EXECUTIVE SUMMARY

INTRODUCTION

Background to the study

The National Water Act (NWA) prescribes the minimum components of a catchment management strategy and prime amongst these are the formulation of water allocation principles and a Water Allocation Plan for each Water Management Area. This Project was proposed to focus on a very particular part of the allocation challenge, namely the allocation of "Water Quality Use". Intuitively, allocation may be associated with water quantity, but a significant innovation of the NWA is that it defines "water use" very broadly - amongst others to include the use of the resource to dispose of waste. The complexity of point and non-point delivery and transport processes that determine the water quality constituent loads in a catchment, the relatively poor water quality databases and the role that statutory Resource Quality Objectives are required to play in water resource management (WRM) (Section 13 of the NWA) all indicated that a focused research effort was required to unpack the conceptual and technical components of the water quality part of the allocation challenge.

An objective of the project was to effect a process of "learning-by-doing" by applying the framework in a stressed catchment with water quality concerns. For this purpose, the ACRU*salinity* model was applied to the Berg River catchment because it also offered a ready-made water quality information system (WQIS) previously developed under a Water Research Commission (WRC) Project. However, resolving technical problems during the ACRU modelling phase expended most of the project resources and the team had to forgo the critical testing of the water quality use allocation framework.

Aims of the project

The project objectives as formulated in the Agreement with the Water Research Commission, were:

- Develop a conceptual framework for water quality use allocation procedures, and
- Develop and disseminate Technical Guidelines for water quality use allocation procedures.

Research outputs

The research outputs from this project were two reports:

- Rossouw, J.N., Kamish, W. and Görgens, A.H.M. (2007). *Technical Instruments to Support Water Quality Use Allocation.* WRC Report No. K5/1301/1/07, Water Research Commission, Pretoria. **(This report)**
- Kamish, W., Rossouw, J.N., Görgens, A.H.M. and Clark, F. (2007). *Improvements to the ACRUsalinity model and upgrading of the Berg River Water Quality Information System.* WRC Report No. K5/1301/2/07, Water Research Commission, Pretoria.

REVIEW OF INTERNATIONAL BEST PRACTICE IN WATER QUALITY USE ALLOCATION

Objective

The conceptual review of international best practice in water quality use allocation procedures focused on reviewing the approaches and technical support required to implement these in the USA, European Union, and in Australia.

Australia

Australia is a commonwealth of states; the Commonwealth sets strategies and policies at a national level, and the state and territory governments develop implementation strategies and policies at state level to meet national goals and objectives.

A number of initiatives were reviewed:

- The National Water Quality Management Strategy that consisted of three key elements, namely policies, processes, and guidelines for water quality management,
- The National Action Plan for Salinity and Water Quality that was specifically developed to address severe salinity problems. Implementation of this strategy in the Murray-Darling Basin was specifically reviewed, and
- Use of market-based instruments in water quality management - the Hunter River Salinity Trading Scheme that was an example of trading salinity discharge allocations.

United States of America

Water quality management in the USA is rooted in the Clean Water Act. One of the provisions of the Act required all states to identify their impaired streams and to develop and implement Total Maximum Daily Loads (TMDLs) for those streams to halt and restore it to an unimpaired state. The TMDL process was reviewed to understand the key elements of the programme.

It was recognised that the core of a TMDL is usually a model that estimates the relationships between the water body, the pollutant sources, and/or the alternatives for loading reduction. Better water quality modelling was identified as among the most significant of all the TMDL-related scientific needs and five aspects were identified that needed urgent attention:

- Applied modelling technical support
- Development of models of appropriate complexity
- Filling gaps in model application
- Public domain model acceptance
- Training in modelling

A further recommendation was that better guidance should be given to the development of allocations and methods to translate allocations into implementable control actions.

It was concluded that the TMDL approach appeared to have a lot in common with the Resource Quality Objectives approach described in the South African National Water Act.

European Union

Water legislation aimed at ensuring water of an acceptable quality in the European Union (EU) is accomplished through the issuing of directives which member states have to comply with. Examples of directives dealing with water quality issues include (European Commission, 2003):

- Water Framework Directive (2000/60/EC)
- Urban Waste Water Treatment Directive (91/271/EEC)
- Discharges of Dangerous Substances Directive (76/464/EEC)
- Nitrates Directive (91/676/EEC)
- Drinking Water Directive (98/83/EC)

The Water Framework Directive was reviewed. The directive requires the setting of water quality objectives to meet, as a minimum, a good environmental status for EU Rivers. The directive required the signatories to comply by December 2003 and not much information could be obtained about how the total load on a system would be allocated to individual contributors. The administrative procedures to implement river basin management were largely left to the discretion of Member States.

