_makepts.aml <new polmon cover> <province> {routine}

Arc: &r pol_makepts transvaal transvaal
```

3. Combine all DWAF regional coverages into a single POLMON coverage: Once the coverages for all the regions exist, APPEND the coverages to create a coverage containing pollution monitoring stations for the whole country:

```
Arc: append polmon point
Enter coverages to be APPENDed. (Type END or a blank line when done):
==================================================
Enter the 1st coverage: natal
enter the 2nd coverage: highveld
Enter the 3rd coverage: freestate
Enter the 4th coverage: transvaal
Enter the 5th coverage: ecape
Enter the 6th coverage: swcape
Enter the 7th coverage: END

Appending coverages...
```

4. Delete old coverages from WaterMarque data directory:

```
Arc: kill $WMSYS/wmdata/general/polmon all
Killed $WMSYS/wmdata/general/polmon with the ALL option
Arc: kill $WMSYS/wmdata/general/transvaal all
Killed $WMSYS/wmdata/general/transvaal with the ALL option
Arc: kill $WMSYS/wmdata/general/highveld all
Killed $WMSYS/wmdata/general/highveld with the ALL option
Arc: kill $WMSYS/wmdata/general/swcape all
Killed $WMSYS/wmdata/general/swcape with the ALL option
Arc: kill $WMSYS/wmdata/general/ecape all
Killed $WMSYS/wmdata/general/ecape with the ALL option
Arc: kill $WMSYS/wmdata/general/natal all
Killed $WMSYS/wmdata/general/natal with the ALL option
Arc: kill $WMSYS/wmdata/general/freestate all
Killed $WMSYS/wmdata/general/freestate with the ALL option
```

5. Copy new coverages to WaterMarque data directory:

```
Arc: copy polmon $WMSYS/wmdata/general/polmon
Copied polmon to $WMSYS/wmdata/general/polmon
Arc: copy natal $WMSYS/wmdata/general/natal
Copied natal to $WMSYS/wmdata/general/natal
Arc: copy freestate $WMSYS/wmdata/general/freestate
Copied freestate to $WMSYS/wmdata/general/freestate
Arc: copy transvaal $WMSYS/wmdata/general/transvaal
Copied transvaal to $WMSYS/wmdata/general/transvaal
Arc: copy ecape $WMSYS/wmdata/general/ecape
Copied ecape to $WMSYS/wmdata/general/ecape
Arc: copy swcape $WMSYS/wmdata/general/swcape
Copied swcape to $WMSYS/wmdata/general/swcape
Arc: copy highveld $WMSYS/wmdata/general/highveld
Copied highveld to $WMSYS/wmdata/general/highveld
```

Data formatting procedure for Water Quality attribute data for POLMON stations

The exported water quality data for POLMON stations for a DWAF region is contained in qual_val.txt. Follow these steps to convert the ASCII data into a INFO file:

1. Load ASCII file:
Create a temporary workspace for loading the data and running the procedures to ensure that existing data is not overwritten immediately:

```
Arc: cw tempwork
Arc: w tempwork
```

2. Run C program for each DWAF region to reformat data into 4 ASCII files:

```
Arc: &amlpath $WMSYS/ptool/aml
Arc: polcon.2
Usage: polcon <POLMON FILE> <OUTPUT FILE>

where <POLMON FILE> must be sorted according to station, date
eg. sort -o qual_val.srt +3 -4 +7.6 -8 +7.3 -7.6 +7.0 -7.3 qual_val.txt

*********************************************************************
* *
* P O L M O N C O N V E R T *
* *
* A program by W. F. Geldenhuys. August 1995. *
* *
*********************************************************************
```

The <POLMON FILE> is usually extracted from the POLMON system in the correct sort order, but if not the above usage for the sort can be used to sort the file.

```
Arc: polcon.2 qual_val.txt gauteng
```

The output will be gauteng.1, gauteng.2, gauteng.3, gauteng.4

3.AML for each DWAF region to generate INFO table. This AML must be run for each DWAF region:

```
Arc: &r pol_qual2info

Usage: &r pol_qual2info.aml <Ascii prefix> <INFO prefix> {routine}


Arc: &r pol_qual2info gauteng gauteng
```

The output will be an INFO table called gauteng

4. Merge the INFO tables of the DWAF regions into one table and rename the table to POLMON.DAT:

```
Arc: copyinfo transvaal polmon.dat
Arc: info
INFO EXCHANGE CALL
31/03/1998 11:47:22
```

```
INFO 9.42 11/11/86 52.74.63*
Copyright (C) 1994 Doric Computer Systems International Ltd.
All rights reserved.
Proprietary to Doric Computer Systems International Ltd.
US Govt Agencies see usage restrictions in Help files (Help Restrictions)
ENTER USER NAME>ARC

ENTER COMMAND >SELECT GAUTENG
839 RECORDS SELECTED
ENTER COMMAND >MERGE INTO POLMON.DAT ON STATION
ENTER COMMAND >SELECT SWCAPE
176 RECORDS SELECTED
ENTER COMMAND >MERGE INTO POLMON.DAT ON STATION

ENTER COMMAND >SELECT WCAPE
n RECORDS SELECTED
ENTER COMMAND >MERGE INTO POLMON.DAT ON STATION
ENTER COMMAND >SELECT ECAPE
456 RECORDS SELECTED
ENTER COMMAND >MERGE INTO POLMON.DAT ON STATION

ENTER COMMAND >SELECT NATAL
332 RECORDS SELECTED
ENTER COMMAND >MERGE INTO POLMON.DAT ON STATION

ENTER COMMAND >SELECT HIGHVELD
1002 RECORDS SELECTED
ENTER COMMAND >MERGE INTO POLMON.DAT ON STATION
```

5. Delete old POLMON.DAT in WaterMarque data directory and copy new INFO table:

```
Arc: &ty [delete $WMSYS/wmdata/wq/polmon.dat -info]

Arc: copyinfo polmon.dat $WMSYS/wmdata/wq/polmon.dat
```

Data formatting procedure for Permit data

The exported permit data for POLMON stations for a DWAF region is contained in permit.txt. Follow these steps to convert the ASCII data into a INFO table and to create a frequency table:

1. Load ASCII file:
Create a temporary workspace for loading the data and running the procedures to ensure that existing data is not overwritten immediately:

```
Arc: cw tempwork
Arc: w tempwork
```

2. Run AML for each DWAF region to reformat data into 4 ASCII files:

```
Arc: &amlpath $WMSYS/ptool/aml
Arc: &r pol_permitup.aml
Usage: &r pol_permitup.aml <INPUT ASCII file> <province name> <In Path>
<Out Path> {routine}

Arc: &r pol_permitup permit.txt gauteng $WMSYS/tempwork $WMSYS/tempwork
```

The output will be two INFO tables named permit.gauteng and freq.gauteng. The province names are changes to the abbreviations and names as used in WaterMarque.

3. Merge the permit INFO tables of the DWAF regions into one table and rename the table to PERMIT.ALL:

```
Arc: copyinfo permit.gauteng permit.all
Arc: info
INFO EXCHANGE CALL
31/03/1998 11:47:22
INFO 9.42 11/11/86 52.74.63*
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ENTER USER NAME>ARC


ENTER COMMAND >SELECT PERMIT.ECAPE
839 RECORDS SELECTED
```

```
ENTER COMMAND >MERGE INTO PERMIT.ALL ON STATION

ENTER COMMAND >SELECT PERMIT.SWCAPE
176 RECORDS SELECTED
ENTER COMMAND >MERGE INTO PERMIT.ALL ON STATION

ENTER COMMAND >SELECT PERMIT.TRANSVAAL
456 RECORDS SELECTED
ENTER COMMAND >MERGE INTO PERMIT.ALL ON STATION

ENTER COMMAND >SELECT PERMIT.NATAL
332 RECORDS SELECTED
ENTER COMMAND >MERGE INTO PERMIT.ALL ON STATION

ENTER COMMAND >SELECT PERMIT.HIGHVELD
1002 RECORDS SELECTED
ENTER COMMAND >MERGE INTO PERMIT.ALL ON STATION
```

4. Run the frequency command on the merged file:

```
Arc: frequency permit.all freq.all

Enter Frequency item names (type END or a blank line when done):
============================================================
Enter the 1st item: station
Enter the 2nd item: end


Enter Summary item names (type END or a blank line when done):
============================================================
Enter the 1st item: end
```

5. Delete existing files in WaterMarque data directory:

```
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.ecape -info]
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.swcape -info]
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.highveld -info]
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.transvaal -info]
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.natal -info]
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.gauteng -info]
Arc: &sv d [delete $WMSYS/wmdata/wq/permit.all -info]
```

6. Copy new files to data directory:

Permit files:

```
Arc: copyinfo permit.ecape $WMSYS/wmdata/wq/permit.ecape
Arc: copyinfo permit.transvaal $WMSYS/wmdata/wq/permit.transvaal
Arc: copyinfo permit.highveld $WMSYS/wmdata/wq/permit.highveld
Arc: copyinfo permit.natal $WMSYS/wmdata/wq/permit.natal
Arc: copyinfo permit.swcape $WMSYS/wmdata/wq/permit.swcape
Arc: copyinfo permit.gauteng $WMSYS/wmdata/wq/permit.gauteng
Arc: copyinfo permit.all $WMSYS/wmdata/wq/permit.all
```

Frequency files:

