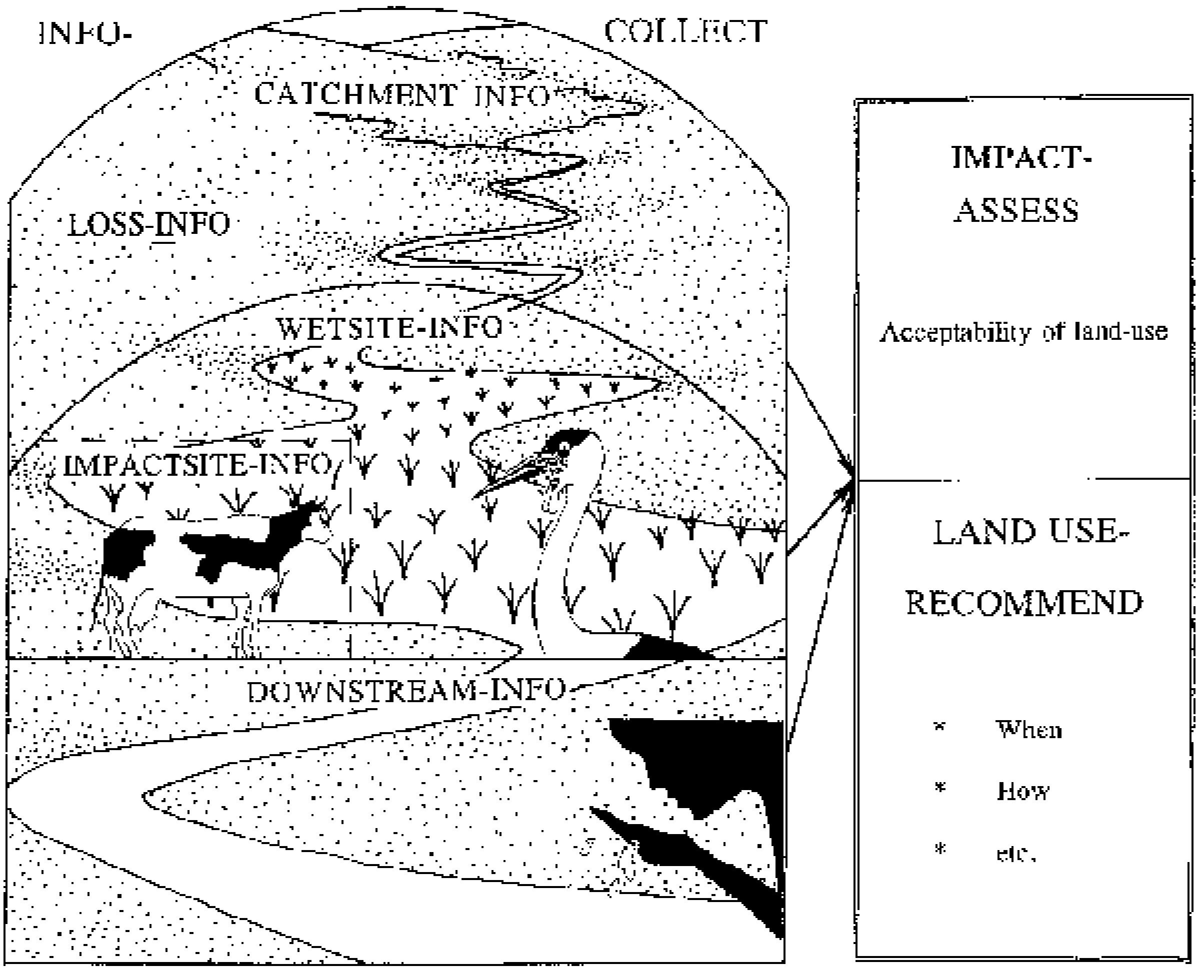
W E T L A N D - U S E

A wetland management decision support system

for South African freshwater palustrine wetlands



PART 1: Biophysical assessment

KOTZE D C, BREEN C M, and KLUG J R 2000

South African Wetlands Conservation Programme

Department of Environmental Affairs and Tourism

PREFACE

All terms first appearing on boldface are defined in the glossary.

Even though **wetlands** have many benefits to society (e.g. water purification) the destruction and poor management of wetlands continues. WETLAND-USE is a tool to assist agricultural and nature conservation extension staff, working closely with local resource users and managers, in promoting the **wise use** of wetlands. It applies to fresh water **palustrine** wetlands. Although it was developed and tested primarily for the Eastern coastal slope and Northern escarpment regions given by Cowan (1995), which includes most of the higher rainfall areas of South Africa, it is likely to be relevant to other parts of South Africa. WETLAND-USE has two parts, the first dealing with biophysical features of wetlands and the second dealing with the social and organizational context of the wetland.

- Part 1 assists in: describing the **biophysical features** of the wetland that are of direct relevance to management; predicting the likely environmental impacts of different land-use options (e.g. grazing of natural vegetation); and making ongoing management decisions for particular land-use options.
- Part 2 assists in: describing the social and organizational context of the wetland (i.e. who uses the wetland directly and which organizations influence this use); and in establishing and maintaining a wetland management system.

The various components of Part 1, are shown on the cover of the document. The cow represents the direct use of wetlands, with livestock production being one of the most common direct uses made of wetlands in South Africa. The wattled crane, chosen to represent the ecological benefits of wetlands, is a threatened species for which wetlands provide essential habitat. The clean water being obtained by the person downstream of the wetland represents the hydrological benefits provided by wetlands.

Before using WETLAND-USE you should at least attend a short wetland training course (currently conducted by the Rennies Wetlands Project, phone: 011-4863294/5). Also, refer to:

- WETLAND-USE Booklet 1 (Kotze, 1997a), which describes the various benefits provided by wetlands and the impacts that different land-uses have on these benefits; and
- WETLAND-USE Booklet 2 (Kotze, 1997b), which describes what a wetland is and how to recognize a wetland, and provides basic information on wetland **hydrology** and soils.

It is best that at least both an agricultural and a nature conservation worker apply the system together, and always consider the limitations and assumptions of WETLAND-USE (see Section 5).

A system such as WETLAND-USE cannot provide the final answer as to what land-use is best in a particular situation. It does, however, help the user/s in arriving at a decision by assisting in the collection of relevant information on the wetland and its surrounding landscape, and in the prediction of likely environmental impacts of different land-use alternatives. It also ensures that a record is kept of how the decision was made. Furthermore, WETLAND-USE is useful for organizing the collection of biophysical data for wetland management plans and for providing a baseline for monitoring.

TABLE OF CONTENTS

TABLE OF CONTENTS

Index

ACKNOWLEDGMENTS AND BACKGROUND

WETLAND-USE was developed in two phases. In Phase 1, funded by the Natal Town and Regional Planning Commission and the Water Research Commission, a prototype system (Kotze *et al.*, 1994) was developed for use in privately-owned, large-scale commercial farms in the KwaZulu-Natal Midlands. In Phase 2, funded by the Department of Environmental Affairs and Tourism (DEAT), the prototype system was refined and expanded to make the current system more widely applicable (see Kotze, 1999). This was undertaken through: field studies; a questionnaire survey for people familiar with WETLAND-USE; a series of field workshops which included the application of WETLAND-USE by extension workers; and the application of WETLAND-USE to case study wetlands.

The DEAT are gratefully acknowledged for funding Phase 2. Mzi Dlovu, Jane Browning and Angela Beaumont are thanked for some of the drawings, and sincere thanks is also expressed to all those individuals who provided valuable comment in the revision of WETLAND-USE Part 1, including:

- Participants in the field workshops, including: N Collins, J Dini, D Lindley, A Linström, K McCann, D. McKenzie, K Morrison, N Nsele, E. Qonya, L Shabane, G. Shaw, M St. Clair Hill, and H Urquart, and managers and wetland users from case-study wetlands, especially to the people of Mbongolwane and Wakkerstroom;
- D Lindley of the Rennies Wetlands Project, and K McCann, J Dini, N Collins and A Linström for written comment;
- C Griffon, University of Massachusetts;
- The Assessment and Participatory Management of **Riparian** Systems Project, funded by the WWF for components on alien plant control and rehabilitation;
- J Wyatt, the author of the Wetland Fix series (see References); and
- J Mander and N Quinn, for comment regarding the assessment of environmental impacts.

SECTION 1, OVERVIEW OF WETLAND-USE PART 1

1.1 Introduction

Presently, the use of wetlands is often planned from the narrow perspectives of those who use the wetland directly (e.g. for pasture production). Little attention is generally given to the impacts of land-use activities on indirect wetland benefits to society (e.g. water purification and **biodiversity** support). In other words, the costs to society are not considered.

In response to this situation, a wetland management **decision support system**, termed WETLAND-USE was developed to assist extension workers in providing sound land-use advice and encouraging wetland users/owners to give consideration to the impacts on indirect benefits provided by wetlands. The system enables non-specialists to undertake wetland assessments provided that they have introductory training and they seek the input from specialized disciplines where required. WETLAND-USE comprises 2 parts, the first dealing with the biophysical aspects of wetland management and planning and the second dealing with the social and organizational aspects.

1.2 The design and purpose of Part 1

Although WETLAND-USE is designed primarily for use in commercial agriculture, forestry and rural communal areas, it may also be used in areas protected specifically for biodiversity conservation. WETLAND-USE Part 1 is a rapid assessment system with three main components (see cover): (1) INFO-COLLECT, which guides the user in collecting useful information about the wetland and its catchment, cumulative loss context and the downstream service area; (2) IMPACT-ASSESS, which assists in selecting appropriate land-use alternatives for a given wetland area by predicting the likely impacts of the proposed land-uses on the indirect benefits of the wetland area; and (3) LAND USE-RECOMMEND, which recommends how the wetland area be managed for the chosen land-use. The assumptions on which WETLAND-USE Part 1 is based and the scientific support for these are given in Section 5. Part 1 may be used for three main purposes, requiring different components of the system:

Purposes of WETLAND-USE Part 1	Components you will require
Do you wish to provide an overall description of the wetland, which will serve as the basis for management and for identifying areas (e.g. an actively eroding head-cut) which require urgent attention?	INFO-COLLECT (excluding its final sub-component: IMPACTSITE-INFO)
Do you wish to assess the impacts of a proposed land-use at a scoping or pre-application level or need assistance for reviewing a scoping report involving a wetland?	INFO-COLLECT and IMPACT-ASSESS
Do you wish to provide ongoing management guidelines for particular land-uses (e.g. stocking rate) or management problems (e.g. erosion)	LANDUSE-RECOMMEND

INFO-COLLECT

INFO-COLLECT has five main sub-components.

WETSITE-INFO poses questions regarding the overall wetland site (e.g. distribution and extent of wetness zones) and assists in identifying management concerns in the wetland (e.g. erosion).

LOSS-INFO is concerned with the extent of cumulative loss of wetlands.

CATCHMENT-INFO poses questions relating to the **wetland catchment** (e.g. land-uses).

DOWNSTREAM-INFO deals with the extent of water use and floodable properties downstream of the wetland.

IMPACTSITE-INFO requests specific information (eg. erosion hazard) about that part of the wetland to which the proposed land-use is to be applied.

> Impacts on wetlands result from both 'on-site' activities at the wetland site and from 'off-site' activities in the wetland's surrounding catchment. WETLAND-USE is designed to assess on-site impacts. The land-uses considered are agricultural, including crop and pasture production, damming and natural grazing. While the general criteria of WETLAND-USE for assessment of land-use impacts are applicable to other land-uses (e.g. peat mining), additional information about the wetland site would be required to assess these land-uses.

IMPACT-ASSESS

IMPACT-ASSESS assists in predicting the likely environmental impact of the chosen land-use by assessing its likely effects on those wetland functions indirectly benefiting society. The following indirect benefits, described in WETLAND-USE Booklet 1, are considered by IMPACT-ASSESS:

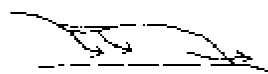
Indirect benefits from wetlands

- Hydrological, which include:

  a. Water purification/**water quality** enhancement (by removing suspended sediments, excess plant nutrients, and other pollutants) 

  b. Flood attenuation/reduction 

  c. Water storage and enhancement of sustained streamflow

  d. **Groundwater** recharge and discharge 

- Erosion control;  
- Ecological (maintenance of biotic diversity by providing habitat for wetland-dependent fauna and flora); and 
- Global climate stabilization (primarily through wetlands storing carbon and sulphur, i.e. acting as carbon/sulphur (C/S) sinks). 

When assessing the impacts of a particular direct use (e.g. drainage and cultivation) on the indirect benefits of wetlands, eight principal factors need to be considered (see Box 1 on the following page). WETLAND-USE is designed to assist you in considering these factors with limited available time and resources.

How the above factors affect particular wetland benefits is obviously very complex, and is influenced by interacting and cumulative effects (see Brinson, 1988; Preston and Bedford, 1988). However, for the purposes of IMPACT-ASSESS these are represented in a simple matrix (Table 1.1, page's 10&11). The effect on the hydrological, erosion control and carbon/sulphur sink benefits is related directly to factors 1 to 6, as indicated in Table 1.1, and the effect on the ecological benefits is related further to factors 7 and 8. The loss of indirect benefits is likely to be high if: (1) the cumulative loss of wetlands in the region is high; (2) the wetland is hydrologically altered through drains; (3) frequent and high levels of artificial fertilizers were applied; (4) an annual crop requiring frequent disturbance of the soil is established; (5) soil organic matter is depleted as a result of (2) and (4); (6) the crop has a low surface roughness; (7) natural vegetation is replaced totally by introduced species in the area cultivated; and (8) Red Data species were lost from the area. (The loss of hydrological benefits is likely to be even higher if the pollutant inputs to the wetland were high and there was human use of water downstream.) The overall loss of indirect benefits is likely to be much lower in a situation where a **perennial crop**, not requiring drainage, and having a high surface roughness is established, and low levels of artificial fertilizers are applied and no Red Data species were previously present.

Box 1 Principal factors to consider in assessing land-use impacts on a wetland area

	Level of impact: Negligible/low	Medium	High
1. What is the cumulative loss[3] of wetland over a broader area (i.e. in the overall wetland, the Veld Type and the quaternary **catchment**)?	☐	☐	☐
2. How much is the flow pattern of water in the wetland area being altered through on-site modifications (e.g. through drainage channels or **infilling**) and/or from off-site modifications to **runoff** quantity and timing into the wetland (e.g. as a result of afforestation of the wetland's surrounding catchment)?			
3. How great is the addition of pollutants to the wetland (e.g. as a result of leaching from fertilized fields)?	☐	☐	☐
4. How extensively, and how frequently, is the soil disturbed (making it more susceptible to erosion) and how close is the disturbed area to the wetland outlet or a channel linked directly to the outlet?			
5. What amount of **organic soil material** is mechanically removed or oxidised as result of altered flow patterns causing the drying out of the wetland and/or increased soil disturbance?	☐	☐	☐
6. How much is the roughness of the wetland surface (which offers resistance to the movement of water) reduced and/or vegetation cover reduced?			
7. What amount of natural wetland vegetation is replaced by introduced/alien plants (which may not necessarily be associated with a change in vegetation structure or flow patterns)?			
8. To what extent are wetland-dependent species, particularly **Red Data species**, negatively affected?	☐	☐	☐

[3] A wetland area is considered lost when it has been altered so much that its functioning and the indirect benefits it supplies are severely limited (e.g. when it is drained and cultivated).

Table 1.1 The extent to which particular benefits* supplied by a wetland are potentially reduced by the eight land-use impact factors given in Box 1

***Cumulative loss of wetland area is not included in the table because all benefits are obviously diminished by a reduction in surface area and it is assumed that the greater the cumulative loss of wetlands, the greater will be the impact of further loss on all indirect benefits.

Principal impact factors and level of each (i.e. Medium or High)	Indirect benefits[1]					

	Water purification[a]	Steamflow regulation[a]	Flood attenuation[b]	Erosion control	Ecological	C/S sink
2. Flow pattern disruption: Drains Med (Medium)	Med	Med	Low-med[c]	Low- high[d]	Med-high	Med[e]
High	V(very) high	High	Low-high[c]	Med-v high[d]	High-v high	V high[e]
Dams Med	Low-med	Low-high[f]	Low-med[g]	Low-high[h]	Low- high[f]	Low-med[e]
High	Med-high	Med-v high[f]	Low-med[g]	Low-v high[h]	Med-v high[f]	Med-high[e]
3. Water quality alterations Med	Low-med [I]	Low	Low	Low	Med	Low
High	Low-high[i]	Low[j]	Low[j]	Low-med[j,d]	High	Med-high[ej]
4. Soil disturbance Med	Med-high[d]	Low	Low	Med-high[d]	Med[k]	Med[e]
High	High-v high[d]	Med	Low	Med-v high[d]	High[k]	High[e]
5. Organic matter depletion Med	Low-med[e]	Med	Low	Low-high[d]	Low-med [k]	High[e]
High	Med-high[e]	Med-high[e]	Low	Med-high[d]	Med-high[e,k]	Very high[e]
6. Roughness/ cover reduction Med	Med	Med	Med	Low-high[d]	Med[k]	Low-med[e]
High	High	High	V high	Med-high[d]	High[k]	Med-high[e]
7. Loss of natural vegetation Med	-[l]	-[l]	-[l]	-[l]	Med-high[k]	-[l]
High	-[l]	-[l]	-[l]	-[l]	High-v high[k]	-[l]
8. Loss of species/ habitats Med	-[l]	-[l]	-[l]	-[l]	Med-high	-[l]
High	-[l]	-[l]	-[l]	-[l]	High-v high	-[l]

[1]Groundwater discharge and recharge are not considered as the effect of wetlands on these processes is complex and poorly understood. However, it would appear that factors having a high impact on streamflow regulation are also generally likely to impact negatively on groundwater discharge and recharge.

Note: explanations for the ratings in the table are given on the following page**.**

Table 1.1 (continued) Explanations of ratings

[a] For a given impact, the loss of benefit will be greater if downstream water users are present and, in the case of water purification, also if the wetland is receiving pollutants.

[b] For a given impact the loss of benefit will be greater if there is floodable property downstream of the wetland.

[c] This depends on the size of the channels and their capacity for containing floodwaters. If this is low and the channels are readily filled and overflow occurs across the wetland then the reduction in flood attenuation benefits would be low.

[d] The impact is strongly dependent on erosion hazard and is likely to be particularly high if the erosion hazard is high.

[e] The high impact would result only if the wetland was acting as a C/S sink prior to the impact, as is likely to be the case if permanently wet areas were present. It should be noted, however, that on a global scale South Africa's wetlands contribute less than 0.05% of the worlds peat resources, which comprises the primary C sink provided by the country's wetlands (Grundling, 1997. *Pers. comm.* Council for Geoscience, Pretoria).

[f] This depends greatly on the particular outlet control and water abstraction from the dam.

[g] This depends on the extent to which the dam is maintained full and therefore with a low capacity for storing additional water.

[h] The effect of dams on erosion control is often positive but is negative where dams are incorrectly built and burst.

[I] The impacts will only be high if the wetland's capacity for assimilation is exceeded, resulting in a feedback effect.

[j] Water quality alterations would generally not detract from these benefits. Even if, for example, an increase in nutrients resulted in a change from a *Cyperus* dominated wetland to a *Typha* dominated wetland there would be little change in structure. However, if extreme water quality changes resulted in a change in structure (e.g. a dramatic increase in salinity causing the loss of *Phragmites australis*) the impacts on these benefits are likely to be high.

[k] Within a relatively small spatial area the effect may be positive, by increasing habitat diversity. This would apply particularly to wetlands which previously supported large herbivores that would naturally have disturbed the wetland.

[l] The impact of natural vegetation loss and threatened species/habitat loss on this particular benefit depends on how this in turn affects impact factors 1 to 7.

The effect on ecological benefits depends directly on the extent to which natural vegetation is replaced and populations of wetland-dependent species, particularly threatened Red Data species, are reduced (see Box 2). It also depends indirectly on factors 1 to 7. As the presence of water is the dominant factor affecting the plant and animals in a wetland, the greater the impact on the hydrology, the greater will usually be the loss of ecological benefit. Thus, in most cases where land-use activities detract from the erosion control and hydrological benefits of a wetland, they will also detract from the ecological benefit.

Box 2 Threatened animal species dependent on freshwater palustrine wetlands in South Africa

Cape caco (*Cacosternum capense*)	Wattled crane (*Grus carunculata*)
Striated caco (*Cacosternum striatus)*	White-winged flufftail (*Sarothrura ayresi*)
Long-toed tree frog (*Leptopelis xenodactylus*)	Grass owl (*Tyto capensis*)
Pickersgill's reed frog (*Hyperolius pickersgilli*)	
Mist belt chirping frog (*Arthroleptella ngongoniensis*)	
Micro frog (*Microbatrachella capensis*)	Water rat (*Dasymus incomtus*)
Cape chirping frog (*Arthrolptella lightfooti*)	Serval (*Felis serval*)
Marsh frog (*Poyntia paludicola*)	African striped weasel (*Poecilogale)*
Arum lily frog (*Hyperolius horstoki*)	(*albinucha albinucha*)

Environmental Impact Assessment (EIA) and WETLAND-USE

In terms of the regulations under the Environmental Conservation Act, 1989, several activities are listed which may have a substantial detrimental effect on the environment and which require that application to be made to the relevant authority (see DEAT, 1998a). Those listed activities of particular relevance to wetlands include: the reclamation of inland water including wetlands; construction of dams, levees or weirs affecting the flow of a river; and change of land-use from use for grazing to any other form of agricultural use. IMPACT-ASSESS provides a useful framework for a scoping study as defined by DEAT (1998b) in the EIA procedure. If the scoping report shows that there are likely to be significant impacts and the intention is to continue with the proposed land-use then a full impact assessment (which is beyond the scope of WETLAND-USE) would be required to assess if the proposed land-use was acceptable. EIA falls within Integrated Environmental Management (IEM) (DEA, 1992 and DEAT, 1998b) and the Environmental Impact Management initiative of the DEAT. WETLAND-USE assists in dealing with wetlands in this broader context, which is designed to ensure that the environmental consequences of development are understood and adequately considered in planning and implementation (see WETLAND-USE Part 2). WETLAND-USE follows the underlying principles of IEM, including: decision making is informed, accountable, and open, involving the relevant authorities and stakeholders; alternative options are considered; all of the above are done from the beginning of the process; and development is equitable and sustainable (see DEAT, 1998b). *For further information see:* Part 2, Section 5.1.

