STRATEGIC OVERVIEW OF THE RESEARCH NEEDS FOR WETLAND HEALTH AND INTEGRITY

Prepared on behalf of the
Water Research Commission

by

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STRATEGIC OVERVIEW OF THE RESEARCH NEEDS
REGARDING WETLAND HEALTH AND INTEGRITY

EXECUTIVE SUMMARY

This report documents the findings of a strategic overview of the research needs for wetland health and integrity, and presents the terms of reference (TOR) for a research programme to address those needs. It describes why tools to assess the ecological condition and to assess the socio-economic importance of wetlands are central to effective conservation and management of these systems. The process that was followed to identify the research needs is described. Gaps in the understanding of wetland ecology, functioning, management and outstanding policy issues that were identified during the overview are highlighted. Reports on conferences attended, or workshops held, are provided as appendices to the main document.

Rationale

Until recently, wetlands in South Africa have been neglected in terms of research and monitoring. There is, however, a growing recognition of their importance in the hydrological cycle, substantiated by the protection these systems are now afforded under the National Water Act (1998). For effective implementation of the National Water Act, but also for a wider range of activities such as conservation planning and management, it is important that the ecological condition (also referred to as the ecological "health" or integrity) of a given wetland be ascertained. In South Africa although the techniques for rivers are well established, in the case of wetlands there is currently no definitive, well-developed method, or suite of methods, for assessing ecological health.

There is also growing recognition of the important "goods and services" provided by wetlands and the critical role they play. In many areas of the country, sectors of the population are directly dependent on wetlands for subsistence use. At the same time, there is demand for resources such as water and land which are becoming increasing scarce. There is a great need for tools that will help place a value (monetary or otherwise) on the benefits wetlands supply to the people living around them. Thus, to be able to make rational decisions concerning the management of wetlands themselves, in addition to development in the surrounding catchments, we need to be able to assess the social importance as well as the economic benefits that are (or potentially could be generated) from a wetland.

The approach taken

A summary of the approach that was taken to prepare this strategic overview is shown in Table 1. At the same time that this strategic review was initiated, a literature review was commissioned by

DWAF, focussing to a large extent on biotic indices that can be used to assess wetland condition. The literature review (DWAF 2004), titled "*Development of a framework for the assessment of wetland ecological integrity in South Africa. Phase 1: Situation Analysis,"* was compiled by Dr Mandy Uys (Laughing Waters, East London, *pers. comm*. Sept 2004). Complementing the literature review, a bibliography was produced (Malan, Day and Marr, 2005) to provide a list of relevant sources on all aspects of wetland assessment. Considerable use was made of the recommendations given in DWAF (2004) in drawing up the TOR for the proposed research programme.

Table 1: A summary of the process followed during the strategic overview.

Step	Action taken	Product
1	Perusal of the literature (including DWAF 2004) and preparation of an annotated bibliography on wetland assessment methods.	Malan *et al. (2005*)
2	Communication with South African and SADC wetland scientists via various e-mail listservers informing them of the strategic overview.	
3	Consultation with individual wetland specialists.	Inclusion of suggestions and comments in this document.
4	Attendance of Malan and Day at Intecol conference, Utrecht.	This document (Appendix A)
5	A workshop held at the WATERNET/WARFSA conference, Namibia.	This document (Appendix B)
6	Attendance of Malan at the SAWAG meeting, Lake St Lucia.	Interviews with wetland scientists, identification of current initiatives.
7	A two-day joint DWAF-WRC workshop on assessment of ecological condition and socio-economic importance.	This document (Appendix C)
8	An analysis of wetland assessment needs, the tools currently available, and the research/development gaps. Circulation of the analysis to wetland scientists for comment.	This document (Table 3)
10	Synthesis of information from all the above steps into a TOR for the Research Programme on Wetland Health and Integrity.	This document (Chapter 3)

The proposed terms of reference for the Wetland Health and Integrity Research Programme

Aims

The proposed aims of the research programme on wetland health and integrity are:

1. to develop tools for assessing wetland ecological condition that will address the major needs of the users in South Africa, including DWAF, DEAT, and conservation bodies
2. to develop tools for assessing wetland socio-economic importance, that will begin to satisfy the needs of users in South Africa
3. to facilitate integration of current initiatives in wetland research in South Africa, and in the SADC region
4. to begin to address some of the gaps in wetland science and in the understanding of wetland functioning in this country.

Scope of the research programme

The Wetland Health and Integrity Research Programme will be directed towards *palustrine wetlands* and is expected to extend over a period of three years.

The Terms of Reference

A summary of the proposed Terms of Reference (TOR) is presented in Table 4. The following general comments apply.

- Wetlands in this country have been considerably neglected in terms of research (both basic and applied) and in terms of monitoring. Because of monetary constraints, however, the envisaged deliverables have had to be rated in terms of their considered priority. All deliverables of high priority and most of those considered to be of medium priority have been included.
- Because of the heterogeneity of wetlands (in terms of types and between ecoregions), it is envisaged that there will be a suite of assessment tools, not all of which will be applicable under all situations.
- Knowledge of most aspects of wetland biota is limited, thus development of indices of ecological condition will further fundamental research and lead to a more comprehensive understanding of the ecology of wetland systems.

Table 4. A summary of the deliverables for the Research Program on wetland health and integrity (WHI).

	DELIVERABLE	**PRIORITY**	**TIME FRAME**
1	A **scoping study** of investigations in South Africa to value the "goods and services" supplied by wetlands.	High	Year 1
2	Testing of existing assessment tools within an Intermediate or Comprehensive wetland **Reserve determination study**. The tools would include Wet-Ecoservices (Wetland-Assess), Wet-Health, the EIS method of Kleynhans, and the soil-moisture/macrophyte distribution assessment method. Production of protocols for assessing ecological condition and socio-economic importance as required for RDM.	High	Year 1 - 2
3	Testing of the **usefulness of Wet-Ecoservices as a basis for rapid valuation** of the "goods and services" supplied by wetlands (link with 2 and 12).	High	Year 1
4	Development of a **biotic index based on macrophytes** (including consolidation of the existing records of wetland plant species).	High	Year 1 - 3
5	Development of a **biotic index based on diatoms**.	Medium	Year 1
6	Investigation into the feasibility of a **biotic index based on invertebrates** (including micro-crustaceans).	Medium	Year 1-2
7	Investigation into the feasibility of biotic metrics for use in wetlands during **dry conditions**.	Medium	Year 2 - 3
8	Development of a method to assess the cumulative impact of wetland loss at the **landscape level**.	Medium	Year 1- 2
9	Development of metrics to assess: i) **ecological sustainability** ii) **social sustainability** iii) **economic sustainability** of wetland use.	Medium	Year 2 - 3
10	Development of a metric to assess **socio-economic dependency** of communities on a given wetland.	Medium	Year 2 - 3
11	Desk-top investigation of the effect of rehabilitation on **vectors of disease.**	High	Year 2 - 3
12	**Joint application of ecological assessment tools and socio-economic tools** to key wetland areas (preferentially at SAEON nodes).	High	Year 2 - 3
13	A protocol of the steps to be followed and the methods/tools to be used when undertaking **a resource-economics** study of wetlands.	High	Year 3
14	Based on the above, a **communication package for local authorities** to advise on valuing the benefits of wetlands in their area.	High	Year 3
15	An integrated **framework of wetland inventory, assessment and monitoring**, and a national database.	High	As soon as possible
16	A **communication strategy** for the WHI Research Programme, including standardised reporting of ecological condition and socio-economic importance.		Year 1 - 3

- Several tools for assessing wetland condition or importance have already been developed, but require modification to a greater or lesser extent. Even for tools that have not yet been developed these should not be developed *a priori* but adapted, where possible, from existing national and international approaches.

Other gaps in wetland science in South Africa

The following key research and development needs (other than those in the field of assessment) were identified during the course of this strategic overview.

- The effect of land tenure (and changes therein) on the wise use and conservation of wetlands urgently needs to be investigated. This should link with work carried out under the "Wetland rehabilitation research programme" on the responsibilities/accountability of landowners with regard to wetland management.
- Indigenous knowledge of wetland functioning, benefits and wise use needs to be evaluated and preserved.
- A research project is required to assess the effectiveness of wetland conservation in this country.
- Allied to the above is the need to review the existing laws and policy regarding wetlands, to establish if these are adequate, and the extent to which they are, or are not, being implemented.
- Further basic research needs to be carried out on the organisms that are present in wetlands. This should include studies on their life-histories, identification and distribution with regard to different wetland types and ecoregions. In addition, long-term environmental data should be collected at key wetland sites (e.g. at SAEON nodes).
- A national assessment of the total economic value of the wetlands in the country is a potentially useful initiative. Caution would be needed in this exercise because of the difficulty of valuing intangible benefits and the heterogeneity of South African wetlands.
- A strategy needs to be drawn up to ensure a systematic approach to the conservation of wetlands in South Africa.
- Fairly simple hydrological/hydraulic modelling software is required for use in individual wetlands.
- Further research into the links between surface and groundwater is required. Knowledge is also needed about the sources of water supplying wetlands in different areas, and for different wetland types.

Conclusion

The actions that need to be taken to achieve the aims of the Wetland Health and Integrity Research Programme have been presented in this overview. Unfortunately, because of the legacy of neglect with regard to research and management of these aquatic resources, much work needs

to be done. Although the proposed actions should go a long way towards enhancing conservation and management of wetlands, not everything could be covered and many areas still need attention. Nevertheless, this research programme should lay down the important preliminary groundwork. It is hoped that the TOR represents a structured "action plan" and will focus attention in a rational way towards the areas that are most urgently required. We hope that research initiatives other than the proposed WHI programme can also be integrated and directed along the same paths so that the common goal of achieving maximum benefit from, and conservation of, wetlands is achieved.

STRATEGIC OVERVIEW OF THE RESEARCH NEEDS FOR WETLAND HEALTH AND INTEGRITY

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ACKNOWLEDGEMENTS

The project team would like to thank the many people who contributed to this project, both in South Africa and in the other SADC countries. Many people attended the workshops, gave up time to be interviewed or submitted comments and suggestions by email. We would especially like to thank Mr Bonani Madikizela (DWAF) and Dr Mandy Uys (Laughing Waters) for allowing us to make use of the seminal work carried out by them on wetland ecological assessment. This provided an admirable platform on which to base this study. Many thanks also to the Water Research Commission for funding this project. We sincerely hope that this overview will provide the Terms of Reference necessary for a successful research programme in wetland assessment methods, and that this will in turn contribute to the conservation of South Africa's wetlands.

ABBREVIATIONS

DEAT – Department of Environmental Affairs and Tourism
DWAF – Department of Water affairs and Forestry
EIS – ecological importance and sensitivity
NDA – National Department of Agriculture
PES – present ecological state
RDM – resource directed measures
REC – recommended ecological class
RC – reference condition
SADC – Southern African Development Community
SAEON – South African Environmental Observation Network
SANBI – South African National Biodiversity Institute
SASS – South African scoring system
SAWAG – South African Wetland Action Group
TOR – Terms of reference
WHI – Wetland health and integrity (Research Programme)
Wet-HAT – Wetland Health Assessment Technique (renamed Wet-Health)
WIAM – wetland inventory, assessment and monitoring
WRC – Water Research Commission

CHAPTER 1: INTRODUCTION

1.1 The Wetland Research Programme

A collaborative interagency programme to address the shortfalls in the current understanding of wetland ecological functioning and management methods was launched in 2003. The agencies involved are the Water Research Commission (WRC), the Department of Environmental Affairs and Tourism (DEAT), the Department of Water Affairs and Forestry (DWAF), the National Department of Agriculture (NDA), the Department of Minerals and Energy and the Mondi Wetlands Project. The over-arching objective of the Wetlands Research Programme is (WRC 2003):

"*To develop a sound scientific and technical foundation to promote conservation and sustainable use of wetlands through a systematic and effective rehabilitation programme*"

The objectives of the research programme are:

1. To initiate, support and manage research projects that contribute to wetland management.
2. To ensure the effective transfer of information on wetlands to institutions and persons involved in wetland management.
3. To promote human resource capacity in wetland management.
4. To ensure financial long-term sustainability of wetland research in South Africa.

