The Design of a National Wetland Monitoring Programme

Consolidated Technical Report

Volume 1

Report to the
WATER RESEARCH COMMISSION

by

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PREFACE

This document is the consolidated technical report for the South African National Wetland Monitoring Programme. It details all the technical inputs made by various stakeholders in the design of the Implementation Manual.

The Technical Report is Volume 1 of the wetlands monitoring programme (WRC Report 2269/1/16). Volume 2 is an Implementation Manual detailing the steps necessary to implement the programme (WRC Report 2269/2/16).

EXECUTIVE SUMMARY

Wetlands are complex and dynamic ecosystems that provide indispensable services to the people and the environment of South Africa. In order to protect and manage the remaining wetlands of the country, assessment, monitoring and reporting on the state of wetlands is crucial.

The South African Department of Water and Sanitation conceptualized a National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) in the early 1990s. Although a number of monitoring programmes have been implemented under the NAEMP, a wetlands monitoring programme has yet to be established.

With this need in mind the WRC, in 2013, issued a directed call for a project entitled *the design of a National Wetland Monitoring Programme (NWMP) following a phased approach*. The phases were:

- Phase 1 – conducting a situation analysis regarding the complexities of monitoring wetland health or integrity and developing a framework that can serve as the basis for phases 2 and 3;
- Phase 2 – designing a monitoring programme and developing an implementation plan;
- Phase 3 Pilot testing.

The Objectives:

The monitoring programme design had the following objectives, to:

1. conduct an extensive literature review on wetland monitoring and assessment;
2. determine and illustrate fully the links with the National Aquatic Ecosystem Health Monitoring Programme, Working for Wetlands and other related programmes operated by national departments and provincial conservation authorities, ESKOM, etc.;
3. suggest scientifically accepted objectives that will lead to the design of NWMP;
4. develop or refine a core suit of practical and user-friendly indicators;
5. develop a sustainable governance structure and implementation plan;
6. describe the human capacity and budget required for a successful pilot and full scale implementation of the programme;
7. produce, test and refine, where necessary, the scientific viability of the Implementation Manual(s) based on selected sites;
8. recommend further research on wetland health assessment methods.

All the objectives were attempted and achieved. This Implementation Manual for the NWMP relates directly to objective 7 above.

Methodology

An extensive literature review on wetlands monitoring and assessment is provided in this report, including a review of international wetland inventory, assessment and monitoring (IAM) frameworks and IAM methods and programmes. International experience in the design and development of IAM Frameworks and IAM methods provided invaluable insight into the design of the NWMP.

The international review is complemented by a review of the South African wetland institutional environment and arrangements. This review includes an investigation of South African wetland policy, legislation, strategies, regulations and organisations and a review of wetland inventory, assessment and monitoring methods and initiatives in the country, linking these to the design of the NWMP.

The framework, approach and decisions made in the designing of the NWMP are included in this document. Design was based on an approach of (1) minimising duplication, particularly with regard to wetland IAM methods and indicators currently being used; (2) minimising resource use, while maximising the value of outputs of wetland assessment and monitoring; (3) finding suitable methods for prioritising wetlands to be assessed and monitored; (4) adaptive management; and (5) maximum engagement and participation by stakeholder.

Indeed, the project team engaged stakeholders at all stages of the NWMP design process. Emanating from this stakeholder engagement process was an agreed purpose for the programme, namely *to* ***assess and monitor the extent of wetlands, threats to, and the change in the present ecological state and ecosystem services provided by wetlands in the country.*** A core suite of practical and user-friendly indicators were also selected for the NWMP by the stakeholders involved in the design process. The programme design was tested on the selected sites, which further strengthened the final reports

Results and Discussions

Two reports have emanated from this assignment, the Consolidated Technical Report (Volume 1, this report) and the Implementation Manual (Volume 2, both available from WRC). This Consolidated Technical Report is a consolidation of all deliverables of the assignment, providing the starting framework, indicators, methods, tools and procedures for implementing the NWMP in South Africa. It is based on the principle of adaptive management, which requires that the programme continues to evolve, adapting the framework, indicators, methods, tools and procedures, as appropriate, as experience is gained through implementation.

The Implementation Manual on the other hand, provides the processes, procedures and methods required to report Tier 1 indicators, to prioritize wetlands for Tier 2 and 3 assessments, and to carry out assessment and monitoring at each level.

The intention of the NWMP is to assess and monitor wetlands at three different spatial scales.