```
Arc: copyinfo freq.ecape $WMSYS/wmdata/wq/freq.ecape
Arc: copyinfo freq.transvaal $WMSYS/wmdata/wq/freq.transvaal
Arc: copyinfo freq.highveld $WMSYS/wmdata/wq/freq.highveld
Arc: copyinfo freq.natal $WMSYS/wmdata/wq/freq.natal
Arc: copyinfo freq.swcape $WMSYS/wmdata/wq/freq.swcape
Arc: copyinfo freq.gauteng $WMSYS/wmdata/wq/freq.gauteng
Arc: copyinfo freq.all $WMSYS/wmdata/wq/freq.all
```

Return to index page

List of GIS data sets used by WaterMarque, with links to the metadata.

Please read the copyright details carefully

COVERAGE DATA

(Please note that not all metadata links are accessible from the Internet)

Tue Mar 2 07:00:04 GMT 1999

Title	File
Acocks veld types of South Africa	acocks
Catchments of South Africa - primary	hca_primary
Catchments of South Africa - quaternary	hca_quater
Catchments of South Africa - secondary	hca_secondary
Catchments of South Africa - tertiary	hca_tertiary
Climate zones of South Africa	climate
Dams and some lakes of South Africa	wla_500
Ecoregions for South Africa	ecoregions
Elevation data: Digital Chart of the World - 200 metre slices	tev200m
Evaporation (mean annual) of South Africa (WR90 file eip.e00)	mav_wr90
Farm boundaries of South Africa	farm_bound
Geology map of South Africa with simplified lithostratigraphy for geohydrological use	hgh_1000
Land cover for South Africa	landcover
Magisterial districts of South Africa	magisterial
Monitoring stations of the Department of Water Affairs & Forestry	hwq
Monitoring points in KwaZulu-Natal	hwq_natal
Monitoring points in Eastern Cape	hwq_ecape
Monitoring points in Free State	hwq_fstate
Monitoring points in Gauteng	hwq_gaut
Monitoring points in Mpumalanga	hwq_mpum
Monitoring points in Northern Cape	hwq_ncape
Monitoring points in Northern Province	hwq_nprov
Monitoring points in North-West Province	hwq_nwest
Monitoring points in Western Cape	hwq_wcape
Monitoring points in Other Areas	hwq_other
Precipitation (mean annual) over South Africa (WR90 file rip.e00)	map_wr90
Provinces and neighbouring country borders of South Africa - polygons	sa_prov
Regions of Department of Water Affairs & Forestry (interim)	dwafreg
Rivers of South Africa	wri_500

Rivers of Southern Africa outside of South Africa	wri_not_sa
Roads of South Africa	roads
Towns of South Africa - points	sa_towns
Towns of South Africa - Digital Chart of the World	pppoint

INFO FILES

Title	File
Hydrological monitoring variable information from HIS	inorganic.dat
Pollution monitoring variable information from Regions	polmon.dat

GRID DATA

Title	File
USGS Hillshaded relief grid	grdshade

WaterMarque System Bug Report Form

Please send this information to GIMS Hotline

by E-mail (support@gims.com) or fax (011) 315 0395

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Customer number	
Site	
Arc/Info version number	
WaterMarque version number	
Platform (computer type)	
Operating system (e.g. Solaris 2.5)	
Menu where bug emerged	
Action which produced the problem	
AML or system error message	
AML line number, if known	

WaterMarque Document Bug Report Form

Please send this information to GIMS Hotline

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Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Customer number	
Site	
Document version number	
Module where bug found	
Page number(s)	
What has been incorrectly described?	
What changes do you suggest?	
Other comments	

WaterMarque POLMON Data Bug Report Form

Please send this information to Geert Grobler

by E-mail (tdb@dwaf.pwv.gov.za) or fax (012) 323 0321

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Postal Address	
WaterMarque version number	
Station code	
Province or region	
Type of error (location of point, anomalous concentration, etc.)	
Suggested correction	

WaterMarque Quality Data Bug Report Form

(Hydrological Information System Data -- not POLMON)

Please send this information to Johan Wentzel

by E-mail (sdj@dwaf.pwv.gov.za) or fax (012) 326 1488

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Postal Address	
WaterMarque version number	
Station code (e.g. A2H027Q01)	
Station type (stream, dam, etc.)	
Type of error (location of point, anomalous concentration, etc.)	
Suggested correction	

WaterMarque System Bug Report Form

Please send this information to GIMS Hotline

by E-mail (support@gims.com) or fax (011) 315 0395

Name of user	
Date bug detected	
Contact phone number	
Contact fax number	
Contact E-mail address	
Customer number	
Site	
Arc/Info version number	
WaterMarque version number	
Platform (computer type)	
Operating system (e.g. Solaris 2.5)	
Menu where bug emerged	
Action which produced the problem	
AML or system error message	
AML line number, if known	

WATER QUALITY DECISION-MAKING FACILITATED THROUGH THE DEVELOPMENT OF AN INTERFACE BETWEEN A GEOGRAPHIC INFORMATION SYSTEM AND A WATER QUALITY DATABASE

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ABSTRACT

Decision-making in the field of water quality management requires access to comprehensive data stores of relevant information. Such databases are becoming increasingly available due to the efforts of several agencies engaged in monitoring environmental conditions. On its own, this store of information is not sufficient for adequate understanding and interpretation of real-world problems, as objective decisions rely on a transformation of information into knowledge. This transformation is all too often accomplished within the reference framework of the individual manager, based on intuitive understanding and past experience. This paper outlines development currently being undertaken with the aim to provide an objective knowledge base synthesised from a wide range of water related variables, through the platform of a Geographic Information System (GIS). A GIS provides the potential for powerful geographical analyses and interpretation of hydrological data in a spatial context. A customised menu-driven system is being developed to facilitate access to and interrogation of a water quality database. The system allows on-screen display and analysis of data at a range of scales and detail, with a selection of methods of analysis and presentation of results.

INTRODUCTION

Geographic Information Systems (GIS) are computer-based tools that store, analyse and manage spatial data (Burrough, 1986; Lanfear, 1989; Openshaw, 1987). Initially, development of GIS arose out of the need for computerised cartography. With further enhancement the GIS took on a greater capability, with the ability to store and manipulate large volumes of spatial and associated data, and to present the data in summarised and analysed forms in a useable and accessible way. Currently, available GIS are far advanced beyond the simple cartographic origins, and are powerful tools capable of combining spatial database management, statistical analysis and cartographic modelling techniques (Star and Estes, 1990). GIS can be defined as an enhanced information system that aids decision-making by referencing data to spatial or geographic coordinates (Schoolmaster and Marr, 1992).

Water quality cannot be considered independently of the spatial context within which it occurs. Water quality indices are generally measured at monitoring point stations but reflect the influence of the wider environment, possibly events taking place several hundred kilometers from the site of sampling. Effective management of water quality must therefore take diverse factors into account, and depends on information from a variety of sources and a range of scales. Such diverse information must be assimilated and presented in as concise and accurate a form as possible, and as rapidly as possible so as to support real-time management of water quality problems as and where they may occur. Traditionally, the water quality manager has had to rely on experience and intuition, and to synthesise the relevant data within the scope of this experience. As most water resources data can be referenced geographically, GIS is ideally suited as a management tool (Lanfear, 1989).

A GIS has the capacity to integrate large volumes of information from a wide variety of sources, and to present the data in a summarised and timely way in the environmental context within which they occur (Schoolmaster and Marr, 1992). The ability of the GIS to store and manipulate large amounts of data allows an historical perspective, where long-term data records exist to show the emergence of trends. This perspective can support predictive and anticipatory management decisions, especially where changes in water quality are linked to concomitant changes in landuse activity. Data in a GIS can be accessed, transformed and manipulated interactively, and therefore the GIS acts as a test bed for studying environmental processes, or for analysing the results of trends and anticipating the results of planning decisions (Burrough, 1992). Collection, analysis and reporting of water use data is time-consuming, and the resultant large and diverse database presents a number of logistical problems that contribute to the lag-time between when the information is gathered and when it can be used in the planning process. The database management capabilities of GIS can facilitate the collation of information from diverse sources, expedite automated data collection, and thus accelerate the reporting of spatial and temporal water quality trends (Schoolmaster and Marr, 1992; Shih, 1989).

The accessibility of the data in a useful form, however, depends on the structure and organisation of the GIS, which in this study was tailored to the specific needs of the water quality manager. Further, the integration of a water quality database, incorporating historical data as well as rapidly updated recent data required development of a system beyond that provided in the GIS software. For this purpose a series of programmes was developed to produce a set of menus allowing the water quality manager to step through the relevant data, at relevant scales, in combination with any information that may be pertinent.

As a management tool this system forms part of the development towards a long term water quality management information system within the Department of Water Affairs and Forestry, consisting of an initial demonstration testing ground on which further detail may be added. During the course of its development, a number of directions in which the system should be expanded have been identified to increase its capacity.

AIMS AND OBJECTIVES

The primary objective of this research was to develop a generic set of programmes allowing rapid access, presentation and analysis of water quality related data, to support management of water resources. The development was modularised to allowed the incremental development of different phases without impairing the functionality of completed modules.

Specific aims include:

* To allow any combination of a variety of data layers to be viewed on screen for inspection by the manager. Background information includes vegetation types, geology, soils, climatic variables, altitude and landuse activities obtained from satellite imagery. Composite satellite images and scanned topographic maps are also provided for selection as background information.
* To allow the manager to zoom into and out of selected areas of interest, once problems are identified at a coarse scale.
* To allow the manager to view water quality variables within their spatial context for selected sites, selected time periods and selected water quality variables.
* To allow the manager to manipulate and interrogate all spatial data. Information to be readily supplied includes:
    - all characteristics of a selected homogeneous unit,
    - the surface areas of selected landuses or water bodies,

- relative distances between points or areas of significance,
- highlight zones where a combination of specified factors occur.

* To allow interrogation of spatial water quality data through the use of summary diagrams, time series, statistical summaries and simple linear regression analyses.
  - Water quality indices must be assessed against recognised guidelines, namely for domestic, agricultural, industrial, recreational and environmental user groups.
  - Exceedance diagrams should immediately indicate which monitoring points exceed a certain concentration level, and where a potentially toxic combination of factors occurs the affected points should be flagged.
  - Different concentration levels can then be manipulated to ascertain what the potential effect of effluent discharges or landuse changes in an area would have on different user groups.

METHODOLOGY

A number of water quality managers within the Department of Water Affairs and Forestry was consulted during a series of meetings and interviews to assess the perceived information needs underlying decision-making. A literature survey was carried out to support the findings of the consultations. A geographic database was then assembled on the GIS ARC/INFO v 6.0.1 consisting of spatial information and associated attribute information. Spatial data comprise areal, linear and point type data. Sources of data are primarily topographic maps, which are converted into digital form through digitising or scanning of color separates and subsequent vectorising. Areal data is based on homogeneous units within which a certain factor is assumed constant, similar to a choropleth map. This type of data includes political boundaries, catchment boundaries, altitude, vegetation, geology, soils and climatic variables such as mean annual rainfall and evaporation. Areal data such as dams and urban areas may be seen as point data with change in scale. Linear data includes the river network and lines of communication. Monitoring points are the only true "point" data, and are located according to latitude and longitude. Satellite imagery providing evidence of land cover conditions can be used as a backdrop to the areal, linear and point data. Scanned 1:250 000 topographic maps are also included, over which other data can be overlain.

The spatial database was then linked to the water quality laboratory chemical database which is used to store results of water samples analysed by the Hydrological Research Institute (HRI). This link was possible because the database language ORACLE and ARC/INFO v 6.0.1 are both UNIX based and the data can be directly transferred without the necessity for conversion or alteration of data type and intermediate preprocessing. A monthly batch process updates all chemical data on the GIS, and if more recent data is required there are additional menus provided to automate the import process. Rapid access to the water quality data with reference to previously identified aspects of immediate relevance to water quality management was then initiated.

A set of programmes was developed on a UNIX workstation using ARC/INFO macro language AML. This system consists of a series of user-friendly menus and associated programmes to facilitate the access to and interpretation of water quality information within the spatial context. The initial query development was based on the spatial database, to allow the user to investigate the prevailing conditions, such as geology, mean annual rainfall or soil type, in a particular area of interest. The surface area of each homogeneous unit could also be found, such as the surface area of dams, irrigated lands and urban settlements. An important precursor to all further development was the option allowing the user to zoom in and out of selected areas. Once the spatial interrogation and presentation aspect was complete, the water quality data associated with the national monitoring network was integrated into the system, allowing analysis and presentation of variables chosen by the user for a selected time period, within the spatial context.

APPLICATIONS

The application of the system can be viewed in two complementary ways, namely near real time presentation of water quality data, and long term analysis of water quality trends.

Near Real Time Presentation

Near real time presentation implies an instantaneous "snapshot" picture of the status of water quality throughout the country at the most recent point in time. The instantaneous spatial variability in water quality throughout the country can be viewed in this way. Concentrations of each water quality variable analysed can be rapidly viewed and assessed against the management guidelines for specific water user groups. Those monitoring points at which the concentration of a particular variable is approaching or exceeding the guideline can be identified and remedial action can then be directed towards these river reaches (Figure 1).

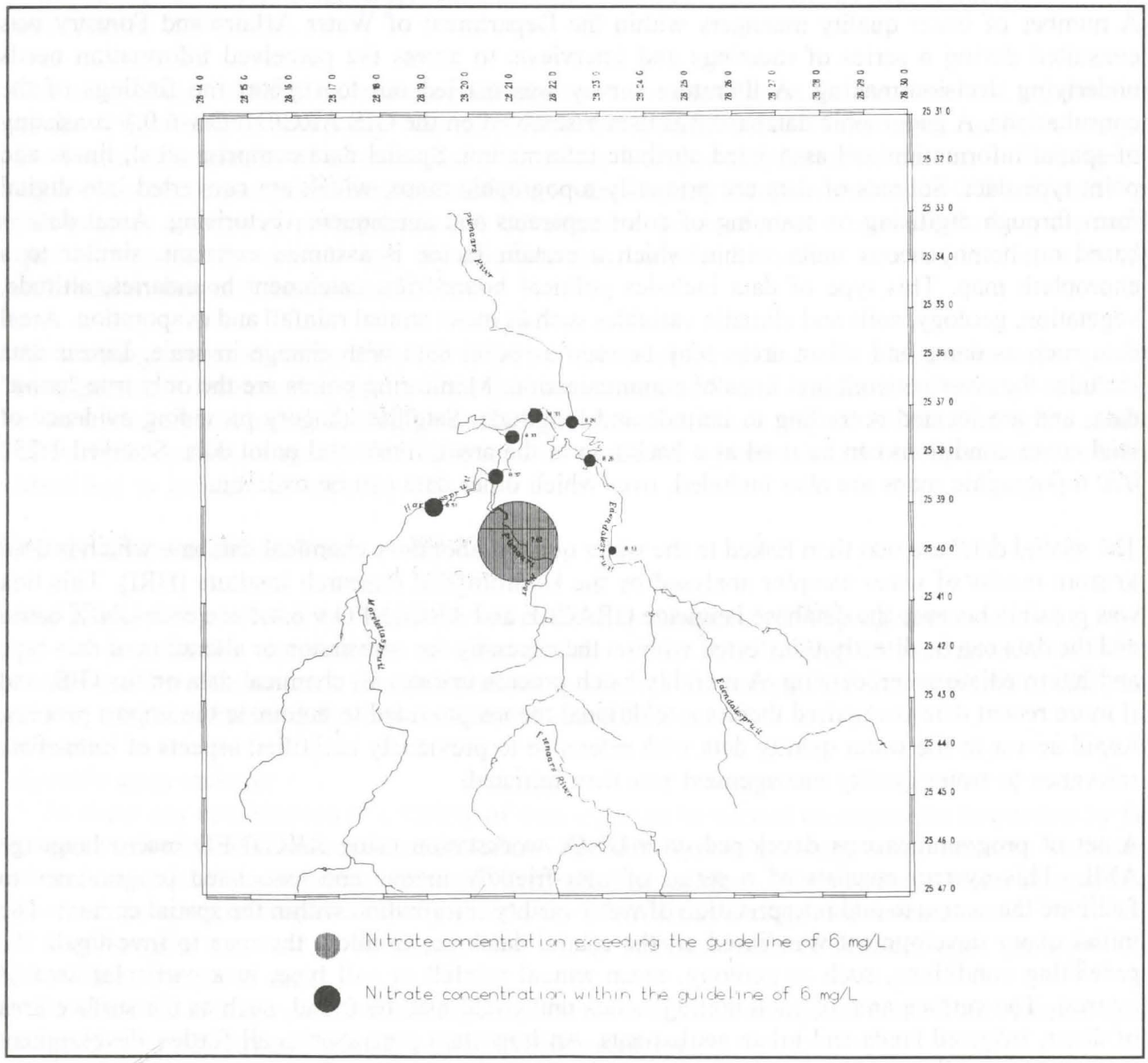

Figure 1: Monitoring points within the Roodeplaat Dam Catchment which exceed the 6mg/ Nitrate guideline for domestic use (Water Quality Guide for Domestic use, 1993), as at 11 May 1993

Trend Analysis

Water quality varies temporally as well as spatially and the system also allows the changes over time to be highlighted. This is an application particularly well suited to the GIS, as spatial changes in the catchment can be represented on screen alongside changes in water quality. The period of time to be reselected from the database is specified and represented in a number of different ways. The most easily interpreted application of temporal change is to plot a time series of the water quality variable of interest (Figure 2), which can be combined with the recommended guideline for the variable against which the actual values can be compared. Seasonal and other cyclic trends are immediately identified in this way. Other summary diagrams available include box plots, star diagrams and maucha plots, although these do not give an indication of changes with time.

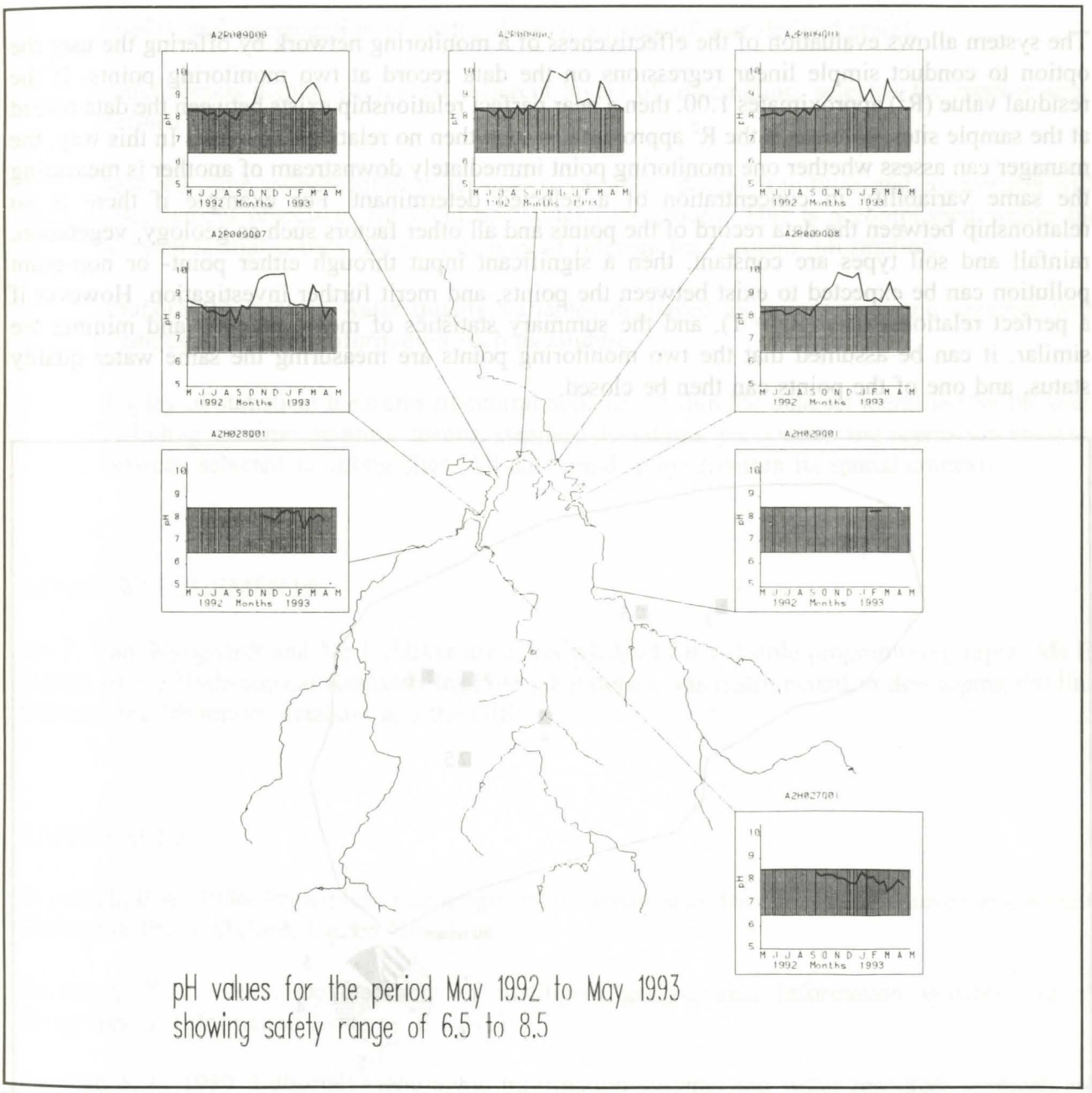

Figure 2: Time series plots for pH at monitoring points within the Roodeplaat Dam catchment, showing the recommended recreational guideline range of 6.5 - 8.5 (Water Quality Guide for Recreational use, 1993)

Statistical Analysis

Summary statistics available through the system include maxima, minima, means, standard deviations and percentiles for any data record specified by the user. These statistics can be represented in tabular form at the base of a map of the area or alongside each monitoring point. The user may choose an option to draw pie diagrams showing a slice of one color to indicate the percentage of time the criteria was exceeded during the period selected, and a slice of another color for the proportion of time the concentrations were within the guideline set for the specific variable. In this way it can clearly be seen which monitoring points are seldom above a management objective, and which points continuously exceed a specified level.

Regression Analyses

The system allows evaluation of the effectiveness of a monitoring network by offering the user the option to conduct simple linear regressions on the data record at two monitoring points. If the residual value (R^2) approximates 1.00, then a near perfect relationship exists between the data record at the sample sites, whereas if the R^2 approximates 0.00 then no relationship exists. In this way, the manager can assess whether one monitoring point immediately downstream of another is measuring the same variability in concentration of a selected determinant. For example if there is no relationship between the data record of the points and all other factors such as geology, vegetation, rainfall and soil types are constant, then a significant input through either point- or non-point pollution can be expected to exist between the points, and merit further investigation. However if a perfect relation exists (R^2 = 1), and the summary statistics of mean, maxima and minima are similar, it can be assumed that the two monitoring points are measuring the same water quality status, and one of the points can then be closed.

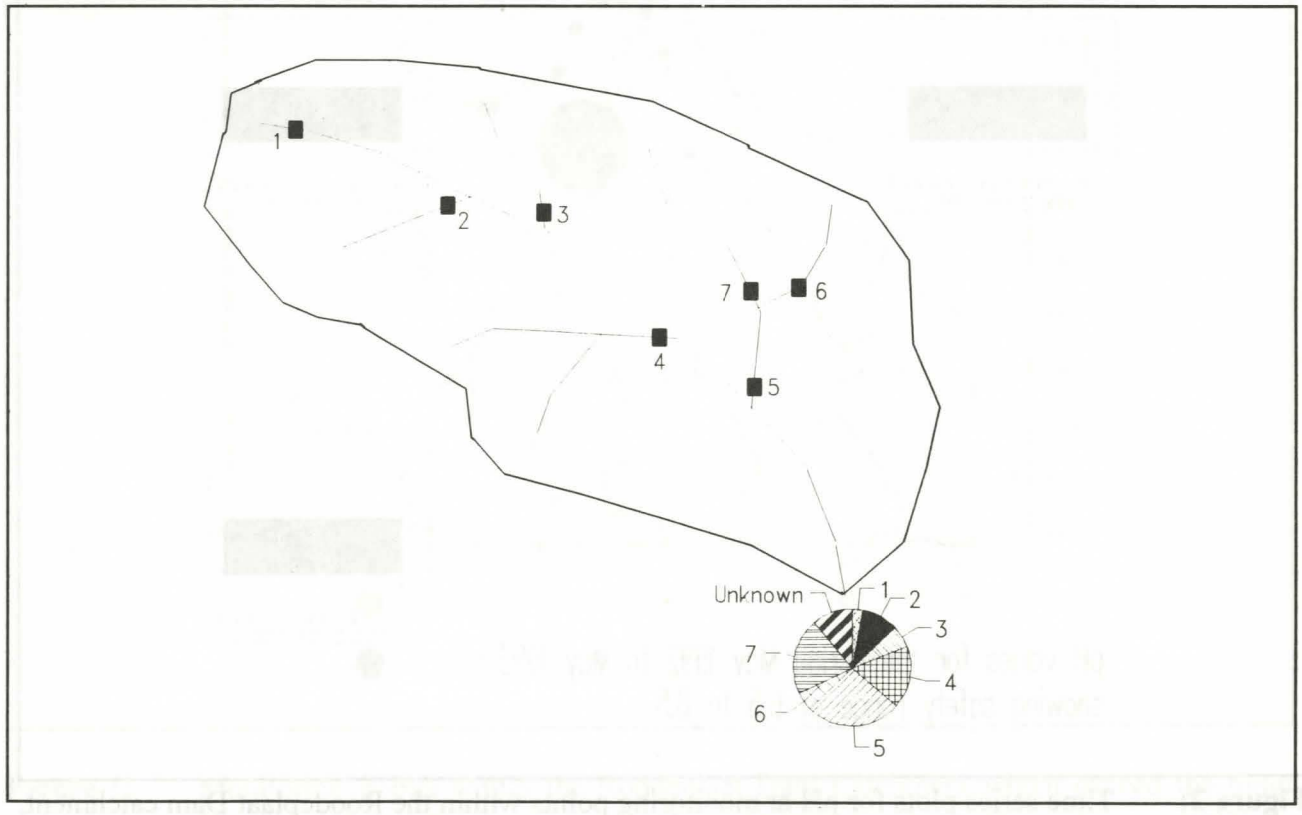

Figure 3: An example catchment where a multivariate analysis indicates the proportionate contribution of each tributary to the total load

Further development of this application is taking place, with the aim to allow multivariate analyses of the water quality variables at several monitoring points within a catchment (Figure 3). It is intended that the outcome of this development will be to determine the proportionate contribution of each section of the catchment to the overall load leaving the catchment. Changes in contribution can then be monitored with change in landuse such as growth in industrial, urban or agricultural areas.

CONCLUSION

A GIS is an essential tool in the collection, management, analysis and display of water quality data, and the use of GIS in communicating spatial and temporal trends in water quality is demonstrated. The following applications have been successfully identified:

* display and interrogation of spatial data, at a range of user-defined scales,

* simultaneous display of several different layers of information, selected for specific user-defined applications,

* near real-time assessment of water quality variables at a point in time, and comparison with management objectives for identified water user groups. This is accomplished within the relevant spatial context through display of relevant background information,

* temporal changes in water quality variables displayed as time series, and together with changes in relevant information such as landuse,

* display of statistical measures of central tendency within the data set identified by the user, including maxima, minima, means, standard deviations, percentiles and regression analyses between selected sampling sites. All data are displayed within its spatial context.

ACKNOWLEDGEMENTS

Mr P. Van Wyngaardt and Mr I. Parker are acknowledged for valuable programming input. Ms E. Davies of the Hydrological Research Institute laboratories was instrumental in developing the link between the laboratory database and the GIS.

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SIXTH SOUTH AFRICAN NATIONAL HYDROLOGICAL SYMPOSIUM

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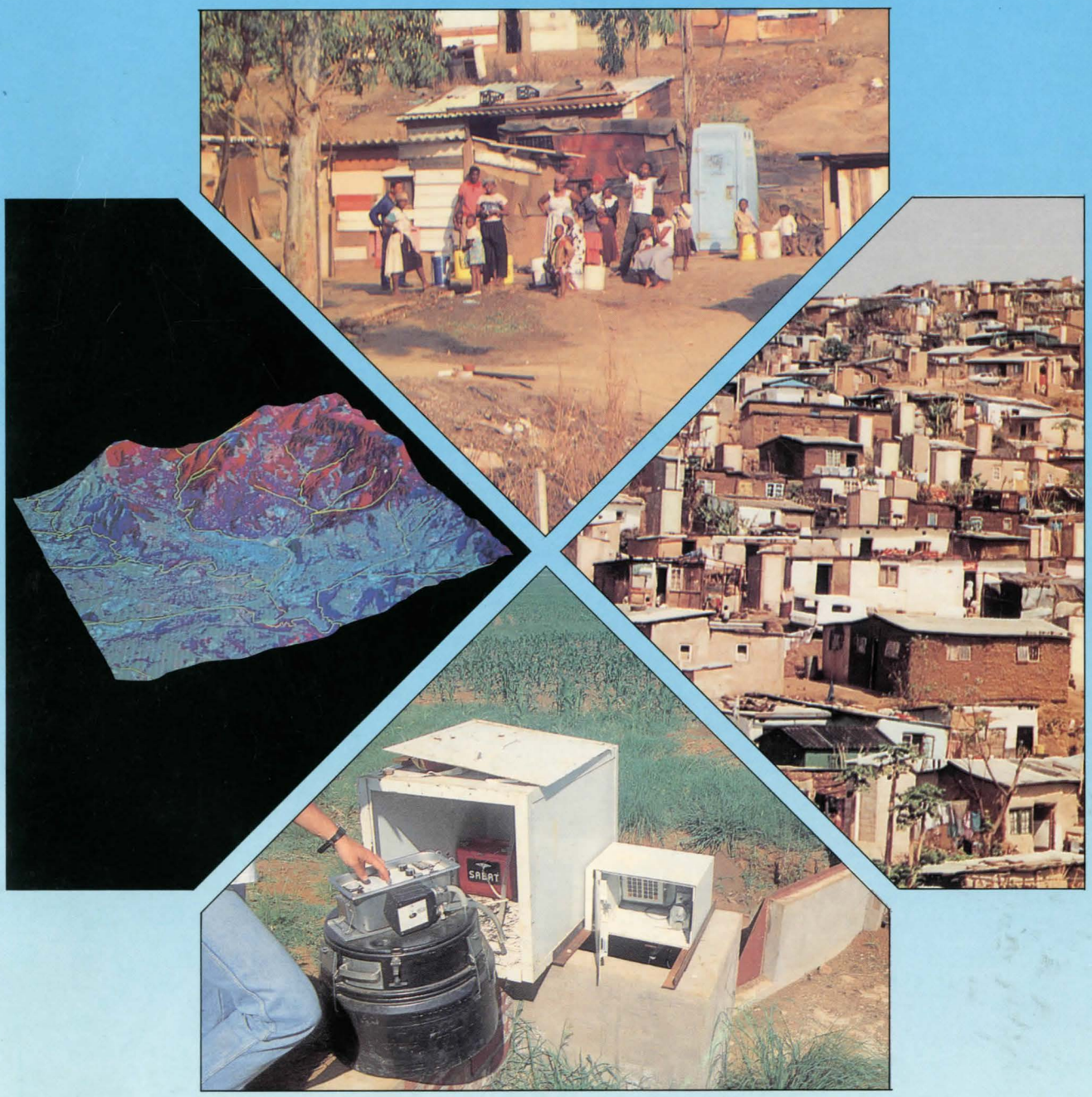
Volume II



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ASSESSMENT OF WATER QUALITY THROUGH A MENU-DRIVEN USER INTERFACE ON A GEOGRAPHIC INFORMATION SYSTEM PLATFORM

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ABSTRACT

Water quality is an elusive and fluctuating component of the hydrological system, affected by a range of environmental factors which vary on independent time and spatial scales. The quality of water supply is a limiting factor for resource utilisation, with different user groups able to tolerate differing conditions. Attempts to quantify, assess, interpret and explain the variable water quality conditions throughout the country are dependent on an holistic consideration of a range of disparate data. A development project currently in progress at the Institute for Water Quality Studies aims to integrate all relevant databases within the context of a Geographic Information System (Arc/Info v 6.1.1.), possibly the only tool sufficiently powerful to attain such a goal. Ready access to water quality databases maintained by the Department of Water Affairs and Forestry, within the framework of background information facilitates the process of water quality assessment.

INTRODUCTION

Integrated information management for diverse applications in the field of water quality assessment entails access and control of large aspatial and spatial data sets. The efficiency of electronic storage and processing media has led to the establishment of a wide variety of databases, on different computer hardware and software platforms. Mechanisms to integrate and navigate through information using locational and associated aspatial attributes, with the capability to process selected data subsets are unique to Geographic Information Systems (GIS). Such systems are ideal for applications that need to integrate a variety of relevant data, including those that have not necessarily been gathered for spatial processing. This data, while not inherently spatial, can be incorporated in a GIS through defining spatial association.

Recognising the time constraints in training users to the level of proficiency needed to optimise the GIS, the Institute for Water Quality Studies (IWQS), in partnership with the CSIR, has developed a menu-driven interface which allows rapid access to a wide range of data in an integrated fashion, previously

impossible to achieve. Conventional spatial data incorporated include infrastructure, environmental, geographic, demographic and hydrological features such as rivers and dams. Monitoring networks maintained by the Department of Water Affairs and Forestry (DWAF) constitute an additional spatial component, to which the vital temporal water quality data is linked. Although tied to monitoring point locations, the water quality record can be extrapolated to explain changing conditions over a wider area, with the potential for classifying river reaches in terms of user-related criteria.

Water quality cannot be considered independently of the spatial context within which it occurs, as changes in physiographic conditions over time and space may be reflected in the water quality record, after lag times ranging from hours to years. Water quality indices measure the conditions at a monitoring point location for an instantaneous moment in time but reflect the influence of the wider environment, possibly events taking place several hundred kilometers from the site of sampling and several days, months or years prior to the time of sampling. The menu-based GIS development will ultimately provide the capability to correlate land use conditions with associated water quality parameters, which will provide an indication of potential impacts likely to arise with future development.

WATER RESOURCE MANAGEMENT

Effective understanding of water quality must take diverse factors into account, and relies on information from a variety of sources and a range of scales. Such information must be assimilated and presented in a logical, accurate and timely way to support real time management of water quality. Until recently, the tools for holistic integration of relevant data were not available, and comprehension of the water quality perspective could only be achieved through the intuition and experience of the water resource specialist.

The purpose of the IWQS is to investigate water quality conditions throughout the country, and support the effective management of national water resources. Primary tasks include the measurement, assessment, evaluation and reporting of water quality. These tasks are addressed through a number of detailed functions. Figure 1 illustrates the continuum between data gathering, processing, interpreting and management, where a multi-directional feedback loop exists between all stages.

Water Quality Monitoring and Laboratory Analysis

Design, establishment and maintenance of monitoring networks on national, regional and local scales are the first steps in data gathering. New and emerging trends in monitoring technology must be identified and additional networks are designed where necessary to meet additional monitoring needs. Currently, a monitoring network for microbiological indices is under investigation, and protocols for

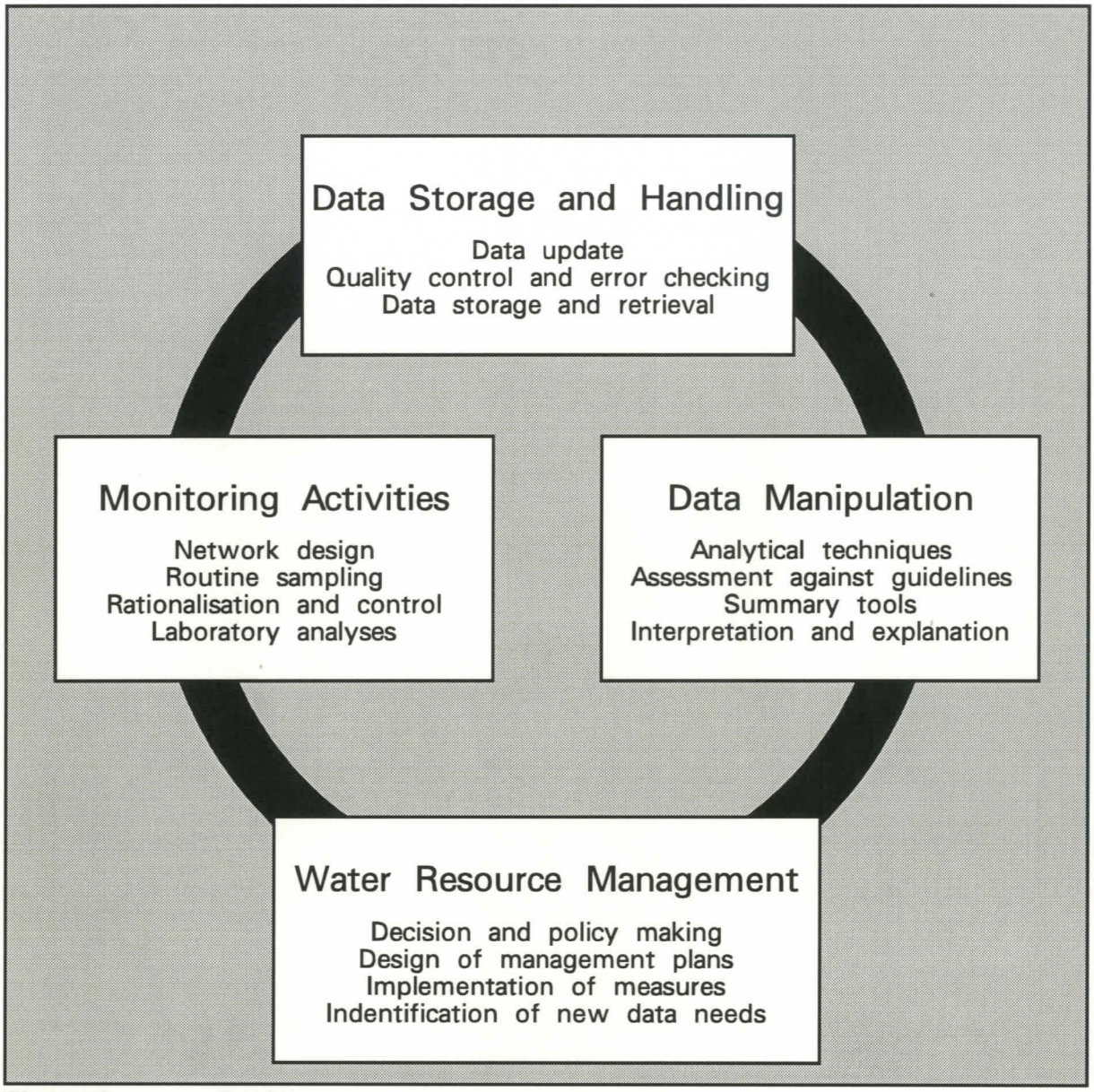

Figure 1: Continuum in approach to water quality management

macroinvertebrate and fish monitoring are in the testing phase.

Once in place, a monitoring network yields a regular supply of raw data. Water samples are analysed for a comprehensive range of constituents, laboratory techniques and equipment are evaluated and new techniques for gauging water quality, including ecological, biotic and toxicity indices, are tested. Laboratory data are stored in a computer database, and are available for reporting on the country's water quality status to managerial, scientific and public forums, at a range of resolution from national to regional levels, and localised where specific problems arise.

Ongoing re-evaluation of monitoring networks to provide requisite data must be carried out in view of rapid changes in both natural and built environments. New demands for water, technological developments, urban and industrial growth introducing more and new kinds of contaminants, and growing environmental awareness stimulate management needs, leading to concomitant changes in monitoring needs. Monitoring technology is advancing into fields such as telemetry, toxicity, ecosystem health indices and biotic status indicators. These new methods in turn provide challenges for management to incorporate and extend policy and existing strategy.

Table 1: Recognised user groups identified for water quality guidelines (DWAF, 1993)

User Group	Sub-user Groups
Domestic	Potable
Recreation	Full contact Intermediate contact Non-contact
Agriculture	Irrigation Livestock water Fresh water aquaculture
Industrial	Iron and steel Pulp and Paper Leather and Tanning Petrochemicals Power Generation Textiles
Natural Environment	(in preparation)
Coastal and Marine	(in preparation)

Water Quality Assessment

Assessment of water quality is done against selected criteria for different recognised user groups (Table 1). Research into the validity of established water use guidelines against local and international norms leads to recommendations for new criteria where necessary. Guidelines have not been established for all water quality indices for all recognised users, and more detailed sub-user groups are continually identified.

As water quality cannot be considered independently of the environmental context, the impact of different landuses as diffuse pollution sources on water quality is assessed through comparison

between water quality and spatial data largely obtained through the use of remotely sensed data. Techniques for the analysis and interpretation of satellite imagery have been developed with the emphasis on water quality related features. Widespread informal settlements are a major source of microbiological contamination of the surface water supplies on which the communities depend. There is little cadastral data on the location and geographical extent of these settlements, and remote sensing techniques are successfully applied to delineate the areas of informal settlement. Substantial point source effluent contributors must comply with permit regulations specified by the DWAF, and the discharge is monitored with data stored on the POLMON system, a database designed for this purpose.

Water Quality Evaluation and Managment

Effective management incorporates an understanding of relations between spatial and aspatial data, such as how changes in the natural and man made environment affect changes in water quality. Environmental monitoring reveals the unsustainable consumption of natural resources such as site specific crises and long term gradual degradation over widespread areas, reflected in loss of biodiversity, resource quality and bioaccumulation of pollutants (Woodrow, 1993). A concept of accountability can only be based on a foundation of appropriate monitoring information. Activities that degrade or consume natural resources generate the need for policy and the information to make that policy.

Development of decision-support tools, including predictive models, allow testing of different management options to address real world problems. The development of modelling and other non-intrusive monitoring techniques such as remotely sensed data challenge existing data structures for storage, manipulation and access, and require new applications and approaches from management.

Better understanding of hydrological and environmental processes, and changes in political and economic interests are among the many factors influencing the realm of water resource management. Such a dynamic field requires dynamic and flexible tools, with the requisite processing capacity to handle large databases.

GEOGRAPHIC INFORMATION SYSTEMS CAPABILITIES

Geographic Information Systems (GIS) are computer-based tools that store, analyse and manage spatial data (Burrough, 1986; Lanfear, 1989; Openshaw, 1987). The essential roots of GIS technology lie in its foundations within the cartographic profession, and addressing the question "where" (Muller, 1993). The data processing and analysis capabilities of GIS have received comparatively little developmental attention, with the database remaining limited and essentially isolated from associated

spatial and aspatial data. This restricts the potential information that can be obtained from the data, which in turn limits the cost effective utility of data which has been expensive to accumulate. Automated map and output production has been and remains a primary function of GIS, and increasingly applications attempt to manage diverse data types and distil more than different mapping methods from the database.

In a review of GIS applications, Muller (1993) reports that a substantial proportion focus on natural resources and environmental issues, reflecting an awareness that we are engaged in a world-wide race between environmental threats and the technological, methodological and institutional solutions to remove those threats. Spatial science, of which GIS is a tool, can play a decisive role in promoting economically and socially feasible solutions to environmental related problems (Muller, 1993). Over the past 5 years, concern for the natural environment has seen water companies utilising the potential of GIS to explore environmental applications such as river basin management and pollution modelling (Woodrow, 1993). GIS offers convenient tools to monitor and analyse the availability of physical resources required for human survival, and to make policies designed to protect and manage those essential resources (Atkinson, 1993).

