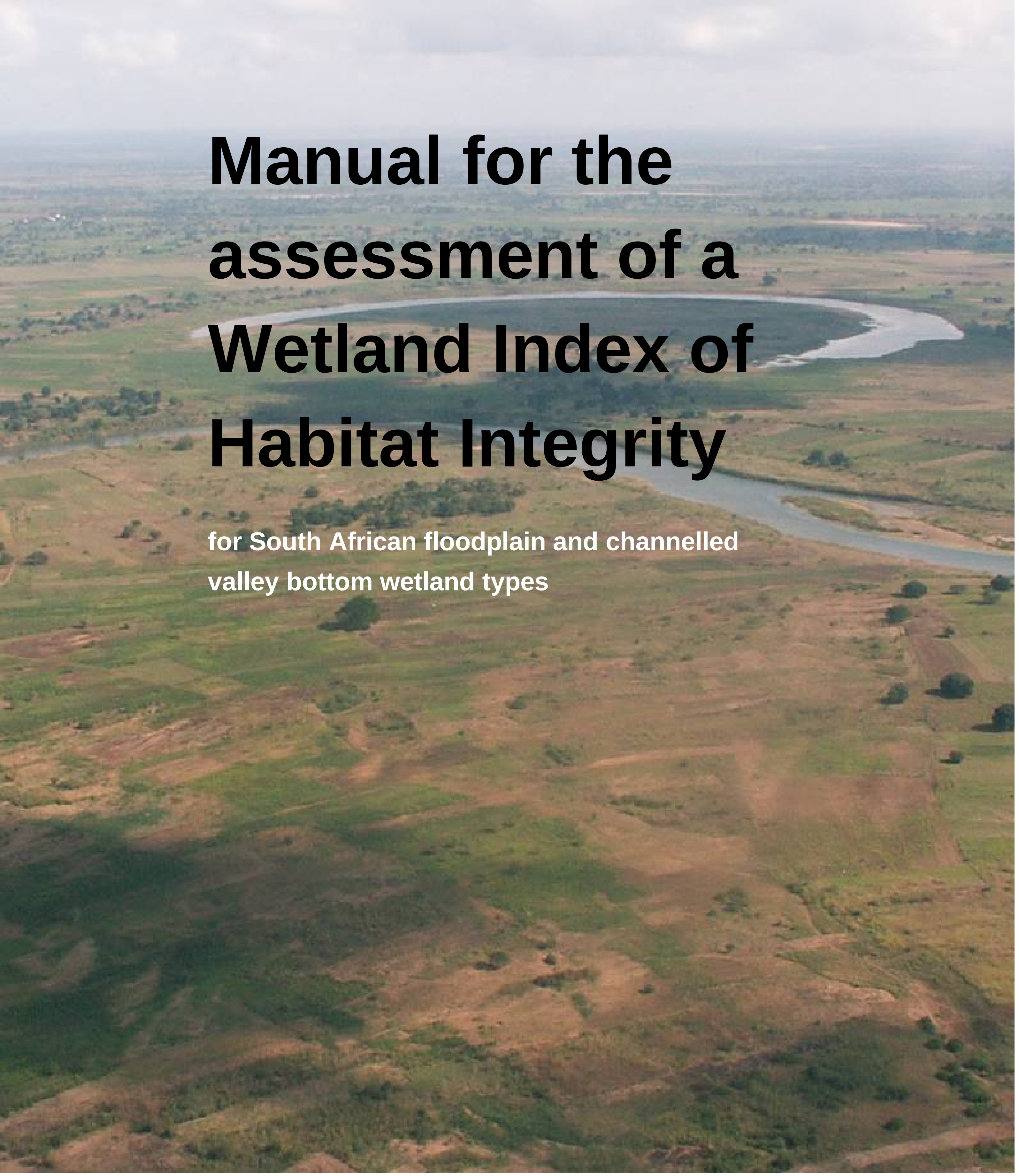


# Manual for the assessment of a Wetland Index of Habitat Integrity

**for South African floodplain and channelled valley bottom wetland types**

water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

Republic of South Africa

# Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types

**Department of Water Affairs and Forestry**
**Resource Quality Services**

**August 2007**

**First Edition**

**August 2007**

Published by:

Department of Water Affairs and Forestry
Resource Quality Services
Private Bag X313
Pretoria
0001
Republic of South Africa
Tel: (012) 808 0374

Co-ordinated by: Resource Quality Services



This document should be cited as:

DWAF (2007). *Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types* by M. Rountree (ed); C.P. Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

## DOCUMENT STATUS AND APPROVAL

**WORKING TITLE:** Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types

**AUTHORS:** Rountree, M.W., Todd, C.P., Kleynhans, C.J., Batchelor, A.L., Louw, MD., Kotze, D., Walters, D., Schroeder, S., Illgner, P. Uys. M and Marneweck, G.C.

**EXTERNAL REVIEWER:** Professor Heather Malan (Freshwater Research Unit, University of Cape Town).

**REPORT STATUS:** Edition 1.0, Final

**REPORT NUMBER:** N/0000/00/WEI/0407

**DATE:** August 2007

Recommended for the Department of Water Affairs and Forestry:

________________________

Mr Axel Diefenbach
Acting Director: RQS

Approved for the Department of Water Affairs and Forestry:

________________________

Mr Mbangiseni P. Nepfumbada
Chief Director: WRIM

# ACKNOWLEDGEMENTS

The development of the "Manual for the assessment of a Wetland Index of Habitat Integrity for floodplain and channelled valley bottom wetland types" was undertaken on behalf of the Department of Water Affairs and Forestry (Directorate: Resource Quality Services) by Wetland Consulting Services in collaboration with a large team of experts from across South Africa. The valuable contributions of these individuals in the development of the WETLAND-IHI are gratefully acknowledged. In addition, Professor Heather Malan provided many valuable comments in the development and review phases of the project.



| PROJECT TEAM MEMBERS | AFFILIATIONS |
|---|---|
| **Mark Rountree** | **FLUVIUS Environmental (Project Leader)** |
| **Colleen Todd** | **DWAF: Resource Quality Services** |
| **Neels Kleynhans** | **DWAF: Resource Quality Services** |
| **Allan Batchelor** | **Wetland Consulting Services** |
| **Delana Louw** | **Water for Africa** |
| **Donovan Kotze** | **University of KwaZulu-Natal** |
| **Damian Walters** | **Mondi Wetlands Project** |
| **Simone Schroeder** | **Wetland Consulting Services** |
| **Pete Illgner** | **Private Consultant** |
| **Mandy Uys** | **Laughing Waters** |
| **Gary Marneweck** | **Wetland Consulting Services** |

# CONTENTS

**ACKNOWLEDGEMENTS** ..... i

**ABBREVIATIONS** ..... iii

**GLOSSARY** ..... iv

**1. INTRODUCTION AND MODEL STRUCTURE** ..... 1
Background ..... 1
Wetland Drivers, Modifiers and Responders ..... 2
Assessing Wetland Drivers ..... 2
Assessing Wetland Modifiers ..... 3
Assessing Wetland Responders ..... 3
EcoClassification of wetlands ..... 4
Who should use this and when? ..... 4

**2. MANUAL AND GUIDELINES FOR MODEL USE** ..... 5
PREPARATION FOR THE FIELD/SITE VISIT (Desktop work) ..... 6
Step 1: Collation of available data ..... 6
Step 2: Delineation of the study area and site selection ..... 6
FIELD ASSESSMENT ..... 8
General ..... 8
Step 1: Site Information ..... 8
Step 2: Classify the wetland type ..... 8
Step 3: Assess vegetation alteration *(landuse activities)* ..... 9
Step 4: Assess Hydrological PES ..... 10
Step 5 Assess Geomorphological PES ..... 13
Step 6: Assess Water Quality PES ..... 15
Step 7: Assess Overall PES score ..... 16

**3. FIELD FORMS FOR THE WETLAND-IHI** ..... 17

**4. REFERENCES** ..... 24

**5. APPENDIX I: RESULTS FROM TESTING** ..... 27

**6. APPENDIX II: BACKGROUND TO THE DEVELOPMENT OF THE WETLAND-IHI** ..... 28
Wetland Assessments ..... 29
Objective of the study ..... 30

**7. APPENDIX III: BACKGROUND TO WETLAND CLASSIFICATIONS, AND THE CLASSIFICATION SYSTEM DEVELOPED FOR THIS STUDY** ..... 32
History of Wetland Classifications in South Africa ..... 32
Linking Wetland Assessments to Classification Systems ..... 33
The proposed national Wetland Classification for SA ..... 33
The modified Classification System adopted in this study ..... 35
Rivers ..... 39
Meandering Floodplain ..... 39
Channelled Valley Bottoms ..... 39
Unchannelled Valley Bottoms ..... 40
Lakes ..... 40
Seepage wetlands (connected to river) ..... 40
Seepage wetlands (connected to pan) ..... 40
Seepage wetlands (isolated) ..... 40
Pans ..... 40
Extrapolation potential between sites and EcoRegions ..... 41

# ABBREVIATIONS

| | |
|---|---|
| DWAF | Department of Water Affairs and Forestry |
| HGM | Hydrogeomorphic, in reference to a wetland classification/typology system based on the hydrological and landscape (geomorphic) characteristics of wetlands |
| IHI | (River) Index of Habitat Integrity |
| NAEHMP | National Aquatic Ecosystem Health Monitoring Programme |
| NWRCS | National Water Resources Classification System |
| PES | Present Ecological State – the health or integrity of biophysical attributes, determined by comparison of the current condition to the natural (or close to natural), so-called “reference” condition. |
| RHP | River Health Programme |
| RQS | Resource Quality Services Directorate within DWAF |
| WETLAND-IHI | The DWAF Wetland index of habitat integrity tool – developed under this study |

# GLOSSARY

**Alluvial fan:** A depositional feature which can occur on a floodplain surface (often associated with sediment-laden lateral tributaries). The deposition of sediment creates a fan-shaped deposit over time.

**Channel competency**: The ability of a channel to transport water. Related to its size, slope and roughness.

**Channelled valley bottom**: Linear fluvial, net depositional valley bottom surfaces which have a straight channel with flow on a permanent, seasonal or ephemeral/episodic basis. The straight channel tends to flow parallel with the direction of the valley (i.e. there is no meandering), and no ox-bows or cut-off meanders are present in these wetland systems.

**Connectivity**: In this context, referring to either the upstream-downstream or lateral (between the channel and the adjacent floodplain) connectivity of a drainage line. Upstream-downstream connectivity is an important consideration for the movement of sediment as well as migratory aquatic biota. Lateral connectivity is important for the floodplain species dependent on the wetting and nutrients associated with overbank flooding.

**EcoClassification**: This is a procedure to determine and categorise the ecological state of various biological and physical attributes compared to the reference state. The procedure of EcoClassification describes the health of a water resource and derives and formulates management targets / objectives / specifications for the resource. This provides the context for monitoring the water resource within an adaptive environmental management framework. The classification ranges from A (natural) to F (highly impacted).

**EcoRegions**: "*Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources*", and are designed to serve as a spatial framework for the research, assessment, management and monitoring of ecosystems and ecosystem components (US EPA). Several levels or scales of EcoRegions can be delineated (eg: Level I low resolution/detail; Level III high resolution and detail). In South Africa, EcoRegions form the basis of the River Health monitoring assessments.

**EcoStatus**: The overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component Ecostatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).

**Floodplain**: Linear fluvial, net depositional valley bottom surfaces which have a meandering channel. The meandering channel flows within an unconfined depositional valley, and ox-bows or cut-off meanders - evidence of meandering – are usually visible at the 1:10 000 scale.

**HGM unit:** A HydroGeomorphic Unit – a single "reach", segment or unit of a particular type of HGM wetland type. Refer to page 21 for an example of how HGM units can be delineated.

**Infilling:** To fill in a wetland (or riparian area) in order to raise the ground level above the flooding or saturated zone; usually for the purposes of construction.

**Macro-channel:** Over much of southern Africa, uplift in the recent geological past and subsequent incision has caused many rivers to flow within an incised 'floodplain', outside of which flood flows have no recorded influence. This incised feature has been termed the macro-channel.