1. Tier 1: National Scale Assessment of Wetlands, largely using existing datasets and desktop assessment methods. Results from Tier 1 of the NWMP will allow the NAEHMP to report on the extent of wetlands in the country, land-cover and land ownership and their surroundings and the extent to which wetlands in the country are protected.
2. Tier 2: Rapid Assessment of Prioritised Wetlands involves the prioritisation of certain wetlands for further investigation, followed by field assessors spending approximately 4-8 hours at each wetland. Results from Tier 2 will allow reporting of eight indicators, namely the extent of the wetland; the present state of hydrology, geomorphology, vegetation and water quality; present ecological state based on land use; scores for ecosystem services provided by the wetland; and a measure of the threats posed by listed invasive plants to the wetland.
3. Tier 3: Detailed Monitoring of a Sub-set of Wetlands, most of which will have been selected from Tier 2. The purpose of Tier 3 is to build a body of knowledge of wetland ecosystems and to monitor wetlands assessed as being of concern for one reason or another. A suite of indicators and protocols are provided for monitoring wetlands at this level of detail. Not all indicators will necessarily be monitored at Tier 3 wetlands. A monitoring plan will need to be developed for each of these wetlands, the details of such a plan, including the indicators, will depend on the reasons for investigating the wetland.

Conclusion and Recommendations

Implementation and Technical Manuals have been produced. This Implementation Manual provides the processes, procedures and methods required to report Tier 1 indicators, prioritize wetlands for Tier 2 and 3 assessments and to carry out assessment and monitoring at each level. This manual provides the information necessary for DWS to implement the NWMP. The nature of the design of the NWMP is that the programme could be implemented in the very near future. Similarly, the selection of indicators was stakeholder driven, hence very few indicators which were recommended by stakeholder were excluded from the programme. As a result, research needs to be able to implement the NWMP and report indicators in the NWMP are limited. There are, however, a limited number of research needs that are required (1) to implement the NWMP and (2) to conduct wetland assessment and monitoring in the country include:

- The development of a field guide of listed alien species which are potentially found in South Africa, with likely geographical localities
- Research to see if the currently used qualitative indicators in Tier 2 are adequately sensitive to change in wetland condition, or if quantitative methods are needed for any of them.
- Research on all aspects of Reference Wetlands or Reference Conditions for wetlands.
- Research is required to determine a process for reducing current limitations in the National Wetland Inventory, for instance by incorporating local data generated outside of formal state institutions.
- The need to develop methods for assessing PES where WET-Health, IHI and other NWMP-recommended methods cannot be used (e.g. depressions and seeps).
- Further research natural variations in water chemistry across wetland types, ecoregions, etc. and their responses to influent pollutants.
- An urgent need to develop simple, user friendly combined field data collection tools for Tier 2 indicators – these should be developed in a paper format initially, while keep in mind that in future electronic data collection should be considered
- An urgent need to combine or rework the IHI and Wet-Health methods into a single, standardise assessment method. Indications are that this activity is already underway.
- A need to address the methods gaps and limitations of highlighted by Ollis and Malan (2014); Kotze et al. (2009) and Kotze et al. (2014)
- A need for guidelines for the development of Wetland Monitoring Plans.
- The need to test the method of prioritisation of wetlands in Tier 2 and Tier 3 of the NWMP
- A need to continue research into the use of plants and microbes as biological indicators for monitoring wetlands.
- Research on the wetland characteristic which are monitored using the Tier 3 protocols to refine these into indicator (if possible) which demonstrate a response to a change in a wetland stressor (i.e. landuse change; cultivation; mining).
- Other indicators that should be examined in future include:
    - Hydroperiod indicator
    - Fauna (small vertebrate) indicator.

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1 INTRODUCTION

1.1 BACKGROUND TO THE NATIONAL WETLAND MONITORING PROGRAMME (NWMP)

The collection of data and the interpretation of information on water are critical to all aspects of water management. Without accurate information, the correct picture of the water situation cannot be determined and policy formulation could be compromised. Hence, information based on well-organised monitoring programmes is a prerequisite for accurate assessments of the status of water resources and the magnitude of water problems.

Monitoring is necessary to collect sufficient and accurate data to inform decision making, and reduce and manage risks. Therefore, the ultimate goal is to provide information needed for planning, decision making and operational water management and related infrastructure at local, national and regional levels. Monitoring programmes are also fundamental for protection of human health and of the environment. Chapter 14 of the National Water Act (1998) advocates the establishment of national monitoring systems; whose purpose it is to facilitate the continued and co-ordinated monitoring of various aspects of water resources by collecting relevant information and data.

