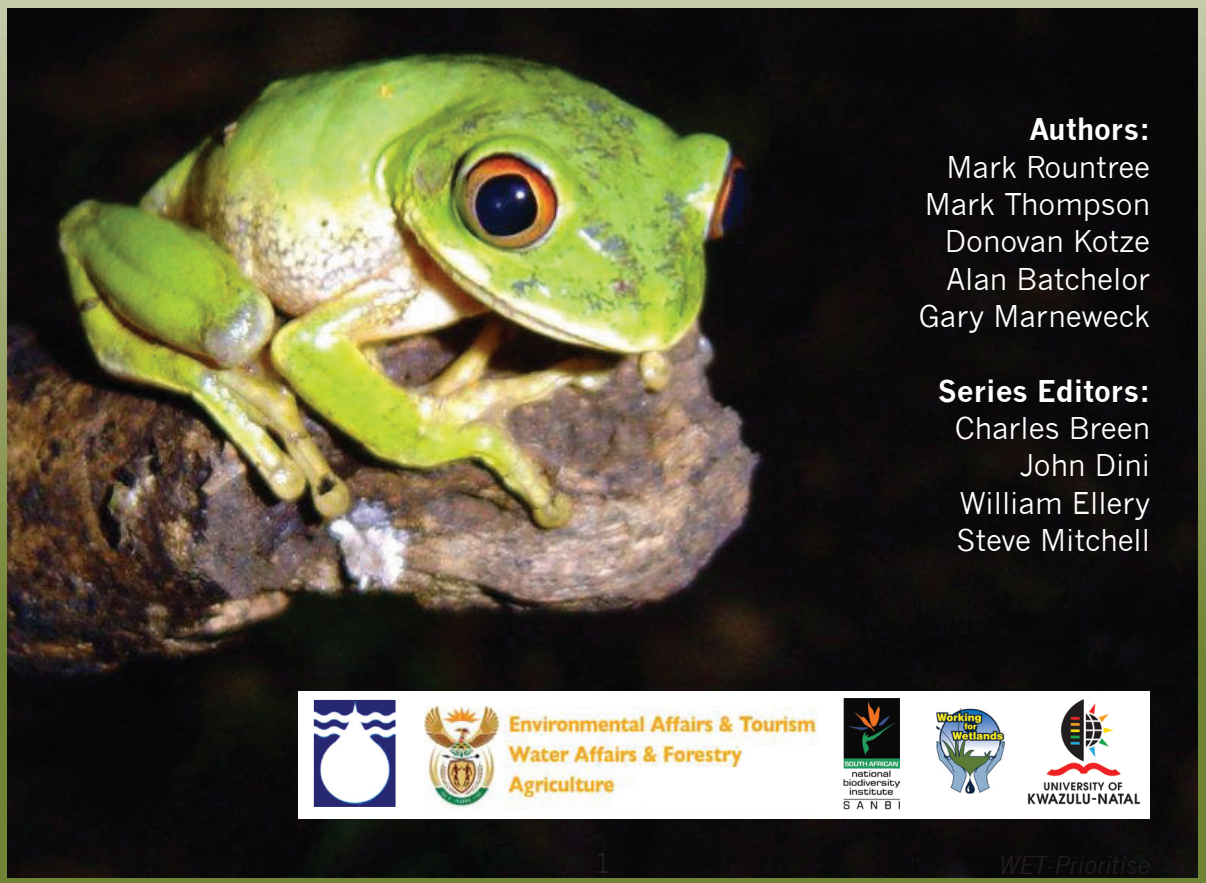
Wetland Management Series

WET-Prioritise

Guidelines for prioritising wetlands at national, regional and local scales

WRC Report TT 337/09
March 2009



Authors:
Mark Rountree
Mark Thompson
Donovan Kotze
Alan Batchelor
Gary Marneweck

Series Editors:
Charles Breen
John Dini
William Ellery
Steve Mitchell

Environmental Affairs & Tourism
Water Affairs & Forestry
Agriculture

SOUTH AFRICAN national biodiversity institute SANBI

Working for Wetlands

UNIVERSITY OF KWAZULU-NATAL

Obtainable from:

Water Research Commission
Private Bag X03
Gezina
0031

The publication of this report emanates from a project entitled: *Wetlands Research Programme: Wetland Rehabilitation* (WRC Project No. K5/1408)

WRC Report TT 337/09

ISBN 978-1-77005-636-7

Set No 978-1-77005-631-2

Printed in the Republic of South Africa

Authors:

Mark Rountree
Mark Thompson
Donovan Kotze
Alan Batchelor
Gary Marneweck

Series Editors:

Charles Breen
John Dini
William Ellery
Steve Mitchell
Mandy Uys

Front cover: A colour composite image produced from the visible bands 1, 2 and 3 of a Landsat 7 ETM+ image taken on 7 May 2001, showing a portion of the iSimangaliso Wetlands Park that is internationally known for the wide diversity of freshwater, estuarine and marine wetlands within its boundary.
Image processing: Frank Sokolic

Inside front cover: Boneberg's frog (*Natalobatrachus bonebergi*), commonly known as *Ngoye* frog, is a threatened endemic species along the coastal region of KZN.
Photograph: Errol Douwes

Preface: Background to the *WET-Management* Series

The need for wetland rehabilitation in South Africa is compelling: loss and degradation of wetlands have been great and national policy and legislation provides clear direction and support for rehabilitation. However, rehabilitating wetlands is often complex because wetlands and their links with people are complex (e.g. through the ways that people use wetlands and the different benefits that people receive from the ecosystem services that wetlands supply). Thus, a series of tools has been developed to assist those wishing to undertake wetland rehabilitation in a well-informed and effective way (Box 1P).

These tools were developed as part of a comprehensive nine-year research programme on wetland management which was initiated in 2003 by the Water Research Commission (WRC) and a range of partners that examines wetland rehabilitation, wetland health and integrity and the sustainable use of wetlands. The rehabilitation component, which was co-funded by the WRC and the Department of Environmental Affairs and Tourism, through the Working for Wetlands (WfWetlands) programme, was prioritised to take place first because of the need to provide a firm scientific and technical foundation for the extensive rehabilitation work already underway.

The Working for Wetlands Programme is a national initiative that seeks to promote the protection, rehabilitation and wise use of wetlands in South Africa. As part of this initiative, WfWetlands has a national programme for the rehabilitation of wetlands, including a structured process of prioritising rehabilitation sites and supporting their rehabilitation. At the same time, however, it is acknowledged that sustainable use of wetlands in the long term can be achieved only through the dedicated participation of civil society, whose wetland interests may have a strong local focus. Thus, the tools have been developed in such a way that they can be applied outside of the Working for Wetlands Programme, and without having to engage the process of national or provincial prioritisation should the user not desire to do so. Even so, the tools encourage local wetland rehabilitation efforts to strengthen links with the national initiative and the opportunity this provides for fruitful partnerships.

The series consists of a roadmap, two background documents, eight tools and an evaluation of the success of six individual projects (Box 1P). From Table 1P it can be seen that some of the tools (e.g. *WET-RehabMethods*) are designed to be used by those dealing specifically with wetland rehabilitation and its technical requirements. Other tools (e.g. *WET-Health*) have much wider application such as assessing impacts associated with current and future human activities in Environmental Impact Assessments or assessing the Present Ecological State of a wetland in an Ecological Reserve Determination.

One can locate the tools in terms of some basic 'who', 'what', 'where' and 'how' questions that any team undertaking wetland rehabilitation should be asking (Table 2P). Furthermore, each of the tools can be used individually, but there are close links between them (Figure 1P).

Box 1P: Overview of the *WET-Management* Series

The series includes documents that provide background information about wetlands and natural resource management, tools that can be used to guide decisions around wetland management, and an evaluation of rehabilitation outcomes in a number of case studies.

WET-Roadmap

WET-Roadmap provides an introduction to the *WET-Management* tools and includes:

- A brief outline of the documents and tools in the *WET-Management* series and how they inter-relate
- An index of wetland rehabilitation related terms
- Reference to specific sections in the relevant tools.

WET-Origins

WET-Origins describes the remarkable geological and geomorphological processes that give rise to wetlands in South Africa, and provides a background description of:

- The geology, geomorphology, climate and drainage of southern Africa
- An introduction to wetland hydrology and hydraulics
- Geomorphic controls on different wetland types
- Wetland dynamics due to sedimentation and erosion.

It incorporates this understanding into a methodology that can be used to help develop insight into the hydrological and geomorphological factors that govern why a wetland occurs where it does, which is useful when planning rehabilitation.

WET-ManagementReview

WET-ManagementReview has four parts:

1. An assessment of effectiveness at programme level, including:
   - a national overview of land-uses affecting the status of wetlands and the institutional environment that affects wetlands.
   - an overview of 5 natural resource management programmes affecting wetlands and their impact in different land-use sectors; Working for Wetlands, Working for Water, LandCare, the Crane Conservation Programme of the Endangered Wildlife Trust, and the Mondi Wetlands Programme.
2. An assessment, using the *WET-EffectiveManage* tool, of the management effectiveness of 21 wetland sites in a variety of different land-use and land-tenure contexts.
3. An assessment of stakeholder participation in wetland rehabilitation at six wetland sites.
4. A framework for assessing the effectiveness of collaboration between partners, described and applied to a site where a rehabilitation project has been underway for several years.

WET-OutcomeEvaluate

WET-OutcomeEvaluate is an evaluation of the rehabilitation outcomes at six wetland sites in South Africa, including an evaluation of the economic value of rehabilitation. The six sites are:

1. Killarney Wetland
2. Manalana Wetland
3. Kromme River Wetland
4. Dartmoor Vlei
5. Kruisfontein Wetland
6. Wakkerstroom Vlei.

WET-RehabPlan

WET-RehabPlan offers a process that can be followed to develop comprehensive wetland rehabilitation plans. It has three main elements:

- Introduction to rehabilitation, planning and stakeholder involvement.
- General principles to follow in planning wetland rehabilitation.
- Step-by-step guidelines for undertaking the planning and implementation of wetland rehabilitation at a range of scales from national/provincial to catchment to local. It directs the user to the right tools and sections at appropriate points in the rehabilitation process.

Good planning ensures a rational and structured approach towards rehabilitation as well as a clear understanding of the reasons for rehabilitation, the actions and interventions required, and the benefits and beneficiaries.

WET-Prioritise

WET-Prioritise helps to identify where rehabilitation should take place once the objectives of rehabilitation are identified. It works at three spatial levels. At national and provincial level, an interactive GIS modelling tool assists in identifying priority catchments by evaluating a range of scenarios, based on different combinations of 13 socio-economic and bio-physical criteria (e.g. Biodiversity Priority Areas, High Poverty Areas). Once a catchment is selected, the tool helps to identify areas for rehabilitation within that catchment. Finally, individual wetlands are selected based on the predicted cost-effectiveness and sustainability of rehabilitation.

WET-Prioritise provides step-by-step guidelines applicable at all three spatial scales, including:

- Identifying objectives and an appropriate scale.
- Developing prioritisation criteria.
- Applying the criteria, usually in a two step process of rapidly screening all candidate sites to arrive at a preliminary set of sites, from which individual priority sites are selected.

Three case examples of prioritisation are described.

WET-Legal

WET-Legal presents South African legislation that is relevant to wetland rehabilitation, including the Conservation of Agricultural Resources Act (CARA), National Environmental Management Act (NEMA), and National Water Act (NWA), as well as relevant international agreements such as the Ramsar Convention on Wetlands. *WET-Legal* lists the environmental impacts potentially associated with typical wetland interventions and the legislative provisions that apply to each of these impacts. It also covers laws compelling rehabilitation and the legal responsibilities of different parties involved in rehabilitation.

WET-EcoServices

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision-making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

WET-Health

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, *WET-Health* helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. *WET-Health* is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland for purposes of Ecological Reserve determination in terms of the National Water Act, and for environmental impact assessments. There are two levels of complexity: Level 1 is used for assessment at a broad catchment level and Level 2 provides detail and confidence for individual wetlands based on field assessment of indicators of degradation (e.g. presence of alien plants). A basic tertiary education in agriculture and/or environmental sciences is required to use it effectively.

WET-EffectiveManage

WET-EffectiveManage provides a framework that can be used to assess management effectiveness at individual wetlands based on 15 key criteria (e.g. the extent to which a regularly reviewed management plan is in place for the wetland). A scoring system is provided for rapidly assessing the criteria. This tool is Chapter 2 in the *WET-ManagementReview* manual.

WET-RehabMethods

WET-RehabMethods is used to guide the selection and implementation of rehabilitation methods that are appropriate for the particular problem being addressed and for the wetland and its catchment context. It provides detailed practical rehabilitation guidelines for inland palustrine wetlands and their catchments, and focuses particularly on wetlands associated with natural drainage networks. It can be adapted to meet specific needs. Some aspects of the tool require high levels of civil engineering expertise, but it is designed primarily for rehabilitation workers who have completed training in soil conservation, life sciences or engineering at a diploma level or higher, and who have practical field experience.

WET-RehabMethods includes the following:

- Key concepts relating to wetland degradation, particularly those

resulting from erosion.

- Guidelines for the selection of an appropriate type of rehabilitation intervention (including both 'soft' and 'hard' engineering options).
- Detailed guidance, provided for designing a wide variety of intervention types (e.g. determining an adequate spillway to account for runoff intensity).
- Detailed guidance provided for the implementation of the different intervention types.

WET-RehabEvaluate

WET-RehabEvaluate is used to evaluate the success of rehabilitation projects, and is designed with the understanding that monitoring and evaluation are closely tied to planning, which, in turn, should accommodate monitoring and evaluation elements. *WET-RehabEvaluate* provides the following :

- Background to the importance of evaluation of wetland rehabilitation projects.
- Step-by-step guidelines for monitoring and evaluation of rehabilitation projects, both in terms of project outputs and outcomes. The outcomes are based on system integrity and the delivery of ecosystem services, and results from *WET-Health* and *WET-EcoServices* are therefore included. The guidelines include: review project objectives, identify performance indicators and standards, develop and implement a monitoring and evaluation plan, evaluate and report on performance.

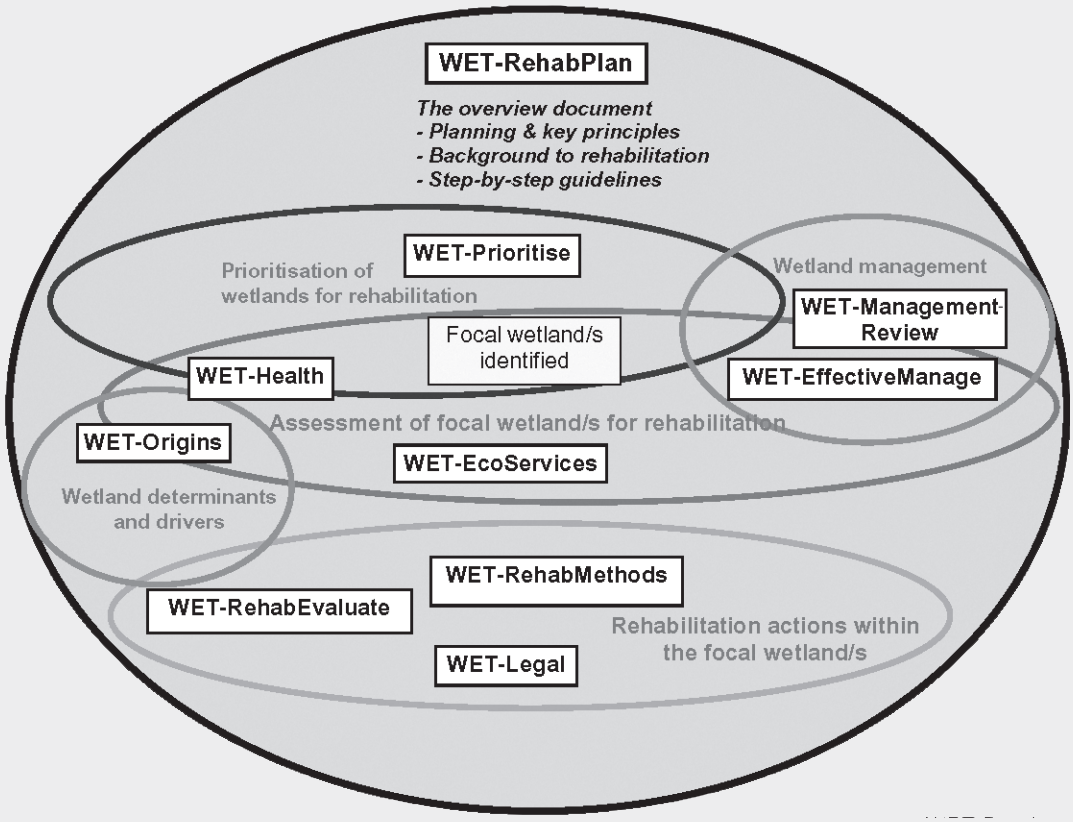


Figure 1P: How do the *WET-Management* tools relate to each other in a rehabilitation context?

Table 1P: Likely relevance of the background reading and tools in the *WET-Management* series to a variety of different potential uses

Potential users	*WET-Origins*	*WET-Management - Review*	*WET-RehabPlan*	*WET-Prioritise*	*WET-Effective-Manage*	*WET-Legal*	*WET-Rehab-Methods*	*WET-Eco-Services*[1]	*WET-Health*[2]	*WET-Rehab-Evaluate*
Rehabilitation planning - wetland specialist										
Rehabilitation planning - engineer		Part 1	Step 5							
Rehabilitation programme coordination - *national*										
Rehabilitation programme coordination - *provincial*										
Rehabilitation implementation			Step 5							
Impact assessment		Part 1						Level 1	Level 2	
Wetland management										
Ecological Reserve Determination - DWAF officials & consultants		Part 1						Level 1	Level 2	
Catchment planners - CMAs and others		Part 1								
Broad-scale biodiversity conservation planning		Part 1								

The tool is likely to have some relevance

The tool is likely to have a very high level of relevance

[1] *WET-EcoServices* is of particular relevance in determining the Ecological Importance and Sensitivity (EIS) of a wetland.

[2] *WET-Health* is of particular relevance ino determining the Present Ecological State (PES) of a wetland.

CMA = Catchment Management Agency
DWAF= Department of Water Affairs and Forestry

Table 2P: Rehabilitation-related questions typically posed at different spatial levels, and the tools most relevant to assisting the user in answering each question

Common questions	Tool/s likely to be relevant in addressing the question
Questions that might typically be asked at the national or regional level	
What is causing the degradation of wetlands?	*WET-Health* (Level 1) & *WET-ManagementReview*
Which are the most important wetlands?	*WET-Prioritise* & *WET-EcoServices* (Level 1)
Which wetlands should we rehabilitate?	*WET-Prioritise*
How should wetland rehabilitation be integrated within broad-scale catchment management?	*WET-Prioritise* & Dickens *et al*. (2003)
Questions that might typically be asked at the local level	
How effectively is the wetland being managed?	*WET-EffectiveManage*
What is causing the degradation of the wetland?	*WET-Health* (Level 2)
Is the wetland in need of rehabilitation?	*WET-Health* (Level 2) & *WET-Origins*
How do I decide what rehabilitation interventions will be appropriate for meeting my rehabilitation objectives?	*WET-RehabPlan* (Step 5F) & *WET-RehabMethods*
What are specific technical considerations I must make when designing a rehabilitation intervention?	*WET-RehabMethods*
Will the planned project be legally compliant?	*WET-Legal*
How do I evaluate my rehabilitation project?	*WET-RehabEvaluate*
Who should be involved in the rehabilitation project?	*WET-RehabPlan*
How do I align my rehabilitation project with catchment-, regional- or national-level programme/s?	*WET-RehabPlan* & WfWetlands Strategy (Working for Wetlands, 2005)

The National Water Act defines wetlands as:

'....land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils.'

