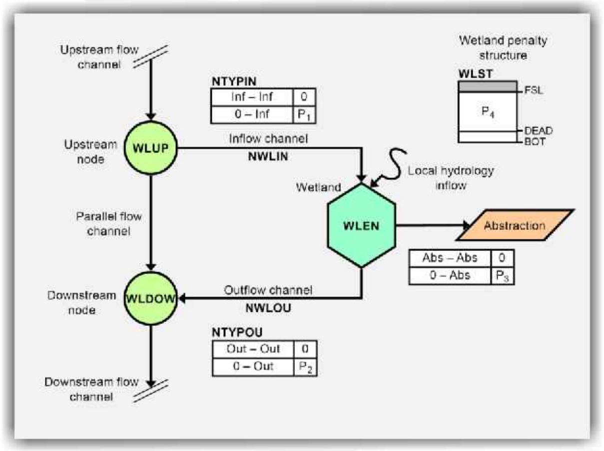
MODEL ARCHITECTURE

A major strength of the IWRSM is the modular approach of adding new features and functions. Over the years, the need for many additional features, sometimes unique to Southern African conditions, has resulted in a number of additional functions being included in the model. As research into various methodologies of assessing different components of a water resources system is completed, the experience gained is added to the model and in so doing enhances it's capabilities.

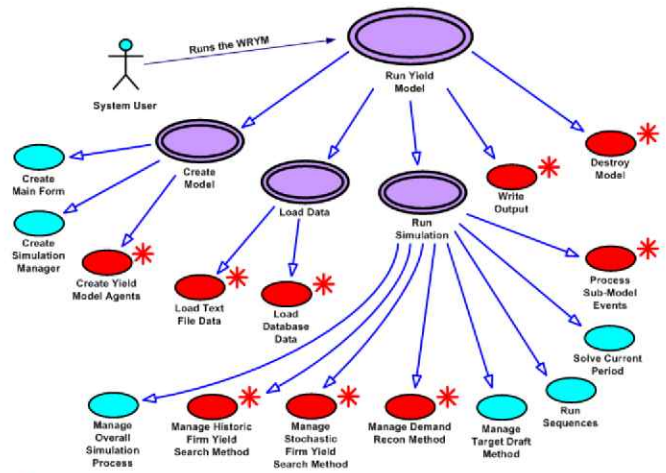
22. WRYM Training Data Set – Skip Sequences – Historic Start Mode	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
23. WRYM Training Data Set – Skip Sequences – Bootstrap Start Mode	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stochastic Mode – 25 Sequences – Random Start Mode	Orig	7	701	702	703	704	71	711	72	721	722	723	73	731	74	741	75	751	752	753	754	755	756	7561	7562	7563	7564	7565	7566	7567	7568	7569
24. WRYM Training Data Set	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
25. WRYM Training Data Set – 5 Target Drafts	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
26. WRYM Training Data Set – Skip 100 Sequences	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year 2000	Orig	7	701	702	703	704	71	711	72	721	722	723	73	731	74	741	75	751	752	753	754	755	756	7561	7562	7563	7564	7565	7566	7567	7568	7569
27. Training System Historic Spanning year 2000	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
28. Training System Historic with 136 Year Sequences	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
29. Training System Stochastic Spanning year 2000	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
30. Training System Stochastic with 136 Year Sequences	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Irrigation Blocks – Training – F17	Orig	7	701	702	703	704	71	711	72	721	722	723	73	731	74	741	75	751	752	753	754	755	756	7561	7562	7563	7564	7565	7566	7567	7568	7569
31. Training System – Historic, Type 1, Drought Reduction Off	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Strict control is kept of model release versions, and all executables are carefully checked and tested before a release is made. All executables are backwards compatible, meaning that a specific data set can be run with a newer version of the model even though it does not need to utilise certain new features that may have been added.

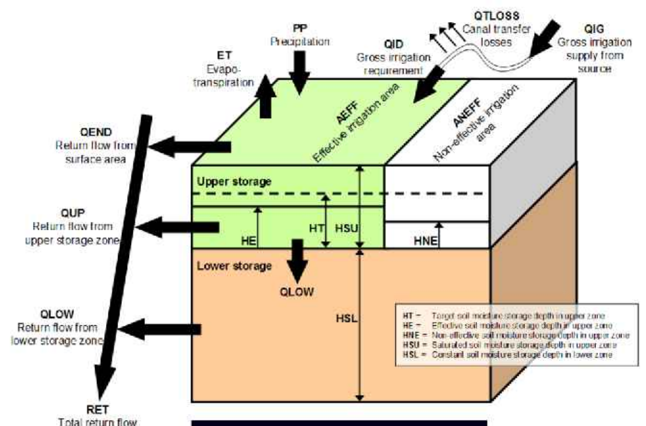
Recent new features added to the model include:



The ability to simulate wetlands added to the WRYM and WRPM



High level use case design of WRYM



Irrigation Module added to WRYM

Future additions:
Research in the pipeline by DWA, WRC and collaborating organizations.