LAND USE-RECOMMEND

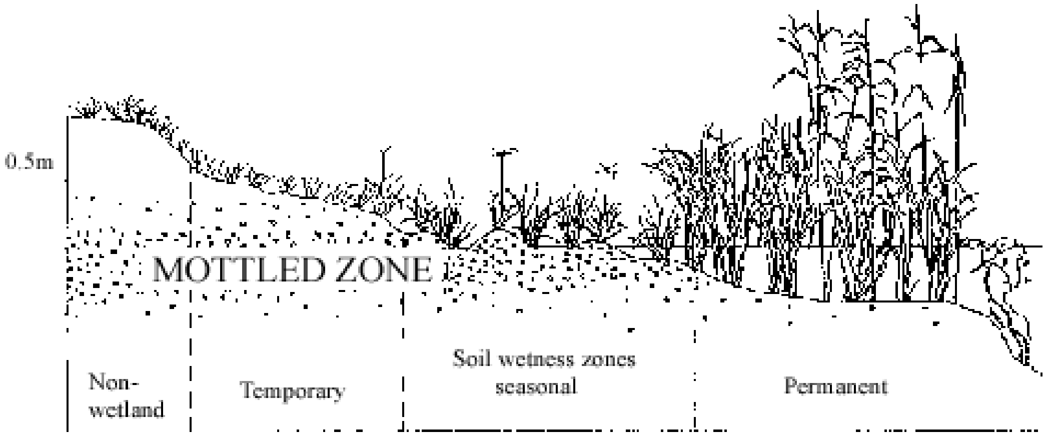
LAND USE-RECOMMEND provides recommendations aimed at minimizing the environmental impacts of the chosen land-use, while at the same time maximizing the land user's benefit. Although broad recommendations, reference documents and expertise are given for a wide range of land-uses (e.g. roads and ecotourism) the focus is primarily on agricultural land-uses, for which more comprehensive recommendations are given. For crops and planted pastures, the recommendations deal mainly with minimizing the impact of such activities as fertilizer application on the hydrological values of the wetland. For the grazing of natural wetlands, the recommendations focus on regulating the **stocking rate** and timing of grazing. Burning recommendations concern timing and frequency of fires as well as measures designed to influence fire behaviour.

1.3 Wetness zones used by WETLAND-USE to describe the wetness of wetland areas

To begin, what is a wetland? Wetlands are areas transitional between terrestrial and aquatic systems, where the soil is flooded or saturated at or close to the soil surface frequently and long enough for **anaerobic** conditions to develop which favour the growth of predominantly water loving (hydric) plants and particular soils features (e.g. low **chroma** matrix colours). A wetland is therefore defined in terms of hydrology (flooded or saturated soils), plants (adapted to saturated soils: see Appendix 3) and soil (show hydric features: see Table 1.2). Wetlands range from areas which remain permanently flooded or saturated to the soil surface for the entire year to areas which are flooded or saturated at or close to the soil surface for only a few weeks in the year but still long enough to develop anaerobic conditions. Many wetland areas are not wet all the time. The term "wetland" includes all those areas commonly called a **marsh**, **swamp**, **vlei** or **bog**.

In order to make informed wetland management decisions it is important to identify the boundary of the wetland and to zone the wetland into broad areas which are as homogeneous as possible from a management point of view. The **water regime** is generally one of the most important factors affecting functioning and management potential. Thus it is necessary to describe the wetness zones within a wetland. As long term hydrological data are usually lacking, the best surrogate (substitute) measure possible, soil morphology, is used by WETLAND-USE. A four class system is used for identifying wetness zones based on soil morphological features (notably colour of the soil matrix and the presence and abundance of **mottles**) and vegetation (Table 1.2). The description of soils, is a very important part of WETLAND-USE, and forms the basis for its land-use planning recommendations.

Table 1.2 Soil wetness zones recognized by WETLAND-USE



	SOIL WETNESS ZONES			
SOIL	Non-wetland	Temporary	Seasonal	Permanent/Semi-permanent
Soil depth 0-10 cm	Matrix usually brown/red (**chroma** >1) No/very few mottles Nonsulphidic	Matrix brown to greyish brown (chroma 0-3, usually 1 or 2) Few/no mottles Nonsulphidic	Matrix brownish grey to grey (chroma 0-2) Many mottles Sometimes sulphidic	Matrix grey (chroma 0-1) Few/no mottles Often sulphidic
Soil depth 30-40 cm	Matrix usually brown (chroma >2) No/few mottles	Matrix greyish brown (chroma 0-2, usually 1) Few/many mottles	Matrix brownish grey to grey (chroma 0-1) Many mottles	Matrix grey (chroma 0-1) No/few mottles Matrix chroma: 0-1
VEGETATION (see Appendix 3)	Dominated by plant species which occur extensively in non-wetland areas; hydrophytic species may be present in very low abundance	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophytic plant species which are restricted largely to wetland areas	Hydrophytic sedge and grass species which are restricted to wetland areas, usually <1m tall.	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), **sedges** and bulrushes (*Typha capensis*), usually >1 m tall (**marsh**); or (2) floating or submerged aquatic plants.

Key to Table 1.2:

Sulphidic soil material has sulphides present which give it a characteristic "rotten egg" smell, and nonsulphidic material lacks sulphides.

Soil material (usually in the seasonal zone) may be so greatly mottled that the mottles make up a greater area than the matrix, which may be confusing when determining the chroma of the matrix.

Chroma refers to the relative purity of the spectral colour, which decreases with increasing greyness. To determine chroma, a **Munsell** colour chart is required. If this is not available then in order to characterise the colour of the soil matrix, use the following colour descriptions, given in order of increasing greyness:

Brown/Red Greyish brown Brownish grey Grey

How to describe soil wetness zones in the field

Start outside of the wetland and extract a core of soil to a depth of 50 cm using a soil auger (a hand tool for boring holes into the ground). Then walk in a straight line into the wetland, extracting cores at intervals along the transect. Identify the wetness zone of each of the soil samples by using Table 1.2. The boundary of the wetland may be unclear and it may be necessary to go back along the transect and take further sample/s. Remember, however, that the boundary is a human construct that we place along a gradually changing gradient.

The upper 50 cm of soil is considered as this is where most of the roots of herbaceous wetland plants are concentrated. The presence of surface water or a shallow water table may serve as additional indicators but it should be remembered that these change according to season and rainfall pattern. Landform setting may also assist in confirming the presence of a wetland, with wetlands tending to be associated with flat, **bottomland** (valley bottom) areas, and the lowest areas generally being the wettest. However, not all bottomlands are wetlands and, furthermore, wetlands may be found on hill slopes, particularly where groundwater is discharging such as at the "eye" of a stream (see WETLAND-USE Booklet 2: Kotze 1997b).

Some problems you may have in identifying soil wetness zones using Table 1.2

In some wetlands, mottles are very scarce throughout the wetness zones. Nevertheless, the general trend is likely to be encountered of an increase and then a decrease in mottle abundance as one moves from outside the wetland and through the temporary and seasonal zones into the permanent zone.

The water regimes of certain soil types are very difficult to determine based on soil morphology. These soil types include the following.

*** Mollisols (Melanic A) and vertisols (Vertic A):** are dark coloured, base-rich soils typically having dark topsoil layers and low chroma matrix colours to considerable depths. The low chroma colours of these soils are not necessarily owing to prolonged saturation.

*** Soils with humic A horizons:** which refers to a freely draining topsoil **horizon** with low base status, that has accumulated high amounts of humified organic matter under moist, cool or cold climatic conditions. It differs from organic horizons in that both site and profile drainage is good (Soil Classification Working Group, 1991). Humic A horizons may be characterized by low chromas, and if they are deep, this may lead to the soil being mistakenly identified as hydric.

*** Entisols:** are recently formed soils that have little or no evidence of pedogenically developed horizons, e.g. soils of the Oakleaf form. Some hydric entisols are easily recognised, but others pose problems because they do not possess typical **hydric soil** field characteristics.

For further information on delineating and identifying wetland zones see Kotze (1997b) or consult someone with experience in the delineation of wetlands. For information on the South African Soil Classification System (Soil Classification Working Group) in relation to wetlands see Appendix 1. As described in Appendix 1, some of the soil forms in this system are characteristic wetland soils, while other forms are usually or only sometimes associated with wetlands.

SECTION 2, INFO-COLLECT

Note:

*1. You may be unable to gather the information requested for all **descriptors**. That which is not available indicate with "NA".*

2.Further descriptors which are not considered essential to the assessment of the acceptability of individual land-uses and for making ongoing management decisions but which provide useful background and more detailed information are given in Appendix 2.

2A WETSITE-INFO

Requirements:

1) 1 :50 000 topocadastral maps and 1:10 000 orthophotos, both available from the Surveyor General. Airphotos, available from the Chief Director: Surveys and Mapping, would also enhance the assessment, particularly if comparisons between photos could be made to detect change, using a recent set and the earliest set available.

2) At least one site visit, preferably with a camera.

3) A soil auger

How to gather the information:

1) Do a preliminary **delineation** of the wetland boundary on the orthophoto or topocadastral map.

2) Read through Descriptors A1 to E3 to see what information is required. Those descriptors marked with "" can often be obtained in the office.

3) Always obtain permission from the landowner/authority to visit the wetland.

4) Inspect the wetland in the field with the aid of transects. Complete each transect by starting outside of the wetland, finding the boundary of the wetland (see Section 1.3) and walking in a straight line across the wetland. At least one transect every 500 m to 1000 m of the wetland is required, depending on how varied the wetland is. If the wetland is very varied and has many land-uses applied to it then transects at more regular intervals are likely to be required. Mark the transect/s on the orthophoto. For each transect note the percentage distance occupied by the temporary, seasonal and permanent zones respectively (Table 2.1). To help you identify the zones take soil samples along the transect and refer to Section 1.3. Also, take particular note of features not easily visible from the air- or orthophotos, including: artificial drains; the extent and species of alien plants; details of crops (e.g. annual or perennial) and important localized features such as headcuts of erosion gullies and point sources of pollution.

5) Mark the location of the important localized features (e.g. headcuts of erosion gullies) on the map and take photos of those that may require management attention.

6) From a vantage point (e.g. on a hill next to the wetland) make any changes to the preliminary delineation on the map and complete the data sheet. Take a panoramic photo of the wetland.

7) For particularly large wetlands (i.e. > 50 ha) complete separate data sheets for the different portions of the wetland.

Date/s of site visit/s ....

Name, address & tel. of :

(1) wetland assessors

....

....

....

....

(2) wetland owner or management authority

....

....

....

....

A1. Wetland name ....

A2. Geographical coordinates ......^{o}........'S.........^{o}........'E

A3. Quaternary catchment No. ....

See "catchment" in Glossary

A4. Veld Type (Acocks, 1953) ....

or vegetation type (Low &Rebelo, 1996) ....

A5. Wetland surface area (ha)...

Note: the area does not have to be wet at the time of the assessment to be classed as a wetland but should have wetland soils and/or vegetation (see Section 1.3). Temporary wetland areas may be wet for only a few weeks in the year, which you may miss in your site visit.

A6. Recorded **Red Data** (threatened) animal and plant species found in the wetland

1. ....
2. ....

Note: a single site visit is not sufficient to identify all Red Data species that may be present, as some are difficult to observe and are not identifiable or are absent during certain seasons. Consult the relevant Provincial Conservation Department and the Wildlife and Environment Society of South Africa for possible information.

A7. Wetland habitat type/s in the impact area which are considered on a provincial or national level to have been subject to particularly high levels of loss (e.g. forested wetlands) or to be particularly rare (e.g. dolomitic eye wetlands).
....

Forested wetlands, which are dominated by trees and often referred to as swamp forests, are most extensive at low altitudes in northern KwaZulu-Natal. A Dolomitic eye is the point where a dolomitic (calcium/magnesium carbonate deposits) aquifer is exposed to the surface. This usually results in a spring, which provides points of recharge and discharge for water contained in the aquifer.

A8. Noteworthy natural features (e.g. a heron breeding colony)...

Table 2.1 Information gathered for individual transects

Transect number	Percentage distance				Notes
	Temporary	Seasonal	Permanent	Hummocked[1]	
1	*	*	*	*	*

2	*	*	*	*	*
3	*	*	*	*	*
4	*	*	*	*	*
5	*	*	*	*	*
6	*	*	*	*	*

[1]"Hummocked" refers to areas with earth hummocks about 20-50 cm in diameter and 50 cm high, covered with vegetation, and usually permanently saturated between hummocks.

A9. Wetness zones (defined in Section 1.3)

% cover Dominant species (see Appendix 3 for a guide to some common wetland plant species)

a. Temporary ....

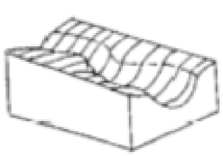
b. Seasonal ....

c. Permanent ....

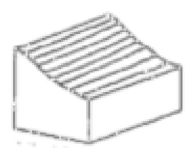
d. Hummocked ....

Although it is not essential to identify the dominant species for an assessment, this provides useful supplementary information

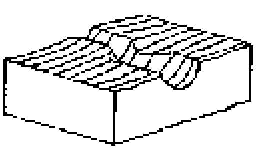
A10. Landform setting/s which best describes the form of the wetland



Channel: a water course, which may be shallow or deep but always has clearly defined margins ....



Hill slope: situated outside of valley bottom areas and is characterized by colluvial (i.e. transported by gravity) movement of material ....



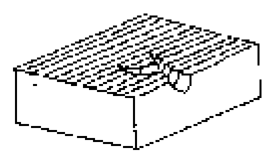
Channelled valley bottom: a valley bottom area, often described as a floodplain, through which a channel passes...........

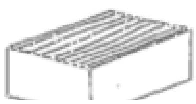
* flooding from the main channel is frequent (i.e. more frequently than one out of every three years) ....

* flooding is infrequent ....

Valley bottoms are the low-lying areas of a valley characterized by the alluvial transport and deposition of materials by a stream/river.

Flow concentration area: that area where diffuse flow, either across a non-channelled valley bottom or down a slope, concentrates to flow within a channel. ....



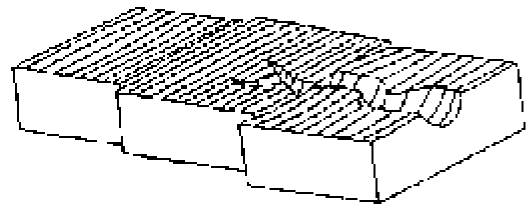


Non-channelled valley bottom: a valley bottom area lacking a channel (and therefore characterized by the diffuse flow

Depression: a basin shaped area which is inward draining and has no outlet and usually does not have

	of water across its surface)..........	clearly defined margins........... *found within a valley bottom area .... *found outside of a valley bottom area ....

Remember that a wetland may consist of a combination of landforms. One of the commonest of these, particularly in large wetlands, is shown here: In this case you would mark all of the three landforms as present.



A11. Percentage area and rating of on-site land-use impacts on the indirect wetland benefits

		Level of impact (negligible, low, medium, high)	Describe effect on wetland (only medium & high)	*For guidelines for ongoing management see:*
Dams	☐ .....%	☐☐☐☐	....	*Section 4.6*
Weirs	☐ .....%	☐☐☐☐	....	*4.6*
Planted pastures (Drains: Yes ☐ No☐)	☐ .....%	☐☐☐☐	....	*4.3*
Subsistence crops (Drains: Yes ☐ No ☐)	☐ .....%	☐☐☐☐	....	*4.4*
Commercial crops (Drains: Yes ☐ No ☐)	☐ .....%	☐☐☐☐	....	*4.4*
Sugar cane (Drains: Yes ☐ No ☐)	☐ .....%	☐☐☐☐	....	*4.18*
Forest plantations	☐ .....%	☐☐☐☐	....	*4.18*
Buildings/infrastructure	☐ .....%	☐☐☐☐	....	*4.13&4.10*
Informal settlement	☐ .....%	☐☐☐☐	....	*4.13*
Eroded land	☐ .....%	☐☐☐☐	See A13	*4.7*
Other disturbed areas (e.g. mining)	☐ .....%	☐☐☐☐	....	*4.11*
Infilling	☐ .....%	☐☐☐☐	....	*4.10*
Alien invasive vegetation	☐ .....%	☐☐☐☐	Alien species:...	*4.8*
Natural vegetation (with artificial drains)	☐ .....%	☐☐☐☐	....	*4.1&4.7*
Natural vegetation (without artificial drains)	☐ .....%	-	....	*4.1*
Natural vegetation (rehabilitated)	☐ .....%	-	....	*4.1*
Livestock: grazing	☐ -	☐☐☐☐	....	*4.2*
movement (trampling)	☐ -	☐☐☐☐	....	*4.2*
Mechanized cutting of natural vegetation	☐ -	☐☐☐☐	....	*4.5*
Hand cutting of natural vegetation	☐ -	☐☐☐☐	....	*4.5*
Hunting	☐ -	☐☐☐☐	....	*4.16*
Fishing	☐ -	☐☐☐☐	....	*4.16*
Medicinal plant harvesting	☐ -	☐☐☐☐	....	*4.17*
Water abstraction	☐ -	☐☐☐☐	....	*4.6*
Bird-watching	☐ -	☐☐☐☐	....	*4.15*
Water sports	☐ -	☐☐☐☐	....	*4.15*
Solid waste (litter)	☐ -	☐☐☐☐	....	*4.20*
Roads and rail roads	☐ -	☐☐☐☐	....	*4.12 & 4.10*
Bridges	☐ -	☐☐☐☐	....	*4.12 & 4.10*
Powerlines	☐ -	☐☐☐☐	....	*4.14*
Other/s	☐ -	☐☐☐☐	....	

Note: "impact" refers to an effect which reduces the indirect benefits supplied by a wetland. When assessing level of impact see Box 1 and Table 1.1.

A12. Total % of the wetland lost ...... *Note: a wetland area is "lost" if it has been developed or degraded so that the indirect* *benefits it supplies are severely limited, as would be the case if it was eroded, dammed or drained and planted to crops or pastures. A12=100% - (Natural vegetation without artificial drains + Natural vegetation rehabilitated).*

A13. Erosion type,		Severity (negligible, low, med., high)	Describe whether currently active & the causes & effect on wetland
Streambank	☐	☐☐☐☐	....
Gully, within flow concentration area	☐	☐☐☐☐	....
Gully, outside of flow conc. area	☐	☐☐☐☐	....
Sheet	☐	☐☐☐☐	....

Note: when assessing gully erosion, pay particular attention to the headcut/s of the gully to see if they are actively eroding or have stabilized.

A14. What is the frequency (e.g. every year) and timing (e.g. winter/early spring) of burning? ....
(*For management recommendations see Section 4.1)*

A15. Land ownership types in the wetland and estimated % contribution of each land ownership type (indicate the boundaries on the wetland map)

Privately owned land ......

Declared protected area ......

Government owned/ municipal land ......

Natural Heritage Site*......

Communally owned tribal land ......

Site of Conservation Significance* ......

**These are not land ownership types but are of relevance to the use of land.*

A16. Is there evidence of high nutrient concentrations entering the wetland (e.g. algal blooms or actual measurement of high concentrations)? ....

Note: consult the local water authority for information they may have regarding descriptors A16-A18 (for ongoing management recommendations see Section 4.19).

A17. Is there evidence of waterborne toxicants entering the wetland (e.g. fish kills or actual measurements of hazardous concentrations)? ....

A18. Water-associated diseases (e.g. bilharzia) known to be present in the wetland. ....

Note: consult the local hospital or health office for information (see also Section 4.21).

A19. Is the wetland culturally important and, if so, for what reason (e.g. it is a site for religious ceremonies).
....

2B LOSS-INFO

Requirements: All available wetland inventory information for the region. For much of the country wetland inventory information is lacking. Wetland inventories have, however, been conducted for some **catchments.** See DEAT (1998c) for a listing of inventories.

B1. Extent of wetland loss (expressed as a % of total wetland area) in the quaternary catchment in which the wetland falls .....

Each primary catchment in South Africa has been sub-divided into secondary catchments, which, in turn have been divided into tertiary and finally into quaternary catchments. These sub-divided catchments provide the basis on which catchments are sub-divided for integrated catchment planning and management (see DWAF [1994]).

B2. Extent of wetland loss (expressed as a % of total wetland area) in the Veld Type (Acocks, 1953) or the vegetation type (Low and Rebelo, 1996) in which the wetland falls ....

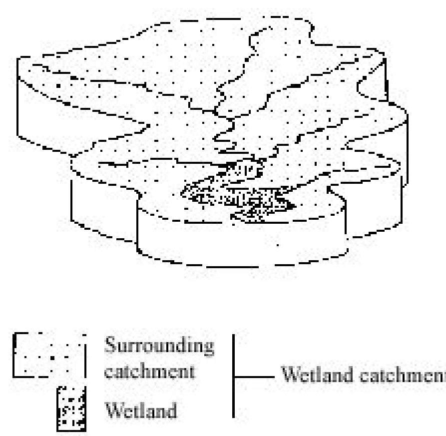
Note: if information on wetland loss for the Veld Type is lacking then information on the general loss of the particular Veld Type may be used (see Descriptor B3) based on the assumption that if this is high then the loss of wetland area within the Veld Type will also be high.

B3. Extent of overall loss of the Veld Type (Acocks, 1953) or the vegetation type (according to Low and Rebelo, 1996) in which the wetland falls ....

Several provincial conservation organizations have records of loss of natural vegetation either according to the system of Acocks (1953) or Low and Rebelo (1996).

C CATCHMENT-INFO

Requirements: 1:50 00 map and orthophotos and the latest airphotos, if available. The "wetland catchment" refers to the area up-slope of the wetland (from which water flows into the wetland) and includes the wetland itself. The "surrounding catchment" excludes the wetland itself.



C1. Land covers in the surrounding catchment and the approximate % area under each.