This is the definition used by the *WET-Management* Series.

Summary of *WET-Prioritise*

There are tens of thousands of wetlands in South Africa, and in situations where there are numerous possible points of intervention or study, prioritisation is required when the necessary resources are insufficient to target all sites simultaneously (Leibowitz, 2002). Prioritisation procedures thus allow for identification of the highest-priority sites for intervention, so that the limited resources can be directed most appropriately and with the maximum impact.

The word 'prioritisation' implies ranking or valuing one above another such that those with a higher rank or value are by definition regarded as more important than those with a lower rank or value. The ranking or value ascribed per resource or wetland unit would be highly dependent on the objectives of the prioritisation process being undertaken.

The *WET-Prioritise* tool is a suite of procedures for identifying and prioritising catchments and wetlands which match particular objectives, be they for rehabilitation, conservation or monitoring activities. The procedures provide an iterative, spatially-nested approach to collecting data, screening and prioritising and verifying the identified wetlands or catchment areas. The actual prioritisation process adopts a seven-step approach:

Step 1: Define the aims and objectives of the prioritisation project
Step 2: Identify the spatial extent of the study area (the spatial scale of the assessment determines which specific information and protocols can be used)
Step 3: Collate available information
Step 4: Develop prioritisation criteria
Step 5: Screen for candidate catchments
Step 6: Prioritise catchments
Step7: Assess the potential of prioritised catchments to meet the objectives

These seven steps can be used at different spatial scales. At a national or provincial scale they can be used to prioritise tertiary level catchments, at a regional scale they can be used to prioritise quaternary catchments and at a local spatial scale they can be used to prioritise individual wetlands, or clusters of wetlands. This prioritisation process can be done in an iterative manner, starting at a national level and working through the seven steps, then proceeding in the same manner through the seven steps at the regional level, and then using the same steps at a local level as well.

Although the procedure is presented as a largely top-down approach (i.e. starting at a national or provisional level), the design of the prioritisation procedure is such that it allows multiple points of entry, which depend on the spatial scale of operation. Thus, whereas national or provincial bodies (government departments or NGOs) that operate at the regional to national scale may focus on prioritisation of quaternary catchments within a focal tertiary catchment, more localised government sectors (e.g. municipalities) and specific conservation groups or landowners may initiate prioritisation procedures at a more localised level, such as prioritising individual wetland systems within a focal quaternary catchment.

These seven steps of the *WET-Prioritise* tool provide a framework for rationalising the many possible sites for wetland rehabilitation or other activities in order that priority areas for intervention (i.e. those that would maximally benefit) are identified. The *WET-Prioritise* procedure has application in wetland rehabilitation, wetland conservation and wetland reserve projects. Case studies for a variety of projects demonstrating the applicability of the tool for a variety of projects are provided to illustrate the application of the tool.

Acknowledgements

The Water Research Commission (WRC), the South African National Biodiversity Institute (SANBI) and Working for Wetlands (WfWetlands) are gratefully acknowledged for funding the development of this tool. The research programme was managed by Fred Ellery of the University of KwaZulu-Natal (UKZN) who was ably assisted by Kerry Philp.

Several individuals are thanked for providing valuable feedback and inputs into earlier drafts, in particular Fred Ellery, University of KwaZulu-Natal, Charles Breen of the Institute of Natural Resources, University of KwaZulu-Natal, and Mandy Uys of Laughing Waters. Karen Ellery provided substantial editorial input during the production of this document.

Citation

The correct citation for this document is:
Rountree MW, Thompson M, Kotze DC, Batchelor AL, and Marneweck, GC, 2009. *WET-Prioritise: Guidelines for prioritising wetlands at national, regional and local scales.* WRC Report No. TT 337/09. Water Research Commission, Pretoria.

Feedback

In South Africa the rehabilitation of wetland ecosystems is still in its infancy. In order to promote the growth of this activity, this manual may need to be revised by including the experiences of those individuals involved in wetland rehabilitation. Any comments or advice can be sent to:

Mark Rountree
Fluvius Environmental Consultants
E-mail: mark.rountree@iburst.co.za

OR

Donovan Kotze
University of KwaZulu-Natal
E-mail: kotzed@ukzn.ac.za

OR

Mark Thompson
Environmental Remote Sensing Applications
GeoTerraImage (GTI) (Pty) Ltd
E-mail: mark.thompson@geoterraimage.com

TABLE OF CONTENTS

1 BACKGROUND TO *WET-PRIORITISE*

1.1 Envisaged users of this manual

The methods and guidelines contained in this document are intended to assist with the selection of priority catchments and priority wetlands. The aim is to develop a structured, yet relatively simple, approach for prioritising wetlands based on the:

- use of currently available data-sets at the catchment-level (for prioritising amongst catchments)
- development of new procedures for assessing and prioritising wetlands within priority catchments.

The protocol provides a rational and structured approach for wetland prioritisation, using a seven-step process and a suite of available selection criteria. The procedure was designed to be used in a top-down manner to enable national or provincial governments to prioritise funding for wetland-rehabilitation efforts (Figure 1). However, the design of the prioritisation procedure is such that it allows multiple entry points, depending on the spatial scale of operation (Figure 2). This enables local or regional initiatives to make use of these prioritisation procedures, whether it be to provide focus for their own regional initiatives, or to provide local or regional context for their focal wetland-system.

The *WET-Prioritise* procedure thus allows for the identification of priority areas, from identifying focal tertiary catchments at the national or provincial level, down to identifying priority quaternary catchments and the individual wetland-systems within these. The appropriate guidelines and tools that are used are determined by the spatial scale of management, or the extent of jurisdiction or the interest of stakeholders.

The envisaged primary users of these guidelines are at present the staff of the Working for Wetlands (WfWetlands) programme, and the development of these methods and guidelines has been designed for their ease of use. This procedure will facilitate the Working for Wetlands programme in selecting priority catchment-areas and priority wetland-sites for rehabilitation activities, as well as regional wetland-conservation planning. The prioritisation procedure also has potential for application to the DWAF's wetland reserve methods.

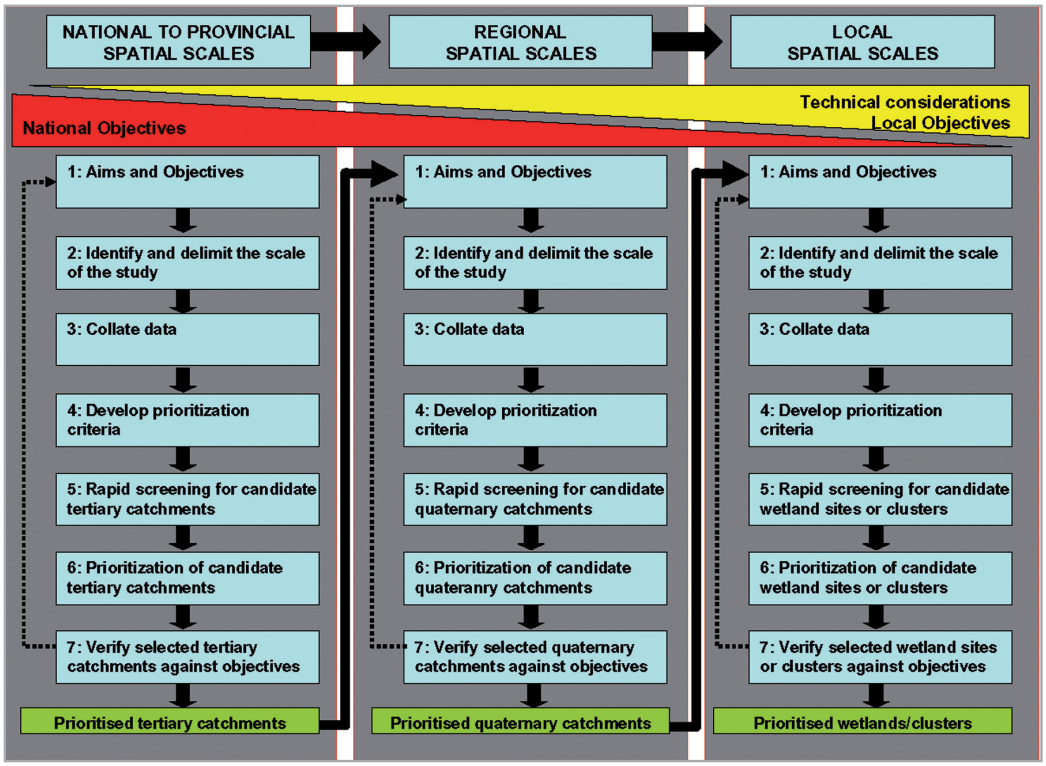


Figure 1: Wetland prioritisation procedures: the steps required at three different spatial scales.

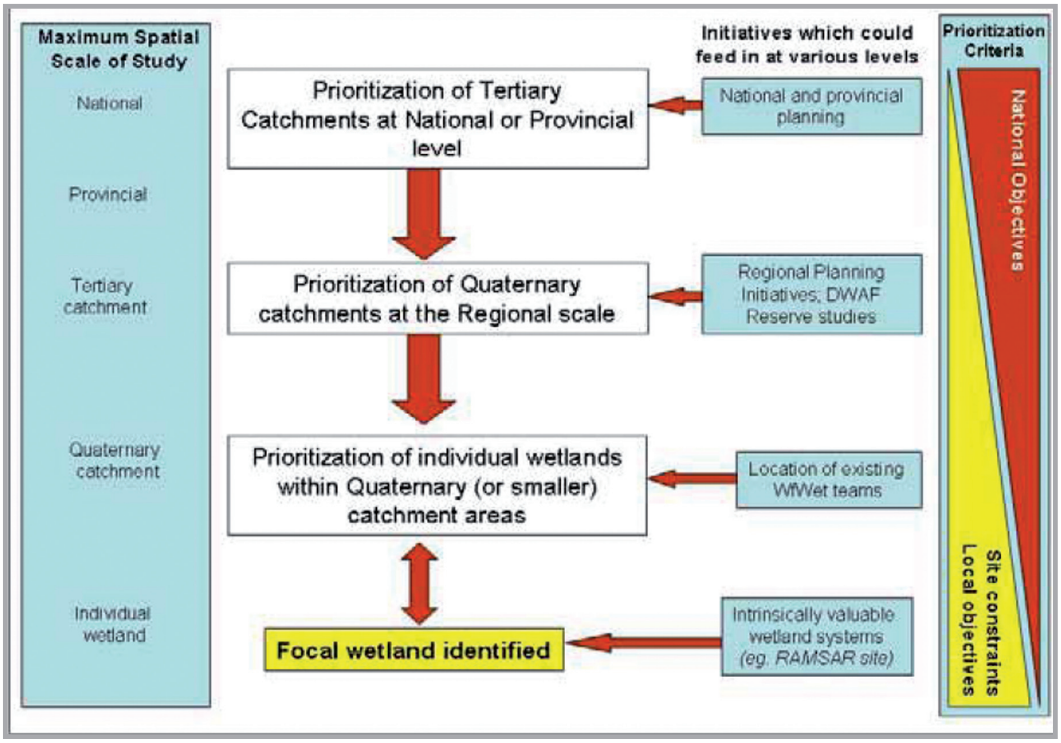


Figure 2: The spatial scales of prioritisation, from national down to individual sub-catchments to the focal (prioritised) wetland.

1.2 The Working for Wetlands Programme

The vision of the Working for Wetlands (WfWetlands) programme is to facilitate the conservation, rehabilitation and sustainable-use of wetland ecosystems, in accordance with South Africa's national policy and commitment to international conventions and regional partnerships. In so doing, WfWetlands seeks to optimise opportunities with respect to ecological integrity, water and food security, human well-being and poverty alleviation.

South Africa lacks a comprehensive overview of the extent, diversity, distribution, status and relative importance of its wetlands. In addition, there is no clear national understanding or agreement on the priority catchments wherein wetland rehabilitation should be focused, nor of the priority sites for intervention within these catchments. Currently, the WfWetlands programme operates within the constraints of existing knowledge, and uses additional factors to determine the location of interventions, such as poverty nodes and priority areas for individual partners. However, it is necessary for the activities of the programme to take place within the context of a strategic and systematic approach to rehabilitation, based on a sound scientific and technical foundation. Such an approach complies with the best-practice guidance on wetland restoration, adopted through Resolution VIII-16 at the 8th Conference of the Parties to the Ramsar Convention in 2002 (Convention on Wetlands, 2002). This document is a tool that should assist in the prioritisation of wetlands for rehabilitation.

1.3 What is Wetland rehabilitation?

It is well known that wetlands provide a wide range of goods and services that are of value to society. However, many wetlands have been, or are being, degraded and this degradation impairs their ability to provide many of the goods and services. Wetland rehabilitation is the process of assisting in:

- the recovery of a degraded wetland's health and ecosystem service-delivery by reinstating the natural ecological driving forces, or
- halting the decline in health of a wetland that is in the process of degrading, so as to maintain its health and ecosystem service delivery.

Wetland rehabilitation is thus an attempt to promote the improvement of a wetland ecosystem which is in a degraded or damaged state, such that some of the lost goods and services that it previously supplied to society are reinstated. Wetland rehabilitation does not necessarily set out to return all degraded wetlands to a 'pristine' state although this may be an objective in some cases. Rehabilitation can involve the use of structures designed and built by civil engineers, but construction of such rehabilitation structures is not, in its own right, wetland rehabilitation. Rather, engineering structures are a means of achieving rehabilitated wetlands. Readers are referred to the *WET-RehabPlan* tool (Kotze *et al.*, 2009a) for background and more detail on the development of comprehensive rehabilitation plans.

1.4 What is prioritisation?

The word prioritisation implies ranking or valuing one above another such that those with a higher rank or value are by definition regarded as more important than those with a lower rank or value. The ranking or value ascribed per resource or wetland unit would be highly dependent on the objectives of the prioritisation process being undertaken. Therefore the value of a wetland may variously refer to criteria or attributes such as hydrological functions, socio-economic value derived from the wetland as well as biodiversity-support aspects. Due to the wide-ranging criteria

which can be used to assess and describe wetland value, often only a subset of these would be applicable to the aims of the specific prioritisation study being initiated. Thus, prioritising the same set of wetlands for different objectives would have different outcomes. For example the priority wetlands for rehabilitation (generally those systems under threat from erosion or degradation) may not be the same as those selected for priority conservation-areas as the latter may be pristine wetlands with high species diversity. The objectives of the prioritisation procedure thus determine the criteria or attributes of the wetlands which will be assessed in order to prioritise between them.

There are hundreds of thousands of wetlands in South Africa, many of which are in need of management intervention. In such situations, where there are numerous possible points of intervention or study, prioritisation is required when the necessary resources are insufficient to target all sites simultaneously (Leibowitz, 2002). Prioritisation procedures thus allow for the highest priority sites for intervention to be identified, so that the limited resources can be directed most appropriately and with the maximum impact.

1.5 The need for planning

Sound planning is fundamental to the successful implementation of a rehabilitation procedure (Rutherfurd *et al.*, 2000). A good plan is as important in the rehabilitation process as is the technical skill required for defining, identifying and designing measures for rectifying problems. Planning is essential in order to:

- promote efficiency in the implementation of the project
- focus on the most important issues relating to the project
- identify and focus on the causes of problems rather than the symptoms
- identify and understand the domains of scale of the problem
- set clear and measurable goals and objectives that will allow the manager to evaluate the success of the completed project.

Furthermore, rehabilitation is often costly and invasive, both of which have legal and social implications. For this reason, it is also essential that the planning procedure is transparent, thus ensuring public accountability with respect to the costs, implementation and the outcome of the project. Readers can refer to the *WET-RehabPlan* document for further information on the planning of rehabilitation activities.

1.6 Principles to consider for prioritisation

Besides identifying those systems in need of rehabilitation, a key aspect of conservation-planning is the protection of those systems that are still in good condition (Rutherfurd *et al.*, 2000). This important principle, that of conserving what is still in good condition before trying to fix what has deteriorated (National Ocean Service and National Marine Fisheries Service, 2002), is unfortunately frequently overlooked. The inherent resistance to this principle arises because it is contrary to the common assumption that the wetland in the worst condition should be considered for priority attention when it comes to rehabilitation. Logically, however, it is far more efficient to preserve wetlands that are in good condition, rather than trying to fix what is already highly degraded. There are several reasons why this should be the case:

- it is often very difficult to restore natural systems, or reinstate natural biophysical processes. In highly-degraded systems, the likelihood of restoring the system to near-pristine conditions (or restoring the original ecosystem processes) is poor
- rehabilitation is often prohibitively expensive
- it is irresponsible to invest large amounts of public funding in rehabilitation

activities at one site while another, which is in reasonably good condition, and threatened, is allowed to deteriorate unabated.

Another way of looking at the issue is in terms of the long-term efficiency and sustainability of the intervention. Although the assumption is that one would eventually like to rehabilitate all wetlands that have been degraded, finances and manpower can be limiting. The best long-term return can be obtained from focusing on moderately degraded systems (where the likelihood of successful rehabilitation is high and the costs are not prohibitively expensive) rather than on highly degraded systems (where the outcome of rehabilitation activities is less certain and the costs extremely high).

The following principles should therefore guide the process of prioritisation for rehabilitation:

- Wetland rehabilitation planning should be developed through open local and regional processes that incorporate the contribution of land holders or users and other key stakeholders, although recognizing that comprehensive stakeholder-engagement is often costly and time-consuming and therefore not always practicable.
- Rehabilitation of damaged wetlands should not divert attention away from protecting and using wisely those wetlands that are in good condition
- it is generally more cost-effective to protect what is still intact, particularly that which is of a high priority, than to rehabilitate what is damaged. Thus protection, wise use and rehabilitation should go hand in hand in an integrated way within an overall programme.
- When prioritising wetland sites for rehabilitation, consideration must be given to the broader catchment and landscape context of the wetland, and it should be aligned with catchment and biodiversity conservation planning objectives.
- Rehabilitation plans, including clearly stated measurable objectives, must be developed by a multi-disciplinary team that includes expertise in both the ecological-functioning of the wetland and the design and planning of rehabilitation structures.

In general, for studies relating to both conservation and rehabilitation prioritisation, the following principles should also be considered:

- protect wetlands that are in relatively good condition before trying to rehabilitate those in poor condition
- focus on wetlands that are deteriorating before focussing on stable or improving wetlands
- focus on those that would be relatively easier to rehabilitate before those that would be more difficult to rehabilitate
- prioritise on the basis of rarity of the ecosystem and/or importance in terms of biodiversity or wetland type
- prioritise on the basis of goods and services provided by the wetland
- since the current state of a wetland reflects the effect of cumulative activities occurring at a much broader spatial scale than the wetland itself, the identification of priority wetlands for rehabilitation should incorporate a broader-level assessment to identify problems outside of the wetland itself
- recognise those wetlands where essentially irreversible changes have occurred. Lost causes should be recognised for what they are, and rehabilitation efforts focused on other systems where there is a higher chance of success
- consider the willingness and capacity for local people and local structures to become involved and address the causes of degradation.