Muller (1993) observed that the greatest challenge to GIS users is no longer technical, but lies in the organisational ability to maximise the potential of GIS through project management and planning. Technological issues will continue to be resolved, but issues of management and optimal application are not specifically addressed. Successful GIS projects depend on thorough planning of all levels of GIS application, from data capture, structure, quality and final presentation phases.

Data capture and storage

Spatial databases are becoming increasingly available through data capture technology and greater capacity storage media. The ability to capture and manipulate massive amounts of data is due to developments in computing and electronic technology, increased processing power and speed, and drastic reductions in cost and size. Available data sources can virtually bury the scientific and professional communities in information (Muller, 1993). Many organisations are engaged in data gathering for diverse programmes. A major component of this data is generated from remotely-sensed imagery, providing "seamless" synoptic views of large and often inaccessible areas. According to Morrison (1991) by the year 2000 most map series revisions will be done from monoscopic imagery, removing the need for manual mapping and surveying.

The result of this development is the large scale increase in the size of available databases, extending in multiple directions:

* the *horizontal data dimension* is extending as more spatial data is gathered and at finer resolutions than previously possible. Areal data is increasingly obtained from remotely sensed satellite imagery, as the most accurate and cost effective means of repeatedly covering a wide spatial extent, for an instantaneous and hence comparable picture of prevailing conditions. The resolution of spatial data is dependent on the resolution of the imagery, with the trend towards greater resolution reflected in satellite imagery developments. The early satellite Multi-Spectral Scanner data first available in the 1970's had a resolution of 80m, while the Thematic Mapper imagery first available in South Africa in 1989 had a resolution of 30m. SPOT data allowed resolution of 10 m in 1991, and imagery from the Russian satellites and other planned satellites are expected to allow resolutions of from 5 down to 1 m. Concomitantly, the resolution of spatial data extracted from the satellite imagery has also increased, with a greater visibility for fine details.

* the *vertical data dimension* extends as more layers of different data types are added to the GIS. Information previously stored on non-digital media is being converted to electronic format, such as scanning of topographic maps. Demographic information from census and municipal records is also being electronically stored. New categories of landuse are emerging, and existing categories are subdivided into more detailed classes as the spectral range and resolution of satellite and airborne scanners improves.

* the *temporal data dimension* encompasses all data that changes over time. The extension of geographical and landuse data over time may be limited only by the orbiting frequency of different satellites and the cloud cover during overpass, where remote sensing is used. Routinely collected aspatial datasets including climatic and hydrological data, are usually electronically stored, and these databases are continually incrementing with time.

Data structure

To utilise such massive datasets, the database must be structured in an efficient manner. Optimal use of space and layout will allow manipulation and navigation through various levels and types of data. Lengthy extraction and conversion processing activities, previously the norm on mainframe-type storage facilities, can be avoided through the use of a GIS which has an internal data structure facility.

Data quality

The accuracy of the database and not the accuracy of the map which depends on the database is most relevant in quality control of spatial data (Muller, 1993). The use of variable resolutions for data capture

leads to difficulty in matching disparate datasets, and comparisons between features captured at different scales may be erroneous. Remotely sensed spatial data must have a measure of positional or classification accuracy, together with a level of confidence applied to it (Aronoff, 1991). Ultimately, the quality of analysis of either spatial or aspatial data is dependent on the accuracy of the data, and not the capacity of the GIS.

Spatial Decision Support Systems (SDSS)

SDSS are intelligent systems developed within the GIS environment to support spatial decisions and resolve problems (Muller, 1993). Development of these systems is economically hindered as the highly specific nature of each application limits wide marketing. Expert system technology to support the intuition and experience of human experts through integration of a GIS and other computerised tools, can be expanded to provide the basic knowledge for sound decisions where untrained individuals are required to make decisions, such as in many Third World countries.

MATCHING GIS CAPABILITY TO WATER RESOURCE MANAGEMENT NEEDS

Water resource assessment requires an integrated view of a variety of factors, including background environmental conditions, prevailing climatic conditions and landuses under human activity. Knowledge of the water users and potential water impacters must be available, together with information regarding the direction and magnitude of change in any of the relevant factors. Accurate assessment, evaluation and forecasting of the quality of surface water resources must be based on a wide range of data types, both spatial and temporal in nature, and the tools to integrate and process this data must be sufficiently powerful to allow rapid outputs, ideally in real time where crises occur. The question that must be addressed moves beyond the simple "WHERE", fixing features in space, moving to an understanding of "WHY" and "HOW"; only with this understanding can resource managers attempt to solve real world problems for the dynamic conditions and rapidly changing demands and impacts (Muller, 1993).

As most water resources data can be referenced geographically, GIS is ideally suited as a management tool (Lanfear, 1989). The ability to store and manipulate large volumes of spatial and associated data, and to present the data in summarised and analysed forms renders the GIS an essential tool for resource management. The developmental roots of GIS as an automated cartographic facility have left a legacy of well developed mapping output capabilities, in combination with powerful integrative and processing facilities.

However, unrealistic performance claims, high capital costs involved in hardware and software acquisition, lengthy training periods and slow and expensive data gathering has led to disillusionment

among GIS users. It has been argued that limited manpower and economic resources might be better directed to manual data processing and reporting on small spreadsheet packages where results are proven. If the GIS capacity can be harnessed without the excessive time investment necessary for adequate training that is often not feasible for water quality managers and policy makers it will be of great value to the assessment of water quality. Recognising the utility of GIS as a support tool for decision-making the IWQS embarked on a project aimed at developing a system that reduces the time and training deficit, allowing major projects to be rapidly completed.

Research in the field of natural resources in South African has consisted of numerous "pilot" studies carried out on the GIS, using its capabilities to different degrees and leading to an accumulation of discontinuous datasets and findings of limited general use. This pattern reflects that of many other countries, including Britain, where there is an attempt to coordinate work done across governmental Departments and other Authorities, and to facilitate the wider implementation of data and research (Peel, 1993).

The primary approach of the IWQS research is generic, designed to incorporate a range of data, at a range of scales and resolutions with the potential to expand as more data becomes available over time. The system is flexible enough to include both discontinuous datasets from intensive localised studies and nation-wide data. As more data is received through completion of small studies the database is incremented and gradually a more complete picture of the factors influencing the quality of our national water resources will be built up.

The water quality specialist can select any area of interest within the country, access any data that is available, and carry out relevant statistical analyses. Different combinations of data can be selected, and a camera-ready hard copy output created once the analysis phase is complete. Routine reporting, special studies into problem areas and assessment of long term trends are readily supported by the system. Where temporally changing landuse data is available, it can be correlated with temporal changes in associated surface water quality, and the system can support investigations into the relationship between landuse and its impact on receiving water quality. The identification of pollutant inputs to river systems previously difficult to isolate is now possible, and the partitioning of various pollutant source contributions to river water quality can then be determined.

Assessment of the monitoring networks themselves can be carried out through correlation between water quality constituents at different sampling stations. For example, if the variation in water quality at adjacent upstream and downstream monitoring points is statistically identical, then both are measuring the same parameters and one can be removed or relocated to a more suitable position.

METHODOLOGY

A framework for the development of a menu-driven interface, anchored to a broad spectrum of spatial and aspatial data was outlined in a project proposal initiated at the IWQS. A literature survey and investigation of the ESRI-L Bulletin Board revealed that there was nothing available to meet the specific requirements for water quality reporting, assessment, evaluation and presentation of the IWQS.

The main aims of the project were:

* The integration of a range of diverse databases from different sources, relevant in the consideration and assessment of water quality, to facilitate rapid and easy access to data on a coherent platform.
* The development of a menu-driven interface allowing access to the database established. On viewing the data in a holistic fashion, many trends and potential applications may become apparent.
* The development of tools for detailed assessment and analysis of water quality data, within its spatial context. Standard statistical routines are to be incorporated into the menu structure, with maximum flexibility for customised applications.
* The development of a mapping facility, to allow production of high quality maps for inclusion in reports, papers and other communication documents.

In partnership with the CSIR: Watertek, the project was carried out in two phases. Phase one consisted of a systematic itemisation of needs - both real and perceived - for fulfilment of water quality assessment tasks. Phase two consisted of a technical development phase where user requirements were operationalised on the GIS platform. Ongoing development was planned for continuation beyond the completion of the initial phases.

The success of the first phases can be attributed to the well-defined and highly structured nature of the project, where deadlines were set and adhered to and the modularity of development allowed incremental growth of the system into more advanced and sophisticated functionality.

PHASE ONE: Needs Analysis

The initial phase of this study established the nature of tools required to carry out the functions of water quality assessment and reporting. The needs outlined by a selection of water quality specialists were itemised and a detailed user-needs document was produced after a series of meetings throughout the initial development of the system (Development of Water Quality Assessment Procedures, 1994). Primary requirements and expectations were tailored to the GIS environment through demonstrations

of the developing system and a gradual "education" of the target professionals. Priority needs were identified at each level of the analysis, with the overall goal being to streamline and automate repetitive and data-intensive analysis methods.

PHASE TWO: Interface Development

Concomitant with the needs analysis was the interface development. A menu-driven system was developed on a modular basis, where functions were partitioned into discrete programme routines. This allowed incremental development of the system, with continual expansion of functionality as additional modules were completed and incorporated. Feedback from the needs analysis ensured the direction of development remained focused on the user requirements, which in turn became increasingly sophisticated with the educative impact of regular demonstrations.

Data Requirements

A range of data types were identified as necessary for water quality assessment. A major task was to organise widely varying datasets into a master database that allowed rapid navigation and user-defined selections of relevant information.

Two main categories of data were identified: spatial and aspatial. Spatial data is defined as geographic locational data, such as geology, rivers and towns, comprising conventional GIS feature layers or coverages. Aspatial data consists of the temporal data records that have been accumulated by numerous agencies, primarily the water quality data collected by the DWAF, but using the Computing Centre for Water Research (CCWR) to access climatic data such as mean annual rainfall from the Dept. of Agricultural Engineering, Natal University. These data constitute a record of changes in selected water quality or climatic parameters over a long time period and so are termed temporal, although spatially linked to a geographical locality.

The aspatial data was arranged into a database structure designed to allow regular update. Access to aspatial data is achieved through an indicator common to the spatial layer representing the sampling or measurement points. Although stored separately, the user is not aware of seams between the spatial and aspatial data.

Spatial Data

Diverse datasets identified as relevant to understanding water quality during the needs analysis were located where possible and the geographic projection standardised to Albers equal area; 24°E, standard

parallels of 18°S and 32°S, Clarke 1880 spheroid. Stable geographic feature layers were incorporated into a map library, which affords protection against corruption and damage that may occur in a multi-user network environment. Fluctuating features, such as monitoring points which are periodically updated, are stored in an independent directory and are not part of the library.

Table 2: Geographic feature layers assembled for reference during water quality assessment

COVERAGE	SCALE	SOURCE
Geology	National 1: 1 500 000	Geological Survey
Vegetation	National 1: 1 500 000	Acocks Veld Type Map (1988)
Climate Zones	National	CCWR
Ecoregions	National 1: 1 500 000	IWQS
Perennial Rivers	National 1: 1 000 000	DCW*
Seasonal Rivers	National 1: 1 000 000	DCW*
Perennial Dams and Lakes	National 1: 1 000 000	DCW*
Seasonal Dams and Lakes	National 1: 1 000 000	DCW*
Springs	National 1: 1 000 000	DCW*
Boreholes	National 1: 1 000 000	DWAF
Altitude	National 1: 1 000 000	DCW*
Political Boundaries	National 1: 1 000 000	DCW*
Cities	National 1: 1 000 000	DWAF
Roads	National 1: 1 000 000	DCW*
Railways	National 1: 1 000 000	DCW*
Power Lines	National 1: 1 000 000	DCW*
Drainage Regions	National 1: 1 000 000	DWAF
Catchment Boundaries	National 1: 000 000	DWAF
Landuse	National and localised	Various
Water Quality Monitoring Points	National and localised	DWAF; IWQS

* DCW = Digital Chart of the World, compiled from 1:1 000 000 aeronautical charts (DCW, 1992)

Geographic data consists of two types, listed in Table 2, the predominate form being nationally available spatial layers. The second form of spatial data is discontinuous, gathered from localised studies and comprising a patchwork of different landuse and landcover categories, derived largely from classification of satellite imagery for isolated areas. While the objective of this study is to develop a generic system, equally applicable to any area of interest, the discontinuous datasets have also been included within the framework. In this way a more complete picture will emerge as more studies are completed and incorporated into the database. The user is able to access any information available for

the area defined, and data from such isolated studies provides the potential for enriching the historical perspective of the catchment concerned.

Table 3: Aspatial datasets available for water quality assessment

DATASET	SCALE	SOURCE
Inorganic chemistry	National	DWAF
Organic chemistry	National	DWAF
Trace metals	Regional (A,B,X)	DWAF
Trihalomethanes	Localised	DWAF
Algal identification	Localised	DWAF
Habitat diversity	Localised	DWAF
Invertebrates	Localised	DWAF
Sediment concentration	National	DWAF
Flow	National	DWAF
Water physical parameters: temperature, turbidity	National	DWAF
Bacteriology	Localised	DWAF
Toxicity	Localised	DWAF
Ecological Health	Localised	DWAF
Groundwater chemistry	National	DWAF
Effluent discharge	Regional (Highveld)	DWAF
Rainfall	National	CCWR
Temperature	National	CCWR
Evaporation	National	CCWR
Wind speed/direction	National	CCWR

Aspatial Data

Temporal data sets currently available on the database are listed in Table 2. As with geographical data the aspatial monitoring networks exist on a range of scales from national to regional and localised. Many areas of southern Africa lack substantial water quality data records and some monitoring networks, such as biomonitoring and bacteriology, are in preliminary planning phases with little measured data available.

Sampling periods vary between datasets, from intensive and continuous for recordings at flow gauging stations, to weekly or monthly intervals for water quality sampling. Some types of monitoring require specific sampling intervals, such as the biotic integrity index which requires a six week recovery period between sampling exercises (Moore and McMillan, 1992). Other surveys are conducted annually or over longer time intervals, such as the bioaccummulation survey of the Middle Vaal fish which was conducted in 1983 and 1991 (Grobler, 1994). All sampling intervals are subject to interference

depending on the presence of flowing water, and sampling may become sporadic during prolonged drought conditions. As new networks come on line and regular sampling takes place the data can be rapidly incorporated into the database if it is locally analysed, through a slow serial line to the Laboratory Information Management System.

Interface modules identified for development

A structure for interface development was outlined, based on functions that could be grouped into logical modules (Table 4). Priorities identified in the needs and technical discussion groups directed the order of development where system constraints permitted. Although a high priority, the output module used for generating maps and presentation documents was developed towards the end of the project, as it was dependent on development of the other modules. The database module was planned as the first logical module to be developed on which the subsequent functions would be tested, but was the last module to be finalised due to continual additions of new datasets.

The developmental procedure followed was to develop the functionality of the system to carry out the required task, irrespective of speed or efficiency. Once in working order, different programming options were explored to optimise each functional process. A major drawback encountered in the early demonstration stages before optimisation was in demonstrating the system to users who grew impatient with a slow and clumsy interaction. Fine tuning and streamlining of algorithms is painstaking and time-consuming in a field with little available information and much experimentation. Where possible, analytical programmes were re-written in C Programming Language, which proved superior in execution speed to the GIS Arc Macro Language (AML). A network of "parent" AML programmes control the interface with C programmes called where necessary, writing results to temporary files. The temporary file is then accessed by the calling AML which then performs the user defined request, such as drawing box and whisker plots based on C calculated median values.

Methods of statistical analysis of water quality data include measures of central tendency (maxima, minima, arithmetic and geometric means, percentiles) for user defined time increments and display in a range of standard symbols including time series, box plots, proportional circles, user-related symbology, rose and star diagrams. All water quality presentation symbols, with the exception of Maucha Diagrams, are referenced against the water quality guidelines for use as outlined by the DWAF (1993) selected by the user (Table 1), as water quality cannot be meaningfully assessed in absolute terms but must be balanced against the user requirements. The system is flexible to allow manipulation of guidelines other than the recommended concentrations. This means scenario testing can be carried out at a simplistic level. For example, in the planning stages of a catchment management strategy the existing water quality can be assessed against suggested water quality objective values, and those

Table 4: Modular components of the interface structure, showing selected functions for each module

MODULE	FUNCTION
Database	Design, populate, quality control and error checking. Update facilities. Access control and temporary work space allocation. Speed optimisation.
Spatial query and interrogation	Navigational facility. Display options for color and symbol. Overlay facility, zooming function.
Aspatial data query	Navigational facility. Examine data properties, sampling intervals, number of records, parameters measured, missing data. Examine and display monitoring points. Select dataset for detailed analysis
Aspatial data analysis	Suite of analytical tools for central tendency, trend analyses and correlational analyses with reference to guidelines for use. Deseasonalisation of water quality data. Assessment against water use guidelines.
Presentation symbology: all referenced against the water use guideline selected to indicate exceedance, level of exceedance, duration of exceedance or compliance.	Conventional symbols: Colored shapes Water use symbols Pie diagrams Proportional circles Star diagrams Box and whisker plots Time series Non-conventional symbols: Maucha diagrams Box plots - time series Box plots - radial
Multiple output design	High quality hardcopy maps in a range of standard sizes and layouts, routinely required for reporting, wall map display and communication of results: A5, A4, A3, A1, A0 Landscape and portrait Color, black and white Draft, final Formats for Pen Plotter, HP Printer, Electrostatic Plotter, Laser Printer

sampling sites most affected will be easily isolated. Attention can then be directed towards ameliorative procedures in such problem areas.

Different scenarios can also be investigated where a new landuse is planned for development, and existing user requirements will be modified. The new water requirements can be selected in the system, and the most suitable location for the development determined in water quality terms. Conversely, the least disruptive location relative to existing water users in the catchment can also be selected in water quality terms.

Although further considerations will have to be assessed which may eventually determine the final location chosen, the ability to evaluate multiple options provides valuable input to the decision making process.

TESTING AND APPLICATION OF THE SYSTEM

During development the system is continually tested as new programming routines are incorporated. The statistical accuracy of C programmes is tested against both manual calculations and results obtained from commercially available statistics packages, including STATGRAPHICS and WQSTAT. The system has been applied to a number of different water quality investigations, from a national scale to primary and tertiary catchment scales.

National Assessment

National assessment of surface water quality in streams and reservoirs has the advantage of summarising water quality conditions at a coarse scale. Even at this level trends and problem areas can be detected. The user can then focus on these areas where attention to detail may help in explanation. Figure 2 illustrates median total salts concentrations in reservoirs throughout the country during the summer period October 1992 to March 1993. The national status can be readily assessed against the guideline for domestic use of 450 mg/L.

While Figure 2 gives a general picture of the status of water quality, more detail can be gauged from a consideration of selected individual water quality constituents (Figure 3). Clear spatial patterns are now identifiable, and the overall salt concentration is partitioned into primary contributing ions:

* characteristically high sodium-chloride concentrations along the coastline in the Southern Cape, the Wilderness Lakes and St Lucia.
* inland the water quality is marked by increased alkalinity levels, concomitant increases in calcium and magnesium, and a relative decline in sodium and chloride concentrations.
* sulphate levels in the Eastern Transvaal, notably the Witbank area, are the highest of the entire country and warrant closer investigation.
* sodium levels in the PWV province are locally elevated, without the related chloride increase characteristic of coastal waters.
* Eastern Cape diagrams show the imported water from the Orange-Fish interbasin transfer scheme with a "bat" shape symmetry, which is distinct from the naturally occurring water in the area with bipolar sodium-chloride dominance or the alkalinity dominated water of the Buffalo River.

At a national level, inclusion of too much detail can obscure the map, so environmental parameters such as landuse and settlement patterns cannot be incorporated in an attempt to explore detailed reasons for the variation in water quality. However, broad patterns identified using generalised criteria can be investigated in more detail, according to the catchment or area of concern. A selection of case studies focusing on different aspects of water quality assessment illustrates the wide application potential of the system.

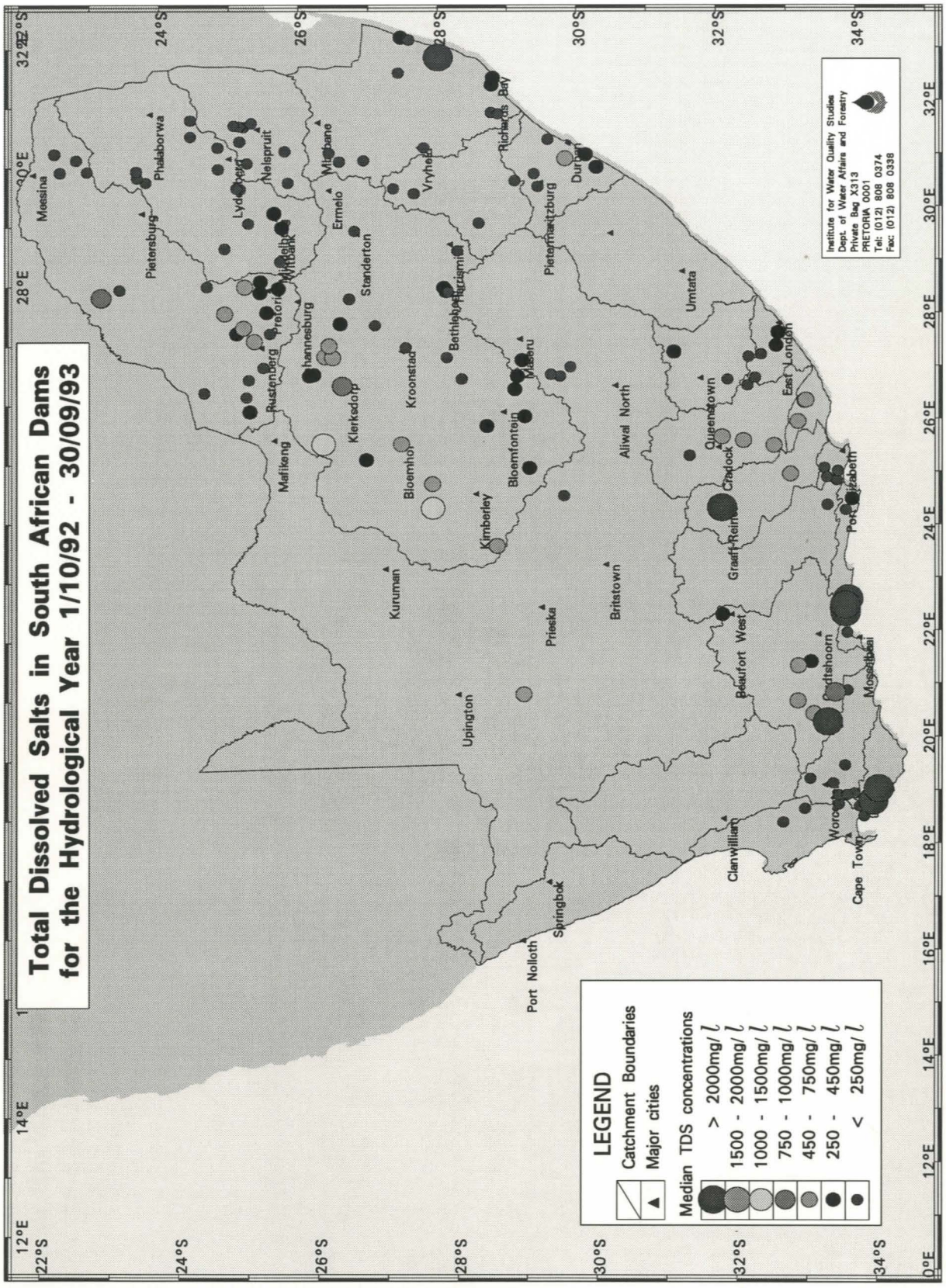

Figure 2: National water quality assessment of total dissolved salts in South African reservoirs

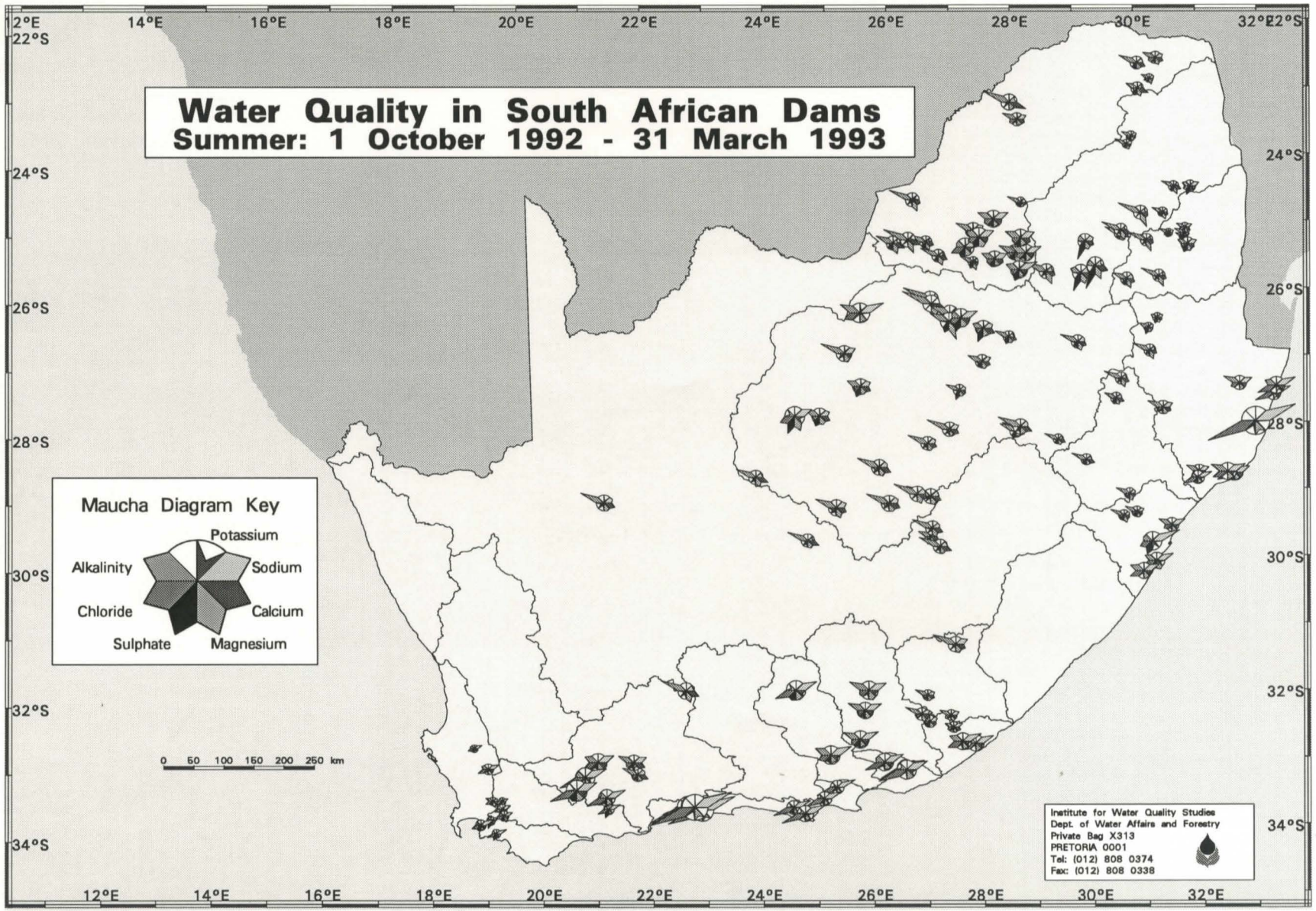

Figure 3: Water quality constituents in South African Dams

Case Study 1: *Witbank Mining Area*

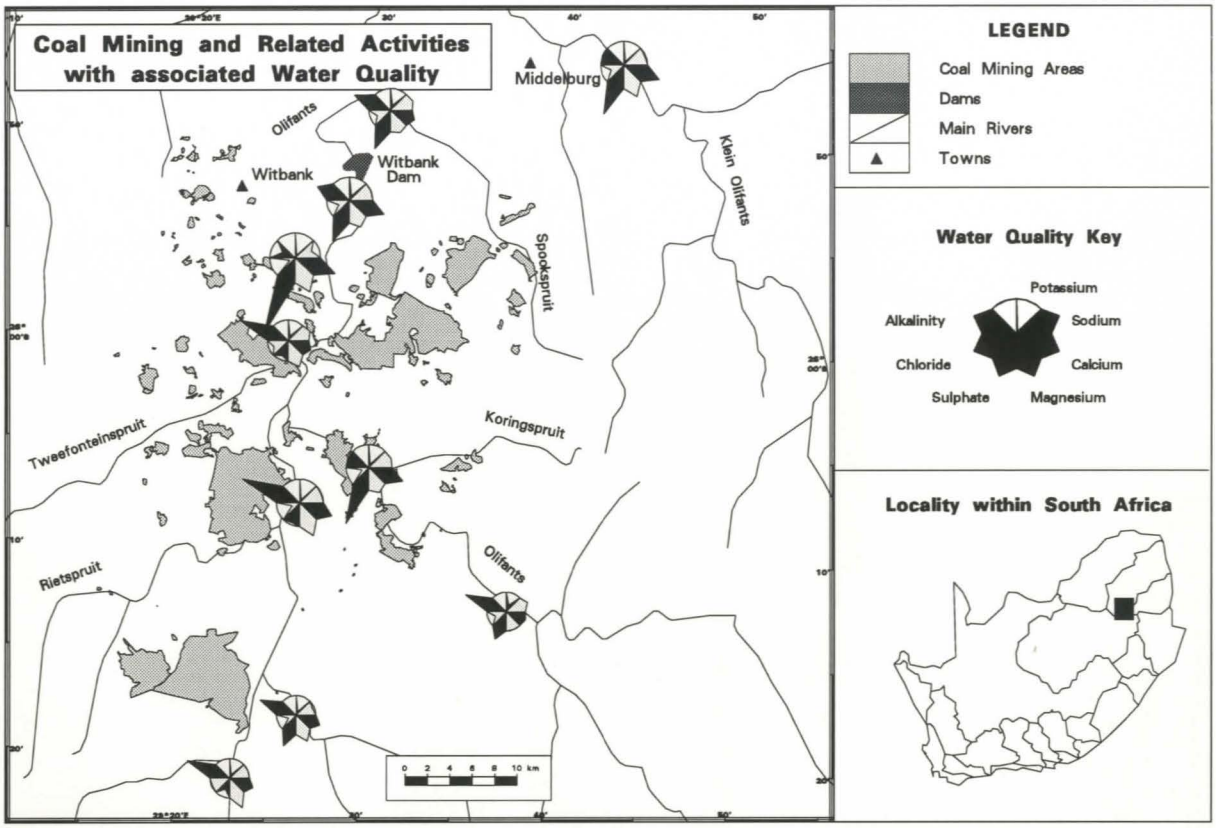

Figure 4: Witbank mining area, showing sulphate enrichment due to mining and related activities

Landuse classification data from a localised study (Vadeveer and Carter, 1993) was used in an assessment of water quality in the intensive coal mining area around Witbank. Coal mining and related activities have led to sulphate enrichment in the associated surface water, through surface runoff and acidic leachate seeping into the rivers. Figure 4 illustrates the trend where sulphates are preferentially enriched in rivers adjacent to and downstream of mining and related activities. Water quality conditions upstream of mining activity are summarised in the symbols on the southernmost limbs of the Olifants River. Natural water shows a relative predominance of alkalinity (carbonates and bicarbonates), which is significantly reduced where sulphate dominates the water quality. Note the recovery of the sulphate levels in Witbank Dam, possibly due to storage attenuation.

Case Study 2: *Jukskei River Catchment*

The Jukskei River catchment is intensively developed in the upper reaches, which drain parts of Johannesburg and Midrand. The total dissolved salts concentrations are assessed against the recommended guideline for domestic use, as there are large informal settlement communities living

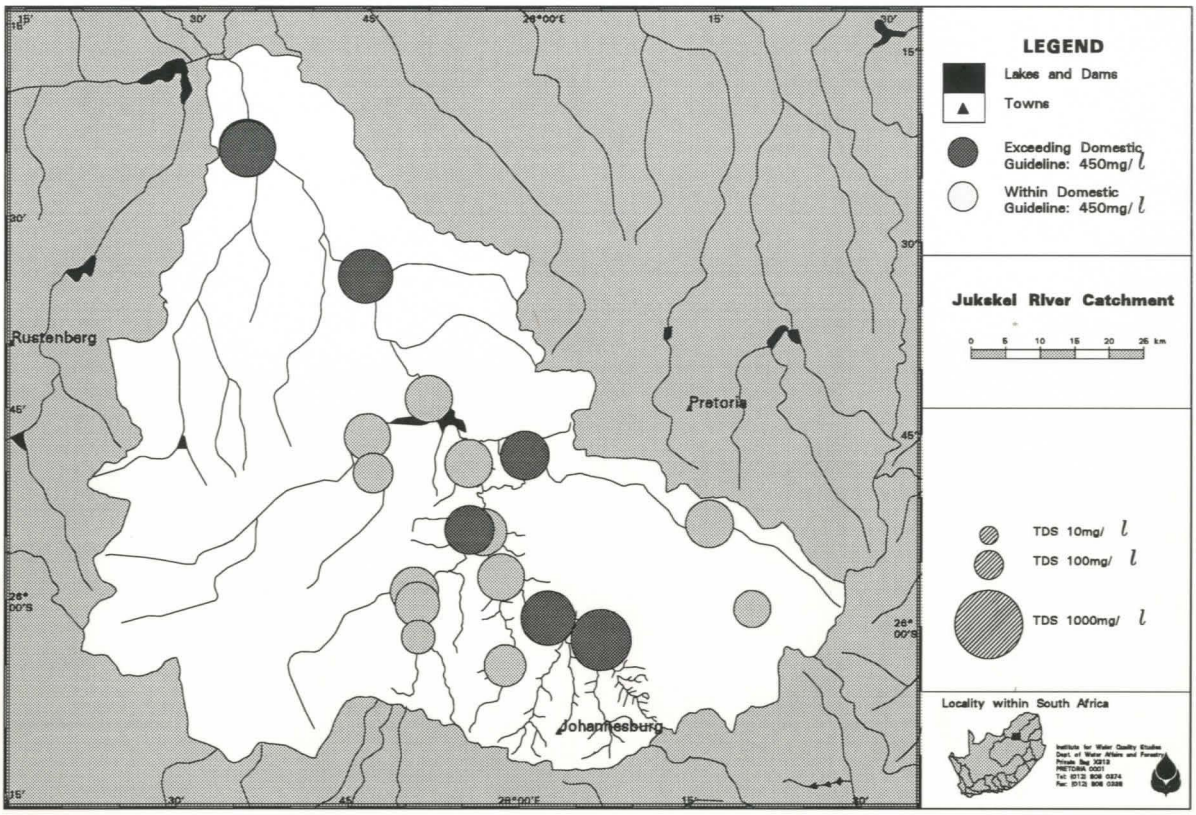

Figure 5: Median total dissolved salts concentrations, for the period June - December 1993, in the Jukskei River catchment, central Transvaal

along the river which may serve as a water source. Figure 5 shows the exceedance of total salts concentrations for the period June - December 1993.

Case Study 3: *Olifants River System*

The Olifants River system in the Eastern Transvaal has a long history of mining and industrial activities. The ecosystem health of an aquatic environment reflects the degree of disturbance from natural conditions. A healthy, balanced aquatic ecosystem reflects the status of the water, and in turn assists the recovery of the surface water after pollutant inputs. The ability of a river to absorb pollution is termed the "environmental capacity", where low capacities indicate highly impacted catchments and require ameliorative management intervention. Figure 6 shows the gradual recovery of biotic health downstream of mining and industrial activity measured using the SASS2 scoring system, a biological index for biotic health assessment (Roux, et. al., 1994). Acid drainage from mining in the upper catchment near Witbank results in severe biotic impairment in the Olifants River. In an immediately adjacent catchment, a monitoring point downstream of Bronkhorstspruit Dam shows the aquatic health to be unimpaired. The aquatic ecosystem recovers to moderate and considerable impairment upstream of Loskop Dam. At Groblersdal, only moderate impairment exists.

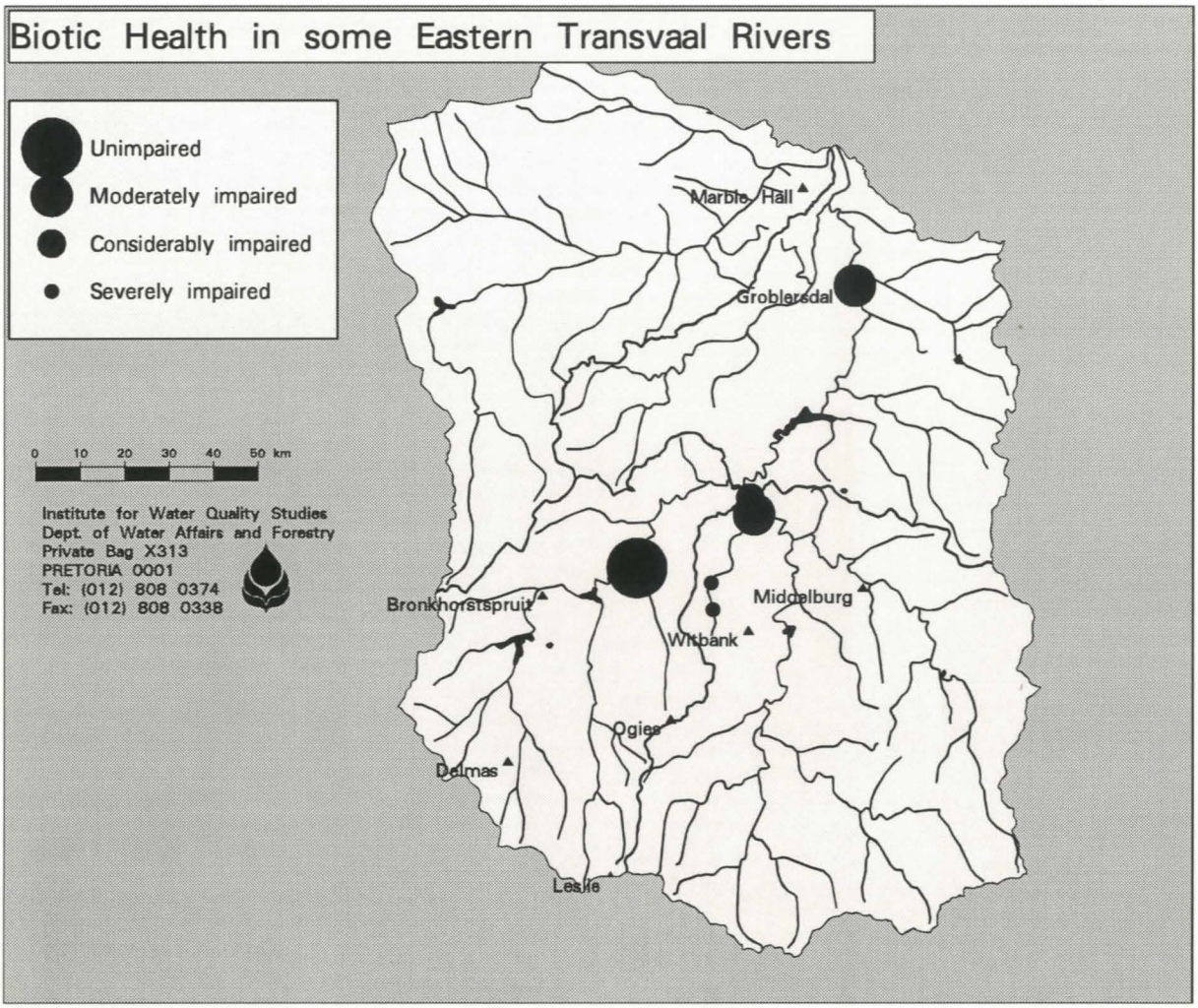

Figure 6: Biotic health, measured using SASS2 scores in the Olifants River Catchment, Eastern Transvaal

CONCLUSION AND FUTURE DEVELOPMENT

This research initiative has produced a menu-driven system on a GIS platform that offers a simple interface which is tailored to meet the needs of water quality assessment and reporting. The main goal of the research is to provide an holistic means to distil useful information from data, and to base understanding of a highly fluid system on sound analyses. Multiple levels of the interface meet differing requirements, from paging through the data to detailed searches for trends and correlations, and more advanced statistical analytical procedures whereby multiple variables are taken into account. The spatial component is used as an integrator, with the map as a visualisation tool within which water quality can be explored and from which knowledge and understanding of real world problems is attained.

Phases 3 and 4, scheduled in the original study proposal, have started and expand on the skeleton system developed in the initial phases. Problems concerning the database already identified will be

investigated, additional datasets must be located and incorporated or captured. Important datasets to be obtained are continuous flow records, the known point- and non-point sources of pollution to surface water resources, which will be obtained through the Regional Offices database POLMON, and the use of remotely sensed satellite land use classifications.

The ability to assess upstream sources against downstream users should be possible through the use of a networking facility within the GIS, Arc/Info's NETWORK module, in which parcels of inputs can be passed through the river network allowing for temporary storage, channel and evaporative losses, and riparian abstraction. A plethora of enhancements emerging almost on a daily basis must be evaluated for feasibility within the established structure and prioritised for incorporation. Training programs must be devised, including detailed training and users manuals, and the system must be installed and stabilised on platforms other than the workstation currently used for development.

Wherever possible AML programmes must be translated to C programming language. With the development moving increasingly into the Unix C environment, the incorporation of predictive water quality and landuse models is the logical step. Before this takes place, however, a test exercise must determine the efficiency of incorporating models into an ever-growing, data-hungry, disk-hungry system. The existing modular system should allow easy integration, and selected models may be built into the system to support water quality scenario testing, once the assessment and evaluation stages have been attained. As a database interface is already in place the system will allow rapid inputs to management models running in C, and the outputs can be fed back into the GIS environment for display of predicted results in conjunction with actual water quality data.

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GRAPHICS

COMPUTER 94

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Exporting data from STASKAT

One method for getting STASKAT (Station Catalogue) data off the HIS (Hydrological Information System) is to use the HydroGIS project developed in ArcView 3.0a by J. Duvenhage at DWAF Head Office.
The Hydrology Directorate is the custodian of HydroGIS. Please contact J. Wentzel in Hydrology for more information.
Other ODBC applications, e.g. in Delphi, may exist to extract STASKAT data.

In the main View of HydroGIS, select the **STASKAT stations** theme.
Open the attributes table of this theme (Theme Table).
In Tables, go into the table properties and remove the check marks so that only the following are selected:

- Station/GaugingPointNumber
- MostRecent Description 1
- MostRecent Description 2
- Longitude
- Latitude
- DrainageRegion
- MeasurementsIn/At1
- MeasurementsIn/At2
- PlaceName
- CommonName
- Province

Export the theme as a comma-delimited (csv or txt) type of file, e.g. `staskat.txt`.
Using `awk`, convert the comma-delimited file to something that makes sense to the WaterMarque import routine.
Below is an example:

```
BEGIN{FS=",";OFS=",";First=1;OFMT="%.8g";}
{
 if ( First == 1 )
 {
  First = 0;
 }
 else
 {
  lon = (substr($4,1,2)*1)+(substr($4,3,2)/60)+(substr($4,5,2)/3600)
  lat = -1*((substr($5,1,2)*1)+(substr($5,3,2)/60)+(substr($5,5,2)/3600))
  line = $1","$7","$8","$2","$3","$9","$10","lon","lat","$6","$11;
  a = gsub( " *", "", line );
  a = gsub( "  ", " ", line );
  print line;
 }
}
# Example of input data:
# ---------------------
#"Station/Gauging Point Number","Most Recent Description 1","Most Recent Description
2","Longitude","Latitude","Drainage Region","Measurements In/At 1","Measurements In/At 2","Place
Name","Common Name","Province"
#A1H001,GAUGING WEIR,,255114,252721,A10,UPPER EYE DINOKANA,,DINOKANA,AT PUMP STATION,NW
```

Use this awk file as follows (assuming that the file is named staskat.awk):

```
awk -f staskat.awk staskat.txt > staskat.all
```

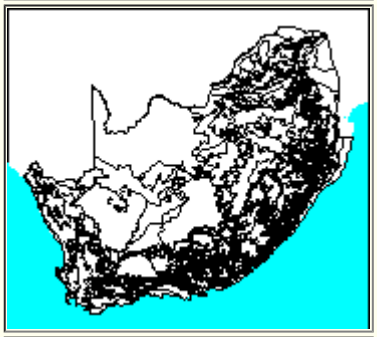
Select the water quality stations
STASKAT stores the data for all stations, including quality monitoring, flow gauging and evaporation measurements. Use the `grep` command to write only the water quality stations to a file:

```
grep QUALITY staskat.all | sort > staskat.dat
```

Acocks veld types of South Africa

acocks

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:31:13
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-814132W	.	957597E	
-2319988S	-		-	-2319988S
-3887338S	.	.	.	-3887338S
	-814132W	.	957597E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1500000
Date
1982
Description
Acocks veld types of South Africa
Owner
National Botanical Institute
Owner_address
Private Bag X101
PRETORIA
0001
Owner_contact
Dr MC Rutherford, National Botanical Institute
Owner_country
South Africa
Owner_phone
(021) 804 3200
Owner_fax
(021) 804 3211
Owner_email
xxx@xxx.xxx.gov.za
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Copyright_warning

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History

Logo

../images/nbg

Annotation items, 1kbyte:
19 Mar 1994, elise:
Polygon items, 75kbyte:
19 Mar 1994, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	152476832	4.3	floatpnt		
PERIMETER	6791335.5	4.3	floatpnt		
ACOCKS#	1	4.0	binary		
ACOCKS-ID	38	4.0	binary		
VELD_TYPE	18	4.0	binary		(Indexed)
DESCRIPTION	'MIXED BUSHVELD'	100	character		
KM2	152.48	10.2	numeric		
KM	112.99	10.2	numeric		

Map specifications:

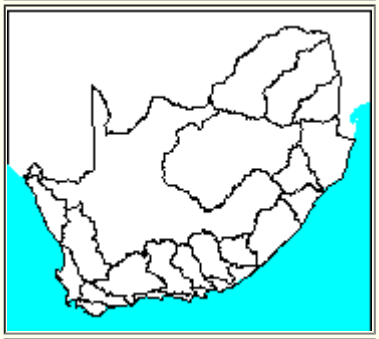
```
  Description of SINGLE precision coverage /spek/waterm/wmdata/general/acocks

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                     1389
POLYGONS                                  549       140      Yes      Yes
NODES                                    1017
ANNOTATIONS             (blank)             0

                              SECONDARY FEATURES

Arc Segments                            93631
Polygon Labels                            548

                                 TOLERANCES

Fuzzy   =                 0.694 V          Dangle  =                 0.000 N

                              COVERAGE BOUNDARY

Xmin =              -733599.125            Xmax =               877063.688
Ymin =             -3806804.500            Ymax =             -2400521.250

                                   STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                           COORDINATE SYSTEM DESCRIPTION

Projection               ALBERS
Units                    METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                        -18  0  0.000
2nd standard parallel                                        -32  0  0.000
central meridian                                              24  0  0.000
latitude of projection's origin                                0  0  0.000
false easting (meters)                                              0.00000
```

```
false northing (meters)                                    0.00000
```

Catchments of South Africa - primary

hca_primary

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:34:31
File owner: elna, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812452W	.	957182E	
-2319445S	-		-	-2319445S
-3887253S	.	.	.	-3887253S
	-812452W	.	957182E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1990
Description
Catchments of South Africa - primary
Owner
Water Research Commission
Owner_address
Water Research Commission
PO Box 824
PRETORIA
0001
Owner_contact
Hugo Maaren
Owner_country
South Africa
Owner_phone
(012) 330 0340
Owner_fax
(012)
Owner_email
hugo@wrc.ccwr.ac.za
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History

```
1996 - Water Research Commission report number 298/1/94
       (DC Midgley, WV Pitman & BJ Middleton, Surface Water Resources of
        South Africa 1990 - User's Manual - ISBN 1 86845 143 7)
1996 - CATNUM dropped from quaternary coverage, separate coverage for primary
       catchments created - Mike Silberbauer.
Some of the fields included as attributes:
CMAP  Mean annual precipitation in mm
MAR   Mean annual runoff in mm
MAR4Q Mean annual runoff in million cubic metres
MARnQ Mean annual runoff in million cubic metres at the n-ary level
```

Logo

/hri/db/clip/wrc

Annotation items, 4kbyte:
12 Mar (less than 1yr ago), elna:
Arc items, 6kbyte:
12 Mar (less than 1yr ago), elna:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	2	4.0	binary		
LPOLY#	1	4.0	binary		
RPOLY#	2	4.0	binary		
LENGTH	128289.234375	4.3	floatpnt		
HCA_PRIMARY#	1	4.0	binary		
HCA_PRIMARY-ID	5	4.0	binary		
TYPE	I	1	character		

Polygon items, 1kbyte:
12 Mar (less than 1yr ago), elna:
7 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	109548707840	4.3	floatpnt		
PERIMETER	7036865	4.3	floatpnt		
HCA_PRIMARY#	1	4.0	binary		
HCA_PRIMARY-ID	1	4.0	binary		
PRIMARY	A	1	character		
PRIM-ID	1	4.0	binary		
MAR1Q	2386.34	10.2	numeric		

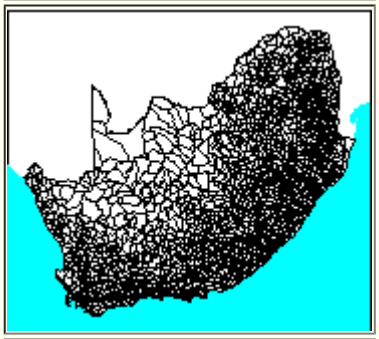
Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/hca_primar

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                      216        30
POLYGONS                                   23        32               Yes
NODES                                     195
ANNOTATIONS             (blank)            25

                               SECONDARY FEATURES

Tics                                      124
Arc Segments                            76895
Polygon Labels                             22

                                  TOLERANCES

Fuzzy   =                 0.766 V          Dangle  =                 0.000 N

                               COVERAGE BOUNDARY

Xmin =              -732014.125            Xmax =               876744.312
Ymin =             -3806815.250            Ymax =             -2399882.500

                                    STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                        -18  0  0.000
2nd standard parallel                                        -32  0  0.000
central meridian                                              24  0  0.000
latitude of projection's origin                                0  0  0.000
false easting (meters)                                             0.00000
false northing (meters)                                            0.00000
```