C1. Land covers in the surrounding catchment and the approximate % area under each.

		With irrigation?		
Planted pastures	☐ .....%	Yes ☐ No☐	Dams	☐ .....%
Subsistence (non-mech'ed) crops	☐ .....%	Yes ☐ No☐	Eroded land	☐ .....%
Commercial (mechanized) crops	☐ .....%	Yes ☐ No☐	Buildings & informal settlements	☐ .....%
Commercial sugar cane	☐ .....%	Yes ☐ No☐	Mining	☐ .....%
Forest plantations	☐ .....%		Natural vegetation	☐ .....%
			Other:	☐ .....%

C2. Extent to which the natural runoff is being reduced by land-uses in the catchment that reduce runoff (i.e. damming, irrigation and afforestation).

Negligible ......

Low ......

Moderate ......

High ......

C3. Level of sediment input into the wetland. Sources contributing sediments in the wetland's catchment include: areas (>0.5 ha) which are cultivated or eroded land, roads, surface mines and forest plantations.

Negligible ......

Low ......

Moderate ......

High ......

Note: the closer a sediment or nutrient/toxicant source is to the wetland the more likely it is to contribute to input into the wetland, particularly if it is connected directly to the wetland by a stream.

C4. Level of nutrient/toxicant input into the wetland. Non-point sources in the wetland's catchment include areas (>0.5 ha) of fertilized crop or pasture land; areas (>0.5 ha) where the density of houses with septic tank systems exceeds 6 houses per ha; mines; pesticide treated areas; and oil runoff sites (*see C3 Note*). Point sources in the wetland catchment that may contribute pollutants include sewage or industrial outfalls, dairies or feedlots. See also A16 and A17.

Negligible ......

Low ......

Moderate ......

High ......

C5. Based on the descriptor values for C3 and C4, indicate the level of combined sediment and nutrient/toxicant input.

Negligible ......

Low ......

Moderate ......

High ......

2D DOWNSTREAM-INFO

Requirements: 1:50 00 map and orthophotos and preferably a brief visit.

All wetlands are considered to be hydrologically important, and the two descriptors below seek to determine whether a wetland is particularly important from the point of view of having *identifiable* downstream beneficiaries. This concerns the extent of water use and floodable properties downstream of the wetland. This information is useful in determining the hydrological benefits currently being provided by a wetland. Although enhancement of sustained streamflow is not considered specifically, water users deriving benefit from water purification are also likely to derive benefit from sustained streamflow. Ability of a wetland to influence water quality and attenuate floods decreases with increasing distance downstream of the wetland outlet, and from an assessment point of view it becomes increasingly impractical to assess downstream influence as downstream distance increases. A cut-off of 12 km is used. It should be emphasised, however, that there are several interacting factors determining the wetland's distance of influence, including the size of the wetland and the influence of tributaries entering downstream. However, these are considered to be beyond the scope of WETLAND-USE.

D1. Is there direct use of stream water downstream of the wetland by people for irrigation, stock watering or, particularly, for domestic use?

Yes .....

No .....

D1 and D2 will generally need to be described based on local knowledge. If this is lacking and you do not have time to inspect the downstream area, these descriptors should best be left out. Descriptors D3-D8 given in Appendix 2 provide a semi-quantitative means of describing the level of water use and amount of floodable property in the downstream area of influence based on an inspection of the area.

D2. Is there floodable property downstream of the wetland?

Yes .....

No .....

2E OVERALL CURRENT STATE AND FUTURE THREATS

E1. Assess the overall level of impact on the wetland based on on-site and catchment impacts.

Negligible ......

Low ......

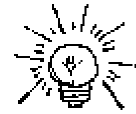
Moderate ......

High ......

E2. Likely future changes (notably, active erosion and further invasion by alien plants)

....

E3. Which are the priority management activities that need to initiated? (i.e. where are the "flashing lights"?). *Consider E1 and other land-uses given in A11.*



....

....

2F IMPACTSITE-INFO

This concerns the area to which the proposed land-uses are to be applied. If the impact area includes more than one wetness zone type (e.g. temporary, seasonal and permanent) then for the purposes of the assessment the wetness zone should be taken as the wettest zone.

Requirements: as for WETSITE-INFO but Soil Classification: a taxonomic system for South Africa (Soil Classification Working Group, 1991) is also required.

F1. Indicate on the wetland map, the area to which the proposed land-use will be applied and which of the following land-uses is being considered? ......

a. natural vegetation for stock grazing: answer questions F6 to F12

b. cutting/harvesting natural vegetation: answer questions F6 to F12

c. planted pastures: answer questions F2 and F6 to F19

d. crops (mechanized): answer questions F3 and F6 to F19

e. crops (non-mechanized/traditional): answer questions F3 and F6 to F19

g. dams: answer questions F4 to F7 and F14 to F20

F2. Pasture species............................, and whether annual or perennial

F3. Crop type ....

F4. Indicate (Y or N) if an outflow control is intended for inclusion in the dam wall ....

F5. Intended uses of the dam: irrigation waterfowl hunting stock watering watersports fishing

F7. Surface area of the impact area (ha). ....

F8. Landform factor (L) of the impact area (see A10). ......

...... Impact area is a flow concentration zone then L=5

...... Impact area includes a channel then L=2

...... Impact area is a slope or valley bottom flat or depression (away from any flow concentration area or channel) then L=1

...... Impact area is a depression outside of a valley bottom then L=0.5

F9. Slope factor (S) of the impact area. *This should preferably be estimated from 1: 10 000 orthophotos.*

...... <1% Slope: **S=1**

...... 1-3% Slope: **S=2**

...... 4-15% Slope: **S=3**

...... 16-30% Slope: **S=4**

...... >30% Slope: **S=5**

Note: in a 1% slope, for every 100m travelled horizontally there is a vertical drop of 1 m.

F10. Soil form .... and soil family .... according to *Soil Classification* (see Soil Classification Working Group, 1991 in References).

F11. Erodability (i.e. the K value) of the soil (using Appendix 1, Table A2)

Very low (0.15) ......

Low(0.2) ......

Moderate (0.3) ......

High (0.4) ......

Very high (0.5) ......

F12. Erosion hazard index (EH) for the site ...., where EH= L x S x K, and L= Landform setting factor (Descriptor F8); S= Slope factor (Descriptor F9); K= Soil erodability (Descriptor F11).

An example of a wetland site with an extremely high erosion hazard is one in a channel, with a slope of 24% and with an Estcourt form (which has a very high erodability), where: EH =2 X 4 X 0.5 =4. An example of a wetland site with a low erosion hazard is one on a flat setting away from a channel, with a Katspruit form, Lammermoor family (moderate erodability) and a slope of 0.1%, where: EH =1 X 1 X 0.3 =0.3.

F13. Using Table 1.2, Section 1.3, determine the soil wetness zone.

Permanent ......

Seasonal ......

Temporary ......

Note: if an area is hummocked it should be considered as permanent. If more than one wetness zone is present in the impact area, that which is wettest should be taken.

F14. Red Data species (see Descriptors A6) in the impact area. ....

Note: a Red Data species present in the overall wetland may not be present and dependent on the impact site. Consult the relevant Provincial Conservation Department and the Wildlife and Environment Society of South Africa for possible information.

F15. Wetland habitat type/s in the impact area which have been subject to high levels of loss or are rare (see Descriptor A7). ....

F16. Severity of existing erosion within the impact area.

Negligible ......

Low ......

Moderate ......

High ......

F17. Extent (in hectares) of the impact area that is currently untransformed (i.e. not drained, planted to crops or pastures or dammed) ....

F18. Roughness of the wetland surface in the impact area ('N' is Manning's **roughness coefficient**).

...... Tall (>3 m), dense, robust emergent vegetation: N= 0.08

...... Moderately tall (1-3 m), dense, robust emergent vegetation: N= 0.06

...... Short and sparse emergent vegetation: N= 0.04

Note: the roughness of the wetland surface slows down the flow of water, which assists in erosion control and water purification.

F19. Direct benefits (e.g. harvesting of plants for craftworks, medicinal plants, natural grazing) currently being derived from the impact area in its untransformed state (see A11).

Negligible ......

Low ......

Moderate ......

High ......

Describe the benefits ....

Note: this refers to the benefits that would be lost with transformation.

F20. Is the wetland in a catchment where further damming is undesirable from a water supply point of view and therefore which has been designated as an area where no further dam permits will be issued by The Department of Water Affairs and Forestry? Yes No

SECTION 3, IMPACT-ASSESS

The impact of different land-use activities on the indirect benefits provided by wetlands varies considerably according to the nature of the wetland area and its context (e.g. does it have Red Data species or are there people downstream of the wetland that use the water that has flowed through the wetland?) and according to the nature of the particular land-use (e.g. does it involve intensive and frequent disturbance of the soil?).

3.1 Steps to follow in carrying out an assessment

In order to assess the level of impact and the acceptability of a proposed land-use you will need to have completed INFO-COLLECT. Now, follow these three steps:

①Complete Table 3.1, page 24, by following the instructions given in the table

②Assess the overall level of impact using Box 3

③ Seek alternatives to the proposed land-use using Box 4

- Low: the proposed land-use is acceptable, proceed provided that recommendations in Section 4 are followed
- Medium
  - No alternative: the proposed land-use is acceptable, proceed provided that **mitigation** is carried out (see Section 3.3) and that recommendations in Section 4 are followed
  - Alternative present: the proposed land-use is unacceptable
- High
  - No alternative: if the applicant wishes to proceed, a comprehensive impact assessment is required, possibly including tools such as benefit-cost analysis and Scenario-based Policy Planning, which is beyond the scope of WETLAND-USE[4]
  - Alternative present: the proposed land-use is unacceptable

---

[4] A cost-benefit analysis requires the expertise of an economist and possibly also biological or hydrological expertise to gather and interpret more comprehensive data on the indirect benefits provided by the wetland. Consideration would need to be given to the direct benefits for the user as well as the contribution it will make to the economy, particularly how it affects poor people (e.g. how will it stimulate new employment opportunities or stabilize existing employment levels in the local region; stimulate the local economy; generate significant new taxes; or contribute to local food security?). Scenario-based Policy Planning (SBPP) incorporates diverse and conflicting objectives into public policy evaluation in a systematic and coherent manner. It provides a uniform framework for handling and comparing tangible and intangible goals of society without reducing these to monetary or similar terms (Stewart *et al.*, 1997).

Table 3.1 Checksheet for determining the likely impacts of particular land-uses (additional land-uses are given on the following page)

Descriptors (obtained in INFO-COLLECT)	Site	Example	Impact level for individual land-uses: *Trad. crops* Low	Med.	High	*Mech. crops* Low	Med.	High
F14& F15 Red Data species or Threatened habitat types	.....	No	No □		Yes □	No □		Yes □
A12, B1&2 Cumulative wetland loss	.....	30%	<20%□	20-50%□	>50%□	<20%□	20-50%□	>50%□
F12 Site erosion hazard	.....	1.2	<0.4 □	0.4-1.0 □	>1.0 □	<0.4 □	0.4-1.0 □	>1.0 □
F13 Wetness zone	.....	S	T/S □		P □	T □		S/P □
D1 Downstream water use	.....	N	N □	Y □		N □		Y □
C5 Pollutant input	.....	M	N/L □	M □	H □	N/L □	M □	H □
F16 Severity of existing erosion	.....	L	N/L □	M □	H □	N/L □	M □	H □
F17 Extent of impact area untransformed	.....	2 ha	<0.5ha□	0.5-5ha□	>5ha□	<0.5ha□	0.5-5ha□	>5ha□
F18 Roughness coefficient	.....	0.06	<0.05□	>0.05□		<0.05□	>0.05□	
F19 Current direct benefits	.....	L	N/L □	M □	H □	N/L □	M □	H □
F20 Catchment unsuitable for dams	.....	N	-	-	-	-	-	-

Degree of wetness:

T= Temporarily wet

S= Seasonally wet

P= Permanently wet

Level of impact:

N=Negligible

L=Low

M=Medium

H=High

Instructions for use of the checksheet

- Fill in the site column for all descriptors relevant to the land-use that is being proposed (e.g. traditional crops). Those descriptors which are not relevant to a particular land-use are indicated by a '-' in the land-use column in question.
- Based on the descriptor values, indicate with a cross in the appropriate box the level of impact associated with each descriptor.
- For all of the land-use types assessed it is assumed that the ongoing recommendations given in Section 4 will be followed (e.g. the area will not be grazed more heavily than recommended).

Note for A12, B1, & 2 (Cumulative loss): include the proposed area to be transformed with the existing values for A12, B1 and B2 (e.g. if 25% of the wetland was developed and the proposed development would add a further 5% to the area developed then A12=30%). Out of the respective values for A12, B1 and B2 take that which is highest percentage. For example, if A12=30%, B1=28%, and B2=41% then the cumulative loss for the assessment would be taken as 41%..

Note for F17: the loss of indirect benefits to society as a result of transformation of a wetland which has already been developed/transformed is less than that which would otherwise result if the wetland was not transformed.

Note for traditional crops: it is assumed that artificial drainage channels are not involved, crops tolerant of waterlogging are planted and pesticides, chemical fertilizers and herbicides are not used. If these assumption do not hold then it should be considered as mechanized crops.

Note for annual pastures: if a pastures is annual, consider it as mechanized crops because, although providing better cover once established, annual pastures involve considerably more frequent disturbance of the soil than perennial pastures. In addition, commonly grown annual pastures tend to have lower wetness tolerances than the commonly grown perennial pasture species: Festuca arundinacea and Acroceras macrum (see Section 4.3).

Note for dams: it is assumed that the dam will be structurally sound and have an adequate spillway. Consult the local soil conservation officer for more information.

Note that non-mechanized cutting of natural vegetation is not included in Table 3.1 but restrictions on the timing and extent of cutting (hand and mechanized) are given in Section 4.5.

Table 3.1 (continued) Checksheet for determining the likely impacts of particular land-uses

Descriptor	Impact level for individual land-uses: *Graze*			*Mech. Cutting*			*Dams*			*Mech. Pastures*		
	Low	Med.	High	Low	Med.	High	Low	Med.	High	Low	Med.	High
F14&15	-	-	-	-	-	-	No □		Yes □	No □		Yes □
A12, B1&2	-	-	-	-	-	-	<20% □	20-50%□	>50% □	<20% □	20-50%□	>50% □
F12	<1.0 □	1.0-2.8 □	>2.8 □	<1.0 □	1.0-2.8 □	>2.8 □	-	-	-	<0.7 □	0.7-1.8 □	>1.8 □
F13	T/S □	P □		T □	S □	P □	-	-	-	T □	S □	P □
D1	N □	Y □		-	-	-	N □	Y □		N □		Y □
C5	-	-	-	-	-	-	N/L □	M □	H □	N/L □	M/H □	
F16	N/L □	M □	H □	N/L □	M □	H □	-	-	-	N/L □	M/H □	
F17	-	-	-	-	-	-	<0.5ha□	0.5-5ha□	>5ha□	<0.5ha□	0.5-5ha□	>5ha□
F18	-	-	-	-	-	-	<0.05□	>0.05□		<0.05□	>0.05□	
F19	-	-	-	-	-	-	N/L □	M □	H □	N/L □	M □	H □
F20	-	-	-	-	-	-	No □		Yes □	-	-	-

Box 3 Criteria for assessing the likely overall level of impact of the land-use on the indirect benefits of the wetland:

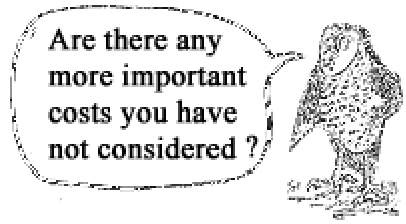
High= At least one of the relevant descriptors is high

Medium= At least three of the relevant descriptors are medium, and none are high

Low= Less than three of the relevant descriptors are medium, and none are high

In the example site given in Table 3.1 (which has an erosion hazard of 1.2) if traditional crops were being considered then the impact level for site erosion hazard is high and the likely overall impact would therefore be high. If, however, perennial pastures were being considered for the example site, the impact levels are predominantly medium (i.e. 6 out of the 10 relevant descriptors are medium) and none are high, resulting in the overall likely impact being medium. If, to take another example, the site had an erosion hazard index of 2.9 then both crop and perennial pastures are likely to have high impacts because both of their erosion hazard impact levels would be high. The reasoning behind the criteria is given in Section 3.2.

Note: additional factors that the assessor or stakeholders raise as further issues may need to be added to the assessment. For example, a wetland may be particularly important in providing natural habitat which acts as a corridor for the movement of certain animals and if the wetland were cultivated this would be lost.



If an assessment is required for a project which does not fit any of the land-use categories then an alternative way of assessing the likely impact of a proposed land-use would be to:

- Refer back to Box 1 and answer the 8 questions each dealing with a particular aspect of impact; and
- Assess how the above are affecting the indirect benefits provided by the wetland, by referring to Table 1.1.

This alternative method of assessing impacts is open to greater personal interpretation, and would be of particular use to assessors with much experience in wetland assessment.

Box 4 Considering alternatives to the proposed project

Is there an alternative site available outside of the wetland for the proposed development which has habitat that is less threatened or which has already been transformed; or is there opportunity for an alternative lower impact land-use within the wetland (see below)? yes no

Some possible low-impact alternative uses of natural wetlands

- Ecotourism: See Section 4.15
- Harvesting of indigenous plants for crafts: See Section 4.5 (note particularly Box 5)
- Livestock grazing: See Section 4.1 and 4.2
- Fishing and hunting: See Section 4.16

If managed correctly, the above land-uses provide possible ways of using a natural wetland area on a sustainable basis, with little or no loss in the indirect benefits provided by the area. Such land-uses may result in just as much economic benefits to wetland owners and local wetland users as uses (e.g. cultivation) which result in high impacts to wetlands. Another advantage is that the same area can be used for all of the above (i.e. a multiple-use system). This contrasts with many high impact land-uses that tend to reduce the number of uses available in the wetland.

The greater the benefits that are derived by a wetland owner from a functioning natural wetland, the smaller will be the incentive to modify/transform the wetland (e.g. by drainage). Consequently, the loss of value of the wetland to society that would occur with modification, would be avoided.

CONSIDER THE "NATURAL ALTERNATIVES!"

3.2 Reasoning behind the impact level criteria (see Section 5 for more detail)

Habitat, threatened species and cumulative wetland loss

Crop (mechanized and traditional) and planted pasture production involve the total replacement of the indigenous vegetation. Although a dam may improve the habitat provided by a wetland for certain common species such as the spur-winged goose (*Plectropterus gambensis*), the flooding of a wetland by a dam usually also results in the loss of most of the indigenous vegetation and makes the wetland unsuitable for specialized and threatened wetland-dependent species (e.g. the white-winged flufftail: *Sarothrura ayresi*). Consequently it is considered together with crop and pasture production as "transformation-orientated land-uses".

If any threatened wetland-dependent species or habitat types are present in the proposed site, or if the cumulative loss of wetlands in the individual wetland, the local quaternary catchment, or the Veld Type is high (i.e. >50%) then any transformation orientated land-use is likely to have an unacceptably high impact on the ecological benefits provided by the area. This is because wetlands with threatened species or habitats are of particular **ecological value**. Also, aside from the presence of Red Data species, if the cumulative loss of wetland area is already high, further loss is likely to have a greater impact than if the level of existing loss was low. The cumulative loss of wetlands is also of great relevance to the hydrological benefits provided by wetlands.

Site erosion hazard

On sites with very high erosion hazards no form of cultivation or any land-use involving machinery (including mechanized vegetation cutting) is considered acceptable. On sites which have medium erosion hazards, crop production is not considered acceptable because it requires that the soil be frequently disturbed (rendering it vulnerable to erosion) but perennial pastures are considered acceptable because the soil is disturbed considerably less frequently. Judiciously managed perennial pastures generally constitute less of an erosion hazard than crop production.

Wetness zone

Generally the wetter the area, the greater the likelihood that cultivation will have a high impact on the wetland (e.g. as a result of organic matter depletion). In permanently wet areas no form of cultivation is considered acceptable because no commonly grown crops are able to tolerate such conditions and the hydrology would have to be altered significantly, detracting from the hydrological and ecological values of the wetland area. In seasonally wet areas only pastures (e.g. tall fescue or Nile grass) and crops (e.g. madumbes) which are able to tolerate **waterlogged** conditions are considered acceptable as they do not require extensive hydrological modification.

Downstream water use

Drainage, disturbance of the soil and regular application of fertilizers, detracts from the water purification value of wetlands. Furthermore, should the wetland be disturbed and its hydrology altered, this may cause the accelerated release of pollutants already trapped in the wetland sediments, and may detract from the wetland's future water purification potential. Thus, if water is being used for human consumption in the downstream area, the conversion of the wetland to cropland could potentially detract from this benefit. Although dams are not as efficient in the removal of nutrients, particularly nitrogen, they perform a degree of water purification, notably in the trapping of sediment. As such, the water quality constraints on dams, although accounting for situations where pollutant inputs are high, are not as stringent as for the cultivation of crops.

The retention of water in wetlands is diminished when wetlands are drained, with the result that the streamflow regulation benefit provided by wetlands is reduced.

Pollutant input

If there was pollutant input to a wetland then the wetland is afforded opportunity for the purification of water. Thus, if its capacity for water purification were diminished (e.g. through drainage) then the loss of water purification benefits would be potentially greater than if it was not afforded this opportunity.

Catchment unsuitable for dams

Runoff is reduced in catchments which are dammed. This is particularly so in catchments where **evaporation** is high, where a high percentage area is occupied by dams and where there is abstraction of water from the dams. Thus, in certain catchments considered particularly important from a water supply point of view, severe restrictions have been placed on the construction of further dams to prevent excessive runoff reduction.

Extent of existing transformation of the wetland

If a wetland area is already transformed (e.g. if it is artificially drained) then the loss of benefits resulting from a further transformation (e.g. damming of the drained area) in the same area is likely to be less than would result if the area was un-transformed. This is not to exclude the possibility of rehabilitating transformed areas, but it is based on the premise that it is generally more cost-effective to place a priority on securing intact (un-transformed) wetlands than rehabilitating degraded ones.