**Pan:** A wetland which occurs predominantly in depressions in crest positions in the landscape; which has a circular or oval shape.

**PES**: Present Ecological State: the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State.

**Platform**: The elevated surface of an ***infilled*** area of wetland or riparian zone. Platforms are often constructed using *ex-situ* material which is used to increase the ground level height in order to reduce flooding or saturation of the soils. Platforms can then be used for construction of residential or commercial properties, or for cultivation of crops.

**Reference State**: (*also Reference Condition*). The natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development.

**Seepage:** A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows.

**Unchannelled valley bottom**: Linear fluvial, net depositional valley bottom surfaces which do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas.

**Wetland:** *land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).

# Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types

## 1. INTRODUCTION AND MODEL STRUCTURE

### *Background*

The Wetland Index of Habitat Integrity (WETLAND-IHI) is a tool developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI has been developed to allow the NAEHMP to include floodplain and channelled valley bottom wetland types to be assessed and the monitoring data incorporated into the national monitoring programme. The output scores from the WETLAND-IHI model are presented in the standard DWAF A-F ecological categories (Table 1), and provide a score of the Present Ecological State of the habitat integrity of the wetland system being examined.

**Table 1: Descriptions of the A-F ecological categories (after Kleynhans, 1996, 1999).**

| Ecological Category | PES % Score | Description |
|---|---|---|
| A | 90-100% | Unmodified, natural. |
| B | 80-90% | Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. |
| C | 60-80% | Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. |
| D | 40-60% | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. |
| E | 20-40% | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. |
| F | 0-20% | Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible. |

This project is the first in a series of wetland assessment methods. It is envisaged that additional tools for similar Habitat Integrity assessments for other wetland types (such as pans, seepage wetlands and unchannelled valley bottom wetland types) will be developed in the near future. These tools, developed in a similar format to the River Ecostatus monitoring tools, will allow wetlands to be assessed and that information to be incorporated into the NAEHMP.

## *Wetland Drivers, Modifiers and Responders*

The model is composed of four modules (Figure 1). The "Hydrology", "Geomorphology" and "Water Quality" modules all assess the contemporary ***driving processes*** behind wetland formation and maintenance. The last module, "Vegetation Alteration", provides an indication of the intensity of human landuse activities on the wetland surface itself and how these may have ***modified*** the condition of the wetland. The integration of the scores from these 4 modules provides an overall Present Ecological State (PES) score for the wetland system being examined. The development of the four modules is described briefly below.

## Assessing Wetland Drivers

### Hydrology Module

The hydrology module was developed through iterations of workshops and subsequent desktop, and later field, testing of the draft versions of the module. The module evaluates the catchment as well as "on-site" (i.e. within the wetland system) effects on hydrological regime.

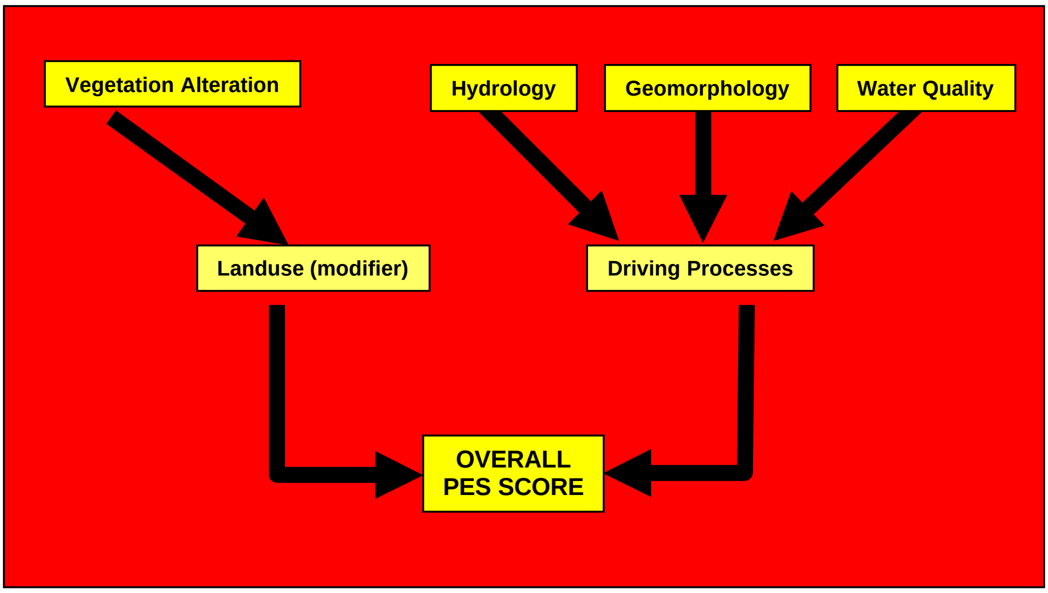



**Figure 1:** The four modules of the Wetland-IHI model, and their relationship to the overall Present Ecological State (PES) score which is derived from them.

### Geomorphology Module

The geomorphology module was developed through iterations of workshops and subsequent desktop, and later field, testing of the draft versions of the module. The module evaluates the catchment as well as "on-site" (i.e. within the wetland system) effects on geomorphological condition. We gratefully acknowledge the inputs and insights gained from the riverine EcoStatus model (Rowntree and du Preez, *in prep*.) in the development of this module.

### Water Quality Module

Whilst it was beyond the terms of reference, or budget and time constraints, of this project to develop a water quality module, the importance of such a driver in the assessment of floodplain and channelled valley bottom wetland systems could not be overlooked. Particularly in the case of the nutrient-poor wetland systems in the Western Cape which are adversely impacted through increased nutrient loads, but also in the case of sewage return flows which is a ubiquitous impact across the country. To account for such impacts, an "add-on" water quality module has been included in the Wetland-IHI.

This add-on has been provided through the Riverine IHI's Physico-Chemical module. Some slight modifications have been made to this module to adapt it for floodplain/channelled valley bottom use. Specifically, the thresholds which were included in the Riverine IHI have been removed, as it is generally acknowledged that wetlands are less sensitive to impacts such as reduced oxygen loads than are true river environments. In general, many wetland biota are well-adapted to widely varying water quality conditions because of the stagnant, low-oxygen conditions that can naturally develop in wetland environments.

## Assessing Wetland Modifiers

The above drivers create conditions which are suitable for the development of wetlands. In the case of both rivers and wetlands (but wetlands more so), on-site landuse activities can modify the conditions which exist at a site (such as the removal of riparian vegetation in the case of river, or agricultural disturbance across the floodplain surface in the case of wetlands).

### Vegetation Alteration Module

To account for these important on-site modifications, a "Vegetation Alteration" module was included in the model. Because this is a Habitat Integrity index (assessing the quality, quantity and suitability of the physical environment to supports the biota), the extent of vegetation alteration is not examined for the sake of the vegetation itself, but the focus is more on the degree of alteration from the natural structure and density of vegetation in so much as it may affect other biota dependent on it. The vegetation module does thus not examine vegetation change at a species or species richness level, but at a broader level in order to address habitat integrity. It instead considers landuse activities that are practiced at the site and rates their impacts and intensity.

## Assessing Wetland Responders

The driving processes and subsequent modifiers (such as landuse activity on the site) result in an overall ecological condition of a particular wetland (Figure 3). Particular groups of organisms (such as macro-invertebrates, diatoms and birds) then "respond" to that underlying condition (through changes in abundance, altered species assemblages etc). The biotic responders can therefore also be used to assess the state of the ecosystem. However, responders are not being evaluated in this tool as this is a Habitat Integrity assessment tool, which assesses the quality, quantity and suitability of the physical environment to support the biota, but not actually measuring the biota itself. Habitat Integrity is often a more rapid component of the environment to assess, and generally requires less specialist insight than, for example, specialist assessments of all responder groups or organisms at a site.

## *EcoClassification of wetlands*

This tool is designed for the EcoClassification of floodplain and channelled valley bottom wetland systems. EcoClassification is the procedure to determine and categorise the ecological state of various biological and physical attributes compared to the reference state (Kleynhans and Louw, 2007). The procedure of EcoClassification describes the health of a water resource and derives and formulates management targets / objectives / specifications for the resource. This provides the context for monitoring the water resource within an adaptive environmental management framework. The classification ranges from A (natural) to F (highly impacted) (Table 1).

This tool provides a method and model to determine the PES of floodplain and channelled valley bottom wetland systems. Such wetlands are part of larger drainage networks, and would often have riverine reaches either up- or downstream of them, or both. Separate EcoStatus models exist to determine the PES of rivers. To integrate the scores of the up- and downstream reaches with the floodplain or channelled valley bottom wetland unit being assessed, the wetland reach should be considered as any other river reach (with its own individually determined PES scores), and the PES scores of the reaches or Resource Units could possibly be integrated through weighting according to length to generate an overall score for the drainage line, if so required.

At present the WETLAND-IHI is only suitable for the assessment of channelled valley bottoms and floodplain wetlands, and this assessment is a rapid field-based method. Catchment or quaternary-catchment level indices of wetland condition are not available at this time.

## *Who should use this and when?*

The WETLAND-IHI is designed for rapid assessments (River Health-type approach) for use by non-wetland specialists. However, some training in the use and application of the tool is *essential* and should be sought through the EcoStatus training courses.

***This version of the tool is only appropriate for application on meandering floodplain and channelled valley bottom wetland types*** (Table 2). It is therefore essential that the Reference State of the wetland being assessed is either a floodplain or channelled valley bottom wetland system. Please refer to Appendix III for more detail on the wetland classification and descriptions of wetland types.

**Table 2: Landscape settings and flow characteristics of the HGM wetland types (after Rountree and Batchelor, *in prep.)*. The characteristics of the floodplain and channelled valley bottom wetland types are highlighted.**

| Landscape setting | | Flow pattern | HGM Wetland Type |
|---|---|---|---|
| Valley Bottoms | *confined* | channelled | **River** |
| | | standing water | **Lake** |
| | *unconfined* | diffuse | **Unchannelled Valley Bottom** |
| | | channelled (parallel to valley) | **Channelled Valley Bottom** |
| | | channelled (meandering across valley) | **Meandering Floodplain** |
| Slopes | | diffuse => diffuse | **Seepage (isolated)** |
| | | diffuse => surface/channel | **Seepage (connected)** |
| Crests | | diffuse flow => standing water | **Seepage (connected)** |
| | | standing water | **Pans and Depressions** |

# 2. MANUAL AND GUIDELINES FOR MODEL USE

The Wetland Habitat Integrity (WETLAND-IHI) model is ***designed for the RAPID assessment of floodplain and channelled valley bottom wetland types***, for the purposes of determining an index of WETLAND-IHI for the purposes of reporting on the Present Ecological state (PES) of the wetland system in question.

The WETLAND-IHI model is an MS Excel-based model, and the data required for the assessment are generated during a rapid (approximately 3 hour) site visit in the field. Additional data may be obtained from remotely sensed imagery (aerial photo's; maps and/or satellite imagery) to assist with the assessment.

The interface of the WETLAND-IHI has been developed in a format which is similar to DWAF's River EcoStatus models which are currently used for the assessment of PES in riverine environments. Although the model has been designed for application by non-wetland experts, some training in the WETLAND-IHI model application is required. Prior experience with other EcoStatus models is also preferable as this will ensure easier application of the model by the end user.

The following terminology is consistently used in WETLAND-IHI model and its assessment of habitat integrity. These are:

Ranking: Ranking of the factors that are being evaluated from most important/influential (1) to least important. Ranking does not influence the score outcome directly – it is used to guide the user as to the relative weightings of factors being considered.

Weighting: The relative importance of each factor being assessed needs to be weighted against the other factors, since not all would be important to the same degree. Those factors that ranked as number 1 (highest) should score 100% and other factors must be ranked relative to that.

Rating: The rating value is a score of the degree of impact or change for the factor that is being evaluated. Ratings are normally between 0 (no change) to 5 (most extreme change).

Extent: This concept has been adopted from the more comprehensive WET-Health wetland assessment method (MacFarlane et al, 2007). In this context, the users are required to estimate the approximate percentage of the areal extent of the wetland system which has been impacted by the factor being evaluated.