National Water Resource Strategy (DWS, 2013)

Wetlands are complex and dynamic ecosystems that provide indispensable services to the people and the environment of South Africa. In order to protect and manage the remaining wetlands of the country, assessment, monitoring and reporting of wetlands in the country is crucial.

The South African Department of Water Affair and Sanitation conceptualized a National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) in the early 1990s (DWAF, 2006). The NAEHMP is expected to implement, maintain and improve the monitoring of all inland aquatic ecosystems in South Africa (DWAF, 2006). According to DWAF (2008), the objectives of the NAEHMP are to:

- Measure, assess and report on the ecological state of aquatic ecosystems;
- Detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems;
- Identify and report on emerging problems regarding the ecological state of aquatic ecosystems; and
- Ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

Although a number of monitoring programmes have been implemented under the NAEMP, a wetlands monitoring programme has yet to be established. With this need in mind, the WRC, in 2013, issued a directed call for a project entitled *the design of a National Wetland Monitoring Programme (NWMP) following a phased approach*. The phases of the project included:

- Phase 1 – conducting a situation analysis regarding the complexities of monitoring wetlands health or integrity and to develop a framework that can serve as the basis for the other phases of the programme;
- Phase 2 – Monitoring programme design and development of an implementation plan;
- Phase 3 – Pilot Testing.

Phase 4 of the NWMP is expected to include the full-scale implementation of the NWMP, funded and led by national implementing agencies.

Sustento Development Services was appointed to complete this assignment, specific objectives of which are listed below.

- Conduct an extensive literature review on wetland monitoring and assessment (Sections 2 and 3 and Appendix B of this report).

- Determine and illustrate fully the links with the National Aquatic Ecosystem Health Monitoring Programme, Working for Wetlands and other related programmes operated by national departments and provincial conservation authorities, ESKOM, etc. (Section 4 of this report)
- Suggest scientifically accepted objectives that will lead to the design of NWMP (Sections 5.1 and 5.2 of this report)
- Develop or refine a core suit of practical and user-friendly indicators (Section 5.6 of this report).
- Develop a sustainable governance structure and implementation plan (Section 6 of this manual and the NWMP Implementation Manual, NWMP Vol 2).
- Describe the human capacity and budget required for a successful pilot and full scale implementation of the programme (Section 6.1 f this report)
- Produce, test and refine, where necessary, the scientific viability of the Implementation Manual(s) based on selected sites (section 5.8 of this report and the NWMP Implementation Manual, NWMP Vol 2)
- Recommend further research on wetland health assessment methods (Section 7 of this report)

This report, the Consolidated Technical Report, supports the NWMP Implementation Manual, NWMP Vol 2. It consolidates and updates the contributions from all the deliverables linked to this research, submitted between 2013 and 2015 and thus provides the background information required to address objectives 1-6 and 8. Objective 7 is addressed mostly by the NWMP Implementation Manual, NWMP Vol 2 and Section 5.7.

1.2 Overview of Wetland Assessment and Monitoring Issues and Definitions in South Africa

One of the critical requirements when designing and developing monitoring systems is the need ensure that there is clarity on terminology and concepts that underpin the system. This section introduces some of the terms and concepts which were agreed during the design of the NWMP or which emerged as needing clarity in the design of the NWMP.

1.2.1 Defining a Wetland

Central to any National Wetland Monitoring Programme is an agreed and standardised definition of the term *wetland*. To date, however, there is no universally agreed definition. Even in the South African context, at least two definitions (Table 1) have emerged are applied, namely a Ramsar definition (Ramsar Convention Secretariat, 2007), which is applied by the Department of Environmental Affairs (DEA), and a National Water Act (No. 36 of 1998: NWA) definition, which is used in the water sector.

Table 1: Wetland definitions used in South Africa.

Article 1.1 of the Ramsar Convention	National Water Act (Act No. 36 of 1998)
Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres”	Land that 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 support or would support vegetation typically adapted to life in saturated soil.

Internationally the most commonly accepted definition of a wetland is that of the Ramsar Convention, which addresses habitats as diverse as mangrove swamps, peat bogs, water meadows, coastal beaches, coastal waters, tidal flats, mountain lakes and tropical river systems (Cowan, 1994). South Africa is a signatory to the Ramsar Convention and has adopted this broad definition for most purposes. As custodians of the RAMSAR wetlands, this definition is used by the Department of Environmental Affairs (DEA). The definition in the National Water Act is restricted to non-flowing inland waters and is used by the Department of Water and Sanitation (DWS) for water management purposes (Ewart-Smith et al., 2006).