Roughness coefficient

Transformation-orientated land-uses (including crops, pastures and dams) generally have a low surface roughness. Thus, if surface roughness is high in an untransformed wetland then surface roughness and its associated benefits are likely to be lost if any of these land-uses are applied to the wetland area.

3.3 Mitigation of impacts

Mitigation measures should compensate for the effects of the proposed land-use. For example, extra soil conservation measures may be used on a site that has an erosion hazard which would otherwise be considered too high for cultivation. The loss of important habitat at the **impact site** may be mitigated by restoring an equivalent area of wetland in the surrounding landscape. It should be stressed, however, that mitigation measures should not be seen as a "loop-hole" but rather as means of accounting for those instances where a potential wetland user is genuinely able to mitigate the effects of the proposed land-use. This will obviously require expert advice and need to be followed up by regular monitoring. Mitigation may be either on-site or off-site.

On-site mitigation

On-site mitigation may include such measures as:

- Avoiding changes to water flow patterns in the wetland
- Avoiding all unnecessary disturbance and soil compaction within the wetland
- Avoiding depositing spoil in wetland areas or having spoil washing into the wetland from nearby
- Keeping the area of impact as small as possible
- Controlling alien plants that may increase as a result of the disturbance
- Minimizing the impact on flow patterns through the wetland
- Setting aside topsoil from the area and using it for rehabilitation

Off-site mitigation

Off-site mitigation can be undertaken by:

- Creating, in other nearby location/s, the wetland area that has been impacted; or
- Rehabilitating existing degraded wetlands in other nearby locations.

In the USA the creation of original impacted wetlands in different locations has become a common mitigation strategy for balancing demand for land for development with the protection of ecosystems (LaRoe, 1986; and Kusler *et al.*, 1988). Creation of wetlands as a means of mitigation should, however, be approached with caution because these so called "created" wetlands often do not adequately compensate for the original (Kusler *et al.*, 1988). Furthermore, in South Africa we have very little experience in the re-creation of wetlands. Thus, it will be expected that the created wetlands are unlikely to be of equivalent quality as the original wetlands, and will only be possible for certain wetland types. Depression wetlands are likely to be the easiest to create. Wetlands on slopes are often found where particular geological phenomena result in the discharge of groundwater (see WETLAND-USE Booklet 2), making it very difficult to re-create these wetlands. Thus, it is recommended that wetland rehabilitation is preferable to wetland creation but this would obviously depend on suitable sites being available.

SECTION 4, LAND USE-RECOMMEND:

MANAGEMENT GUIDELINES FOR INDIVIDUAL LAND-USES

From the sections given below, which deal with ongoing management guidelines for particular land-uses, proceed to the section which deals with the land-use/s that interest you.

21. Control of water associated parasitic diseases*: 4.21

* These are not land-uses *per se* but may be important activities required to meet wetland management objectives.

The primary focus of WETLAND-USE is on the agricultural uses of wetlands (Items 1 to 6), for which comprehensive management guidelines are provided. Brief guidelines and directions to important documents are given for Items 7 to 21.

4.1. Management guidelines for burning

4.1.1 Positive and negative effects of burning

The burning of wetlands has several potential positive effects, including: assisting in alien plant control; increasing plant productivity by removing old dead material; improving the habitat value for wetland dependent species and improving the grazing value. However, burning may also have negative effects. The young of wetland-dependent species are particularly vulnerable to the direct effects of burning, heat and asphyxiation. Most species are summer breeders and are therefor little affected by winter/early spring burns. Some species, notably the wattled crane, are, however, winter breeders. In South Africa, fire is one of the most important causes of wattled crane egg failure and chick mortality. Fire may also negatively affect autumn/early winter breeding species such as the grass owl. Furthermore, combined with other factors such as grazing, fire may contribute to increased levels of erosion. Thus, it is very important that the guidelines in the following section are followed.

There are two main groups of fire management decisions: (1) the time of year to burn and the frequency of burning; and (2) additional actions to influence fire behaviour (e.g. burning with or against the wind).

4.1.2 Recommendations about the timing and frequency of burning

- See 4.1.2.1 if the wetland falls within an afforested area.
- See 4.1.2.2 if the wetland is not within an afforested area and regular burning is required to:

  * enhance grazing potential;

  * promote plant vigour and control alien plant infestation;

  * enhance the habitat for wetland-dependent fauna and/or flora; or

  * to prevent the build-up of exceedingly high fuel loads;

- Otherwise see 4.1.2.3

4.1.2.1 Wetlands in afforested areas

May wetlands in afforested areas are burnt annually in early winter because of the fire risk that wetlands pose to the trees. Early winter burns generally have greater impacts on the hydrological and ecological benefits of wetlands than late winter/early spring burns. Absence of loose surface and standing plant litter (removed by the early winter fire) for the entire winter is likely to result in a significant increase in the evaporative loss of water from permanently wet areas, where the water table remains close to the soil surface through most of the winter season. The increase in evaporative loss as a result of burning is likely to be lower in seasonally wet areas and considerably lower in temporarily wet areas, where the water table normally drops well below the soil surface and evaporative loss is limited by the upper dry soil layers. Little can be done to minimize the hydrological impact of early winter burning, other than to protect permanently and seasonally wet areas where possible. Early winter burning may detract from the grazing resource if large numbers of herbivores are attracted to the early winter flush, and grazing of these areas should preferably commence only after the end of winter.

Late summer/winter breeding species, notably the threatened grass owl and the African marsh harrier and the marsh owl may be severely affected by early winter fires. In areas in which these species breed, burn rotationally through block burning and check before burning by having 'beaters' 10 m apart walking through the area and then closely examining all localities where these birds are flushed (Johnson, *Pers comm*., KwaZulu-Natal Nature Conservation Services). Leave areas unburnt where chicks have still not fledged, or, if possible, delay burning for that year. Wattled crane may also have started breeding at this time (see recommendations in following section).

4.1.2.2 Late winter/ early spring burning

If burning in late winter/early spring, do so approximately every second year if the rainfall is >800 mm per year or every fourth or fifth year if the rainfall is <800 mm per year. Occasional late autumn/winter burns (at an average ten-year interval) may also be included to enhance diversity. Early spring burning may result in the death of wattled crane chicks, as the wattled crane is a winter to early spring breeder. Thus, if this species is breeding in the wetland then:

If a nest with eggs is present temporarily remove the eggs and place in a small incubator (an insulated box warmed with hot water bottles can be used but do not place the eggs directly on the hot water bottles).

- Consider delaying burning until the chick can fly and therefor escape the fire
- If burning cannot be delayed long enough then attempt to catch the chick, perform a patchy burn and then release the chick after the burn. Alternatively, if the chick cannot be caught (which will probably be the case, observe where the chick is at the time of the burn and burn strategically, sometimes having to burn a break around where the chick is hiding.
- In all cases it is vitally important that a patchy burn is performed so as to leave sufficiently tall vegetation areas for the chick to hide from predators.

For information about cranes and burning, contact the Southern African Crane Foundation 033-332737.

4.1.2.3 Infrequent burning

Wetlands that meet the requirements for infrequent burning should not be burnt more frequently than every ten years. As the burning of wetlands, and of the landscape in general, is the norm in the humid and sub-humid grasslands and savannas of South Africa, the assumption is made that most wetlands in the landscape are likely to be burnt regularly. Thus, by promoting the infrequent burning of some wetlands, the diversity of habitats provided by wetlands in the overall landscape will be enhanced.

4.1.3 Additional actions to influence fire behaviour

The following generally applicable recommendations are made, aimed at reducing the extent, intensity and damage caused by fire.

- Burn when the relative humidity is high and the air temperature is low, preferably after rain, in order to keep the fire as cool as possible and increase the likelihood of a patch burn.
- Head fires (burning with the wind) are generally preferable to back fires (burning against the wind). Temperatures at ground level tend to be higher in back fires and consequently the impact on the growing points of plants is greater. Although the fire front advances less rapidly in a back fire, direction is more difficult to predict. Also, because the fire front advances more rapidly with head than with back fires, particularly if the wind speed is high, the fire has less time to spread laterally. Thus, head fires can be used more effectively for burning only portions of the wetland without the use of fire breaks. However, this method of burning portions of a wetland is dependent on many factors outside the manager's control, such as wind direction changes, and cannot be relied upon for consistent block burning.
- If conditions are unfavourable for burning (e.g. if the soil is very dry and susceptible to sub-surface fires or if the weather conditions are consistently unsuitable) delay burning until the following year.
- Give preference to burning areas with abundant dead (moribund) stem and leaf material that is obviously limiting new growth.
- If possible, divide the wetland into two burning blocks and alternately burn each half, leaving the other half unburnt to provide refuges for wetland-dependent

animals from which they can recolonise the burnt area/s. If this is impractical, the entire wetland may be burnt every second year provided there are other wetlands nearby (preferably within 1 km) left unburnt for the year in which the wetland is burnt. Effective fire breaks are often difficult to achieve in wetlands, as fires may easily burn across the break through the loose surface litter, or even below it in the upper organic matter-rich soil layers if they are dry.
- Protect areas known to be important bird breeding areas (e.g. reed marsh areas used by herons or sedge marsh areas used by ducks) but even these may need to be burnt every fourth or fifth year to stimulate new plant growth.
- Where wetland plants are being harvested, do this in areas useful for fire breaks, as far as is possible.
- Keep records of management practices, to monitor progress.
- Cattle, by reducing the fuel load and creating puddles, can be used to good effect in promoting patch burns, but this would obviously need to be where erosion hazard is low.

For more information on burning and its affects, contact your provincial nature conservation organization.

4.2 Management guidelines for the grazing of natural wetlands by domestic stock

4.2.1 Positive and negative effects of grazing by domestic stock

Many wetlands evolved with grazing by indigenous animals such as buffalo, which would have had an important effect on the habitat provided by the wetlands. Where these indigenous animals no longer occur, domestic livestock may have a similar and therefor positive effect in maintaining particular habitats. This is particularly so where a diversity of tall and shortly grazed areas result from the grazing. However, where wetlands are grazed heavily and uniformly short, the quality and diversity of habitats provided is likely to be decreased. Wetlands with high erosion hazards may erode easily when disturbed by trampling and grazing, with the soils being particularly susceptible when they are wet. The flow concentration zone (see Section 2, Descriptor A7) is generally the most sensitive part of the wetland and disturbance of this area by cattle may cause gully erosion to advance into the wetland, drying it out and destroying most of its value. Thus, it can be seen that the impact of grazing depends on grazing intensity and timing and location relative to sensitive areas. Therefor it is important that the guidelines in the following section are followed to avoid the negative effects and maximize the positive effects.

4.2.2 Stocking rate

Potential grazing capacity, which refers to the amount of grazing that can be sustained in a particular area, varies according to bioclimatic region. Contact your nearest Department of Agriculture office to obtain the recommended potential grazing capacity for the bioclimatic region in which the wetland falls. For a given bioclimatic region, grazing capacity tends to be higher in temporarily wet areas than in nearby non-wetland areas, and is estimated to be 1.5 times greater than the Department of Agriculture's recommendations for non-wetland areas.

Grazing capacity also depends on the condition of the veld and is lowered with a reduction in veld condition. Thus, reduce stocking rate by an amount proportional to the veld condition (see Table 4.1). In non-wetland areas veld condition is determined by comparing species composition with that of a benchmark site. Benchmarks have not been described for wetlands. Thus, a simplified system to be applied to temporarily wet areas should be used, whereby the recommended stocking rate is reduced by an amount proportional to the relative abundance of Increaser II species present. These species have low palatability and/or perenniality, and increase in mis-managed veld where grazing pressure is heavy. *Eragrostis plana* is one of the most common Increaser II species in the wetlands of the South Africa (see Appendix 3). A veld condition assessment should be conducted by randomly placing a point 200 times in the temporarily wet zone and at each point recording whether or not the closest species is an Increaser II. Consult your agricultural extension officer for assistance in conducting a veld condition assessment.

Table 4.1 Stocking rate adjusted to account for veld condition:

Percentage of Increaser II species	Stocking rate (expressed as a percentage of the potential grazing capacity for wetlands in the given Bioclimatic Group)

0- 30%	100%
30-60%	85%
>60%	70%

If seasonally and permanently wet areas are used by livestock, include them in the stocking rate calculations for the spring season only, when plants in these areas are most palatable. Later in the season, plants in these areas become much less palatable and the soils are also often too wet for use. A maximum stocking rate of 0.5AU/ha is recommended for these areas during spring only. During droughts these areas can be used as an emergency food supply and grazed for more extended periods.

Calculations:

A. Recommended grazing capacity for non-wetland areas:

..... AU/ha

B. Increased grazing capacity for wet grasslands:

A x 1.5 = ... AU/ha

C. Stocking rate adjusted for veld condition:

B x 1.0 (veld condition good),

x 0.8 (veld con. medium), or

x 0.75 (veld con. poor)

=......AU/ha

D. Total area of wet grassland

......ha

E. Total AU's the temporarily wet area can support for the grazing season

C x D =......AU.

F. Total area of wet meadow and marsh

......ha

G. Total additional AU's the area can support during spring only

0.5AU x F =......AU

Example Site: falls within an area having a recommended grazing capacity in non-wetlands of 0.4AU, and 46% of Increaser II species (which according to Table 4.1 is medium condition veld), and has 50 ha temporarily wet and 30 ha seasonally/permanently wet.	A. 0.4 AU/ha B. 0.4 x 1.5 = 0.6 AU/ha C. 0.6 x 0.85 (veld con. medium) = 0.51 AU/ha

	D. 50 ha E. 0.51 x 50 = 26 AU F. 30ha G. 0.5AU x 30 =15 AU

Remember the recommended adjusted stocking rate is only a guideline and may need to be modified to account for particular local circumstances

4.2.3 Fencing of wetland areas and other means of reducing area-selective grazing

Because wetlands have special management requirements, grazed wetlands should be fenced off as special use camps if possible. However, this is often impractical, particularly for small wetlands. Alternatively, reduce area selective grazing by:

- Herding animals away from the wetland into under-utilized non-wetland areas;
- Ensuring water availability in nearby non-wetland areas, which is particularly relevant to slope and channelled wetlands as they are generally susceptible to erosion cause by the trampling of cattle going to drink;
- Placing any supplementary feed and provide shade or shelter in non-wetland areas rather than within wetland areas. Also ensure that supplementary feed is not in a place that results in the animals having to repeatedly cross a particular wetland area; and
- Cutting herbage for hay or green chop, mow old grass, or strategically burn (in the non-growing season only) to attract more grazing to otherwise under-utilized areas away from wetland areas.

4.2.4 The grazing system

Graze wetlands using a rotational system, whereby the animals are moved out of the wetland area before the vegetation has been grazed to an average of <8 cm or when most of the tufts of the favoured species have been grazed. A full 12 months' rest is included every 4 years.

If the soil becomes flooded or saturated to the surface, remove grazing livestock until the area dries out again. Soils, particularly those with a high clay content, are more susceptible to compaction and **poaching** when wet. Poaching, which refers to the disruption of soil structure caused by the repeated penetration of hooves into the soil, decreases herbage production, and increases susceptibility to erosion. The exclusion of grazing when soils are wet can usually be easily accommodated in a grazing system because when the need for grazing to supplement non-wetland grazing is high it is usually in dry periods when the wetland soils are acceptably dry for use. When wetland soils are too wet for use it is often during wet periods when non-wetland forage production is relatively high. If downstream water users are present (see Descriptor D1) it is particularly important that the wetland not be grazed when flooded as livestock may contaminate the water through defecation and urination.

For more information contact your provincial departments of agriculture and nature conservation.

4.3. Management guidelines for planted pastures

4.3.1 The negative effects of planted pasture and crop production

Drainage and the production of pastures or crops in wetlands has several negative effects and most of the indirect benefits of the wetland are lost. The removal of indigenous plants greatly reduces the habitat value for most wetland dependent species. Drainage channels speed up the movement of water through the wetland, reducing its effectiveness in regulating streamflow and purifying water as well as increasing the danger of erosion. The addition of fertilizers and pesticides further reduces the effectiveness of the wetland in purifying water. The disturbance of wetlands, whether it be for the cultivation of pastures or crops or for any other purpose, is strongly discouraged by conservation and environmental bodies. There are two important regulations, the Conservation of Agricultural Resources Act and the Environmental Conservation Act, which are applicable to wetland disturbance and must be adhered to (see Part 2, Section 5.1).

Because of the impacts discussed above, consider the possibility of rehabilitating areas currently converted to planted pastures or crops and returning them to their natural state (see Section 4.7). For those areas which are being legally and safely cultivated under planted pastures, follow the guidelines given below to avoid still further loss of benefits.

4.3.2 Selection of species

Perennial species, such as *Festuca arundinacea* (tall fescue) and *Acroceras macrum* (Nile grass), are preferable to annuals, such as *Lolium multiflorum* (annual ryegrass), as they require the soil surface to be disturbed less frequently, detracting less from the erosion control value of the wetland. Species with a high wetness tolerance, such as *Festuca arundinacea*, are preferable to species with a lower tolerance, such as *Medicago sativa* (lucerne) and *L. multiflorum* because they require less alteration of the hydrology, and consequently they detract less from the hydrological values of the wetland.

4.3.3 Drainage channels

As emphasised in the previous section, wetland drainage is strongly discouraged by all government and non-government environmental bodies and a permit is required to drain any wetland area (see Part 2, Section 5). Drainage will always detract from the hydrological and ecological benefits of a wetland. It may also be that an already drained area requires a revised drainage plan because of earlier poor planning. For areas that have permits for drainage the following should be adhered to: the water regime should not be altered any more than is necessary, and complete control of the ground water level should be maintained so that the water regime of the wetland can be returned to its original state at any time (see Scotney, 1970). Under no circumstances alter the outlet of the wetland, either by the creation of new drainage channels or by the straightening and/or deepening of existing channels. In addition, the area immediately above the outlet and any flow concentration areas in the wetland should be left under natural vegetation. The Department of Agriculture should be consulted about the final design and placement of the drainage channels.

Surface drainage channels usually require regular excavation and disturbance of the soil to remove plants growing in the channels, which may further detract from the water purification benefits of the wetland. However, although it in no way compensates for the natural habitat lost through development, surface drainage channels provide a small amount of micro-habitat absent from sub-surface drained areas Thus, it detracts less from the ecological benefits.

4.3.4 Timing of grazing

As is the case in natural wetlands, grazing should be avoided when the soil is saturated, making it susceptible to erosion and compaction. If the pastures are irrigated, it is important that a co-ordinated irrigation and grazing schedule be devised. Extra care should be exercised in grazing pastures during the first year or two after planting. Older pastures are at a lower risk than younger pastures.

4.3.5 Fertilizer application

Measures should be taken to minimize nitrogen and phosphorus losses into drainage waters as this not only detracts from the economic returns derived from pasture production but also from the water purification benefits of the wetland. These measures include:

- Limitation and proper timing of fertilizer application according to the special needs of the pasture
- Multi-cropping with nitrogen-fixing legumes and grasses (which reduces the application requirements) and possibly also mulching with straw (which decreases loss)
- Modern fertilizer technology (e.g. slow release-fertilizers)
- Avoiding over-irrigation
- Limiting soil erosion, as the greatest loss of phosphorus is generally in association with the loss of soil mineral particles (phosphorus leaches less readily than nitrogen) (see Section 4.3.3).

Limitation and proper timing of mineral fertilizer application according to the needs of the pasture

Fertilizer applied should be just enough to meet the requirements of the specific pasture species. Split applications in at least three or four dressings is recommended for nitrogen (i.e. frequent small applications are preferable to infrequent large applications). Although increasing labour costs, nitrogen use is generally more efficient and toxic fertilizer concentrations in the soil solution are less likely. In newly established pastures, nitrogen from decomposed organic matter is likely to meet the initial requirements of the plants. Thus, it is recommended that the first application be reduced or that nitrogen fertilizer be applied only two weeks after establishment.

When applying fertilizer, take the seasonal growth patterns of the pasture into account. In the highland sourveld, for example, growth in the mid-winter is restricted by low temperatures, and nitrogen dressings should be drastically reduced during this period.

As with nitrogen, the amount of phosphorus applied should not exceed the plants' requirements, allowing for soil fixation. Determination of these requirements involves taking into account such factors as soil texture and pH (see Department of Agriculture and Water Supply, 1987).

Intercropping with legumes and mulching

Nitrogen-fixing legumes, provide naturally produced nitrogen, and the amount of expensive mineral fertilizer required would be reduced. In legume/grass pastures the legume may contribute from 50 to 250 kg N/ha annually to the pasture. Some of the nitrogen from the legume is made available to the grass via excreta. Thus, cutting and removing material and having animals deposit their excreta off the pasture is likely to reduce the available nitrogen and limit grass growth (Miles and Bartholomew, 1991).

Mulching involves placing pasture herbage back onto the soil, and can be used to capture fertilizer or manure nitrogen and assimilate it into organic matter through the action of micro-organisms. This is particularly applicable to annually established pastures and crops, and would assist in counteracting the steady decrease in organic matter often associated with cultivation and, in so doing, would have additional benefits such as increasing the soil's moisture holding capacity. It is important to note, however, that this biologically-blocked nitrogen will not be available to the plants until the organic matter has been broken down, which may take months.

Modern fertilizer technology

Slow release nitrogen fertilizers can improve nitrogen-efficiency by allowing a controlled release of nutrients to the roots. Nitrification inhibitors accumulate ammonia by retarding the nitrification of ammonium to nitrate. Leaching of nitrogen is reduced because nitrate is most prone to leaching. Thus, as in coatings and slow release fertilizers, the roots are continuously supplied with small quantities of nitrogen.

Avoiding over-irrigation

Over-irrigation will not only waste costly irrigation water through run-off, but may cause nutrient losses into the drainage system through leaching. Once the soil is nearing saturation, the irrigation system should be moved or shut down until the soil has dried out sufficiently to require irrigation again.

For more information see Macdonald (1991) and contact your provincial department of agriculture.