Impact Score: The product of the Rating and Extent generates the Impact Score. This is in some cases multiplied by the weighting (to generate the Weighted Impact Score) to account for the differential influence of the factors being evaluated.

Confidence: Confidence scores are assigned where impact scores are evaluated by the assessors. The confidence scores provide a means of ranking the confidence in the impact scores; where a low confidence (1) would be where there is derived data and very scarce data, and a high confidence (5) would be where observed information as well as ecological/system knowledge is available .

## *PREPARATION FOR THE FIELD/SITE VISIT (Desktop work)*

Some data collection is recommended prior to the first site visit. This is specifically to aid in the assessment of the Reference State condition, as well as to guide the assessment in terms of intensity and extent of impacts. In particular, aerial photographic or high resolution satellite imagery (such as from Google Earth) is recommended, as often area estimations are difficult to conduct on the ground. This is particularly the case if the landscape is very flat and no suitable vantage point (such as up the side of a steep valley slope) can be found. Often such assessments would be done in conjunction with RHP surveys, and the additional information and expertise available from these up- and downstream assessments should be considered.

### Step 1: Collation of available data

The following information should therefore be obtained prior to the site visit:

- a 1:50 000 map of the area (and catchment if possible);
- Recent aerial photographs OR good quality Google Earth imagery OR other high resolution satellite imagery of the site.
- Land-cover data and/or aerial video survey information should be obtained if available.

In addition, any River Health monitoring data from up- or downstream sites should be collected, since this may provide valuable additional information on other indices (such as fish or invertebrates) which are not examined in the Wetland-IHI. Additional information may also be obtained through the NWRCS database on the condition of upstream river and tributary reaches.

As much information as possible should be also obtained regarding the state of the catchment and types of activities in the catchment area (e.g. prevalence of forestry; location of large dams; hydrological information of the main river system, if applicable).

### Step 2: Delineation of the study area and site selection

Using the maps and aerial photographs or other imagery, the approximate extent of the floodplain or valley bottom wetland should be mapped out. Major breaks between different units can be identified, as for example as been done for Franklin Vlei, a large inland wetland system in KwaZulu-Natal (Figure 2). Four HGM units were delineated in this wetland system, the “breaks” located at significant geological controls (evident from the “pinching” or narrowing of the wetland system at these points). These breaks or “pinches” tend to coincide with changes in the HGM types of the wetland character; such that HGM units 1 and 2 are channellised valley bottom wetland types, HGM 3 is predominantly an unchannelled valley bottom wetland unit and HGM 4 is a meandering floodplain unit.

From these units, either (1) a single representative HGM unit will need to be selected to conduct the field assessment component OR (2) individual field assessments on all three HGM units would need to be conducted if time and available budget/resources permitted this (i.e. assessments on HGM units 1, 2 and 4 – the WETLAND-IHI is not currently suitable for unchannelled valley bottom systems which represents HGM unit 3).

Sites would then need to be selected for the field visit – i.e. access points or vantage points that can be used to obtain an "on-the-ground" view of the condition of the wetland system. Consideration should be given to the ease of accessibility, and the representivity of the sites selected. During the field visit one needs to access and see as much of the wetland system as possible, bearing in mind that only 2 to 3 hours are allocated for the field component of the study.

Remember to take all available maps and imagery to the site when the field visit is conducted. Notes from these visual desktop data sources could be used to make preliminary estimates of the extent and intensity of landuse activities. These estimates must be verified in the field assessment. Additionally, having the maps/imagery of the entire wetland system enables a "bigger picture" view to be maintained when one is visiting only a small section of a large system.

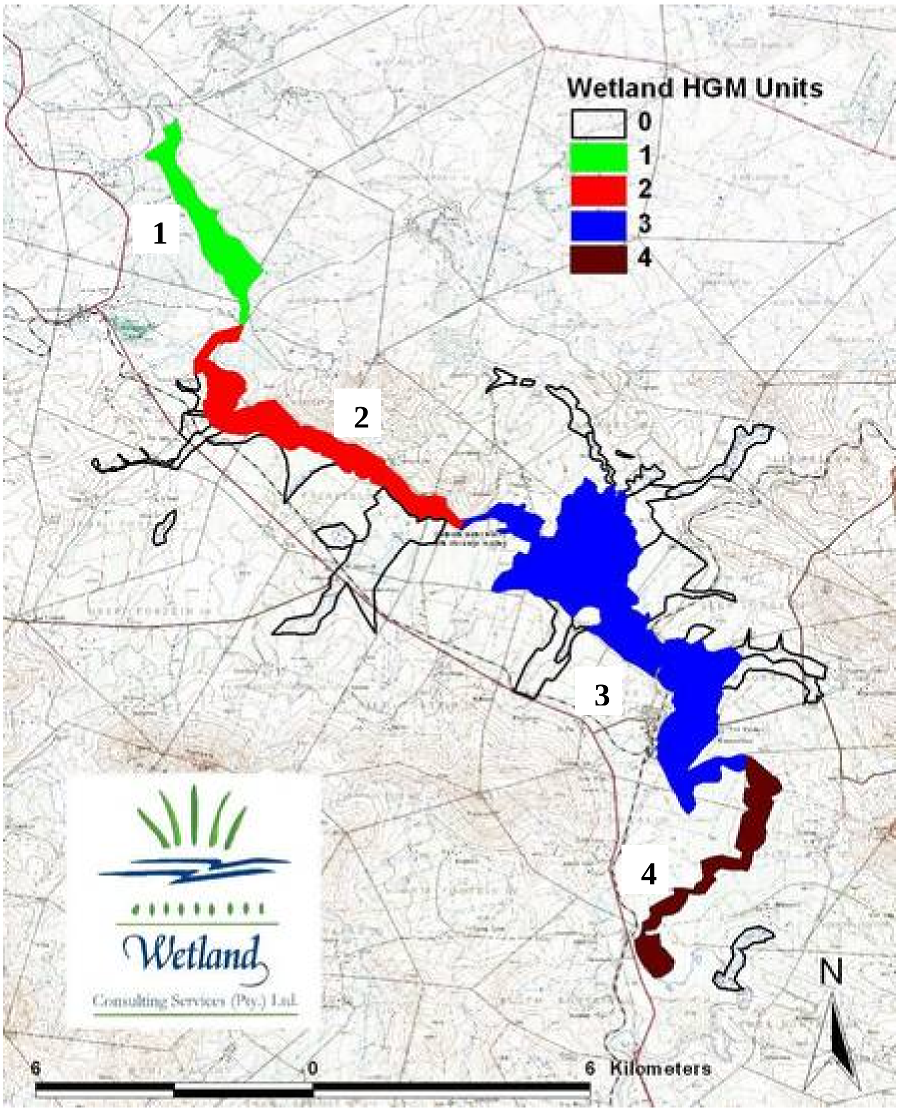



**Figure 2:** The four HGM units identified in the Franklin Vlei wetland system.

## *FIELD ASSESSMENT*

The following steps and information should be assessed and recorded during the site visit (field assessment), using the **WETLAND-IHI field forms**. This field assessment should be completed within approximately 3 hours. The field data are then put into the EXCEL-based WETLAND-IHI model, and this calculates the PES scores for the system.

### General

Following steps 1 through 7 below will provide all the information required to be input into the EXCEL-based WETLAND-IHI model (following the site visit) to derive a PES score for the wetland system being evaluated. To use this model and its data sheets, fill in the shaded cells as follows:

LIGHT YELLOW CELLS: these formula are fixed and can not be altered by the user

BLUE CELLS show recommended values for this component, but these can be altered by experts or when confidence for the new value is high.

WHITE CELLS: Data inputs, or notes and comments, are always required in here.

### Step 1: Site Information

The following information should be provided on the first page of the field forms ("Site Info"):

- Site name;
- Location (GPS co-ordinates);
- The 1:50 000 topo map reference;
- The EcoRegion the site is located in;
- The dominant geology of the site (if available – information can be obtained from 1:250 000 geological series maps);
- The recorder/assessor conducting the WETLAND-IHI assessment; and
- The date of the survey.

It is recommended that a sketch map and notes of the site be made in the space provided. Comments on the access and contact details of the landowner, if applicable, should also be noted.

### Step 2: Classify the wetland type

Step 2 is the second page of the Excel model. Although there are a number of wetland types, at present the WETLAND-IHI model is only designed to evaluate two HydroGeomorphic (HGM) wetland types; namely floodplain and channelled valley bottom wetland types. ***Ensure that the REFERENCE STATE of the system being evaluated is one of these two types!***

To determine the REFERENCE STATE, consider what the site would have looked like in the absence of any on-site and catchment landuse, hydrology, geomorphology and water quality alterations or impacts. In the case of this tool (which is only appropriate for naturally channelled valley bottom and floodplain wetlands), one needs to assess if the valley bottom system was naturally a channelled system under Reference conditions. Unchannelled valley bottoms can occasionally become channelled due to increased peak runoff from rapidly urbanising catchments or through the direct engineering (canalization) activities of landowners. In such cases, examine the floodplain surface and/or aerial photography for evidence of the original channels. Be wary of *extremely* straight channels, as these are often artificially engineered or dredged. If in doubt, source historical aerial photographs or consult regional wetland experts for clarification.

## Step 3: Assess vegetation alteration *(landuse activities)*

An assessment of the proportion of the extents of the landuse activities/changes on (within) the wetland, and a rating of their impacts, is required for this section. The Total Extent must always add up to 100%; thus if there is a site with two types of impact in the same location; score according to the larger impact weighting. *For example, if 10% of the floodplain area has been mined, and vegetation loss has consequently occurred, then for that 10% area of the floodplain only the mining impact is recorded since this is the larger impact rating.*

The rating guidelines provided for the evaluating landuse activities below are guidelines (which can be modified using expert opinion, although notes should be made on the motivation for any alterations). The guidelines are as follows:

| **Mining/Excavation**: | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 5: | Active Open Cast mining of the wetland |
| 3: | Deep (>2m) sand mining or Peat mining |
| 1: | Shallow sand mining |

| **Infilling or backfilling in the wetland (platform construction):** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 5: | Platform never flooded and platform developed (urbanisation) |
| 3: | Infilling used for cultivation |
| 2: | Isolated/sporadic infilling; natural vegetation persists |

| **Vegetation Clearing/Loss/Alteration:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 5: | Dam |
| 3: | Cropping - currently ploughed fields OR grassland to woodland transition |
| 2: | Planted pastures |
| 1: | Historical ploughing OR Heavy grazing |

| **Invasive plants:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 5: | Highly invasive species; excludes native vegetation |
| 3: | Competitive invasive species (including reeds and *Typha*) inhibits reference state vegetation. Terrestrialisation (encroachment of terrestrial species) can also be considered here. |
| 1: | Invasive species have little perceptible effect on native vegetation (*NOTE: remember to consider the effect of drying out the wetland in the case of exotic trees for instance*). |

**Reference State:** assess the proportion of the wetland that is still in the Reference State with regard to vegetation characteristics. To determine the REFERENCE STATE consider the site without any of the previous impacts and without the on-site and catchment hydrology, geomorphology and water quality alterations/impacts. The rating is "0" for the Reference State category. ***A description of the Reference State conditions should be provided in the box provided.***

***THE TOTAL OF THE EXTENTS OF THE VARIOUS LANDUSE ACTIVITIES SHOULD EQUAL 100%.*** *(i.e. the wetland surface area that is: % mined/excavated + % infilled + % vegetation clearing + % invasive plants + % reference state = 100%).*

## Step 4: Assess Hydrological PES

The catchment-scale as well as the altered water regime within the wetland itself is considered.

***At the catchment scale***; the following criteria need to be evaluated and rated:

Changes in flood peaks and/or frequencies:
Evaluate the changes in peak (flood) flows from the catchment (assessing the impacts of large dams; farm dams and/or catchment hardening). Consider if there have been any likely increases (Is there catchment hardening (urbanisation) in the catchment?) decreases (Are there many small dams, or a very large dam, upstream of the wetland?) in flood peaks and/or frequencies.