Because the purpose of the NWMP is to report on the 'health' of wetlands under the auspices of the NAEHMP of the Department of Water and Sanitation, the NWA definition of wetlands is used in this document. The programme thus addresses the imperatives of the South African wetland regulatory authority, although the definition it is much narrower than the current Ramsar definition used in the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis et al., 2013; Ollis et al. 2015).

1.2.2 Wetland Typing

To ensure that the full diversity of wetland types is included in any assessment and monitoring programme, it was necessary for the NWMP to follow the South Africa's standardised wetland typing system. (Note that the term "typing" is used here instead of the more commonly used "classification", because DWS uses the term "classification" in a particular and idiosyncratic way not related to biophysical types.)

Wetland typing (classification) according to Ewart-Smith et al. (2006) is defined as:

the process of typing wetlands according to their biophysical characteristics and the way in which they function.

RAMSAR recognises five major wetland types:

- **marine** (coastal waters to 6 m depth, including coastal lagoons, rocky shores, and coral reefs);
- **estuarine** (including deltas, tidal marshes, and mangrove swamps);
- **lacustrine** (lakes and coastal lakes);
- **riverine** (rivers and streams); and
- **palustrine** (meaning "marshy" – marshes, swamps and bogs).

A further category, **artificial wetlands**, includes systems such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms and canals. Lacustrine and palustrine systems fall within the commonly accepted definitions of wetlands and are the systems addressed in this document. The monitoring of rivers and estuaries in South Africa is undertaken in two other programmes under the auspices of DWS.

A Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis et al., 2013; Ollis *et al.,* 2015) (hereafter referred to as the Classification System) is based on the principles of hydrogeomorphology (HGM) and assumes that wetland type is related to the landform in which it is situated. The South African system is designed to promote multiple uses, to be simple but to maintain scientific rigour, and to be easily understood and thus useful to a wide range of potential user-groups (Ollis et al., 2013).

The Classification System applies a hierarchical framework consisting of six levels, each level requiring increasing knowledge about the wetland (Figure 1). The first four levels distinguish between different types of aquatic ecosystems on the basis of 'primary discriminators', which are criteria that consistently differentiate between the specified categories at a particular level. The four levels progress from Level 1: Systems (Marine; Estuarine; Inland), to Level 2: Regional Setting; to Level 3: National-level Unit; and Level 4: Hydrogeomorphic (HGM) Units. 'Secondary discriminators' are applied at Level 5: Hydrological Regime and descriptors at Level 6 (Ollis et al., 2015).

The HGM Unit (Level 4) is the focal point of the typing of wetlands and, together with Level 5: Hydrological Regime (if known), identifies wetland functional units (Ollis et al., 2013).