2 GUIDELINES FOR PRIORITISING WETLANDS

Setting priorities for protection and rehabilitation efforts is necessary whenever resources are insufficient to target all sites simultaneously (Leibowitz, 2002).

Wetlands are amongst the most impacted-on and degraded of all ecological systems, and global assessments indicate that the majority of the remaining wetlands are degraded or under threat of degradation (Finlayson and Spiers, 1999). In South Africa, water resources are in a worse ecological state than any other ecosystem component, and are being further degraded at a faster rate than any other ecosystem type (Driver *et al*., 2005).

Considerable effort is therefore required to maintain and improve the quality of our water resources, and wetlands in particular. However, available resources are never going to be sufficient to tackle all sites at once. It is therefore necessary to prioritise various areas or individual wetland systems to ensure that effort is focused on those areas or sites which offer the greatest returns. The outcomes of a prioritisation procedure should therefore provide strategic direction for focusing the limited resources.

In a resource-limited environment the prioritisation procedure should allow the user, with currently available information or knowledge, or with very limited additional data collection, to develop a 'short-list' of candidate sites for more focused studies, rehabilitation work or conservation efforts.

Whilst the prioritisation of wetlands for rehabilitation is an essential component of the WfWetlands programme, prioritisation also has applicability to local, provincial and national conservation planning. For example, the prioritisation of conservation efforts on South Africa's rare and/or declining wetland types as well as for the implementation of the National Water Act; specifically the reserve (environmental flow) determination procedures. For these reasons the prioritisation procedure that has been developed has remained flexible to allow for modification of the procedure to meet the needs of a variety of users, with different objectives.

The steps which should be followed for the prioritisation process are outlined in the following sections. The procedure comprises three sub-modules that are defined according to the spatial extent of the study being undertaken (Figure 1). Within these sub-modules, seven basic steps are applied to prioritise the catchments or the wetland systems. Although the seven steps are repeated in each sub-module, the scales of analysis, and therefore the type and detail of information assessed, are different within each of the sub-modules. Thus at the coarser national and provincial/regional scales, the prioritisation of tertiary catchment areas is undertaken, and not wetlands *per se*. At the smaller regional scales (generally within one or a very few tertiary catchments), the prioritisation of quaternary catchment areas is undertaken. In both of these sub-modules, due to the paucity of available information on wetland location, extent and condition across large spatial scales, surrogate information (such as land use activities and intensity) must be used. Within the local scale sub-module, individual wetlands or clusters of wetlands can be assessed within a single quaternary scale. Thus at coarser scales the detail of the information relating to wetlands is less, and less direct, whereas at the smaller scales the level of detail of the information required for prioritisation increases, and this information is then collected for only small areas (i.e. few individual wetland systems).

The general *WET-Prioritise* procedure for prioritising wetlands uses a spatially-nested, seven-step approach. Thus, starting at the national scale, priority tertiary catchments are identified, and then in the next sub-module, priority quaternary catchment areas are identified. Finally, in the last sub-module, priority wetland clusters or priority individual wetland systems are identified.

In some cases, within a single sub-module, iterations of the procedure (i.e. several rounds of screening and prioritisation of progressively smaller groups of candidate catchments or sites) can be undertaken. As the iterative process proceeds and increasing amounts of information is being collected for each catchment, wetland cluster or individual wetland, the size of the candidate group reduces. To illustrate the application of the procedure in practice, three individual case studies (prioritisation for regional-scale wetland rehabilitation; regional wetland conservation and local scale rehabilitation) are provided at the end of this document.

At the outset of the prioritisation process, the first step is to specify the aims and objectives of the prioritisation.

2.1 Step 1: Setting aims and objectives

The first step in prioritising wetlands is to identify the aim of the programme which is being initiated, for which the prioritisation project is required. The aim is a broad statement that relates to the overarching goal of the programme. To achieve the aim of the project, a number of objectives of the prioritisation need to be set. The objectives provide more specific detail of what has to be achieved. A guide to specifying the objectives is to ask: what is the anticipated end point of the prioritisation procedure? What should be produced?

Although there may be others, the three main groupings of projects which we believe are currently appropriate for the prioritisation procedure are:

- rehabilitation projects that aim to improve the current condition of wetlands.
- conservation planning that aims to preserve biodiversity.
- wetland reserve (environmental flow determination) studies that aim to improve understanding and management of wetlands.

Whilst these groupings represent broad associations of common aims, the specific objectives of two similar exercises may differ. It is therefore necessary to specify what specific objectives need to be achieved.

2.1.1 Rehabilitation projects

Rehabilitation projects may be variously focused on achieving enhanced biodiversity support, water quality improvement, sediment stabilisation or reinstated flooding regimes. The WfWetlands programme has the additional objectives of job creation and poverty relief to consider as part of its role in the government's expanded public works programmes.

At present the focus of the WfWetlands programme is generally on the structural rehabilitation (i.e. engineering solutions) of degraded wetland types, and this is often linked to reporting on the number of people employed and the man-days taken for the rehabilitation activities. The current WfWetland focus is on wetlands that are moderately degraded (Case Study 1: Prioritisation for rehabilitation in the Free State), and on wetlands that are close to previously-disadvantaged communities, in order to provide employment opportunities to members of these communities.

However, other rehabilitation exercises may be focused on water quality improvement,

or on the wise use of wetlands, in which case the specific objectives of the rehabilitation exercise would be different from the current WfWetlands programme, and thus a different set of wetlands may be prioritised based on these specific objectives.

2.1.2 Conservation planning

In December 2006, the South African National Biodiversity Institute (SANBI) released an updated wetlands map of the country. This was a first and significant step towards developing a detailed inventory of the country's wetlands. A more detailed map is planned, one that will identify many of the smaller wetland systems that are not included in the current version of the map. The inventory will propose a refined wetland classification system that can be applied to the map to generate informative attributes for the wetland map (Ewart-Smith *et al*., 2006). In addition, some provinces and municipal areas in the country have already developed, or are in the process of developing, their own high-resolution wetlands maps.

The next logical step is to begin focusing the conservation and possibly also the rehabilitation efforts on those wetland types which are rare and/or increasingly under threat. Such an approach would probably be along the lines of the USA's National Wetlands Priority Conservation Plan, which largely focuses on wetlands that:

1. provide a high degree of public benefits
2. are representative of rare or declining wetland types within an ecoregion
3. are subject to an identifiable threat of loss or degradation. Wetlands that meet these criteria are considered priority for conservation.

In South Africa, for example, the objective of national conservation efforts may be to maintain RAMSAR sites, or, as the attributes of SANBI's wetlands maps become available, it may be to maintain and improve rare and/or declining wetland types. The specific objectives of the conservation undertaking thus dictate the criteria that are selected for a particular wetland.

Objectives for such an exercise may variously comprise:

- identification of high risk/threatened wetland systems
- identification of unique or rare wetland types
- identification of wetlands which provide habitat for endangered biota.

2.1.3 Wetland reserve (environmental flow determination) studies

The Department of Water Affairs and Forestry (DWAF) is the custodian of all South Africa's water resources, including wetlands. Wetland reserve (environmental flow determination) studies are increasingly required to be undertaken by or on behalf of DWAF. Additionally, there is an urgent need to set resource quality objectives and ecospecs (ecological specifications of the required or desired state of a particular water resource) for the many wetlands in the country to ensure that adequate protection standards of the resources are maintained.

Given the estimated many tens-of-thousands of wetland systems in the country, it is impossible to undertake a detailed study of every wetland system. It would be more practical to implement stratified sampling, and to study representative systems, or to focus only on priority wetland-systems in a given water management area. The *WET-Prioritise* procedure endeavours to provide an additional approach which can be utilized by the DWAF to select and identify priority wetland-systems in a catchment or water management area.

Objectives for such an exercise may variously comprise:

- identification of high risk/threatened wetland systems
- identification of high ecological integrity wetland systems
- identification of wetlands which provide a high level of goods and service values to an area
- identification of wetlands likely to be impacted on by water allocation to other users
- representative wetlands of a particular water management area.

2.2 Step 2: Identify the appropriate spatial scale

Once the specific objectives relating to the aim of the project have been identified, the spatial scale of the study must be defined. This provides a focus for the study and guides the assimilation of relevant knowledge, information and data and the development of prioritisation criteria for selecting or scoring between various wetland areas or individual systems.

In some cases, the spatial scale may be obvious, for example in the case of a national or provincial prioritisation exercise. In other situations, however, the spatial scale may not be immediately apparent. At all times of an assessment, a catchment-based understanding is recommended. Even when the focus of the study may be on a particular wetland system (such as a Ramsar site), it is imperative to recognise that the current and future condition of a particular wetland system is largely a product of the condition of the catchment. Case Study 3 (Local scale prioritisation) provides an excellent example of the importance of developing an appropriate catchment-based understanding of individual wetland 'problems', since often the identified problem is merely a symptom of other factors higher up in the catchment.

Once the appropriate spatial scale of the prioritisation process has been specified, the relevant data and information for that area can be collated.

2.3 Step 3: Collate available information

All available information about the wetlands, including data and local knowledge sources, as well as any other possible indicators of wetland extent, type, characteristics and condition, should be collated for the study area. The type of information that is collated is guided by the objectives of the study and the extent of the study area. Consider what sort of information you will require to address the specific objectives of the study.

Some examples of the types of information which can be sourced to assist in the prioritisation process, and their potential uses, are tabulated below (Table 1). This list will expand as new data (such as the SANBI Wetlands Probability map) becomes available.

2.4 Step 4: Develop prioritisation criteria

Once the objectives of the prioritisation process have been determined and the information available on the study area has been identified and collated, the prioritisation criteria can be developed. The prioritisation criteria can be qualitative or quantitative, depending on the resolution of data and specialist knowledge, but should explicitly address the objectives (Box 1).

Any number of criteria can be employed to distinguish the different wetland systems or wetland areas, but the criteria which are selected, and how they are assessed or 'scored' for each system depends on the objectives of the study. When developing prioritisation criteria, ensure that the criteria which are selected and

the way in which they are assessed and scored, correspond with the objectives of the study, the scale of analysis, and the data and information that are available at that scale to address those criteria.

Some examples of prioritisation criteria are:

- wetland size
- wetland condition
- connectivity between the site and other wetlands or downstream rivers
- rare plant/animal populations (biodiversity support)
- wetland type (rarity)
- diversity of vegetation types
- level of ecosystem goods and services
- proximity of the site to suitable nodes of employment (in the case of rehabilitation programmes like WfWetlands which are linked to poverty alleviation)
- level of threats or likely future impacts, and
- specific ecosystem services of the wetland (e.g. prioritising the types of wetlands which improve water quality in a catchment with large water quality impacts over those that attenuate floods).

As an example of developing prioritisation criteria readers are referred to Case Study 2 (Prioritisation for Conservation in the Upper Olifants Catchment, Mpumalanga). In this case study, the wetland systems identified had a specific composition of wetland types, they were of a minimum specific size, were relatively secure from future mining threats and were in a good ecological condition (as per international norms for prioritising conservation areas – i.e. protect the best, then start on the rest). The criteria that were used in this case study were therefore:

- wetland size
- wetland condition
- wetland type, and
- level of threats or likely future impacts.

Table 1: Information available for screening or prioritising wetlands

Available information	Use in screening or prioritisation
National, Provincial and Tertiary Catchment Scales	
National Wetlands Map	Coarse national-coverage showing the location and extent of larger wetlands across South Africa
Geology	Classification of wetland groupings
Biomes	Classification of broad-scale wetland groupings
EcoRegions	Classification of wetland groupings
Provincial Conservation Plans	Provides higher resolution information on wetland location, extent and possibly biological attributes. Not always available.
Land cover transformation	Gives an indication of the current bio-physical condition of wetlands
Regional and Quaternary Catchment Scales	
Vegetation Types	Classification of more-detailed wetland 'types'
Geology	Classification of wetland 'types'
EcoRegions	Classification of wetland 'types'
Provincial Conservation Plans	Provides higher resolution information on wetland location, extent and possibly biological attributes. Not always available.
Aerial photography or high-resolution satellite imagery	Gives an indication of the current bio-physical condition of wetlands

Box 1: Developing Prioritisation Criteria: an example

Aim of Programme:

Representative, national conservation of wetlands

Objectives of prioritisation:

Prioritise wetlands which
1. represent rare types
2. support high species diversity in order to focus limited resources on the protection an/or wise use of these systems

Available Data:

- national wetlands map
- South African biomes
- ecoregions
- provincial conservation plans

Prioritisation criteria

To prioritise rare wetland types:

At present there is little information on wetland typology at national scale. A national classification system has been proposed (Ewart-Smith *et al*., 2006) which used hydro-geomorphic (HGM) wetland types as a basis for distinguishing wetland types.

- If possible, separate HGM wetland types (at least pans, valley bottoms and seeps) using the SANBI national wetlands map (this information should be available)
- Identify the HGM wetland types per biome (coarse level) and ecoregion levels (finer level analysis)
- Score the presence of HGM wetland types per ecoregion (eg: common, moderate, rare, none present)
- Prioritise rare wetlands in each ecoregion

To prioritise wetlands with high species diversity:

At present very little detailed information exists at the national level with regard to wetland species diversity and richness. It would thus be advisable to focus only on the prioritised wetland systems identified as rare types identified above, and then source provincial or local information on species richness (from, for example, provincial conservation plans) for this much smaller group of candidate sites for prioritisation. The rarer wetland types in each ecoregion which have a high species diversity could then be prioritised.

2.5 Step 5: Screen the pool of all possible sites to develop a candidate list

Under most circumstances, available resources will, at least when dealing with the large national and provincial scales of analysis, preclude the specific collection of extensive additional new data over wide areas. It would, for instance, be impracticable to collect even the smallest amount of field information for all of the numerous wetlands across South Africa.

The *WET-Prioritise* process adopts an initial screening step to generate a 'short-list' of potential candidate sites which can be considered for prioritisation. In this way, the entire initial list of all potential catchments or wetlands within a particular study area can immediately be reduced to provide a short list of potential sites for further investigation. The short listed sites provide a more manageable number of sites on which to undertake additional or more detailed analysis and data collection.

For example, if a conservation-prioritisation assessment is undertaken to identify wetlands in need of conservation focus, then wetlands which have their catchment areas, and are themselves, entirely within a proclaimed conservation-area, could be excluded from the prioritisation process. Resources could instead be allocated to sites which may be important but that are not in protected areas.

In the case of rehabilitation projects, sites which are in a near-pristine condition would gain little from rehabilitation activities, i.e. there would be little ecological improvement associated with the rehabilitation of such sites. In contrast, sites which are very heavily degraded may be beyond reasonable rehabilitation measures, such that even expensive rehabilitation activities would yield little ecological improvement. Thus sites which are heavily degraded, as well as sites that are near to pristine, could be excluded from the prioritisation procedure. This point is well illustrated in Case Study 1 (Prioritisation for rehabilitation in the Free State).

If it is not possible to screen the sites to generate a short list of candidate sites, then all areas or wetlands within the study area are to be considered as potential candidate sites, i.e. all potential sites within the study area are identified and are included in the candidate list for step 6.

2.6 Step 6: Prioritise candidate sites

Prioritisation criteria are developed to address the project objectives. In the Case Study 2 example, some of the considerations for the candidate sites were simple yes/no assessments, whilst others were qualitative or quantitative assessments. Using this approach, the candidate sites could be assessed according to a uniform set of criteria in order to develop a prioritised list of potential sites which could meet the project objectives.

The reader will recall that prioritisation of wetland areas or individual wetland systems can occur at a variety of spatial scales (Figure 2). For ease of application we have divided the prioritisation procedure into three spatially-nested components, according to prioritisation of

- tertiary catchments at the national to provincial scales
- quaternary catchments at the regional scale
- individual wetlands within quaternary (or smaller) catchment areas.

Due to the varying resolution and general availability of information relating to wetlands at these different scales (local, provincial and national), different tools and procedures are recommended to accommodate these limitations and differences in the availability of information.

At the national and provincial scales, a GIS-based tool has been developed that can be used to prioritise tertiary catchment areas that are likely to contain wetlands matching a specified set of criteria. The tertiary catchments are prioritised by the selection and up or down weighting of national landcover and other national scale data. These data are proxy indicators of the criteria being evaluated. A current lack of landcover or other proxy (surrogate) data at the quaternary catchment scale and smaller means that, for prioritisation procedures undertaken at quaternary catchment and smaller spatial scales, more emphasis must be placed on:

- local and regional specialist knowledge
- rapid desktop analysis to generate new data
- rapid field-based (so-called 'bakkie window') assessments.

The procedures and, where available, specific models for assessment (at each of the three scales) are discussed in separate sections below. It is important to note that at each scale of assessment it may be necessary to revisit the objectives and prioritisation criteria adopted for the study to ensure that the aims and objectives of the larger scale (e.g. national-scale) are not lost when local scale constraints and opportunities are encountered at the smaller scales of assessment.

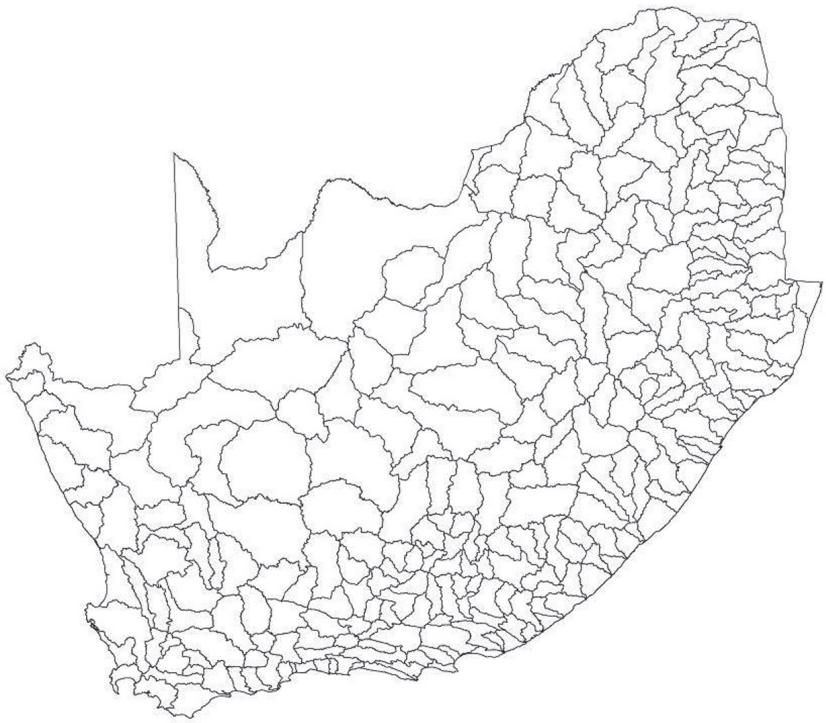


Figure 3: The Tertiary Catchments of Southern Africa.

2.6.1 Prioritising tertiary catchments at national to provincial scales

The scale of investigation for this component is the national to provincial scale (Figure 3). Due to the lack of available data on wetland distribution, location and condition, a GIS-based tool was developed to use available (national coverage scale) data to enable the identification and prioritisation of Tertiary scale catchments within which wetlands that matched specific criteria would be likely to occur. The details of installation and running the GIS prioritisation tool are provided in Appendix I, whilst further background to the model is provided in Appendix II.

This GIS tool allows nationally or provincially driven prioritisation programmes to identify tertiary catchments in which wetlands associated with particular selected criteria would be located. This then allows for resources to be most appropriately focused in these areas. The selection of priority tertiary catchments is determined according to the underlying objectives or the specific national or provincial prioritisation programme.