Rate the changes in the catchment which may be affecting flood peaks as follows:

| **Changes in flood peaks and/or frequencies:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| -5: | Large dam immediately upstream with no allowance for high flow releases; nor any tributaries between the dam and the wetland to reinstate some of the flows. |
| -2: | Numerous small (earthern) farm dams for irrigation, but no large dams |
| 0: | No change from Reference |
| +1: | Heavy, extensive grazing in the catchment |
| +2: | Peri-urban catchment (smallholdings/plots) or small interbasin transfer scheme. |
| +5: | Entirely urbanized catchment, or large interbasin transfer scheme. |

Changes in base flows:

Evaluate the changes in base flows from the catchment (assessing the impacts of abstractions; interbasin transfers). Liaise with local experts and/or regional DWAF staff for catchment information. Consider if there have been any likely increases (are there any interbasin transfers; sewage return flows; releases of elevated flows to cater for irrigation; suburban water contributions in the catchment?) or decreases (is there extensive abstraction for irrigation, or extensively afforested areas, upstream of the wetland?) in base flows of the system.

Rate the changes in the catchment that are affecting base flows as follows:

| **Changes in base flows:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| -5: | More than 50% reduction in baseflow (from abstractions/transfers) |
| -2: | Moderate levels of irrigation/abstraction |
| 0: | No change from Reference |
| +2: | Introduction of indirect flows from upstream suburban areas |
| +5: | More than doubled the baseflow (e.g. large interbasin transfer; sewage return flows) |

Changes in seasonality:

Evaluate the changes in seasonality of flow as a result of any upstream developments. Consider the effect of attenuation of early wet season flows due to dams (large or numerous small farm dams) as well as any altered seasonality as a result of abstraction for irrigation, or high flow releases during the dry season. Rate the changes as follows:

| **Changes in seasonality:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 2: | Moderate alteration (e.g. delayed floods; higher base flows). |
| 5: | Complete switch in seasonality of flows (can occur in highly regulated systems used for irrigation). |

Change in the occurrence/duration of zero flow periods:

Evaluate the changes in the occurrence and/or duration of zero flow periods as a result of any upstream developments/activities. Consider the effects of forestry, dams (large or numerous small farm dams) and abstraction for irrigation. Rate the changes as follows:

| **Changes in occurrence/duration of zero flow periods:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 2: | Seasonal system with increased duration of zero flows |
| 5: | Formerly perennial system with long zero flows |

The weighting of the Zero Flow factor should be adjusted according to the reference state conditions (if it was seasonal, down-weight to 10%, but if it was perennial, increase the weighting up to 50%).

***Within the wetland***, several factors can influence the way in which water occurs in or on the wetland. Again the intensity (rating) and extent (5) of the impact need to be recorded. The total extent must therefore always be 100%, since this is a description of the entire floodplain extent. If there is a site with two types of impact in the same location; score according to the larger impact rating.

The "within-wetland" factors are evaluated as follows:

Connectivity - altered channel size/competency:
Channel competency is usually increased as a result of engineering and/or as a result of erosion in the channel. This results in larger flows being contained within the channel, and fewer flows extending out of the channel on to the floodplain. This can be achieved by deepening and/or widening the channel; channel straightening and/or levee construction along the channel edge. These changes should be evaluated relative to the reference state of the system. Rate according to the following criteria:

| **Connectivity - altered channel size/competency:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 3: | Channel competency (width and/or depth) has increased by 100%. |
| 5: | Channel is so incised that no flows ever overtop. |

The weighting of the Channel Competency factor can be adjusted according to the sandy (100%) versus clay (80%) nature of floodplain sediments, since this influences the channel-floodplain connectivity and hence susceptibility to drying out in the event of increased channel competency.

Increased water retention on the floodplain:
Dams and other structures on the floodplain can, in the areas affected, increase the period of time that water remains on the floodplain. Rate, and assess the extent of the impact, according to the following guidelines:

| **Increased water retention on the floodplain:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 2: | Shallow dam; emergent vegetation still present |
| 5: | Dam >2m deep, no emergent vegetation possible |

Decreased water retention on the floodplain:
Drains (ditches/dongas/gullies) can, in addition to increasing the competency of the main channel, also remove water from the floodplain more rapidly than would have occurred under Reference Conditions. Rate, and assess the extent of the impact, according to the following guidelines:

| **Decreased water retention on the floodplain:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 2: | Some drains/ditches present, but flow capture and removal is ineffective |
| 5: | Drains/ditches/dongas/erosional gullies have been constructed to capture most flows and remove water rapidly from the floodplain. |

**Reference State:** The proportion of the wetland system which still experiences Reference State wetting patterns should also be recorded. To determine the REFERENCE STATE consider the site without any of the previous impacts and without the on-site and catchment hydrology alterations/impacts. The rating is “0” for the Reference State category.

***If the weighted value of the "within-wetland effects" for Hydrology exceeds 3.5, then a threshold value is exceeded and this affects the overall PES score. This is to ensure that where wetlands are highly degraded due to on-site impacts, the resultant scores are not masked by possible good catchment conditions***

## Step 5 Assess Geomorphological PES

Floodplain and valley bottom wetlands are low energy, depositional environments. The accumulation of sediment in conjunction with the presence of water creates the conditions for wetland development and persistence. Increases in the energy of the environment, or decreases in sediment supply, can create conditions that do not favour wetland persistence.

The geomorphological processes are considered at catchment-scale as well as within the wetland itself.

***At the catchment scale***; the alteration to the balance between sediment supply (deposition) and sediment transport (erosion energy) needs to be evaluated and rated:

Changes in Sediment Budget:
The interaction between sediment supply and the sediment transport capacity of a section of a drainage line is the driving geomorphological process responsible for wetland formation. Wetlands occur on areas where, over the long (decadal to century) scale, sediment supply exceeds sediment transport capacity; such that a depositional environment results due to the imbalance. In contrast, bedrock gorges, for instance, occur in areas where the sediment transport capacity far exceeds the sediment supply level, creating net erosive conditions.

The interaction between these two suites of processes should be evaluated according to the table provided. Using this table the effects of sediment supply and transport capacity can be assessed as follows:

| **Changes in Sediment Supply:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| +10: | Most extreme increase possible - a burst sediment-laden dam immediately upstream of the wetland system. |
| +6: | Extensive catchment-wide degradation causing a more than 2x increase in sediment delivery to the wetland. |
| +3: | Moderate catchment degradation causing increased sediment delivery to the wetland. |
| +1 | Low to moderate catchment degradation causing increased sediment delivery to the wetland (gullying/cattle paths/bank erosion in the upstream areas) |
| 0 | No change from Reference |
| -1: | Low to moderate reduction in sediment supply through sediment trapping in |

| | |
|---|---|
| | small weirs |
| -3: | Moderate reduction in sediment supply through sediment trapping in small dams (but upstream tributary influences ameliorates the impact) |
| -6: | Large reduction in sediment supply through sediment trapping in very large dams |
| -10: | Most extreme decrease possible - a large dam immediately upstream of the wetland with no tributaries to introduce sediment. |

*Sediment Transport Capacity:*

| **Changes in Sediment Transport Capacity:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| +10: | Most extreme increase possible - interbasin transfers with sustained high flows and very large peak flow increases, or a very highly urbanised catchment with no flow attenuation abilities |
| +6: | Moderately urbanised, or moderate increase in peak flows. |
| +3: | Some urbanisation, or small interbasin transfer, or dam releasing higher frequency of high flows. |
| 0 | no change |
| -1: | Small-scale abstraction. |
| -3: | Moderate reduction due to dams, but tributary influences may restore some high flows. |
| -6: | Large reduction due to large dams and removal of peak flows |
| -10: | Most extreme decrease possible - large dam removes all high flows (e.g. flow diversion). |

***A single score, to account for the interaction between the two factors, must then be derived from the table provided in the model.***

***Within the wetland***, depositional and erosional processes can usually be identified; which are often responding to the upstream catchment changes. These "within-wetland" factors are evaluated as follows:

Erosional Processes:

The impact of erosional processes (evidence of gullies/dongas; presence and extent of overgrazing or ploughing; and decreased veg robustness and/or cover) across the floodplain should be evaluated as follows:

| **Erosional Processes:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 1: | Grazing but no erosional dongas/gullies; and/or Ploughing (<50% of the floodplain) but no erosional dongas/gullies |
| 3: | Some erosion dongas; or incised main channel (cut/vertical banks on both sides of the channel for more than 80% of the length of the channel), but no other headcuts into the floodplain |
| 5: | Extensive donga formation (>5m deep) and associated threat of erosion across the whole floodplain. |

If donga formation appears to be rapid, it is recommended that the provincial Working for Wetlands representatives be contacted to notify them of the problem. Dongas lower the local water table, resulting in desiccation of the adjacent wetland areas, as well as higher energy flow paths through the wetland.

Depositional Processes:

The impact of depositional processes should be assessed. Look for evidence of new sediment deposition (look at the banks opposite cut banks); alluvial fans; increased vegetation robustness and/or cover (e.g. recent extensive expansion of *Phragmites*) across the floodplain. These impacts should be rated as follows:

| **Depositional Processes:** | |
|---|---|
| ***Rating Score*** | ***Description of the type of impact at the site*** |
| 0: | No change from Reference |
| 1: | Increased vegetation robustness (e.g. grassland to reeds/Typha); herbaceous to trees (score 1.5) |
| 3: | Alluvial depositional features extend over more than 50% of the floodplain |
| 5: | Recent deposition of more than 50 cm across most (>80%) of the floodplain (can be associated with European settlement and associated clearing of slopes and/or urbanization). Examine any cut banks for evidence of this process. |

***If the weighted value of the "within-wetland effects" exceeds 3.5, then a threshold value is exceeded and this affects the overall PES score. This is to ensure that where wetlands are highly degraded due to on-site impacts, the resultant scores are not masked by good catchment conditions.***

## Step 6: Assess Water Quality PES

Due to time and budget constraints, the water quality assessment module in the WETLAND-IHI is an "add-on" that was adapted from the Riverine IHI's Physico-Chemical module (Kleynhans et al, 2007). This module may require further refinement in future.

Seven components of water quality are assessed in the module, namely:

- pH;
- Salts;
- Nutrients;
- Water Temperature;
- Turbidity;
- Oxygen, and
- Toxics.

The assessor is required to consider how these various components of water quality is likely to have changed as a result of a variety of impacts/activities in the catchment, or as suggested through indicators of water quality change, namely:

- Modified flow conditions
- Inundation by weirs

- Inundation by dams
- Effluent from urban areas
- Effluent from cultivation (agricultural activities; return flows)
- Effluent from Industries
- Effluent from Mining
- Instream plants (macrophytes) & algae (incl. blue-green)
- Forestry
- Roads & crossings
- Invasive riparian vegetation
- Riparian vegetation removal
- Bed disturbance: Bull dozing, sand mining, etc.
- Bank disturbance: vegetation removal, artificial covering.
- Solid waste disposal (rubbish disposal)

The assessors are required to assign an impact rating (-5 to +5) in each of the white boxes on the data sheet, reflecting the change in the particular water quality component (pH, Salts, Nutrients, Water Temperature, Turbidity, Oxygen or Toxics) associated with each landuse activity (as listed above). Some combinations are not required to be assessed as there are no likely perceived impacts relating to wetland systems. In these cases, the boxes are hatched and shaded out.

## Step 7: Assess Overall PES score

Once all the data have been collected, the relative importance of the driving processes versus on-site impacts can be adjusted, dependent on the location of the wetland.

**Weighting Water Quality**

In general, many wetland biota are well-adapted to widely varying water quality conditions because of the stagnant, low-oxygen conditions that can naturally develop in wetland environments. Thus the Overall PES score assigns a low weight to the water quality PES, in part due to these factors and also to account for the rapid, low confidence manner in which water quality is being addressed.

In the case of nutrient-poor wetland systems (such as in the Western Cape) which are highly sensitive to increased nutrient loads and other water quality impacts, the weighting should be increased to reflect this sensitivity.

**Weighting Vegetation Change ("on-site" landuse impacts)**

Wetlands in the upper catchment areas should have on-site impacts rated higher than those lower down in the catchment; since the importance of the on-site impacts would diminish going downstream (i.e. as the catchment gets bigger).

