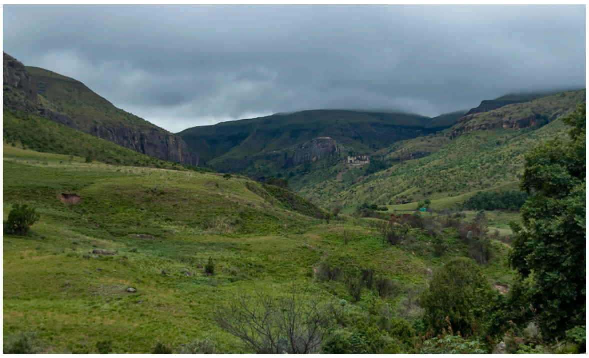
TECHNICAL BRIEF

November 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.

Exploring the potential of Cathedral Peak as a living lab

A newly-completed Water Research Commission (WRC) study explored the potential of the Cathedral Peak research catchments to act as a living laboratory.

Background



High altitude catchments are often important headwater catchments. However, much uncertainty surrounds environmental change and its impacts on hydrological responses, particularly in these high altitude catchments.

It is therefore imperative to improve our understanding of water distribution and movement in these catchments as any changes in the hydrological responses from these catchments could have significant social, economic and environmental consequences downstream.

To be able to achieve this understanding, detect changes and reduce uncertainty, long-term hydrological monitoring is crucial. Long-term hydrological monitoring sites, however, are limited, particularly in high altitude regions.

Thus, any long-term hydrological monitoring initiative should be supported and the best use of the data be made. This WRC projects built on the South African Environmental Observation Node's (SAEON) initiative to resurrect streamflow and climate monitoring in the Cathedral Peak research catchments.

The long history, the wealth of data collected, and knowledge that exists surrounding the Cathedral Peak research catchments makes them an ideal site for long-term monitoring to understand environmental change, as well as providing an opportunity for capacity building.

The overall objective of the project was to improve the understanding of environmental change by collecting and analysing current and historical data from the Cathedral Peak catchments, and through this refining the design for a robust and relevant monitoring network for environmental change monitoring while at the same time building capacity.

Catchment description and history

The final report offers a comprehensive description of the catchments as well as the history behind the catchments' use as research catchments.

The Cathedral Peak research catchments are located in the northern part of the uKahlamba Drakensberg. The catchments fall in the summer rainfall region, with a mean annual precipitation of around 1 400 mm.

Data gathered from the monitoring of the Cathedral Peak research catchments under various treatments has contributed significantly to hydrological understanding. Among others, research in the catchments, which have been extensively afforested, have underpinned the legislation to control afforestation and the estimation of water use of commercial afforestation to date.

The second area to which research undertaken using the data from the Cathedral Peak research catchments has contributed significantly is hydrological model development and related research.

Although substantial use of the data from the Cathedral Peak catchments has been mad to improve hydrological understanding, there is much that can be done. The long-term climatic and streamflow records that exist for Cathedral Peak prior to the 1990s, offer the opportunity of changes in climate and hydrological responses to be detected, monitored, and analysed to allow for improved process understanding.

Data collection and management

A wealth of data has been collected for the Cathedral Peak research catchments, with the CSIR being the custodian of the hydrological and climatological datasets until SAEON's involvement in the catchments. Historically, there were two primary weather stations recording climatic variables for the research catchments. In addition to these meteorological stations, precipitation was historically monitored at 25 sites. Streamflow monitoring was initiated in the late 1940s and 1950s, and expanded on in later decades. Groundwater was monitored for the 1994/95 hydrological year for two boreholes.

Quality control of the historical data

To error check the rainfall records, a graphical analysis of the historical data records was undertaken which showed that a number of monthly records were missing. Following this, the historical rainfall records were error checked by comparing neighbouring and similar gauges to flag any outliers.

Given the missing records and the flagged errors, the historical rainfall records needed to be infilled. Five different infilling methods were investigated to determine the best suited technique to use.

A statistical comparison between the methods indicated that for most gauges, the Nearest Neighbour by Correlation method gave the best results, thus it was used to infill the rainfall records.

Error checking and extension of streamflow records focused on some catchments. The daily data was graphed to check for outliers and anomalies. Besides missing records, no outliers or anomalies were found.

With any long-term monitoring site it is essential that the data collected is of high quality. Thus, with the reestablishment of monitoring in the catchments the quality of the data must be ensured by following a set of data collection procedures and protocols on each site visit.

These standard procedures and protocols maintain raw data quality, govern the data processing and error checking procedures, thus providing stationarity to time series data. These procedures and protocols including the protection of equipment and personal safety are detailed in the final report.