Defining national criteria for prioritising catchments for wetlands

To streamline the decision-making process and enable WfWetlands and other national or provincial scale programmes to arrive at informed decisions regarding the allocation of resources, it would be useful to be able to identify which areas of the country/province should take priority over others. The best approach to deciding upon priority areas is to base the decision on key strategic national needs or services that are promoted, improved or sustained through the goods and services provided by the wetlands in particular catchments. These could range from biodiversity support to resource supply and/or erosion control.

The Department of Environmental Affairs and Tourism convened a workshop in July 2003, which was the first phase in the development of the national-scale prioritisation protocol. The attendees of the workshop represented national and provincial government, statutory bodies, civil society and the private sector. At this workshop, a list of criteria was presented by representatives from each of the nine provinces, and agreement was reached that the prioritisation criteria could be grouped into the following six categories:

- hydrology
- biodiversity
- socio-economic
- threats/impacts
- physical
- strategic.

A team of wetland specialists subsequently refined the list (Table 2), which was then circulated to the workshop participants for comment. The list provides the prioritisation criteria which need to be incorporated in the development of the tool that identifies and prioritises large-scale (national and provincial) tertiary catchment areas.

Selection of prioritisation criteria indicators

Proxy datasets that could provide good indicators of the desired prioritisation criteria (Table 2) were sourced from existing datasets of national coverage. The selection of these prioritisation criteria indicators was limited to pre-existing, national level GIS datasets, i.e. no new datasets were generated as part of the tool development. In the end, thirteen indicators were selected to address the prioritisation criteria. These are:

1. National Biodiversity Priority Areas
2. Protected Areas
3. Peat Wetland Eco-regions
4. Ramsar Sites
5. Water-stressed Catchments
6. Water (Chemical) Quality
7. Spatial Development Initiatives (SDIs)
8. Water Catchment Management Agencies (CMAs)

Table 2. Criteria used for Tertiary-catchment level prioritisation (National and Provincial Scale)

National criteria	Examples of sub-criteria
Biodiversity	Biodiversity nodes/hotspots (biodiversity map)
	Protected areas
	Threatened or priority wetlands including the peat eco-regions
	Ramsar sites and their catchments
Hydrological	Water-stressed catchments
	Runoff per capita
	Water supply catchments
	Water quality at catchment scale
	International obligations with respect to water sharing
Socio-Economic	Nodes identified under the Integrated Sustainable Rural Development Strategy
	Urban renewal projects
	Livelihoods dependent on wetland goods and services?
	Poverty indicators
Threats / Impacts	New land cover map
Physical	Erodibility index
	Unique natural features e.g. karst landscapes
	Density and distribution of wetlands (new land cover; wetland coverage; Cowan wetland regions)
Strategic	International rivers and boundaries
	Spatial development initiatives
	Existence of Catchment Management Agencies

9. Conservation Status Index
10. Erodibility (Soil) Index
11. Working For Water/Wetland Project Locations
12. Poverty Gap Index
13. Integrated Sustainable Rural Development And Urban Renewal Nodes.

Each criteria indicator dataset was adjusted to a standardized 5-level index scale (i.e. 0, 1, 2, 3, 4), based on either a 'percentage weighted area' or simple 'occurrence/no occurrence' rule of that particular criteria within each tertiary catchment across South Africa across South Africa (e.g. for the water stress criterion, a tertiary catchment was assigned a score of 0 if there was no water stress through to a score of 4 for the worst case of water stress).

A GIS-based model for prioritising tertiary catchments

The thirteen indicators (proxy data correlated with the required criteria for identifying quaternary catchments with priority wetlands) have been incorporated into an interactive, digitally-based GIS model. These criteria indicators can be selected and weighted to provide a single qualitative wetland-priority index value for each tertiary catchment (Figure 3). This priority index value for a specific tertiary catchment is calculated from the sum of either all, or a selection of, user-defined criteria indicators, associated with that particular tertiary catchment. The output from the prioritisation model can either be expressed as absolute or relative index values, according to user requirements, where:

- the absolute index value represents the total sum of all selected criteria index values for that tertiary catchment; and
- the relative index value represents a normalised 5-class representation of this absolute data range, which is more useful for comparing the outputs of several modelling scenarios.

The outputs from this GIS model are essentially maps that show the prioritisation of tertiary catchments within South Africa in terms of desired attributes (prioritisation criteria), based on an index derived from an integrated evaluation of the criteria indicators. Individual criteria indicators can be included or de-selected from the evaluation and assessment of the tertiary catchments. Additionally, criteria indicators can be down- or up-weighted, depending on the specific objectives of the user. The dynamic nature of this approach allows various combinations and relative weightings of criteria indicators to be tested and evaluated, to cater for changes in programme objectives, or use by other programmes.

The model is designed to run on ArcView 3.2, and all datasets are in Geographic / WGS84 format. The selection of criteria and weightings assigned to them are dependent on the objectives of the programme for which sites are being prioritised. Details of the sources of the datasets and how this model is to be installed and used are provided in Appendix I. Appendix II shows how the above-mentioned 13 prioritisation criteria can be used to generate prioritisation maps.

2.6.2 Prioritising quaternary catchments at the provincial level

As mentioned previously, wetlands information for South Africa is generally limited. The updated wetlands map for the country was released by SANBI, but there is currently no attribute-information linked to this map, i.e. it only provides information on the location and the likely extent of the indicated wetlands. Additionally, whilst proxy data on wetland condition (such as land use transformation) could be used at the coarse tertiary catchment scale, such data are not generally available at the detailed quaternary or sub-catchment scales. These limitations in available data have constrained the prioritisation procedures which can be adopted at the regional (sub-tertiary catchment) scales. As with the tertiary catchment prioritisation approach, the requirement was to use existing, available information, since extensive regional data collection was not within the scope of this research project, nor within the scope of the *WET-Management* series.

Unfortunately it was quickly apparent that the national databases used in the tertiary catchment scale prioritisation were not useful in prioritising the smaller quaternary catchments within the tertiary catchments because the spatial resolution of the data was not sufficiently detailed. Provincial databases, of a sufficiently detailed resolution to enable distinctions between quaternary catchments to be made, are largely non-existent at this time. Although the availability of regional databases is likely to improve as individual provinces develop systematic conservation plans and other planning tools, at the time of the development of these guidelines such databases are not readily available.

Presented with the limitations of data resolution and availability, the advocated approach for the regional scale (sub-

tertiary catchment) of prioritisation is in the form of guidelines for outlining the criteria and considerations for prioritisation of quaternary catchment areas, using expert knowledge, and/or regional databases as these become available. When working within a priority tertiary catchment identified using the GIS-based model, then the prioritisation process should begin again at step 1. This is required in order to reassess the objectives and prioritisation criteria of the study. Whilst at the national scale the criteria or considerations for prioritisation are dominated by national objectives, at smaller scales these factors become increasingly strongly influenced by regional and local considerations, constraints and opportunities (Figure 2). For example, it may be that the national objective of a particular conservation prioritisation programme is to identify, in order to conserve, the best examples of rare wetland types. At the local scale it may occur that the type specimen of a particular wetland type is not prioritised because the local landowners will not buy into an effective management plan for the wetland. Instead, another similar wetland system, but perhaps not the best example of that wetland type, is chosen due to more favourable land tenure arrangements (such as a wetland of similar type within a conservation area).

Collate what information is available for the priority tertiary catchment or smaller region of the new regional study area. Screen all the potential sites or areas to develop a short-list of candidate sites (Step 4) and develop the prioritisation criteria, using the available information, where possible, to prioritise the sites.

Sources of available data, or rapidly available information, at the regional scale can include:

- regional experts/specialists
- SANBI wetlands map to inform on the likely location and density of wetlands in a particular sub-catchment
- high-resolution satellite, aerial photography or other imagery such as GoogleEarth to conduct desktop surveys of wetland condition
- provincial C-plan wetlands information (not available for all provinces).

A scoring system can be developed to score each area (for instance, each quaternary catchment area within the priority tertiary catchment study area) in terms of that catchment's suitability to meet the prioritisation criteria. This will provide a prioritisation score for each candidate catchment being considered, allowing for the development of a list of prioritised catchments.

2.6.3 Prioritising individual wetlands within quaternary (or smaller) catchments at the local level

Once a priority quaternary catchment, or a particular focal wetland (a specific wetland of local interest, identified and selected independently) has been identified, a sub-catchment (quaternary catchment) scale assessment should be initiated.

Again, steps 1 through 5 of the prioritisation process must be revisited to reassess the objectives and prioritisation criteria of the study. The information available for the new local study area must then be collated. If an individual wetland has already been identified and prioritised independently, it is advisable to at least do a rapid assessment of the wetlands (using Level I *WET-Health* (MacFarlane *et al.*, 2009) and *WET-EcoServices* (Kotze *et al.*, 2009b) within the catchment to ensure that the problems or priorities identified on-site are not caused by other catchment factors.

If the prioritisation process reveals a short

list of candidate sites, an assessment of all such wetlands within the study area (sub-catchment) should be undertaken to allow for the prioritisation of individual wetlands relative to one another, so that focal wetland/s can be identified. The level of detail of this assessment will be dictated by the available resources, data availability and resolution of data for the catchment.

Sources of available data, or rapidly available information, at the local scale can include:

- local experts/specialists
- SANBI wetlands map, which will probably later inform on the likely location and density of wetlands in a particular sub-catchment
- municipal wetlands maps, if available
- high-resolution satellite, aerial photography or other imagery such as GoogleEarth to conduct desktop surveys of wetland condition
- provincial C-plan wetlands information (not available for all provinces).

Because studies at these scales generally involve small spatial areas, it is recommended that at least rapid (Level I *WET-Health* and *WET-EcoServices*) assessments be undertaken for the candidate sites which are identified. These can be in the form of a rapid 'bakkie window' assessment, or, if the available resources permit, a more detailed on-site wetland condition assessment. As an initial assessment, the current ecological condition (or Present Ecological State, as per the DWAF definition) should be assessed. This information is required for the rehabilitation, conservation and reserve planning methods. Defining the present ecological state ('health') involves determining the current condition of the wetland system relative to some ecological reference state (usually taken to mean the natural or pre-impact condition of the system and the dynamics associated with this). Classifying the wetland type according to its hydro-geomorphic characteristics (which is discussed in both *WET-Health* and *WET-EcoServices*) should be undertaken and then the historic or pre-impact (reference) state determined, followed by an evaluation of the current state. Current condition assessments can range from

- low confidence desktop and rapid 'bakkie window' assessments, to
- moderate-confidence rapid field-assessement methods (e.g. *WET-Health* Level I or the DWAF Wetland Index of Habitat Integrity), through to
- high confidence detailed on-site assessments (e.g. *WET-Health* Level II).

The level of detail required for the assessment of the present ecological-state of the wetland would depend on:

- the information and knowledge available for the particular wetland system concerned (both scientific data as well as expert experience)
- the level of detail required to assess the rehabilitation or other goals of the intended activity
- the available resources
- the extent of stakeholder-involvement
- the costs of getting it wrong.

Again, a scoring system can be developed to score each wetland system in terms of their suitability to meet the prioritisation criteria. This will provide a prioritisation score for each candidate wetland-system, allowing a list of prioritised individual wetlands to be developed. Some prioritisation criteria that are specifically concerned with wetland rehabilitation programmes are provided in Box 2.

An additional important criterion which can be considered for prioritisation purposes is the benefit/s of the wetland in question. Individual wetlands differ according to their characteristics and the particular wetland benefits that they supply to society. Therefore different

sectors of society may consider different wetlands as more important than others. *WET-EcoServices* is a tool developed under the *WET-Management* series, designed for rapid assessments of the ecosystem services supplied by wetlands (Table 3).

The results of the assessments are used for the prioritisation of the wetlands within a catchment context. The procedure is not designed to provide a single overall measure of importance of a wetland, nor is it designed to quantify (in monetary or other terms) the benefits supplied by a wetland, but to assign indices of services which can be used for comparative purposes between different wetlands. Different criteria are assessed and weights are assigned to the indices, depending on the objectives of the prioritisation project.

Like *WET-Health* (used for the determination of current condition), *WET-EcoServices* (the assessment of a wetland's ecological goods and services) can be undertaken at a variety of levels, from very fast desktop through to more detailed field-based assessment methods.

2.7 Step 7: Assess the potential of the prioritised catchments/wetlands to meet the aims and objectives of the project

Once the prioritised sites have been identified, these are assessed against the original project objectives, as occasionally the criteria indicators, or the way the criteria have been scored, do not adequately reflect the original intentions of the objectives. Specifically, sometimes the proxy (surrogate) data used to inform the assessment may not be of sufficiently high resolution, or the correlation between the surrogate data and the actual parameter being assessed, is weak. In such situations the prioritisation criteria may not provide a true measure of the desired parameter. Thus this last step is merely a 'cross check' to ensure that the prioritisation criteria have been accurately assessed and scored, and that the selected priority sites are able to address the objectives of the study. If the prioritised sites are deemed to be unsuitable, it may be necessary to reassess and refine how the prioritisation criteria were scored.

Box 2: Criteria to consider at the local scale for identifying wetlands for rehabilitation

- Focus on wetlands that are rare or represent rare types
- Focus on wetlands that are in good condition before those that are in poor condition
- Focus on deteriorating before stable or improving ones
- Focus on on problems that are easiest to fix
- Focus on those sites that will generate a guaranteed immediate positive benefit before those that have potentially longer-term, but less cetrain, positive benefits
- Focus on those problems or sites perceived to be important by local communities and stakeholders before those not perceived to be important
- Recognise lost causes for what they are, and focus effort problems and sites where there is more chance of success
- Focus on those problems known to have tried and tested remedies
- Incorporate a broader(catchment or sub-catchment) level assessment to identify any causes that may be outside of the wetland itself
- Focus on wetlands with a good recovery potentia
- Focus where the willingness and capacity for local people and local structures to become involved and address the causes of degradation is high.

Table 3: Ecological services and benefits which are assessed in *WET- EcoServices*

Wetland benefits (goods and services)			
	Indirect benefits	Hydrological benefits	Flood attenuation
			Streamflow augmentation
			Sediment trapping
			Phosphate assimilation
			Nitrate assimilation
			Toxicant assimilation
			Erosion control
		Biodiversity conservation – integrity	
		Biodiversity conservation – irreplaceably	
	Direct benefits	Water supply	
		Provision of harvestable resources	
		Socio-cultural significance	
		Tourism and recreation	
		Education and research	

3. REFERENCES

Convention on Wetlands, 2002. *Resolution VIII. 16 Principles and guidelines for wetland restoration*. In: 8th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971)

Dickens C, Kotze D, Mashigo S and Graham M, 2003. *Guidelines for integrating the protection, conservation and management of wetlands into catchment management planning.* WRC Report No. TT220/04. Water Research Commission, Pretoria.

Dickens C, Kotze D, Mashigo S and Graham M, 2003. Guidelines for integrating the protection, conservation and management of wetlands into catchment management planning. WRC Report No. TT220/04. Water Research Commission, Pretoria.

Driver A, Maze K, Rouge M, Lombard AT, Nel J, Turpie JK, Cowling RM, Desmet P, Goodman P, Harris J, Jonas Z, Reyers B, Sink K and Strauss T, 2005. National Spatial Biodiversity Assessment 2004: Priorities for Biodiversity Conservation in South Africa. *Strelitzia*, 17. South African National Biodiversity Institute, Pretoria.

Ewart-Smith JL, Ollis DJ, Day JA and Malan HL, 2006. *National Wetland Inventory: development of a wetland classification system for South Africa*. WRC Report No. KV 174/06. Water Research Commission, Pretoria.

Finlayson CM and Spiers AG (eds.) 1999. *Global review of wetland resources and priorities for wetland inventory*. Supervising Scientist Report 144, Supervising Scientist, Canberra. 524pp.

Kotze DC, Ellery WN, Rountree M, Grenfell MC, Marneweck G, Nxele IZ, Breen DC, Dini J Batchelor AL and Sieben E, 2009a. *WET-RehabPlan: Guidelines for planning wetland rehabilitation in South Africa.* WRC Report No. TT 336/09. Water Research Commission, Pretoria.

Kotze DC, Marneweck GC, Batchelor AL, Lindley DS and Collins NB, 2009b. *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* WRC Report No. TT 339/09. Water Research Commission, Pretoria.

Leibowitz SG, 2002. An approach to geographic prioritisation of wetland management given limited effort and information. In: RW Tiner (ed.) *Watershed-based wetland planning and evaluation. A collection of papers from the Wetland Millennium Event* (August 6-12, 2000, Quebec City, Quebec, Canada). Association of State Wetland Managers, Berne, NY. p 17-40.

Macfarlane DM, Kotze DC, Ellery WN, Walters D, Koopman V, Goodman P and Goge M. 2009. *WET-Health: A technique for rapidly assessing wetland health*. WRC Report No. TT 340/09. Water Research Commission, Pretoria.

National Ocean Service and National Marine Fisheries Service, 2002. *A national strategy to restore coastal and estuarine habitat.* Restore America's estuaries, USA.

Rutherfurd ID, Jerie K and Marsh N 2000. *A Rehabilitation Manual for Australian Streams, Volume I*. Cooperative Research Centre for Catchment Hydrology and Land and Water Resources Research and Development Corporation.

Working for Wetlands, 2005. *Working for wetlands strategy*. Working for Wetlands, Pretoria.

APPENDIX I:
Installation and use of the GIS-based tertiary catchment prioritisation model

A dynamic, digitally based model for prioritising tertiary catchment areas that are likely to have wetlands matching a specified set of criteria has been produced (see CD appended on back cover). The model is based on an ArcView 3.2 GIS extension, written specifically for this application, which allows an end-user to define the inclusion or exclusion of selected criteria indicators, as well as alter the weighting factors (if required) allocated to each criterion indicator. This approach allows various criteria combination scenarios to be tested and evaluated so that changes in programme objectives, and use by other programmes, can be catered for. The ArcView 3 extension is written in such a manner that entry-level GIS users can generate various scenarios and print these as paper-map products. In order to utilise and run the ArcView 3 extension, a user must have access to ArcView 3 GIS software.

An interactive model is preferable to a single, paper-based map of catchment priority, since this allows for modification or re-evaluation of objectives and the selection and weighting of prioritisation criteria indicators. This allows the tool to be used by other programmes wishing to identify and prioritise wetland areas.

Model overview

The GIS model is based on the calculation of a qualitative wetland priority index value for each tertiary catchment across the entire country. This priority index value for a specific tertiary catchment is calculated from the sum of all (or a selected subset of user-defined) prioritisation criteria.

Prioritisation criteria

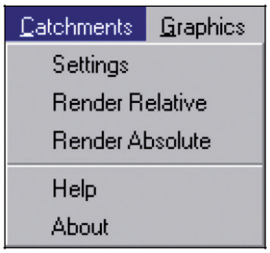
Workshops were held early in the project with stakeholders to identify prioritisation criteria which would be required to identify priority wetlands or wetland areas. Proxy (surrogate) datasets were sourced which could provide indicators of the required criteria. These thirteen prioritisation criteria indicators were obtained from existing datasets with national coverage:

1. National Biodiversity Priority Areas
2. Protected Areas
3. Peat Wetland Eco-regions
4. Ramsar Sites
5. Water-stressed Catchments
6. Water (Chemical) Quality
7. Spatial Development Initiatives (SDIs)
8. Water Catchment Management Agencies (CMAs)
9. Conservation Status Index
10. Erodibility (Soil) Index
11. Working For Water/Wetland Project Locations
12. Poverty Gap Index
13. Integrated Sustainable Rural Development And Urban Renewal Nodes.

