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ScienceDirect
Physics and Chemistry of the Earth 32 (2007) 1040–1049
PHYSICS and CHEMISTRY of the EARTH
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Determining operating rules for the Letaba river system in South Africa using three models

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Available online 2 August 2007

Abstract

An increasing importance is being placed on the operation of reservoirs and water resource systems in South Africa. Since 1985 the water resources yield model (WRYM) and the water resources planning model (WRPM) have been applied to support decisions concerning the operations of water supply to the Gauteng region. Other models such as the Reservoir Operating Model and the Rationing Model have been developed for application on less complicated systems. In this study the WRYM/WRPM modeling system, the Mike Basin and the Water Resources Modeling Platform (WReMP), are applied on the Letaba River System. The general approach on operational analysis is explained. An attempt is made to have the same set-up on all three models. The results show that the relative advantages of each model depend on user experience with a specific model and their preferred way of presenting results. The selection of a model also depends on the nature of the problem being investigated, preferred conceptual representation and availability of data. The format for presentation of results tends to vary between modelers. However, the link to a GIS interface on the Mike Basin means that preparation of schematics is easier and relates better to real operation of water resources in a catchment than the other two models. This paper also discusses possible use of the output to support operational decisions and presents tabulated data which could be useful to a system or reservoir operator. Recommendations are given on possible future research.
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Keywords: Stochastic yield analysis; Operating rules; Water requirements; Limpopo basin; International catchments

1. Introduction

The Letaba catchment falls within the Limpopo Basin, which is shared by South Africa, Botswana, Zimbabwe and Mozambique. The Letaba River is located wholly within South Africa as shown in Fig. 1. It is a tributary of the Olifants River which directly flows into Mozambique hence the operation of the water resources in the Letaba catchment is of international importance. The current approach to water resources management in the Letaba catchment is places emphasis on the operational management of the Letaba River system. Effective water resource and risk management has the potential to prevent considerable hardship and financial losses, throughout the Letaba catchment.

The Letaba River system can be divided into three subsystems (see Fig. 1) as follows:

- The Groot Letaba River sub-system stretching down to its confluence with the Klein Letaba River.
- The Klein Letaba River sub-system stretching to its confluence with the Groot Letaba River.
- The Lower Letaba sub-system which stretches from the confluence of the Klein and Groot Letaba Rivers to the confluence with the Olifants River just upstream of the border with Mozambique.

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doi:10.1016/j.pce.2007.07.003

