

Preliminary analysis of low-flow characteristics of South African rivers

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Abstract

Information on low-flow characteristics is required for many research, design, planning and management purposes in both water quality and quantity fields. The paper examines different user requirements for low-flow information and describes the set of automated procedures for low-flow analysis developed by the Institute for Water Research which estimate various low-flow indices of different time exceedance and frequency, analyse the duration and deficit of consecutive low-flow events, calculate recession and baseflow characteristics of a stream, etc. The paper also refers to some aspects of the spatial variability of low-flow indices in South Africa.

Nomenclature

ADF	: average daily flow
BFI	: baseflow index - the ratio of baseflow to total streamflow; calculated by baseflow separation techniques for a year or several years of daily flow record
MAM	: mean annual 1-d minimum flow; calculated from a series of daily minima extracted from each year of flow record
MAM 10, MAM30	: mean annual 10-d (or 30-d) minimum flows; calculated from a series of 10-d (or 30-d) averaged minima extracted from each year of record
MAR	: mean annual runoff
MMDEF50	: mean of annual maximum deficits built during consecutive low-flow events below a referenced discharge of 50% of ADF
MMD50	: mean of annual maximum durations the river continuously stays below a referenced discharge of 50% of ADF
REC50	: 50 percentile recession ratio estimated from a distribution of ratios of current discharge to the discharge one day previously
Q75, Q90, Q95	: flows extracted from flow duration curve and exceeded 75, 90 and 95% of the time respectively.

Introduction

The frequent droughts in South Africa place the efficient utilisation of water resources in sharp focus, highlighting amongst others, problems associated with the hydrology of rivers and catchments during periods of limited flow. Low-flow hydrology poses a variety of questions, the most general ones being ;

- What is the best way to quantify low flows in different regions of the country and for different purposes?
- How should changing low-flow conditions at different scales be represented?

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- How sensitive are low-flow regimes to various anthropogenic effects and physical processes in the catchment?
- How should low flows for natural conditions be estimated when most of the observed records include at least some anthropogenic effects?
- How should the low-flow characteristics of ungauged streams be estimated when no flow records are available?

Different specialists in water-related fields may have different answers, perceptions and requirements for low-flow information. The term "low flows" could mean different things to different interest groups. To many it may be considered as the flows occurring during the dry season, while others may be concerned with the length of time and the conditions occurring between flood events in semi-arid flow regimes. Consequently, there exist a broad variety of measures and indices which have been presented in the literature (Beran and Gustard, 1977; Institute of Hydrology, 1980; Task Committee, 1984; FRENZ, 1989) and which potentially can be used for characterising low flows in South Africa.

Recently there seems to be a tendency to encourage specialists dealing with low-flow problems to communicate using common terminology. To support and promote this tendency the variety of existing low-flow criteria, potentially required in different water-related areas, should be assessed and evaluated in a local context. It also seems logical that the following basic steps should be undertaken before extensive low-flow studies are undertaken in South Africa.

- Examine the state-of-art of low-flow hydrology in South Africa and specify the requirements of all potential users of low-flow information.
- Develop a multipurpose tool which allows the low-flow characteristics required by different water-related disciplines to be estimated.
- Examine the variability and sensitivity of different low-flow characteristics and decide what is the most appropriate time and spatial resolution to be used.

The paper refers to these three issues and describes some results obtained from initial attempts to address them.

Low-flow survey

In order to define the community of users of low-flow information, we outline the problems experienced in low-flow hydrology and to