Hydrological and hydraulic modelling of the Nyl River floodplain Part 1. Background and hydrological modelling

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Abstract

The Nyl River floodplain is a seasonal wetland of great conservation importance in Limpopo Province, South Africa. Water resource developments in the upstream catchments are changing the quantity and timing of water delivery to the floodplain, and this is expected to have an ecological impact. Hydrological and hydraulic models have been developed to help assess this impact. This paper describes the calibration and application of hydrological models of the contributing catchments. The hydraulic modelling and scenario applications to predict changes to vegetation habitat associated with upstream developments are presented in two companion papers. Hydrological simulations were performed using two models, one using daily time steps and the other using monthly time steps. The models were calibrated using historical data on 10 gauged catchments. Their performance was similar in producing average monthly and annual flows, although the higher resolution daily model agreed more closely with the historical data. Simulated estimates of mean annual runoff values for individual catchments compared well with results from previous studies. The daily model also predicted acceptable measures of probability distributions of maximum annual daily flows and daily flows exceeding a specified threshold.

Keywords: Nylsvley, Nylsvlei, Nyl River floodplain, WRSM2000, wetland, hydrological modelling

Background

The Nyl River floodplain is a seasonal wetland in the semi-arid Limpopo Province in the north of South Africa (Fig. 1). With an area of about 24 250 ha and a length of about 70 km, it is the largest example of a floodplain wetland in South Africa (Rogers and Higgins, 1993). This internationally renowned conservation area incorporates the Nylsvley Nature Reserve, a designated RAMSAR Wetland of International Importance, and is home to more than 420 bird species, including 102 water birds, of which 58 breed on the floodplain. It supports 61% of the breeding population of inland water birds south of the Zambezi and Cunene Rivers, and 92% of Southern African water bird species have been recorded here at some time. Other inhabitants of the river and the floodplain are 70 mammal species, 58 reptile species, 16 fish species and about 10 000 insect species (Tarboton, 1987).

The floodplain owes its existence to the geological characteristics of the region, having formed in a basin created by the Zebediela Fault at its downstream end (Tooth et al., 2001). The basin lies at an altitude of about 1 100 m above sea level, between the Waterberg Mountains to the north-west and the Springbok Flats, a large featureless expanse, to the south-east. In its upper reach the floodplain is confined to the local synclinal basin and is relatively narrow (<1.8 km wide). The river channel gradually decreases in size through the Nylsvley Nature Reserve (Fig. 2), and eventually disappears to form an extensive, flat floodplain at the lower end of the study area. Beyond the Zebediela Fault, the channel reforms as the Mogalakwena River which joins the Limpopo River 250 km further north and ultimately reaches the Indian Ocean.

The floodplain and contributing catchments lie in the summer rainfall region of South Africa. The mean annual rainfall is about 620 mm, usually occurring as thundershowers with a small areal extent, but is highly variable and can range from 250 mm to 1 100 mm within a 15- to 21-year cycle (Tooth et al., 2001). The streams supplying the floodplain with water rise in the Waterberg Mountains on its north-western side, with negligible contribution from the Springbok Flats to the south- east. The main streams are the Groot Nyl, Klein Nyl, Olifantspruit, Middelfonteinspruit, Bad se Loop, Tobiasspruit, Andriesspruit and Dorpspruit (Fig. 1). On average, flows from these streams cause inundation of at least parts of the floodplain in three out of every five years during the summer season between October and April. Only occasionally do the floodwaters persist throughout a year to the following wet season.

Developments in the study area have mainly been increases in the areas irrigated. Over the last 70 years the area of irrigation has increased from about 1.5 km^2 to about 9 km^2 which translates into an increased water demand of about 4 x 10^6 m^3. The catchment with flow-gauge A6H010 on the Bad se Loop tributary shows the largest amount of irrigation and therefore flow entering the Nyl River from this tributary would have decreased over the years accordingly. Also of importance in this regard are the catchments upstream of flow-gauges A6H006 and A6H011 (Klein Nyl and Groot Nyl Rivers respectively).

Increasing water resource development for urban and agricultural use is taking place in the catchments of the contributing streams, and this affects the delivery of water to the floodplain. Because water is one of the fundamental drivers of the ecological functioning of the floodplain, such development must have ecological consequences and these need to be recognised and quantitatively described in development planning. Development directly influences the catchment hydrology through land-use changes and extraction of water from rivers, and hence the quantity and timing of water delivered to the floodplain. The water delivered to the floodplain produces hydraulic conditions such

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