The overall Wetlands Research Programme consists of three major thrusts:

- Rehabilitation
- Wetland health and integrity (WHI)
- Wise use

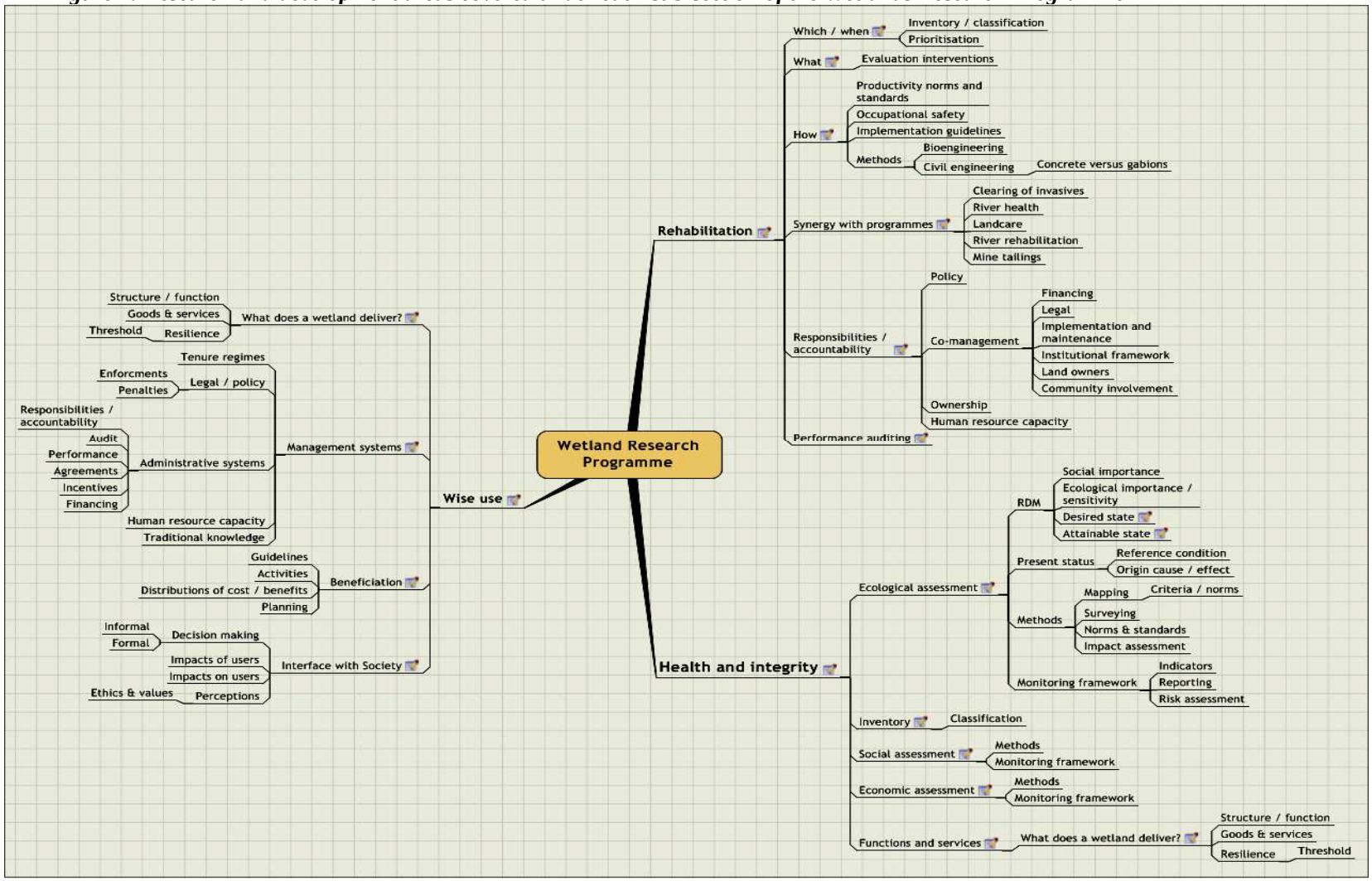
A three-year research programme on wetland rehabilitation was launched in 2004 under the leadership of Prof. Ellery of the University of KwaZulu-Natal. A major aim of this initiative is to support the research requirements of the Working for Wetlands public works programme. The current strategic overview of the research needs on wetland health and integrity is to provide the preparatory work for the second research thrust listed above, with a view to launching this initiative in 2006 (Mitchell, WRC, Pretoria, *pers. comm.*, Feb 2005). No work has, as yet, started on the last of the research thrusts, "wise use".

The partitioning of research and development activities under the three thrusts is shown in Figure 1. It can be seen that whilst the scope of the WHI research programme is wide, most of

the research activities are concerned with *assessment* of some or other aspect of wetlands. These aspects may be ecological, social, economic or concerned with the functions ("goods and services") provided by these systems. Thus the development of tools to assess the ecological condition, or the socio-economic importance, of wetlands has been given a very high priority in drawing up of the terms of reference (TOR) for the proposed Wetland Health and Integrity Research Programme.

Inevitably, there are overlaps between the three sub-programmes. For example, during workshops held during the course of preparing this strategic overview, valuable insight was gained from participants concerning areas that fell under the ambit of "wise use". Such information has been recorded but is listed separately from that of wetland health and integrity (Chapter 4). Furthermore, assessment of ecological condition or wetland functioning can also be used to evaluate the success of rehabilitation interventions. Most of the tools required for rehabilitation evaluation are being developed under the Rehabilitation Programme, and some of those tools (e.g. Wet-Health – previously known as WHAT and Wet-Ecoservices – previously known as Wetland-Assess) will be further developed under the WHI Research Programme for wider use than rehabilitation alone. In addition, some activities, for example wetland classification (i.e. establishing the ecological type of a wetland), inventorising and delineation of wetland boundaries, are cross-cutting and central to many aspects of wetland conservation and management. Such issues may best be addressed by collaborative research efforts.

Figure 1: Research and development areas covered under each sub-section of the Wetlands Research Programme



1.2 Rationale for this overview

Until recently, wetlands in South Africa have been neglected in terms of research and monitoring. There is, however, a growing recognition of their importance in the hydrological cycle, substantiated by the protection these systems are now afforded under the National Water Act (1998). The Act guarantees for all significant wetlands both the quantity of water that is required to ensure a given level of ecosystem functioning, and the quality of that water. For effective implementation of the National Water Act, but also for a wider range of activities such as conservation planning and management, it is important that the **ecological condition** (also referred to as the ecological "health" or integrity) of a given wetland be ascertained. In South Africa although the techniques for rivers are well established, in the case of wetlands there is currently no definitive, well-developed method, or suite of methods, for assessing ecological health.

There is also growing recognition of the important "goods and services" provided by wetlands and the critical role they play in flood attenuation, groundwater recharge and amelioration of water quality (amongst other functions). In many areas of the country, sectors of the population are directly dependent on wetlands for subsistence use. At the same time, there is demand for resources such as water and land which are becoming increasing scarce. Many regulating authorities have to make decisions that will impact either directly or indirectly on wetlands (e.g. in-filling for development, abstraction of water, effluent discharge). There is a great need for tools that will help place a value (monetary or otherwise) on the benefits wetlands supply to the people living around them. Thus, to be able to make rational decisions concerning the management of wetlands themselves, in addition to development in the surrounding catchments, we need to be able to assess the **social importance as well as the economic benefits** that are (or potentially could be generated) from a wetland.

In full, tools that allow an assessment of the ecological health and integrity, or the socio-economic importance, of a wetland will be invaluable in that they will facilitate the following:

- determination of the ecological Reserve. Such tools will aid in establishing both the reference condition (RC) and the present ecological state (PES), and ultimately in specifying the desired state for which a wetland will be managed
- establishment of a final management class for wetlands that takes into account ecological requirements and those of the people dependent on the resource
- securing sustainable livelihoods for people directly dependent on wetlands for subsistence use
- fostering the wise-use of wetlands

- general “State of the Environment” monitoring and reporting
- conservation planning and the implementation of management plans
- wise decisions by local authorities with regard to development in and around wetlands
- checking of compliance with regulations (e.g. effluent discharge)
- assessing the efficacy of rehabilitation interventions
- prioritisation of wetlands for rehabilitation.

1.3 Objectives of this overview

The objectives of this strategic overview of the research needs for wetland health and integrity, as stated in the original project proposal, are given below:

i) To establish what research has been carried out internationally to determine wetland health and integrity and what ecological, social and economic tools are currently in use.

ii) To establish what research has been carried out in South Africa and other SADC countries to determine wetland health and integrity, and what tools are currently in use.

iii) To determine what techniques show the best potential for a) South Africa and b) the southern African region.

iv) To assess the research needs for development of the required assessment tools, and to gain a thorough understanding of the ecological functioning of wetlands in South Africa.

The ultimate goal is to draw up the terms of reference (TOR) for the Wetland health and integrity (WHI) Research Programme that will address the need for wetland assessment tools in South Africa.

1.4 The approach used

There have been many initiatives world-wide, as well as within the SADC region, attempting to develop assessment (including biomonitoring) techniques specifically for wetlands. Within South Africa itself, there is considerable interest in this topic from individuals and universities as well as DWAF and DEAT. A wide range of approaches is being used internationally, including those that rely primarily on habitat assessment and those utilising various faunal or floral groups (e.g. macrophytes, diatoms, macroinvertebrates). An important part of this project therefore was to examine the international literature, and to liaise with scientists in South Africa and neighbouring countries.

At the same time that this strategic review was initiated, a literature review was commissioned by DWAF which focussed to a large extent on biotic indices that can be used to assess wetland condition. The literature review (DWAF 2004), titled "*Development of a framework for the assessment of wetland ecological integrity in South Africa. Phase 1: Situation Analysis,"* was compiled by Dr Mandy Uys (Laughing Waters, East London, *pers. comm.* Sept 2004). The above document forms an invaluable introduction to the subject of the assessment of wetland ecological health, since it evaluates the current situation both in South Africa and internationally. Complementing the literature review, a bibliography was produced (Malan, Day and Marr, 2005) to provide a list of relevant sources on wetland assessment. In line with the requirements of the strategic overview, however, a wider range of topics is covered in the bibliography than in DWAF (2004). Papers that present methods for assessing the socio-economic importance of wetlands are included for instance. With regard to assessment of ecological condition, methods have been incorporated ranging from the "hydrogeomorphic approaches" that look at wetland functioning, through simple assessments of habitat degradation and anthropogenic activities in the catchment that impact on wetlands, to bioassessment using a variety of faunal and floral groups. Furthermore, descriptions of local tools in wetland assessment (e.g. -HAT – the Wetland Health Assessment Technique, Macfarlane, SAPPI, *pers. comm*. October 2004, renamed Wet-Health) are also provided, including many of those that are still under development and have not yet been published.

In addition to perusal of the literature review (DWAF 2004) and preparation of the annotated bibliography (Malan *et al.* 2005) the following steps were taken in the commission of this strategic overview. These steps are described below and summarised in Table 1.

- E-mails were sent out informing wetland scientists of the project and asking for information on assessment tools being used/developed, assessment needs not presently being addressed and what the recipients considered to be the major gaps in wetland science in South Africa. These e-mails were sent to the South African wetlands listserver, to members of the Western Cape Wetlands Forum, and to wetland scientists in the SADC region.
- A workshop was held in Namibia (at the WATERNET conference) to obtain input from SADC countries. A joint DWAF-WRC workshop was also held in Pretoria over two days. The first day considered assessment of ecological condition, whereas the second was largely concerned with socio-economic aspects (reports given in the appendices).
- Presentations were given and report-backs held at meetings of the Western Cape Wetlands Forum.