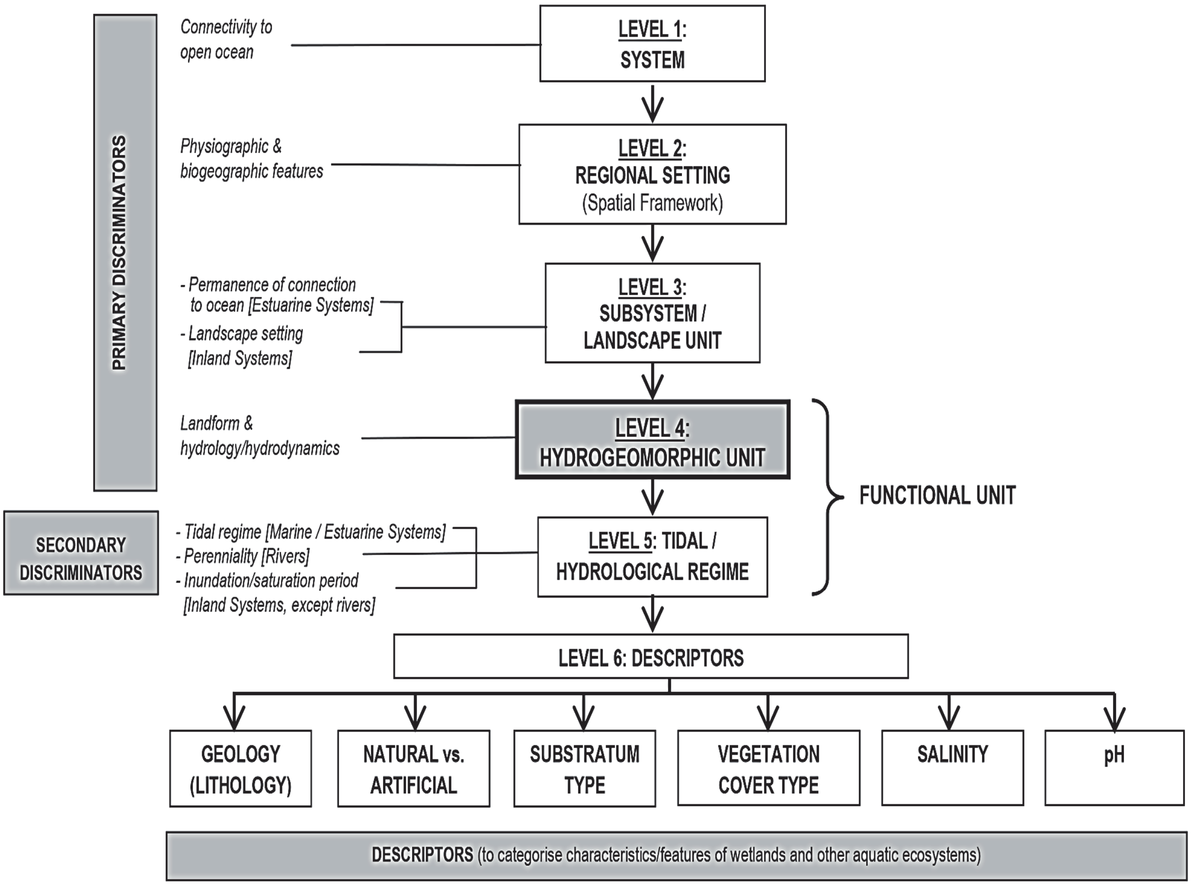

Figure 1: Conceptual overview of the typing system for wetlands (from Ollis et al., 2015).

Level 4 of the Classification System types wetlands on the basis of hydrogeomorphic (HGM) units (Table 2). Since landform and hydrology are the two fundamental features that determine the existence of all wetlands, the HGM classification system for wetlands is based on (1) landform (shape and local setting); (2) hydrological characteristics (nature of water movement into, through and out of the wetland) and (3) hydrodynamic characteristics (direction and strength of flow through the wetland) (Ewart-Smith et al., 2006). The Classification System recognizes seven primary HGM types for Inland Systems at Level 4A, six of which relate to wetlands in the country (Table 2). Note that a single wetland may in fact be made up of several HGM Units.

Table 2: Wetland hydrogeomorphic types typically supporting inland wetlands in South Africa (Source: Ollis et al., 2015). "Exorheic" means with an outflow channel and "endorheic" means inward-draining.

HGM TYPE	LONGITUDINAL ZONATION/LANDFORM/OUTFLOW DRAINAGE	LANDFORM/INFLOW DRAINAGE
A	**B**	C
River		
Channelled valley-bottom wetland	n/a	
Unchannelled valley-bottom wetland	n/a	
Floodplain wetland	Floodplain depression	n/a
	Floodplain flat	n/a
Depression	Exorheic	with channelled inflow
		without channelled inflow
	Endorheic	with channelled inflow
		without channelled inflow

HGM TYPE	LONGITUDINAL ZONATION/LANDFORM/OUTFLOW DRAINAGE	LANDFORM/INFLOW DRAINAGE
	Dammed	with channelled inflow
		without channelled inflow
Seep	With channelled outflow	n/a
	Without channelled outflow	n/a
Wetland flat	n/a	n/a

The NWMP has adopted this system for typing wetlands and a User Manual (Ollis et al., 2013) is available to assist in the typing process.

1.2.3 Wetland Inventory

Wetland monitoring programmes involve *inventory and assessment* as well as monitoring (Finlayson et al., 2001); DWAF (2004a) and the current project have followed this distinction.

Wetland inventory or mapping precedes wetland assessment and monitoring and provides a basis for guiding appropriate assessment activities. It is defined as the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.

Finlayson et al., 2001

Wetland inventories are conducted for a number of purposes:

- providing a list of a particular type, or all types of wetlands in an area;
- identifying wetlands of national or international importance based on agreed criteria;
- describing the occurrence and distribution of various taxa;
- identifying or describing natural resources;
- identifying the functions and values of each wetland and providing a base for assessing wetland loss or degradation (Finlayson et al., 2001);
- establishing a baseline for measuring change in a wetland and a tool for wetland planning and management (Costa et al., 1996).