- Groundwater - surface water interaction submodel
- Stochastic Rainfall generator

TRAINING, SUPPORT AND ACCESS

The WRYM-IMS is supported by the User Support System (USS), which consists of a help desk and website. The Support is provided for: software registration, model updates, training courses, system demonstrations, general queries on the software and associated data sets.
USS is accessible at www.usersupport.co.za. For more information, please contact the UserSupport Liaison Officer on: (012) 336 7090 or email: usersupport@dwaf.gov.za

Training courses are arranged on demand and typically held annually. Information sessions are arranged on request.

Executable copies of the model are freely available to all existing users and people who have completed the training. Copies of the model can be obtained as an installation package loadable on an individual Desktop / Laptop. Registration on the User Support website is required to activate the model. Intermittent updates can be requested from the Department's IWRP User Support System.

Produced by WRP Graphics Department
WRP: C:\Projects\A0002\Brochures\Integrated Water Resources System Model.cdr
Last updated: 2011/07/29

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Integrated Water Resources System Model

BACKGROUND

In the early 1980's the South African Department of Water Affairs (DWA) realised the need for a computerised modelling tool to analyse the Vaal River Supply System. Unique to this system was its ever increasing complexity due to the growing number of dams and contributing catchments which required it to be operated as a single large system. It was realised that a powerful modelling tool was required and it was then that the Integrated Water Resources System Model (IWRSM) was birthed. The model was based on the well known ACRES Reservoir Simulation Program (ARSP) which was at the forefront of water resources analyses at that time.

The IWRSM has since been steadily expanded, improved and modernised by the DWA over the years and is now at the fore-front of this kind of technology. For South Africa, being a water scarce country and requiring water transfers over large distances between catchments, the IWRSM remains an essential tool to analyse water availability and to assist with decision making regarding system capacity expansion, operational decision-making and drought management.

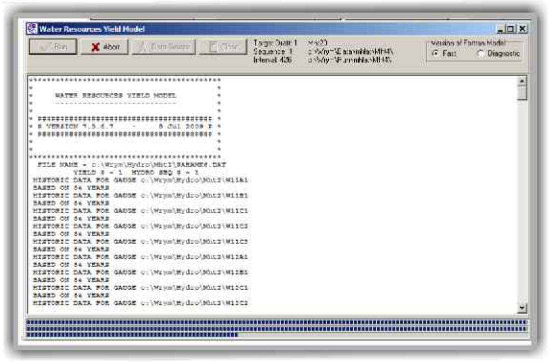
INTRODUCTION

The IWRSM includes two main model components namely:

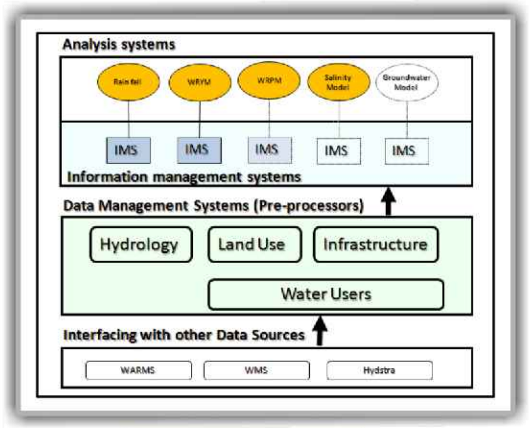
- The **WATER RESOURCES YIELD MODEL (WRYM)** and
- The **WATER RESOURCES PLANNING MODEL (WRPM)**

Both models are very similar in many respects but are used separately with some of the results from the WRYM being used as input to the WRPM.

The IWRSM has been developed using a modular approach in which the physical characteristics and operating rules for a specific catchment in question are defined through input screens and are not hard-coded into the software. In this manner, the same software can be used to analyse different water resource systems without the need to make any changes to the source code.



WRYM processing data input for the Mhlathuze system



Framework

WRPM modernization under development

PURPOSE

The IWRSM is a modelling system for operations and development planning, water use allocation and high resolution modelling in large integrated system such as the Orange-Senqu Basin.