Table 1: A summary of the process followed during the strategic overview.

Step	Action taken	Product
1	Perusal of the literature (including DWAF 2004) and preparation of an annotated bibliography on wetland assessment methods.	Malan *et al. (2005*)
2	Communication with South African and SADC wetland scientists via various e-mail listservers informing them of the strategic overview.	
3	Consultation with individual wetland specialists.	Inclusion of suggestions and comments in this document.
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8	An analysis of wetland assessment needs, the tools currently available, and the research/development gaps. Circulation of the analysis to wetland scientists for comment.	This document (Table 3)
10	Synthesis of information from all the above steps into a TOR for the Research Programme on Wetland Health and Integrity.	This document (Chapter 3)

- Interviews were held with key ecologists, sociologists, and resource economists with experience in wetlands. Specialists consulted included: Bethune, S.; Ellery, W. (University of KwaZulu-Natal); February, R. (SANBI); Goldin, J.; Haigh, L. (IWR, Rhodes University); Jewitt, G.; Job, N. (SANBI); Kareko, J. (University of KwaZulu-Natal); Kotze, D. (University of KwaZulu-Natal); Leiman, A. (Dept. Economics, UCT); Macfarlane, D. (Sappi); Mander, M. (FutureWorks); Traynor, C. (University of KwaZulu- Natal); Turpie, J. (Dept Zoology, UCT); Uys, M. (Laughing Waters); Walters, D. (Mondi Wetlands Project). Many scientists gave input during the workshops or via e-mail. Lists of attendees at the WATERNET and Pretoria workshops are given under the appropriate appendix.
- The team members participated in several wetland-related conferences, namely, Intecol (Utrecht, August 2004) and the South African Wetland Action Group (SAWAG) meeting (Lake St Lucia, October 2004).

From the information gleaned in these ways, a framework was drawn-up (Table 3) listing the perceived needs of various user groups for wetland assessment tools. These were linked (where deemed appropriate) with existing assessment tools and the research gaps identified. In addition, lists of proposed research/development projects in terms of wetland health and integrity, wise use, rehabilitation, and overall gaps in wetland science were compiled (Chapters 3 and 4). A priority rating (high, medium, or low) was assigned to each proposed research/development project that falls within the scope of the Wetland health and integrity Research Programme (Table 4).

1.5 Definitions and terminology

The terms listed below have the following meaning in this document:

Assessment

Assessment is taken to be the preliminary identification of wetland status/importance/value (both ecological and socio-economic) and threats to the present state. In this document ecological health/integrity/condition/status are taken to be more or less synonymous, likewise socio-economic importance and value.

Classification

The grouping of similar types of wetlands with homogeneous natural attributes (e.g. hydrogeomorphic or morphological characteristics) into categories and sub-categories, typically for the purpose of wetland inventory. This is different from the meaning used by DWAF and NDA, where classification (of rivers, wetlands, estuaries etc.) is a grading system that uses various categories to describe the condition of a water resource, or part thereof (DWAF 2004).

Delineation

The objective of wetland delineation (as used in South Africa) is to identify the outer edge of the temporary aquatic zone that marks the boundary between the wetland and adjacent terrestrial areas (DWAF 2003).

Inventory

Wetland inventory is defined as the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities (Finlayson *et al.* 2001, cited in DWAF 2004).

Palustrine

Palustrine systems are non-tidal wetlands dominated by emergent plants (e.g. reeds), shrubs or trees and include a variety of systems commonly described as marsh, floodplain, vlei or seep (Kotze *et al*. 2004).

Wetland

The Ramsar Convention definition of wetlands is used both in the Wetland Research Programme (WRC 2003) and in this document. Thus, wetlands are described as "*areas of marsh, fen, peatland or water, whether natural of artificial, permanent or temporary, with water that is static, or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.*" It is understood that, at least for the initial stages of the Wetlands Research Programme, attention should be concentrated on *palustrine wetlands*.

CHAPTER 2: APPROACHES TO WETLAND ASSESSMENT

In this chapter an attempt is made to capture some of the ideas garnered during this project, including the recommendations of DWAF (2004). As described in Chapter 1, a framework (Table 3) is presented in which potential users of wetland assessment tools and the existing tools that have been developed (or are in the process of being developed) are collated. From this exercise, potential research gaps are identified.

2.1 General discussion

A major part of the research programme on wetland health and integrity is directed towards assessment (i.e. "measurement") of the ecological condition or status of wetlands. Another major aim is to develop methods for assessing the social and economic importance of these systems. With regard to ecological condition, a whole range of attributes can be measured, some of which will be useful for establishing ecological condition, and others will not. One approach is to look at factors ("drivers") such as hydrology or water quality that are likely to have a direct impact on wetlands. Allied to this is a "risk-assessment" approach that seeks to list and quantify all the impacts that have impinged, or are likely to impinge on wetlands. This latter approach is used in Wet-Health (Macfarlane, D., SAPPI, *pers. comm.* 2005) and is closely linked to habitat assessment techniques. Mapping the distribution of hydromorphic soils/soil moisture and macrophytes in order to delineate wetlands can also be used to assess wetland condition (Marnewecke, Wetland Consulting Services, *pers. comm.*, March 2005). In such an approach the historical extent of flooding (as indicated by hydromorphic soils) can be compared with present-day inundation as shown by the extent of macrophytes.

An alternative way of establishing ecological status is to examine the biotic responses of the wetland flora and fauna themselves. Using living organisms to assess the ecological condition of rivers has become standard practice in many parts of the world (see for example the UK "RIVPACS" system (Armitage 2000); the Australian "AusRivAS" programme (Smith, Kay, Edward *et al.* 1999) and in South Africa, "SASS" (Chutter 1998)). There is now a strong movement internationally towards the development and use of biomonitoring methods for wetlands in combination with measurements of physical and chemical parameters (Yoder and Rankin 1998). Utilising living organisms offers the advantage of integrating the effect of all stresses on a system (e.g. the cumulative effect of more than one pollutant). They also integrate effects over time (this is in comparison to the spot measurements usually taken during a monitoring programme). Another benefit of biomonitoring is that it is frequently rapid and cheap, which is ideal for situations of limited resources such as in South Africa.

Development of methods for assessing the degree of ecological integrity of wetlands, however, seems to lag considerably behind those for rivers. To develop an effective rapid bioassessment system and to link (for example) the presence of macroinvertebrate species with ecological integrity, requires a great deal of detailed knowledge of what species may be found and what their habitat requirements are. It is difficult to choose suitable indicators of wetland integrity because wetland ecology is not well enough developed as a science to tell us what the essential properties of these systems are (Keddy 2000). In South Africa even basic information on wetlands, let alone knowledge of ecosystem functioning, is lacking. It should also be remembered that whilst a rapid, cost-effective biomonitoring technique would be invaluable for determining overall wetland health, such techniques are often non-specific. They may indicate that ecological functioning is impaired, but often do not give much information as to the cause. As a consequence, several metrics or techniques that assess different aspects of wetland health will be required. This is analogous to the techniques used in the River Health Programme which assesses and tracks the ecological integrity of rivers in this country using several indices (e.g. SASS, the Fish Assemblage Integrity Index, the Riparian Vegetation Index).

Wetlands perform useful roles in the landscape, but because they are so heterogeneous, the nature and extent of these functions tend to vary. Therefore, a useful approach to assessing both wetland condition and value, although admittedly anthropocentric, is to determine and quantify the functions carried out by a given wetland (for example by using "Wetland-Assess" – Kotze, Marneweck, Batchelor *et al.* 2004. Note that this method has been renamed "Wet-Ecoservices" – Kotze, D., UKZN, *pers. comm*. Dec. 2005). This can serve as a useful link between ecological condition and socio-economic importance through quantifying the "goods and services" that are generated. It should be remembered, however, that the importance of wetlands is much greater than the "goods and services" they provide, and that valuation of the less tangible attributes (e.g. irreplaceablity of a particular wetland type) is contentious and fraught with difficulty. Assessment of ecological condition and assessment of wetland functioning are complementary ways of looking at wetlands. For example, a wetland may be pristine, with high biodiversity, and yet perform few functions. Other wetlands (e.g. many urban wetlands in the highveld region of South Africa) are in poor condition, dominated by a few hardy species, and yet are vital from a hydrological point of view (Ellery, W., University of KwaZulu-Natal, *pers. comm*. 2004).

Assessment of the social or economic importance of wetlands conceptually involves many aspects. In some areas of South Africa people are directly dependent on wetlands for subsistence use. In other areas wetlands are of commercial importance, either directly from the harvesting of resources, or indirectly due to factors such as tourism.

But wetlands are important to people also as wilderness areas, and some wetlands (e.g. Lake Fundudzi) are of cultural and religious significance.

From the above discussion it can be seen that many different approaches can be used to assess wetland condition, and that a wealth of attributes can be measured, not all of which will be useful. Furthermore, many aspects need to be considered when determining the socio-economic importance of a wetland. This is perhaps a reflection of the complex nature of these ecosystems. Not surprising, then, a major conclusion of both DWAF (2004) and from this strategic overview is that whilst efforts have been made around the world to develop wetland assessment tools, there is no universal acceptance of a single approach. Furthermore, because wetlands are complex in their ecological functioning, and different aspects need to be considered, a suite of assessment techniques, rather than just one, is required.

2.2 Provisional recommendations arising from DWAF (2004)

The objectives of the DWAF-funded project on integrated wetland biological assessment were as follows (DWAF 2004).

- to review the approaches and methods used worldwide in wetland bioassessment
- on the basis of the review, to make recommendations regarding the development of an integrated bioassessment technique(s) for different types of South African wetlands. Amongst other uses, this protocol will be applied in the Wetland Reserve Determination process, and will possibly be incorporated into the River Health Programme.

As can be seen from Chapter 1, and from the discussion in section 2.1 the proposed scope of the WHI Research Programme is considerably wider than covered in DWAF (2004), covering, as it does, all types of wetland assessment, including socio-economic importance.
Nevertheless a critically important aspect, namely the use of organisms to assess wetland condition, has been well researched and discussed in the review.

The review of DWAF (2004) also makes recommendations for *inter alia*, the development of an integrated inventory, assessment and monitoring framework (Table 2).

We support the recommendations in Table 2, and to a great extent its recommendations are incorporated into the list of deliverables presented under the TOR for the proposed research programme in Chapter 3. Furthermore, the suggested phased approach of situation analysis, method development, and testing has also been retained. Minor changes include a slight alteration in the order of priority for development of the biotic indices.

Table 2: A summary of the recommendations for the development of an integrated assessment protocol for use in evaluating wetland condition (from DWAF 2004).