## 3. FIELD FORMS FOR THE WETLAND-IHI

| | |
|---|---|
| Site name: | |
| Location (GPS co-ordinates): | |
| 1:50 000 topo map reference: | |
| EcoRegion: | |
| Geology (if available): | |
| Recorder: | |
| Date: | |

| Notes and/or Sketch of the site |
|---|
| |

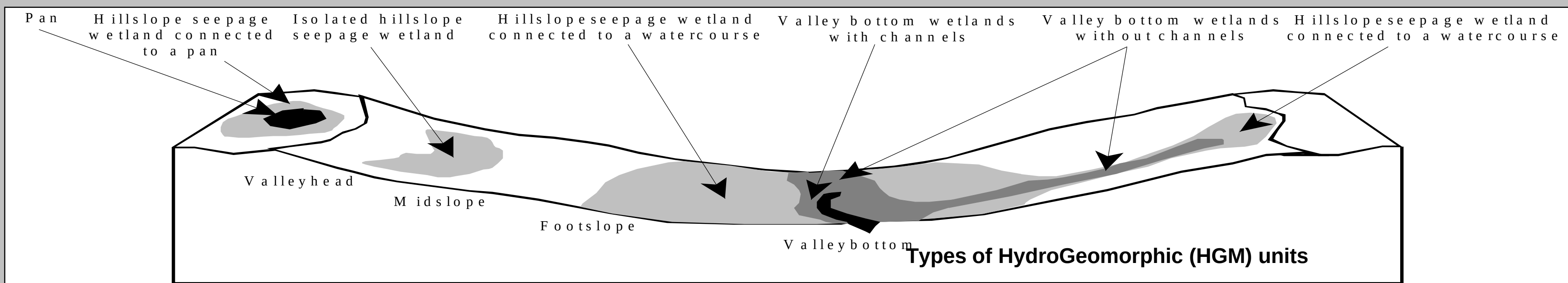
| WETLAND CLASSIFICATION | | | | |
|---|---|---|---|---|
| Level I | Level II | | | Level III |
| System | EcoRegion | Dominant Geology | Landscape Position/ Setting | HydroGeomorphic Unit |
| INLAND | Data on EcoRegions is available from the National Spatial Biodiversity Assessment, 2004. A map of South African EcoRegions is provided in the manual. | Data on geology can be obtained from the regional 1:250 000 (or better) geological series maps. | Valley Bottom | River |
| | | | | Lake |
| | | | | Unchannelled Valley Bottom |
| | | | | Channelled Valley Bottom |
| | | | | Meandering Floodplain |
| | | | Slopes | Seepage (isolated) |
| | | | | Seepage (connected) |
| | | | Crest | Seepage (connected) |
| | | | | Pan |

**This model (WHI) is designed for the RAPID assessment of floodplain and channeled valley bottom wetland types, for the purposes of determining the PES.**

**PES (Present Ecological State) is an indication of the current ecological state of the wetland, relative to its Reference (natural) State - i.e. the deviation from the historic/pre-development condition of the wetland.**

| | |
|---|---|
| *Type of wetland system:* | |
| *Confidence in the assessment (1-5)* | |

**This current model is only designed for floodplains and channeled valley bottoms.**




**Types of HydroGeomorphic (HGM) units**

**VEGETATION ALTERATION - the impacts of landuse activities *within* the wetland on the vegetation of the wetland**

Estimate the impact **RATING** (0-5) and aerial **EXTENT** (0-100 %) of the various landuse activities on the wetland system

| **Landuse Activities on the wetland** | **Ranking** | **Rating (0-5)** | **Extent (0-100%)** | ***Confidence Rating (1-5)*** | ***Notes (describe the details of impacts here)*** |
|---|---|---|---|---|---|
| Mining/Excavation | 1 | | | | |
| Infilling/Backfilling | 2 | | | | |
| Vegetation Clearing/Loss/Alteration | 3 | | | | |
| Weeds or Invasive plants | 4 | | | | |
| **Percentage in Reference State** | 6 | 0 | | | |
| | **Total Extent: (MUST equal 100%)** | | | | |

**Reference State :** this is what the site would have looked like without the landuse activities and without the on-site and catchment hydrology, geomorphology and water quality alterations/impacts which have occurred.

**Description of the Reference State:**

## HYDROLOGY

| *Catchment Effects* | Weighting (0-100%) | Rating | *Confidence Rating (1-5)* | *Notes* |
|---|---|---|---|---|
| | | | | |
| Changes in flood peaks/frequencies | ***100*** | | | |
| Changes in base flows | ***60*** | | | |
| Changes in seasonality | ***60*** | | | |
| Zero flows | 10 | | | |

| *Within-wetland Effects* | Rating | Extent (0-100%) | *Confidence Rating (1-5)* | *Notes* |
|---|---|---|---|---|
| | | | | |
| Connectivity - altered channel size/competency | | | | |
| Increased water retention on the floodplain | | | | |
| Decreased water retention on the floodplain | | | | |
| Reference State conditions | 0.0 | | | |
| **Total Extent: (MUST equal 100%)** | | | | |

## Assessing Catchment Effects

| | |
|---|---|
| **Changes in flood peaks** | |
| INCREASE? Is there catchment hardening (urbanisation) in the catchment? | large increase / moderate increase / small increase / no change |
| DECREASE? Are there many small dams, or a very large dam, upstream of the wetland? | None / Few / Many |
| **Changes in base flow** | |
| INCREASE: are there any interbasin transfers, or releases of elevated flows to cater for irrigation? | large increase / moderate increase / small increase / no change |
| DECREASE: is there extensive abstraction for irrigation, or extensively afforested areas, upstream of the wetland? | large decrease / moderate decrease / small decrease / no change |

## GEOMORPHOLOGY

| *Catchment effects* | *Confidence Rating (1-5)* | *Notes* |
|---|---|---|
| **Change in SEDIMENT BUDGET: Calculated using the SEDIMENT BUDGET guidelines and table provided below** | | |

### SEDIMENT BUDGET

**If you don't know the answer, leave the cell blank**

| **Increases in sediment supply** | ***Change?*** | **Increase in sediment transport capacity** | ***Change?*** |
|---|---|---|---|
| Can you see evidence of extensive active erosion in the catchment? | large increase / moderate increase / small increase / no change | Have flood peaks increased due to catchment hardening? | large increase / moderate increase / small increase / no change |
| Is there active bank erosion of the channel in the wetland? | large increase / moderate increase / small increase / no change | Has an interbasin transfer scheme increased the erosive capacity of the flow? | large increase / moderate increase / small increase / no change |
| Are there many dirt roads in the catchment, and/or are the hillslopes under cultivation? | None / Few / Many | Have releases from upstream dams *increased* the erosive capacity of the flow? (e.g. sustained high flow releases below very large dams) | large increase / moderate increase / small increase / no change |
| Have any upstream dams or weirs been breached, causing an increase in sediment supply? | large increase / moderate increase / small increase / no change | Has the capacity of the channel been increased by, for example, levee construction along the channel edges, or channel deepening/widening and/or straightening? | large increase / moderate increase / small increase / no change |
| Has the vegetation cover of the catchment decreased for any reason? | large decrease / moderate decrease / small decrease / no change | | |
| **Decreases in sediment supply** | | **Decrease in sediment transport capacity** | |
| Is sediment being trapped by dams or weirs upstream of the wetland? | large decrease / moderate decrease / small decrease / no change | Has the frequency and/or size of floods been reduced by an upstream dam? | large decrease / moderate decrease / small decrease / no change |
| If there are upstream dams, are there any major tributary confluences between the dam and the wetland system that could introduce replace some sediment? | None / Few / Many | Has there been a decrease in flow due to diversions from the upstream channel? | large decrease / moderate decrease / small decrease / no change |
| Are there weirs or causeways or other obstructions across the channel, upstream of the wetland, which would trpa sediment? | None / Few / Many | | |
| Has there been sediment mining in any areas? | None / Few / Many | | |
| Has there been an increase in the catchment vegetation cover? | large increase / moderate increase / small increase / no change | | |
| **Given the above, to what extent do you think the sediment supply to the wetland has changed? (-10 to +10)** | | **Given the above, to what extent do you think the transport capacity in the wetland has changed? (-10 to +10)** | |

| *Within-wetland Effects* | **Rating (0-5)** | *Confidence Rating (1-5)* | *Notes* |
|---|---|---|---|
| Erosional features | | | |
| Depositional features | | | |

| | Confidence (1-5) | | CONSIDER THE IMPACT OF THESE ACTIVITIES ON WATER QUALITY: | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modified flow conditions | Inundation: Weirs | Inundation: Dams | Effluent: Urban areas | Effluent: Cultivation (agricultural activities; return flows) | Effluent: Industries | Effluent: Mining | Instream plants (macrophytes) & algae (incl. blue-green) | Forestry | Roads & crossings | Invasive riparian vegetation | Riparian vegetation removal | Bed disturbance: Bull dozing, sand mining, etc. | Bank disturbance: vegetation removal, artificial covering. | Solid waste disposal (rubbish disposal) |
| **Water Quality Components** | | **pH** | X | X | X | | | | | | | X | | X | X | X | X |
| | | **Salts** | | | | | | | | X | X | X | X | X | X | X | X |
| | | **Nutrients** | | | | | | | | | X | X | X | | X | X | X |
| | | **Water Temp.** | | | | | X | | | | X | X | | | X | X | X |
| | | **Turbidity** | | | | | | | | | | | | | | | X |
| | | **Oxygen** | | | | | | | | | X | X | X | X | X | X | |
| | | **Toxics** | X | X | X | | | | | | X | | X | X | X | X | |

***Notes***

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | Notes (if the weightings are adjusted, please provide justification here |
|---|---|---|---|---|
| | **Ranking** | ***Recommended Weighting*** | **Weightings (if adjusted)** | |
| **DRIVING PROCESSES:** | | **100** | | |
| Hydrology | 1 | 100 | | |
| Geomorphology | 2 | 80 | | |
| Water Quality | 3 | 30 | | |
| **WETLAND LANDUSE ACTIVITIES:** | | **80** | | |
| Vegetation Alteration Score | 1 | 100 | | |
| Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)* | | | | |

# 4. REFERENCES

Brinson, M. M. 1993. A hydrogeomorphic classification for wetlands. Wetlands Research Program Technical Report WRP-DE-4. U. S. Army Corps of Engineers, Waterway Experiment Station. Vicksburg, MS: Bridgham and Richardson.

Bullock, A., K. Gilman, M. McCartney, D. Waughray, K. Blyth and A. Andrews. 1998. Hydrological strategy to develop and manage African wetland resources for sustainable agricultural use IN Wetland Characterization and classification for sustainable agricultural development, Food and Agriculture Organization of the United Nations (FAO), Sub-Regional Office for East and Southern Africa (SAFR), Harare.

Department of Water Affairs and Foresty, 2006. Achievements of the River Health Programme 1994-2004: a national perspective on the ecological health of selected South African Rivers. Joint publication from DWAF and DEAT, Pretoria, South Africa.

Department of Water Affairs and Forestry, 2005. A practical field procedure for identification and delineation of wetland and riparian areas. DWAF, Pretoria.

Dini J. and G. Cowan. 2000. Classification System for the South African Wetland Inventory. Second Draft, June 2000. South African Wetlands Conservation Programme, Department of Environmental Affairs and Tourism, Pretoria.

Dini J., G. Cowan and P. Goodman. 1998. South African National Wetland Inventory. Proposed Wetland Classification System for South Africa. First Draft, August 1998. South African Wetlands Conservation Programme, Department of Environmental Affairs and Tourism, Pretoria.

Ellery, W.N., D.C. Kotze, T.S. McCarthy, H. Beckedahl, N. Quinn and L. Ramsay. 2005. The Origin and Evolution of Wetlands. Water Research Commission Report, (*draft*).

Ewart-Smith, J.L., DJ Ollis, J.A. Day and H.L. Malan. 2006. National Wetland Inventory: development of a wetland classification system for South Africa. WRC Report No. KV 174/06.