Catchments of South Africa - quaternary

hca_quater

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:34:42
File owner: elna, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812452W	.	957182E	
-2319445S	-		-	-2319445S
-3887253S	.	.	.	-3887253S
	-812452W	.	957182E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1990
Description
Catchments of South Africa - quaternary
Owner
Water Research Commission
Owner_address
Water Research Commission
PO Box 824
PRETORIA
0001
Owner_contact
Hugo Maaren
Owner_country
South Africa
Owner_phone
(012) 330 0340
Owner_fax
(012)
Owner_email
hugo@wrc.ccwr.ac.za
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History

```
1996 - Water Research Commission report number 298/1/94
       (DC Midgley, WV Pitman & BJ Middleton, Surface Water Resources of
        South Africa 1990 - User's Manual - ISBN 1 86845 143 7)
1996 - CATNUM dropped, separate coverages for tertiary, secondary,
       primary catchments created - Mike Silberbauer.
Some of the fields included as attributes:
CMAP  Mean annual precipitation in mm
MAR   Mean annual runoff in mm
MAR4Q Mean annual runoff in million cubic metres
MARnQ Mean annual runoff in million cubic metres at the n-ary level

Related lookup table: hca_q_mnth.lut
Mean monthly runoff in mm, from WR90:
```

COLUMN	ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC	ALTERNATE NAME	INDEXED?
1	QUATERNARY	4	4	C	-		-
5	Q_JAN	4	12	F	2		-
9	Q_FEB	4	12	F	2		-
13	Q_MAR	4	12	F	2		-
17	Q_APR	4	12	F	2		-
21	Q_MAY	4	12	F	2		-
25	Q_JUN	4	12	F	2		-
29	Q_JUL	4	12	F	2		-
33	Q_AUG	4	12	F	2		-
37	Q_SEP	4	12	F	2		-
41	Q_OCT	4	12	F	2		-
45	Q_NOV	4	12	F	2		-
49	Q_DEC	4	12	F	2		-

Logo

/hri/db/clip/wrc

Annotation items, 4kbyte:
12 Mar (less than 1yr ago), elna:
Polygon items, 190kbyte:
12 Mar (less than 1yr ago), elna:
23 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	1764610048	4.3	floatpnt		
PERIMETER	7036865	4.3	floatpnt		
HCA_QUATER#	1	4.0	binary		

HCA_QUATER-ID	1	4.0	binary		
QUATERNARY	A71L	4	character		
CATID	1	4.0	binary		
CMAP	287.84	8.2	numeric		
MAR	1.9	6.1	numeric		
CURVE	6	3.0	integer		
HYDROZ	X	1	character		
MAR4Q	3.35	10.2	numeric		
TERTIARY	A71	3	character		
TERT-ID	1	4.0	binary		
MAR3Q	53.56	10.2	numeric		
SCND-ID	1	4.0	binary		
SECONDARY	A7	2	character		
MAR2Q	71.9	10.2	numeric		
PRIM-ID	1	4.0	binary		
PRIMARY	A	1	character		
MAR1Q	2386.34	10.2	numeric		
QAT_LETTER	L	1	character	(ReDefined)	
TER_LETTER	1	1	character	(ReDefined)	
SEC_LETTER	7	1	character	(ReDefined)	

Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/hca_quater

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                      6092
POLYGONS                                  1947       100               Yes
NODES                                     4147
ANNOTATIONS             (blank)             25

                              SECONDARY FEATURES

Tics                                       124
Arc Segments                            394128
Polygon Labels                            1946

                                 TOLERANCES

Fuzzy   =                 0.766 V          Dangle  =                 0.000 N

                              COVERAGE BOUNDARY

Xmin =              -732014.125            Xmax =               876744.312
Ymin =            -3806815.250            Ymax =             -2399882.500

                                   STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                           COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                        -18  0  0.000
2nd standard parallel                                        -32  0  0.000
central meridian                                              24  0  0.000
latitude of projection's origin                                0  0  0.000
```

```
false easting (meters)                                  0.00000
false northing (meters)                                 0.00000
```

Catchments of South Africa - secondary

hca_secondary

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:35:08
File owner: elna, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812452W	.	957182E	
-2319445S	-		-	-2319445S
-3887253S	.	.	.	-3887253S
	-812452W	.	957182E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1990
Description
Catchments of South Africa - secondary
Owner
Water Research Commission
Owner_address
Water Research Commission
PO Box 824
PRETORIA
0001
Owner_contact
Hugo Maaren
Owner_country
South Africa
Owner_phone
(012) 330 0340
Owner_fax
(012)
Owner_email
hugo@wrc.ccwr.ac.za
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Data products may only be used for water research.
History

```
1996 - Water Research Commission report number 298/1/94
       (DC Midgley, WV Pitman & BJ Middleton, Surface Water Resources of
        South Africa 1990 - User's Manual - ISBN 1 86845 143 7)
1996 - CATNUM dropped from hca_4, separate coverage created for secondary
       catchments created - Mike Silberbauer.
See quaternary coverage for attribute details.
```

Logo

/hri/db/clip/wrc

Annotation items, 4kbyte:
12 Mar (less than 1yr ago), elna:
Polygon items, 7kbyte:
12 Mar (less than 1yr ago), elna:
11 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	15768259584	4.3	floatpnt		
PERIMETER	7036865	4.3	floatpnt		
HCA_SECONDARY#	1	4.0	binary		
HCA_SECONDARY-ID	1	4.0	binary		
SECONDARY	A7	2	character		
SCND-ID	1	4.0	binary		
MAR2Q	71.9	10.2	numeric		
PRIM-ID	1	4.0	binary		
PRIMARY	A	1	character		
MAR1Q	2386.34	10.2	numeric		
SEC_DIGIT	7	1	character	(ReDefined)	

Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/hca_second

                                FEATURE CLASSES

                                    Number of  Attribute     Spatial
Feature Class          Subclass     Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                      578
POLYGONS                                  149        48               Yes
NODES                                    4145
ANNOTATIONS             (blank)            25

                              SECONDARY FEATURES

Tics                                      124
Arc Segments                           148454
Polygon Labels                            148

                                  TOLERANCES

Fuzzy   =                 0.766 V          Dangle  =                 0.000 N
```

COVERAGE BOUNDARY

Xmin =	-732014.125	Xmax =	876744.312
Ymin =	-3806815.250	Ymax =	-2399882.500

STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

COORDINATE SYSTEM DESCRIPTION

Projection	ALBERS		
Units	METERS	Spheroid	CLARKE1880
Parameters:			
1st standard parallel			-18 0 0.000
2nd standard parallel			-32 0 0.000
central meridian			24 0 0.000
latitude of projection's origin			0 0 0.000
false easting (meters)			0.00000
false northing (meters)			0.00000

Catchments of South Africa - tertiary

hca_tertiary

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:35:20
File owner: elna, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812452W	.	957182E	
-2319445S	-		-	-2319445S
-3887253S	.	.	.	-3887253S
	-812452W	.	957182E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1990
Description
Catchments of South Africa - tertiary
Owner
Water Research Commission
Owner_address
Water Research Commission
PO Box 824
PRETORIA
0001
Owner_contact
Hugo Maaren
Owner_country
South Africa
Owner_phone
(012) 330 0340
Owner_fax
(012)
Owner_email
hugo@wrc.ccwr.ac.za
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History

```
1996 - Water Research Commission report number 298/1/94
       (DC Midgley, WV Pitman & BJ Middleton, Surface Water Resources of
        South Africa 1990 - User's Manual - ISBN 1 86845 143 7)
1996 - CATNUM dropped from hca_4, separate coverage for tertiary
       catchments created - Mike Silberbauer.
See quaternary coverage for attribute details.
```

Logo

/hri/db/clip/wrc

Annotation items, 4kbyte:
12 Mar (less than 1yr ago), elna:
Polygon items, 17kbyte:
12 Mar (less than 1yr ago), elna:
14 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	12306194432	4.3	floatpnt		
PERIMETER	7036865	4.3	floatpnt		
HCA_TERTIARY#	1	4.0	binary		
HCA_TERTIARY-ID	1	4.0	binary		
TERTIARY	A71	3	character		
TERT-ID	1	4.0	binary		
MAR3Q	53.56	10.2	numeric		
SCND-ID	1	4.0	binary		
SECONDARY	A7	2	character		
MAR2Q	71.9	10.2	numeric		
PRIM-ID	1	4.0	binary		
PRIMARY	A	1	character		
MAR1Q	2386.34	10.2	numeric		
TER_DIGIT	1	1	character	(ReDefined)	

Map specifications:

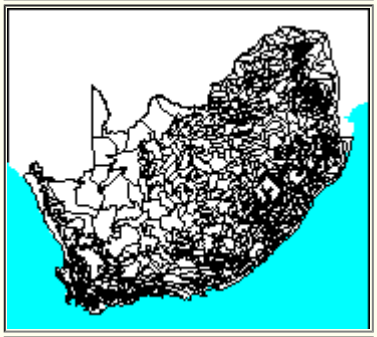
```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/hca_tertia

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                       948
POLYGONS                                   279         64               Yes
NODES                                     4145
ANNOTATIONS             (blank)             25

                               SECONDARY FEATURES

Tics                                       124
Arc Segments                            204052
```

```
Polygon Labels                          278

                                  TOLERANCES

Fuzzy   =                0.766 V          Dangle  =                0.000 N

                               COVERAGE BOUNDARY

Xmin =              -732014.125           Xmax =              876744.312
Ymin =             -3806815.250           Ymax =            -2399882.500

                                    STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                           COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                      -18  0  0.000
2nd standard parallel                                      -32  0  0.000
central meridian                                            24  0  0.000
latitude of projection's origin                              0  0  0.000
false easting (meters)                                           0.00000
false northing (meters)                                          0.00000
```

South African 712 climate zones

climate

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:32:04
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-814124W	.	957589E	
-2319994S	-		-	-2319994S
-3887430S	.	.	.	-3887430S
	-814124W	.	957589E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1866

Scale
1000000
Date
1987
Description
South African 712 climate zones
Owner
Department of Agricultural Engineering, Natal University
Owner_address
Computing Centre for Water Research
University of Natal
PIETERMARITZBURG
3201
Owner_contact
Mark Dent
Owner_country
South Africa
Owner_phone
(0331) 260 5177/8/9
Owner_fax
(0331) 61 896
Owner_email
dent@aqua.ccwr.ac.za
Disclaimer
No responsibility for the accuracy of the data is accepted.
Copyright_message
Raw data from a variety of State and private sources, including

the South African Weather Bureau, the Department of Agriculture and Water Supply, the South African Sugar Association, organised agriculture and individuals.

Copyright_warning

Data products obtained from or through the CCWR may only be used for water research.

History

```
The boundaries of the climate zones were painstakingly estimated using an
underlay of topography and a plot of the mean annual precipitation of all
long term rainfall stations.  Care was taken to make the zones as small as
possible in mountainous terrain.  However, one of the major criteria was that
each zone should contain a good long term daily rainfall station.  For this
reason some of the smaller zones in mountainous areas have a wide range of
altitudes and mean annual rainfall values.  The zones in Lesotho are an
example of this shortcoming.
1988 - Water Research Commission report number 118/1/88
       (MC Dent, RE Schulze, GR Angus:  Crop water requirements,
        deficits and water yeild for irrigation planning in Southern Africa.)
1989 - Water Research Commission report number 109/1/89
       (MC Dent, SD Lynch, RE Schulze, AW Seed, HMM Wills:
        Mapping mean annual and other rainfall statistics over
        Southern Africa).
1994 - Updated zone boundaries obtained from CCWR.
1995 - Zone rainfall and temperature characteristics obtained from CCWR
       and combined with zone boundaries to form a polygon coverage
       (Michael Silberbauer, IWQS)
```

Logo

../images/univnatl

Annotation items, 1kbyte:
12 May 1994, elise:
Arc items, 56kbyte:
12 May 1994, elise:
7 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	2	4.0	binary		
TNODE#	1	4.0	binary		
LPOLY#	1	4.0	binary		
RPOLY#	2	4.0	binary		
LENGTH	158561.671875	4.3	floatpnt		
CLIMATE#	1	4.0	binary		
CLIMATE-ID	690	4.0	binary		

Polygon items, 22kbyte:

3 Jul 1995, elise:
7 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	2267292928	4.3	floatpnt		
PERIMETER	6796483	4.3	floatpnt		
CLIMATE#	1	4.0	binary		
CLIMATE-ID	690	4.0	binary		
ZONE	14	5.0	integer		(Indexed)
DESCRIPTION	690	6.0	integer		
SYMBOL	14	5.0	integer		

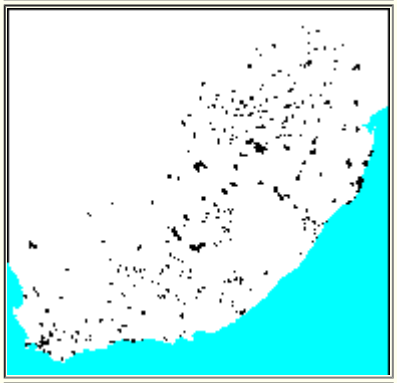
Map specifications:

```
  Description of SINGLE precision coverage /spek/waterm/wmdata/general/climate

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                      2047         28
POLYGONS                                   713         32               Yes
NODES                                     1346
ANNOTATIONS             (blank)              0

                               SECONDARY FEATURES

Tics                                         4
Arc Segments                             67158
Polygon Labels                             712

                                  TOLERANCES

Fuzzy   =               194.352 V          Dangle  =                 0.000 N

                               COVERAGE BOUNDARY

Xmin =              -733592.000            Xmax =               877056.688
Ymin =             -3806897.250            Ymax =             -2400526.750

                                    STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                           COORDINATE SYSTEM DESCRIPTION

Projection               ALBERS
Units                    METERS             Spheroid             CLARKE1866
Parameters:
1st standard parallel                                          -18  0  0.000
2nd standard parallel                                          -32  0  0.000
central meridian                                                24  0  0.000
latitude of projection's origin                                  0  0  0.000
false easting (meters)                                            0.00000
false northing (meters)                                           0.00000
```

Dams and some lakes of South Africa

wla_500

Institute for Water Quality Studies metadata.
Summary created by Michael with catalog.aml on 1999-06-10 - 02:55:34
File owner: michael, last modified: 8 Jun (less than 1yr ago)
Map extent:

	-601867W	.	946020E	
-2376301S	-		-	-2376301S
-3861277S	.	.	.	-3861277S
	-601867W	.	946020E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
500000
Date
1994-1999
Description
Dams and some lakes of South Africa
Owner
Chief Directorate of Surveys and Mapping
Owner_address
Department of Land Affairs
Private Bag X10
MOWBRAY
7705
Owner_contact
H J du Plessis
Owner_country
South Africa
Owner_phone
(021) 685 4070 x 143
Owner_fax
(021) 686 9884
Owner_email
xxx@xxx.xxx.gov.za
Disclaimer

Copyright_message

State Copyright
Copyright_warning
State data - not in the public domain - except DWAF polygons!
Copies of digital data may not be given to third parties
History

```
1994 - Digital data supplied to Department of Water Affairs
1995 - Dam polygons closed by GisLAB
1995 - Dams cleaned and named by IWQS (over-cleaned?)
1996 - Dams fixed and stations added by IWQS (mjs)
1996 - Extra dams & lakes added from satellite images
1999 - Extra dams added from 1:50 000 blue plate coverage
     - Some 1:500 000 arcsreplaced by 1:50 000 arcs
     - Errors in station numbers fixed
     - TYPE field added
     - Z field used for metadata
```

Attributes

```
Polygons:
TYPE - ISLAND, RESERVOIR, NATURAL
NAME - Most current name, with best possible spelling
STATION - Department of Water Affairs & Forestry hydrological code
        - the presence of a station number does not imply that
          flow or quality data exists.
Arcs:
Z    - 500 = from 1:500 000 scanned blue plates
     - 50  = from 1:50 000 scanned blue plates
```

Logo

../images/s&li

Arc items, 197kbyte:
8 Jun (less than 1yr ago), michael:
11 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	2	4.0	binary		
LPOLY#	1	4.0	binary		
RPOLY#	1	4.0	binary		
LENGTH	13.8125	4.3	floatpnt		
WLA_500#	1	4.0	binary		
WLA_500-ID	10	4.0	binary		
NAME	??	40	character		
CLASS	Dam_Wall	40	character		
Z	50	4.0	binary		
TYPE	''	10	character		

Polygon items, 38kbyte:
8 Jun (less than 1yr ago), michael:
16 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	207110.625	4.3	floatpnt		
PERIMETER	7587373.5	4.3	floatpnt		
WLA_500#	1	4.0	binary		
WLA_500-ID	1	4.0	binary		
STATION	A7R001Q01	9	character		
NAME	'Dr Neethling'	40	character		
X-COORD	30.41140556335	4.3	floatpnt		
Y-COORD	0	4.3	floatpnt		
TYPE	RESERVOIR	10	character		
STN	A7R001	6	character	(ReDefined)	
PRIMARY	A	1	character	(ReDefined)	
SECONDARY	A7	2	character	(ReDefined)	
STNTYPE	R	1	character	(ReDefined)	
MONPTNUM	001	3	character	(ReDefined)	
MONITYPE	Q	1	character	(ReDefined)	
SUBMONPT	01	2	character	(ReDefined)	

Map specifications:

```
    Description of SINGLE precision coverage wla_500

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                      1653        122
POLYGONS                                   464         84               Yes
NODES                                     1646

                              SECONDARY FEATURES

Tics                                       247
Arc Segments                            209317
Polygon Labels                             464

                                 TOLERANCES

Fuzzy   =                 0.745 V          Dangle  =                 0.000 N

                              COVERAGE BOUNDARY

Xmin =              -531508.875            Xmax =               875661.875
Ymin =             -3790918.000            Ymax =             -2446659.500

                                   STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                           COORDINATE SYSTEM DESCRIPTION

Projection               ALBERS
Units                    METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                          -18  0  0.000
2nd standard parallel                                          -32  0  0.000
central meridian                                                24  0  0.000
latitude of projection's origin                                  0  0  0.000
```

```
false easting (meters)                                  0.00000
false northing (meters)                                 0.00000
```

Digital Chart of the World Digital Elevation Data - 200 metre slices

tev200m

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:57:56
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-1476093W	.	1969274E	
-1442362S	-		-	-1442362S
-3964345S	.	.	.	-3964345S
	-1476093W	.	1969274E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1995
Description
Digital Chart of the World Digital Elevation Data - 200 metre slices
Owner
Customer Services EROS Data Center
Owner_address
Customer Services
EROS Data Center
Mundt Federal Building
Sioux Falls, SD 57198
Owner_contact
FTP to 152.61.128.6 (edcftp.cr.usgs.gov)
Owner_country
United States of America
Owner_phone
(605) 594-6151
Owner_fax
(605) 594-6589
Owner_email
klarson@dgl.cr.usgs.gov, jenson@dg1.cr.usgs.gov
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Copyright_message
USGS & EROS
Copyright_warning
data in the public domain

History

```
This is a reclassed version of the USGS African DEM, at 200m intervals.
See the lut INFO file with the same name as the coverage for
information on what the item GRID-CODE means.
See the source file for tev1000m for more (lots!) on the USGS DEM.
```

Logo

/hri/db/clip/usgs

Point items, 851kbyte:
2 Dec 1996, elise:
5 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	20398428160	4.3	floatpnt		
PERIMETER	12577662	4.3	floatpnt		
TEV200M#	1	4.0	binary		
TEV200M-ID	63	4.0	binary		
GRID-CODE	7	4.0	binary		

Map specifications:

```
  Description of SINGLE precision coverage /spek/waterm/wmdata/general/tev200m

                              FEATURE CLASSES

                                   Number of  Attribute     Spatial
Feature Class          Subclass    Features   data (bytes)  Index?   Topology?
-------------          --------    ---------  ------------  -------  ---------
ARCS                                   60498
POLYGONS                               43562        20      Yes    Preliminary
NODES                                  36645

                            SECONDARY FEATURES

Tics                                       4
Arc Segments                          606318
Polygon Labels                         43561

                               TOLERANCES

Fuzzy   =               345.826 V          Dangle  =                 0.000 N

                            COVERAGE BOUNDARY

Xmin =             -1319485.500            Xmax =              1812666.125
Ymin =             -3807737.750            Ymax =             -1598970.000

                                 STATUS

Use BUILD or CLEAN to create Topology from Preliminary POLYGONS.

                        COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                    -18  0  0.000
2nd standard parallel                                    -32  0  0.000
central meridian                                          24  0  0.000
latitude of projection's origin                            0  0  0.000
false easting (meters)                                         0.00000
false northing (meters)                                        0.00000
```

Evaporation (mean annual) of South Africa (WR90 file eip.e00)

mav_wr90

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:51:32
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812443W	.	957172E	
-2319505S	-		-	-2319505S
-3887336S	.	.	.	-3887336S
	-812443W	.	957172E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1990
Description
Evaporation (mean annual) of South Africa (WR90 file eip.e00)
Owner
Water Research Commission
Owner_address
Water Research Commission
PO Box 824
PRETORIA
0001
Owner_contact
Hugo Maaren
Owner_country
South Africa
Owner_phone
(012) 330 0340
Owner_fax
(012)
Owner_email
hugo@wrc.ccwr.ac.za
Disclaimer
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Copyright_message
Raw data from a variety of State and private sources, including

the South African Weather Bureau, the Department of Agriculture and Water Supply, the South African Sugar Association, organised agriculture and individuals.