In Denmark, for example, models are used to support integrated river basin management. Models are widely used by water authorities and these vary from very simple empirical models, up to fully dynamic models of lakes, rivers, groundwater and estuaries). For example, *empirical models* are used to make high-level decisions about the potential benefits of restoration projects. *Dynamic water quality models* are widely used in Danish water administration, in particular for water level or flood prediction applications that also require water quality assessments. Dynamic models are generally used to investigate specific water quality issues such measures to mitigate diffuse pollution and in-river nutrient retention. Empirical models are used as a first order estimate to short-list viable management options at coarser spatial scale and dynamic models are then used to assess specific management interventions, often at a finer spatial scale.

Common elements in international best practice of water quality use allocation

There were a number of common elements in the international approaches that were reviewed:

- Water quality standards or management objectives – water quality standards or water quality management objectives served as the departure point for allocating constituent loads that would not infringe on those targets.
- Identification of impaired water bodies – in many approaches the identification of impaired rivers or river reaches acted as the catalyst for specific actions. The level of impairment often dictated the level of effort expended or resources allocated to restore the impaired water body.
- Load allocations estimated at large scale to meet standards or targets – water quality targets were often set as end of catchment targets and total load allocations were then determined to meet those targets without necessarily apportioning the loads to specific contributors.
- Upstream/downstream dependencies taken into account – in

setting end of catchment, upstream/downstream dependencies were often taken into account because the targets may restrict certain upstream activities in order to protect the water quality of certain downstream users.

- Procedures supported by models with appropriate levels of complexity – models of differing complexity support the process. It appears that coarse scale models support the process of setting end of catchment while more complex models are used when considering management actions at a smaller geographic scale.

SOUTH AFRICAN WATER RESOURCE POLICIES THAT HAVE A BEARING ON WATER QUALITY USE ALLOCATION

The process of water resources management

The process of water resources management described in the National Water Act was reviewed. The class and resource quality objectives for a water resource provides the foundation for making decisions about the allocation of water and the allocation of allocatable water quality for the discharge of water containing waste.

Water quality component of a catchment management strategy

The Department developed a set of guidelines for the development of the water quality component of a catchment management strategy. A Water Quality Use Allocation Plan will be developed as part of a catchment water quality management strategy. This strategy sets the goals for water quality management in a catchment. The National Water Resource Classification System provides the *resource quality objectives* (RQOs) for a water resource. *Resource water quality objectives* (RWQOs) are derived from these, taking into account the requirements of users and use of the resource to dispose of water containing waste. This forms the foundation for determining the *source management objectives* (SMOs). The next step is to decide how SMOs will be managed across a water management area by formulating a *water quality management framework-plan.* A Water Quality Allocation Plan is one of the components of such a framework-plan.

Water allocation planning

The framework for water allocation planning was designed to address three broad scenarios:

- Catchments where water is freely available for the foreseeable future
- Catchments which are exhibiting some signs of stress and where licence applications may exceed the remaining available resources
- The compulsory licensing situation, i.e. closed or soon to be closed catchments

The complexity of the allocation process, and supporting technical tools, increased as the level of stress increased. The processes clearly point towards a two-tiered approach to water allocation in those cases where compulsory licences are required; the first tier being undertaken at a strategic level and focusing on water use sectors, and the second tier focusing on individual users and local impacts.

Source management

The document, *Source Management in South Africa* provides a detailed description of the development of a Source Management Plan (SMP) at a regional/Catchment Management Agency (CMA) level. It describes the steps that should be followed to develop a SMP and provides a guide for selecting the most appropriate source management instrument for different sectors.

Resource directed management of water quality

The document, *Resource Directed Management of Water Quality*, provided a guideline which describes a practical, consistent approach to the determination of RWQOs, by integrating the results of Catchment Vision, Resource Classification and Reserve, and water user requirements to develop RWQOs. It also provides definitions and practical tools for deriving RWQOs for different levels of water quality stress in a catchment.

National Water Resource Classification System

A National Water Resource Classification System (NWRCS) was still under development at the time of preparing this report. However, some of the concepts that were emerging from the development were used to inform the development of a water quality allocation framework. It transpired that the need to take upstream/downstream dependence into account and the need to evaluate alternative scenarios could only be addressed if simple, strategic level analytical tools or models were available to support decision making in the classification process.

CONCEPTUAL FRAMEWORK FOR WATER QUALITY USE ALLOCATION PROCEDURES

Guiding principles

The *technical components* of a Water Quality Use Allocation plan should be guided by the following principles:

- Precautionary principle approach
- Integrated and holistic approach
- Due consideration given to alternative options
- Carrying capacity
- Equity and fairness
- Simplicity

Principles that have more to do with the *process* being followed were briefly described in the main report.

Regulatory environment

The sections of the National Water Act that have a bearing on water quality use allocation planning were reviewed to determine the statutory requirements of the Act.