1	To collaboratively develop a national framework for a Wetland Inventory, Assessment and Monitoring System (WIAMS) to form the basis of a Wetland Monitoring Programme for SA. This programme should be coordinated by DEAT (who also have responsibility for the Wetlands Inventory), but should have the custodianship of a number of different organisations, projects, government bodies, and programmes.
2	To adopt an approach of combining functional and biological assessment methods in the evaluation of wetland state. To measure environmental variables alongside these as a standard procedure.
3	Prioritise the development of indices of biological condition (IBIs) or similar methods as follows: i. Plants ii. Aquatic macroinvertebrates iii. Fish iv. Algae and Diatoms
4	Utilise the extensive existing knowledge and experience-base, and methods already in use, for the further development of a plant-based index of wetland condition for incorporation into the Wetland Reserve Determination method.
5	Develop an invertebrate index for use in wetland assessment, based either on the IBI approach used in the US, or the sensitivity index approach used in Australia. Initially, use metrics which have been tested elsewhere and shown correlation with human disturbance and water quality variables.
6	Develop a fish Index of Biological Integrity (along similar lines to that used in rivers in South Afric) for use in wetlands with direct connectivity to river systems, i.e. the following palustrine wetland types: floodplain; valley bottom with a channel, valley bottom without a channel. DWAF has the capacity to drive this development.
7	Incorporate algae into the wetland assessment process, at a purely descriptive and field-based level. Commission a colour photographic guide to the algae of aquatic ecosystems in SA for this purpose.
8	Assist and encourage the development of quantitative and computer-assisted methods for the use diatoms in wetland assessment. The development of an index using algae and diatoms should be seen as a longer-term goal.
9	Encourage more directed research into birds and amphibians of wetlands. Amphibians have potential as qualitative indicators of the larger spatial-scale issues relating to wetlands within landscapes, and wetland connectivity within and across continents. Investigate linkages with specialists who have experience in the use of amphibians as bioindicators, or who see potential for the use of audio recordings (frog calls), to provide a wetland biodiversity and condition assessment.

2.3 A synthesis of the perceived needs for wetland assessment tools

From the various sources of input gathered during the preparation of this strategic overview a framework has been drawn up (Table 3). The perceived needs of users for wetland assessment tools, the existing tools available and the apparent research needs are included. The table, together with key points arising from the strategic overview, was circulated to wetland scientists for comment and has been amended where appropriate.

From examination of Table 3, the following research/development needs have been identified:

- development of metrics (especially rapid screening tools) using organisms (e.g. invertebrates)
- modification of various existing tools that can be used for wetland assessment within ecological Reserve determinations (Wet-Health, Wet-Ecoservices etc); since it is not clear what the roles, advantages and disadvantages of each are, they need to be tested together in actual Reserve determinations
- Wet-Ecoservices (Wetland-Assess) requires evaluation as the platform for studies on wetland resource economics
- a method for estimating the importance of wetlands at the catchment/landscape level is required in order to estimate the cumulative effect of wetland loss
- various tools to evaluate the effectiveness of wetland rehabilitation activities
- indices of wise use, including an assessment of the sustainability of use, the dependency of communities on wetlands, and the effectiveness of governance structures
- various protocols for indicating where and when the different assessment tools should be used.

The above research/development needs have been incorporated into the proposed terms of reference for the WHI Research Programme (Chapter 3).

Table 3: An analysis framework to show the assessment needs, the tools that have already been developed (underlined) and the perceived areas that require research and development.

ECOLOGICAL CONDITION		
Assessment tool needed for:	**Assessment tool:**	**Comments:**
(e.□. **Resource Directed Measures (DWAF)**	Wet-Health (Wet-HAT. Macfarlane *et al. in prep*.).	All the listed tools will aid in setting the RC, PES, EIS and RQOs.
Ecological Reserve Determinations:	Soil-moisture/plant distribution method (Marneweck *in prep*.) A range of biotic indices (e.g. at screening level – plants, inverts; and for more detailed assessments e.g. diatoms for WQ). Wet-Ecoservices (Kotze *et al.* 2004) Tools for establishing the ecological importance and sensitivity (e.g. update of current RDM method – Kleynhans *et al.* 1999). [Measurement of physico-chemical parameters]	The use of soil-moisture/macrophyte distribution to indicate the extent of flooding needs to be developed & formally included in wetland RDM methods. The method to establish the EIS of a wetland would need to take into account biodiversity, habitat diversity, irreplaceability of a wetland etc. The need to link changes in flow/water quantity with changes in geomorphology, biota, functioning and water quality, has been identified as a research need. A protocol is needed to indicate how and what tools should be used under which circumstances.
National Resource Classification Project:	Screening methods to assess ecological status for all significant water resources nationally. A screening tool to assess wetlands at the catchment level (e.g. Wet-Ecoservices, level 1).	This will be combined with socio-economic importance (see below). A DWAF-funded project to develop the methods for this task will start mid-2005 (Brown, *pers.* □*omm.*. Feb 2005). Possibly the same tools can be used as for Reserve determinations.
B. Assessment/monitoring of wetland ecological condition (e.g. SOE reports, EIAs, management plans)	Wet-Health, Wet-Ecoservices Biotic indices e.g. screening level – plants, inverts and for more detailed assessments (e.g. diatoms) A screening tool to assess wetlands at the catchment level (e.g. Wet-Ecoservices, level 1). [Measurement of physico-chemical parameters]	Use for monitoring implementation of Reserves, EIAs, to check for compliance (e.g. of effluent discharge), to assess and then monitor general wetland ecological condition Individual wetlands in themselves may not be functionally important, but the cumulative loss may be significant.

ECOLOGICAL CONDITION		
Assessment tool needed for:	**Assessment tool:**	**Comments:**
D. Miscellaneous Monitoring by volunteers Active biomonitoring	Very simple assessments of e.g. water colour, extent of wetting. Bioassays of the effect of toxic components on captive organisms (e.g. frogs in cages)	Could potentially be linked to CWAC counts – some work has already been done on this by the ADU. For monitoring of toxicity in areas where pollution is likely. This tool has been partly developed – is there a need to implement it nationally?
SOCIO-ECONOMIC IMPORTANCE		
Assessment tool needed for:	**Assessment tool:**	**Comments:**
E. Resource Directed Measures (DWAF) Reserve Determinations National Resource Classification Project	Wet-Ecoservices Rapid economic appraisal methods. Rapid social/cultural importance appraisal methods.	All these tools (and possibly those from section F) will form a toolbox that can be used for assessing the social and economic importance for input into the overall DWAF management class. Possibly the same tools used in the National resources classification project and in Reserve Determinations.
F. Wise use	Sustainability index (i.e. ecological, social and economic sustainability) Dependency index Wet-Ecoservices (Kotze *et al.* 2004)	All these tools (and possibly some from sections A, B, and D) will form a toolbox that can be used for assessing the sustainability of use. The "Dependency Index" would take into account the poverty of people in the area, alternative livelihoods, the extent to which they are dependent on the wetland etc. A protocol is required to indicate which tools should be used and when.
G. Governance	An index determining the effectiveness of governance of a wetland.	A research project also needs to be implemented to ascertain the effectiveness of current wetland conservation initiatives, land tenure issues.

RC= Reference condition, PES = Present ecological state, EIS = Ecological importance and sensitivity, RQOs = Resource quality objectives,

WfWet = Working for Wetlands, SOE = State of the Environment, RDM = Resource Directed Measures,

ADU = Avian Demography Unit (University of Cape Town)

CHAPTER 3: TERMS OF REFERENCE FOR THE WETLAND HEALTH & INTEGRITY RESEARCH PROGRAMME

3.1 The structure of this chapter

This chapter is laid out in the following manner. Firstly, general comments that apply to the whole research programme are given. This is followed by the aims of the research programme and then a list of deliverables that are considered to be important for achieving those aims. The deliverables are divided into Phase I (Situation analysis), Phase II (Development of assessment tools) and Phase III (Testing of assessment tools) and lastly, a section titled "General products". The latter is necessary because the research programme is required to address a wider field than just assessment (see Figure 1), although development of assessment tools does form the major part. The priority of the deliverables does not necessarily follow the above order. For example, the trialling of existing tools (e.g. Wet-Ecoservices) is considered to be an urgent requirement, even though this falls under Phase III. Because the Wetland Health and Integrity (WHI) Research Programme will need to be implemented in a phased manner, at the end of each deliverable, the priority is indicated (high priority, medium priority, or low priority). At the end of this chapter, the most important deliverables are presented in a summary table along with the envisaged time-frame.

3.2 General comments

The following general caveats and conclusions apply to the TOR presented in this chapter.

- Wetlands in this country have been considerably neglected in terms of research (both basic and applied) and in terms of monitoring. Because of monetary constraints, however, the envisaged deliverables have had to be rated in terms of their considered priority. Nevertheless, all the listed research gaps are considered to be important, and for this reason have been included in this document, if not in the TOR, in the hope that they will ultimately be addressed.
- The list of tasks to be undertaken is divided for convenience into aspects concerned with ecological condition, those concerned with wetland socio-economic importance and those of overall importance (''General products"). It is, however, essential that there is synergy between the approaches and that methods/tools produced are not developed in isolation. Integration could be fostered by holding regular meetings of the role players involved, and/or establishing joint research projects at key wetland sites (see Phase III below).

- Because of the heterogeneity of wetlands (in terms of types and between ecoregions), it is envisaged that there will be a suite of tools, not all of which will be applicable under all situations. Protocols will need to be developed to guide users as to which methods (tools) to use under which circumstances. For example, it will be necessary to develop a range of biotic indices, since an index using invertebrates cannot be applied if the wetland is dry. Similarly, birds may only be useful if monitoring data are available over a relatively long time period and large spatial scale. Knowledge of most aspects of wetland biota is limited, thus development of indices will further fundamental research and lead to a more comprehensive understanding of the ecology of wetland systems.
    - As indicated in Table 3, many tools have already been developed, but require modification to a greater or lesser extent. Even for tools that have not yet been developed these should not be developed *a priori* but adapted, where possible, from existing national and international approaches.
    - Although the TOR should be applied in a structured manner, it is important that it is not too prescriptive. For example if promising new fields of research appear these might also need to be included.
    - There should be integration with the DWAF-funded "National resource classification project" which requires fairly low-confidence, screening methods for assessing the ecological condition of wetlands nationally (Brown, Southern Waters Consulting, Cape Town, pers. comm., March 2005). This is in addition to estuaries, groundwater resources and rivers. Furthermore, measures of the socio-economic importance of resources are needed, in conjunction with stakeholder input in order to finalise an overall recommended ecological class (REC) for each significant water resource (the ultimate aim of the initiative). The REC will guide the level of ecological condition for which a resource will be managed, and hence the level of protection. The likely requirements of the above project in terms of assessment tools for both ecological health and socio-economic importance are shown in Table 3.
    - There should be collaboration with NEPAD/IUCN-ROSA who are in the process of developing a SADC-wide research programme on wetlands. (See for example website http://workd.water-forum3.com/en/finalreport.commitment03).
    - There should be collaboration with DEAT/SANBI with regard to the national initiative aimed towards preparing an inventory of wetlands in South Africa. This could most usefully be through the National Landcover Project and associated follow-up activities (Dini, Working for Wetlands, *pers. com.*, March 2005).

3.3 Aims of the WHI Research Programme

The aims of the research programme are as follows:

a) To develop tools for assessing wetland ecological condition that will address the major needs of the users in South Africa, including DWAF, DEAT, and conservation bodies.
b) To develop tools for assessing wetland socio-economic importance, that will begin to satisfy the needs of users in South Africa.
c) To facilitate integration of current initiatives in wetland research in South Africa, and in the SADC region.
d) To begin to address some of the gaps in wetland science and in the understanding of wetland functioning in this country.

3.4 Scope of the WHI Research Programme

The Wetland Health and Integrity Research Programme as specified in the terms of reference is directed towards *palustrine wetlands*. The activities listed in the TOR (Table 4) are expected to extend over a period of three to four years.

3.5 Deliverables

3.5.1 Phase I: Situation analysis

Ecological health and socio-economic importance

The requirements of this phase have largely been covered by DWAF (2004 – the work of Uys and colleagues); Malan *et al. (*2005 – the annotated bibliography), and in the current report.

ALREADY ADDRESSED

Still outstanding:

- A **scoping study** to check what investigations have already been carried out in South Africa to value the "goods and services" supplied by wetlands. The quality of the work, the methods used and how successful the studies were, would also need to be analysed critically. From this, a decision would be made about the necessity of carrying out further resource economic studies, and which methods should be used.

HIGH PRIORITY

- An investigation into the need, or otherwise, for **active biomonitoring** for on-going assessment of the accumulation of toxics compounds in wetland biota.

