ABSTRACT

Water is characterised by both its quantity (availability) and its quality. Salinity, which is one of the major water quality parameters limiting use of a wide range of land and water resources, refers to the total dissolved solutes in water. It is influenced by a combination of several soil-water-salt-plant related processes. In order to develop optimum management schemes for environmental control through relevant hydrological modelling techniques, it is important to identify and understand these processes affecting salinity. Therefore, the various sources and processes controlling salt release and transport from the soil surface through the root zone to groundwater and streams as well as reservoirs are extensively reviewed in this project with subsequent exploration of some hydrosalinity modelling approaches.

The simulation of large and complex hydrological systems, such as these at a catchment scale, requires a flexible and efficient modelling tool to assist in the assessment of the impact of land and water use alternatives on the salt balance. The currently available catchment models offer varying degrees of suitability with respect to modelling hydrological problems, dependent on the model structure and the type of the approach used. The *ACRU* agrohydrological modelling system, with its physically-conceptually based characteristics as well as being a multi-purpose model that is able to operate both as a lumped and distributed model, was found to be suitable for hydrosalinity modelling at a catchment scale through the incorporation of an appropriate hydrosalinity module.

The main aim of this project was to develop, validate and verify a hydrosalinity module for the *ACRU* model. This module is developed in the object-oriented version of *ACRU, viz. ACRU2000,* and it inherits the basic structure and objects of the model. The module involves the interaction of the hydrological processes represented in *ACRU* and salinity related processes. Hence, it is designated as *ACRUSalinity*. In general, the module is developed through extensive review of *ACRU* and hydrosalinity models, followed by conceptualisation and design of objects in the module. It is then written in Java object-oriented programming language. The development of *ACRUSalinity* is based mainly on the interaction between three objects, *viz*. Components, Data and Processes. Component objects in *ACRU2000* represent the physical features in the hydrological system being modelled. Data objects are mainly used to store data or information. The Process objects describe processes that can take place in a

conceptual or real world hydrological system. The Process objects in *ACRUSalinity* are grouped into six packages that conduct:

- the initial salt load determination in subsurface components and a reservoir
- determination of wet atmospheric deposition and salt input from irrigation water
- subsurface salt balance, salt generation and salt movement
- surface flow salt balance and salt movement
- reservoir salt budgeting and salt routing and
- channel-reach salt balancing and, in the case of distributed hydrosalinity modelling, salt transfer between sub-catchments.

The second aim of the project was the validation and verification of the module. Code validation was undertaken through mass balance computations while verification of the module was through comparison of simulated streamflow salinity against observed values as recorded at gauging weir U1H005 which drains the Upper Mkomazi Catchment in KwaZulu-Natal, South Africa. Results from a graphical and statistical analysis of observed and simulated values have shown that the simulated streamflow salinity values mimic the observed values remarkably well. As part of the module development and validation, sensitivity analysis of the major input parameters of *ACRUSalinity* was also conducted. This is then followed by a case study that demonstrates some potential applications of the module. In general, results from the module evaluation have indicated that *ACRUSalinity* can be used to provide a reasonable first order approximation in various hydrosalinity studies.

Most of the major sources and controlling factors of salinity are accommodated in the *ACRUSalinity* module which was developed in this project. However, for a more accurate and a better performance of the module in diversified catchments, further research needs to be conducted to account for the impact of salt loading from certain sources and to derive the value of some input parameters to the new module. The research needs include incorporation in the module of the impact of salt loading from fertilizer applications as well as from urban and industrial effluents. Similarly, further research needs to be undertaken to facilitate the module's conducting salt routing at sub-daily time step and to account for the impact of bypass flows in heavy soils on the surface and subsurface salt balances.