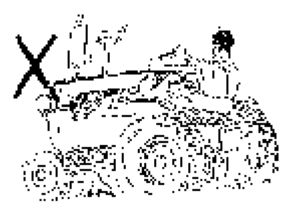
4.4 Management guidelines for crop production

See section 4.3.1 emphasising the severe impacts that may result from cultivation of any form within wetlands. Crop production tends to have an even higher impact than planted pastures and LANDUSE- ASSESS lists stringent requirements for the acceptability of wetland cropping (see Section 3.1). Where these requirements are met and permission from the relevant authorities have been granted for development, great caution must nevertheless be exercised in utilizing these areas.

Recommendations concerning drainage and minimizing the impact of artificial fertilizer applications given for planted pastures are also applicable to crop production (see Sections 4.3). Also implement long ley rotations. In dry years, the moisture conditions in wetland areas are generally more favourable than in drier non-wetland areas. Consequently, they may provide useful alternative dryland crop production areas during drought years but they cannot be relied upon for continuous cropping. A one-in-three year ley is recommended, where for every year the area is cropped, it is left fallow or under perennial pastures for three years. For a ley to serve its purpose (primarily to restore depleted soil organic matter levels) at least three consecutive years for each rotation is required. The most generally applicable system would probably be three years of cropping alternating with nine years of perennial pasture ley.

Traditional cultivation tends to have much lower impacts on wetlands than commercial mechanized cultivation provided that you follow the practices such as those listed below. (Several of these practices may be incorporated into commercial mechanized crop production.)

- Grow crops such as madumbes (*Colocasia esculenta*) which are tolerant of waterlogging, in preference to crops with low tolerance as this minimizes the need to reduce the wetness of the soil.
- Do not use artificial drains.
- Till and harvest by hand, which results in less soil compaction and disturbance than with mechanical tillage and harvesting.
- Avoid the use of heavy machinery.
- In the case of shifting cultivation, leave areas fallow for at least 2 to 3 years for every year cultivated.
- Add mulch to reduce soil organic matter depletion and associated problems (e.g. increased erosion hazard).
- Leave strips of indigenous vegetation between crop patches, which would assist in reducing flood water velocity, thereby reducing the loss of the crop (a short-term loss) and loss of soil (a long-term loss of the productivity of the area).
- Do not use of pesticides and artificial fertilizers, thereby reducing the impact on water quality.

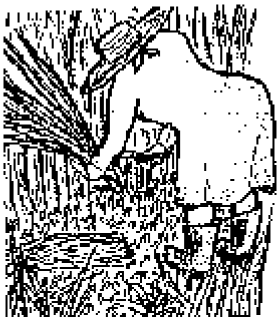


For more information generally contact your provincial department of agriculture and for information on ecological agriculture contact the Valley Trust (Tel: (031) 7771955)

4.5 Management guidelines for the cutting of natural wetland vegetation for hay, crafts and construction

The cutting of natural vegetation generally has a lower impact on a wetland in comparison to cultivation because there is minimal disturbance to the soil. It may, however, result in some unnecessary impacts on the wetland, particularly if extensive areas are cut. To avoid such impacts follow the guidelines below.

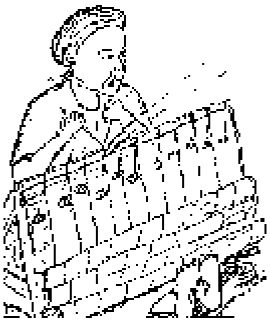
- If the wetland is also grazed by domestic stock then <30% of any wetness zone in the wetland should be harvested in any one year because, if exceeded, this may detract from the ecological value and would also reduce its flood attenuation value. If the wetland is not being used for grazing then this value may be increased to 50%.
- Do not carry out mechanized cutting when the soil is wet! As with grazing, this increases the risk of soil erosion, particularly if machinery gets stuck.
- If mechanized cutting is being used consider using hand cutting. Although more labour intensive, this harvesting method is less constrained by soil surface conditions and would have less impact on the soil, thereby decreasing the loss of hydrological and erosion control benefits.
- Harvesting should preferably take place outside or towards the end of the breeding season of bird species, thereby minimizing direct disturbance of the birds. Late summer/autumn breeding species may nevertheless be negatively affected. See the recommendations for these species in Section 4.1.2.1, paragraph 2.
- Rather than cutting a single extensive large area it is better to break up the cut area into several small areas, which provides more suitable habitat for wetland dependent species.
- When cutting by hand, avoid unsustainable harvesting practices involving the cutting of all culms (including short young ones) and discarding material to form a mat of litter that retards new culm growth. Instead, select and cut/pull only suitable culms. This applies particularly to highly sought after species such as *Juncus krausii* (incema). If harvesting is beyond the resource's capacity for renewal, the resource will be degraded and the benefits derived by the users will be lost.



In wetlands where the removal of leaf material through other factors (e.g. grazing and burning) is limited then cutting may improve the habitat benefits provided by the wetland. Cutting would reduce the standing dead material, which would otherwise develop under a very infrequent burning regime. Such dead plant material reduces plant productivity and restricts the movement of secretive wetland birds such as flufftails (Taylor P B, 1997 *Pers. comm.* Department of Zoology and Entomology, University of Natal, Pietermaritzburg). The use of harvested wetland plants may also be particularly useful in providing material for poor rural people to generate income (see Box 5).

Cultivation of sought-after species such as incema will aid in reducing the demand for harvesting the wild plants. *For information on the cultivation of incema see Mander et al. (1996).*

Box 5 Craft production from wetland plants as a low impact use of wetlands for promoting rural development



Several wetland plant species are currently used for weaving crafts, including the salt marsh rush, *Juncus krausii* and the freshwater sedges: *Cyperus latifolius*, *C. textilis* and *C. sexangularis*. These species are used for making sleeping mats and sitting mats but *J krausii* is used to make a wider range of products, including decorative wall mats, rolled twine and beer strainers.

The harvesting of wetland plants for craft and construction purposes represents one of the simplest examples of management for sustainable resource utilization, mainly because the plants being exploited are generally very productive and resilient to harvesting . Handcraft production from wetland plants has many benefits as a development option in poor communities: it makes use of local traditional skills; it requires a low capital input and has the potential for immediate cash returns; it increases the net inflow of financial resources into rural communities; and, by increasing the financial benefits to the users, it reduces the incentive to transform the utilized wetland, thereby contributing to the conservation of natural habitats. However, the activity and associated income are obviously dependent on harvesting the wetland plants on a sustainable basis.

Craftworks are traded at three levels: informal (inter-homestead sales or barter), semi-formal (roadside stalls and travelling markets) and formal (bulk trading by wholesalers and urban craft shops). Historically trade was predominantly informal but recently semi-formal and formal craftwork trade has increased greatly. In order to promote craft production as a means of rural development it will be necessary to explore semi-formal and formal markets. In order for this to be viable products will need to be identified for which there is a particular demand in these markets. It will often be necessary to develop new products, particularly those which can be produced using existing skills and materials. For example, at Mbongolwane wetland, KwaZulu-Natal, craftworkers have adapted the traditional sleeping mat made from the locally common *Cyperus latifolius* (ikhwane) to produce place mats and pinboards made from the same material and using similar methods.

4.6 Management guidelines for dams, weirs and water extraction

Whilst dams perform certain wetland functions (e.g. sediment trapping) they do not perform other functions well. The habitat required by specialised wetland dependent species is frequently lost when a wetland is dammed. Dams may greatly reduce the streamflow, particularly when water is pumped out of dams. Furthermore, bursting of farm dams is a frequent occurrence that may have high impacts on downstream areas. As is the case with cultivation, application must be made to the relevant authorities for damming. In order to minimize the negative impacts of dams that are legally and safely in place it is important that the guidelines given below are followed.

Construction of the dam wall and spillway

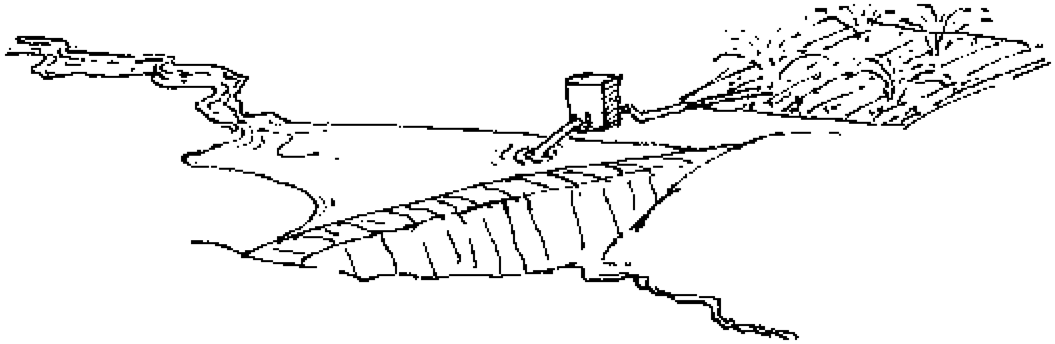
The dam wall and spillway should be built to withstand flooding because the bursting of dams usually has a high environmental impact, increasing flood peaks, sediment loads and streambank erosion. In addition, weirs and spillways should be built to allow for the movement of aquatic species. All dams should also preferably have an outflow control. Consult the local Department of Agriculture soil conservation officer or an engineer to plan the dam wall and spillway and to check whether it has been built to specifications.

Ongoing management

The main factors within the manager's control once a dam or weir has been built are: (1) water extraction; and (2) outflow control.

The first wet season flows from a dam's catchment are often retained in the dam because levels are depleted at the end of the dry season This may impact both the river biota and downstream users (Bruwer and Ashton, 1989). Thus, take measures to ensure water release through the outflow control so that at least 50% of the early season flow entering the dam is released. Extraction of water from a dam or directly out of the stream channel can also potentially alter the water regime of the wetland on-site, as with drainage of a wetland area. In managing the outflow control and extraction of water it is essential that the needs of the downstream water users and the natural environment are accounted for (see Section 5, Part 2 which deals with water law and includes some of the key principles to follow).

Extraction of water often causes sudden, large fluctuations in the water level of a dam, hindering the establishment and growth of wetland vegetation. Together with wave action, this also contributes to hardening of the soil to produce an armoured shoreline, which decreases the ecological value of the area. In some instances, however, drawdown on shorelines with a soft soil improves the ecological value as these exposed areas are often good for mud-probing birds. If Red Data species (e.g. wattled cranes) are breeding on the edge of the dam then winter draw-down should be limited as this is likely to leave the nest exposed and make the site unsuitable for breeding.



For more information contact your provincial department of environmental affairs and the National Department of Water Affairs.

4.7 Rehabilitation of wetlands

Although wetlands are areas where sediment is characteristically trapped, sometimes wetlands erode and more sediment is removed from the wetland than is trapped. Wetlands with high erosion hazards (e.g. those with erodible soils and steep slopes See Section 3, Descriptor F12) are the most susceptible to erosion. The most common erosion problem in wetlands is gully erosion. The head of a gully may move rapidly into a wetland particularly if the area is disturbed by cattle, sometimes advancing several metres in a single storm. The erosion of channels, both natural and artificial is another common problem in wetlands. Erosion gullies not only increase the amount of soil lost by the wetland but, as with drainage channels, they also dry out a wetland. Thus, they detract greatly from the indirect benefits supplied by the wetland, and rehabilitation of eroded areas (particularly areas which are currently actively eroding) and drained areas (particularly areas which are not being used for production) should be considered. Rehabilitation can be very costly. Thus, choose priority wetlands which will supply the greatest increased benefits. When prioritizing wetlands for rehabilitation it is important to have a catchment and landscape perspective, with rehabilitation best placed in catchments and portions of catchments with water quality problems and in ecoregions (i.e. Veld Types) where the loss of wetlands has been high.

Several methods are available for rehabilitating eroded or drained areas (see Fig 4.1 for some examples).

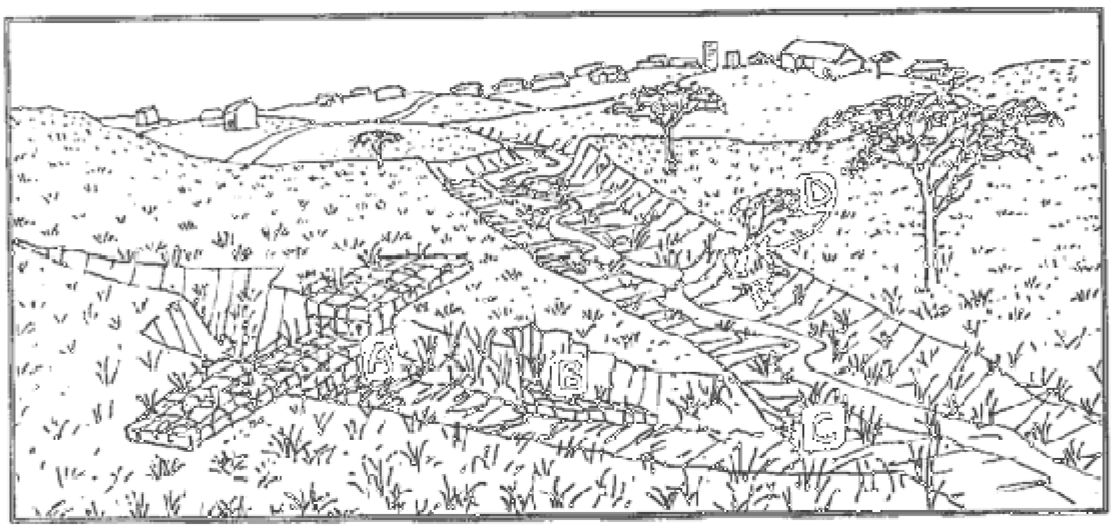


Fig 4.1 Some methods for stabilizing stream channels and erosion gullies. (A) Gabions, which are well anchored into the banks, are preventing the head of the gully incising further by trapping sediment and stabilizing the gully bed. Plants that establish in the gabions also assist. (B)Grasses planted on the streambanks and gabions placed at the base of a collapsed bank assist in stabilizing the banks. © Grasses and sedges planted, and allowed to establish naturally in the channel, trap sediment and stabilize the channel bed. (D) Trees established on the banks of a wide channel and next to the channel assist in stabilizing the banks.

See WETLAND FIX Part 3 (Wyatt, 1993), where these, and additional methods are given in detail and guidelines in choosing between the use of woody or herbaceous plants for the rehabilitation of particular situations. Remember:

- Address all factors contributing to erosion or the problem will start all over again. These may include disturbance by livestock or cultivation, or changes to the water flow pattern which result in more concentrated water flow in the wetland. If livestock were contributing they would need to be excluded from the area.
- Never underestimate the power of floodwaters!
- Any streambank stabilization and erosion control structures need to be properly anchored into the river bank otherwise they are likely to make the problem even worse

(see A, Fig 4.1)!
- It is essential that land owners/users take ownership and responsibility for the structures, which may require maintenance from time to time.

For additional advice on wetland rehabilitation contact: Directorate Resource Conservation, National Dept. of Agriculture (012) 3196000 and your provincial Department of Agriculture

4.8 Alien plant control

Invasion by alien plants, which out-compete the indigenous plants, may greatly reduce the indirect benefits provided by a wetland because:

- The quality of habitat and the biodiversity support benefits provided by the wetland are reduced
- Many alien plants (e.g. wattle trees) are less effective in controlling erosion than the indigenous plants, which are specifically adapted to these conditions
- Some alien plants use more water through transpiration than the indigenous plants, which leads to a reduction in the natural flow in streams
- The grazing value of most alien plants is lower than the indigenous grasses and sedges that they replace.

The first step in controlling alien plants is to identify the particular species of alien plants that are to be controlled. See WETLAND FIX Part 6 (Wyatt, 1993), which covers the control of 29 alien plant species known to invade wetlands and streambanks in South Africa. Controlling alien plant species requires that appropriate pre-treatment, initial treatment, and follow-up treatment/s be applied that vary from species to species.

Pre-treatment by cutting or burning may be necessary where herbicide treatment is required and the alien plants are too tall and/or dense to reach. Initial and follow-up treatments may be carried out through:

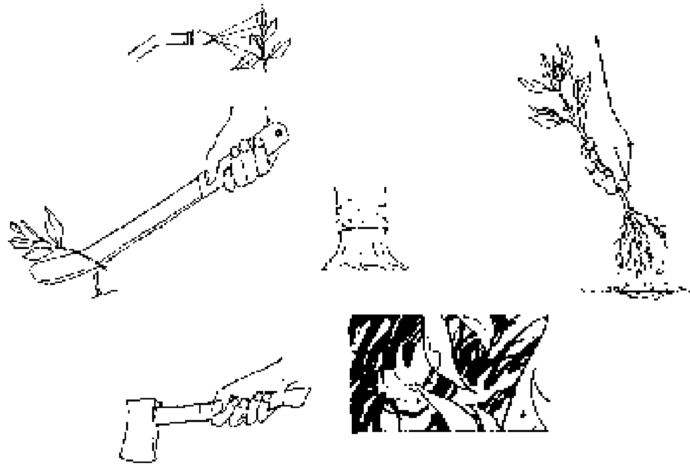
Application of herbicide to growth or regrowth (following pre-treatment or a previous treatment)

Cutting and/or grazing to deplete the nutrient reserves of the plant, which usually will then require several follow-up treatments.

Hand-pulling, particularly of young plants where the roots can be easily pulled out

Ring and strip-barking

Felling of treesBurning (see Section 4.1)



Always remember to conduct follow-up treatments. Many people fail to do this, which allows the alien plants to regrow and is a waste of the initial effort and money spent!

The importance of using herbicides with caution:

- Consider alternatives to herbicides (e.g. cutting and ring-barking)
- Use only chemicals with a toxicity rating of III (requires caution=table salt) or IV (not harmful);
- Do not use any chemical that is not clearly labelled
- Follow the guidelines on the label for safe and efficient application methods and storage
- When in doubt always consult an expert!

Effective alien plant control needs to be well co-ordinated and the responsibilities for carrying out different actions clearly defined. Some strategies that may be used to increase the level of support for the control of alien plants are:

- "Adopt a wetland" where an organization such as a scout group may assume responsibility for controlling alien plants in a particular area.
- Alien plant clean-up days, where, for example, an urban conservancy may organize a day where volunteers clear alien plants in collaboration with the local authority, who may provide expertise and equipment.
- Programmes such as the Working for Water Programme (see Part 2, Section 5) which may potentially fund local, unemployed people to clear alien plants.

For more advice refer to WETLAND-FIX Part 6 (Wyatt, 1993)Alien plant control guide or consult the Plant Protection Institute (012-8080364; 0331-3559100).

4.9 Spring protection

Springs refer to localized areas where groundwater is discharging to the surface (sometimes referred to as the eye of the stream). If a spring needs to be rehabilitated as a result of erosion or modified to allow for the improved collection and storage of water then see WETLAND-FIX Part 4 (Wyatt, 1993). It must be remembered that the modification of a spring may alter its ecological character (e.g. it may cause the loss of a Red Data species) and therefor the impact that this modification needs to be assessed (See Section 3). If a spring is a favoured drinking area for cattle, in addition to providing an alternative drinking area it may also be necessary to exclude cattle by fencing off the spring.

4.10 Infilling

Infilling of a wetland involves the dumping of soil or solid waste onto the wetland surface. Infilling generally has a very high and permanent impact on wetland functioning, and a full assessment of the impact and application to the relevant authorities is required by law. The impacts of infilling are similar to drainage in that the upper soil layers are rendered less wet, usually so much so that the area no longer functions as a wetland. Flow patterns in the wetland are altered and the natural vegetation is lost. Factors to consider in minimizing impacts of infilling include:

- Avoid unnecessary disturbance and compaction of the surrounding area
- Minimize the change in flow patterns within the wetland
- Control invasion of alien plants, which generally increase rapidly in disturbed areas (see Section 4.8).

4.11 Mining (excavation)

Mining is generally one of the most destructive land-uses applied to wetlands, certainly in the short term, and an assessment of the environmental impact and approval by the relevant authorities are obviously required. Two very important issues are the manner of mining and rehabilitation following excavation. Some general factors to consider in minimizing the impact of mining include:

- Avoid unnecessary disturbance and compaction of the surrounding area
- Set aside the upper soil layer (preferably more than 50 cm) with vegetation material included
- Restore the original flow patterns in the wetland as closely as possible
- Re-establish indigenous vegetation, which will be considerably easier if the upper soil layers are set aside
- See also Section 4.7 dealing with rehabilitation
- Control alien plants, which are prone to increase rapidly in disturbed areas (see Section 4.8)

The main forms of mining that take place within wetlands are sand-winning and peat mining. For peat mining, contact the Directorate of Agricultural Resource Conservation (012-3196000) to obtain the manual and proforma for the drafting of an "Operational and rehabilitation plan for the cultivation of a vlei for the purpose of harvesting peat". The manual provides detailed guidelines. See Directorate of Agricultural Resource Conservation (1995; 1996) in the References in Section 6. It is important to stress, however, that peat is not a renewable resource like wood. It forms over very long periods and a peatland can only return to its original state if left for hundreds or even thousands of years (Grundling and Dada, 1999). Peat extraction drastically reduces the water storage and filtering properties of wetlands. Thus, the negative impacts of peat extraction are enormous and last for generations (Grundling and Dada, 1999). Peat, which is used in the horticultural and mushroom industries, can be substituted with numerous viable alternatives, and Grundling and Dada (1999) emphasise that extraction in South African peatlands cannot be sustained ecologically or economically.

For sand-winning, which also has the potential to have an extremely high impact on a wetland, contact the Department of Minerals and Energy (012-3179000) to obtain the document "Impact assessment and management programme for sand-winning".

4.12 Roads, including bridges and culverts

Road crossings may greatly modify local water flow patterns in wetlands, and the building of structures in a wetland requires that, by law, application be made to the relevant authority. In addition to having a damming or draining effect on the flow upstream of the road, causeways and culverts often concentrate water flow downstream and increase its flow energy. This will not only dry out the area out but often also results in serious gully erosion, detracting from the ecological and hydrological values of the wetland. Unless the road is raised above the wetland, there will obviously be complete destruction of all habitat and associated functions and values in the areas directly in the road path. In the areas adjacent to the road, the following additional impacts are anticipated:

- Direct interference in the movement of animals, including the mortality of animals crossing the road;
- Disturbance of animals, particularly large birds such as cranes which may breed in the wetland;
- A source of pollutants washing off the road, particularly from roads which carry many vehicles

In addition to referring to the recommendations for minimizing the impacts of infilling, which are directly applicable to roads, also consider the following:

- Seek an alternative route
- Ensure that causeways have minimal disruption to flow patterns, both upstream and downstream of the crossing.