The compilation of some kind of inventory of wetlands in a region is fundamental to the conservation and management of wetland ecosystems (Finlayson and Van der Valk, 1995; Scott and Jones, 1995; Tiner, 1999). South Africa has recognised for many years that there is a need for such an inventory of the country's wetlands. Cowan and Van Riet (1998) compiled a preliminary inventory of the major wetlands in South Africa (Dini and Cowan, 2000; Thompson et al., 2002). At the time, Dini and Cowen (2001) indicated that the lack of spatial information on wetlands in South Africa had *consistently been identified as an obstacle to the development, implementation and monitoring of wetland conservation strategies at national, provincial and local levels.* This is not to say that there was no wetland mapping in the country, but rather that these mapping projects were localised and were seldom comparable. The sector thus recognised a need to prioritise the collection of information on the distribution and status of South Africa's wetlands (Dini and Cowen, 2001).

In 1997 a national workshop was convened to discuss the conceptual design of an inventory and soon afterwards the Department of Environmental Affairs and Tourism (now Dept. of Environmental Affairs) initiated the South African Wetlands Conservation Programme to undertake the development and coordination of an inventory (Dini and Cowen, 2001). The programme would provide a consistent set of standards and methods for mapping of wetlands. By 2001, foundation work had already been completed for the mapping of wetlands on a national scale, including a catalogue, or meta-database, of known wetlands.

The pilot study in the early 2000s, using remotely-sensed data, resulted in the generation of data on the extent, location and distribution of many wetlands. The completed national wetland inventory was expected to provide a GIS-based digital map of these data (e.g. extent, distribution and diversity) for wetlands throughout the country. The accompanying wetland inventory database was planned as a repository for data on the attributes, functions and values of individual wetlands as these became available. The development of the national wetland inventory was closely linked to the development of the Wetland Classification System (Section 1.2.4) SANBI, 2009). With the promulgation of the National Environmental Management: Biodiversity Act (NEM:BA) in 2004, SANBI assumed responsibility for the maintenance and reporting of the National Wetland Inventory (NWI).

The NWI is intended eventually to include information on the extent, distribution and diversity of South Africa's wetlands, and to identify the functions and values of individual wetlands, including ecological, social and cultural values (SANBI, 2009). The NWMP is designed to use the NWI as the core dataset for the programme, congruency in the needs of the NWMP and the NWI being paramount in the design process. Hence data and information collected and stored by both initiatives should benefit both.

1.2.4 Wetland delineation and mapping

The wetland delineation process in South Africa, as outline in DWAF (2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas,* makes use of four indicators to ascertain the outer extent of the 'outmost' zone of a wetland. These indicators are

- the Terrain Unit Indicator, which helps to identify those parts of the National-level where wetlands are more likely to occur.
- the Soil Form Indicator, which identifies soil forms as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- the Soil Wetness Indicator, which identifies the morphological signatures of "wetness", developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator, which identifies hydrophilic vegetation associated with frequently saturated soils.

Wetland delineation and mapping are a crucial component of the NWMP. The NWMP defines delineation of a wetland as *the identifying of the outer edge of the temporary zone of the wetland, which marks the boundary between the wetland and adjacent terrestrial area* (DWAF, 2008a).

Although a detailed delineation of a wetland is not a requirement for the NWMP, due to resource constraints, the WRC NWMP Implementation Manual does include wetland mapping in two steps of the NWMP process, namely in Section 5.7 which involves a *Desktop Assessment of Extent and Preliminary Typing of the Prioritised Wetland* and in Step 2.1: Step 2.1: G*round-truthing the Preliminary Desktop Map of the Prioritised Wetland* in Section 6.3.2 of the same report.

In Tier 1 of the NWMP a *Desktop Assessment of Extent and Preliminary Typing of the Prioritised Wetland* is carried out during which the boundary of the wetland is estimated from aerial photographs (available from http://www.ngi.gov.za/index.php/what-we-do/aerial-photography-and-imagery) and drawing it onto the image, using clues such as topography, presence of water, and differences in vegetation. Wetland vegetation can be distinguished from adjacent terrestrial vegetation in aerial photos and using Google Earth by differences in colour, shading, texture and elevation (DWS, 2005). It is possible to conduct a preliminary desktop boundary delineation of the wetland using the method outlined in Mbona et al. (2015).