Model installation

This Arcview 3.2 extension prioritises tertiary catchments according to a sum of weighted criteria indicators. The extension (catchments.avx) comes with an object database file (catchments.odb) which must be installed into the same directory as the extension in the ESRI Arcview EXT32 folder. The accompanying catchment.pdf file, which is the project

document, must also be copied into the same EXT32 folder for the 'help' function to work. To implement the model, the extension (catchments) must first be activated during ArcView startup. This is the menu that should appear with the extension when it is installed:



The extension is now ready to be used.

Model usage

The menu associated with the Catchments extension (national scale GIS model) refers to the following options:

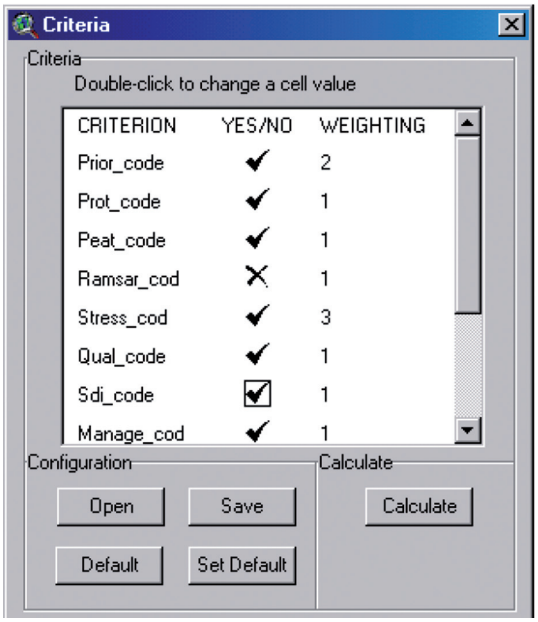
- Show Dialog/Settings: this menu option configures the criteria indicators.
- Render Relative: this menu option renders the catchments theme according to an equal interval range of five classes.
- Render Absolute: this menu option renders the catchments theme according to an equal interval range of a user-prompted number of classes (the calculated field).

These options are explained in more detail below.

Adjusting criteria indicator selection and weighting

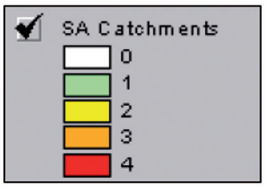
Select to configure the criteria indicators (refer to section 3.1.4). Double-click on a value in the listbox (shown below) in order to select ('tick') or deselect ('cross') the criteria indicators, or to adjust their weightings (from 1-5). To save or change the criteria, use the task buttons as indicated below:

- *Open*: this button restores the configuration according to the last saved configuration.
- Save: this button saves the current configuration.
- *Default*: this button restores the configuration according to the default configuration which is made by the administrator and saved with the distribution of the extension.
- *Set Default*: this button saves the current configuration as the default configuration. It is password-protected and it is reserved for the administrator of the extension to set before distributing the extension.
- *Calculate*: this button recalculates the field ABSOLUTE according to the sum of the weighted criteria. Criteria that are crossed are not included in the calculation.

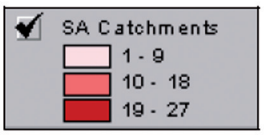


Rendering the theme

Rendering the theme on the field RELATIVE yields an equal interval range classification with 5 classes (0.4).



Rendering the theme on the field ABSOLUTE yields an equal interval range classification and the user is prompted for the number of classes.



Technical considerations

The extension depends on the catchments theme being active in the view. The actual name of the file is irrelevant. It also requires the shapefile to be editable, i.e. not read-only, because the field ABSOLUTE is calculated dynamically.

The extension relies on the following structure of the attributes:

1. The first 6 fields are ignored as criteria.
2. 7...n numeric criteria fields in the middle. The name of each field is irrelevant but it is limited to the dbase limitation of 10 characters.
3. The fields RELATIVE and ABSOLUTE are the last two numeric fields which are ignored as criteria (added automatically if not present).
4. The fields are essentially read-only except for ABSOLUTE and RELATIVE which are calculated.

The administrator must set the default settings before distributing the extension. The catchments shapefile must then also be distributed with the extension. The object database file, catchments.odb, and the shapefile itself must be writeable. Beware if copying from a CD.

Attributes of Catchments.shp

Shape	Drainage	crit_01	crit_02	crit_03	relative	ABSOLUTE
Polygon	DPNTF286	1	1	1	1	5
Polygon	DPN2T141	1	4	2	1	11
Polygon	DAP8T102	2	1	3	2	12
Polygon	DAP3T216	1	1	1	1	5
Polygon	DPN1T147	1	1	1	1	5
Polygon	DPNRI259	2	1	3	2	12
Polygon	DHNRV327	1	1	1	1	5
Polygon	DPN3T5730	1	1	1	1	5

APPENDIX II:
Prioritisation criteria indicators used to prioritise tertiary catchments

Thirteen criteria indicators were obtained from existing datasets (with national coverage) to address the criteria identified by stakeholders in earlier workshops. These criteria indicators are:

1. National Biodiversity Priority Areas
2. Protected Areas
3. Peat Wetland Eco-regions
4. Ramsar Sites
5. Water-stressed Catchments
6. Water (Chemical) Quality
7. Spatial Development Initiatives (SDIs)
8. Water Catchment Management Agencies (CMAs)
9. Conservation Status Index
10. Erodibility (Soil) Index
11. Working For Water/Wetland Project Locations
12. Poverty Gap Index
13. Integrated Sustainable Rural Development And Urban Renewal Nodes.

These criteria indicators have been used to develop the WET-Prioritise I GIS tool. Supporting information and GIS datasets for the criteria indicators were sourced from a variety of organizations, namely:

- Council for GeoScience
- Council for Scientific and Industrial Research (CSIR – Environmentek)
- CPH Water (cc)
- Department of Environment Affairs and Tourism (DEAT)
- Department of Water Affairs and Forestry (DWAF), incl. Institute for Water Quality Studies (IWQS)
- Human Sciences Research Council (HSRC)
- National Department of Agriculture, incl. Institute for Soil, Climate, Water (ISCW)
- STATS SA
- Wetlands Consulting Services (Pty.) Ltd.
- Working for Water
- Working for Wetlands

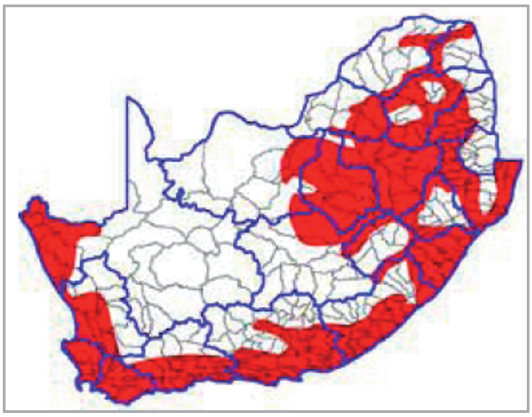
Each criteria indicator dataset was adjusted to a standardized 5-level index scale (i.e. 0, 1, 2, 3, 4), based on either a 'percentage weighted area' or simple 'occurrence/no occurrence' rule of that particular criteria within each tertiary catchment across South Africa. In each case 0 represents either 'no data' or 'no coverage' for that tertiary catchment. Two alternate area-weighted scoring systems, according to the original value range and/or geographical complexity of the source data, were used in the generation of the 5-level index values (Table I). Details of the source of the data, how the data was used in the model, and the criteria indicator code in the GIS model, are provided below for each criterion indicator.

Table I. The two weighted scoring systems used to adjust the national datasets

Index Rating	System A	System B
0	0	0
1	> 0-10	> 0-2
2	> 10-20	> 2-5
3	> 20-50	> 5-10
4	> 50	> 10

1) National Biodiversity Priority Areas

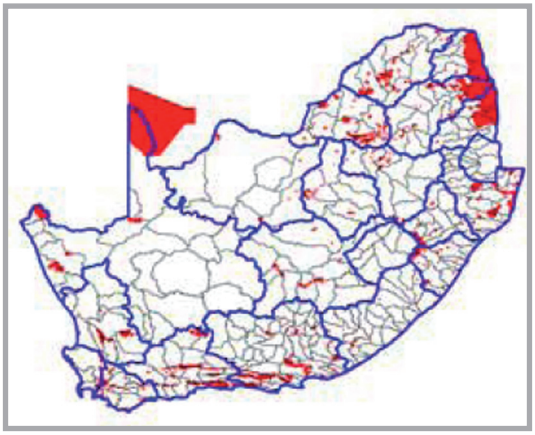
Source Data	Sourced directly from the 'biodiversity priority areas" spatial data layer in the NBI's "National Spatial Biodiversity Assessment" GIS database (draft version April 2004).
Model Usage	1.1.1.1.1. Tertiary scoring based on the occurrence of a priority area within a tertiary catchment, where the index value was calculated on an area-weighted system A, where a rating of 4 indicates maximum area coverage in a specific tertiary catchment.
Criteria Code	BIODIVSITY



Biodiversity Priority Areas, Water Management Areas (WMA's) and Tertiary Catchments.

2) Protected Areas

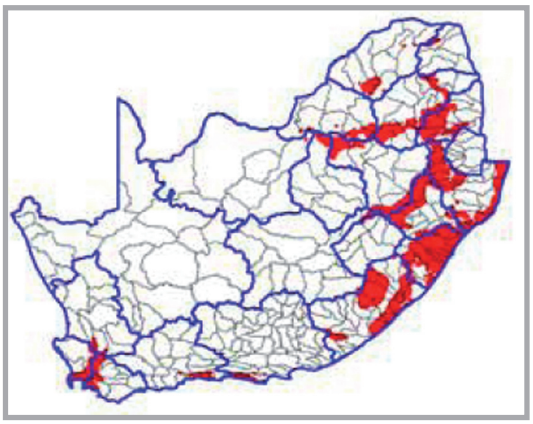
Source Data	Cumulative area combination of SANParks (*SANparksmay04.shp*), National, Provincial and (key) Private Sector Parks and Game Reserves (*cons_nat.shp*), all sourced from DEAT GIS Department.
Model Usage	Tertiary scoring based on the occurrence of a priority area within a tertiary catchment, where the index value was calculated on an area-weighted system B, *where a rating of 4 indicates maximum area coverage in a specific tertiary catchment.*
Criteria Code	PROTECTED



Protected Areas, Water Management Areas (WMAs) and Tertiary Catchments.

3) Peat Wetland Eco-regions

Source Data	Sourced from Marneweck, G.C., Grundling, P.L. and Muller, J.L. 2001. *Defining and classification of peat wetland eco-regions in South Africa.* Wetland Consulting Services (Pty.) Ltd. report No. 37/2000. Report to the Institute for Soil Climate and Water (ISCW), Agricultural Research Council, for the Directorate of Land and Resource Management (DLRM), Department of Agriculture, Pretoria, South Africa). Dataset represents a 5 km buffer around the accepted definitive national dataset on location and extent of peat ecoregions (peatmodel_5km_buffer.shp).
Model Usage	Tertiary scoring based on the occurrence of a priority area within a tertiary catchment, where the index value was calculated on an area-weighted system A, where a rating of 4 indicates maximum area coverage in a specific tertiary catchment.
Criteria Code	PEATLAND



Peat Wetland Eco-regions (5 km buffer), Water Management Areas (WMAs) and Tertiary Catchments.

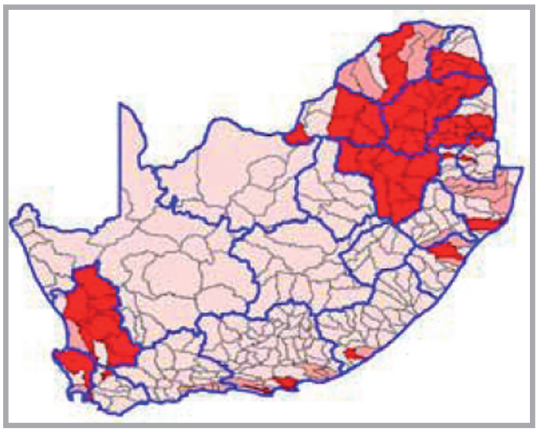
4) Ramsar Sites

Source Data	Sourced from DEAT GIS Department (Ramsar.shp).
Model Usage	Ramsar sites were simply coded according to presence (4) and absence (0) within a particular tertiary catchment, regardless of geographical extent.
Criteria Code	RAMSAR

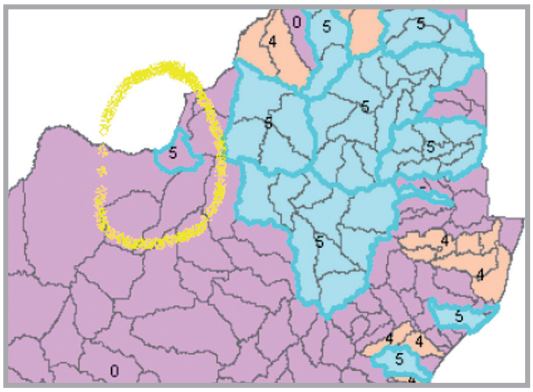
Ramsar sites, Water Management Areas (WMAs) and Tertiary Catchments.

5) Water Stressed Catchments

Source Data	Generated from the 3-level DEAT ENPAT (Environmental Potential Atlas) dataset, which was derived from DWAF's Water Situation Assessment Model (stressed catchments.shp).
Model Usage	Water Stressed Catchments were already in tertiary catchments and were simply coded according to original stress ratings, based on stress 0 : index 0, stress (1 & 4) : index 2 and stress (5) : index 4, where a rating of 4 indicates worst case water stress. Note: the source data included a value for only a sub-section of tertiary catchment D41 (Groot Marico area). This value was applied to the whole of catchment D41 in the final modelling process, since no sub-divisions of tertiary catchments were included in the model framework (see illustration below).
Criteria Code	WATER_STRS



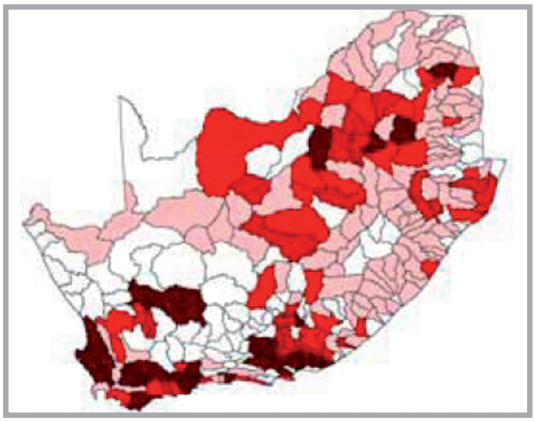
Sub-section of tertiary catchment D41 with unique water stress index value.



Water stressed catchments, Water Management Areas (WMAs) and Tertiary Catchments.

6) Water (Chemical) Quality

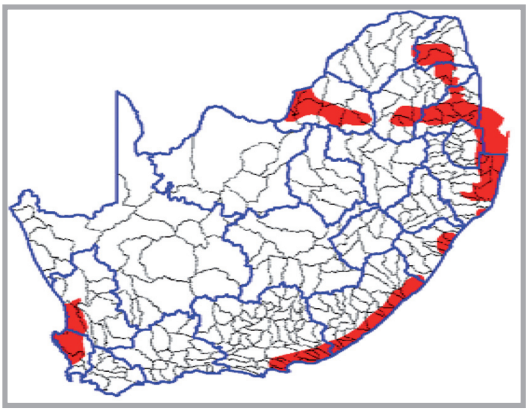
Source Data	Generated from a (spatially incomplete) national dataset derived by DWAF's Institute for Water Quality (M Silberbauer), based on re-configured quaternary level domestic / agricultural water quality thresholds circa 1996-2000. Cautionary note: this data should be seen as illustrative rather than quantitative, based on data quality comments supplied by the source. (ChemCriteria_ter.shp).
Model Usage	Water Quality values are based directly on the IWQS modeled outputs, based on : no data and/or stress 0 : index 0, stress (1 & 4) : index 2 and stress (5) : index 4, where a rating of 4 indicates worst case water quality.
Criteria Code	WATER_QUAL



Water Quality index values coded for Tertiary Catchments (courtesy of IWQS-DWAF).

7) Spatial Development Initiatives (SDIs)

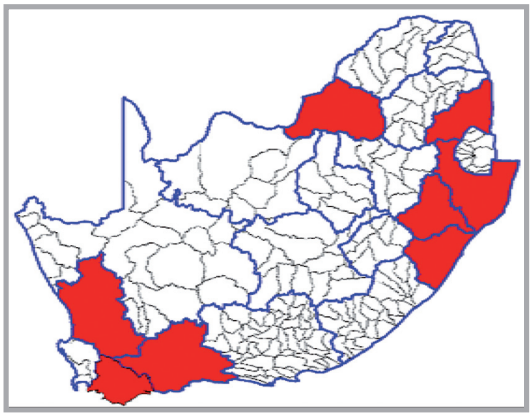
Source Data	Sourced from DEAT GIS Department (SDI.shp).
Model Usage	Tertiary scoring based on the occurrence of a priority area within a tertiary catchment, where the index value was calculated on an area-weighted system A, where a rating of 4 indicates maximum area coverage in a specific tertiary catchment.
Criteria Code	SDI



Spatial Development Initiative (SDI) corridors, Water Management Areas (WMAs) and Tertiary Catchments.

8) Catchment Management Agencies (Water CMAs)

Source Data	Spatial data sourced from DWAF, based on the extent to which CMAs have been or are prioritised to be established. Non spatial information on CMA organisations associated with WMAs sourced from DWAF and DWAF-IWQS and CSIR. Only two CMAs are currently officially recognized (a) Crocodile West (Groot Marico) and (b) Inkomati.
Model Usage	CMAs are based on WMA boundaries. Because WMA boundaries are not always exactly the same as amalgamated tertiary boundaries, tertiary coding was based on a simple allocation of index value 4 for all full tertiary catchments falling completely within the designated CMAs, and index value 2 for all tertiary catchments partially intersecting with the CMAs (i.e. Crocodile West Groot Marico).
Criteria Code	CMA

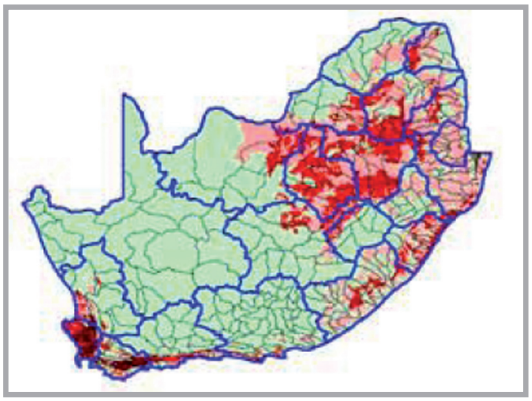


Catchment Management Agencies (CMAs), Water Management Areas (WMAs) and Tertiary Catchments.