Additional benefits include:

- Data management and repository.
- Information sharing.
- Adaptability to apply dependable and relevant hydrological analysis using proven methods while allowing for new research.
- Rigorous water availability risk analysis to cope with dry and highly variable flow in rivers of Southern Africa.
- Consistency in analysis to provide coherent decision support for water resource managers.
- Integrated water resource management by combining operational and development planning as well as quality (salinity) and quantity in a single simulation system.

Key purposes include:

WRYM:

- Assess historic firm and long term stochastic yields of a system
- Assess system capabilities at a specific development level
- Analyse long term operating rules for a system
- Develop short term stochastic yield curves for use in WRPM.

WRPM:

- Analyse a system under projected future demands that grow over time
- Analyse the impact of new development options which are introduced through a changing system configuration
- Undertake annual management decisions using short term yield capabilities
- Analyse filling times of potential new reservoirs
- Simulation of possible water quality constraints with regard to TDS and sulphates
- Provides a decision support tool for real time operation of complex water resource systems

WR-IMS

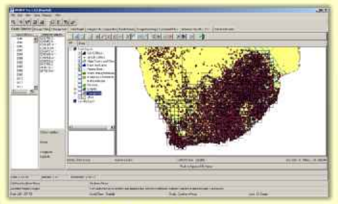
In recent years the IWRSM has been modified to take advantage of the benefits of the latest Windows based software with all of its user-friendly graphical capabilities. The DWA also saw a need to consolidate all water resources modelling tools and relevant data obtained from many studies in a one stop shop, the

WATER RESOURCES INFORMATION MANAGEMENT SYSTEM (WR-IMS)

Features of the WR-IMS include:

RAIN-IMS

- A database of all rainfall gauges located in RSA and surrounds including GIS functionality to select gauges.
- Monthly rainfall data including flags for missing and suspect data
- The CLASSR and PATCHR models which are used to check raw and patch incomplete rainfall records

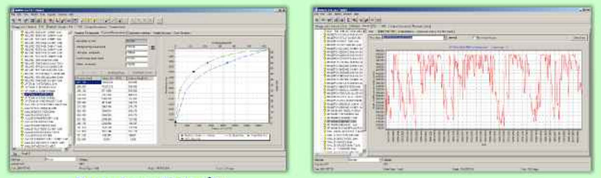


GIS Rainfall database

Monthly Rainfall database

WRYM

- All data required for execution of the WRYM are input through screens in the IMS
- The IMS undertakes validation testing of data input to ensure that it has been completed correctly
- A WRYM run scenario is started from inside the IMS
- Output data is assessed using the IMS

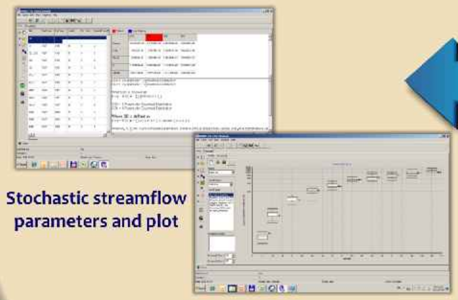


Dam Area Capacity Relationship input screen

STOMSA

Stochastic Model South Africa

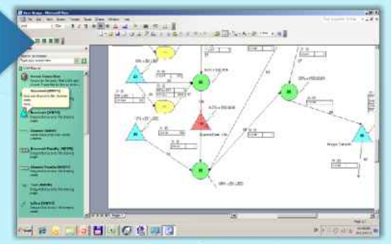
- Creates stochastic streamflow records based on historical natural record
- Creates parameter file for use in WRYM & WRPM
- Prepares graphs to validate stochastic flows



Stochastic streamflow parameters and plot

NETWORK VISUALIZER

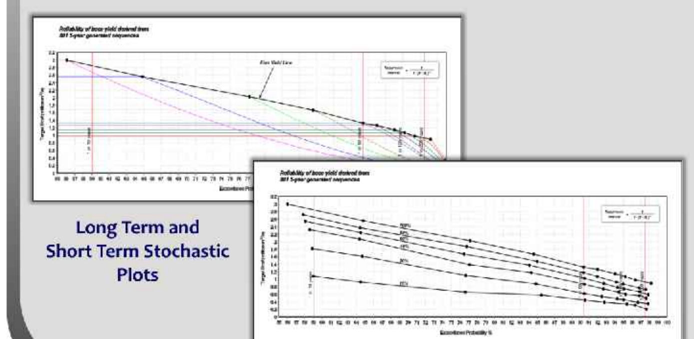
- Linked to Microsoft Visio, the network visualizer allows the modeller to create a representative network diagram with all components linked to the data set for the specific study area
- The data can be configured and results assessed using the network visualizer