In Tier 2 of the NWMP, Step 2.1: G*round-truthing the Preliminary Desktop Map of the Prioritised Wetland* has the purpose to ensure that the wetland meets the requirements of the national definition of a wetland (see glossary for definition) and to map its boundaries. The Preliminary Desktop Map referred to in this step is that same map which was generated in Tier 1, as discussed in the previous paragraph. The most reliable indicators of wetlands are the redoxymorphic soil features[1], which develop due to prolonged saturation of the area (DWAF, 2008a). These features can be used to indicate permanently, seasonally or temporarily inundated or saturated zones in the wetland (DWAF, 2008a). A preliminary map, (from Tier 1) will be provided to the field assessor, who should use the Rapid Assessment Datasheet (see Section 9.2.2 of the WRC NWMP Implementation Manual), developed by Mbona et al. (2015), to rapidly ground-truth the boundaries of a wetlands. The mapped extent can be confirmed in the field by taking GPS positions points using vegetation as a guide, and taking soils samples if time allows.

The NWMP thus recommends the use of the most recent, standardised methods which are already being applied in the mapping of wetlands in the country. The use of such methods should ensures harmony between the NWMP wetland mapping process and delineation of wetlands for other purposes such as Environment Impact Assessments, Reserve Determinations, etc., ensuring that the NWMP dataset can be used in for other purposes, including legislative requirements. (see Section 3.2 for more details on these processes).

1.2.5 Wetland assessment

*Wetland assessment is the preliminary identification of **wetland status** and **threats to present state**. This provides the first-level information from which a 'monitoring' plan is devised. Assessment describes a suite of actions relating to the evaluation of wetland health relative to a known range of conditions from wetlands cross a disturbance gradient. It includes the evaluation of both the **functions** and **condition/ecological integrity** of the wetland system.*

Finlayson et al. (2001)

Wetland assessments are largely linked to assessment of wetland state and/or value, where:

- Wetland condition is defined as the *state of the physical, chemical, and biological characteristics of the wetland, and the processes and interactions that connect them*.
- Wetland functions are *defined as physical, chemical, or biological processes occurring within wetland systems* and
- wetland values are *attributes of wetlands which are perceived as valuable to society* (Thiesing, 2001).

Based on these definitions, a wetland assessment is an objective, measurement of the condition or function of the wetland, while assessment of the value of a wetland is inherently subjective and is usually more difficult to assess.

In the NWMP, a wetland assessment is the act of assessing a suite of wetland indicators related to the status and use of wetlands in the country. This provides the first-level information from which a monitoring plan is devised for ongoing monitoring of a prioritised wetland.

1.2.6 Wetland monitoring

Wetland monitoring is the collection of specific information for management purposes and the use of these monitoring results for implementation purposes.

adapted from DWAF (2004)

[1] physical and chemical changes in the soil due to (1) in the case of gleying, a change from an oxidizing (aerated) to reducing (saturated, anaerobic) environment; or (2) in the case of mottling, due to switching between reducing and oxidizing conditions (especially in seasonally waterlogged wetland soils) (DWAF, 2008a).

A popular definition of monitoring used by (Finlayson et al., 1999).and in the Ramsar Convention (2002b) is the *collection of specific information for management purposes in response to hypotheses derived from assessment and the use of the monitoring results for implementing management*. Simply, monitoring determines whether the management of an ecosystem is effective in maintaining or improving the condition of a wetland (Western Australian Department of Environment and Conservation, undated). Monitoring is an essential component of every wetland management programme as it is the only way to ensure that management activities actually improve (or maintain) the condition of the ecosystem.

Collection of time-series data that do not have the purpose outlined above is termed surveillance, rather than monitoring (Finlayson et al., 1999).

The NWMP adopts the DWAF (2004); Finlayson et al. (1999) and Ramsar Convention (2002b) definition of monitoring, which is collection of specific information for management purposes in response to hypotheses derived from assessment and the use of the monitoring results for implementing management. In other words, for a monitoring programme to be effective, it is necessary for the implementers to have a conception of what changes may (or may not) be taking place so that appropriate measurements can be made and suitable indicators chosen for study.

1.2.7 Defining Reference Conditions

Implementation of an effective wetland monitoring programme is contingent upon the identification of explicit, generally accepted, wetland conditions to be achieved and maintained. These are commonly known as ecosystem objectives, or what DWS calls "resource quality objectives". Reference conditions represent the 'natural' or best attainable situation for a given wetland (Cairns et al., 1993) and management of aquatic ecosystems is generally aimed at achieving and maintaining such conditions.