Adequate culverts are required so as to have minimal impact on water flow patterns through the wetland.
- Manage runoff from roads, which may be a potential source of pollution.

For more information contact your provincial Department of Environmental Affairs.

4.13 Infrastructure

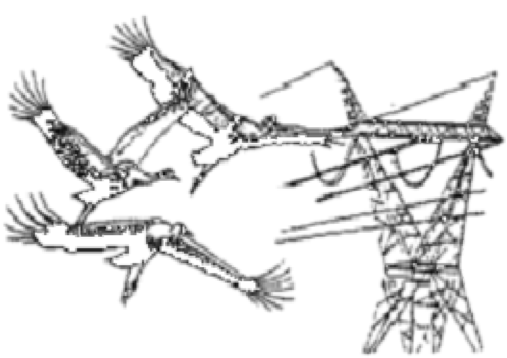
Wetland soils generally present problems for construction, particularly in the case of soils with shrink-swell clays (i.e. Rensburg form and, to a lesser extent, the Willowbrook form, which are commonly found in wetlands) and soils prone to subsidence (i.e. soils with high organic matter levels or high ***n* Values**). Many wetland areas are also subject to flooding, placing buildings and lives at risk. Furthermore, the construction of infrastructure in wetlands generally requires either drainage or infilling and obviously the total replacement of indigenous vegetation at the building site and often much further away. Thus, only under very exceptional circumstances, where there is no possible alternative site, should wetlands be used as construction sites and this would obviously require a full assessment of impact and approval by the relevant authorities. Such situations are most likely to arise in urban areas, where space is limited. In addition to the general regulations relevant to wetlands, the requirements of the local town planning ordinances also need to be met.

In order to minimize the impact of construction on the wetland:

- See Section 4.9 dealing with infilling
- Avoid unnecessary destruction of wetland areas alongside any buildings. This can be achieved by maintaining these wetland areas as attractive features and including innovative building features such as buildings on stilts and the use of board walks.
- Pit latrines should under no circumstances be within or adjacent to a wetland

4.14 Powerlines

The company responsible for electrical power provision in South Africa is Eskom. In terms of the Eskom guideline for environmental legislation, issued by the Distribution Engineer Manager, damage to wetlands both on farmland and elsewhere (e.g. conservation areas) is prohibited. See Section 4.13 giving recommendations on infrastructure in wetlands.



Besides the direct disturbance that pylons may have on a wetland, powerlines within and near to wetlands pose a particular threat to large wetland dependent birds (notably cranes) that may fly into the powerlines. Any incidents of bird mortalities on powerlines or any other interactions between birds and electricity infrastructure can be reported to the Eskom/Endangered Wildlife Trust Partnership at 0800111535 or by e-mail to Chris van Rooyen at EWT (chrisewt@global.co.za). Eskom and EWT will be able to investigate the incident and take action to try and prevent the incident re-occurring (e.g. modifying the transformer).

4.15 Ecotourism

Ecotourism is by definition a low impact, culturally sensitive land-use with the potential for generating income for local people. However, it is only be feasible at a wetland with a reasonable tourist potential; and should be conducted in an appropriate manner. In order to determine the tourism potential of a wetland and its surrounding area consider the following:

- Does the wetland have reasonable access?
- Does the wetland provide attractive scenery, including a diversity of colours and textures, preferably with some interspersed water?
- Is there a diversity and abundance of wildlife?
- Are there other features of interest (e.g. cultural and historical)?
- Does the wetland fall within a general area with a reasonable tourism potential?

- Is there existing infrastructure?

To ensure that ecotourism operations are carried out in an appropriate way make sure that:

- All developments have low environmental impact.

  * If infrastructure, such as a hide, is specifically required in the wetland it should have minimal hydrological impact (e.g. by building it on stilts (see Section 4.13). An assessment of the impact of such infrastructure would obviously be required (see Section 3).

  * All other infrastructure and roads should be located outside of the wetland or any other sensitive natural areas. (See section 3 & 4.11 and 4.12)

  * Any sanitation system would need to account for the fact that wetlands are characterized by high watertables, which are areas considered unsuitable for pit latrines

  * Disturbance of animals by human presence should be minimized. Certain species may be vulnerable to disturbance caused by human presence, particularly during breeding season (e.g. wattled crane). Thus, it may be necessary to implement control measures such as restricting access during these times (contact your provincial nature conservation office).

- Any infrastructural or other developments should have low visual impact
- The local economy is supported (e.g. where ever possible employ local people (e.g. as guides, caterers or builders).
- There is meaningful involvement of local people and sensitivity to their culture
- Local skills are harnessed and there is provision for the transfer of skills.

Usually one of the greatest attractions of wetlands for tourists are the bird-watching opportunities that the wetland provides. Threatened species are a particular asset because of their rareness value. With this in mind there are several management actions that can be undertaken (e.g. maintenance of mudbanks for waders and managing burning and grazing [see Section 4.1 & 4.2]) to attract a diversity and abundance of birds. There are also several actions that can be conducted to optimize the visitors' bird watching experience (e.g. erection of hides, creation of trails and the production of resource material).

For further information and advice contact your provincial nature conservation organization, existing ecotourism operators in the general area and SATOUR. (012-3056693). Much can be learnt for existing ventures (see Box 6).

Box 6 Wakkerstroom: an example of wetland ecotourism

The Wakkerstroom vlei lies next to the small town of Wakkerstroom in the upper Tugela catchment. It supports numerous breeding pairs of crowned crane and many other bird species, notably the white-winged flufftail, one of Africa's rarest birds. Most of the wetland is owned by the Wakkerstroom municipality and leased out for grazing, which, together with ecotourism, is one of the main direct uses of the wetland.

The Wakkerstroom Natural Heritage Association (WNHA), which was founded in 1991 and has many local people, gained a 10 year lease of the wetland, commencing in July 1992. Information on the wetland and its use and management was gathered and management guidelines drawn up in consultation with the primary users of the wetland. The overall management goal for the wetland is the **sustainable use** of the wetland while maintaining its functioning and the benefits it provides to local people and society. Through the work of the WNHA and the co-operation of the local people in controlling such aspects as grazing, burning and illegal hunting of birds, the functioning of the wetland and its value for eco-tourism is being assured. The town now has several guesthouses and bed and breakfast facilities, and the wetland and its associated birdlife is one of the key attractions for visiting tourists. Interest in the WNHA has continued, as measured by the increasing annual membership and volunteer time is provided by several key members of the WNHA. Contact: Warwick Tarboton, 014-7431438.

4.16 Hunting and fishing

With the exception of some wetlands such as the Pongola Floodplain, the fish stocks of most palustrine wetlands in South Africa are generally low. Although this can be increased through the construction of dams and introduction of species, these actions may have severe impacts on the wetland. If a dam is considered then its impact, which is often great, should also be assessed (see Section 3). The introduction of fish into drainage systems where they did not previously occur, may negatively affect the indigenous species through predation and competition for space and food. This may cause the loss of Red Data species if present. In addition, indigenous species should not be moved between different drainage systems as they may be genetically different and this will reduce the genetic diversity of the species. Thus , it is important that by law application must be made to the Provincial Nature Conservation Department before any species are moved or introduced.

Although the potential for hunting wildfowl is relatively low for many palustrine wetlands in South Africa, the harvesting of waterfowl on a sustainable basis may be viable for some of the commoner species such as spur-winged goose. Many wetlands support southern Reedbuck, which can readily be hunted on sustainable basis. The Provincial Nature Conservation Department should be contacted for further information and to obtain the necessary approval.

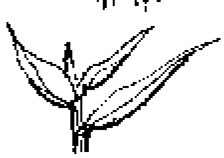
4.17 Harvesting of medicinal plants

A wide range of plants are harvested for medicinal purposes. Although little is understood about the details of exactly how harvesting affects populations of particular species, it is well known that harvesting can have very severe impacts. The harvesting of particular plant parts may have potentially much greater impacts than harvesting others (e.g. the harvesting of bulbs generally has greater impact than harvesting of leaves, which usually regrow more readily). Some very general guidelines for the harvesting of different general types of plant parts should be followed:

Bark. Never take more than 1/10 of the bark and always harvest the bark from side branches rather than the main trunk, particularly near its base where extensive harvesting may cause the tree to be ring-barked and die.

Rhizomes, tubers and bulbs. Never take more than 1/4 of the material in an area in a particular year

Leaves If only young leaves are harvested then never take more than 1/3 of the young leaves; and if mature leaves are harvested then never take more then ½ of the leaves in a particular year (See Section 4.5).



In the case of all the different plant parts, if the supply of the plant resource is decreasing in a particular area then harvesting should be stopped until it recovers. Also, it is preferable to grow indigenous plants and use the wild plants for replenishing the supply of cultivated plants. This applies particularly to slow growing species. For more information regarding the collection of medicinal plants, particularly those which are protected, contact your Provincial Nature Conservation Organization. See also "Growing indigenous medicinal plants" by Mander *et al.* 1995.

4.18 Forestry and sugar cane plantations

Sugar cane is a commercial crop with high levels of artificial fertilizer application and a tolerance to waterlogging which is medium to low. The planting of sugar cane in wetlands is not considered generally acceptable, particularly where drainage channels are used because of the impact on the hydrological benefits of wetlands. Both forest plantations and sugar cane within wetlands also greatly reduce the value of the habitat that wetlands provide for wetland dependent species. Thus, this crop should preferably be withdrawn from wetland areas. If, however, sugar cane plantations which are legally in wetlands are to be retained, see the recommendations given for planted pastures (Section 4.3). For more information contact the SA Sugar Association, (031) 3056161.

Regulations governing plantations and wetlands are contained in the Forest Act, and for further information on forestry management see "Guidelines for environmental conservation management in commercial forests in South Africa" by the Forestry Industry Environmental Committee (1995). According to the Forest Act, forest plantations in wetlands are not considered acceptable because of the high water use of trees. Forest plantations within wetlands often have high alien plant infestations (see Section 4.8) which further adds to the impact of afforestation in wetlands. Serious consideration should be given to withdrawing forest plantations from within all wetlands.

4.19 Wastewater treatment

As indicated in Table 2 and the WETLAND-USE Booklet 1, wetlands perform a very useful function in purifying water. The use of wetlands to treat wastewater may, however, reduce other benefits provided by the wetland, particularly if inputs are high and exceed the wetland's capacity for assimilation. It is very important to emphasise that wetlands should not be regarded as substitutes for water treatment. If a natural wetland in a water course is to be used for purification, the effluent entering it must comply with the water quality standards set by the Department of Water Affairs and Forestry for that particular catchment. If this is not the case then constructed wetlands may assist in the purification of poor quality effluent, but the quality of the water leaving these systems and entering the streamcourse must, again, comply with the relevant Water Quality standards. Two key questions need to be addressed when examining the use of wetlands for wastewater treatment:

1. What is the wetland's capacity to assimilate the pollutants it will be receiving?

2. How will use of the wetland for wastewater treatment impact the wetland and the other benefits that it provides?

The wetland's capacity to assimilate pollutants

The capacity of a wetland to improve water quality is difficult to predict and will depend on the particular pollutants and the nature of the wetland. A specialist should therefor be consulted if a wetland is to be used for wastewater treatment. Some general features that enhance the capacity of wetlands for improving water quality that would need to be considered in assessing the effectiveness of a particular wetland, include:

- Flow patterns in the wetland. Diffuse flow (where flow is spread evenly across the wetland) is more effective than channel flow (where flow is largely confined to a small portion of the wetland).
- Factors which slow down the flow of water, notably a gradual slope and the resistance offered by wetland vegetation, which results in water being retained in the wetland for longer periods and suspended particles being more readily deposited.
- Contact between water and sediments (with diffuse flow and shallow water leading to high levels of sediment/soil-water exchanges).
- A variety of anaerobic and **aerobic** processes, such as denitrification and chemical precipitation, that remove pollutants from the water;
- The high plant productivity of many wetlands, with high productivity leading to high rates of mineral uptake by vegetation.
- High soil organic matter contents (accumulated primarily as a result of anaerobic conditions) which favours the retention of elements such as heavy metals.
- Microbial **decomposition** of certain organic substances (such as those introduced through sewage addition). Wetland plants provide substantial surface area for the attachment of microbes, both above-ground and below-ground due to the aerobic rhizosphere around the roots.

Impacts of wastewater inputs

Assessing the impacts of particular wastewater inputs is extremely complex and again specialist input will often be required to do so. Some of the general impacts commonly associated with particular groups of pollutants are given below.

Nutrient enriched effluents. The ability of different plant species to respond to enriched nutrients varies, with the result that species composition may change drastically, eventually comprising a few dominant species, such as *Typha latifolia* that have a high ability to respond. The increased plant production may result in increased decaying plant material which would increase the Biological oxygen demand (BOD) and this in turn may have severe impacts on aquatic life.

Suspended sediment. Accumulating sediment may change the flow patterns in the wetland, decreasing the extent of diffuse flow. In addition, other pollutants attached to the sediment would be introduced along with the sediment.

Acid and saline deposits. Most of these substances affect the physiological functioning of plants and animals and may have extremely severe impacts. Tolerance levels vary greatly among species, which makes setting an acceptable water quality standard for acidity and salinity levels difficult. Increased acidity may also cause toxic effects from certain metals such as mercury which, under acidic conditions, are soluble and extremely toxic to wetland biota. These heavy metals persist in the sediment indefinitely and may be released back into the water in response to a change in pH.

Biocides are specifically targeted at organisms and it is therefore inevitable that wetland biota will be negatively affected.

Pathogens. A number of bacteria and viruses are found in wastewater, particularly sewage effluent. Besides being effective at removing these, most wetlands are little affected by these pathogens.

For further information on the effectiveness of wetlands in treating wastewater and in predicting the likely impacts of wastewater on the wetland contact: A Batchelor, CSIR, (012) 8413461, and Dr N Kleynhans, Institute for Water Quality Studies, Department of Water Affairs and Forestry (DWAF), (012) 8080374. For information on the legal aspects of wastewater treatment contact your DWAF regional office (012-3387500; http://www-dwaf.pwv.gov.za).

4.20 Solid waste (litter)

Solid waste is a common problem associated with wetlands in urban areas. One of the primary impacts of solid waste is a reduction in the aesthetic appeal of the wetland. Try to find the source of the litter. It may be:

- far away from the wetland area and be carried there by stormwater drains;
- from local residents; or
- from people from elsewhere who use the wetland.

Look for ways to reduce the amount of litter at the source (e.g. by creating awareness and motivating for refuse bins). It may be difficult to control the source of the litter, and ongoing effort will be needed to clear the litter from the wetland. As is the case with alien plant control, it is useful to devise a litter control plan in which responsibilities are clearly defined. One of the most effective ways of clearing litter is to involve youth groups in litter clearing events. For advice and assistance contact the Institute of Waste Management (011-7823503/4) to see if your town has a local "keep clean association".

4.21 Water-associated parasitic disease control

The two primary diseases that are associated with wetlands in South Africa are bilharzia and malaria, both of which occur mainly in the sub-tropical parts of the country. Although there may be little that a wetland manager do about these diseases, factors affecting the occurrence of the disease would need to be considered as part of an integrated management system. In the case of both bilharzia and malaria, the disturbance of the wetland for development often provides ideal breeding places (e.g. in drainage channels) for these species. Thus, measures to prevent such practices may need to be taken. For more information on the individual diseases see Appleton *et al.* (1995) and contact your local health office to find out about any disease control programmes.

Bilharzia is particularly common amongst children who have contact with water.

SECTION 5, ASSUMPTIONS OF WETLAND-USE PART 1

5.1 Primary assumptions of IMPACT-ASSESS

1. The greater the cumulative loss of wetland, the greater will be the impact resulting from further loss. At a very general level this is well supported in the literature (e.g. Brinson, 1988; Preston and Bedford, 1988; Johnston, 1994). However, several different relationships between function and area may exist which would vary according to several factors, including the function examined and spatial configuration of the wetlands, and empirical evidence allowing for specific function-area relationships are largely lacking (Johnston, 1994).

2. The greater the alteration of flow patterns in the wetland, leading to a change in the wetland's hydrological regime, the greater will be the impact on all the wetland's indirect benefits. This is well supported in the literature as a general principle (e.g. Goode *et al.*, 1977; O'Brien, 1977; Lavesque, *et al.*, 1982; Brinson, 1988; Ingram, 1991). Again, the specific relationships are likely to depend on the nature of the particular site. For example, the relationship between level of drainage and the loss of value of a wetland for improving water quality is likely to vary according to the site and its context.

3. The greater the change in water quality the greater the greater the likelihood of impacts on wetland functioning. There is much literature showing the high level of impact a change in water quality may have on the functioning of a wetland (e.g. Coetzee, 1995; Ewel, 1997) but the impact is obviously very specific to the type of change (e.g. an increase in nitrates) and the nature of the wetland. A high nutrient input has been widely shown to generally decrease plant species diversity (Sather and Smith, 1984; Cooke *et al.*, 1990; Ehrenfield *et al.*, 1991; Ewel, 1997). High *E. coli* levels, however, generally have a lesser effect on wetland functioning (Coetzee, 1995).

4. The greater the extent to which the soil is disturbed, the greater will be the loss of water purification and erosion control values. This is general support for this assumption (e.g. Willrich and Smith, 1970; Miles and Manson, 1992). The ultimate effect will, however, obviously depend on several interacting factors, including the erodability of the soil on the wetland site (See Section 5.2).

5. The greater the extent to which soil organic matter levels are lowered, the greater will be the impact on the hydrological and erosion control values. There is support for this general assumption (e.g. Ingram, 1991; Miles and Manson, 1992) but, again, this will depend on the interacting factors affecting the above item.

6. The greater the reduction in surface roughness of the wetland, the greater will be the impact on the hydrological and erosion control values, because the wetland area will become less effective in slowing down the rate of water flow. This has been clearly shown in the literature (e.g. Reppert *et al.*, 1979; Adams *et al.*, 1987) as has the relation between detention time and wetland function (Kadlec and Kadlec, 1979; Hammer, 1992).

7. The greater the loss of indigenous vegetation, the greater will be the impact on the wetland's ecological (biotic diversity) value. This assumption is backed by the fact that the indigenous vegetation makes up a component of the biodiversity of wetland as well as forming a key component of the structure and functioning of wetlands (Mitsch and Gosselink, 1986).

8. The greater the extent to which wetland dependent species, particularly Red Data species are negatively affected, the greater will be the impact on biodiversity. Species make up an important, and readily measured, component of biodiversity (Noss, 1990) and Red Data species are those which have been identified as having a high priority from a species conservation point of view (see Breen and Begg, 1989).

5.2 Assumptions concerning the erosion hazard index and individual land-uses

* Erosion hazard index

The three most important (readily measured) parameters which relate to the wetland site and which influence the susceptibility of an area to erosion (resulting from use by stock) are: (a) soil erodability, (b) slope, and © landform.

The effect of soil erodability and slope on erosion susceptibility have been shown in the literature (e.g. Anon, 1976). However, the slope limits employed by WETLAND-USE are not based on findings in the literature but were arbitrarily chosen in consultation with soil conservation workers from the Department of Agriculture.

Little evidence has yet been found in the literature to support the assumption that landform has an important influence on susceptibility to erosion. However, this assumption is supported by empirical evidence from wetlands in KwaZulu/Natal (see Kotze 1999, Chapter 5). For example, wetlands in depression settings show less evidence of erosion than those in channel settings and the transition (i.e. the flow concentration zone) from non-channelled to channelled valley bottom areas has high incidence of gully erosion.

*** Burning**

1. Provided that the burning recommendations (given in Part 2) concerning burning timing, frequency and influences on burning behaviour are adhered to, burning usually enhances the habitat value of wetlands. Although there is a lack of reported work on the effect of burning, some studies have clearly demonstrated the general advantages of burning to wetland-dependent species (e.g. Vogl, 1973; Smith and Kadlec, 1985; Taylor, 1994; D Johnson, 1994. *Pers. comm.* KwaZulu-Natal Nature Conservation Services and B Taylor, 1994. *Pers comm.* Zoology Department, University of Natal, Pietermaritzburg; W Tarboton, 1994. *Pers. comm.* Nylstroom).

2. Burning every 2 to 3 years generally does not significantly detract from the ecological value of wetlands in the study area. This assumption is based on the fact that biennial burning has not been shown to be detrimental to any valued wetland-dependent species in the study area.(D Johnson,1994. *Pers. comm*. and B Taylor 1994. *Pers. comm*.). However, there are many species for which fire investigations have not been undertaken. Some of these species may well require a fire return frequency of more than 2 years.

3. When a wetland area is burnt, other wetland area/s nearby should be left unburnt to provide adequate cover for wetland-dependent species. No evidence in the literature was found for or against this assumption and it is based on the intuitive logic of species specialists (D Johnson,1994. *Pers. comm* .; B Taylor 1994. *Pers. comm.*; W Tarboton, 1994. *Pers. comm*.).

4. Late winter/early spring burning has the least impact on the ecological value of a wetland because it occurs when the fewest species are breeding. This is based on well-researched information on the life histories of wetland-dependent species, primarily birds.

5. Fire is an important cause of chick mortality in wattled cranes. This has been substantiated in the literature (Johnson and Barnes, 1991) and based on personal observation (McCann, 1998, *Pers. comm.*, Eskom/EWT National Crane Conservation Project, Mooi River).

6. Burning generally does not have a negative effect on the soil provided extensive sub-surface fires do not occur. This is supported by some literature findings (e.g. Schmulzer and Hinkle, 1992) and observation by fieldworkers with extensive experience in wetlands, notably J Wyatt (1998, *Pers. comm.* KwaZulu-Natal Nature Conservation Services, Congela, Durban).

7. Fire may be used to control alien plants effectively. Although published evidence for this is lacking, empirical evidence, obtained by making comparisons between unburnt and regularly burnt portions of numerous wetlands in South Africa, supports this assumption (Otter, 1992; Kotze and Breen, 1994).