Only two CMAs are currently officially recognized (a) Crocodile West (Groot Marico) and (b) Inkomati. The remainder are in the process of being established but have at least been identified as priorities : Mvoti-Umzimkulu, Breede, Gouritz, Olifants-Doorn, Thukela and Usutu-Mhlathuze

9) Conservation Status Index

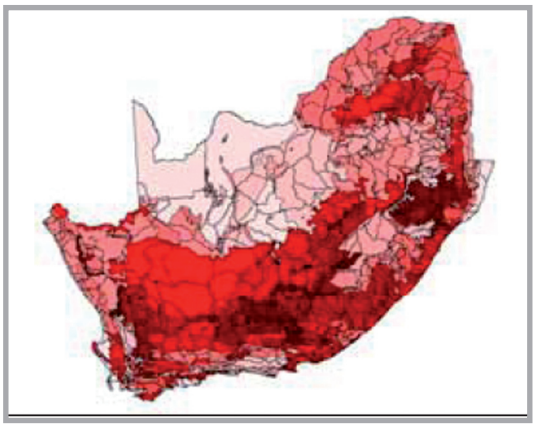
Source Data	Sourced directly from the 'conservation status' spatial data layer in the NBI's 'National Biodiversity Assessment' GIS database (draft version April 2004). Spatial data sourced from DWAF, based on Water Management Areas (WMAs).
Model Usage	Tertiary scoring based on area-weighted index of multiple input classes, based on the original source data, which was re-coded prior to modelling as: no data = index 0, not threatened = index (1), vulnerable = index (2), endangered = index (3), critically endangered = index (4).
Criteria Code	CONSV_STAT



Conservation Status, Water Management Areas (WMAs) and Tertiary Catchments.

10) Erodibility (Soil) Index

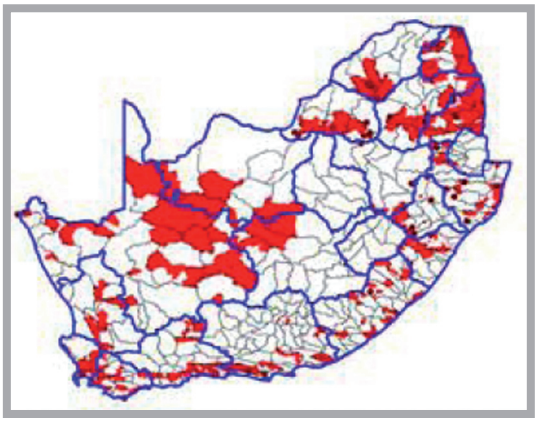
Source Data	Generated from the 20-level DEAT ENPAT (Environmental Potential Atlas) 'Erodibility Index' dataset, which represents the potential susceptibility of soils to wind and water erosion (erosion.shp).
Model Usage	Tertiary scoring based on area-weighted index of multiple input classes, based on the original source data, which was re-coded prior to modelling into 5 classes based on equal range source data values, e.g. (1-4) = 4, (5-8) = 3, (9-12) = 2, (13-16) = 1, (17-20) = 0; where a rating of 4 indicates maximum susceptibility to erodibility.
Criteria Code	ERODE_INDX



Erodibility Index and magisterial boundaries, courtesy of ENPAT-DEAT.

11) Working for Water / Wetland Project Locations

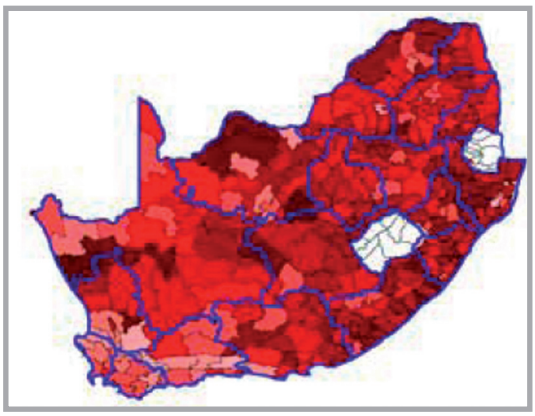
Source Data	This data layer was chosen to represent the criteria indicator 'livelihoods dependent on wetlands', and is based on the location of completed and ongoing 'Working for Wetlands' and 'Working for Water' projects. The assumption being that such projects typically result in income generation for participating local communities. Similar information on the National Department of Agriculture's Landcare Programme projects may be incorporated in a later version. Working for Water dataset sourced from WfW (Cape Town): national overview of all quaternary catchments containing WfW projects up to March 2004. Working for Wetland datasets sourced from WfW (J Coetzee): national overview, based on point-based coverage linked to closest town to project location (circa 2003) (wetlands_projects.shp & wetlands_projects.shp).
Model Usage	Tertiary scoring based simply coded according to presence (4) and absence (0) within a particular tertiary catchment, regardless of geographical extent.
Criteria Code	WFW_SITES



Working for Water and Working for Wetland project locations, Water Management Areas (WMAs) and Tertiary Catchments.

12) Poverty Gap Index

Source Data	Generated from Poverty Gap Index (0-1) data sourced from the Human Science Research Council (HSRC). The original 'Poverty Gap' dataset is based on index values per magisterial district. These have been converted to tertiary applicable area units in the wetland model. A special note of thanks is given to the HSRC for making this commercial dataset freely available to the project (SA_Poverty_Gap_2001.shp).
Model Usage	Tertiary scoring based on area-weighted index of multiple input classes, based on the original source data, which was re-coded prior to modelling into 5 classes based on equal range source data values, e.g. (0-0.2) = 0, (>0.2-0.4) = 1, (>0.4-0.6) = 2, (>0.6-0.8) = 3, (>0.8-1.0) = 4; where a rating of 4 indicates highest poverty levels in a given tertiary catchment.
Criteria Code	POVERTY

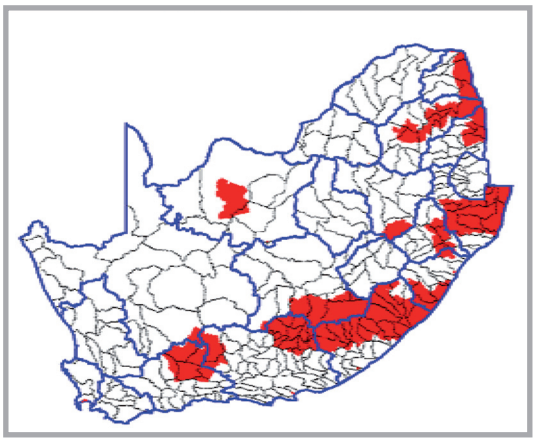


HSRC

Poverty Gap index, based on magisterial districts, and Water Management Areas (WMAs).

13) Integrated Sustainable Rural Development and Urban Renewal Nodes

Source Data	Integrated Sustainable Rural Development and Urban Renewal Node datasets sourced from STATS SA as thematic units, based on individual programme project boundaries (Nodal_Areas.shp, Nodal_Areas_Urban.shp).
Model Usage	Tertiary scoring based on a two-tiered, combined approach, where scoring for the (geographically larger) rural nodes was calculated on an area-weighted basis using B. This was then combined with the occurrence of (the geographically smaller) urban nodes which were scored simply on occurrence, regardless of geographical extent. The two (0-4) index ratings were then amalgamated using a maximum value rule, into a final (0-4) index; where a rating of 4 indicates maximum coverage by a development node.
Criteria Code	DEV_NODES



Integrated Sustainable Rural Development and Urban Renewal Nodes, Water Management Areas (WMAs) and Tertiary Catchments.

APPENDIX III: CASE STUDIES

CASE STUDY 1: The prioritisation and planning of wetland rehabilitation in the Free State province
Donovan Kotze

1.1 Background to the case study

Rehabilitation refers to reinstating the driving ecological forces (including hydrological, geomorphological and ecological processes) that underlie a wetland, so as to improve the wetland's health and the ecological services that it delivers. Effective rehabilitation planning therefore requires an assessment of how the hydrological, geomorphological and ecological processes in a wetland have been impacted on or threatened. Furthermore, it requires an assessment of the predicted contribution that wetland rehabilitation will make to improving wetland health and ecosystem delivery through addressing the identified impacts and threats.

This report provides the application of a prioritisation procedure to a case study undertaken for the Free State Province.

1.2 Round 1: Prioritisation of Quaternary Catchments within the province

It was mentioned in the sections introducing the WET-Prioritise method that the process is hierarchically nested according to the spatial scale of the study, and that the seven steps involved in the prioritisation procedure are iterative. This case study demonstrates both of those aspects of the WET-Prioritise procedure.

The first step in this prioritisation procedure was to identify priority wetland areas (at the quaternary-catchment level) within the province.

1.2.1 Step 1: Aim and objectives

The case study formed part of the Working for Wetlands (WfWetlands) national process for prioritising and planning wetland rehabilitation work undertaken in 2007. Wetland systems in the Free State province, which had a high priority in terms of rehabilitation needed to be identified.

1.2.2 Step 2: Identification of the spatial extent of the study area

Although the rehabilitation planning project was intended for the entire province (in order to identify priority quaternary catchments within the province to screen for potential rehabilitation sites), the planned wetland rehabilitation work at the Ramsar site, Seekoeivlei, in the Klip River catchment, occurring in the Golden Gate National Park and in the neighbouring Phuthaditjhaba, is not included in this case study.

1.2.3 Step 3: Collation of available information

At this coarse provincial scale, regional experts (including the provincial Wetlands Forum) were engaged to access the local specialist-knowledge.

1.2.4 Step 4: Development of the prioritisation criteria

The prioritisation criteria, to identify sites for future rehabilitation-planning work, were:

1. River catchments in which no current rehabilitation activities were occurring,
2. Sub-catchments in the headwaters, since wetlands in these sub-catchments

would experience comparatively little effects of upstream catchment degradation. This meant that most or all of the potential problems at a particular wetland site were likely to originate on site, or in the immediate small catchment area, and that rehabilitation activities were more likely to be successful because these types of problems (on-site causes) lend themselves to more successful outcomes than problems which arise remotely from the site being studied.

1.2.5 Step 5: Screening for candidate catchments

The Free State Department of Tourism, Environmental and Economic Affairs (FSDTEEA) had already identified the Wilge River, Meulrivier and Klip River catchments as priority catchments. This decision was endorsed by the stakeholders of the Free State Wetland Forum. The FSDTEEA had been following a systematic procedure of identifying wetlands in need of rehabilitation, starting in the upper sections of the river catchments, which are the most important areas from a water supply perspective because the rainfall is much higher than it is lower down in the catchment. Thus these three catchment areas had already been prioritised by the local stakeholders.

1.2.6 Step 6: Prioritisation of catchments

Extensive rehabilitation work had already been undertaken in the Wilge and Klip River catchments, in partnership with Rand Water and Working for Wetlands, but rehabilitation work had only recently begun in the Meulrivier catchment. The Meulrivier catchment was therefore deemed to be in the greatest need of wetland rehabilitation-prioritisation planning.

Additionally, quaternary catchments C81L and C81M were prioritised for rehabilitation assessment because they are uppermost in the Meulrevier catchment, and therefore not subject to any upstream disturbances.

1.2.7 Step 7: Assessment of the potential of the prioritised catchments to meet the objectives

The identification of priority quaternary-catchment areas was the first step in identifying priority wetlands for rehabilitation. Now that priority quaternary catchment areas had been identified, the resolution of the study could be increased to focus in more detail on these smaller priority catchments (as opposed to the more general prioritisation approach adopted at the provincial level).

1.3 Round 2: Prioritisation of wetlands within the prioritised catchments

1.3.1 Step 1: Aim and Objectives

The aim of this section of the study was to identify within the prioritised quaternary catchments, priority individual wetlands for rehabilitation activities for the WfWetlands programme. The wetlands in question would need to be in a condition that would benefit favourably from rehabilitation activities.

No specific wetland management/ rehabilitation objectives existed for the two catchments being surveyed. However, owing to the critical importance of the selected catchments to supplying Gauteng Province with water, the FSDTEEA and the Free State's Wetland Forum identified maintaining or enhancing the hydro-geomorphological integrity of the wetlands in the catchment as a primary objective. Had specific wetland objectives relating to biodiversity conservation, for example, existed for the catchment, the

prioritisation process may well have been conducted differently in order to tailor it to meet the specific objectives.

1.3.2 Step 2: Identification of the spatial extent of the study area

The two focal quaternary catchments (C81L and C81M) in the upper Meulrevier catchment were prioritised for rehabilitation assessment in the first part of the study, largely through consultation with the regional stakeholders and experts. Collectively the two selected quaternary catchments cover an area of 1886 km^2.

1.3.3 Step 3: Collation of available information

Little information existed on the location or the extent of wetlands in these catchments, so recent 1:30000 aerial photographs for the area were sourced to provide information on the wetlands in these catchments.

1.3.4 Step 4: Development of the prioritisation criteria

The procedure used to prioritise amongst the individual candidate sites within the chosen cluster was to describe the hydro-geomorphic wetland type (see *WET-EcoServices*: Kotze *et al*., 2009a) and assess the overall health of the wetland using a Level 1 *WET-Health* assessment (Macfarlane *et al*., 2009). Following from the Level 1 assessment, the specific impacts and/or threats which could be addressed by structural rehabilitation were described at a Level 2 assessment. For example, for headcut erosion, the specific dimensions and level of activity of headcuts are described.

Suitable rehabilitation objectives (such as halting erosion) were then set and preliminary rehabilitation intervention measures were planned. The likely contribution of the proposed rehabilitation intervention to wetland health and ecosystem delivery was then assessed in terms of

1. the spatial area likely to be affected by the proposed intervention/s (i.e. area potentially protected)
2. the likely benefits that would result from achieving the rehabilitation objective/s in terms of the integrity of the affected area of the wetland (using *WET-Health*) and the ecosystem services that the area delivers (using *WET-Ecoservices*), essentially health status as well as goods and service improvement.

The criteria were assessed by comparing the likely situation without rehabilitation (i.e. no intervention) to the likely situation with rehabilitation. For areas that were threatened by headcut erosion, the benefits in terms of health were determined based on the difference between the 'current health' and the projected health if the headcut proceeded to erode through the threatened area. In this case, halting the propagation of the headcut through rehabilitation interventions (e.g. gabion structures) was assumed to secure the current situation.

A combination of the health of the system and its size was used to calculate 'hectare equivalents'. For example, a 30 ha area of wetland threatened by gully erosion, with a 'current health' score of 9/10 projected to decline to 3/10 if the erosion is allowed to proceed. A rehabilitation intervention that would halt this erosion would therefore secure a hectare equivalent of (9-3=6)/10 of the area's integrity, i.e. 60% of its integrity. This would equate to securing 18 ha (30ha x 6/10) of wetland integrity - 18 'hectare equivalents'.

For all of the scores that were allocated, written justification of the underlying rationale was provided. Health was assessed separately for the hydrology,

the geomorphology and the vegetation components, with all three components being scored on the scale of 0 (critically altered) to 10 (pristine). The scores for these three respective components were then integrated, based on a weighted average of 1, 0.6 and 0.4 respectively, to derive a single score. The particular weightings were chosen based on the importance of water supply in the catchment, as discussed above. Had biodiversity been of greater importance relative to water supply, the vegetation component would have been scored higher, and would have been weighted above geomorphology. The procedure is discussed in more detail in the document *WET-RehabPlan* (Kotze *et al*., 2009b).

The projected costs of the required rehabilitation undertakings at each of the sites were also assessed. This allowed the cost per hectare equivalent to be calculated, and provided a valuable index of comparing anticipated cost-effectiveness of rehabilitation studies across a number of sites.

In order to achieve the rehabilitation objectives cost-effectively, it is important that operational considerations are also included in the procedure. The most important of these considerations is the clustering of projects. If individual projects are very widely scattered, it is more difficult to manage the individual projects than it is if the projects are grouped within clusters. Clustering, which results in several projects located in a single 'neighbourhood', also allows the stakeholder-engagement process to be conducted more efficiently (Nxele and Kotze, 2009). Thus priority wetlands were identified in the following two-step process:

- Based on a preliminary screening of individual wetland sites, candidate clusters of wetlands within the chosen quaternary catchments were identified (Step 5, below).
- Within the chosen cluster, those individual wetlands likely to yield the greatest rehabilitation returns on investment were selected (Step 6, below).

1.3.5 Step 5: Raid screening for candidate wetland clusters

Resources, and in particular time, were too limited to conduct an airphoto-based survey of the wetlands across the entire area of quaternary catchments C81L and C81M. Thus steep areas were excluded because the extent of wetlands is limited in these areas, and they are also generally very difficult to access in order to implement rehabilitation interventions,

In this study, support was kindly provided by the Bataleurs volunteer pilots. This involvement from civil society greatly reduced the costs of the prioritisation procedure, and local knowledge could be gained directly from the pilots. The area was flown with a light aircraft and a team of four, including the pilot, the navigator and two spotters, one on either side of the plane, who identified and photographed problem areas (e.g. erosion headcuts and drainage channels) considered potentially suitable for structural rehabilitation. The flexible approach to flying was useful, in that when 'promising areas' were identified, the plane would deviate off its route to search further before coming back onto the route, while in areas showing "little promise" the plane would continue along the designated route.

From this stratified sampling of the quaternary catchments, thirty-one candidate-wetland sites were identified from the air and their GPS coordinates recorded. All of these sites were then examined on recent 1: 30000 aerial photographs, and with reference to the photographs taken on the flight, if available, a preliminary assessment was

Table 1.1: Classes for scoring the potential suitability of wetland sites for rehabilitation

Score	Description of the class
0	The returns are considered to be very low or the sites considered 'lost causes' that are extremely degraded (e.g. with a deeply incised gully throughout the length of the wetland) and which would be prohibitively expensive to rehabilitate
1	A site which has potential (e.g. reasonably intact areas threatened by headcut erosion) but where the returns are likely to be low (e.g. because the intact areas is relatively small, i.e.< 3 ha and/or appears to have a low level of wetness) or uncertain
2	A site where the returns are potentially moderate (e.g. a moderately sized area with artificial drains that could be plugged or a moderately sized area threatened by gully erosion)
3	A site where returns are potentially high (e.g. a large area, i.e. > 20 ha, with artificial drains that could be plugged or a large area threatened by gully erosion)

made of each site in terms of its potential for structural rehabilitation. Sites were scored using a four class system (Table 1.1).

The 31 sites were geographically located in three general clusters: a central cluster, a western cluster and an eastern cluster. For operational reasons it is more efficient to work on a cluster of sites in close proximity rather than working on very widely dispersed sites. Therefore the three clusters were each evaluated for their potential suitability for structural rehabilitation as a unit by adding the scores of the individual wetlands in the cluster. The collective scores of the clusters were as follows: east 8, central 10, west 5. The central cluster was therefore selected because it scored the highest overall for potential suitability. An added advantage of this cluster was that there was already rehabilitation work under way in this cluster, which made it easier to undertake maintenance while the new work was being done. The wetlands in the central cluster were also more accessible than those in the eastern cluster.

1.3.6 Step 6: Prioritisation of individual wetlands within the selected wetland cluster

The seven individual wetlands in the central cluster, which had been identified from the aerial survey, were examined in the field. Before proceeding with a full assessment and detailed planning, an initial judgment was made as to whether the sites were clearly unsuitable for structural rehabilitation. The purpose of this step was to screen the individual sites in order to prevent wasting resources on assessing (for detailed prioritisation) a site that is unlikely to be suitable for rehabilitation. Unsuitability was based on whether the site was considered to be one of the following.

