Hydrological and hydraulic modelling of the Nyl River floodplain Part 2: Modelling hydraulic behaviour

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Abstract

Catchment land-use and water resource developments may threaten the ecological integrity of the Nyl River floodplain, a world-renowned conservation area. The effect of developments on the water supply regime to the floodplain can be predicted by hydrological modelling, but assessing their ecological consequences requires transformation of discharge into ecologically-relevant hydraulic characteristics. Studies of Wild Rice (*Oryza longistaminata*) have indicated that the important variables are the extent, depth, duration and timing of flood inundations. One-dimensional hydraulic modelling has been successfully applied to predict these flood characteristics, using a suite of models comprising Quicksurf, RiverCAD, HEC-RAS and HEC-DSSVue. Separate but linked models were developed for three contiguous portions of the large floodplain. The topography was surveyed by airborne laser mapping, and extensive discharge, water level, rainfall, infiltration and evapotranspiration data were collected for model calibration and verification. The models were successfully calibrated through adjustment of Manning's *n* for the main channel and floodplain in each portion, and are able to predict flooding characteristics at a resolution appropriate for ecological interpretation.

Keywords: Nyl River floodplain, Nylsvlei, Nylsvley Nature Reserve, modelling wetland hydraulics, wetland evapotranspiration, floodplain water balance, LIDAR.

Introduction

The Nyl River is situated in the Limpopo Province of South Africa and represents the southernmost tributary of the Mogalakwena River. Along its course, the Nyl River passes through the Nyl River floodplain, known as 'Nylsvlei' (Fig. 1), flanked to the north and west by the Waterberg Mountains, and to the south and east by the Springbok Flats (Fig. 2). The floodplain is a unique and highly biologically productive ecological system (Higgins et al., 1996). Because of its large size and the variety of wildlife it supports, including several Red Data bird species, the area is recognised internationally as an important wetland.

The ecological status of the floodplain is under threat from increasing water resource developments in the upstream catchments, which affect the amount and timing of water delivered to the floodplain. To assist with future water resources planning, the Department of Water Affairs and Forestry (DWAF) commissioned this study in 1996 to develop models for predicting the impacts of upstream development on the flooding regime of the floodplain.

The Hadejia-Nguru wetlands in northern Nigeria were modelled by Thompson and Hollis (1995) using a water balance to predict the effects of upstream dam developments on inundation. A hydrological monthly mass-balance was calibrated using flood extents and applied to determine the economic impact of the dam construction on wetland productivity. Dincer et al. (1987) also used a water balance at a monthly time-scale to predict water depths, inundation areas and outflows from the Okavango Delta in Botswana. The cell-based model was calibrated using observed water levels and used to predict changes in inundated areas and outflows due to changes in inflows and channels of the delta.

Figure 1
Photograph of the upper floodplain (between Middelfontein and the Nylsvley Nature Reserve) looking downstream, with the Deelkraal gauge (A6H002) in the distance (Photo: K Rogers, WITS University)

In the Nylsvlei study, temporal and spatial modelling scales were determined by the nature of the ecological interpretations required from the output, as defined in the next section: 'Model scale and resolution'. Modelling was carried out in two stages. First, hydrological models were used to predict the supply regime to the floodplain (accounting for the effects of land use and water exploitation in the catchments), and then this was transformed into flooding characteristics by hydraulic

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