8. From a water storage point of view, a late winter/early spring burn is preferable to an early winter burn because the wetland is left exposed (due to removal of standing dead material) for a shorter period. As such, evaporative loss is lower. This is supported by the study of Donkin *et al.* (1993) which show that evapo-transpirative loss of water from wetlands with standing dead material is less than loss from open water.

*** Grazing**

1. The grazing capacity of wet areas are generally at least 1.5 times greater than the Department of Agriculture's recommendations for non-wetland areas. This is based on information gathered from isolated wetlands, notably Blood River in KwaZulu-Natal and Memelvlei in the Free Sate (Oellermann, 1994), and may need to be modified when further research has been conducted.

2. If the veld condition in temporarily wet areas is poor, the stocking rate should be decreased to account for the lower production potential, and to allow the veld to recover. It has been shown for non-wetland areas that veld in poor condition has a lower grazing potential than veld in good condition (Edwards and Tainton, 1981). Although this is assumed to hold true for wetland areas as well, no such studies have been undertaken in wetlands. There is also no published support for the arbitrarily chosen reduction factors to account for veld condition. These were chosen in consultation with N M Tainton, a grazing specialist, Grassland Science Department, University of Natal.

3. Wetlands should be rotationally grazed. There is some published support for the merits of rotational grazing for natural non-wetland areas in South Africa (e.g. Anon, 1951). It is also widely recommended by veld management specialists (e.g. Edwards and Tainton, 1981). Although no studies of rotational grazing in wetlands have been undertaken, it is assumed that the results obtained from non-wetland areas are applicable, particularly to temporarily wet areas. Rotational grazing also allows greater flexibility in the grazing system (e.g. to exclude wetlands areas when conditions are unfavourable and have reserve grazing during drought periods).

4. Animals should be moved out of rotationally grazed wetland before it has been grazed to a specified height. Even for non-wetlands there is little literature to support a specific prescribed level of use as this is affected by numerous variables (e.g. climatic variation). However, the specified height given in WETLAND-USE was based on the recommendations of a grazing specialist Prof. N M Tainton. It is assumed that grazing beyond the prescribed level is likely to begin detracting from the hydrological, ecological and production potential benefits of an area.

5. Grazing wetland areas when the soil is wet is more likely to result in erosion and/or compaction than grazing when the soil is dry. This assumption is based on a report by Wilkins and Garwood (1986).

*** Hay making/mowing**

1. Cutting of natural vegetation does not significantly detract from the ecological value of wetlands provided that not more than 30% of any wetness zone in a wetland is cut in a given year if the wetland is being grazed and not more than 50% of any wetness zone if the wetland is not being used for grazing. There is little research available concerning the effect of hay cutting on wetland fauna. Although there are a number of European studies (e.g. Bakker, 1989) which show that cutting enhances plant species diversity, and indications that it has a short term negative effect on fauna by reducing cover (Bryan and Best, 1991; Tarboton, 1994. *Pers. comm.*) there are no local studies and the 30% and 50% thresholds were arbitrarily chosen based on the assumption that in a grazed area the cover would have already been partly reduced.

2. Cutting with machinery when the soil is wet is more likely to result in soil erosion than cutting when the soil is dry. (see Grazing Assumption 5).

*** Pasture production**

1. Perennial species are preferable to annuals because they require that the soil be disturbed less frequently. This assumption is supported by the fact that soil disturbance has negative effects such as organic matter depletion and increased susceptibility to erosion (Miles and Manson, 1992).

2. Species with a high wetness tolerance are preferable to those with a low wetness tolerance because they require less lowering of the water table. See the reasoning for Primary assumption 1.

3. Intensive pastures, particularly those in drainage lines, may contribute to a deterioration in the quality of runoff waters. This general assumption is well supported (e.g. Amberger, 1983; Canter, 1986; and Miles and Manson, 1992). However, it is important to note that the effect of intensive pastures depends on several variables (e.g. fertilizer application rates and soil type), and may be negligible.

4. Measures should be taken to minimize fertilizer leaching losses from planted pastures. The measures recommended by WETLAND-USE for minimizing leaching losses from pastures are based primarily on those recommended by Amberger (1983) and also on those of Miles and Manson (1992).

*** Mechanized crop production**

1. Crop production is generally considered to have one of the severest agricultural impacts on wetlands. The high impact associated with wetland drainage and conversion to cropland has been well demonstrated (e.g. Willrich and Smith, 1970).

2. The recommendations and associated assumptions concerning minimizing drainage requirements and nutrient leaching from planted pastures are also applicable to crops.

3. Ley cropping should be implemented to reduce the impact. The benefits (e.g. reduced organic matter depletion) that accrue from ley cropping have been clearly demonstrated (Wardle, 1961; Lockhart and Wiseman, 1988).

*** Traditional crop production**

The impacts of traditional cultivation are considered to be lower than commercial cultivation based on observations at KwaZulu-Natal wetlands (see Kotze, 1999) and evidence presented by Whitlow (1991) and Dadnadji and van Wetten (1993). For this to be so, however, It is assumed that in traditionally cultivated areas:

- The crops grown are tolerant of waterlogging, minimizing the need to alter the water regime.
- Tillage and harvesting is by hand, which results in less disturbance, and hence potential erosion, than with mechanical tillage and harvesting.
- Pesticides and artificial fertilizers are not used, reducing the impact on water quality.
- Mineral soils are cultivated, with some of the soils in areas where sediment from excessive erosion in the uplands has recently been deposited, and thus cultivation does not lead to extensive depletion of soil organic matter as would be the case in cultivated organic soils.
- areas cultivated are shifted from year to year, with most individual patches being continuously cultivated for less than 4 years compared with large-scale cultivation where areas are continuously cultivated and not shifted;
- The spatial configuration of areas cultivated is generally in the form of small isolated areas rather than larger consolidated areas
- Areas with moderate or high erosion hazards are avoided (see Descriptor F12).

If these assumptions are not met then the impacts are likely to be closer to those associated with commercial cultivation.

*** Damming**

Dams generally have a negative effect on the habitat in the area which it floods and often also on downstream habitats as a result of altered flow regimes. The loss of habitat that follows flooding by dams and the negative effect that dams have on the downstream biota due to the altered flow regime are well documented (e.g. Davies and Day, 1986; Bruwer and Ashton, 1989; and Conley, 1992). The decreased runoff that results from evaporation from dams has been shown (Schulze *et al.*, 1989).

SECTION 6, REFERENCES

ACOCKS J P, 1953. Veld types of South Africa. *Memoirs of the Botanical Survey of South Africa* 28: 1-128.

ADAMUS P R, CLARAIN E J, SMITH R D, and YOUNG R E. 1987. *Wetland evaluation technique (WET).* US Army Corps of Engineers, Vicksburg, MS. Tech. Rep. T-87.

AMBERGER D, 1983. Ways to control the availability, turnover and losses of mineral fertilizer N in soils. United Nations Economic Commission for Europe. *Developments in Plant and Soil Sciences* 10: 145-169.

ANON., 1951. Pasture research in Southern Africa. *Progress Report.* Division Agric. Education and Extension, Department of Agriculture, South Africa.

ANON., 1976. Soil loss estimator for southern Africa. *Bulletin of the Natal Agricultural Research Institute, Agricultural Technical Services Department, Pietermaritzburg. No. 7.*

APPLETON C C, SHARP B L, LE SUEUR D, 1995. Wetlands and water-related parasitic diseases of man in southern Africa. In: COWAN G I (ed.) *Wetlands of South Africa.* Department of Environmental Affairs and Tourism, Pretoria.

BAKKER J P, 1989. *Nature management by grazing and cutting.* Kluwer Academic Publishers, Dordrecht.

BEGG G W, 1988. The wetlands of Natal (Part 2): The distribution extent and status of wetlands in the Mfolozi catchment. *Natal Town and Regional Planning Report 71.*

BREEN C M, and BEGG G W, 1989. Conservation status of southern African wetlands. In HUNTLEY B J, (ed.) *Biotic diversity in southern Africa: concepts of conservation.* Oxford University Press, Cape Town.

BRINSON M M, 1988. Strategies for assessing the cumulative effects of wetland alteration on water quality. *Environmental Management* 12: 655-662.

BRUWER C A, and ASHTON P J, 1989. Flow modifying structures and their impacts on lotic ecosystems. In: FERRAR A A (ed.) Ecological flow requirements of South African rivers. South African National Scientific Programmes Report No. 162., CSIR, FRD, Pretoria.

BRYAN G G, and BEST L B, 1991. Bird Abundance and Species Richness in Grassed Waterways in Iowa Rowcrop fields. *American Midlands Naturalist* 125: 128-231.

CANTER L W, 1986. *Environmental Impacts of Agricultural Production Activities.* Lewis Publishers, Chelsea, Michigan.

COETZEE M A S, 1995, Water pollution in South Africa: its impact on wetland biota. In: COWAN G I (ed.) *Wetlands of South Africa.* Department of Environmental Affairs and Tourism, Pretoria.

CONLEY A H, 1992. The impact of flow modifying structures on aquatic ecosystems. In: Water Week Conference 17-19 August, 1992.

COOKE J G, COOPER A B, and CLUNIE N M U, 1990. Changes in the water, soil and vegetation of a wetland after a decade of recieving a sewage effluent. *New Zealand Journal of Ecology* 14: 37-47.

COWAN G I, 1995. Wetland Regions of South Africa. In: COWAN G I (ed.) Wetlands of South Africa. Department of Environmental Affairs and Tourism, Pretoria.

COWARDIN L M, CARTER V, GOLET FC, LAROE E T, 1979. Classification of wetlands and deepwater habitats of the United States. US Department of Interior, Fish and Wildlife Services Report FWS/UBS 79-31.

DADNADJI K D, and VAN WETTEN J C J, 1993. Traditional management systems and integration of small scale interventions in the Logone floodplains of Chad. In: DAVIS T J (ed.) Towards the wise use of wetlands. Wise Use Project, Ramsar Convention Bureau, Gland, Switzerland.

DAVIES B R, and DAY J A, 1986. *The biology and conservation of South Africa's vanishing waters.* The Centre for Extra-mural Studies, University of Cape Town.

DEA, 1992. The integrated environmental management procedure. Department of Environmental Affairs, Pretoria.

DEAT, 1998a. Environmental Impact Managment: EIA Regulations guideline document for implementation of Sections 21, 22 and 26 of the Environment Conservation Act. Department of Environmental Affairs and Tourism, Pretoria.

DEAT, 1998b. Environmental Impact Managment: A national strategy for Integrated Environmental Managment in South Africa - Discussion document. Department of Environmental Affairs and Tourism, Pretoria.

DEAT, 1998c. South African National Wetland Inventory: Catalogue of inventories. South African Wetlands Conservation Programme, Department of Environmental Affairs and Tourism, Pretoria.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY, 1987. Pasture Production in Natal. Bulletin 414. Directorate of Agricultural Information, Pretoria.

DIRECTORATE OF AGRICULTURAL RESOURCE CONSERVATION, 1995. Manual for the drafting of an operational and rehabilitation plan for the cultivation of a vlei for the purpose of harvesting peat

DIRECTORATE OF AGRICULTURAL RESOURCE CONSERVATION, 1996. Operational and rehabilitation plan for the cultivation of a vlei for the purpose of harvesting peat

DONKIN A D, SMITHERS J C, and LORENTZ S A, 1993 Direct estimation of total evaporation from wetlands: initial results. In: LORENTZ S A, KIENZLE S W, and DENT M C, 1993. Proceedings of the 6th South African National Hydrological Symposium, 8-10 September. University of Natal, Pietermaritzburg.

DWAF, 1994. *Quaternary catchments*. Department of Water Affairs and Forestry, Pretoria.

EHRENFIELD J G, and SCHNEIDER J P, 1991. *Chamaecyparis thyoides* wetlands and suburbanization effects on hydrology, water quality and plant community composition. *Journal of Applied Ecology* 28: 467-490.

EWEL K C, 1997. Water quality inprovement by wetlands. In: DAILY G C (ed.) *Nature's services: societal dependence on natural ecosystems.* Island Press, Washington.

FORESTRY INDUSTRY ENVIRONMENTAL COMMITTEE, 1995. *Guidelines for environmental conservation management in commercial forests in South Africa.* Linotek, Pretoria.

GIBBS RUSSELL G E, WATSON L, KOEKEMOER M, SMOOK L, BARKER N P, ANDERSON H M, DALLWITZ M J, 1991. Grasses of southern Africa. Memoirs of the Botanical Survey of South Africa No. 58, National Botanical Gardens, Botanical Research Institute.

GOODE D A, MARSAN A A , and MICHAUD J R, 1977. Water resources. In: RADFORTH and BRAWNER, (eds.) *Muskeg and the northern environment in Canada*. University of Toronto Press, Toronto.

GORDON-GRAY K D, 1995. Cyperaceae in Natal. National Botanical Institute, Pretoria.

GRUNDLING P L, and DADA R, 1999. Peatlands of South Africa. SHARE-NET, Wildlife and Environment Society of South Africa, Howick.

HAMMER D A, 1992. *Creating freshwater wetlands.* Lewis Publishers, Baco Raton.

INGRAM J, 1991. *Wetlands in drylands: the agroecology of savanna systems in Africa. Part 2: Soil and water processes.* International Institute for Environment and Development, Drylands Programme.

JOHNSON D N, and BARNES P R, 1991. The breeding biology of the Wattled Crane in Natal. *Proceedings of the 1987 International Crane Workshop. Quiqihar, China.* 377-385.

JOHNSTON C A, 1994. Cumulative impacts to wetlands. Wetlands 14: 49-55.

KADLEC R H, and KADLEC JA, 1979. Wetlands and water quality. In: GREESON P E, CLARK J R, and CLARK J E, (eds.) *Wetland functions and values: the state of our understanding.* American Water Resources Association, Minneapolis.

KOTZE D C 1997a. *Wetlands and people: what values do wetlands have for us and how are these values affected by our land-use activities? WETLAND-USE Booklet 1.* SHARE-NET, Wildlife and Environment Society of South Africa, Howick.

KOTZE D C 1997b. *How wet is a wetland? An introduction to understanding wetland hydrology, soils and landforms, WWELAND-USE Booklet 2.* SHARE-NET, Wildlife and Environment Society of South Africa, Howick.

KOTZE D C, 1999. A system for supporting wetland management decisions. Ph.D. thesis (submitted). School of Applied Environmental Sciences, University of Natal, Pietermaritzburg.

KOTZE D C, and BREEN C M, 1994. *Agricultural land-use impacts on wetland functional values.* WRC Report No 501/3/94, Water Research Commission, Pretoria.

KOTZE D C, BREEN C M, and KLUG J, 1994. WETLAND-USE, *a wetland management decision support system for the KwaZulu/Natal Midlands.* WRC Report No 501/2/94, Water Research Commission, Pretoria.

KOTZE D C, KLUG J R, HUGHES J C, and BREEN C M, 1996. Improved criteria for classifying hydric soils in South Africa. *S. Afr. Plant Soil* 13: 67-73.

KUSLER J A, QUAMMEN M L, and BROOKES G (eds.), 1988. Proceedings of the national wetlands symposium: Mitigation of impacts and losses. 8-10 October 1986, New Orleans, Louisiana. Association of State Wetland Managers, Berne, New York. Technical report 3.

LAND TYPE SURVEY STAFF, 1986. Land types of the map 2730 Vryheid. *Memoirs of the Agricultural Natural Resources of South Africa No. 7.*

LA ROE E T, 1986. Wetland habitat mitigation: an historical overview. *National Wetlands Newsletter* 8: 8-10

LAVESQUE M P, MARTHUR S P, and RICHARD P J H, 1982. A study of physical and chemical changes in a cultivated organic soil based on palynological synchronization of subsurface layers. *Naturaliste Canada* 109: 181-187.

LOCKHART J A R, and WISEMAN A J L, 1988. Introduction to Crop Husbandry, 6th. edition. Pergamon Press, Oxford.

LOW A, and ROBELO A G, (eds.) 1996. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

MACDONALD C I, 1991. Irrigation of pastures. In: Pastures in Natal, compiled by the Natal Region of the Department of Agricultural Development on behalf of the Co-ordinated Extension Committee of Natal.

MANDER M, HEINSOHN D, and MANDER J, 1996. *How to grow Incema grass.* SHARE-NET, Howick.

MANDER M, MANDER J, CROUCH N, McKEAN S, and NICHOLS G, 1995. *Catchment action: growing and knowing muthi plants.* SHARE-NET, Howick.

MILES N, and BARTHOLOMEW P E, 1991. Nitrogen for pastures. In: Pastures in Natal, compiled by the Natal Region of the Department of Agricultural Development on behalf of the Co-ordinated Extension Committee of Natal.

MILES N, and MANSON A D, 1992. Considerations on the sustainability and environmental impacts of intensive pastures. *Journal of the Grassland Society of Southern Africa* 9: 135-140.

MITSCH W J, and GOSSELINK J G, 1986. Wetlands. Van Nostrand Reinhold, New York.

NOSS R F, 1990. Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology* 4: 355-364.

OBERMEYER A A, 1985. Juncaceae. Flora of South Africa Volume 4: Part 2, Xyridaceae-Juncaceae. Botanical Research Institute.

O'BRIEN A L, 1977. Hydrology of two small water basins in eastern Massachusetts. *Water Resources Bulletin* 13: 325-340.

OELLERMANN R G, 1994. *Economic valuation, and assessment of management practices applied to, selected wetlands in South Africa.* Msc. thesis, Department of Grassland Science, University of Natal, Pietermaritzburg.

OTTER L B, 1992. *Effects of fire on a floodplain grassland.* Honours thesis, Department of Botany, University of the Witwatersrand, Johannesburg. Unpublished.

PITMAN W C, MIDDLETON B J, and MIDGLEY D C, 1981. Surface Water Resources of South Africa (Vol.6). Hydrological Research Unit Report No. 9/81.

PONS L J, and ZONNEVELD I S, 1965. Soil ripening and soil classification. Initial classification of soils in alluvial deposits and a classification of the resulting soils. *Int. Inst. Land Reclam. And Impr. Pub. 13.* Wageningen, The Netherlands.

POOLEY E, 1998. A field guide to wild flowers, KwaZulu-Natal and the eastern region. Natal Flora Publications Trust, Durban.

PRESTON E M, and BEDFORD B L, 1988. Evaluating Cumulative Effects on Wetland Functions: A Conceptual Overview and Generic Framework. *Environmental Management* 12(5): 565-583.

REPPERT R T, SIGLEO W, SRACKHIV E, MESSMAN L, and MEYERS C, 1979. Wetland values: concepts and methods for wetlands evaluation. IWR Res. Rep. 79-R-1, U.S. Army Corps Engrs., Fort Belvoir, VA.

SATHER J H, and SMITH R D, 1984. *An overview of major wetland functions and values*. Fish and Wildlife Service, United States Department of the Interior, Washington.

SCHMULZER P A, and HINKLE C R, 1992. Soil dynamics following fire in *Juncus* and *Spartina* marshes. *Wetlands* 12: 8-21.

SCHULZE R E, 1997. *South African Atlas of Agrohydrology and -Climatology.* Water Research Commission, Pretoria, Report TT82/96.

SCHULZE R E, LYNCH S D, ANGUS, G R, and GEORGE W J, 1989. ACRU: User Manual. University of Natal, Pietermaritzburg, Department of Agricultural Engineering. *ACRU Report* 36.

SCOTNEY D M, 1970. *Soil and land-use planning in the Howick extension area*. Ph.D. thesis, University of Natal, Pietermaritzburg. Unpublished.

SMITH L M, and KADLEC J A, 1985. Fire and herbivory in a Great Salt Lake Marsh. *Ecology* 66: 259-265.

SOIL CLASSIFICATION WORKING GROUP, 1991. Soil classification: a taxonomic system for South Africa. *Memoirs on the Agricultural Natural Resources of South Africa No. 15.* SIRI, D.A.T.S., Pretoria.

SOIL SURVEY STAFF, 1992. Keys to Soil Taxonomy. *SMSS technical monograph no.19, 5th edition. Pocahontas Press, Inc.* Blacksburg, Virginia.

STEWART T J, JOURBERT A, SCOTT L, and LOW T, 1997. Multiple criteria decision analysis: procedures for consensus seeking in natural resources managment. WRC Report No. 512/1/97.

TAINTON N M, EDWARDS P J, and MENTIS M T, 1980. A revised method for assessing veld condition. *Proceedings of the Grassland Society of southern Africa* 15: 37-42.

TAYLOR P B, 1994. The biology, ecology and conservation of four flufftail species, *Sarothrura* (Aves: Rallidae). PhD thesis, University of Natal, Pietermaritzburg.

US ARMY CORPS OF ENGINEERS, 1988. *The Minnesota Wetland Evaluation Methodology For The North Central United States, First Edition.* Minnesota Wetland Evaluation Methodology Task Force and Corps of Engineers, St. Paul District.

VOGL R J, 1973. Effects of fire on the plants and animals of a Florida wetland. *American Midlands Naturalist* 89: 334-347.

WARDLE G J F, 1961. *Ley studies.* M. Sc. thesis. Department of Pasture Management and Soil Conservation, Faculty of Agriculture, University of Natal, Pietermaritzburg.

WHITLOW R, 1991. Wetland use and abuse in Zimbabwe. Transactions of the Zimbabwe Scientific Association 65: 24-33.

WILKINS R J, and GARWOOD E A, 1986. Effects of treading, poaching and fouling on grassland production and utilization. In: FRAME (ed.) *Grazing. British Grassland Society Occasional Report No. 19*. Hurley, Berks, England.

WILLRICH T L, and SMITH G E, 1970. *Agricultural practices and water quality*. Iowa State University Press, Ames, Iowa.

WYATT J, 1993. *Assessment, management and rehabilitation of South African wetlands: an illustrated field guide for practical use by land agency extension services*. Renfreight Wetlands Campaign.

SECTION 7, GLOSSARY

Aerobic: having molecular oxygen (O_2) present.

Anaerobic: not having molecular oxygen (O_2) present.