Copyright_warning

Data products may only be used for water research.

History

```
1996 - Water Research Commission report number 298/1/94
       (DC Midgley, WV Pitman & BJ Middleton, Surface Water Resources of
        South Africa 1990 - User's Manual - ISBN 1 86845 143 7)
1996 - EVAPCODE field added (1 to 11 with increasing evaporation)
       - Mike Silberbauer.
```

Logo

$WMSYS/ptool/template/wrc_logo

Annotation items, 8kbyte:
12 Dec 1996, elise:
Arc items, 6kbyte:
12 Dec 1996, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	2	4.0	binary		
LPOLY#	1	4.0	binary		
RPOLY#	2	4.0	binary		
LENGTH	46292.328125	4.3	floatpnt		
MAV_WR90#	1	4.0	binary		
MAV_WR90-ID	1400	4.0	binary		
MAE	1400	5.0	integer		

Polygon items, 2kbyte:
13 Dec 1996, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	9200565248	4.3	floatpnt		
PERIMETER	7036608	4.3	floatpnt		
MAV_WR90#	1	4.0	binary		
MAV_WR90-ID	84	4.0	binary		
COLOR	84	3.0	integer		
RANGE	'2000-2200 mm'	20	character		
EVAPCODE	9	4.0	binary		
CODE	9	3.0	integer		(Indexed)

Map specifications:

Description of SINGLE precision coverage /spek/waterm/wmdata/general/mav_wr90

FEATURE CLASSES

Feature Class	Subclass	Number of Features	Attribute data (bytes)	Spatial Index?	Topology?
ARCS		180	34		
POLYGONS		43	46	Yes	Yes
NODES		149			
ANNOTATIONS	(blank)	47			

SECONDARY FEATURES

Tics	4150
Arc Segments	33609
Polygon Labels	42

TOLERANCES

Fuzzy = 1.008 V Dangle = 1.008 N

COVERAGE BOUNDARY

Xmin = -732005.938 Xmax = 876734.812
Ymin = -3806899.250 Ymax = -2399942.500

STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

COORDINATE SYSTEM DESCRIPTION

Projection ALBERS
Units METERS Spheroid CLARKE1880
Parameters:

1st standard parallel	-18 0 0.000
2nd standard parallel	-32 0 0.000
central meridian	24 0 0.000
latitude of projection's origin	0 0 0.000
false easting (meters)	0.00000
false northing (meters)	0.00000

South African farm boundaries - former Transvaal

farm_bound

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:33:23
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	130442E	.	853468E	
-2356272S	-		-	-2356272S
-3044347S	.	.	.	-3044347S
	130442E	.	853468E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1866

Scale
50000
Date
1994
Description
South African farm boundaries - former Transvaal
Owner
Chief Directorate of Surveys and Land Information
Owner_address
Department of Land Affairs
Private Bag
MOWBRAY
7705
Owner_contact
Thomas Krieg
Owner_country
South Africa
Owner_phone
(021) 685 4070 x 143
Owner_fax
(021) 689 1351
Owner_email
xxx@xxx.xxx.gov.za
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Copyright_message

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Copyright_warning
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Copies of digital data may not be given to third parties
History

```
1994 - Digital data supplied to Department of Water Affairs
```

Logo

 ../images/s&li

---

Arc items, 1549kbyte:
13 Sep 1994, elise:
10 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	0	4.0	binary		
TNODE#	0	4.0	binary		
LPOLY#	0	4.0	binary		
RPOLY#	0	4.0	binary		
LENGTH	0.2490471303463	4.3	floatpnt		
FARM_BOUND#	1	4.0	binary		
FARM_BOUND-ID	1	4.0	binary		
NAME	0000JS0000	40	character		
CLASS	PLASE	40	character		
Z	0	4.0	binary		

Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/farm_bound

                                FEATURE CLASSES

                                    Number of  Attribute     Spatial
Feature Class          Subclass     Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                    14164       112

                               SECONDARY FEATURES

Tics                                        4
Arc Segments                           199145

                                  TOLERANCES

Fuzzy   =                65.730 N          Dangle  =                  0.000 N

                               COVERAGE BOUNDARY

Xmin =               163306.922            Xmax =               820603.375
Ymin =             -3011482.500            Ymax =             -2389137.000

                                    STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                            COORDINATE SYSTEM DESCRIPTION

Projection               ALBERS
Units                    METERS             Spheroid             CLARKE1866
Parameters:
1st standard parallel                                      -18  0  0.000
2nd standard parallel                                      -32  0  0.000
```

```
central meridian                                  24  0  0.000
latitude of projection's origin                    0  0  0.000
false easting (meters)                                  0.00000
false northing (meters)                                 0.00000
```

Geology map of South Africa with simplified lithostratigraphy for geohydrological use

hgh_1000

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:35:34
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-844886W	.	964023E	
-2317957S	-		-	-2317957S
-3889780S	.	.	.	-3889780S
	-844886W	.	964023E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1995
Description
Geology map of South Africa with simplified lithostratigraphy for geohydrological use
Owner
Water Research Commission & Department of Water Affairs & Forestry
Owner_address
The Water Research Commission,
PO Box 824
PRETORIA
0001
Owner_contact
The Executive Officer
Owner_country
South Africa
Owner_phone
(021) 330 0340
Owner_fax
(021) 331 2565
Owner_email
xxx@aqua.ccwr.ac.za
Disclaimer
This coverage represents groundwater on a regional scale, is not site-specific
and cannot be used for borehole siting or deducing any other site-specific

condition
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Geoscience, the Water Research Commission & the Department of Water Affairs &
Forestry.
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History

```
1994 Simplified lithostratigraphy digitised by A Havenga, Council for
     Geosciences
1995 Water Research Commission TT 74/95 report and 2 maps by JR Vegter:
     "An explanation of a set of national groundwater maps" and "Groundwater
     resources of the Republic of South Africa" sheets 1 & 2.
```

Logo

/hri/db/clip/wrc.tif

Arc items, 40kbyte:
17 Apr 1996, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	2	4.0	binary		
LPOLY#	2	4.0	binary		
RPOLY#	1	4.0	binary		
LENGTH	87430.0390625	4.3	floatpnt		
HGH_1000#	1	4.0	binary		
HGH_1000-ID	10	4.0	binary		
LIN	59	4.0	binary		

Polygon items, 14kbyte:
18 Apr 1996, elise:
9 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	1498977664	4.3	floatpnt		
PERIMETER	6918848	4.3	floatpnt		
HGH_1000#	1	4.0	binary		
HGH_1000-ID	999	4.0	binary		
KEY	1	4.0	binary		
LITHO	10	4.0	binary		
ROCK	5	2.0	integer		
METDEF	1	4.0	binary		
LABEL	PTRu	6	character		

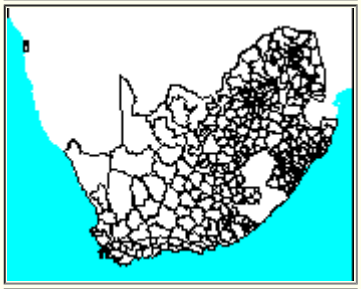
Map specifications:

```
 Description of SINGLE precision coverage /spek/waterm/wmdata/general/hgh_1000

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                     1279        32
POLYGONS                                  390        36      Yes      Yes
NODES                                     938

                              SECONDARY FEATURES

Tics                                       18
Arc Segments                            55107
Polygon Labels                            369

                                 TOLERANCES

Fuzzy   =                 0.751 V          Dangle  =                 0.001 N

                              COVERAGE BOUNDARY

Xmin =              -762662.688            Xmax =               881800.062
Ymin =            -3807556.750            Ymax =             -2400180.250

                                   STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                        -18  0  0.000
2nd standard parallel                                        -32  0  0.000
central meridian                                              24  0  0.000
latitude of projection's origin                                0  0  0.000
false easting (meters)                                          0.00000
false northing (meters)                                         0.00000
```

South African magisterial districts

magisterial

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:50:51
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-1071109W	.	970636E	
-2298931S	-		-	-2298931S
-3907387S	.	.	.	-3907387S
	-1071109W	.	970636E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1866

Scale
250000?
Date
1994
Description
South African magisterial districts
Owner
Chief Directorate of Surveys and Land Information
Owner_address
Department of Land Affairs
Private Bag
MOWBRAY
7705
Owner_contact
Thomas Krieg
Owner_country
South Africa
Owner_phone
(021) 685 4070 x 143
Owner_fax
(021) 689 1351
Owner_email
xxx@xxx.xxx.gov.za
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History

```
1994 - Digital data supplied to Department of Water Affairs
```

Logo

../images/s&li

Annotation items, 1kbyte:
13 Sep 1994, elise:
Point items, 6kbyte:
13 Sep 1994, elise:
4 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	0.4730047881603	4.3	floatpnt		
PERIMETER	74.060546875	4.3	floatpnt		
MAGISTERIAL#	1	4.0	binary		
MAGISTERIAL-ID	1	4.0	binary		

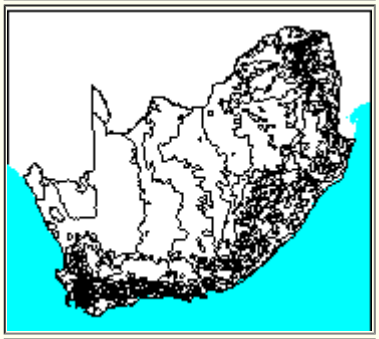
Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/magisteria

                              FEATURE CLASSES

                                   Number of  Attribute     Spatial
Feature Class          Subclass    Features   data (bytes)  Index?   Topology?
-------------          --------    ---------  ------------  -------  ---------
ARCS                                   1059
POLYGONS                                353        16              Preliminary
NODES                                   712
ANNOTATIONS            (blank)            0

                             SECONDARY FEATURES

Tics                                     20
Arc Segments                          85123
Polygon Labels                          350

                                TOLERANCES

Fuzzy   =                46.263 N          Dangle  =                  0.000 N

                             COVERAGE BOUNDARY

Xmin =              -978302.125           Xmax =               877829.438
Ymin =             -3814580.250           Ymax =             -2391737.750

                                  STATUS

Use BUILD or CLEAN to create Topology from Preliminary POLYGONS.

                         COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1866
Parameters:
1st standard parallel                                    -18  0  0.000
2nd standard parallel                                    -32  0  0.000
central meridian                                          24  0  0.000
latitude of projection's origin                            0  0  0.000
false easting (meters)                                       0.00000
false northing (meters)                                      0.00000
```

South African mean annual precipitation (WR90)

map_wr90

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:51:08
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812443W	.	957172E	
-2319505S	-		-	-2319505S
-3887336S	.	.	.	-3887336S
	-812443W	.	957172E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1990
Description
South African mean annual precipitation (WR90)
Owner
Water Research Commission
Owner_address
Water Research Commission
PO Box 824
PRETORIA
0001
Owner_contact
Hugo Maaren
Owner_country
South Africa
Owner_phone
(012) 330 0340
Owner_fax
(012)
Owner_email
hugo@wrc.ccwr.ac.za
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Raw data from a variety of State and private sources, including

the South African Weather Bureau, the Department of Agriculture and Water Supply, the South African Sugar Association, organised agriculture and individuals.

Copyright_warning

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History

```
1996 - Water Research Commission report number 298/1/94
       (DC Midgley, WV Pitman & BJ Middleton, Surface Water Resources of
        South Africa 1990 - User's Manual - ISBN 1 86845 143 7)
1996 - Two patches of W Cape with no rain fixed - Mike Silberbauer.
```

Logo

/hri/db/clip/wrc.tif

Arc items, 26kbyte:
2 Dec 1996, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	2	4.0	binary		
TNODE#	1	4.0	binary		
LPOLY#	4	4.0	binary		
RPOLY#	1	4.0	binary		
LENGTH	62518.34375	4.3	floatpnt		
MAP_WR90#	1	4.0	binary		
MAP_WR90-ID	1	4.0	binary		
AVGMAP	400	4.3	floatpnt		

Polygon items, 8kbyte:
13 Dec 1996, elise:
7 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	5125968896	4.3	floatpnt		
PERIMETER	7035698	4.3	floatpnt		
MAP_WR90#	1	4.0	binary		
MAP_WR90-ID	16	4.0	binary		
AVGMAP	500	4.3	floatpnt		(Indexed)
COLOR	16	3.0	integer		(Indexed)
COLOUR	125	3.0	integer		

Map specifications:

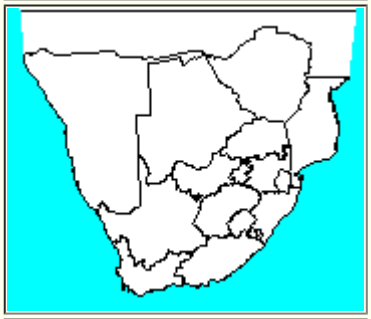
```
 Description of SINGLE precision coverage /spek/waterm/wmdata/general/map_wr90

                                FEATURE CLASSES

                                    Number of  Attribute     Spatial
Feature Class          Subclass     Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
```

```
ARCS                                    845        32
POLYGONS                                302        26      Yes      Yes
NODES                                   792

                              SECONDARY FEATURES

Tics                                      4
Arc Segments                         248757
Polygon Labels                          301

                                  TOLERANCES

Fuzzy   =               10.077 V          Dangle  =                10.077 N

                              COVERAGE BOUNDARY

Xmin =             -732005.938            Xmax =              876734.812
Ymin =            -3806899.250            Ymax =            -2399942.500

                                   STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                      -18  0  0.000
2nd standard parallel                                      -32  0  0.000
central meridian                                            24  0  0.000
latitude of projection's origin                              0  0  0.000
false easting (meters)                                           0.00000
false northing (meters)                                          0.00000
```

Provinces and neighbouring country borders of South Africa - polygons

sa_prov

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:56:20
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-1432172W	.	1384198E	
-1551264S	-		-	-1551264S
-3934894S	.	.	.	-3934894S
	-1432172W	.	1384198E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
50000?
Date
1996?
Description
Provinces and neighbouring country borders of South Africa - polygons
Owner
Chief Directorate of Surveys and Land Information
Owner_address
Department of Land Affairs
Private Bag
MOWBRAY
7705
Owner_contact
Thomas Krieg
Owner_country
South Africa
Owner_phone
(021) 685 4070 x 143
Owner_fax
(021) 689 1351
Owner_email
xxx@xxx.xxx.gov.za
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History

```
Digital data supplied by Department of Water Affairs head office
1996 Michael Silberbauer, IWQS added field TYPE:
I - international border          (/hri/db/symbol/standard.lin symbol number 713)
i - international border on river (/hri/db/symbol/standard.lin symbol number 723)
C - coastline
P - provincial border             (/hri/db/symbol/standard.lin symbol number 743)
```

Logo

 $WMSYS/ptool/template/s_li_logo

---

Arc items, 5kbyte:
9 Oct 1997, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	18	4.0	binary		
TNODE#	30	4.0	binary		
LPOLY#	6	4.0	binary		
RPOLY#	2	4.0	binary		
LENGTH	511492.21875	4.3	floatpnt		
SA_PROV#	1	4.0	binary		
SA_PROV-ID	74	4.0	binary		
TYPE	P	1	character		

Polygon items, 5kbyte:
9 Oct 1997, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	16989135872	4.3	floatpnt		
PERIMETER	10915386	4.3	floatpnt		
SA_PROV#	1	4.0	binary		
SA_PROV-ID	4	4.0	binary		
NAME	GAUTENG	40	character		
CLASS	Province	40	character		
Z	0	4.0	binary		
PROVINCE	Gauteng	40	character		

Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/sa_prov
                                FEATURE CLASSES
                                    Number of  Attribute     Spatial
```

Feature Class	Subclass	Features	data (bytes)	Index?	Topology?
ARCS		175	30	Yes	
POLYGONS		35	140	Yes	Yes
NODES		161			

SECONDARY FEATURES

Tics	4
Arc Segments	52347
Polygon Labels	34

TOLERANCES

Fuzzy = 211.937 V Dangle = 0.000 N

COVERAGE BOUNDARY

Xmin =	-1304155.375	Xmax =	1256181.375
Ymin =	-3806877.500	Ymax =	-1679280.375

STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

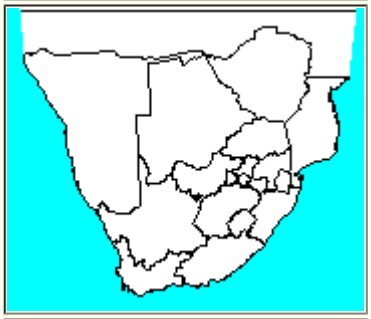
COORDINATE SYSTEM DESCRIPTION

Projection	ALBERS		
Units	METERS	Spheroid	CLARKE1880
Parameters:			
1st standard parallel			-18 0 0.000
2nd standard parallel			-32 0 0.000
central meridian			24 0 0.000
latitude of projection's origin			0 0 0.000
false easting (meters)			0.00000
false northing (meters)			0.00000

Regions of Department of Water Affairs & Forestry (interim)

dwafreg

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:32:54
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-1432172W	.	1384198E	
-1551264S	-		-	-1551264S
-3934894S	.	.	.	-3934894S
	-1432172W	.	1384198E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
500000
Date
1998-05
Description
Regions of Department of Water Affairs & Forestry (interim)
Owner
Department of Water Affairs & Forestry
Owner_address
Department of Water Affairs & Forestry
Private Bag X313
PRETORIA
0001
Owner_contact
Frans le Roux, Boskop Office (Potchefstroom)
Owner_country
South Africa
Owner_phone
(0148) 298 1113
Owner_fax
(0148) 298 1175
Owner_email

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Copyright_message
Used provincial boundaries
Copyright_warning

Use at own risk
History

```
1997 - Frans le Roux compiled and digitised map from information
       supplied by the provincial regions of DWAF. DRAFT MAP!!!
1997 - Michael Silberbauer used this map to generate an even less
       accurate map, using the original provincial borders as a guide.
       This process introduced additional errors, up to 2.5 km.
       Poly attributes CLASS: DWAF region or Country
                       NAME : Name in upper case
                       DWAF_REGION : Name of region in proper case
                       DWAF_SUBREG : Name of sub-region in proper case
       Arc attributes  TYPE : I = international border (no river)
                              i = international border (river)
                              C = coastline
                              X = imaginary line to close polygon
                              R = regional boundary (not on province border)
                              r = regional boundary (same as province)
                              S = sub-regional boundary
1998 - Michael Silberbauer added Gauteng sub-regions and modified Gauteng region border
```

Logo

$WMSYS/ptool/template/dwaf_logo

Arc items, 5kbyte:
15 May 1998, elise:
8 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	2	4.0	binary		
LPOLY#	1	4.0	binary		
RPOLY#	4	4.0	binary		
LENGTH	1736.094360351	4.3	floatpnt		
DWAFREG#	1	4.0	binary		
DWAFREG-ID	71	4.0	binary		
TYPE	I	1	character		

Polygon items, 7kbyte:
15 May 1998, elise:
9 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	390645579776	4.3	floatpnt		
PERIMETER	10915386	4.3	floatpnt		
DWAFREG#	1	4.0	binary		

DWAFREG-ID	11	4.0	binary		
NAME	ZIMBABWE	40	character		
CLASS	Country	40	character		
Z	0	4.0	binary		
DWAF_REGION	'Northern Province'	40	character		
DWAF_SUBREG	Gauteng_N	40	character		

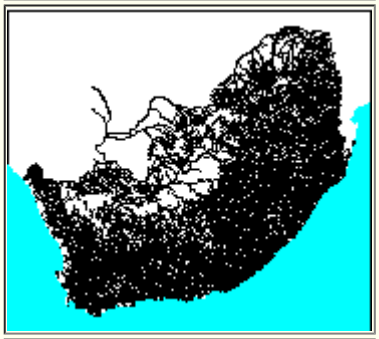
Map specifications:

```
  Description of SINGLE precision coverage /spek/waterm/wmdata/general/dwafreg

                                FEATURE CLASSES

                                    Number of  Attribute     Spatial
Feature Class          Subclass     Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                     187        30
POLYGONS                                  37       180                Yes
NODES                                    545

                              SECONDARY FEATURES

Tics                                       4
Arc Segments                           52813
Polygon Labels                            36

                                 TOLERANCES

Fuzzy   =                0.760 V          Dangle  =                 0.000 V

                              COVERAGE BOUNDARY

Xmin =             -1304155.375            Xmax =              1256181.375
Ymin =             -3806877.500            Ymax =             -1679280.375

                                   STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                           COORDINATE SYSTEM DESCRIPTION

