EXECUTIVE SUMMARY

The implementation design phase of the National Aquatic Ecosystem Biomonitoring Programme (NAEBP) was initiated in August 1997. This programme, subsequently renamed the River Health Programme (RHP), consists of four portfolios, one of which is research and development. The overall objective of the RHP is to develop the procedures and infrastructures for implementation and ongoing maintenance of biomonitoring on a national scale. Within the research and development component, attention has focused on establishing a protocol for the derivation of ecological reference conditions for riverine macroinvertebrates. Macroinvertebrates form one of the main components of the RHP and are the basis for the rapid bioassessment (RBA) technique, SASS4 (South African Scoring System, Version 4), which is used extensively in South Africa for the biomonitoring of rivers. The need for an established benchmark or reference condition with which monitoring information can be compared, has been expressed on several occasions by organisations involved in biomonitoring. Interpretation of biomonitoring data in relation to reference conditions enable the degree of degradation or deviation from natural conditions to be ascertained.

This report focuses on the establishment of a protocol for the derivation of ecological reference conditions for riverine macroinvertebrates and is the last in a series of reports related to such reference conditions. Other reports emanating from this project include:

- Delineation of river types for rivers of Mpumalanga, South Africa: the establishment of a spatial framework for selection of reference sites (Dallas & Fowler 2000),
- Ecological Reference Condition Project: Field-manual. Volume 1: General Information, Catchment Condition, Invertebrates and Water Chemistry (Dallas 2000), and
- A Rivers Database and User Manual (Fowler, Dallas & Janssens 2000).

This study was conducted in Mpumalanga with the field assistance of local biomonitoring practitioners. The report is divided into six chapters. The first comprises a description of ecological reference conditions, providing details on the advantages of using macroinvertebrates for biomonitoring. It provides a synthesis of current approaches for deriving ecological reference conditions for riverine macroinvertebrates, and describes the hierarchical spatial classification of rivers, henceforth termed the "spatial framework" used for delineating homogeneous regions.

Chapter two describes the process of selecting reference sites and preliminary site screening or ground-truthing. The sites selected in Mpumalanga are tabulated together with descriptions of their regional characteristics. Chapter 3 outlines the data collected, giving details of the importance of each component in characterising a site, and assisting in the derivation of reference conditions and data interpretation. Technical considerations for sampling riverine macroinvertebrates using SASS, including biotope and seasonal variability, habitat assessment, taxonomic resolution and the use of SASS in non-perennial systems is discussed. Environmental variables for future predictive systems are identified.

Chapter 4 represents the bulk of the report and provides details of data analysis performed and the results obtained. The main aims of this chapter were to classify reference sites on the basis of invertebrate data, to compare the resultant clustering of sites into Reference Groups (i.e. groups of reference sites with similar invertebrate communities as determine by multivariate analysis) with *a priori* grouping of sites based on the spatial classification (i.e. ecoregion and sub-regional grouping), to identify the environmental variables which best discriminated between Reference Groups, and to examine the influence of biotope availability and sampling season.

Each reference site was characterised in terms of its ecoregion and sub-region membership, and environmental features. Reference sites were classified on the basis of composite reference communities (i.e. with invertebrate data combined from three seasons and all available biotopes). The spatial framework was examined by comparing Reference Groups derived from multivariate analysis of invertebrate communities with the spatial framework for Mpumalanga. The Reference Groups were generally comparable to level 1 ecoregions, with level 2 sub-regions and level 3 river types varying in their level of importance depending on the particular Reference Group. Three Reference and two sub-group were derived from the reference sites located within the Central Highlands, Great Escarpment Mountains and Lowveld ecoregions.

Environmental variables were identified which best discriminated between Reference Groups. These variables were used to characterise each of the Reference Groups in terms of catchment, site, habitat and water chemistry variables. Enormous potential exists for developing predictive modelling systems which enable the prediction of invertebrate taxa on the basis of selected environmental variables.

Comparing SASS Scores or invertebrate communities from sites, with different biotopes available or which have been sampled in different seasons, may lead to erroneous interpretation with respect to water quality or river health. This aspect has been examined by comparing separate- versus combined-biotope sampling. Biotope availability significantly affected SASS Scores which varied amongst biotope-groups, and certain taxa were more commonly recorded in one or another biotope-group. Seasonal variation in invertebrate communities and SASS Scores was examined and again both SASS4 Scores and number of taxa differed significantly between seasons. Of the three indices, namely SASS4 Score, number of taxa and Average Score Per Taxon (ASPT), ASPT proved to be the most robust and least variable with respect to both biotope availability and season. It is therefore important that ASPT be used in data interpretation.