Animal unit (AU): an animal unit is defined as an animal with a mass of 450 kg and which gains 0.5 kg per day on forage with a digestible energy percentage of 55%. Other types of animals are related to such a unit according to the relationship between the three-quarter power of the mass of such animals and a similar function of the mass of a 450 kg animal, i.e. an animal with a mass *m* constitutes:

$m^{0.75} / 450^{0.75}$ of an animal unit

Aquic moisture regime: a reducing regime virtually free of dissolved oxygen because the soil is saturated. Some **soil horizons**, at times, are saturated with water while dissolved oxygen is present (as may occur if the water is moving). The required **soil saturation** duration is not known (and depends on site factors such as soil texture and temperature), but must be at least a few days (Soil Survey Staff, 1992).

Biodiversity: the variety of life in an area, including the number of different species, the genetic wealth within each species, and the natural areas where they are found.

Biophysical features: biological (e.g. threatened species) and physical (e.g. soil wetness zone) features.

Biological integrity: the fauna and flora that characterise an area (i.e. the area's "naturalness").

Bog: a **mire** (i.e. a **peat** accumulating wetland) that is hydrologically isolated, meaning that it is only fed by water falling directly on it as rain or snow and does not receive any water from a surrounding catchment. Bogs have acidic waters and are often dominated by mosses (Mitsch and Gosselink, 1986). The term bog is frequently used much more broadly in South Africa to refer to high altitude wetlands that have organic-rich soils. Many of these wetlands would not be bogs in the correct sense.

Bottomland: the lowlands along streams and rivers, on alluvial (river deposited) soil.

Catchment: all the land area from mountaintop to seashore which is drained by a single river and its tributaries. Each catchment in South Africa has been sub-divided into secondary catchments, which, in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These sub-divided catchments provide the main basis on which catchments are sub-divided for integrated catchment planning and management *(see DWAF [1994])*.

Chroma: the relative purity of the spectral colour, which decreases with increasing greyness.

Decision support system: procedures (often, but not always computer based) designed to assist in promoting more informed decision making.

Decomposition: the breakdown of dead organic matter into simpler substances.

Delineation (of a wetland): to determine the bounday of a wetland based on soil, vegetation, and/or hydrological indicators (see defenition of a wetland).

Descriptor: a measurable characteristic considered useful in predicting how a wetland's indirect benefits will be affected by management actions.

Direct (wetland) benefits: have worth, quality or importance to humans and are realized by individuals actively using a wetland (e.g. for recreation, or pasture production).

Dominant plant species: the overstory species that contribute most cover to the area, compared to other overstory species.

Ecological value: the value of the wetland in maintaining the biotic diversity of the area. Biotic diversity can be measured at many different levels, and it is almost impossible to prescribe a standard method of describing it. Its assessment may be simplified by determining the degree to which management is affecting biological integrity and populations of valued species.

Evaporation: the change from a liquid or solid state to a vapour.

Fen: a mire (i.e. a peat accumulating wetland) that receives some drainage from mineral soil in the surrounding catchment.

Gley: soil material that has developed under anaerobic conditions as a result of prolonged saturation with water. Grey and sometimes blue or green colours predominate but **mottles** (yellow, red, brown and black) may be present and indicate localized areas of better aeration.

Groundwater: subsurface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric (Soil Classification Working Group, 1991).

Groundwater table: the upper limit of the groundwater.

Horizon: see soil horizons.

Hydric soil: soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hydrophyte: any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats.

Hydrology: the study of water, particularly the factors affecting its movement on land.

Hue: the dominant spectral colour (e.g. red).

IEM: see Integrated Environmental Management

Impact site: that part of the wetland site to which a proposed land-use is to be applied.

Indirect (wetland) benefits: have worth, quality or importance to humans but do not require active use of wetlands by individuals in order for the benefits to be realized. Instead, the wider public benefits indirectly from the services that wetlands provide (e.g. purification of water).

Infilling: dumping of soil or solid waste onto the wetland surface. Infilling generally has a very high and permanent impact on wetland functioning and is similar to drainage in that the upper soil layers are rendered less wet, usually so much so that the area no longer functions as a wetland.

Integrated Environmental Management (IEM): A nationally accepted procedure for promoting better planned development by ensuring that the environmental consequences of development are understood and adequately considered in planning and implementation.

Marsh. a wetland dominated by emergent herbaceous vegetation (usually taller than 1 m), such as the common reed (*Phragmites australis*) which may be seasonally wet but are usually permanently or semi-permanently wet.

Mire: a peat accumulating wetland, including both bogs and fens.

Mitigate: to take actions to reduce the impact of a particular proposal.

Monitor: to keep a check on, and record of something, which would allow changes to be detected.

Mottles: soils with variegated colour patters are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Munsell colour chart: A standardized colour chart which can be used to describe hue (i.e. its relation to red, yellow, green, blue, and purple), value (i.e. its lightness) and chroma (i.e. its purity). Munsell colour charts are available which show that portion commonly associated with soils, which is about one fifth of the entire range.

***n* Value:** the relationship between the percentage of water under field conditions and the percentage of inorganic clay and humus. It can be approximated in the field by a simple test of squeezing the soil in the hand. It is helpful in predicting the degree of subsidence that will occur after drainage (Pons and Zonneveld, 1965; Soil Survey Staff, 1992).

Open water zone: permanently or semi-permanently flooded areas characterized by the absence (or low abundance) of emergent plants.

Organic soil material: soil material with a high abundance of undecomposed plant material and humus. According to the Soil Classification Working Group (1991) an organic soil horizon must have at least 10% organic carbon by weight throughout a vertical distance of 200 mm and be saturated for long periods in the year unless drained. According to the Soil Survey Staff (1975) definition, in order for a soil to be classed as organic it must have >12% organic carbon by weight if it is sandy and >18% if it is clay-rich.

Palustrine (wetland): All non-tidal wetlands dominated by persistent emergent plants (e.g. reeds) emergent mosses or lichens, or shrubs or trees (see Cowardin *et al.*, 1979).

Peat: organic soil material with a particularly high organic matter content which, depending on the definition, usually has at least 20% organic carbon by weight.

Peraquic moisture regime: an aquic moisture regime where the where the ground water is always at or very close to the surface (Soil Survey Staff, 1992).

Perched water table: the upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.

Perennial crop: lasting throughout the year and through many years.

Permanently wet soil: soil which is flooded or waterlogged to the soil surface throughout the year, in most years.

Poaching: this occurs when soils are wet, and refers to the disruption of soil structure caused by the repeated penetration of hooves into the soil (Wilkins and Garwood, 1986). The poaching of soils should be avoided because besides decreasing herbage production, it also greatly increases the susceptibility of the soil to erosion.

Physiognomy: the outer appearance of the vegetation; a function of the architecture of the different canopy layers and the life form of the dominant plants.

Ramsar Convention: an intergovernmental treaty which provides the framework for international cooperation for the conservation of wetland habitats.

Red Data species: all those species included in the categories of endangered, vulnerable or rare, as defined by the International Union for the Conservation of Nature and Natural Resources.

Riparian: the area of land adjacent to a stream or river that is influenced by stream-induced or related processes. Riparian areas which are saturated or flooded for prolonged periods would be considered wetlands and could be described as **riparian wetlands**. However, some riparian areas are not wetlands (e.g. where alluvium is periodically deposited by a stream during floods but which is well drained).

Roughness coefficient: an index of the roughness of a surface; a reflection of the frictional resistance offered by the surface to water flow.

Rule-based model: a model which represents knowledge in the form of IF-THEN statements. The IF part contains a condition or premise and the THEN part contains a result, conclusion or consequence.

Runoff: total water yield from a catchment including surface and subsurface flow.

Seasonally wet soil: soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season, but is predominantly dry during the dry season.

Sedges: Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.

Soil drainage classes: describe the soil moisture conditions as determined by the capacity of the soil and the site for removing excess water. The classes range from very well drained, where excess water is removed very quickly, to very poorly drained, where excess water is removed very slowly. Wetlands include all soils in the very poorly drained and poorly drained classes, and some soils in the somewhat poorly drained class. These three classes are roughly equivalent to the permanent, seasonal and temporary classes

Soil horizons: layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e. soil material that has different characteristics).

Soil profile: the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991).

Soil saturation: the soil is considered saturated if the water table or **capillary fringe** reaches the soil surface (Soil Survey Staff, 1992).

Stakeholders: the people or organizations that have a direct interest in a particular issue (e.g. a wetland).

Stocking rate (SR): the number of animal units AUs per unit of land for a specified period of time; it may be expressed in terms of number of land units per AU.

Sustainable use: use of natural resources which allows that resource to renew itself and which is within biological limits and meets the ecological, social and economic needs of humans such that the future is not compromised for the present (a temporal dimension) and geographic area(s) are not compromised for other geographic area(s) (a spatial dimension).

Temporarily wet soil: The soil close to the soil surface (i.e. within 50 cm) is wet for periods > 2 weeks during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.

Terrain unit classes: areas of the land surface with homogenous form and slope. Terrain may be seen as being made up of all or some of the following units: crest (1), scarp (2), midslope (3), footslope (4) and valley bottom (5).

Transpiration: the transfer of water from plants into the atmosphere as water vapour

Vlei: a colloquial South African term for wetland.

Water regime: When and for how long the soil is flooded or saturated.

Water quality: the purity of the water.

Waterlogged: soil or land saturated with water long enough for anaerobic conditions to develop.

Wet grassland: a wetland area which is usually temporarily wet and supports a mixture of: 1) plants common to non-wetland areas and 2) short (< 1m) hydrophytic plants (predominantly grasses) also common to the **wet meadow** zone.

Wetland: land where an excess of water is the dominant factor determining the nature of the soil development and the types of plants and animals living at the soil surface (Cowardin *et al.*, 1976); lands that are sometimes or always covered by shallow water or have saturated soils long enough to support plants adapted for life in wet conditions.

Wetland catchment: the area up-slope of the wetland from which water flows into the wetland and including the wetland itself.

Wetland delineation: the determination and marking of the boundary of a wetland on a map.

Wet meadow: a wetland area which is usually seasonally wet and dominated by short (usually <1.5 m) hydrophytic sedges and grasses common to temporarily or seasonally wet areas.

Wise use (of wetlands): synonymous with **sustainable use** .

APPENDICES

APPENDIX 1: WETLAND SOILS

As indicated in Kotze *et al.* (1996) the South African Soil classification system (Soil Working Group, 1991) does not require that the soil water regime be determined and the depth to upper limit of the G horizon or any other horizon with signs of wetness is not specified. It may range from <200 mm to >800 mm. This is an important weakness of the system when applied to hydric soils as the depth of waterlogging is crucial in determining whether a soil is hydric or not (Kotze *et al.*, 1996). *Soil Taxonomy* (Soil Survey Staff, 1992), which is the most commonly used soil classification system worldwide, recognizes the aquic water regime. Aquic soils are recognized based on the presence of features of wetness (e.g. mottling and a low chroma matrix) that are visible at <0.5 m from the soil surface. It is within this upper 0.5 m of soil that most of the roots of herbaceous plants are situated.

Despite the limitation of the South African system, it is worthwhile to identify the hydric character of the different soil forms associated with wetlands. This has been done at a preliminary level (see Table A1). Hydric character refers to whether soils in a particular form are always, usually or sometimes hydric (wetland) soils, depending on the depth of the horizon with indications of wetness. The soil forms in the first group (Always Hydric) consistently have signs of wetness close (within the upper 50 mm) to the soil surface identifying them as hydric. It may, however, be that a soil belonging to one of these horizons is encountered that has signs of wetness that are deeper than is usually the case, making the soil non-hydric, but this is the exception. Soil forms in the second group (Usually Hydric) are usually found in wetland areas, depending on the depth of characteristics associated with wetness and the intensity of the indicators of wetness (e.g. the soft plinthic horizon varies according to the intensity of wetness indicators within the profile). Soils in the last group (Sometimes Hydric) are usually non-hydric but, again depending on the depth and intensity of wetness indicators, may sometimes be hydric.

It must be stressed that this is a very preliminary list and it would be great to get wider comment on it.

Table A1 A preliminary classification of the hydric character of soil forms characteristically associated with wetlands.

Diagnostic Horizons and Materials				Hydric character	Soil Form
Topsoil	Subsoil				
Organic	unspecified	*	*	Always	CHAMPAGNE
Vertic	G horizon	*	*	Always	RENSBURG
Melanic	G horizon	*	*	Always	WILLOWBROOK
Orthic	G horizon	*	*	Always	KATSPRUIT
Orthic	E horizon	G horizon	*	Usually	KROONSTAD
Orthic	E horizon	soft plinthic B	*	Usually	LONGLANDS
Orthic	E horizon	hard plinthic B	*	Sometimes	WASBANK
Orthic	E horizon	yellow-brown apedal B	*	Sometimes	CONSTANTIA
Orthic	E horizon	podzol B + placic pan	*	Sometimes	TSITSIKAMMA
Orthic	E horizon	podzol B	unconsolidated material with signs of wetness	?Sometimes	LAMOTTE
Orthic	E horizon	podzol B	saprolite	Sometimes	HOUHOEK
Orthic	E horizon	prismacutanic B	*	Sometimes	ESTCOURT
Orthic	E horizon	lithocutanic B	*	Sometimes	CARTREF
Orthic	E horizon	unspecified	*	Sometimes	FERNWOOD
Orthic	soft plinthic B	*	*	Sometimes	WESTLEIGH
Orthic	yellow-brown apedal B	soft plinthic B	*	Sometimes	AVALON
Orthic	yellow-brown apedal B	unspecified material with signs of wetness	*	Sometimes	PINEDENE
Orthic	red apedal B	unspecified material with signs of wetness	*	Usually?	BLOEMDAL
Orthic	podzol B	unconsolidated material with signs of wetness	*	Usually?	WITFONTEIN
Orthic	pedocutanic B	unconsolidated material with signs of wetness	*	Usually?	SEPANE
Orthic	neocarbonate B	unspecified material with signs of wetness	*	Usually?	MONTAGU

Note: soil forms not listed are absent or very seldom associated with wetlands

Table A2 Erosion hazards for the primary soil forms associated with wetlands in South Africa

Soil Form	Code	Soil Series (Families)	Erosion Hazard Rating (**K**)
Champagne	Ch 11	Champagne	high
	Ch 21	Ivanhoe	high
	Ch 10	Mposa	high
	Ch 20	Stratford	high
Katspruit	Ka 10	Katspruit	mod
	Ka 20	Killarney	high
Rensburg	Rg 10	Phoenix	high
	Rg 20	Rensburg	high
Willowbrook	Wo 21	Chinyike	high
	Wo 10	Emfuleni	high
	Wo 20	Sarasdale	high
	Wo 11	Willowbrook	mod
Estcourt	Es 20	Assegaai	v.high
	Es 11	Auckland	v.high
	Es 22	Avontuur	v.high
	Es 35	Balfour	v.high
	Es 40	Beerlaagte	v.high
	Es 37	Buffelsdrif	high
	Es 42	Darling	v.high
	Es 13	Dohne	v.high
	Es 31	Elim	v.high
	Es 33	Enkeldoorn	v.high
	Es 36	Estcourt	high
	Es 14	Grasslands	v.high
	Es 41	Heights	v.high
	Es 10	Houdenbeck	v.high

	Es 21	Langkloof	v.high
	Es 30	Mozi	v.high
	Es 12	Potela	v.high
	Es 16	Rosemead	high
	Es 32	Soldaatskraal	v.high
	Es 34	Uitvlugt	v.high
	Es 15	Vredenhoek	v.high
	Es 17	Zintwala	high
Kroonstad	Kd 17	Avoca	high
	Kd 16	Bluebank	high
	Kd 22	Katarra	v.high
	Kd 20	Koppies	v.high
	Kd 13	Kroonstad	v.high
	Kd 14	Mkambati	v.high
	Kd 10	Rocklands	v.high
	Kd 15	Slangkop	v.high
	Kd 12	Swellengift	v.high
	Kd 18	Uitspan	v.high
	Kd 21	Umtentweni	high
	Kd 11	Velddrif	v.high
	Kd 19	Volksrust	mod
Longlands	Lo 22	Albany	mod
	Lo 32	Chitsa	mod
	Lo 21	Longlands	high
	Lo 10	Orkney	high
	Lo 30	Tayside	high
	Lo 31	Vaalsand	high
	Lo 20	Vasi	high

	Lo 11	Waaisand	high
	Lo 12	Waldene	high
	Lo 13	Winterton	low
Westleigh	We 10	Chinde	high
	We 32	Davel	mod
	We 22	Devon	mod
	We 20	Kosi	high
	We 30	Langkuil	high
	We 31	Paddock	high
	We 12	Rietvlei	mod
	We 13	Sibasa	low
	We 11	Westleigh	high
	We 21	Witsand	high

APPENDIX 2: ADDITIONAL DESCRIPTORS FOR DESCRIBING THE WETLAND AND ITS CONTEXT

A20. Terrain unit/s (according to Land Type survey Staff [1986]) on which the wetland occurs.

Crest .....

Footslope .....

Scarp .....

Valley bottom .....

Midslope .....

A21 Mean annual precipitation (mm) ....

A22 Mean annual potential evaporation (mm) ....

Note: if data are unavailable for A23 and A24 then these may be obtained from Schulze (1997).

A23 Veld type (according to Acocks, 1953) ....

A24 Dominant soil form/s (according to Soil Classification Working Group, 1991) occurring in the wetland. ....

A25. Underlying geology ....

A26 Average width (m) of the wetland perpendicular to flow. ....

Note: to calculate the average width of the wetland, divide the wetland (perpendicular to the direction of flow) into 5 segments of equal length, and measure the width of each segment (at their centres and perpendicular to the direction of flow), then calculate their average by dividing their sum by 5.

A27 Length of the wetland from the outlet to the inlet (m). .....

Note: this refers to the distance that diffuse water flow would travel from the inlet to the outlet. If the wetland were curved or twisted, the wetland length would be longer than the straight line distance from the inlet to the outlet.

A28 Calculate the average slope of the entire wetland (%). ....

Note: A28= 100 x (Altitude of inlet-Altitude of outlet)÷A27.

A29 What is the stream order of the main input channel.

first order .....

second order.....

third order..........

fourth order or more..........

A30 What is the importance of the wetland for supporting migratory/nomadic birds.

negligible.....

moderate (ca 100-1000 birds) ....

high (> ca 1000 birds)..........

Note: the wetland may be important for only a few weeks each year or even less frequently but, nevertheless, would still be important. It may be necessary to consult an ornithologist.

A31 Indicate (Y or N) if the wetland is part of, and essential to, an ongoing long term environmental research/monitoring programme. ....

A32 Indicate (Y or N) if the wetland is the closest wetland to any environmental education centre, school, university or similar education facility and is within 500 m of a public road with parking. ....

C6. Surface area of the wetland catchment (ha) .....

C7. % of the wetland catchment occupied by the wetland ....

C8. Mean annual runoff generated by the wetland's catchment

Note: The mean annual runoff generated by a wetland's catchment may be approximated very roughly by using mean annual runoff data which has been estimated for quaternary catchments (e.g. Pitman et al. 1981). If for example a wetlands catchment occupies 40% of a quaternary catchment which has an estimated mean annual runoff of $54 \times 10^6\ m^3$ then the estimated mean annual runoff from the wetland's catchment is $54 \times 10^6 \times 0.4\ m^3 = 22 \times 10^6\ m^3$.

Note: D3 to D6 provide a more comprehensive and semi-quantitative means of obtaining the information requested in D1 and D2.

D3. In the water purification service area, rate (0-3) the current human use of the stream for:

1. Potable water users, which includes individuals (in most cases poor rural people) who extract water directly by hand for daily domestic use.

0= Nil users .....

1= 1-3 users.....

2= 4-50 users.....

3= >50 users.....

2. Piped water users, which includes water for irrigation, domestic and industrial purposes

0= No extraction .....

1= 1-10 million m^3 extracted annually.....

2= 11-100 million m^3 extracted annually.....

3= >100 million m^3 extracted annually..........

3. Recreationists who use the water on site for fishing, bathing and/or water sports (expressed on a per km per month basis)

0= No users .....

1= 1-10 users .....

2= 10 - 20 users.....

3= >20 users.....

4. Stock farmers (both subsistence and commercial) that require water for stock watering.

0= No stock watering.....

1= 1-10 **animal units** (AU's) watered per km.....

2= 11-30 AU's per km.....

3= >30 AU's per km.....

D4. D4=D3.1+D3.2+D3.3+D3.4

D5. Now determine the total current importance for human use of water purification in the downstream area of influence using the following rules:

if D3.1 >1 or D4 >6 then significance = high otherwise if D4 6 and >2 then significance = moderate

otherwise if D4> 0 and 2 then significance = low

otherwise if D4= 0 then significance = nil

D6. Downstream flood damage potential. To the end of the downstream service are, determine the current abundance of FU's (Floodable Units, see notes) occurring within the 1 in 50 year flood line and determine the total current significance of flood reduction in the downstream area of influence

TOTAL NO. OF FU's	0	1-10	11-19	>20
CURRENT SIGNIFICANCE	Nil	Low	Medium	High

Note: the benefit derived from flood reduction in a floodable zone below a wetland would obviously increase with increasing abundance of floodable property. In WETLAND-USE, floodable property is expressed in terms of Floodable Units (FU's), where 1 FU is equivalent to 1 house or 20 ha of cropland. Other features of biological, social or economic value should be subjectively allocated FU scores. A riverine forest, for example, while possibly requiring some measure of flooding, may be negatively affected by a marked increase in flood peaks that could result from wetland destruction.

F30. Estimate the *n* Value by squeezing a handful of soil. Observe how easily it flows between the fingers and indicate this. The soil should be taken at 10 cm below the surface and the test should preferably be conducted during the wet season and not in a drought year.

very high (flows easily).....

high (flows with difficulty).....

medium or .....

low (does not flow).....

Note: the n Value refers to the relationship between the percentage of water under field conditions and the percentages of clay and humus. It is helpful in predicting the degree of subsidence that will occur after drainage *and whether the soil may be grazed by livestock or will support other loads (Pons and Zonneveld, 1965; Soil Survey Staff, 1992). The n Value may depends on the conditions at the time of measurement and is therefore not used as a criterion for assessing level of impact.*

PART 2

Index