LOW PRIORITY

3.5.2 Phase II: Method development

Ecological health

- Further development of **Wet-Ecoservices** through trials of the approach in different parts of the country (e.g. Western Cape and arid areas) and modification where necessary. Note that this is largely being carried out under the "Wetland Rehabilitation Research Programme" (Ellery, University of KwaZulu-Natal, *pers. com*. March 2005).

HIGH PRIORITY – ADDRESSED ELSEWHERE

- Possible strengthening of the biodiversity and habitat diversity components of **Wet-Ecoservices**. It will be possible to address this issue only after the application of this approach to test wetlands (in conjunction with Wet-Health and other ecological assessment tools) as recommended in Phase III.

HIGH PRIORITY

- Further development of the **hydrogeomorphic soils/soil moisture/macrophyte** mapping method for delineating wetlands and assessing the Present Ecological State (PES) and, if suitable, formal incorporation into the DWAF RDM methods. Testing of this method in Reserve determinations in combination with other assessment tools (See Phase III).

HIGH PRIORITY

- Further development of the model of Kleynhans *et al.* (1999) as used in DWAF (1999), or other likely tools, to strengthen the ability to determine wetland **Ecological Importance and Sensitivity** (EIS). The following, *inter alia* should be emphasised: biodiversity, habitat diversity, irreplaceability of wetland type, cumulative loss of a given wetland type. Testing of this/these tool(s) in Reserve determinations in combination with other assessment methods (See Phase III).

HIGH PRIORITY

- Develop biotic metrics of wetland condition based on macrophytes, algae, diatoms, invertebrates, amphibians and birds as detailed below:

a) Macrophytes:

- Consolidation of the existing **records of wetland plant species**. Species lists, keys, and photographic guides of obligate and facultative wetland plants need to be compiled for each ecoregion.

MEDIUM PRIORITY

- Development of a **biotic index based on wetland macrophytes**.

HIGH PRIORITY

b) Algae:
   - Development of a **biotic index using diatoms** for assessing water quality. The method(s) developed up to now for rivers needs to be extended to wetlands.

MEDIUM PRIORITY

   - Production of a photographic guide to the **freshwater algae** of South(ern) Africa and a biotic index based on freshwater algae.

MEDIUM PRIORITY

c) Invertebrates:
   - Investigation into the feasibility of using **invertebrates** (including micro-crustaceans) to assess wetland ecological condition using either sensitivity scores or a multi-metric index based on more than one attribute.

MEDIUM PRIORITY

d) Fish:
   - Development of a **fish index** for floodplain systems (possibly adapted from the existing method for rivers). This could be linked with an index of ecological sustainability (see below), and also with assessment of social/economic importance for sustainable livelihoods.

MEDIUM PRIORITY

e) Amphibians:
   - Low-level collection of **species distribution data for frogs**. This would be used to draw up a preliminary knowledge base for the future possible development of a biotic index using frogs.

LOW PRIORITY

- Preliminary investigation into the use of various floral and faunal propagules (e.g. seeds, resting stages of invertebrates, algae, protists) to evaluate wetland **health under dry conditions**. This investigation needs to be linked with the development of assessment methods based on other biotic groups.

MEDIUM PRIORITY

- Low-level research into the use of biological organisms (e.g. tadpoles, snails) in **active biomonitoring** of wetlands. This would be directed towards the development of methods for monitoring toxic substances (especially chemical species that bioaccumulate, such as metals) in heavily polluted wetlands.

LOW PRIORITY

- Tools that can be used to evaluate wetland **ecological condition at the landscape level**. The cumulative loss of wetland functioning is unlikely to be linear and this needs to be investigated.

MEDIUM PRIORITY

- Metrics of the **ecological sustainability** of wetland use based on, for example, the productivity of wetlands and mass of material harvested. This could be linked to Wet-Health and Wet-Ecoservices and combined with measures of social and economic sustainability (see below).

MEDIUM PRIORITY

Socio-economic importance

- A short trial to test the usefulness of **Wet-Ecoservices** as the basis for rapid valuation of the **"goods and services"** supplied by wetlands. This could most usefully be carried out as part of a joint research thrust for a key wetland (see Phase III) and/or part of a Reserve determination. The wetland chosen and the methods used to evaluate the wetland goods and services would be informed by the outcomes of the scoping study carried out in Phase I.

HIGH PRIORITY

- A **protocol** of the steps to be followed and the methods/tools to be used when undertaking a resource-economics study of wetlands. This needs to be relatively easy to apply, legally defensible, and relevant to the South African situation.

HIGH PRIORITY

- Based on the above, a **communication package** for local authorities to advise them on how to value the benefits of wetlands in their area (to aid in making rational decisions around planning).

HIGH PRIORITY

- An investigation (desk-top) into the effect of wetland rehabilitation on vectors of **socio-economically important diseases** such as malaria, bilharzia and liver fluke. This should be coordinated with work carried out under the WRC research project "The effect of flow manipulation on disease vectors".

HIGH PRIORITY

- Development of **Metrics of sustainability**, where sustainability includes ecological (see above), social and economic aspects.

MEDIUM PRIORITY

- Closely allied to the above would be the development of a **"Dependency metric"** indicating the extent to which people are dependent on a wetland.

  This would take into account the poverty of people in the area (using already existing measurements of poverty), accessibility of alternative livelihoods, adaptability of communities, use of wetlands during periods of drought etc. and would need to be linked with Wet-Ecoservices.

  MEDIUM PRIORITY

- Development of a metric of the **effectiveness of governance** of a wetland. This would take into account, amongst other considerations, sustainability of use (see above), and the efficacy of conservation efforts (e.g. is a management plan in place?).

  LOW PRIORITY

3.5.3 Phase III: Method implementation and testing

Ecological health and socio-economic importance

- Use of Wet-Ecoservices in an **Intermediate/Comprehensive Reserve** in combination with other already-developed assessment tools i.e. Wet-Health, the EIS method of Kleynhans *et al.*, and the soil-moisture/macrophyte distribution assessment method. From this, an analysis of the strengths, and weaknesses of each method should be carried out and the gaps and overlaps in the results identified. Development of protocols for assessment of wetland ecological condition and socio-economic importance in Reserve determinations would be a key output, including the refinement of those protocols for all levels of Reserves.

  HIGH PRIORITY

- Joint application of ecological assessment tools (including development of biotic indices) and socio-economic tools to key wetland areas (different wetland types, different ecoregions, urban versus rural) by multidisciplinary task teams. Both individual wetland systems and multiple wetlands at the catchment scale, should be considered, as well as subsistence use. The exercise should optimally be linked to SAEON node(s) and possibly to Reserve determinations (see above). A key deliverable would be the production of comprehensive water budgets for each wetland system.

  One of the objectives of this thrust would be to gather extensive environmental data that could be used to validate the assessment tools.

This data could then potentially be extrapolated to other less data-rich wetland systems. Another deliverable would be the testing of metrics/indices developed under the research programme.

HIGH PRIORITY

4 General products

The deliverables listed below are also important to the success of the WHI Research Programme, but are not linked directly to assessment of ecological condition or socio-economic importance:

- Development of a **framework for a wetland inventory, assessment and monitoring system (WIAMS)** as recommended by DWAF (2004) including:
  - refinement of the classification of wetlands, linked to a standard protocol for carrying out inventories.
  - creation of a national database to act as a repository for data collected during the following activities; inventory, monitoring of physico-chemical parameters, assessment of ecological health, and possibly, assessment of wetland functions and socio-economic importance. The database should be well-curated and easily accessible to a variety of users including town planners, environmental scientists, and researchers.
  - a strategy for collating the existing information on ecological aspects of wetlands and adding this to the national database.
  - a strategy for a national monitoring system of wetland ecological condition. The feasibility of using volunteers for at least some of the monitoring programme should be investigated (see below).

It is recommended that the WIAMS framework be tackled in collaboration with SANBI (see "General comments") using funds external to this research programme.

HIGH PRIORITY – POTENTIALLY ADDRESSED ELSEWHERE

- Environmental water requirements of wetlands need to be studied. **Cause-effect relationships** between water quantity and biotic response, water quantity and water quality, water quality and biotic response, amongst others need to be examined. A predictive capacity needs to be developed so that under a prescribed environmental water allocation, the likely ecological condition of the wetland can be described at least semi-quantitatively. This will aid in setting the Reserve for wetlands.

Predicted scenarios need to be linked to wetland functions and hence impacts to wetland "goods and services." Furthermore, models need to be developed linking changes in water quantity (timing, depth, extent of inundation) and water quality, with the predicted extent and severity of diseases (e.g. malaria, bilharzias) and the socio-economic implications thereof.

MEDIUM PRIORITY

- A **communication strategy** is required for the WHI Research Programme that addresses communication between wetland scientists, managers, funders and with decision makers (particularly those in local authorities), including presentations at appropriate conferences (especially at SAWAG, and possibly SASAQs).

MEDIUM PRIORITY

- A **standard format** needs to be developed for reporting the ecological condition of a wetland, as well as the socio-economic importance.

LOW PRIORITY

- The feasibility of using **volunteers** to monitor wetland condition should be investigated (possibly through the Co-ordinated waterbird counts "CWAC"). The monitoring results could feed into the above WIAMS framework/database.

LOW PRIORITY

A summary of the deliverables considered to be the most critical to achieving the aims of the WHI Research Programme is shown in Table 4. All deliverables considered to be of high priority and most of those considered to be of medium priority have been included. Deliverables rated as "medium priority", not presently listed in the TOR, but that could be considered should the alterations in the budget occur are:

- The development of biotic indices using fish and algae (other than diatoms).
- The production of a photographic guide to freshwater algae.
- Preliminary research into models that can be used in Environmental Water Allocations/Reserve determinations to predict ecological condition and wetland goods and services, including vectors of socio-economically important diseases.

Table 4: A summary of the deliverables for the Wetland Health and Integrity Research Programme including the suggested time frame.

	DELIVERABLE	**PRIORITY**	**TIME FRAME**
1	A **scoping study** of investigations in South Africa to value the "goods and services" supplied by wetlands.	High	Year 1
2	Testing of existing assessment tools within an Intermediate or Comprehensive wetland **Reserve determination study**. The tools would include Wet-Ecoservices, Wet-Health, the EIS method of Kleynhans, and the soil-moisture/macrophyte distribution assessment method. Production of protocols for assessing ecological condition and socio-economic importance as required for RDM.	High	Year 1 - 2
3	Testing of the **usefulness of Wet-Ecoservices as a basis for rapid valuation** of the "goods and services" supplied by wetlands (link with 2 and 12).	High	Year 1
4	Development of a **biotic index based on macrophytes** (including consolidation of the existing records of wetland plant species).	High	Year 1 - 3
5	Development of a **biotic index based on diatoms**.	Medium	Year 1
6	Investigation into the feasibility of a **biotic index based on invertebrates** (including micro-crustaceans).	Medium	Year 1-2
7	Investigation into the feasibility of biotic metrics for use in wetlands during **dry conditions**.	Medium	Year 2 - 3
8	Development of a method to assess the cumulative impact of wetland loss at the **landscape level**.	Medium	Year 1- 2
9	Development of metrics to assess: i) **ecological sustainability** ii) **social sustainability** iii) **economic sustainability** of wetland use.	Medium	Year 2 - 3
10	Development of a metric to assess **socio-economic dependency** of communities on a given wetland.	Medium	Year 2 - 3
11	Desk-top investigation of the effect of rehabilitation on **vectors of disease.**	High	Year 2 -3
12	**Joint application of ecological assessment tools and socio-economic tools** to key wetland areas (preferentially at SAEON nodes).	High	Year 2 - 3
13	A protocol of the steps to be followed and the methods/tools to be used when undertaking **a resource-economics** study of wetlands.	High	Year 3
14	Based on the above, a **communication package for local authorities** to advise on valuing the benefits of wetlands in their area.	High	Year 3
15	An integrated **framework of wetland inventory, assessment and monitoring**, and a national database.	High	As soon as possible
16	A **communication strategy** for the WHI Research Programme, including standardised reporting of ecological condition and socio-economic importance.		Year 1 - 3

4. OTHER GAPS IN WETLAND SCIENCE IN SOUTH AFRICA

4.1 Recommendations for actions in areas other than WHI

During the course of the project, opinions were solicited as to the current major gaps in wetland science. This information is reported below with the research areas generally considered to be the most important placed towards the top of the list.