Ecological reference conditions for three Reference Groups and two sub-groups in Mpumalanga have been described in chapter five. Note, groups have been differentiated into Reference Groups and sub-groups because of the number of representative sites and the uncertainties associated with sub-group membership. Reference Groups are represented by nine or more reference sites and the level of confidence of such groups is high. Sub-groups are represented by five or less sites and the level of confidence is low and group membership therefore requires validation. A key has been formulated for allocating a monitoring site to a Reference Group or sub-group and a biological banding system has been developed to assist with the interpretation of SASS data. Each Reference Group or sub-group is characterised in terms of the expected environmental variables, the expected SASS Scores and the

expected SASS taxa. Biotope considerations and preliminary tables for factoring in biotope availability are also given for each.

Lastly, a list of recommendations is provided. These include the following:

1. The biomonitoring protocol needs to be standardised and adhered to by all SASS practitioners. It is recommended that the Reference Condition manual is used (Dallas 2000). A second version of this manual is planned which takes into account comments from biomonitoring practitioners and knowledge gained as a result of this report. This modified version will be available via the River Health Programme web-site (www.csir.co.za/rhp).

2. Biomonitoring practitioners need to be informed of the importance of correctly assessing a site and ensuring that all peripheral information is assessed. Quality is important.

3. Biomonitoring practitioners need to be made aware of the limitations of SASS and when and where it is not suitable for use, e.g. in canalised rivers with few, if any, biotopes, and in non-perennial systems or wetlands.

4. The issue of sampling biotopes separately needs to be discussed, and standardised. The results of this study clearly show the importance of sampling biotopes separately and the misinterpretation of data that may result through differences in the availability of biotopes. It is recommended that the three biotope-groups discussed in this document are sampled separately. Data should be examined to assess the effect of biotope availability on invertebrate communities and SASS Scores.

5. The Invertebrate Habitat Assessment System (IHAS) needs to be thoroughly tested so that its usefulness as an interpretative tool for SASS may be assessed.

6. During the initial establishment and monitoring of reference sites, it is recommended that sampling is conducted in at least three seasons and that site classification is based on the combined data.

7. The development of a prediction-based modelling system, similar to that of AusRivAs, is strongly recommended. The complexity of invertebrate communities and the uncertainty related to the measurement of them, make deriving sound reference conditions, in the absence of modelling, difficult. By ensuring that all biomonitoring practitioners adhere to the standard sampling protocol, which includes the collection of a subset of environmental variables and separate biotope-group sampling, we will be ensured of an extensive and useful data-set in the future. The vehicle for data storage has already been developed (Rivers Database, Fowler *et al*. 2000). In the long term, it should be possible to develop a series of models based on the RHP data which will automate the allocation of a monitoring site to its appropriate Reference Group, calculate the expected probabilities of each taxon occurring at the monitoring site, calculate the Observed/Expected ratios and thereby generate information on the extent to which the monitoring site has deviated from the expected reference condition. This will greatly simplify data interpretation and reporting on the river health of a

monitoring site or series of monitoring.

8. Biomonitoring practitioners, researchers, consultants and all individuals and organisations likely to participate in the RHP, should be encouraged to develop reference conditions for their region, and to validate components of the RHP such as the spatial framework and the IHAS.

9. Once reference sites have been identified within a region, and reference conditions based on these sites have been derived, annual assessments of the reference sites need to be conducted. In the case of Mpumalanga, it seems that routine monitoring of all reference sites would best be undertaken in spring. In this way changes in the condition of the reference site can be picked up, and the site excluded from future monitoring if it has become impacted. An understanding of the "natural" or expected annual variability in the various components will also be measured.

10. At least one (preferably more) reference site of each type should be included in some formally conserved area or at least afforded some protection. This task could fall to the Catchment Management Agencies.

11. Lastly, whilst SASS has proved to be a useful tool for monitoring water quality and general river health, it should not be a stagnant technique. As our biomonitoring database increases, so does our potential to test and validate the sensitivity/tolerance scores. Other aspects, such as incorporating an abundance rating in the score calculations, are often raised by biomonitoring practitioners. These need to be addressed. SASS is fundamental to the RHP and it also forms one of the key tools used in generating aquatic invertebrate information for the Rapid, Intermediate and Comprehensive Ecological Reserve for Rivers. For this reason, it needs to maintain a solid scientific basis.

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