Faulkner, S.P. and C.J. Richardson. 1989. Physical and chemical characteristics of freshwater wetland soils. pp. 41-72. In: Hamner, D.A. (ed.), Constructed Wetlands for Wastewater Treatment. Lewis Publishers. Chelsea, MI.

Finlayson, C.M. and A.G. Spiers (eds) 1999. Global review of wetland resources and priorities for wetland inventory. Supervising Scientist Report 144, Supervising Scientist, Canberra.

Finlayson CM, Begg GW, Howes J, Davies J, Tagi K and Lowry J. 2002. A Manual for an Inventory of Asian Wetlands: Version 1.0. Wetlands International Global Series 10, Kuala Lumpur, Malaysia.

http://www.epa.gov/OWOW/wetlands/science/hgm.html ; United States Environmental Protection Agency website; accessed May, 2007.

Johnson, J. B. 2005 Hydrogeomorphic Wetland Profiling: An Approach to Landscape and Cumulative Impacts Analysis. EPA/620/R-05/001. U.S. Environmental Protection Agency, Washington, D.C.

Johnston, C.A. 1991. Sediment and nutrient retention by freshwater wetlands: Effects on surface water quality. Crit. Rev. Environ. Control 21:491–565

Jones, M.G.W. 2002. Developing a Classification System for Western Cape Wetlands. M.Sc. thesis, University of Cape Town.

Jones, M.G.W. and J.A. Day, 2003. A Field Classification System for the Wetlands of the Western Cape. Freshwater Research Unit, University of Cape Town.

Kleynhans, C.J. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River. Journal of Aquatic Ecosystem Health 5: 41 - 54.

Kleynhans, C.J. 1999. A procedure for the determination of the ecological reserve for the purposes of the national water balance model for South African Rivers. Institute for Water Quality Studies. Department of Water Affairs and Forestry, Pretoria.

Kleynhans, CJ, C. Thirion, and J. Moolman. 2005. A Level I EcoRegion classification system for South Africa, Lesotho and Swaziland. Report No: N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kleynhans, C.J and M.D. Louw. 2007. Module A: EcoClassification and Ecostatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC report (in press).

Kleynhans, C.J., M.D. Louw and M. Graham. 2007. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Manual for the Index of Habitat Integrity. WRC Report.

Kotze, D.C., Marneweck, G.C., Batchelor, A.L, Lindley, D.S. and Collins, N.B. 2005. A rapid assessment procedure for describing wetland benefits. Mondi Wetland Project.

Kuenzler, E.J. 1989. Value of forested wetlands as filters for sediments and nutrients. In Hook, D.D. and R. Lea. 1989. Proc. Symposium: The Forested Wetlands of the Southern United States, USDA Forest Service General Technical Report SE-50. Asheville, NC.

Lowrance, R.R., R.L. Todd, J. Fail, Jr., O. Hendrickson, Jr., R. Leonard, and L. Asmussen. 1984. Riparian forests as nutrient filters in agricultural watersheds. Bioscience 34:374–377.

Marneweck, G.C. and Batchelor, A. 2002. Wetland inventory and classification. *In*: Ecological and economic evaluation of wetlands in the upper Olifants River catchment. (Palmer, R.W., Turpie, J., Marneweck, G.C and Batchelor (eds.). Water Research Commission Report No. 1162/1/02.

Ramsar Convention, 2002. The Ramsar Strategic Plan 2003-2008, Ramsar Convention on Wetlands http://www.ramsar.org/key_strat_plan_2003_e.htm.

Rountree, M.W. and A.L. Batchelor (*in prep*). A proposed wetland classification system for Southern Africa.

Rowntree, K. and L. du Preez (*in prep*). MODULE B: Geomorphology Driver Assessment Index (GAI), in RIVER ECOCLASSIFICATION: MANUAL FOR ECOSTATUS DETERMINATION (Version 2). Joint DWAF/WRC report.

Semeniuk CA and Semeniuk V (1995). A geomorphic approach to global classification for inland wetlands. *Vegetatio* 118: 103–124.

Smith, R.D., Amman, A., Bartoldus, C. and Brinson, M.M. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Tiner R.W. 1999. Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping. Lewis Publishers, Boca Raton.

Tiner R.W. 2003. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. US Fish & Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA, USA.

Uys, M. 2004. Development of a method for the assessment of wetland ecological integrity in South Africa, Phase 1: Situation Assessment. Report for The Department of Water Affairs and Forestry, Resource Quality Services.

# 5. APPENDIX I: RESULTS FROM TESTING

Testing of the draft WETLAND-IHI was undertaken in two phases.

**Phase I** assessed the sensitivity of a preliminary model and identified areas which needed further refinement. This phase was undertaken as a desktop assessment between 4 groups of specialists. Two sites were assessed. The results

| | **Franklin Vlei** | | **Klip River tributary, Soweto** | |
|---|---|---|---|---|
| | **Score** | **Class** | **Score** | **Class** |
| Group 1 | 1.6 | C | 2.5 | D |
| Group 2 | 1.6 | C | 4.0 | E/F |
| Group 3 | 1.7 | C | 3.2 | E |
| Group 4 | 1.2 | C | 3.9 | E/F |

These results indicated that more guidance was required when assessing highly impact sites (such as the Klip River site). These findings were incorporated in to the model and guidelines before the Phase II field testing was undertaken, and have been incorporated into the final model.

**Phase II** comprised field-based assessments of the subsequent draft model that was developed after Phase I. Field testing was undertaken by regional experts in Gauteng; Mpumalanga; KwaZulu-Natal; Limpopo; the Eastern Cape and the Western Cape. These results generally demonstrated extremely good correlation between the independent testers at each site being evaluated (refer to the table below for detailed field testing results). The various testers all scored within half a category of each other for the various sites, and at all sites except one, the difference in scores between users was less than 6%. The exception was in the Eastern Cape, where the WETLAND-IHI was applied to an estuarine floodplain system. At this site, differences in the assessment of the hydrological driver condition between the two testers caused a large (15%) difference in scores. This as due to differential understanding of the driver conditions at this site. Even so, the overall scores differed by only half a category (C versus a C/D).

# 6. APPENDIX II: BACKGROUND TO THE DEVELOPMENT OF THE WETLAND-IHI

Wetlands are amongst the most impacted and degraded of all ecological systems, and global assessments indicate that the majority of remaining wetlands are degraded or under threat of degradation (Finlayson and Spiers, 1999).

South Africa is a contracting party to the Ramsar Convention on Wetlands and therefore has an obligation to promote the conservation and wise use of wetlands. The assessment and monitoring of wetland condition is an important component in the wise use of wetlands, as recognised in the Ramsar Strategic Plan 2003-2008 (Ramsar Convention, 2002).

**What is a wetland?**

A wetland is "*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).

Wetlands are essentially an expression of the presence of surface or near- surface water in the landscape. This water can either be static (e.g. pans) or slowly moving through the landscape. The source of the water can include surface flow, interflow (water flowing through the soil profile), groundwater (including deep and/or perched groundwater) and direct rainfall, or any combination of these. Whatever the source, the water must be present for long enough to influence both the soil properties as well as the vegetation. In practice, the wetland boundary is defined as the position in the landscape where hydric indicators occur in the soil within 0.5m of the surface (DWAF, 2005). Where these hydric indicators are deeper than 0.5m, they generally no longer continue to support wetland adapted plants. This point traditionally forms the boundary between upland adapted and wetland adapted plant species.

In South Africa, the Department of Water Affairs and Forestry (DWAF) is the custodian of the nation's water resources, including wetlands. The DWAF is mandated through the National Water Act (Act 36 of 1998) to ensure the *conservation, protection and sustainable utilisation of aquatic ecosystems*. For effective implementation of the National Water Act, but also for a wider range of activities such as conservation planning and management, it is important that the ecological condition (also referred to as the ecological "health" or integrity) of a given wetland be determined.

Specifically in terms of monitoring, the National Water Act requires the Minister to establish national monitoring and information systems that acquire, record, assess and disseminate information on water resources.  DWAF: Directorate Resource Quality Services (RQS) houses several water resource monitoring programmes, of which one is the National Aquatic

Ecosystem Health Monitoring Programme (NAEHMP). The mission of the Directorate Resource Quality Services is to provide the national water resource management function with resource quality information. This resource quality information is necessary for addressing the strategic and operational requirements for the assessment, reporting and protection of water resource quality

Initially, the NAEHMP monitoring was focussed on riverine systems through the River Health Programme (RHP). However, the broader focus of the programme is to monitor the integrity of all aquatic ecosystems, including South Africa's wetlands. The development of a wetland assessment tool is thus the first step in developing a wetland monitoring sub-programme. In the context of wetland ecosystems, the objectives of the NAEHMP are:

- To measure, assess and report on the ecological state of aquatic ecosystems;
- To detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems;
- To identify and report on emerging problems regarding aquatic ecosystems; and
- To ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

The long term vision of the NAEHMP is to implement, maintain and improve biomonitoring of all inland aquatic ecosystems (including wetlands) in South Africa (DWAF, 2006). The development of an assessment tool for wetland systems, which is the focus of this study, is a first step to achieving that vision for wetlands.

Other aspects of the National Water Act also require standardised, nationally applicable wetland assessment methods. Environmental water requirements (Ecological Reserve) need to be determined for all significant water resources in the country (including wetlands) and Resource Quality Objectives (aims or targets) must be set for these systems. A standard wetland assessment method is thus required to determine the ecological condition of wetlands for this aspect of the Act to be implemented. Previous work undertaken on behalf of DWAF (Uys, 2004) had noted that, in general, methods for the rapid determination and monitoring of wetland health/integrity were poorly developed. For the development of methods to determine the Reserve for wetlands, it is necessary to address the lack of a standard approach to the assessment of the ecological character and biological condition of wetland systems.

## *Wetland Assessments*

Wetlands play a variety of roles in the landscape, including biodiversity functions, water quality improvement, stormwater attenuation and sediment trapping (Lowrance et al, 1984; Kuenzler, 1989; Faulkner and Richardson, 1989; Johnston, 1991). Although an overall assessment of wetland health should therefore ideally incorporate all the range of functions and attributes, in theory this is often impractical and may not be necessary to meet the required information needs. Assessment methods may therefore be separated into three main groups (Uys, 2004), namely:

1) *Functional Assessments.*
   These are used to evaluate wetland functional (primarily abiotic) processes. Such assessments can be used to evaluate the impacts posed by potential

developments, and could thus be used to evaluate altered goods and service delivery by the wetland.

2) *Biotic Assessments (Bioassessments).*
Bioassessments are evaluations of the biological condition of a wetland using surveys of the structure and function of the community of resident biota, normally evaluated by comparing the present assemblage of biota to the "natural", pre-impacted assemblage.

3) *Habitat Assessments.*
These provide information on the quality, quantity and suitability of the physical environment that supports the biota.

Although some functional assessments of wetlands have been developed for South African wetland systems (e.g. Kotze et al., 2006), the functional attributes and values of wetlands remain difficult to ascribe categorically. For example, in the case of hydrological functions, wetlands can variously have positive, neutral or negative impacts upon baseflow augmentation (Bullock *et al*., 1998).

Uys (2004) focussed on biological indices in a review of international methods for assessing wetland integrity. Biological indices, whilst relatively easy to apply, only account for a small component of the functions of wetlands (i.e. their biodiversity functions within the landscape), and do not explicitly evaluate other wetland functions. Biological assessments cannot be used in isolation, since the biota present in a wetland system are strongly correlated with, and heavily dependent on, the quality of the available physical environment (habitat). Low bioassessment scores could thus purely reflect poor-quality natural available habitat rather than any water quality or quantity impacts from the catchment. Within the ecosystem evaluation framework therefore, habitat assessment is often used alongside bioassessment, to provide information on quality, quantity and suitability of the physical environment supporting the biota being measured. The use of these two approaches in tandem provides an effective means of interpreting biotic data, which may otherwise be misleading (Water Research Commission, Wetland Research, April 2002). In the NAEHMP (formerly River Health Programme), similarly a combination of biotic and habitat assessment methods are used to address this limitation.

In this study, the focus was on the development of a habitat assessment index for wetlands.

