

# Linking flow, water quality and potential effects on aquatic biota within the Reserve determination process

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## Abstract

Linking the potential effects of altered water quality on aquatic biota, that may result from a change in the flow (discharge) regime, is an essential step in the maintenance of riverine ecological functioning. Determination of the environmental flow requirement of a river (as well as other activities, such as classifying the resource) is known in South Africa as determining the "ecological Reserve". This paper describes the philosophy behind the incorporation of water quality concerns in, as well as the constraints that are likely to be in operation during a Reserve determination. Three simple, predictive tools that have been developed for routine use in ecological Reserve assessments are described in this paper. Flow-concentration modelling can be used to predict the water quality that is likely to result from a given, prescribed flow regime. The Biotic Protocol attempts to provide an assessment of the likely implications of the predicted water quality for aquatic macroinvertebrates. Concentration time-series modelling can be used to rank complex flow scenarios with regard to potential consequences for water quality. Finally, a framework is presented for incorporating predictions of water quality and the implications for the aquatic biota in ecological Reserve assessments.

**Keywords:** rivers, water quality, ecological Reserve, environmental flows, instream flow requirement

## Introduction

The South African National Water Act (No. 36 of 1998), is unusual amongst existing legislation internationally, because it recognises that in order to sustain the goods and services that are provided by rivers (e.g. water, riverine flora, fauna and recreational opportunities) it is necessary to conserve the entire aquatic ecosystem (DWAF, 1999). Protection of the biotic components of the system and maintenance of ecosystem functioning at a given required level entail ensuring that the abiotic aspects (the required amount and variability of flow, water quality, fluvial geomorphology) are also addressed. This is recognised in the National Water Act by the provision of a water quantity "Reserve", which is the amount of water and timing of flow that are required to maintain a given level of ecosystem functioning. The Act also stipulates that a water quality component to the Reserve should also be set which represents the values of physical variables and concentrations of chemical constituents that should not be exceeded in a particular reach of a river. But flow and water quality are intimately linked and if flow is altered, water quality will also frequently change (Gregory and Walling, 1973; Jenkins, 1989; Malan and Day, 2002a). One of the most obvious reasons (but by no means the only one) for this effect is that the dilution capacity of the system is likely to be altered. For example, the dilution capacity will be reduced if the recommended environmental flow requirement (also known in South Africa as the "instream flow requirement" or "IFR") represents a smaller quantity of water than that available at present. If amelioration of point sources of pollution does not occur, the concentration of at least some instream chemical components is likely to increase. Water quality in turn is linked to biotic response, and the provision of water of suitable quality is essential to maintain healthy populations

of aquatic organisms (Smith et al., 1999). Different taxa of, for example, macroinvertebrates or fish exhibit differing tolerances to individual water quality variables (Dallas and Day, 1993). If water quality is altered some taxa may thrive, whereas others, because of the unsuitability of the surrounding medium, may disappear from that stretch of river (Perry et al., 1996). Thus, in order to ensure that the entire ecosystem is conserved, it is necessary when setting the Reserve for a river reach, to be able to predict the effect of a given flow regime on water quality and the implications of the resulting water quality for the aquatic biota.

An ecological Reserve determination, as currently carried out in South Africa, involves assessing the IFR, but the process goes further in that the water resource is classified according to its current ecological state, and the level of protection for which the resource will be managed is determined. In addition, resource quality objectives, or benchmarks, are set for various components of the ecosystem including water quality, geomorphology, riparian vegetation, fish, and macroinvertebrates. There are different levels of Reserve determination ranging from planning estimates, to full-scale comprehensive assessments of the IFR. In terms of the National Water Act, at least a preliminary level of Reserve determination needs to be made for each significant water resource, before licences can be issued for abstraction and for other forms of water use. Full Reserve determinations must also be carried out for all significant water bodies (DWAF, 1999; O'Keeffe, 2000).

Due to excessive abstraction, regulation of flow and release of effluent discharge, increasing demands are being made on many rivers. Thus, it is imperative that the Reserve be assessed and implemented for heavily utilised water resources as soon as possible. Yet, although it has long been recognised that water is a limited and vital resource, the amount of money that can be allocated to the protection and management of that resource is relatively small. In addition, there is often a lack of qualified personnel to manage these assets. Thus any methods that are developed and used in the routine determination and implementation of the Reserve need to be reasonably accurate, but also rapid, simple to use, and inexpensive.

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