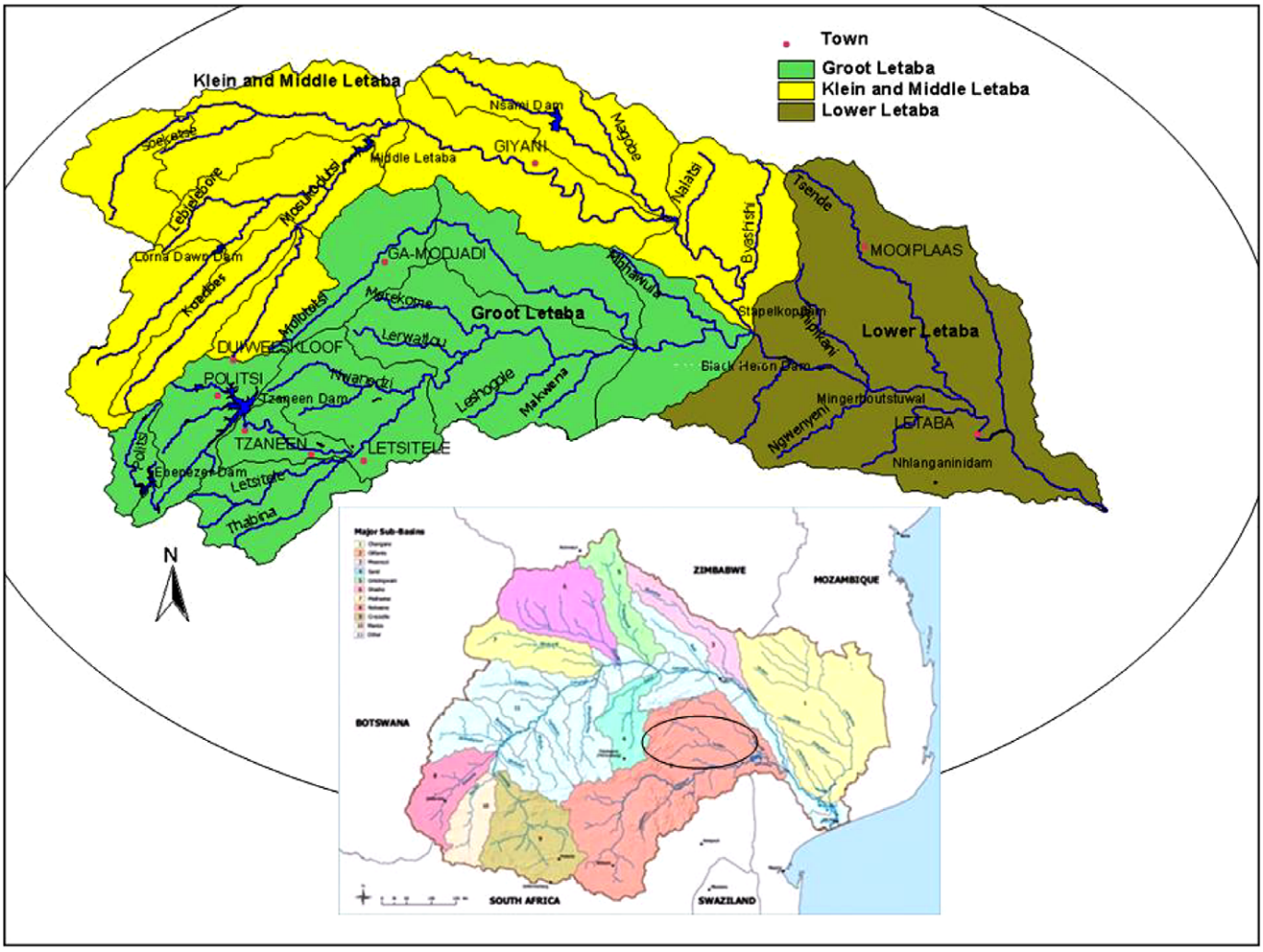

Fig. 1. Letaba River catchment locality map.

The catchment consists of the highland area to the west which is an extension of the Drakensburg Mountains and a low-veld region to the east. Large areas have been planted with commercial forests in the highland area which also receives high rainfall. Intensive irrigation is practised along the Groot Letaba and Letsitele Rivers, on the upper parts of the Klein Letaba River catchment and downstream of the Middle Letaba Dam. Vegetables, citrus and a variety of tropical fruits and nuts are grown in the catchment. Tzaneen and Giyani are the largest urban centres in this area, with some agro-based industries located mainly in Tzaneen. The Kruger National Park in the Lower Letaba covers the eastern part of the catchment up to the border with Mozambique. The catchment has extensive areas under rain fed cultivation. A large number of rural villages are located in the low-lying areas. The population density in the Lowveld is exceptionally high for a rural area. Low population densities occur in the escarpment and mountainous areas with very few people living in the Kruger National Park. Most of the urban population is found in Tzaneen, Nkowakowa and Giyani as the main urban centres (DWAF, 2004b).

Significant spatial variations in climate, water availability, level and nature of economic development and growth are evident in this catchment.

2. Methodology

This paper is based on a study conducted for the Department of Water Affairs and Forestry (DWAF) for the purpose of developing annual operating rules to regulate the availability of water from the Letaba River system in order to reconcile water availability against demands (DWAF, 2006). This involved the application of three modelling systems namely the Water Resources Yield Model (WRYM), the Water Resources Planning Model (WRPM), the Mike Basin and the Water Resources Modelling Platform (WReMP) (Mallory et al., 2005). These models were considered by DWAF to be suitable for the Letaba River system. They are network models which allocate water and perform mass balance calculations at predefined nodes considering resource and user priorities as well as constraints in flow channels. The network programming approach implemented in the WRYM/PM configures

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