## *Objective of the study*

The objective of this study was to develop a wetland habitat integrity index for floodplain and channelled valley bottom wetlands, so that such an index could be used to assess and determine the ecological condition (Ecostatus) of wetland systems. It is envisaged that, ultimately, such an index will be used in conjunction with biological and functional assessment indices, and this will allow for an assessment of overall wetland health (thus accounting for functional, biological and habitat characteristics of wetlands). Although the scope of this study is limited to the development of the Wetland Habitat Index, the design of the index is such that it is consistent with current EcoStatus assessment tools used by DWAF. This will allow for rapid training of personnel already familiar with other EcoStatus tools whilst also allowing for the incorporation of assessment tools/indices to be incorporated as they become available (as with the DWAF River Ecostatus tools, which are a suite of habitat and biotic indices).

In particular, the tool that was developed needed to be an impact-based index to assess wetland habitat integrity. As such, some assessment of the functional attributes of the wetland in question would be required (in order to identify the type and extent of impacts in the wetland), but such functional assessments must be relatively simple assessment techniques that can be applied rapidly in the field (2 to 3 hours per wetland being assessed) and the application and use of the assessment tool need not require advanced wetland expertise. The tool is thus a rapid assessment tool designed for use by non-specialists, although some limited training provided in its application. These limitations constrained the assessment methods primarily towards an impact-based assessment method, and therefore it is possible that some of the more subtle changes in wetland functioning may be beyond the sensitivity of this tool to assess adequately. Specialist, intensive and comprehensive assessment tools, such as the WET-Health assessment tool (MacFarlane et al, 2007) are currently under development and may be useful in such situations.

# 7. APPENDIX III: BACKGROUND TO WETLAND CLASSIFICATIONS, AND THE CLASSIFICATION SYSTEM DEVELOPED FOR THIS STUDY

**What is meant by "classification"?**

Wetland classification refers to the process of grouping wetlands into similar types according to their biophysical characteristics and the way in which they function.

This system should not be confused with the National Water Resource Classification System (NWRCS) of the Department of Water Affairs and Forestry (DWAF), which is the process of classifying every water resource in South Africa in a complex set of technical and social interactions, to be used to guide resource development.

(after Ewart-Smith *et al*., 2006)

## *History of Wetland Classifications in South Africa*

Previous attempts to develop a national wetland classification system for South Africa (Dini *et al.* 1998; Dini & Cowan 2000) used wetland features such as size, depth, vegetation cover and presence of surface water, but these approaches did not group wetlands by functional features. Because these types of classification criteria do not consider the functional aspects of wetlands, they have limited use for management purposes (Brinson 1993; Tiner 1999, 2003).

Landform and hydrology are generally acknowledged as the two fundamental features that determine the existence of all wetlands (Brinson 1993; Semeniuk & Semeniuk 1995; Finlayson *et al.* 2002; Jones 2002; Kotze *et al.* 2005, Ellery *et al.* 2005), and this is the basic foundation for the hydrogeomorphic (HGM) classification system for wetlands (Brinson 1993; Semeniuk & Semeniuk 1995). Essentially geomorphological and hydrological features are used as key criteria in the description and classification of wetland types; classifying wetlands by (1) their hydrological characteristics; by the way water flows into, through and out of the wetland system, and (2) by their geomorphological or landscape settings.

Wetland classification systems based on geomorphic and hydrologic aspects are regarded as far more robust and consistent than classification systems based on other criteria (Finlayson *et al.* 2002). Some adaptation of the Hydrogeomorphic (HGM) classification system has been undertaken for South African Palustrine wetlands (Marneweck and Batchelor, 2002; Jones and Day, 2003; Kotze et al., 2005), and a HGM approach has recently been proposed as the basis for all inland wetland classifications in South Africa (Ewart-Smith et al., 2006).

## *Linking Wetland Assessments to Classification Systems*

Extensive development of wetland health and functional assessment techniques in the USA recommend that assessment methods be linked to suitable classification systems. Due to the variety of wetland types, and associated different drivers, any proposed method of wetland assessment should be linked to a system where such differences in wetland type can be accounted for. This is because there are a variety of different wetland types, and these different wetland types "work" differently – which is largely why reviews of wetland functions often display such widely varying and apparent conflicting results (see for e.g. Bullock et al., 1998).

To account for these different wetland types and varying functions, wetland assessment methods should be linked to a functional-based HydroGeomorphic (HGM) Classification system. Linking the wetland assessment method with the HGM classification should therefore enable the habitat index developed in this study to be effectively linked with future functional assessment methods, as well as developing biological indices, and the proposed South African Palustrine wetland classification. In South Africa (Kotze et al, 2005) and internationally, (Smith et al., 1995 and Johnson, 2005), functional assessments are already conducted using the HGM approach. The USA Environmental Protection Agency in 1997 went so far as to issue instructions (http://www.epa.gov/OWOW/wetlands/science/hgm.html ) to all Federal agencies to initiate a National Action Plan to implement the Hydrogeomorphic approach for assessing wetland functions.

## *The proposed national Wetland Classification for SA*

A 5 level hierarchical system (Figure 1) has been proposed for the classification of South African wetlands (Ewart-Smith et al., 2006). This five-level hierarchy adopts the following structure for the classification of inland wetlands:

- Level 1 (system): Marine; Estuarine; Inland;
- Level 2 (sub-system): for INLAND wetlands; sub-systems of non-isolated or isolated nature;
- Level 3: functional units (HGM classification);
- Level 4: structural units; and
- Level 5: habitat units (vegetation type etc).

Level 3 of this hierarchical classification system adopts a HGM-based system for classifying inland wetland systems (Table 1). This version of the classification system is based on HGM classifications which have been developed and modified for use in South Africa by Marneweck and Batchelor (2002) and subsequently Kotze *et al*. (2005).

Levels I, II and III of Ewart-Smith et al.'s (2006) proposed classification are supposed to identify the primary discriminators of the wetlands. However, there is currently enormous gaps in levels of classification between the HGM level (Level III: Functional Units) and the largest level (level I: System). As currently proposed, all floodplain wetlands in the country are equivalent since they would be identified and classified by the system ("*Inland*"); Subsystem ("*Non-Isolated*") and then Functional Unit ("*Floodplain*"). Such an approach oversimplifies the diversity of wetland types, and at best would severely limit extrapolation, and at worst disguise the applicability of extrapolation, of results from different wetlands to other similar wetland types and/or regions.

Whilst we strongly believe that a HGM classification system for wetlands should be advocated, this needs to be nested within smaller-scale information such as EcoRegions, and then also possibly within the specific geological type of the area, since wetland form and processes are largely determined by the underlying geological formations and soil forms which weather from those.

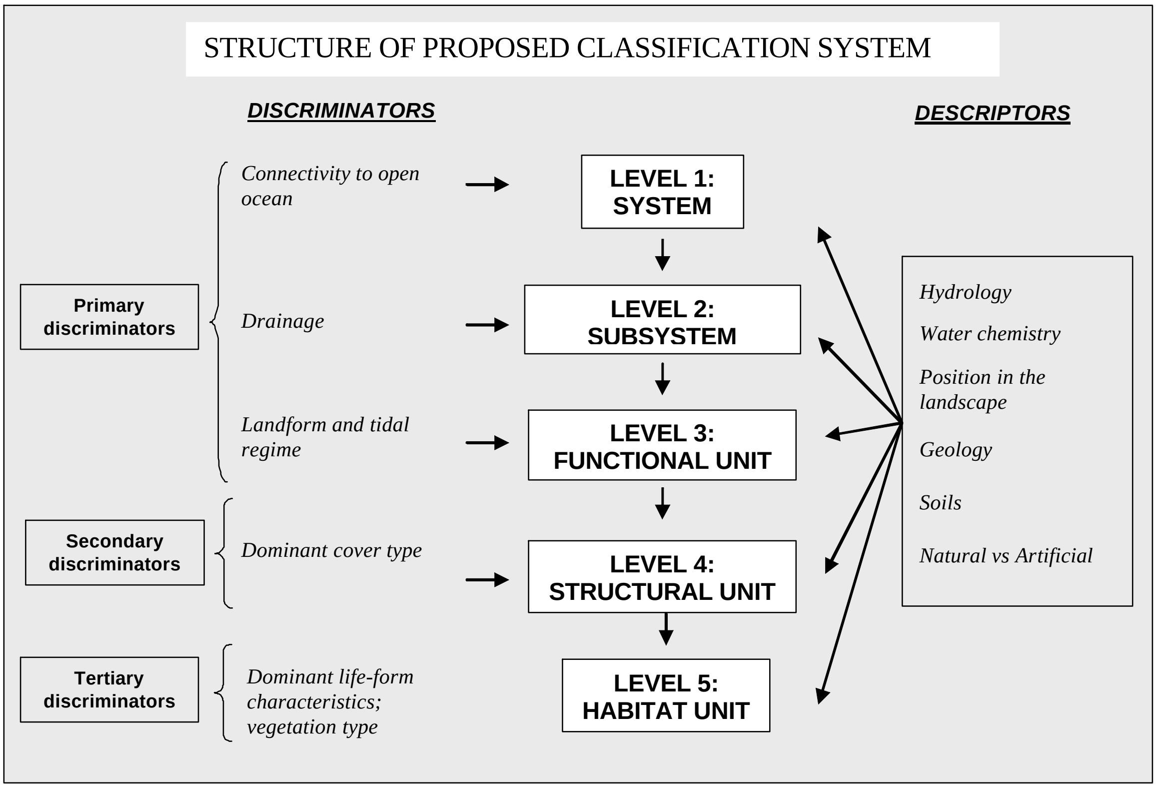



**Figure 1:** Basic structure of Ewart-Smith *et al.*'s (2006) proposed wetland classification system.

**Table 1:** Ewart-Smith *et al.*'s (2006) proposed wetland classification system for South Africa, showing the classification hierarchy down to Level III for inland systems.

| Level I | Level II | Level III |
|---|---|---|
| INLAND | Non-isolated | Channel (river) |
| | | Valley bottom |
| | | Floodplain |
| | | Depression linked to a channel |
| | | Seep with channelled outflow |
| | Isolated | Isolated depression |
| | | Seep without channelled outflow |

These proposed additional criteria for classification would need to be located at the Level II scales, as indicated in Table 2. The incorporation of these criteria would ensure that some extrapolation of results to the regions is possible, and the appropriateness of extrapolation can be determined (by similarity of the EcoRegion and/or geology). For instance, seepage wetlands of all types are likely to be more similar to each other within a particular EcoRegion than would a seepage wetland on the highveld versus a seepage wetland in the Western Cape.

Additionally some rationalization of the level III classification was undertaken. There was some mixing of scales and overlapping of classes (e.g. considering river channel for level III A, and channel - as part of a floodplain or valley bottom - again at level III B; river types by effectively considering geomorphic location/province, but not same criteria for non-riverine wetlands) which necessitated this.

## *The modified Classification System adopted in this study*

Whilst the focus of this project was not to develop a new wetland classification system for South Africa, there was a requirement to ensure that it would be possible to evaluate the potential for extrapolation of results between sites and across regions, since it will never be possible to monitor all of South Africa's many hundreds of thousands of individual wetland systems. Whilst we do not dispute the need for a hierarchical classification system, and have maintained the Level I association (i.e. distinguishing inland wetland systems from others), at the Level II of the classification, new descriptors and discriminators (namely EcoRegions, but optional information would be geology) of the wetland system or region would be required (Table 2). Currently all rivers are classified by their type and then EcoRegional setting in DWAF studies. Maintaining this higher-level framework thus ensures alignment of existing river and future wetland studies. EcoRegion information (Figure 2) is freely and easily available at the desktop level (from www.dwaf.gov.za/iwqs/gis_data/ecoregions/get-ecoregions.htm ). A secondary discriminator which could be applied at Level II is the dominant geology of the catchment or site. This has been included because of the deterministic role that geology is known to play in the formation and functions of wetland types that subsequently develop on the soils that form from the underlying geology. Geological information is available from 1:250 000 series geological maps across the country.