Technical support for water quality use allocation

The degree of technical support for Water Quality Use Allocation was dependent on the degree of water quality stress in the catchment. Three scenarios are envisaged:

- a water quality unstressed situation (i.e. water quality is still ideal to acceptable)
- a potentially water quality stressed situation (i.e. water

quality is tolerable but approaching a poor, status)
- A water quality stressed situation (i.e. water quality is poor)

In a **water quality unstressed** situation, simple tools can be used to support the water quality use allocation process. These tools could entail an inventory of the sources and their loads, per water resource management area, combined with simple mass balance models with conservative assumptions that could be used to allocate loads to individual sources, and to verify if source management objectives and resource water quality objectives were not exceeded.

In a **potentially water quality stressed** situation, the technical support required would be more complex. Allocation scenarios need to be considered at a coarse catchment scale in order to consider upstream/downstream dependencies and impacts. This would entail a simple coarse scale catchment model (no smaller than quaternary catchment scale) and a temporal scale that is equivalent to the water resource planning models commonly used in South Africa. The model needs to accommodate loads from point as well as non-point sources and the models should be calibrated against observed water quality data.

In a **water quality stressed situation**, two tiers of support are required:

- *First tier support* - a simple coarse scale catchment water quality model as described above. The coarse scale catchment model should be set up for the whole catchment.
- *Second tier support* - a finer scale model, set up for complex and problematic sub-catchments or river reaches. The fine scale model would only be set up for specific areas (quaternaries or river reaches) where disaggregation of loads to individual users, or site specific estimates of the water quality impacts, are required. The model would be more deterministic and typically focus on non-conservative substances. The temporal scale would be daily or sub-daily.

Technical Guidelines for water quality use allocation

The following guidelines were proposed to support water quality use allocation:

- **Focus on water quality variables of concern** - water quality use allocation and the tools designed to support the process should focus on the water quality variables of concern.
- **Two tiers of modelling support** - in order to promote efficiency, two tiers of decision support should be applied to water quality load allocations. The decision whether only the first tier or both tiers are appropriate should be based on the level of water quality stress in the catchment or in specific water resource management units. In an unstressed and potentially water quality stressed situation, coarse scale tools would be appropriate to allocate loads to sectors. In a water quality stressed situation, coarse scale tools should be used for allocating loads to sectors within sub-catchments, and finer scale models should be used in

complex sub-catchments to disaggregate the sector allocations to individual users.

- **Link to water resource planning tools** - the coarse scale models should be compatible with water resource planning models, in terms of its spatial and temporal scale.
- **Application of good modelling practices** - modelling and data preparation procedures should be consistent with good modelling practices.
- **Rapid scenario development and evaluation** - the water quality allocation support tools should facilitate the rapid development and evaluation of waste load allocation scenarios.
- **User-friendly model outputs and stakeholder communication** - the tools to support water quality use allocation are technically quite complex and the tools being used should be selected not only according to their ability to produce user-friendly output which the water quality modeller can interpret but also according to their ability to produce output that can be used in interactions with institutional stakeholders.

CONCLUSIONS AND RECOMMENDATIONS

Water quality use allocation framework

The degree of technical support for water quality use allocation is dependent on the degree of water quality stress in a catchment and sub-catchment. The need for higher confidence decision-making increases as the degree of water quality stress increases and the complexity of technical support tools need to mirror this. In a water quality unstressed catchment, simple management oriented tools would be sufficient. However, in a potentially water quality stressed catchment; a coarse catchment scale water quality model would be required. In a water quality stressed catchment, a coarse catchment scale water quality model is required for sector level allocations, and a fine scale river reach or reservoir model is required to support individual allocation decisions at a fine spatial scale.

This approach is aligned with policies that seek to find pragmatic solutions to water quality management and only increases the complexity of the decision-making process and support tools when the situation in the catchment justifies it.

Recommendations

The following research needs have been identified to support water quality use allocation:

Modelling research needs – there is a need for a simple, catchment scale model that can be used for the first tier of water quality use allocations. Such public-domain models should interface with water resource planning models so that the water quality modelling can use the flow simulations that would form the basis of the Water Use Allocation Planning process. There is specifically a need for credible catchment scale models that can simulate nutrients and microbial water quality (non-conservative constituents).

Allocation of loads to individual sources – there is a wide range of methods for allocating constituent loads to individual dischargers. There is a need to investigate which of the methods is appropriate to South Africa given the primary objectives of equity and sustainability embedded in the National Water Act.

Appropriate export coefficients – there is a need to develop export coefficients and/or loading functions for different South African land-uses in order to estimate coarse scale non-point source pollution loads at a quaternary catchment scale. Despite the advances in research on complex physically based models for nutrient transport, the export coefficients approach still plays an important role in regional and catchment scale management.

Uncertainty analysis – there is a need to incorporate uncertainty analysis into the water use allocation process. Decisions would often be taken in a data sparse environment. There is a need to build uncertainty analysis into the modelling processes that would account for the uncertainty or inherent errors in the data and model calculations.