- A 'lost cause', which refers to a site already highly degraded (e.g. severely eroded throughout) that has very little integrity remaining that could be secured and one that would require considerable rehabilitation resources to reinstate lost integrity. Typically a wetland that is eroded by deep gullies throughout its length, and which can easily be distinguished from the air.
- A case of clearly very low returns for the investment (e.g. a major headcut threatening only a very small portion of wetland (Figure 1.1), which may not be distinguishable from the air.
- A 'band-aid case' where the root causes of degradation have not been addressed, and which may only become apparent after the specific management of the site has been discussed with the landowner. A typical example is where the landowner continues to overgraze a wetland. Once

Figure 1.1: Major erosion headcut of approximately 4 m high and advancing along several tongues to threaten a 4 ha portion of wetland in Arm 1 of Live and Hope wetland; (a) headcut in the left hand arm and (b) aerial view of the erosion. See also Figure 1.2 and 1.3

the root causes of degradation (e.g. poor grazing management) have been addressed, the site may then become suitable for detailed assessment.

The estimated cost of the structures required to halt the erosion of Live and Hope wetland, Arm 1 (Figures 1.1, 1.2 and 1.3) was in excess of one million Rand owing to the considerable size of the headcut and the fact that it was very actively eroding along multiple tongues. Given that this headcut was threatening an area of wetland only 4 ha in size, the cost was not justified. However, had it been threatening a much larger area, say of 300 ha, then a more detailed planning and costing of rehabilitation interventions would have been justified. However, even a detailed costing may have shown an inadequate return on investment for the rehabilitation of Live and Hope wetland, Arm 1.

Three of the seven candidate-sites that were identified from the air survey were judged to be unsuitable for rehabilitation. The decisions were based on the fact that candidate sites were either lost causes or likely to have very low returns per effort. The remaining four sites, and a fifth site that was missed on the air survey (but highlighted by the local implementer for Working for Wetlands, Central Wetlands Rehabilitation), were identified as likely candidate wetlands for rehabilitation work.

The five short-listed candidate sites were then assessed in the field, using the assessment tools discussed in section 1.3.4 (Development of the prioritisation criteria).

The prioritisation criteria (area affected and cost-effectiveness of the planned activities) are summarised in Tables 1.2 and 1.3 respectively. These data show that the most cost-effective wetland system is Bagshot. Although San Souci provides the greatest benefits in terms of secured ecosystem services, the site is complicated by the fact that rehabilitation work had already been conducted there at the time of the prioritisation assessment, but it had been insufficient to halt the erosion. Although yielding lower returns on investment, San Souci was prioritised above Bagshot in order to complete the work begun and not let the initial investment go to waste, and also because the headcut was advancing more rapidly, and therefore resulting in greater urgency for rehabilitation. For the purposes

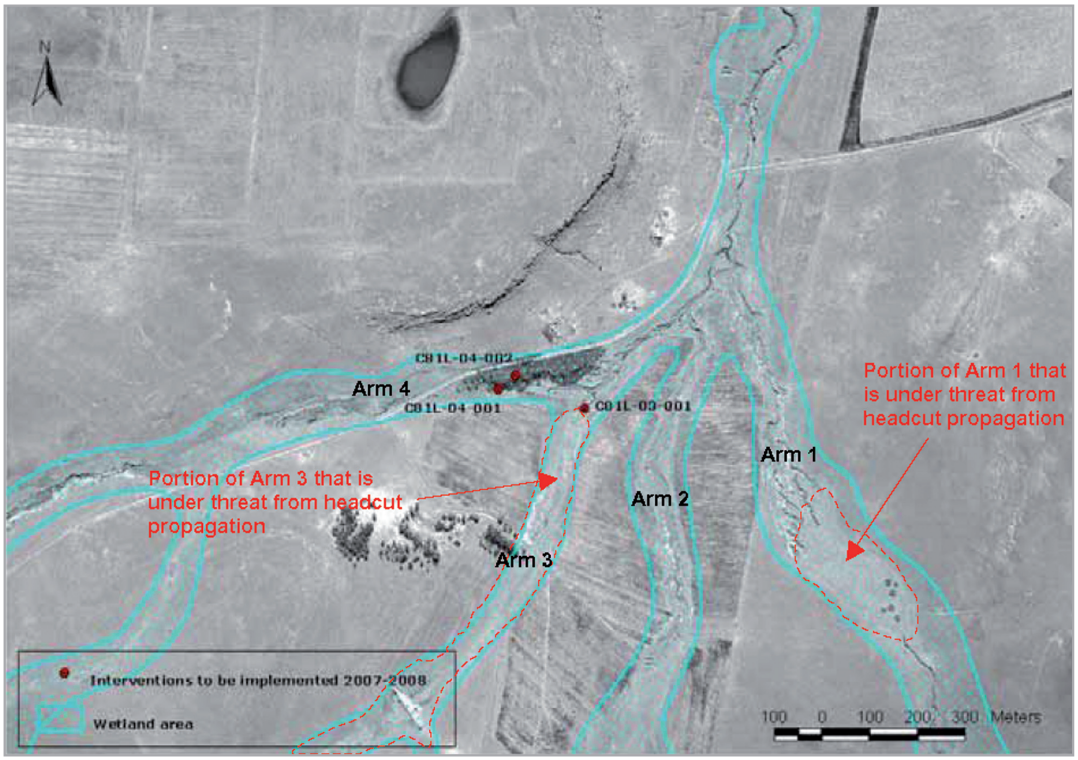


Figure 1.2: Map of the Live and Hope wetland

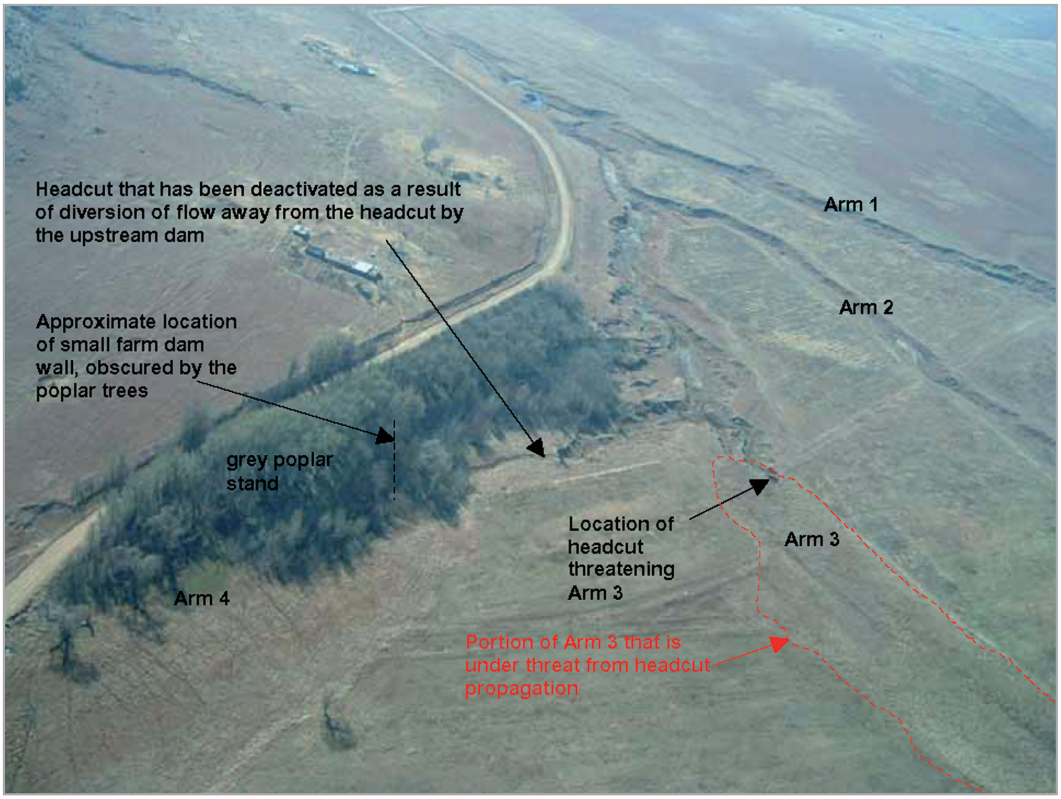


Figure 1.3: An aerial view of the Live and Hope wetland (photo: E Munzhedzi, June 2006).

of prioritising, the rehabilitation costs that had already been incurred from the existing work at San Souci were not included, because if further work was not conducted then all of the benefits of the existing work were likely to be lost. However, when assessing the actual returns on investment once the project has been completed, the costs of the existing work should be included in the overall assessment.

Once the rehabilitation work at San Souci has been completed, Bagshot would clearly be the next wetland that should be rehabilitated. Following that, Sandhurst is more cost effective than Live and Hope in terms of integrity and ecosystem services.

1.3.7. Step 7: Assessment of the potential of the prioritised wetlands to meet the objectives

As indicated, no specific wetland management/rehabilitation objectives existed for the two catchments being surveyed. Thus, owing to the importance of these catchments for water supply, the primary objective for the purposes of prioritising was identified as maintaining or reinstating the hydro-geomorphological integrity of the wetlands in the catchment. Prioritisation of the wetlands in these catchments was based primarily on the cost-effectiveness with which the rehabilitation interventions maintained or reinstated hydro-geomorphological integrity (expressed in terms of the cost

Table 1.2: Hectare equivalents of secured integrity for the five wetland areas assessed

Weighting*:	Hydrology (1)	Geomorphology (0.6)	Vegetation (0.4)	Composite score (weighted average)
San Souci	21	27	30	24.6
Bagshot	22	28	20	23.4
Live & hope 1	4.4	5.5	4.4	4.73
Live and hope 2	0.8	1	0.2	0.74
Sandhurst	10	13	9	10.7

*These weightings were chosen based on the importance of the wetlands in terms of catchment water supply

Table 1.3: Cost-effectiveness of the proposed rehabilitation interventions at the five sites

Wetland name	Cost of the interventions[1]	Hectare equivalents of secured functionality[2]	Affected Area (ha)	Severity of headcut[3]	Secured Ecosystem Services[4]	Cost Effectiveness (Rands per ha)[5]
San Souci	R1,767,000.00	24.6	54	10	17	R71,829.27
Bagshot	R835,000.00	23.4	40	9	12	R35,683.76
Live & hope 1	R876,500.00	4.73	11	8	10	R185,306.55
Live & hope 2	R126,500.00	0.74	2	6	10	R170,945.95
Sandhurst	R1,288,656.00	10.7	20	9	9	R120,435.14

[1] The costs of the rehabilitation interventions are based on the 2007 costs of construction of designs by T Pike of LRI
[2] Derived from Table 1.2
[3] Scored from 0 (no threat) to 10 (most severe threat)
[4] This is scored out of a maximum of 30, given that this is derived from the sum of 15 ecosystem services, each scoring between 0 and 2.
[5] Calculated by dividing hectare equivalents of secured functionality by the costs of the interventions required to secure the affected area

of the intervention per hectare equivalent of maintained/reinstated intact wetland). Thus the potential that the prioritised wetlands will meet the objectives is good in as far as the hydro-geomorphological assessments are a good reflection of the actual situation (which could not be validated within the scope of this project). Operational considerations (including clustering of projects for ease of access and completing work already under way) were built into the prioritisation procedure. However, the commitment of the landowner to the long term management of the rehabilitated wetlands was not assessed.

1.4 Lessons learnt from this case study

- The province, in this case through the FSDTEEA, contributed meaningfully to the planning and prioritisation process, in particular at the higher levels of prioritisation, where key decisions were made regarding the rehabilitation focus in the province.
- The contacts that the provincial departments (in this case FSDTEEA and Department of Agriculture, together with the Working for Wetlands service provider) had with landowners in the identified catchments greatly assisted in the field assessment.
- Local knowledge held by the Working for Wetlands service provider already working in the area proved useful in informing the assessment process.
- The Bateleaurs provided a welcome and much-needed broad assessment/ birds-eye-view of the catchment. This dramatically reduced the costs that would be involved in visiting in the field a much larger set of wetlands, many of which would be found to be of a low priority for rehabilitation.
- An initial health assessment and elimination of low priority candidate sites prior to the engineer visiting the site ensured that the engineer's time is not wasted on low priority sites.
- There is no 'one fits all' approach to be adopted in such procedures due to the varying objectives of different studies.

1.5 ACKNOWLEDGEMENTS

Nacel Collins of the Free State Department of Tourism, Environmental and Economic Affairs, Dries Lategan, a volunteer pilot from Harrismith, Eric Munzhedzi of Working for Wetlands, Johan van der Schyff of Central Wetlands Rehabilitation, Kierie de Jaager of Department of Agriculture, Trevor Pike of Land Resources International (LRI) and the individual landowners of the wetlands assessed are thanked for their useful contributions to the prioritisation undertaken in this case study. Samantha Adey is thanked for her valuable editing of a previous draft of the case study.

1.6 REFERENCES

Kotze DC, Ellery WN, Rountree M, Grenfell MC, Marneweck G, Nxele IZ, Breen DC, Dini J and Batchelor AL, 2009a. *WET-RehabPlan: Guidelines for planning wetland rehabilitation in South Africa.* WRC Report No. TT 336/09. Water Research Commission, Pretoria.

Kotze DC, Marneweck GC, Batchelor AL, Lindley DS and Collins NB, 2009b. *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* WRC Report No. TT 339/09. Water Research Commission, Pretoria.

Macfarlane DM, Kotze DC, Ellery WN, Walters D, Koopman V, Goodman P and Goge M. 2009. *WET-Health: A technique for rapidly assessing wetland health.* WRC Report No. TT 340/09. Water Research Commission, Pretoria.

Nxele IZ and Kotze DC, 2009. Stakeholder participation in wetland rehabilitation: Six case-study wetlands examined. In: Kotze DC, Breen CM, Nxele IZ and Kareko J (eds.) *WET-ManagementReview: The impact of natural resource management programmes on wetlands in South Africa.* WRC Report No. TT 335/09. Water Research Commission, Pretoria.

CASE STUDY 2:
Conservation prioritisation in the Upper Olifants River Catchment, Mpumalanga

Mark Rountree, Allan Batchelor and Gary Marneweck

2.1. Background to the case study

The need to identify priority wetland systems in the upper Olifants catchment area stemmed from the requirement for off-site mitigation (also sometimes called 'offsets') to be initiated as part of the expansion plans of two mines.

The effect of the loss of wetlands, as a result of the expanded mining activities, was required by the authorising agencies to be mitigated through off-site mitigation; specifically with the protection and/or rehabilitation of wetlands of a certain proportion relative to the wetland area which was to be lost.

Subsequent to the initiation of this study, the Department of Water Affairs and Forestry (DWAF) released a draft position-paper outlining the intended policy with regard to wetland management. According to the currently available (October 2006) version of this document, off-site wetland mitigation has been suggested as a possible option for coal mines where impacts on wetlands are unavoidable.

2.2. Round 1: Prioritisation within the immediate quaternary catchment

The first round of the prioritisation procedure in this case study focused on identifying potential sites for off-site mitigation activities within the immediate quaternary catchment in which the mining was to occur.

2.2.1. Step 1: Aim and objectives

The aim of this study was to identify sites which met the off-site mitigation criteria; specifically where sites:

- could meet the area requirements
- were of a similar type to those that were to be lost at the mining site
- were in close proximity to the mine (in order to continue to provide some of the goods and services in that area that were to be lost due to the mine), and
- could be protected from long-term mining pressures.

2.2.2. Step 2: Identification of the spatial extent of the study area

The focus was on the immediate quaternary catchment, to allow for the minimal spatial disruption in the landscape of the loss of goods-and-services due to the loss of the wetlands at the mining site.

2.2.3. Step 3: Collation of available information

Some data were available from extensive in-house experience and expertise relating specifically to the wetlands of the Upper Olifants Catchment. In addition, regional wetland maps had been produced for the sub-catchment, and these were used in conjunction with recent aerial photographs and satellite images to assess the extent and condition of wetlands in the quaternary catchment. In-house information relating to mining areas was also available to provide some insight on the current and likely future extent of mining in the area.

2.2.4 Step 4: Development of the prioritisation criteria

The prioritisation criteria linked back to the aim and objectives of the study in that potential sites needed to meet the following criteria:

- the size of the wetland system needed to be of a certain, minimum size;
- the composition of HGM wetland types at the potential site had to be similar to that at the mining site; and
- the wetlands at the potential site could be protected from long-term mining pressures.

2.2.5 Step 5: Screening for candidate sites

None of the sites in the immediate quaternary catchment matched the minimum-size criteria, composition of HGM wetland types and a good likelihood of being protected from long-term mining pressures. This is because most of the large wetland systems in the immediate quaternary catchment were under threat from mining.

2.2.6 Step 6: Prioritisation of wetlands

No candidate sites were identified in step 5, and therefore no prioritisation could be undertaken.

2.2.7 Step 7: Assessment of the potential of the prioritised sites to meet the objectives

There were therefore no sites in the immediate quaternary catchment that could meet the aims and objectives of the prioritisation study.

We then reconsidered the aims and objectives of the study in light of these findings. It became apparent that:

1. Whilst most of the objectives and the associated prioritisation criteria for the study were valid and did address the aim of the study, focusing only within the immediate quaternary catchment did not offer large wetland-areas for conservation and the option of numerous small patches was not deemed to be practical.
2. The intensity and extent of current and historic mining in the quaternary suggests that mining pressures here are likely to continue to be high in the short to medium term, and thus it may not be possible to offer a high likelihood of protection of wetland areas.
3. Due to the extent of mining, and because most of wetlands and drainage lines in this quaternary are already impacted by mining, selection of such areas for wetland conservation is not in line with international practices of conserving the best condition sites first.

To address these limitations, the study was then expanded to include the entire Upper Olifants catchment.

2.3 Round 2: Prioritisation within the entire Upper Olifants River Catchment

2.3.1 Step 1: Aim and objectives

Although the search for priority wetlands took place across a much larger area than in Round 1, the aim of the study remained the same in that sites were identified which met the off-site mitigation criteria specifically sites that:

- could meet the area requirements
- were of a similar type to those that were to be lost at the mining site
- could be protected from long-term mining pressures.

2.3.2 Step 2: Identification of the spatial extent of the study area

The entire Upper Olifants catchment area was evaluated for potential sites for off site mitigation activities.

2.3.3 Step 3: Collation of available information

Regional information on wetland type and extent, supplemented by extensive in-house experience and expertise relating to the wetlands of the area, was available. These sources of information were used in conjunction with recent aerial photographs and satellite images of the catchment area which were used to assess the extent and condition of wetlands. Some information relating to mining areas was also available to provide some insight on the current and likely future extent of mining in the area.

2.3.4 Step 4: Development of the prioritisation criteria

The prioritisation criteria again linked back to the original aim and objectives of the study in that potential sites needed to meet the following criteria:

- the size of the wetland system needed to be of a certain minimum size
- the composition of HGM wetland types at the potential site had to be similar to that at the mining site, and
- the wetlands at the potential site could be protected from long-term mining pressures.

2.3.5 Step 5: Screening for candidate sites

The screening for candidate sites in the Upper Olifants catchment was based on size and wetland type criteria.

Of the hundreds of wetlands within the upper Olifants-catchment, the screening based on size and wetland-type criteria focused the study on less than a dozen candidate-wetland sites. These candidate sites were identified because:

1. They were able to meet the minimum size criterion required for the wetland off site mitigation area.
2. They were composed of similar types of wetlands (predominantly seepage wetlands and also valley bottom units) to those that would be lost to the proposed mining activities.

2.3.6 Step 6: Prioritisation of wetlands

The group of candidate sites were then assessed using a combination of desktop and rapid field methods.