Network visualizer creating a representative schematic drawing

RESULT PRESENTER

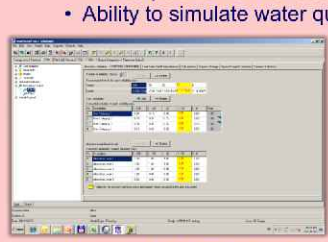
- Time series tables and graphs of any network component
- Water supply reliability and risk of deficits analysis graphs
- Yield vs. reliability graphs of multi reservoir systems
- Scenario evolution graphics features



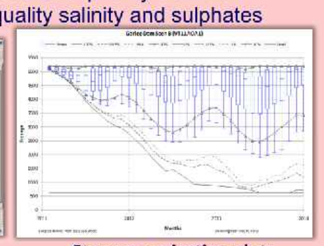
Long Term and Short Term Stochastic Plots

WRPM: WORK IN PROGRESS

- All data required for execution of the WRPM are input through screens in the IMS
- The IMS undertakes validation testing of data input to ensure that it has been completed correctly
- A WRPM run scenario is started from inside the IMS
- Output data is assessed using the IMS
- Involves yearly water requirement projections for long term planning
- Incorporation of risk based user priority definition
- Ability to simulate water quality salinity and sulphates



User priority classification input screen



Storage projection plot: output of WRPM

INTELLECTUAL PROPERTY

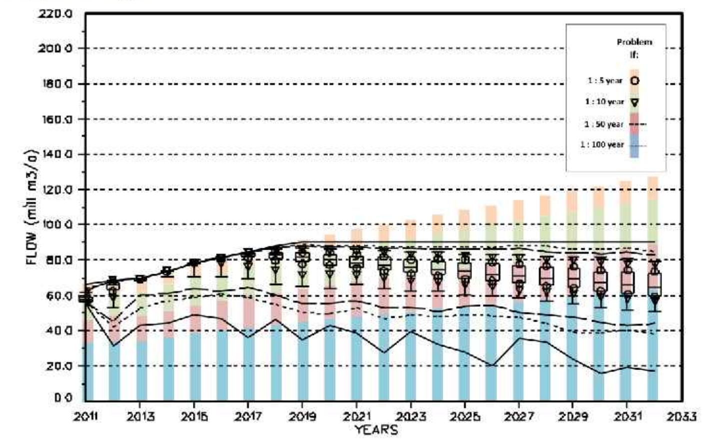
Until recently, intellectual property considerations restricted the distribution and use of the IWRSM. DWA was only allowed to share the model within South Africa and with our direct neighbours, ie. The countries over which catchment boundaries fall. Upon our request, Hatch / Acres has kindly relinquished all rights to the software paving the way for DWA to make it available to share the model freely with the outside world. The opportunity is thus presented to make it known, especially within Africa, that DWA is willing to share this model. It is envisaged that the model could especially be valuable in those parts of Africa confronted with issues of water scarcity.

HATCH™

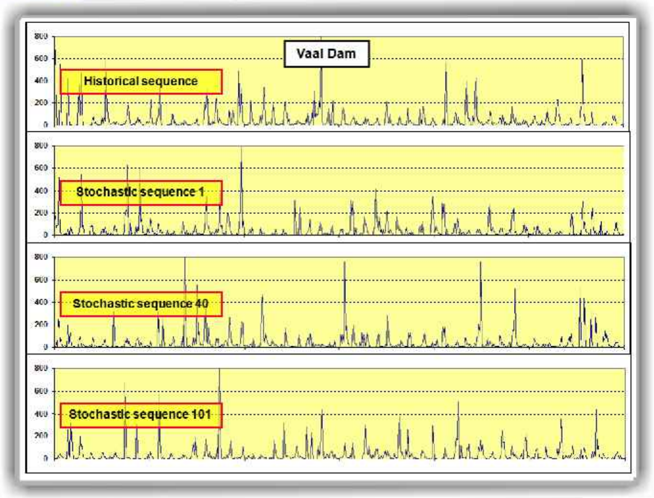
WORLD CLASS MODELLING METHODOLOGIES

While there are many water resource models in the world, there are no comparable models currently available that explicitly deal with risks and reliability of water supply in such a pragmatic and systematic manner as the IWRSM. The major strength lies in the fact that all results are quoted statistically in terms of risk. By simulating not only the known historical streamflow record, but a number (often 1000) statistically similar, but not identical, stochastic streamflow sequences , results can be quoted in terms of assurance of supply or risk of failure.