Projection               ALBERS
Units                    METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                        -18  0  0.000
2nd standard parallel                                        -32  0  0.000
central meridian                                              24  0  0.000
latitude of projection's origin                                0  0  0.000
false easting (meters)                                             0.00000
false northing (meters)                                            0.00000
```

South African rivers

wri_500

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 15:01:32
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-812023W	.	948359E	
-2319925S	-		-	-2319925S
-3880529S	.	.	.	-3880529S
	-812023W	.	948359E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1866

Scale
500000
Date
1994
Description
South African rivers
Owner
Chief Directorate of Surveys and Land Information
Owner_address
Department of Land Affairs
Private Bag
MOWBRAY
7705
Owner_contact
Thomas Krieg
Owner_country
South Africa
Owner_phone
(021) 685 4070 x 143
Owner_fax
(021) 689 1351
Owner_email
xxx@xxx.xxx.gov.za
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History

```
1994 - Digital data supplied to Department of Water Affairs
1995 - Rivers selected to match national monitoring network by GisLAB
 - Gaps in rivers at dams closed
 - Rivers made to point downstream
 - River names checked
 - WARNING - may be wrong spheroid (Clarke1866) which means errors up to
             100 metres in furthest extremities.
```

Logo

 ../images/s&li

---

Arc items, 1065kbyte:
31 Oct 1995, elise:
12 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	3	4.0	binary		
LPOLY#	2	4.0	binary		
RPOLY#	2	4.0	binary		
LENGTH	6301.582519531	4.3	floatpnt		
WRI_500#	1	4.0	binary		
WRI_500-ID	991	4.0	binary		
NAME	Limpopo	40	character		(Indexed)
CLASS	Perennial_river	40	character		
Z	0	4.0	binary		
ORDER	5	4.0	binary		(Indexed)
PRIMARY	A	1	character		

Map specifications:

```
  Description of SINGLE precision coverage /spek/waterm/wmdata/general/wri_500

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                      9238       118      Yes
NODES                                    43824

                              SECONDARY FEATURES

Tics                                      1167
Arc Segments                            380877

                                  TOLERANCES

Fuzzy   =               160.035 N          Dangle  =                 0.000 N
```

COVERAGE BOUNDARY

Xmin =	-732005.938	Xmax =	868341.750
Ymin =	-3800511.750	Ymax =	-2399942.500

STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

COORDINATE SYSTEM DESCRIPTION

Projection	ALBERS		
Units	METERS	Spheroid	CLARKE1866
Parameters:			
1st standard parallel			-18 0 0.000
2nd standard parallel			-32 0 0.000
central meridian			24 0 0.000
latitude of projection's origin			0 0 0.000
false easting (meters)			0.00000
false northing (meters)			0.00000

Southern African rivers outside of South Africa

wri_not_sa

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 15:02:51
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-1453800W	.	1880877E	
-1447453S	-		-	-1447453S
-3305908S	.	.	.	-3305908S
	-1453800W	.	1880877E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1992?
Description
Southern African rivers outside of South Africa
Owner
Environmental Systems Research Institute, Inc. (ESRI)
Owner_address
380 New York Street,
REDLANDS
California
92372 USA
Owner_contact
Contracts Manager
Owner_country
United States of America
Owner_phone
1-909-793-2853
Owner_fax
1-909-793-????
Owner_email
esri.com
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History

```
1994-Digital Chart of the World: southern Africa extracted S of 15deg S.
1995-Rivers selected from DCW using ArcPlot and method in ch6 of Arc6
     librarian user's guide - extracted to new file
    -"link" arcs used to join gaps in rivers, particularly on the
     Mozambique border with South Africa.  About 20 arcs, with dnlnstat=5.
```

Logo

 ../images/esri

---

Arc items, 456kbyte:
31 Oct 1995, elise:
10 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	1	4.0	binary		
TNODE#	2	4.0	binary		
LPOLY#	0	4.0	binary		
RPOLY#	0	4.0	binary		
LENGTH	117.0220642089	4.3	floatpnt		
WRI_NOT_SA#	1	4.0	binary		
WRI_NOT_SA-ID	3762	4.0	binary		
DNNET#	1	4.0	binary		
DNLNTYPE	1	2.0	integer		
DNLNSTAT	1	2.0	integer		

Map specifications:

```
Description of SINGLE precision coverage /spek/waterm/wmdata/general/wri_not_sa

                                FEATURE CLASSES

                                    Number of  Attribute     Spatial
Feature Class          Subclass     Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                    12958         36     Yes
NODES                                      43

                              SECONDARY FEATURES

Tics                                        4
Arc Segments                           197314

                                 TOLERANCES

Fuzzy   =               303.152 N          Dangle  =                 0.000 N

                              COVERAGE BOUNDARY

Xmin =             -1302223.625            Xmax =              1729301.000
```

```
Ymin =             -3154331.500            Ymax =             -1599028.750

                                    STATUS

The coverage has edit masks, use BUILD or CLEAN to restore topology

                          COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                      -18  0  0.000
2nd standard parallel                                      -32  0  0.000
central meridian                                            24  0  0.000
latitude of projection's origin                              0  0  0.000
false easting (meters)                                           0.00000
false northing (meters)                                          0.00000
```

Roads of South Africa

roads

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:54:39
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	14.334E	.	34.944E	
-20.062S	-		-	-20.062S
-35.765S	.	.	.	-35.765S
	14.334E	.	34.944E	

Projection information (see end of this page for details)

Scale
500000?
Date
1994
Description
Roads of South Africa
Owner
Chief Directorate of Surveys and Land Information
Owner_address
Department of Land Affairs
Private Bag
MOWBRAY
7705
Owner_contact
Thomas Krieg
Owner_country
South Africa
Owner_phone
(021) 685 4070 x 143
Owner_fax
(021) 689 1351
Owner_email
xxx@xxx.xxx.gov.za
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History

```
1994 - Digital data supplied to Department of Water Affairs
includes CLASS =
1  Other                18613
2  Secondary             6303
3  Main                   915
4  Nat_Route              166
5  Freeway                 60
```

Logo

$WMSYS/ptool/template/s_li_logo

Arc items, 2850kbyte:
10 Jan 1996, elise:
10 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
FNODE#	24347	4.0	binary		
TNODE#	23975	4.0	binary		
LPOLY#	0	4.0	binary		
RPOLY#	0	4.0	binary		
LENGTH	0.3325923085212	4.3	floatpnt		
ROADS#	1	4.0	binary		
ROADS-ID	1	4.0	binary		
NAME	##012:18619	40	character		
CLASS	Other	40	character		
Z	0	4.0	binary		

Map specifications:

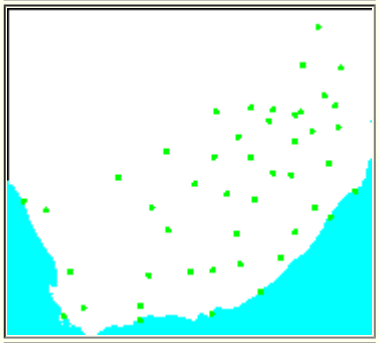
```
   Description of SINGLE precision coverage /spek/waterm/wmdata/general/roads

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
ARCS                                    26057       112
NODES                                   46724

                              SECONDARY FEATURES

Tics                                        4
Arc Segments                           573267

                                 TOLERANCES

Fuzzy   =                 0.002 N          Dangle  =                 0.000 N

                              COVERAGE BOUNDARY

Xmin =                   15.271            Xmax =                   34.007
Ymin =                  -34.828            Ymax =                  -20.999

                                   STATUS
```

```
The coverage has not been Edited since the last BUILD or CLEAN.
                          NO COORDINATE SYSTEM DEFINED
```

Some South African towns - a coarse coverage for temporary use only.

sa_towns

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:56:32
File owner: elise, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-763144W	.	859821E	
-2352350S	-		-	-2352350S
-3804585S	.	.	.	-3804585S
	-763144W	.	859821E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
50000?
Date
1993?
Description
Some South African towns - a coarse coverage for temporary use only.
Owner
Department of Water Affairs and Forestry
Owner_address
ISUS, Residensie Building
Department of Water Affairs and Forestry
Private Bag X313
PRETORIA
0001
Owner_contact
Chief Engineer of Strategic Planning
Owner_country
South Africa
Owner_phone
(021) 299 9111
Owner_fax
(021) 323 2123
Owner_email
xxx@dwaf.pwv.gov.za
Disclaimer
Towns digitised for temporary use - not accurate.
Copyright_message

History

Some South African towns digitised by ISUS, DWAF.

Logo

 ../images/s&li

---

Annotation items, 1kbyte:
12 Dec 1994, elise:
Point items, 2kbyte:
19 May 1998, elise:
5 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	0	4.3	floatpnt		
PERIMETER	0	4.3	floatpnt		
SA_TOWNS#	1	4.0	binary		
SA_TOWNS-ID	4	4.0	binary		
NAME	Messina	20	character		

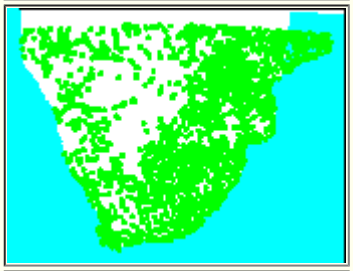
Map specifications:

```
 Description of SINGLE precision coverage /spek/waterm/wmdata/general/sa_towns

                              FEATURE CLASSES

                                   Number of  Attribute     Spatial
Feature Class          Subclass    Features   data (bytes)  Index?   Topology?
-------------          --------    ---------  ------------  -------  ---------
POINTS                                    46        36
ANNOTATIONS             (blank)            0

                             SECONDARY FEATURES

Tics                                      64

                            TOLERANCES

Fuzzy   =               211.145 N         Dangle  =                 0.000 N

                             COVERAGE BOUNDARY

Xmin =              -689372.438           Xmax =              786049.500
Ymin =             -3730813.500           Ymax =            -2426120.750

                                  STATUS

The coverage has edit masks, use BUILD or CLEAN to restore topology

                         COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS             Spheroid             CLARKE1880
Parameters:
1st standard parallel                                    -18  0  0.000
2nd standard parallel                                    -32  0  0.000
central meridian                                          24  0  0.000
latitude of projection's origin                            0  0  0.000
false easting (meters)                                         0.00000
false northing (meters)                                        0.00000
```

Cities and towns of South Africa

pppoint

Institute for Water Quality Studies metadata.
Summary created by Elna with catalog.aml on 1999-04-01 - 14:53:34
File owner: michael, last modified: 1 Apr (less than 1yr ago)
Map extent:

	-1468496W	.	1866520E	
-1449702S	-		-	-1449702S
-3957822S	.	.	.	-3957822S
	-1468496W	.	1866520E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1866

Scale
1000000
Date
1992?
Description
Cities and towns of South Africa
Owner
Environmental Systems Research Institute, Inc. (ESRI)
Owner_address
380 New York Street,
REDLANDS
California
92372 USA
Owner_contact
Contracts Manager
Owner_country
United States of America
Owner_phone
1-909-793-2853
Owner_fax
1-909-793-????
Owner_email
esri.com
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History

```
1994-Digital Chart of the World: southern Africa extracted S of 15deg S.
1999-Cities and towns selected from DCW using ArcPlot and method in ch6 of Arc6
     librarian user's guide - extracted to new file
```

Logo

$WMSYS/ptool/template/esri_logo

Annotation items, 230kbyte:
25 Feb (less than 1yr ago), michael:
Point items, 137kbyte:
25 Feb (less than 1yr ago), michael:
7 data fields

ITEM	EXAMPLES	WIDTH	TYPE	REDEFINED?	INDEXED?
AREA	0	4.3	floatpnt		
PERIMETER	0	4.3	floatpnt		
PPPOINT#	1	4.0	binary		
PPPOINT-ID	999	4.0	binary		
PPPTTYPE	1	2.0	integer		
PPPTNAME	Uanhomba	40	character		
PPPTFLAG	9	2.0	integer		

Map specifications:

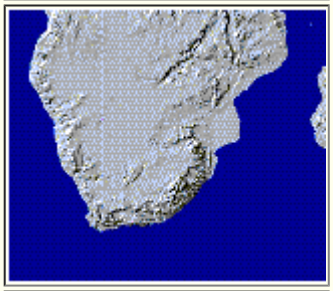
```
  Description of SINGLE precision coverage /spek/waterm/wmdata/general/pppoint

                                FEATURE CLASSES

                                     Number of  Attribute     Spatial
Feature Class          Subclass      Features   data (bytes)  Index?   Topology?
-------------          --------      ---------  ------------  -------  ---------
POINTS                                   2336         60
ANNOTATIONS             (blank)          1417

                              SECONDARY FEATURES

Tics                                       84

                                  TOLERANCES

Fuzzy   =                303.183 N          Dangle  =                 0.000 N

                              COVERAGE BOUNDARY

Xmin =              -1316904.500            Xmax =               1714928.125
Ymin =              -3806230.000            Ymax =              -1601293.500

                                    STATUS
```

```
The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection               ALBERS
Units                    METERS             Spheroid             CLARKE1866
Parameters:
1st standard parallel                                      -18  0  0.000
2nd standard parallel                                      -32  0  0.000
central meridian                                            24  0  0.000
latitude of projection's origin                              0  0  0.000
false easting (meters)                                            0.00000
false northing (meters)                                           0.00000
```

Elevation data: Digital Chart of the World Digital

grdshade

Institute for Water Quality Studies metadata.
Summary created by Michael with catalog.aml on 1999-04-16 - 02:26:17
File owner: michael, last modified: 26 Aug 1998
Map extent:

	10E	.	45E	
-10S	-		-	-10S
-40S	.	.	.	-40S
	10E	.	45E	

Projection information (see end of this page for details)
Projection ALBERS latitude of projection's origin 0 0 0.000
Units METERS Spheroid CLARKE1880

Scale
1000000
Date
1995
Description
Hillshaded relief grid
Owner
Customer Services EROS Data Center
Owner_address
Customer Services
EROS Data Center
Mundt Federal Building
Sioux Falls, SD 57198
Owner_contact
FTP to 152.61.128.6 (edcftp.cr.usgs.gov)
Owner_country
United States of America
Owner_phone
(605) 594-6151
Owner_fax
(605) 594-6589
Owner_email
klarson@dgl.cr.usgs.gov, jenson@dg1.cr.usgs.gov
Owner_website http://edcwww.cr.usgs.gov/landdaac/gtopo30/README.html
http://edcwww.cr.usgs.gov/landdaac/gtopo30/README.html
Disclaimer
No responsibility is accepted for the accuracy of this data
Copyright_message

USGS & EROS
Copyright_warning
data in the public domain
History

This is a reclassed version of the USGS African DEM.
The following are extracts from the README and README_v2.txt files that
came with the 1995 and 1996 DEMs supplied by EROS Data Centre.
The DCW DEM data were created by the EROS Data Center by running
DCW contour, point elevation, and hydrology data through the ANUDEM digital
elevation model generation program.
A Digital Elevation Model (DEM) consists of a sampled array of elevations
for ground positions that are normally at regularly spaced intervals. The
Digital Chart of the World (DCW) DEM data provide 30-by-30 arc-second
digital elevation data produced from the Defense Mapping Agency's (DMA)
1:1,000,000-scale DCW contour and hydrology data. The EROS Data Center's
DCW DEM project includes generation of 30 arc-second data for the entire
world to be distributed on CD-ROM as major geographic regions are completed.
As of July 1, 1995 Africa, North America, Japan, Madagascar, and Haiti, are
complete and available for distribution.
Digital Chart of the World (DCW) Digital Elevation Model (DEM) data are
produced from 1:1,000,000-scale DCW contour, point elevation, and hydrology
data layers.
The map source for the DCW database is the U.S. Defense Mapping Agency
DMA)'s Operational Navigation Chart (ONC) series. This is the largest-
scale map series that provides consistent, continuous global coverage of
essential basemap features.
Data Characteristics
Spatial Resolution
Spacing of the elevations along and between each sample is 30-arc-seconds
(approximately 1 km). The horizontal datum is WGS84. Elevation values
are expressed in feet above mean sea level.
Accuracy
The absolute accuracy of the DCW vector information is 2000 meters circular
error (horizontal) and + or - 650 meters linear error (vertical) at 90-percent
confidence as defined by the Defense Mapping Agency (DMA). The grid generated
from these data will be no more accurate than this source. The accuracy for
the grid has not been measured or calculated.
Moderate resolution (100 meter to 1 kilometer) topographic data have
applications in many diverse land science fields such as geology and
geophysics, ecology, soil science, botany, and glaciology. Topographic data
are also critical to procedures used for correcting and/or presenting remotely
sensed satellite and other global data.
The DCW DEM data, produced for use in conducting large-area studies, has

been generated at a resolution which is compatible with the Advanced Very High Resolution Radiometer (AVHRR) sensor.

References

Defense Mapping Agency, 1992, Development of the Digital Chart of the World: Washington, D.C., U.S. Government Printing Office.

Environmental Systems Research Institute, 1991, Image Integration ARC/INFO User's Guide: Redlands, California, Environmental Systems Research Institute, Inc.

Hutchinson, M.F., 1988, Calculation of hydrologically sound digital elevation models: Proc. Third Inter. Symp. Spatial Data Handling, Columbus, Ohio, August 17-19.

Hutchinson, M.F., 1989, A new method for gridding elevation and stream line data with automatic removal of pits: J. Hydrol, 106, 211-232 p.

Hutchinson, M.F., 1991, A continental hydrological assessment of a new grid-based digital elevation model of Australia: Hydrological Processes 5, 45-58 p.

README_v2.txt 3/6/96

PLEASE NOTE: This is an interim release of an updated portion of the Africa 30 arc second DEM. The Africa 30 arc second DEM was originally released in October 1994, and an update was released in August 1995. The complete Africa DEM was constructed by gridding Digital Chart of the World (DCW) data. For a description of that processing please see the README file at edcftp.cr.usgs.gov in the directory /pub/data/30ASDCWDEM/AFRICA. The data set described here is derived from a different source, Digital Terrain Elevation Data, and it will be used eventually to update the Africa 30 arc second DEM. Comments from users of this data set are welcome. Please contact Dean Gesch (gesch@dg1.cr.usgs.gov) or Sue Jenson (jenson@dg1.cr.usgs.gov) with your comments.

The 3 arc second grids were aggregated to 30 arc second grids using a cell factor of 10 and mean as the aggregation type. Thus, the value for a specific 30 arc second cell represents the mean of 100 full resolution 3 arc second cells. To deal with the boundaries of the input grid when its rows and/or columns are not a multiple of the cell factor, the "truncate" option was used. This option reduces the number of rows and/or columns in the output grid by one. Doing so truncates the remaining cells on the bottom and/or right boundaries of the input grid thus making the number of rows and/or columns in the input grid a multiple of the cell factor. The resulting output grid's spatial extent can thus be smaller than the input grid. The "nodata" option used specifies that if any cell that falls within the spatial extent of a larger cell on the output grid has a value of "no data", then the value for that output cell location will be no data. The final assembly step involved mosaicing together the individual 30 arc second grids.

DEM Coverage and Characteristics

The generalized DTED covers about 50% of the African continent. However, the coverage is in an irregular pattern so this interim DEM extends across the entire continent. The DEM extends from 18 degrees west to 50 degrees east longitude, and from 35 degrees south to 42 degrees north latitude. There is a GIF image named af_dem_v2.gif at edcftp.cr.usgs.gov in the directory /pub/data/30ASDCWDEM/AFRICA which shows the coverage of the DEM. In the DEM, background ("no data") and ocean areas have a value of -9999. The cell values represent elevation in meters above mean sea level. The values range from -405 to 4429. The horizontal coordinate system is latitude/longitude referenced to WGS84. The posting interval (cell size) is 30 arc seconds (0.0083333333333 degrees). The DEM file has dimensions of 9240 rows by 8160 columns.

Logo

 ../images/gtopo30.jpg

---

Map specifications:

```
    Description of SINGLE precision coverage $WMSYS/wmdata/general/grdshade

                        Description of Grid GRDSHADE

Cell Size =             500.000         Data Type:                    Integer
Number of Rows    =       6063            Number of Values =             27
Number of Columns =       7035            Attribute Data (bytes) =        8

           BOUNDARY                                STATISTICS

Xmin =             -1457197.621         Minimum Value =               1.000
Xmax =              2060302.379         Maximum Value =             100.000
Ymin =             -4072819.596         Mean          =              53.806
Ymax =             -1041319.596         Standard Deviation =          1.716

                        COORDINATE SYSTEM DESCRIPTION

Projection              ALBERS
Units                   METERS            Spheroid             CLARKE1880
Parameters:
1st standard parallel                                      -18  0  0.000
2nd standard parallel                                      -32  0  0.000
central meridian                                            24  0  0.000
latitude of projection's origin                              0  0  0.000
false easting (meters)                                           0.00000
false northing (meters)                                          0.00000
```