Both the historical and current data from the Cathedral Peak research catchments, together with the metadata, will be stored and made available through the SAEON data portal. The SAEON data portal houses a diversity of data types, each supported by a background system. The Observations database was specifically developed for the purpose of housing historical and current observations of streamflow and climatic data.

Cross-calibration of raingauges

With the re-establishment of the Cathedral Peak research catchments, modern Davis tipping bucket and Texas High intensity raingauges were installed to replace the historical Snowdon raingauges. The modern and historical raingauges have several differences that result in varying measurements of rainfall at a location.

Thus, to ensure the compatibility of the historical and current rainfall records in the Cathedral Peak research catchments, a cross-calibration of the modern and the historical raingauges was conducted. In addition, the question of the accuracy of the Snowden and modern raingauge was addressed through comparison against a ground level gauge, which the WMO considers to be most accurate.

Across the Cathedral Peak sites, the historical and modern raingauges were found to record similar rainfall volumes for the 16 months monitored, with the difference never exceeding 9%.

Proposed hydrological monitoring plan

The need for quality, long-term datasets has become more important with the current impacts of anthropogenic activities on the environment. These long-term datasets can only be obtained through establishing suitable, sustainable hydrological monitoring networks that adequately characterise the properties, distribution, and circulation of water in the atmosphere, on the land, and in surface waters.

The Cathedral Peak research catchments are ideal as a long-term monitoring site for global change as they are high altitude catchments, have catchments both in pristine and damaged condition and have a long historical record.

The final report proposes a monitoring plan that includes catchment-wide climatological monitoring, streamflow monitoring in key catchments and then focused, detailed monitoring in Catchment VI with the full array of evaporation, soil moisture and groundwater monitoring.

Detection of changes in the Cathedral Peak region

To achieve the objective of determining whether trends in rainfall, temperature and streamflow are evident in the Cathedral Peak area, the approach followed comprised four main stages, namely data quality control, exploratory or visual analysis, application of statistical tests and the interpretation of trends.

Consistent positive trends in minimum, maximum and mean temperature across the three stations analysed indicated warming through the historic period. Due to temperature records for only Mike's Pass meteorological station being available for the current period, it was not possible to conclusively determine if changes were evident between the historical and current periods.

Decreasing trends are evident in the historical streamflow which correspond to the drying trends shown in the historical rainfall. During the historical period analysed the land use in the catchments assessed remained constant, thus it is reasoned that the intensification of the trends in rainfall through the hydrological cycle are the cause behind the negative trends being evident in streamflow across all time steps and seasons while a few statistically significant negative trends are evident in rainfall.

Improving the understanding of rainfall distribution across the catchments'

With a longer data record now available, recent advancements in interpolation methods and the increasing pressure on water resources it was necessary to revise the rainfall estimation for the Cathedral Peak research catchments.

The objective of this research was to ascertain if the use of contemporary geo-statistical interpolation methods provided any improved estimates and understanding of the rainfall distribution across the Cathedral Peak catchments in the Drakensberg escarpment region. The historical monthly rainfall data error checked and infilled through this project was used.

Analysis of the mean annual, wet and dry season rainfall confirmed a strong wet and dry season trend. On average, 83% of the annual rainfall occurs during the wet season (September to February) with the North facing gauges receiving the most rainfall during both wet and dry seasons. Regression analysis was used to determine if the considered predictor variables (altitude, aspect, latitude and longitude) showed any significance in explaining the variation in the annual, wet and dry season rainfall. With fitted parameters of the regression model and of the residual variogram, regression kriging was used to derive rainfall predictions at all locations. The latter showed to be a useful tool in characterising the rainfall distribution.

Development of the Cathedral Peak catchments as a living laboratory

Besides the substantial value of the data collected in the Cathedral Peak catchments and the vast opportunities for improving hydrological understanding, the catchments have immense value as a living laboratory where training and the development of skills can take place.

Postgraduate studies are becoming increasingly important for skill development, training and exposure to research due to the rapidly growing undergraduate class sizes. Using living laboratories allows students to learn through experience and visualisation, for practical hands-on training and the inclusion of students in ongoing 'umbrella' research projects.

Overall, the project was successful in terms of its objectives to advance the initiative of SAEON to re-establish monitoring in the Cathedral Peak catchments, and to show the potential of the catchments for use as a living laboratory for training and capacity building.

Further reading:

To obtain the report, *Establishment of and demonstration of the potential of the Cathedral Peak research catchments as a living laboratory* (**WRC Report No. 2236/1/16**), contact Publications at Tel: (012) 761-9300; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.