Recommendations that fall under the terms of reference of the Research Programme on "Wise use":

- The effect of land tenure (and changes therein) on the wise use and conservation of wetlands urgently needs to be investigated. This should link with work carried out under the "Wetland rehabilitation research programme" on the responsibilities/accountability of landowners with regard to wetland management.
- Indigenous knowledge of wetland functioning, benefits and wise use needs to be evaluated and preserved.
- A research project is required to assess the effectiveness of wetland conservation in this country. For example are DEAT/DWAF doing a satisfactory job and if not what are the major obstacles to attaining effective protection of these systems?
- Allied to the above is the need to review the existing laws and policy regarding wetlands, to establish if these are adequate, and the extent to which they are, or are not, being implemented. To some degree this aspect is being covered under the "Rehabilitation research programme".
- Mechanisms need to be developed whereby the benefits generated by wetlands can be distributed more evenly to society.

Recommendations that fall under the terms of reference of the Research Programme on "Rehabilitation":

- Evaluation of the effectiveness of the Working for Wetlands programme. (This is being addressed already).
- Assessment of the effectiveness of rehabilitation interventions (This is being addressed already).

Miscellaneous recommendations:

- Further basic research needs to be carried out on the organisms that are present in wetlands. This should include studies on their life-histories, identification and distribution with regard to different wetland types and ecoregions.

In addition, long-term environmental data should be collected at key wetland sites (e.g. at SAEON nodes).

- POSSIBLY: A national assessment of the total economic value of the wetlands in the country. This could be a follow-on activity to the DWAF National Resources Classification Project. Caution would be needed in this exercise because of the difficulty of valuing intangible benefits and the heterogeneity of South African wetlands.
- A strategy needs to be drawn up to ensure a systematic approach to the conservation of wetlands in South Africa.
- Fairly simple hydrological/hydraulic modelling software is required for use in individual wetlands.
- Further research into the links between surface and groundwater is required. Knowledge is also needed about the sources of water supplying wetlands in different areas, and in different wetland types.
- A deeper understanding of floodplain systems is required.
- Understanding/knowledge of water balance and sediment transport is required.
- Further research is needed in order to answer the question "What are the limits to the capacity of wetlands to purify effluents?"
- Investigation into the likely effects of global climate change on wetlands in this country.
- Sustainable use of wetlands. What are the thresholds beyond which exploitation will cause irretrievable damage?
- Optimal methods for establishing the recreational carrying capacity of wetlands need to be determined.

4.2 Conclusion

The actions that need to be taken to achieve the aims of the Wetland Health and Integrity Research Programme have been presented in this overview. Unfortunately, because of the legacy of neglect with regard to research and management of these aquatic resources, much work needs to be done. Although the proposed actions should go a long way towards enhancing conservation and management of wetlands, not everything could be covered and many areas still need attention.

Nevertheless, this research programme should lay down the important preliminary groundwork. It is hoped that the TOR represents a structured "action plan" and will focus attention in a rational way towards the areas that are most urgently required. We hope that research initiatives other than the proposed WHI programme can also be integrated and directed along the same paths so that the common goal of achieving maximum benefit from, and conservation of, wetlands is achieved.

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APPENDIX A: REPORT ON THE 7TH INTECOL INTERNATIONAL CONFERENCE ON WETLANDS

(25-30th July 2004, Utrecht, the Netherlands)

The Intecol conferences are the largest meetings of wetlands scientists on Earth. The latest one, in Utrecht, was attended by nearly a thousand delegates from countries as far afield as Finland and New Zealand, Cameroon and Cambodia, and Mexico and Malaysia.

Approximately 500 papers were divided into about seventy sessions, ten of which ran simultaneously. It was thus impossible even to meet all the delegates, let alone to attend all of the papers of interest. The arrangement of sessions was somewhat idiosyncratic so that sometimes parallel sessions dealt with similar topics. Thus although the conference was, in many respects, a huge success, it was - like most very large conferences - a little disappointing in other ways.

Keynote papers

Most of the six keynote papers, fairly predictably, dealt with broad issues (sustainable agriculture and wetlands; biogeochemistry of wetlands; plant survival in anoxic soils; conservation and management; restoration ecology). Remarkably, we still do not know exactly how it is that wetland plants can survive in completely anoxic soils or whether, in aggregate, wetlands are sources or sinks of greenhouse gases.

In his keynote paper on the biogeochemistry of wetlands, Dr Curtis Richardson of the Duke University Wetlands Center provided some interesting statistics derived from NASA: wetlands cover 3.6% of the Earth's total land surface area and contribute 6.3% of primary production, 29% of methane flux, 50% of denitrification, 3.8% of P flux, 9.4% of carbon storage and 2.6% of H_2 S production. On a smaller scale, the soils of the Netherlands are so saturated with nutrients from centuries of cattle production that the shallow edges of streams in that country emit measurable amounts of the nitrogen oxide greenhouse gases.

Professor Chengqing Yin of the Chinese Academy of Sciences in Beijing spoke of a still smaller-scale issue: the tiny village/pond/paddy systems of southern China, which are traditional ways of storing water, growing rice and raising fish. We were all captivated by his description of these highly effective, low-tech, environmentally friendly systems - and disappointed but not surprised to hear that so many of them are giving way to large-scale commercial paddy fields. We also learnt that 50% of the world's wetland surface area is given over to paddy fields.

Main themes and symposia

Although not explicitly indicated, most presentations dealt with one of three main themes: whether wetlands are sources or sinks of greenhouse gases like methane and nitrogen oxides; the restoration of wetlands; and the wise use and management of wetlands. Each is discussed briefly below.

Wetland biogeochemistry: fluxes of nutrients and gases

We/I had gone to the conference in the hopes of getting some concrete answers to the vexed question of whether wetlands are, by and large, sources or sinks of carbon. Alas, the jury is still out, because it turns out to be a very much more difficult question to answer than we had thought. Many papers dealt with aspects of biogeochemistry, examining the conditions under which carbon and nitrogen are sequestered and released from wetlands, particularly wetland sediments. Much of this work is being done on peatlands which, together with the tundra (mostly frozen wetlands) cover - or covered - vast tracts of the northern continents. We are still far from able to quantify the dynamics of these systems so no clear patterns are yet emerging. Instead, it is clear that temperature, the hydrological regime, nutrient levels and the degree of disturbance all have an effect on the balance between production and decomposition, and therefore on the fluxes

of methane and carbon dioxide, and nitrogen oxides. We still do not know, though, whether we can 'sell' wetlands to the politicians as parts of the problem or parts of the solution when it comes to global warming. The fact that warming itself, and the presence of increasing quantities of nutrients of anthropogenic origin, will alter the equilibria between sequestration and emission of carbon will be a further barrier to finding definitive answers.

Estuarine wetlands received particular attention, as did fens and sedge meadows, which are very common in northern temperate areas and sometimes support large numbers of plant species, thus contributing significantly to the biodiversity of the countryside. In contrast, apart from a number of papers on Lake Victoria and its associated swamps, tropical and African wetlands were not widely discussed.

Further sessions on global or ecosystem-wide issues included papers on palaeolimnology and other long-term changes in wetlands, and the effects of climate change itself. Finer-scale studies dealt with wetland sediments and water chemistry, and the microbial 'consortia' involved in nutrient cycling. Intriguingly, it seems that many (dozens?) of different bacteria can be involved in nutrient cycling, even in nitrogen fixation, in a single sample of wetland soil. We have no doubt that microbial ecology of wetlands will be a major topic of the future, both because of the significance of these interesting results for biodiversity, and because of the crucial functional role played by the microbial floras of wetlands.

The restoration and construction of wetlands

The second major theme that ran through the conference was the human manipulation of wetlands, both for the restoration of anthropogenically damaged ones, and for the construction or use of wetlands for treating water. These are very practical issues where wetland scientists, such as geomorphologists and ecologists, have to work together with social scientists and engineers if the intervention is to be successful. Restoration of landscape features, be they rivers or wetlands, is still at least as much of an art as it is a science and many of the papers were case studies of successful (or occasionally of unsuccessful) attempts at restoration.

Although, in contrast, the science behind the construction and operation of new 'artificial' wetlands for water treatment is developing rapidly and construction of treatment wetlands is becoming part of the armament of mainstream water engineers worldwide, most of the papers again dealt with case studies of individual schemes.

The wise use and management of wetlands

Perhaps surprisingly, there was not a great deal of emphasis on wetland management at this conference; the greatest number of papers in this field dealt with policy issues. Our paper was included in a session entitled 'Policy objectives, wise use and functional assessment' and dealt with approaches to setting water quality objectives for wetlands in South Africa. This was a description of some of the outcomes of a Water-Research-Commission-funded project looking at various aspects of the management of water quality in wetlands with regard to the requirements of the National Water Act of 1998. Some of the other sessions on this topic dealt with the effects of basin and floodplain management on wetlands.

A throwaway line by one of the key speakers referred to a totally unexpected consequence of a policy decision by the Canadian government and points to the interconnectedness of natural phenomena. It seems that the numbers of snow geese in Canada have increased by some 5% as a result of agricultural subsidies on bird flyways. One assumes that agricultural subsidies have resulted in an increase in the proportions of plants fed on by the geese.

Assessment techniques

Because the Freshwater Research Unit had been asked by the Water Research Commission to prepare a strategic overview of the research needs regarding wetland health and integrity,

especial attention was paid to talks and posters concerned with assessment of wetland ecological health or socio-economic importance. The abstracts for the papers and posters evaluated below can be found in Malan, Day and Marr (2005) "Assessment of wetland ecological health and socio-economic importance: an annotated bibliography".

Out of a total of over 500 papers and roughly 255 posters only 25 or so covered the topic of assessing wetland ecological condition or methods to evaluate the socio-economic benefits of wetlands. This is surprising, considering that at the 46th annual conference held by the International Association for Great Lakes Research (Michigan, 22nd-26th June, 2003) two special sessions on using indicators to assess lake ecosystems health were held, and considerably more than 27 papers were presented on the topic. A possible reason for this difference in emphasis could arise from the fact that the lakes conference was held in the USA, whereas the Intecol conference, although attracting delegates from all over the world had a high proportion of European delegates. The USA has directed extensive funding and effort towards wetland assessment (e.g. through the Biological Assessment of Wetlands Workgroup - BAWWG).

The 25 abstracts of papers or posters from the Intecol conference represent wetland assessment and valuation in a very broad sense. For example, several papers discuss environmental impact assessment and methods of predicting what the impact of rehabilitation/reconstruction activities will be on biodiversity and wetland functioning (DuBowy; Leuven *et al*.; Schutten). Another paper (Anderson *et al*.) describes how to assess the effectiveness of rehabilitation measures (or the creation of new wetlands in place of wetlands lost as a consequence of development - termed "mitigation" in the USA) once these activities have taken place. Another paper discusses a method for establishing the Reference Condition (i.e. conditions representing the un-impacted state) for flood-plains, with a view to aiding restoration measures (Tockner and Stanford).