The candidate sites were assessed:

1. In relation to the need for assurance of protection for the wetlands in the long term.
   - Information relating to approved or pending mining rights on lands where the candidate wetlands were located was obtained. Wetlands on lands which did not have current exploration rights were prioritised as the risk and likelihood of future mining activities in or near the wetlands was considered to be low.
   - The proximity to existing mines of the various candidate sites was noted, and those wetland systems which were close to mining areas were down-weighted in the assessment as the risk of future expansion, as well as general impacts arising from the mines, would threaten the long-term protection status of the wetlands.

2. According to their current ecological status.
   - A rapid 'bakkie window' field assessment was undertaken of the candidate sites to determine their levels of degradation. Some wetland systems were in a near-pristine state, some had been impacted upon by

grazing and minor erosion, some had been affected by encroachment of agricultural fields, and one system severely degraded by the impact of upstream mining.

- Candidate wetlands which were in a good ecological condition were scored highly in the prioritisation process. WET-Health and WET-EcoServices were used for this component of the assessment.

Only three of the candidate wetlands scored highly in the above criteria. As two of the wetland systems were immediately adjacent to towns, it was considered that because of the impacts of nearby urbanisation (litter, pollution and urban stormwater runoff), as well as the threat posed by future urban expansion around the wetland systems, these should be downweighted due to the threat posed by the towns to the long-term protection of the wetland systems. Thus the remaining wetland area scored the highest in terms of the prioritisation criteria and was identified as the priority area for off-site mitigation.

2.3.7 Step 7: Assessment of the potential of the prioritised sites to meet the objectives

The remaining wetland system (which was in a rural area), was in the best ecological condition, having sections of essentially pristine, highly species-rich seepage grassland areas. Additionally, this wetland area had the highest diversity of wetland types, including seasonal and permanent pans, sections of channelled and unchannelled valley bottom and extensive seepage wetlands. This wetland system was thus identified as the priority wetland for meeting the required objectives for this specific prioritisation project.

Long term environmental management plans for these wetland areas were developed.

2.4 Summary

The application of the WET-Prioritise procedures for the identification of off-site mitigation areas in the Upper Olifants River Catchment in Mpumalanga is an example of a 'top-down' approach to wetland prioritisation. At the catchment scale, objectives for the identification of wetland areas were set and an initial list of candidate sites was identified. The final priority system was then identified through a more detailed assessment of the candidate sites.

The case study demonstrates that where no candidate wetland sites are found which meet the specific criteria for selection in the preferred immediate catchment then the search is repeated over a larger catchment area. (i.e. the net is cast over a wider area).

The steps of *WET-Prioritise* provide a rational, consistent and structured approach to the identification and selection of candidate sites, and provide approaches for prioritising these candidate sites such that priority systems can be identified and justified.

CASE STUDY 3:
River and wetland rehabilitation prioritisation in Gauteng

Allan Batchelor and Mark Rountree

3.1 Background to the case study

Centurion Lake in Gauteng results from a dam that was constructed to provide a waterfront development for office blocks, hotels and a retail shopping complex. Occasional fish deaths and regular high counts of faecal coliform bacteria in the lake eventually led to all recreational activities such as canoeing, boating and swimming being discontinued.

Another problem was the accumulation of sediment in the lake. The levels of sediment threatened to fill the entire impoundment, and where they were exposed to the surfacel at the top end of the lake, vegetation became established. The surface sediment and established vegetation was unacceptable to the property owners and tenants and they demanded that action be taken by their local government to remedy the situation. The Centurion Town Council, the authority responsible for the infrastructure, commissioned a study to attempt to find solutions to the problem.

The immediate concern was to address the sedimentation accumulation in the lake, and a short-term solution was to dredge it. However, problems such as siltation of the streambeds of the Kaalspruit and Hennops River, heavy bacterial contamination of the stream flows, and large quantities of flood debris (especially urban litter) would continue unless a longer-term solution could be found.

It was recognised that a rehabilitation programme for the Kaalspruit and Hennops catchments should be developed, arising as a consequence of water quality and sedimentation problems experienced at Centurion Lake. The need for prioritisation arose from the fact that resources were, and continue to be, limited, and therefore the highest priority sites needed to be identified in order to focus the available resources on those sites.

3.1.1 Step 1: Aim and objectives

The aim of the rehabilitation of the catchments was to create a river system capable of ensuring the well-being of the riverine environment, whilst at the same time providing substantial benefits for communities affected by the existing state.

A number of specific, measurable objectives were proposed to meet this aim, namely to:

- reduce the sediment loads of the Kaalspruit and Hennops River to less than 10% of its present average annual-load.
- reduce the level of bacterial contamination in order to allow for full contact watersports to be resumed in the river (E. coli counts needed to be reduced to between 100 and 150).
- remove most (90%-100%) of the debris comprising urban litter and eroded vegetation from the rivers.
- add substantial value to the communities resident in the Kaalspruit catchment in terms of skills transfer as well as employment.

A number of remedial measures, including the construction of silt-trap dams and the rehabilitation of wetlands, identified to meet these objectives. The ultimate goal of the prioritisation process was to identify opportunities in the upper catchment-area to reduce the rate of siltation and restore water quality to that appropriate for contact recreational use.

3.1.2 Step 2: Identification of the spatial extent of the study area

Initially the focus of the investigation was on the Centurion Lake itself, and the possible remedies for the water quality and sedimentation problems which were occurring there. This focus on the 'problem' site is a common but misleading approach, as often (and in this case also) the problem site is merely a symptom of other processes which are occurring in the upstream catchment. In this case the poor water quality and higher sediment loads being experienced in the lake was a result of the urbanisation of the catchment. As the investigators noted, short-term solutions, such as dredging the lake, could be achieved by focusing on the site, but this would not address the underlying causes or provide a long-term, sustainable solution.

It is thus highly advisable to always adopt a catchment-wide approach to wetland studies, and to examine the catchment upstream of the wetland system in order to assess to what extent problems which may be observed on site are symptoms of wider catchment-issues. In this study, the focus of the assessment was expanded to the catchment scale of the Kaalspruit/upper Hennops River catchments in Centurion, Gauteng.

3.1.3 Step 3: Collation of available information

In order to gain an understanding of the system to be able to prioritise sites, information of the following was required:

- hydrology of the catchment
- sources, quantities and grading (particle size characteristics) of the silt/sediment
- source and extent of the bacterial pollution
- source and extent of the debris problem
- factors influencing the efficiency of sediment-trap dams
- factors influencing the efficiency of wetlands in reducing bacterial water-pollution
- probable cost of constructing the sediment-trap dams and rehabilitating or constructing wetlands.

This information provided an understanding of the system which in turn informed the positioning of sediment-trap dams and wetlands, provided information on the size of the required silt trap dams and wetlands, allowed for estimations of the benefits and costs associated with the proposed structures, and ultimately enabled sites to be compared and evaluated in order to rank and identify priority sites for rehabilitation activities.

Extensive literature reviews, including an assessment of the catchment geology, sediment yield characteristics, rainfall and runoff, and hydrological records, was undertaken. These data were necessary to determine, for example, the origin and quantity of sediment derived from the various geological formations of the catchment.

Following the desktop phase, a rapid field survey was conducted on foot of the upstream drainage lines, rivers and wetlands to obtain a fast, economical overview of the catchment conditions. The condition of the drainage lines, specifically with regard to the sediment, litter and vegetation debris, was noted. The water quality was assessed visually, where, for example, the foam indicated the presence of surfactants in the water. Water quality data were available from previous studies and new data were collected using SASS 4, to give an indication of the 'health' of the river reaches.

In addition, unstructured interviews were held with land owners who in some instances provided valuable historical insights on changes in the catchment, with anecdotal evidence supported in some cases by photographs.

Thus a combination of desktop, rapid field-assessment and anecdotal information was collected for the study area.

3.1.4 Step 4: Screening for candidate sites

Based on the rapid field surveys and on the results of the desktop studies, the catchment was divided into a number of units based on the sub-catchments, geology, and land use (Figure 3.1). Pollutant contributions were estimated for the catchment units based on the information obtained from the field surveys of the river reaches. Details of the methods used for the estimates can be found in George (2003). These summarized data (Table 3.1) identified specific zones within the catchment which had specific characteristics. For example, Table 3.1 clearly shows that Zone 2 is the zone that is responsible for most of the sediment, vegetation debris, and waste water flows. Zone 2 must therefore be a priority for addressing both sedimentation and water quality issues (but, for instance, Zone 1 would also need to be focused on if the urban litter problem is to be addressed, since Zone 1 accounts for the majority of litter input to the system).

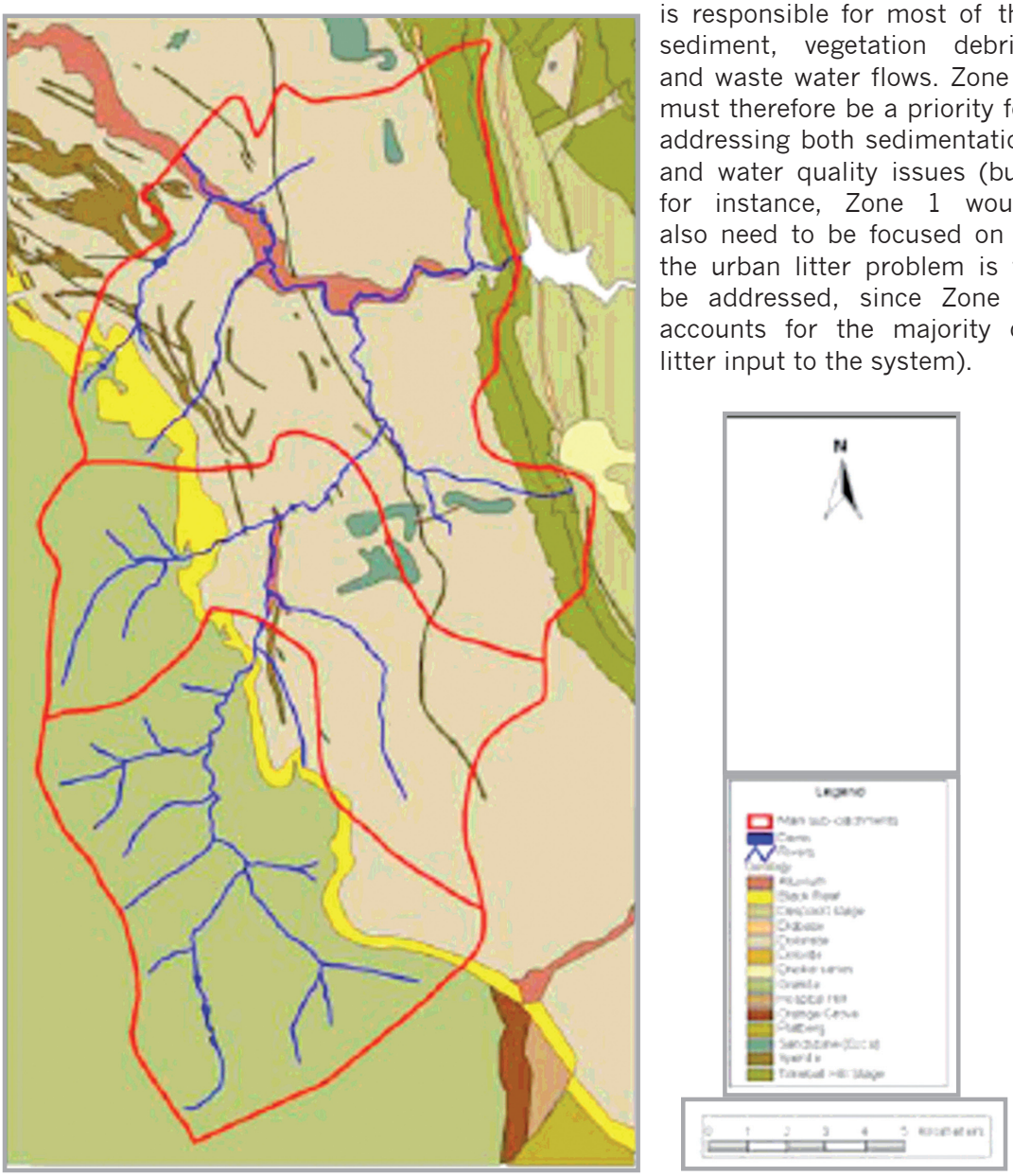


Figure 3.1: The three main zones identified for planning of rehabilitation projects within the identified catchment area (George, 2003; Batchelor, 2005).

Table 3.1. Estimated significance and contribution to the respective environmental problems of three rehabilitation-zones to the total environmental problem in the study area (from George, 2003)

Zone **Geology** Environmental Problem	*Rehabilitation Zone 1* **Upper Kaalspruit** Predominantly Granites % of total problem	*Rehabilitation Zone 2* **Central Kaalspruit** Contact zone between granites and dolomites, predominantly alluvial deposits % of total problem	*Rehabilitation Zone 3* **Lower Kaalspruit / Upper Hennops** Alluvial deposits on dolomites % of total problem	Total
Sediment load	23%	73%	4%	100%
Debris : • Urban litter • Vegetation litter	 55% 0%	 35% 50%	 10% 50%	 100% 100%
Contamination of Water: • Waste flows • Effluent return flows	 13% 0%	 85% 100%	 2% 0%	 100% 100%

Zone 2 was clearly the priority zone in the catchment in terms of addressing the main objectives of the rehabilitation programme, i.e. reducing sedimentation and improving water quality. Based on the information obtained from the field surveys along the drainage lines, the potential sources of sediment within Zone 2 were identified, and estimates of these sediment yields were calculated (Table 3.2). The screening for priority areas within Zone 2 was simplified by the fact that one area contributed substantially to the range of pollutants responsible for the overall degradation of the system (Table 3.2). The site was the Olifantsfontein wetland (Box 3.1).

By focussing on the Olifantsfontein wetland area all the objectives of the study, including water quality (from sediment/ erosion) and vegetation and urban litter would be addressed. Eight intervention-sites were identified to achieve the overall goals originally proposed for the study (Figure 3.1). These eight sites occurred across three municipal areas.

The next step was to evaluate the intervention sites in order to identify and prioritise particular sites for rehabilitation interventions.

Table 3.2. The estimated annual sediment yield from all sources in the catchment (George, 2003)

	Lower estimate cubic metres per annum (m^3/a)	**Upper estimate(m^3/a)**
Dolomites and granites in the catchment	3,504	3,504
Olifantsfontein wetland	8,000	12,000
Erosion of river banks	240	240
Waste water and effluent return-flows	281	281
Total	12,025	16,025

Box 3.1: Olifantsfontein Wetland

Historically the Olifantsfontein wetland area was a low energy depositional zone, and over time more than 6 metres of sediment had accumulated across the wetland. More recently, suggested to have started in the mid 1970s, an erosion channel developed in this depositional zone. The channel formed by erosion is now approximately 2 km long, 15 to 40 m wide and 3 to 6 m deep and is estimated to have contributed 200,000m³ to 300,000m³ of sediment to the downstream environment. It is currently costing Tshwane in the order of R3 million per annum to remove sediment from Centurion Lake, and thus the potential costs associated with continued erosion of this alluvium are considerable.

It was estimated that the Olifantsfontein wetland area contributed about 73% of the sediment, 35% of the litter load, 50% of the debris load, 85% of the microbial load and 100% of the wastewater return flows for Zone 2. Due to these large contributions, this wetland area was recognized as the priority area for intervention.

3.1.5 Step 5: Development of the Prioritisation criteria

For each of the eight intervention sites that were identified, a range of site-specific information was obtained:

- the possible range of intervention types that could be initiated there
- the type of intervention options which would be appropriate for each specific site
- an understanding of the benefits that each possible site and rehabilitation measure would yield.

At each site a range of possible intervention options were considered. For the Olifantsfontein wetland, these included:

- *Maintaining the status quo,* i.e. doing nothing and allowing the wetland to erode and establish a stable watercourse in place of the previous wetland.
- *Constructing a concrete canal* or lining the entire erosion channel with *Armour flex* to stabilise and prevent further erosion.
- *Constructing back to back weirs* along the length of the channel to prevent further erosion and raise the water table for the partial re-establishment of the wetland.
- *Backfilling and creating an engineered-wetland*, constructed in such a way that it would be capable of passing very large floods without eroding.
- *Constructing litter traps* at the upstream end of the wetland.
- *Various combinations* of the above alternatives.

Factors for Consideration

To assist in the evaluation of the pros and cons of the various remedial options outlined above, a list of desirable factors was drawn up:

- erosion prevention
- sediment trapping
- flood attenuation
- water quality improvement
- litter and debris removal
- groundwater recharge
- downstream hydrological impacts
- biodiversity support.

A number of intervention options were developed, and assessed on their ability to achieve the desired benefits. The capital cost of each of the intervention options was calculated.

The criteria for site and intervention type selection were thus:

- where sediment loads could be reduced
- where water quality improvement could be achieved
- where urban litter and vegetation debris loads could be lowered
- the cost of achieving these results.

3.1.6 Step 6: Prioritisation of sites

A series of cost options for intervention was generated for each of the candidate sites. The option that provided the most favourable cost to benefit ratio was considered to be the most appropriate option for that site. This option was presented and discussed with the interested and affected parties. Using the feedback received, the final, proposed rehabilitation-works were designed.

The evaluation of the sites selected as priority sites was based on where the most impact upon the problems within the catchment could be achieved for a given cost. Thus, again, the Olifantsfontein wetland area was identified as a priority, given the enormous likely impact on sediment erosion and wetland stabilisation by the intervention structures, and the extensive area over which this could be achieved.

3.1.7 Step 7: Assessment of the potential of the prioritised sites to meet the objectives

The Olifantsfontein wetland was estimated to be contributing about 73% of the sediment, 35% of the litter load, 50% of the debris load, 85% of the microbial load and 100% of the waste water return flows for the entire catchment of Centurion Lake (Box 3.1: Olifantsfontein wetland). It was thus obvious that any attempt to improve the condition of Centurion Lake should also address the problems within the upper catchment area. Given the contribution of the Olifantsfontein wetland system to the overall catchment pollution loads, improvement of the condition of the wetland would greatly improve the overall condition of the catchment and also the conditions downstream.

3.2 Summary and lessons learned

- The example of the planned rehabilitation activities in the Kaalspruit wetland in Gauteng is an example of a 'bottom-up' approach to wetland rehabilitation.
  - concerned residents around Centurion Lake identified a problem.
  - the problem site was a symptom of wider catchment issues.
  - the priority-area to address the problems at the lake was higher-up in the catchment, and not at the lake itself.
- the identification of priority areas that are remote from the symptom of catchment and wetland degradation is common. It is thus important to distinguish between 'problem' identification and a causal understanding.
- the priority area for intervention to effect an improvement of the Centurion Lake was external to the municipality wherein the effects of the upstream catchment degradation were being experienced.
- institutional constraints prevent Tshwane Metropolitan Council, the council who carry the costs of the sedimentation problems at Centurion Lake, from committing funds to undertake any remediation activities at this site as it falls outside their jurisdictional area.
- the jurisdictional limitations and the failure to adopt a catchment-based approach impair the effectiveness of the implementation of the rehabilitation plans.

3.3 REFERENCES

Batchelor A, 2005. *An overview of the state of the catchment of the Kaalspruit/Hennops River System with a view to implementing specific rehabilitation projects*. Contract Report prepared for the City of Tshwane Metropolitan Municipality Wetland Consulting Services Ref. 155/2005.

George D, 2003. *The Rehabilitation of the Kaalspruit and Upper Hennops River. George Orr and Associates.* Contract Report prepared for the City of Tshwane Metropolitan Municipality.