March 2016
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Water resource management

Water resources accounting

A recently completed project by the Water Research Commission (WRC) has sought to develop an integrated water resources accounting methodology for South Africa.

Background

Water accounting enables water resource managers and policy-makers to clearly view the options available to them together with the required scientific information, and to make decisions based on the water resources available in a catchment with an understanding of the potential impacts on all water users.

This WRC project reviewed existing accounting frameworks; demonstrated the use of a water resource accounting framework to help in understanding water availability and use at a catchments scale; and developed an integrated and internally-consistent methodology and system to estimate the water availability and sectoral water use components of the water resource accounts.

Such an integrated system ideally needs to be able to compute the water balance, quantifying all water fluxes in the hydrological cycle and to distinguish between 1) use by different sectors, 2) different hydrological components (i.e. green and blue water), and 3) beneficial and non-beneficial water use, and 4) consumptive and non-consumptive use.

Review of water accounting frameworks

Several water resource accounting frameworks exist, each developed by different organisations for a different purpose. Following a review of these frameworks, one (the IWMI Water Accounting System) was selected for use in this study.

The so-called WA system was selected for use due to its suitability for catchment scale water accounts, its strong land cover/use focus and its simple format, which makes it suitable for use as a communication tool.

Review of datasets

An investigation into the water resource-related datasets available in South Africa, and a review of water use quantification methodologies previously applied in South Africa and other African countries provided further insight and helped to guide the development of a methodology for estimating water availability and use at a catchment scale.

The data sources and methodologies investigated included:

- Catchment boundaries and altitude
- Rainfall, evaporation and air temperature
- Land cover/use
- Soil moisture and soil hydrological characteristics
- Surface and groundwater storage
- River flow networks and measured streamflow
- Abstractions, return flows and transfers
- Reserved flows

Development of the methodology

The development of the methodology was to some extent an iterative process and had four main components: processing of datasets, compilation of a project database spreadsheet containing catchment configuration information, configuration of the ACRU model using the project database and associated datasets and hydrological simulation and compilation of water resource accounts.

The WA+ Resource Base Sheet was modified to suit the purpose of the project. A land and water use summary table

was also developed to accompany the Resource Base Sheet in the form of a pivot table summarising areal extent, water availability and water use by land cover/use class.

The methodology was intended to have a strong land cover/use focus. There are various land cover/use datasets available for different regions and points in time, and hence all use different land cover/use classifications.

This situation led to the recognition that some means was required to provide consistency in the application of these various datasets and enable water resource accounts compiled using different datasets to be compared.

An important component and achievement of this project was the development of a standard hierarchy of land cover/use classes and an associated database of land use/cover classes containing information describing the hydrological characteristics of these classes. The methodology developed for determining hydrological response unit (HRU) for use in modelling using catchment boundaries, land cover/use, natural vegetation and soils datasets was also a useful development.

The poor spatial representation and poor availability of rain gauge data led to the investigation of remotely sensed rainfall datasets. Four remotely sensed daily rainfall datasets were compared with rain gauge data and the simulated streamflow resulting from the use of these rainfall datasets was compared with measured streamflow.

The results of these evaluations were not conclusive. The remotely sensed datasets compared favourably with rain gauge data in the uMngeni Catchment but performed poorly in the Sabie-Sand catchment.

Although remotely sensed rainfall offers advantages in spatial representation and availability, the coarse resolution and bias in rainfall quantities may be a problem in accurately estimating rainfall at sub-Quaternary scale for use in water resource accounts.

This project focused on the quantification of water use by Natural, Cultivated and Waterbody land cover/use classes as together these typically cover the largest portion of a catchment and are the easiest to represent in a hydrological model for a large number of catchments.

Datasets for, and representation of, the Urban and Mining classes require further research. In this project, urban residential water use was estimated in a simple manner based on population. Industrial and commercial water use was not included in the water use estimates in the case study catchments.

The project database spreadsheet, in which the spatial configuration of catchments, subcatchments, HRUs, river flow networks, dams and other water infrastructure is specified, acts as a useful source of information from which the ACRU model, and potentially other hydrological models, can be configured.

This project database makes catchment configuration more transparent, editable and reproducible, though implementation by individual models will require different model specific assumptions.

A library of Python scrips was developed to process datasets and to populate the project database spreadsheet. Java code was also developed to use the information contained in the project database spreadsheet and associated datasets to configure the ACRU hydrological model.

The ACRU model was further developed to compile the modified WA+ Resource Base Sheets and store the information required to populate the land and water use summary table.

The modified WA+ Resource Base Sheets and the land and water use summary of water resource inflows, use and outflows for a catchment. the WA+ Withdrawal Sheet needs to be implemented to provide information on abstractions, return flows and water stocks.

Application of the methodology

The methodology was applied in two case study catchments – uMngeni catchment in KwaZulu-Natal and the Sabie-Sand catchment in Mpumalanga. These case studies demonstrated the use of available datasets, data processing tools, hydrological model configuration and compilation of water accounts.

These case studies also served to highlight many areas where the methodology requires further development.

Discussion and conclusions

In conclusion, this project has been successful in that it reviewed existing water accounting frameworks; demonstrated the application of a water resource accounting framework to help in understanding water availability and use at a catchment scale; and developed an integrated and internally-consistent water use quantification and accounting methodology to estimate the water availability and sectoral water use components of the water resources accounts.

The methodology focused on quantifying actual water use rather than gross withdrawals. The methodology is suitable for use at a variety of catchment scales and temporal domains and the accounting framework enables aggregation of results from finer to coarser spatial and temporal scales, and also at different levels of land cover/use detail.

Although there is still much work to be done to refine the methodology, a good foundation has been set for the development of a system that in future will enable Quaternary Catchment scale water resource accounts to be compiled for the whole country.

Further reading:
To order the report, *Development and assessment of an integrated water resources accounting methodology for South Africa* (**Report No. 2205/1/15**), contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.