Several papers assessed wetland condition by looking at wetland functioning in terms of hydrology, geochemistry, habitat, vegetation and landscape. The Hydrogeomorphic (HGM) approach was used to assess wetlands at the catchment scale (Whigham *et al*.). Portier *et al.* presented sensitive biogeochemical indicators of eutrophication in wetlands. Of special interest were the papers presented by Maltby *et al.* and Hogan *et al*. on the EU-funded project EVALUWET (European Valuation and Assessment tooL sUpporting Wetland Ecosystem legislaTion). This is a decision support system currently under development, which can be used to enable assessments to be made of potential gains and losses in a range of wetland functions interpreted in social and economic terms.

A special session was held at the conference on Environmental Water Requirements of wetlands. Most of these papers were not of direct relevance in that assessment was not the primary consideration. Ingram *et al.* (2004) however, used wetland bird abundance, diversity and reproductive success as indicators of environmental performance in response to a given hydrological regime. The bulk of the assessment posters and presentations discussed the use of biological organisms to assess ecological health (although, as opposed to the previous paper, not directly in response to setting environmental flows). Several faunal or floral groups were used as biological indicators including testate amoebae, vegetation biodiversity, beetles, crustaceans and aquatic insects, zooplankton propagules and leaf litter (and its rate of decomposition). Yet another paper (Tawfik) discusses assessment of anthropogenic impacts at the level of the individual organism, in that biomarkers of pollution effects in fish are described. Several papers emphasized that a wide range of aspects need to be assessed including physical and biological factors (Anderson *et al.*; Brooks *et al.*, Declerk).

Seven of the papers were concerned to a greater or lesser extent with socio-economic considerations of wetlands and how to value the benefits of wetlands to people (for example, Bene; Kim; Hogan *et al.*; Maltby *et al.*). Some of these appeared to be linked directly to assessment of ecological functioning, whilst others were not. Overall, although the number of

"assessment" papers was low, several were of relevance to a South African research programme on this topic.

Other topics

A number of sessions dealt with other issues such as hydrology; various aspects of modelling; invasive plants and animals; biodiversity; geomorphology; conservation; and geoinformatics including GIS.

Concluding remarks

The abiding irony of the conference, which concentrated so heavily on restoration of wetlands, is that it was held in the Netherlands. The Dutch have probably had more experience in draining and eliminating wetlands than any other people on Earth (after all, their country is no more than the estuary of the Rhine, one of the biggest rivers in Europe). Now they treat every remaining piece of wetland with great respect and spend vast sums of money in restoring even the smallest scrap of erstwhile wetlands that have been farmed fields for generations. The English have a similar response to the restoration of the fenlands of south-eastern England, which have been systematically drained for the last several hundred years. It has been estimated that in South Africa we have already destroyed about 50% of the aerial extent of our wetlands. It is to be hoped that we learn to protect the remaining ones, rather than having to restore them at some future time.

Papers/posters presented at the Intecol conference that covered the field of "wetland assessment" (abstracts given in Malan *et al. 2005*)

1. Abila, R.O. and Othina, A. A socio-economic assessment of Yala wetland fisheries (Kenya).
2. Anderson, J.T. and Balcombe, C.C., Fortney, R.H. and Kordek, W. Biotic response to wetland mitigation methods.
3. Bene, C. Can improved valuation techniques for aquatic ecosystems and fisheries lead to improved management?
4. Boix, D., Gascon, S., Sala, J., Martinoy, M., Gifre, J. and Quintana, X.D. QAELS & ECELS: tools to evaluate wetland quality.
5. Brooks, R.P., Wardrop, D.H. and Bishop, J.A. Integrating biological, physical, and landscape indicators for wetlands, streams, and riparian areas of the mid-Atlantic region.
6. Bullock, A. and Acreman, M. A re-assessment of the water quantity functions of wetlands.
7. Burgess, D., Jackson, N., Hadley, D., Turner, K., Georgiou, S. and Day, B. Assessing the value of a scientifically important wetland ecosystem: the case of the Culm grasslands.
8. Declerck, S. Aim and outline of the BIOMAN project. Patterns of biodiversity and community structure across trophic levels.
9. DuBowy, P.J. Performance measures, ecosystem benefits and habitat units: Evaluating Everglades restoration alternatives.
10. Haslam, S.M. The significance of water type in the assessment and management of wetlands.
11. Hogan, D.V., Pasley, R.S. and Maltby, E. Wetland functional assessment at the landscape scale.
12. Ingram, J., Patterson, N. and DesGranges, J.L. Lake Ontario-St. Lawrence river water level regulation review: Use of wetland breeding bird evaluation criteria within an integrated environmental response model.
13. Kim, K. Spatial and economic analytical tools for wetlands management.
14. Leuven, R.S.E.W., Geerling, G.W., Gerrits, S., Lenders, H.J.R., de Nooij, R.J.W. and Poudevigne, I. Cumulative effect assessment of physical reconstruction and land use changes on riverine biodiversity in floodplains.

15. Maltby, E., Thorne, R. and Chen, H. EVALUWET, WEDSS and the European WFD - Using functional assessment to enhance integrated water management.
16. Mitchell, E.A.D. and Charman, D.J. The usefulness of testate amoebae analysis in ecological and paleoecological studies of wetlands: past, present and future.
17. Pardo, M.T., Esteve, M.A., Martinez, J., Carreno, M.F., Serrano, J. and Gimenez, A. Ground beetles (Carabidae and Tenebrionidae) as bioindicators of habitat alteration on coastal wetlands of the Mar Menor Lagoon (SE Spain).
18. Portier, K.M., Corstanje, R. and Reddy, K.R. Multivariate selection of sensitive biogeochemical indicators of eutrophication.
19. Rinoveanu, G., Nistorescu, M., Ciubuc, C., Postolache, C., Popescu, C., Preda, E. and Vdineanu, A. Leaf litter breakdown rates as tool for assessing functional stream integrity: preliminary results from Romanian streams.
20. Schutten, J. Using wetland knowledge in ecological impact assessment.
21. Tawfik, M. A.A. Biomarkers in fish from polluted water.
22. Tockner, K. and Stanford, J.A. Biocomplexity of floodplains: Defining reference conditions.
23. Vandekerkhove, J., Brendonck, L. and De Meester, L. Biodiversity of zooplankton assessed from the dormant propagule banks.
24. Vickery, E. and Charman, D. Biomonitoring of peatland restoration using testate amoebae.
25. Whigham, D.F., Jacobs, A.D. and Weller, D. E. Using the hydrogeomorphic approach to assess wetlands at the watershed scale.

APPENDIX B: OUTCOMES OF A WORKSHOP HELD AT THE 5TH WATERNET/WARFSA CONFERENCE ON "WETLAND ASSESSMENT METHODS"

(Safari Court, Windhoek, Namibia, 3/11/04, 13.30 – 16.30 pm. Facilitated by Jenny Day, Heather Malan and Kate Snaddon of the Freshwater Research Unit, University of Cape Town).

Introduction

The general aim of the workshop was to establish what methods are currently being used in the Southern African region to assess the ecological condition and social importance of wetlands. This activity forms part of the requirements for the WRC-funded consultancy K5/1108 "Strategic overview of the research needs regarding wetland health and integrity". The aim was achieved by putting carefully-structured questions (listed below) to the delegates. The WATERNET/WARFSA conference was chosen as the venue for this workshop because it was considered to be a cost-effective way of accessing water resource professionals and students from most of the SADC countries.

The delegates

Twenty delegates attended, representing eight countries. The delegates were from a range of organizations including academic institutions (researchers and students), government institutions, private consultants and NGOs. The full list of delegates who attended and their contact details is given at the end of this report. Several members of the Namibian Wetlands Working Group were able to attend and gave very valuable input.

The questions posed

In order to structure the discussion, the following questions were put to the delegates. A summary of the major outcomes is given in the following section.

"Where should research effort be directed in order to be able to assess:

A. Wetland condition (biological integrity, ecological "health")

i) Are any methods currently being used (in SA, SADC, internationally) to assess aspects of wetland integrity ('health')?

ii) What aspects are being considered

- *habitat?*
- functional attributes e.g. hydrogeomorphic assessment, or the ratio of primary production:decomposition?
- *water quality?*
- *conservation status or importance?*
- *biodiversity?*
- *bioassessment using e.g.macrophytes, algae, macroinvertebrates, fish.*
- *indicators of historic wetland condition (indicators of the dry phase) such as diatoms/protozoa, or ostracods.*
- *other indices?*

iii) What wetland classification (typing) systems are being used?

iv) Are the methods adequate? If not, what areas need further research and development?

B. What are the major knowledge gaps in wetland science in southern Africa?

e.g. - a more detailed understanding of the responses of the biota to different water chemistries?
- a better understanding of the faunal groups found in different kinds of wetlands?
- more detailed wetland inventories?
- appropriate monitoring systems?

C. Assessment of the socio-economic importance of wetlands

How is socio-economic importance assessed in your country and how are the following considerations taken into account?

i) Assessment of actual value relative to some 'pristine' state?
ii) Assessment of potential value?
iii) What criteria?
iv) What indices?"

The outcomes

The major points that emerged from the discussions are as follows:

"Are any methods currently being used (in SA, SADC, internationally) to assess wetland ecological "health"?"

- No well-developed method is currently being used in the SADC region (apart from a simple method used in SA). However IUCN-ROSA/NEPAD should be contacted to ascertain what initiatives they are overseeing. A few projects are underway looking at different aspects of wetland condition.
- In Namibia fixed-point reference photos of wetland vegetation are being taken (10-15 years data available) to measure the change in size over time. In addition a chemical monitoring programme is in place. A project to look at floodplain systems will take place in the next few years - they will try to use a Namibian version of SASS/mini-SASS (NASS) as an assessment tool. Mapping of hydric soils and vegetation is being carried out for the Okavango system. NamWater record unicellular algae in the dam for eutrophication monitoring. Bird counts are carried out but no biotic index of wetland condition has been developed using these.
- In Zimbabwe, a PhD study is being carried out using remote sensing data to delineate wetlands (part of the CGIAR Challenge programme).
- In Uganda, wetland vegetation is used to map the extent of wetlands and to give a description of the wetland type. Conductivity and coliforms are measured as surrogates of overall water quality in some wetlands.
- In Tanzania, monitoring of the extent of surface water in wetlands is being carried out and will be compared with the historical extent.
- Most SADC countries tend to follow the guidelines provided by RAMSAR.
- Active biomonitoring using freshwater molluscs and various biomarkers is being carried out in SA on Rietvlei wetland (Victor Wepener, RAU).

"What are the major knowledge gaps in wetland science in southern Africa?"

- Sources of water to wetlands, surface water/groundwater interactions.
- Understanding of floodplain systems.
- Environmental flow requirements of ephemeral rivers and wetlands.
- Understanding/knowledge of water balance and sediment transport (Tanzania).
- Resource economics – putting a value on goods and services provided by wetlands.
- What are the limits to the capacity of wetlands to purify effluents?
- Likely effects of global climate change.

- Sustainable use of wetlands. What are the thresholds beyond which exploitation will cause irretrievable damage?
- Identification and knowledge of the organisms that live in wetlands.
- Indigenous knowledge of wetland functioning, which needs to be evaluated and preserved.

"Are any methods currently being used (in SA, SADC, internationally) to assess the socio-economic importance of wetlands?"

- Work has been done by Dr Jane Turpie on the valuation of the Caprivi wetlands.
- A new project is being initiated in the Okavango to evaluate the goods and services yielded by this system (contact person Glen Murray-Lang).
- Phase I of the project "Every river has its people" has been completed in Namibia and will now be extended to other parts of the country and Botswana, and Angola. A toolkit for socio-economic surveys has been developed (available from the Namibian Nature Foundation – Nadia Manning).
- Also in Namibia, work has been done on valuing the cost of replacing fish protein with beef (if a wetland were to be destroyed). Also the value generated per litre of water (e.g. mining generates 6c/litre, whereas tourism generates 20c/litre).
- Resource economics study completed for Malagarasi, Tanzania.