**What are EcoRegions?**

EcoRegions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources, and are designed to serve as a spatial framework for the research, assessment, management and monitoring of ecosystems and ecosystem components. Several levels or scales of EcoRegions can be delineated (eg: Level I low resolution/detail; Level III high resolution and detail). In South Africa, EcoRegions form the basis of the River Health monitoring assessments.

*For more information go to: www.dwaf.gov.za/iwqs/gis_data/ecoregions/get-ecoregions.htm*

At the Level III of the classification, we have developed a more rigorously HydroGeomorphic–based classification system that can be applied at a single spatial scale. Wetland systems have thus been distinguished, using the HGM approach, on the basis of their landscape (geomorphic) setting or position, and secondly by their flow (hydrological) characteristics (Table 3). Such an approach has been adapted from Marneweck and Batchelor (2002) and

Kotze et al. (2005), modified according to the HGM principles of Brinson (1993) and Semeniuk and Semeniuk (1995). We believe that this revised, HGM-based classification system accounts, at a broad national scale, for the major differences in wetland types and would additionally allow for the automation of classification of the country's wetland systems. Nine major wetland types are recognized at Level III of the classification. These are:

In valley bottoms positions:

- Rivers;
- Lakes;
- Unchannelled Valley Bottoms;
- Channelled Valley Bottoms; and
- Meandering Floodplain systems

In slope positions in the landscape:

- Seepage (isolated), and
- Seepage (connected)

In crest positions in the landscape:

- Seepage (connected), and
- Pans/Depressions.

The landscape settings and hydrological/flow characteristics of these main wetland types are described in Table 3, and individually in more detail below.

**Table 2: Proposed inland wetland classification system (after Rountree and Batchelor, *in prep.)***

| ***Level I*** | ***Level II*** | | ***Level III*** |
|---|---|---|---|
| **System** | **EcoRegion** | ***Dominant Geology (optional)*** | **Functional Unit (HGM wetland type)** |
| **INLAND** | South African EcoRegions (data available from DWAF) | *(from 1:250 000 maps)* | **River** |
| | | | **Lake** |
| | | | **Unchannelled Valley Bottom** |
| | | | **Channelled Valley Bottom** |
| | | | **Meandering Floodplain** |
| | | | **Seepage (isolated)** |
| | | | **Seepage (connected)** |
| | | | **Seepage (connected)** |
| | | | **Pan and Depressions** |

**Table 3: Landscape settings and flow characteristics of the HGM wetland types (after Rountree and Batchelor, *in prep.)*.**

| **Landscape setting** | | **Flow pattern** | **HGM Wetland Type** |
|---|---|---|---|
| Valley Bottoms | *confined* | channelled | **River** |
| | | standing water | **Lake** |
| | *unconfined* | diffuse | **Unchannelled Valley Bottom** |
| | | channelled (parallel to valley) | **Channelled Valley Bottom** |
| | | channelled (meandering across valley) | **Meandering Floodplain** |
| Slopes | | diffuse => diffuse | **Seepage (isolated)** |
| | | diffuse => surface/channel | **Seepage (connected)** |
| Crests | | diffuse flow => standing water | **Seepage (connected)** |
| | | standing water | **Pans and Depressions** |

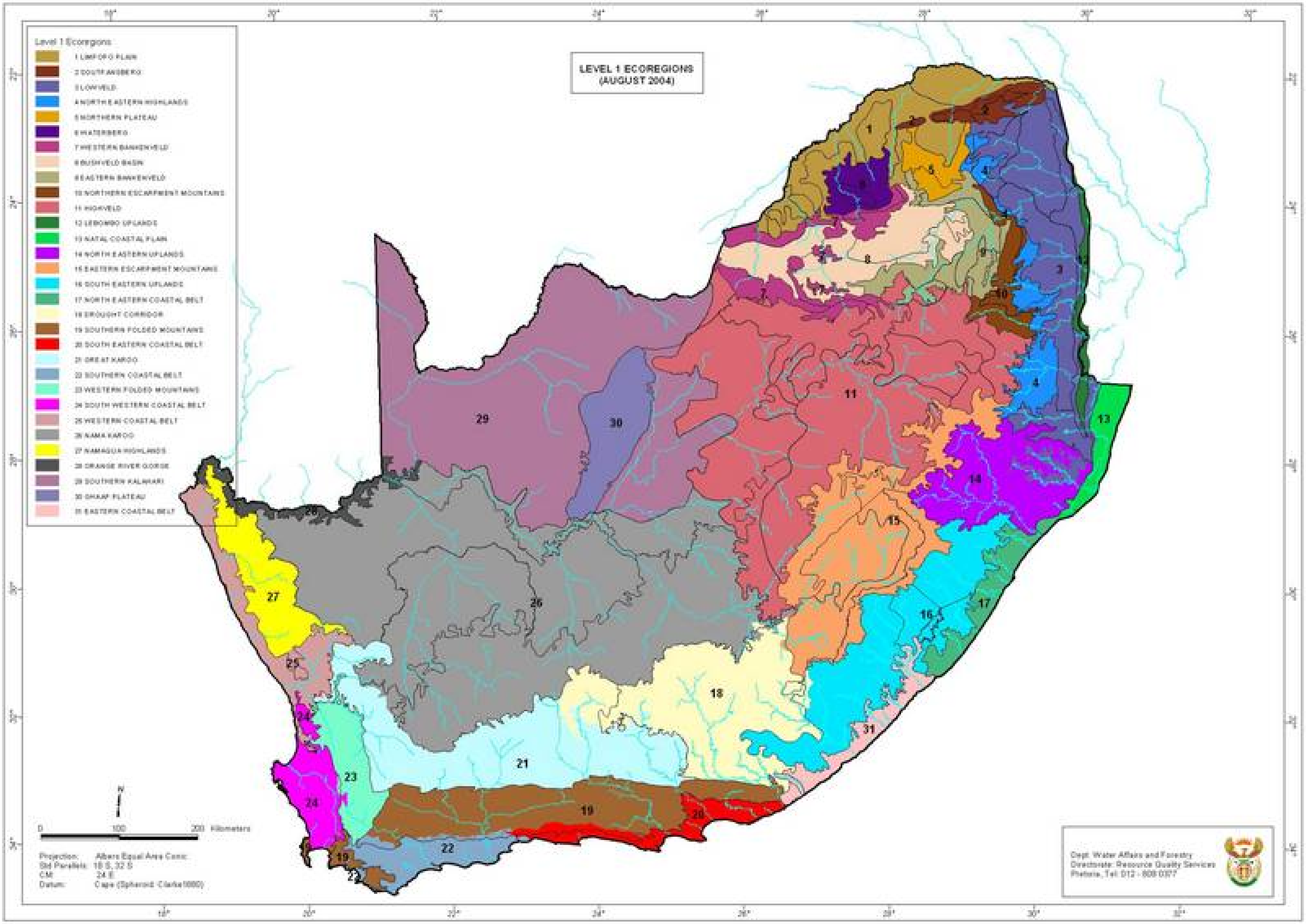



**Figure 2:** Level I EcoRegions for South Africa (Source: Kleynhans et al., 2005).

## Rivers

Linear fluvial, eroded landforms which carry channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorges) or within an incised macro-channel. The “river” includes both the active channel (the portion which carries the water) as well as the riparian zone.

## Meandering Floodplain

Linear fluvial, net depositional valley bottom surfaces which have a meandering channel which develop upstream of a local (e.g. resistant dyke) base level, or close to the mouth of the river (upstream of the ultimate base level, the sea) . The meandering channel flows within an unconfined depositional valley, and ox-bows or cut-off meanders - evidence of meandering – are usually visible at the 1:10 000 scale (i.e. observable from 1:10 000 orthomaps).

The floodplain surface usually slopes away from the channel margins due to preferential sediment deposition along the channel edges and areas closest to the channel. This can result in the formation of backwater swamps at the edges of the floodplain margins.

## Channelled Valley Bottoms

Linear fluvial, net depositional valley bottom surfaces which have a straight channel with flow on a permanent, seasonal or ephemeral/episodic basis. The straight channel tends to flow parallel with the direction of the valley (i.e. there is no meandering), and no ox-bows or cut-off meanders are present in these wetland systems. The valley floor is, however, a depositional environment such that the channel flows through fluvially-deposited sediment. These systems tend to be found in the upper catchment areas.

***This tool (the WETLAND-IHI) is a tool for the assessment of Floodplain and Channelled Valley Bottom wetland types only. It is essential that the Reference (natural/historical) State of the wetland system being assessed is one of these two wetland types.***

***Distinguishing between naturally channelled versus artificially channelled (historically unchannelled) Valley Bottom Systems***

Care should be taken to ensure that the channels in the valley bottom are natural – i.e. that the channelled state of the system is representative of the reference state of the wetland. At times Unchannelled Valley Bottom systems which have become artificially channelised through direct dredging/channel construction, or as a result of increased flood flows due to catchment hardening, can be mistaken for Channelled Valley Bottoms. Therefore evaluate the reference state carefully where the apparent channelised wetland is in an urbanizing catchment area, or where the channel in the valley bottom is very straight or otherwise shows signs of being constructed. Historical aerial photographs can also be used to assess the historical condition.

## Unchannelled Valley Bottoms

Linear fluvial, net depositional valley bottom surfaces which do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas.

## Lakes

These are depressions in the valley bottoms which may be temporarily, seasonally or permanently inundated. Unlike pans, they are not deflationary erosional features, but instead they have, or would have had, an outlet at the downstream end of the valley (a low point); which has been variously blocked or otherwise restricted by dune deposits (Eastern Cape coastal lakes); terminal moraines (e.g. Lake District; U.K.), landslides or other depositional features across the valley bottom.

Their shape is therefore determined by the surrounding slopes/higher ground rather than deflational processes creating the typical circular or oval pan shape.

## Seepage wetlands (connected to river)

Hillslope seepage wetlands are the most common type of wetland (in extent and number), but also probably the most overlooked.

Hillslope seepage wetlands are located on the mid- and footslopes of hillsides, and are connected to valley bottom wetlands or riparian zones. Hillslope seepage wetlands occur where springs are decanting into the soil profile near the surface, causing hydric conditions to develop; or where throughflow in the soil profile is forced up to/near the surface due to impervious layers (such as plinthite laters; or where large outcrops of impervious rock force subsurface water to the surface).

## Seepage wetlands (connected to pan)

As above, but the seepage wetlands fringe the slopes surrounding pan wetlands.

## Seepage wetlands (isolated)

Isolated hillslope seepage wetlands can occur in the hillslope or crest positions of the landscape. As with the other hillslope seepage wetlands, these occur where springs are decanting into the soil profile near the surface, or where throughflow in the soil profile is forced up to/near the surface due to impervious layers

## Pans

Small (deflationary) depressions which are circular or oval in shape; usually found on the crest positions in the landscape. The topographic catchment area can usually be well-defined (i.e. a small catchment area following the surrounding watershed). Although often apparently endorheic (inward draining), many pans are “leaky” in the sense that they are hydrologically connected to adjacent valley bottoms through subsurface diffuse flow paths.

## *Extrapolation potential between sites and EcoRegions*

The modified classification proposed above provides a major advantage in that it allows for the extrapolation potential of well-studied sites across to other, un- or understudied wetland systems, to be evaluated. For instance, some types of HGM wetland types lend themselves to extrapolation across different layers/levels of classification better than others.

The focus of this study is on floodplains and channelled valley bottom systems, and these wetland types are likely to be very well correlated with EcoRegions in that a floodplain in a particular EcoRegion is likely to behave fairly similarly to other floodplains in the same EcoRegion. It may thus be possible for limited extrapolation of data or results from sites where detailed studies have been undertaken to other sites within the same EcoRegion which have wetlands of the same HGM type.

In the case of seepage wetlands particularly, there is likely to be a very strong influence of the underlying geology, such that a seepage wetland on granites may have greater similarity with a seepage wetland on another granite system in a different EcoRegion than with a seepage wetland which is within the same EcoRegion but on a different geology. Whilst this study is only focused on floodplains and channelled valley bottom wetlands, we have included geology as an optional classification criteria to cater for a wider variety of wetland types (such as seepage wetlands) so that extrapolation potential can also be evaluated for other wetland types that may be better evaluated by geological similarity.