A water balance approach to the sustainable management of groundwater in South Africa

KA Wright* and Y Xu
Directorate of Geohydrology, Department of Water Affairs and Forestry, Private Bag X313, Pretoria 0001, South Africa

Abstract

The water balance approach, based on the principles of conservation of mass, is applied to the issue of sustainable groundwater management in South Africa, incorporating the ethos of the National Water Act of 1998, prioritising basic human needs and the needs of aquatic ecosystems over inessential uses. The principle of water balance is described and the benefits (such as prevention of resource misallocation), of applying such an approach to groundwater management, are outlined, with additional practical considerations briefly reviewed. It is hoped that the approach will be tested and refined through application to groundwater case studies.

Introduction

Until recently, groundwater in South Africa has been managed as a separate entity to surface water. Additionally, the status of groundwater as private has led to unsustainable management and subsequent resource degradation, necessitating a new approach.

The new National Water Act (*Government Gazette*, 1998) attempts to redress the problem of past groundwater mismanagement by presenting a number of important policy principles for the guidance of groundwater protection strategies. These include:

- Protection of all significant water resources
- Resource sustainability
- Integrated water resource management (as an ideal).

When applied to groundwater usage, 'sustainability' implies use that does not cause long-term deterioration of the overall resource, in terms of any measurable criteria (e.g. quality and quantity). Although it is uncertain whether this goal can ever be practically achieved, it is recognised that such principles, together with a proactive and adaptable approach to protection, are of paramount importance to successful groundwater management over the long term.

The Act calls for the following resource directed measures (RDMs) for the protection of all significant water resources, including groundwater:

- Resource classification
- Setting of the reserve
- Setting of the resource quality objectives (RQOs).

The concept of the "Reserve" translates as the quantity and quality of water required to satisfy basic human needs for people who are now or who will, in the reasonably near future, be in some way reliant upon the resource (the 'basic human needs' Reserve), in addition to the quantity and quality of water required to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource (the 'ecological' Reserve) (*Government Gazette*, 1998). The reserve is to be calculated for each designated water management area (WMA) of South Africa and water for such high-priority uses will be set aside before allocation to relatively inessential uses is considered. As all water is now recognised as belonging to a larger hydrologic cycle, in a state of continual flux (whereas previously surface and groundwater were treated separately), the determined reserve for each WMA is likely to comprise a surface and groundwater component.

Due to the complexity and spatial heterogeneity of the South African geohydrological system, accurate calculation of the quantity and quality of groundwater sustainably available for use over a large area tends to pose problems. In addition, groundwater may flow between the designated WMAs, emerging to feed surface water or aquatic ecosystems of a different WMA to that from which it originally entered the groundwater system. Planning of the groundwater resource should account for such mechanisms if optimal allocation is the desired goal. Therefore, planning of this component of the overall water resource should occur at a scale at which all water entering and leaving the groundwater system can be accounted for.

The water balance approach is based upon the principle of the conservation of mass and attempts to ensure that chances of misaccounting and subsequent mis-allocation of the water resource are minimised. The approach has been successfully applied to the estimation of recharge, utilising the CRD (cumulative rainfall departure) and SVF (saturated volume fluctuation) methods (Bredenkamp et al., 1995). This paper explores the possibilities of applying the water balance methodology to groundwater management in South Africa and presents an alternative approach to that put forward in Version 1.0 of the *DWAF 1999 RDM for Protection of Water Resources - Groundwater Component* manual (DWAF, 1999).

It may also be worth noting that a user-friendly Excel-based groundwater balancing tool has been produced, with an accompanying users guide (Wright and Xu, 1999). The model allows simple groundwater modelling at the unit scale, with low resolution, and rough estimation of the impact, of allocating quantities (based purely on volumetric criteria at this stage) of groundwater, upon the surface environment, with reference to requirements of overlying aquatic ecosystems.

* To whom all correspondence should be addressed.
☎(012) 338-7867; fax: (012) 328-6397; e-mail: wdc@dwaf.pwv.gov.za
Received 9 June 1999; accepted in revised form 9 February 2000.