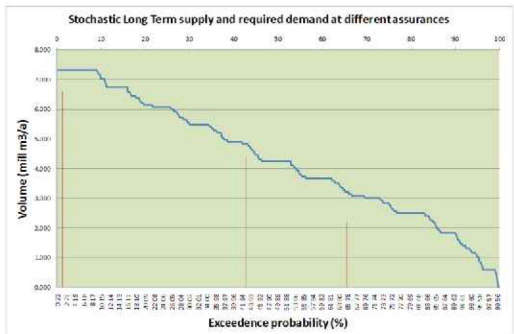
The critical periods in many parts of Africa can be in excess of 10 years and in extreme areas can exceed 20 years. Such long critical periods are reflected by often severe droughts which must be anticipated. The IWRSM has been developed using sophisticated stochastically generated streamflow sequences which allow long-term yield analyses to be undertaken and proper operating rules can be developed to help provide water to consumers even through the longest droughts.



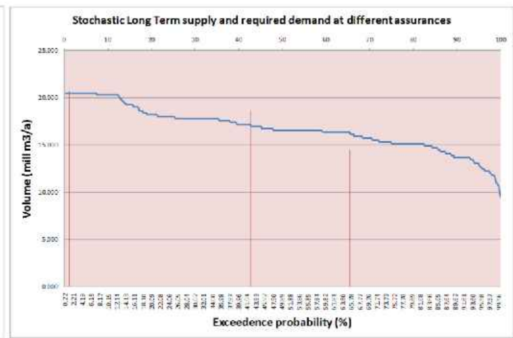
Boxplot of simulated projected supply superimposed over actual demands at different assurance requirements



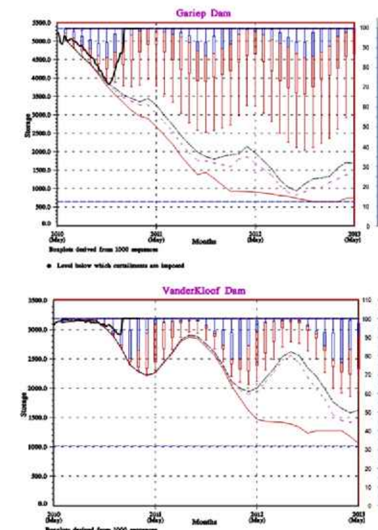
Historical Vaal Inflow Record



Graph showing satisfactory supply for individual demand based on stochastic simulation



Graph showing unsatisfactory supply for individual demand based on stochastic simulation

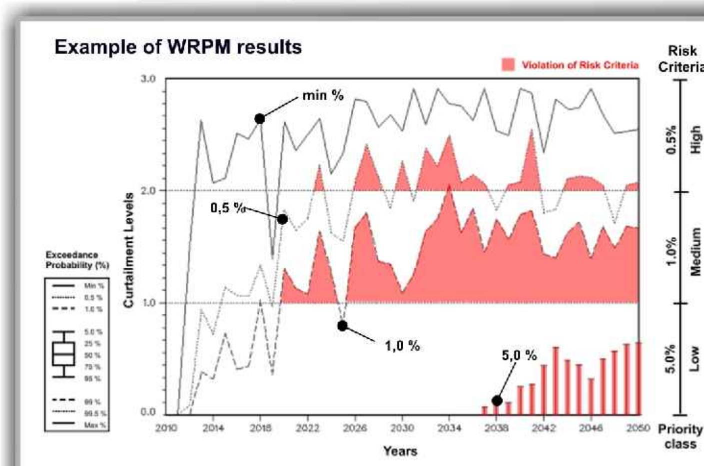


Actual storages plotted over simulated projected storages used for reservoir monitoring

An important element of the IWRSM is in the development of 5 and 10 year projections of what may occur in future so that action can be taken early in a drought event. The methodology involves using the multiple possible future streamflow sequences generated by the model, each of which is analysed as it it was the real sequence. A probability chart is then developed for each component of the system to depict how it is likely to react over the 5 or 10 year horizon. In this manner the probability of system failure can be evaluated and action taken in time to prevent serious problems.

The resulting probability charts are simplified to assist the water supply managers to take appropriate action regarding water restrictions early in a drought sequence. In traditional modelling techniques, the drought event is often only identified when it is already too late to impose basic restrictions by which time more serious restrictions may be necessary.

In addition to monitoring reservoir projection plots, water resource managers can also use model outputs to assess when future augmentation schemes are required. Model inputs include various demands, their projected growths and their assurance requirements. The model results show required restrictions for a system and by assessing the outputs, managers can detect whether or not a particular user's supply assurance requirements can be met. When assurance criteria are violated, system augmentation is required. Model outputs also include the size of restrictions required in order to protect the resource through drought times.



Risk of drought restrictions