General points on resource economics

- There was general agreement that this is a very important field that needs to be expanded because it is a quick and effective way of informing decision makers as to the importance of wetlands.
- For all major wetlands, a cost-benefit analysis needs to be carried out to answer the question "Is the present use of the wetland the most valuable way of using it?"
- Not only direct economic values but also intangible or potential values need to be taken into account, recognizing that some aspects cannot easily be assigned a monetary value.
- The catchment-wide value of wetlands in the landscape, and not just of individual systems needs to be assessed.
- Multiple-use of wetlands usually generates more income than single use.
- The location of a wetland affects the value e.g. wetlands close to a town could be a source of malaria-causing mosquitoes.
- It is important to recognize that the value of a wetland may change over time.

Conclusions

Before the workshop it was suspected that very little work was being carried out in the SADC region on assessing the ecological health of wetlands – and this supposition was confirmed by the delegates at the conference. The pressing need for assessing the socio-economic value of wetlands was also emphasised and it would appear that several large projects of this nature are currently underway, or have been completed, in the region. It does not appear that the needs of other SADC countries for wetland assessment methods are markedly different to those identified in South Africa.

Perhaps the main achievement of the workshop was that it acted as a focal point for specialists interested in wetlands in the SADC region. At the request of the delegates, an email distribution list has been setup and an informal WATERNET wetland interest group has been established.

PARTICIPANTS IN THE WATERNET/WARFSA WETLAND ASSESSMENT WORKSHOP, WINDHOEK

SURNAME	INITIALS	FIRST NAME	ORGANISATION	COUNTRY
Bethune	S	Shirley	Dept. Water Affairs	Namibia
Day	J	Jenny	University of Cape Town	South Africa
Jonker	L	Lewis	University of Western Cape	South Africa
Juizo	D	Dinis	Eduado Mondlane University	Mocambique
Kansiime	F	Frank	Makerere University, IENR, Kampala	Uganda
Malan	H	Heather	University of Cape Town	South Africa
Manase	G		Institute of Water	Zimbabwe
Mayo	A.W.		Dept. Water Resource Engineering, University of Dar es Salaam	Tanzania
Meck	M		University of Zimbabwe	Zimbabwe
Msilimba	G		Geography Dept. Mzuzu University	Malawi
Mthimkhulu	S	Sindy	Water Resources Branch	Swaziland
Mwanukuzi	P		University of Dar es Salaam	Tanzania
Nashipili	N	Ndina	Dept. Water Affairs	Namibia
Njau	K.N		Dept. Chemical & Process Engineering, University of Dar es Salaam	Tanzania
Ravengai	S	Seedwel	University of Zimbabwe	Zimbabwe
Roberts	K	Kevin	Dept. Water Affairs	Namibia
Schachtschneider	K	Klaudia	University of Cape Town	Namibia/South Africa
Similabwi	A	Alex	GWP-SA, Harare	Zimbabwe
Snaddon	K	Kate	University of Cape Town	South Africa
Tirivarombo	S		Chinhoyi University of Technology	Zimbabwe

APPENDIX C: OUTCOMES OF THE JOINT DWAF/WRC WORKSHOPS ON "WETLAND ASSESSMENT METHODS"

(Water Research Commission, 491 18th Avenue, Rietfontein, Pretoria. Facilitated by Dr Mandy Uys, Laughing Waters (16th Feb) and Prof Jenny Day, Freshwater Research Unit, University of Cape Town (17th Feb)).

Introduction

Two back-to-back workshops were held. The first considered biological and functional assessment of wetlands. The second workshop, held on the following day, considered assessment of the socio-economic importance of wetlands.

The aims of the workshops were as follows:

- To find out what work has already been carried out in South Africa with regard to assessing wetland ecological condition, habitat integrity, the value of "goods and services" provided by individual wetlands, and socio-economic importance.
- To establish what "tools" are currently available or are under development.
- To identify what techniques show the best potential and are therefore worth developing further and in particular to prioritise the biological variables that should be used and developed into a biotic index.
- To ensure integration between DWAF, WRC, Working for Wetlands and Mondi Wetland Project with regard to assessment of wetland condition and socio-economic importance.
- To agree on the terminology that should be used.
- To identify the major gaps in wetland science in South Africa (other than assessment techniques).

The proceedings of the workshops were used in designing the TOR for the Wetland Health and Integrity (WHI) Research Programme directed at producing the optimal tools required for

- Assessment of the ecological condition of wetlands.
- Assessment of the social and economic importance.

See attached list of attendees for each workshop (end of document).

Opening presentations

Prof Day first identified two useful sources of information on wetland assessment techniques that have recently been completed. The first is a report compiled by Dr Mandy Uys (DWAF 2004) which is a review of the methods used in South Africa and internationally to assess wetland ecological condition. This was identified as an invaluable contribution and the recommendations included in the report were used as a "strawdog" in the second half of the workshop. The second document was the annotated bibliography of wetland assessment techniques (Malan, Day, and Marr, 2005).

The major tools that are currently in use for assessing wetland condition are as follows.

1) The ecological importance and sensitivity (EIS) method of Kleynhans *et al*. – adapted from rivers, currently used for RDM activities, including wetlands (DWAF 1999).

2) Wetland–Assess (Kotze *et al.* 2004) which is a method for rapidly assessing the functions performed by a given wetland by assigning scores to each function.

3) Wet-Health (Macfarlane *et al. in prep)* which is an approach that assesses the impacts on a wetland.

4) The use of macrophytes/soil moisture/hydromorphic soils (Marneweck, Wetlands Consulting Services).

5) A method developed by Dr Bill Harding (WAP/WETRAM).

In addition there are various initiatives which are aimed at classifying ("ecotyping") wetlands.

Presentations were given on Wetland-Assess (Wet-Ecoservices) by Donovan Kotze, on Wet-Health by Douglas Macfarlane and on some of the findings in the literature review (DWAF 2004) by Mandy Uys.

Terminology

Dr Uys led a discussion on the terminology that is/should be used with regard to wetland assessment. Definitions for terms such as inventory, classification and assessment were presented. These definitions are discussed in DWAF (2004).

Comments on assessment methods

Many of the major conclusions have already be captured elsewhere in the strategic overview and are not duplicated here. Short discussions on the merits and disadvantages of each faunal/floral group were presented based largely on the findings of DWAF (2004).

- It may be possible to develop a simple index for water quality based on arthropods/ostracods/micro-crustaceans. Using families, or even classes can give information about different types of wetlands in terms of water quality or hydrological regime (e.g. acid, very saline, temporary/permanent).
- Plants appear to be the most promising of the biotic groups for development of a biotic index, but several different metrics will be required.
- Invertebrates show potential as bioindicators for wetlands but need further research. They cannot be used when systems are dry, however, so other metrics are also required. Doubt was expressed as to whether a simple tolerance rating score (as used in SASS) would work for wetlands.
- Frogs may eventually be useful as bioassessment tools but extensive research would first be needed. There is a lack of basic knowledge of amphibian ecology in this country, and populations tend to be very variable depending on the time of year and prevailing climatic conditions.
- Similarly, Working for Wetlands uses a structured approach when prioritizing wetlands for rehabilitation. They also need and will be developing tools to assess the effectiveness of rehabilitation measures. There needs to be coherence between the tools used by Working for Wetlands and the assessment methods developed in the research programme.
- Work has been carried out by Barrie Low (Coastec, Cape Town) on using plants and soils to assess wetlands. This work needs to be evaluated.
- Guides and lists of wetland plant species need to be compiled for all ecoregions. Furthermore a photographic guide to the freshwater algae of South Africa needs to be compiled.
- International keys have been compiled of diatoms which are cosmopolitan species and therefore regional-specific keys are unnecessary. Diatoms have been used to assess water quality in rivers. Species level identification is optimum and they are useful for establishing reference condition (paleoconditions). The Diatom Assessment Protocol (Harding, W., DHE Consulting) is being developed using the SA Diatom Collection as a basis. The DAP will have a much higher resolution than SASS (i.e. it will be more than a screening tool).
- Birds can be useful for assessment of ecological condition under some, but not all circumstances. A bird index would require long-term, data and can only be used in wetlands where there is open water. They do, however, show potential for assessments over a large-spatial scale. Birds are iconic and capture the imagination of the general public.

- Active biomonitoring should be considered as a tool for monitoring wetlands (but this needs further research).
- The Hydrogeomorphic approach used in USA can be very useful when considering the cumulative importance of wetlands in a catchment.
- Irreplaceability, and cumulative loss of a particular wetland type needs to be factored into assessments of ecological importance and sensitivity, as well as habitat diversity. There is a possibility of copying the strategy of biodiversity conservation planning that is currently being carried out for rivers and extending it to wetlands.
- Different methods may be required for assessment in Comprehensive Reserve Determination studies, to those used for on-going monitoring.

Socio-economic importance

- Wetland-Assess (Wet-Ecoservices) requires evaluation as the platform for wetland resource economics studies but it appears to be a very useful beginning.
- On-going changes in wetland condition are likely to occur and it is important that these be noted and monitored.
- Indices of wise use including an assessment of the sustainability of use, the dependency of communities on wetlands, and the effectiveness of governance are required.
- Changes in land tenure and the effect on wetland wise-use was identified as an area that urgently requires attention.
- When developing indices of community dependence on wetlands, the number of alternative livelihood strategies needs to be taken into account, including the adaptability of communities.
- It is important to ask for input from communities who are directly dependent on a wetland. They usually have an intimate knowledge of the system and can detect changes in condition.
- Guidance (protocols) will be needed to tell wetland scientists and managers what assessment tools can be used and when.
- There is much confusion with regard to what laws apply to wetlands, and the role of the various government departments in managing them. There appears to be major gaps in the legislation. Communication tools need to be developed to advise in this regard.
- The goods and services produced by wetlands need to be considered at the macro-scale, not just the micro-scale in order to make rational decisions around planning.

General comments

- In general, there should be improved integration of efforts directed towards wetland conservation. For example, there should be collaboration with the FETWATER (Further Education and Training in the Water Sector) wetlands network, and with other agencies identified in DWAF (2004).
- Methods for delineating wetlands need to be standardised – although preliminary steps are now being taken to achieve this (DWAF 2003).
- The way and format in which wetland assessment metrics will be presented needs to be formalised and standardised.
- We need to identify for each wetland type and each ecoregion, which are reference wetlands (i.e. minimally impacted). These can then be used to compare aspects of other wetlands (e.g. biodiversity, functions). It is very important that urban and rural wetlands are considered differently. The functions/importance of urban wetlands may be very different from that of rural but are just as worthy of protection.
- A multi-disciplinary task team is required to study a few wetlands in detail (including socio-economic aspects) and various indices developed. This is important because there is a general paucity of data for wetlands concerning all aspects. From detailed studies it should be possible to extrapolated to other data-poor wetlands that are of a similar type.

- Peatlands are increasingly coming under threat from commercial mining of peat. Tools are required to carry out economic valuation of the ecosystem services offered by this type of wetland in comparison to the short-term value of the mined peat. For peatlands and wetlands in general there is a need to evaluate the benefits to the immediate land-owner in comparison to the overall public benefit of the resource. In some cases it may be wiser on the broad scale to pay the landowner out.
- Work is being done (Peter Goodman *pers. comm.*, SAWAG 2004) using software (C-plan) to prioritize wetlands and estuaries with regard to biodiversity. This could be useful in designing assessment tools.
- A national project to put a value on all the goods and services produced by wetlands might be beneficial in raising awareness of their importance. There is however a danger that the heterogeneity will be under-estimated. Also wetlands are not easy to value because of the many kinds that are found.
- Wetlands are important for protecting downstream dams from siltation and this should be taken into account in resource economic studies.

Gaps in wetland science

The perceived gaps in wetland science that were identified at this workshop and from other sources are listed in Chapter 4.

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