The reference condition of a wetland describes the characteristics that it would have if it were unaffected by anthropogenic activities, and provides the standard or benchmark against which its current state is measured (Stoddard et al., 2006). In the current context, as a minimum, reference conditions should be established for each of the wetland types and ecoregions in South Africa. Note that many artificial wetlands incorporate the entire suite of functions of natural wetlands, and may be valuable in the National-level. Reference conditions for such systems may have to be assumed from reference conditions of nearby natural systems.

Despite various approaches having been used to characterise reference conditions, the literature suggests that the best results will be achieved through the use of a combination of approaches: modelling, expert knowledge and historical data. Deviation from reference condition affects the biota, and the biota in turn provides an indication of the "health" or status of a wetland (Kleynhans et al., 2005). Table 3 below shows some of the approaches to characterising reference conditions for wetlands, and the advantages and disadvantages of each.

Table 3: Strengths and weaknesses of various methods for determining reference condition (taken from the State of Victoria Department of Sustainability and Environment, 2006).

Method	Strengths	Weaknesses
Expert Consensus	• Guides and reviews other procedures • May be used alone • Relatively inexpensive • Common sense and experience can be incorporated	• Qualitative description of 'ideal' community structure • Might be unrealistic and not representative of a best attainable potential • Experts might have strong biases
Biological survey	• Details obtainable best current condition • Any community structure deemed important can be used • Two methods: selected reference sites and best of ambient conditions	• Even best sites subject to human impacts • Degraded sites might lower subsequent biocriteria
Paleolimnology	• Yields historical time series for	• Preservation of fish, invertebrates, macrophytes

Method	Strengths	Weaknesses
	community structure of diatoms, chrysophytes and to a lesser extent, some crustaceans and insects • Can infer water quality	and non-diatom algae is poor • Structure may require complex data analysis and interpretation by experts • Adequate sediment record may not exist in reservoirs
Historical data	• Yields actual historical information on status • Inexpensive to obtain	• Data might be limited • Studies likely were designed for different purposes, data might be inappropriate • Human impacts present in historical times were sometime severe
Predictive models	• Useful when data are insufficient • Work well for water quality	• Extrapolation beyond known data and relationships is risky • Can be expensive

An alternative definition of the reference concept has been developed by the US EPA for hydrogeomorphic (HGM) assessment. In this approach, "reference wetlands are actual wetland sites that represent the range of variability exhibited by a regional wetland subclass as a result of natural processes and anthropogenic disturbance. In establishing reference standards, the geographic area from which reference wetlands are selected is the reference domain." (Smith et al., 1995; page 29). For practical purposes, HGM practitioners define reference standards as: "Conditions exhibited by a group of reference wetlands that correspond to the highest level of functional capacity (highest, sustainable level of functioning) across the suite of functions performed by the regional wetland subclass." (Smith et al., 1995; page A4). Note that with the advent of climate change, the "best achievable" conditions may deviate from the reference condition.

The NWMP has adopted the definition of reference condition as that of *natural or pre-impacted condition of the wetland system.* It is important to note that the reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development

It is important, both in reporting indicators in the NWMP and in determining the reference conditions, to recognise that wetlands are dynamic systems that respond to "naturally dynamic systems that respond to natural external events which occur at varying temporal and spatial scales such as daily or weekly (e.g. a major storm), seasonally (e.g. flood events), long-term climate cycles (operating over time scales of decades, centuries and millennia) and the geological and geomorphological evolution of the National-levels in which they are found" (Kotze et al., 2012; page 285). Defined reference states therefore need to be considered as dynamic (Kotze et al., 2012), or need to refer to ranges rather than single numerical values.

1.2.8 Defining a Monitoring Programme

The intent of this assignment was to design a National Wetland Monitoring Programme. Part of the design process is to clarify what is meant by the term *programme* and what might be included in or excluded from a monitoring programme. A monitoring programme can be defined as a monitoring system, an operation monitoring system, an implementation plan and the funding/management programme (Figure 2). The monitoring system component of the monitoring programme includes:

- A logical monitoring framework
- SMART (simple, measurable, applicable, relevant/repeatable and timeous) indicators
- Instruments to collect and capture indicator data
- Methods for consistently analysing indicator data.

The operation monitoring component provides the components necessary to sustainably operate and maintain the monitoring programme, including

- Mechanisms for storing indicator data
- Communication tools that display indicators in a simple, user-friendly manner
- A management plan to detail update frequencies of monitoring and review of indicators
- Feedback mechanisms and adaptive management of the monitoring programme

A monitoring programme also includes an implementation plan, which outlines a skills plan detailing the expertise required to ensure a sustainable system, and a plan for management of the system and funding of the programme. Overarching the various components of the programme is quality control.

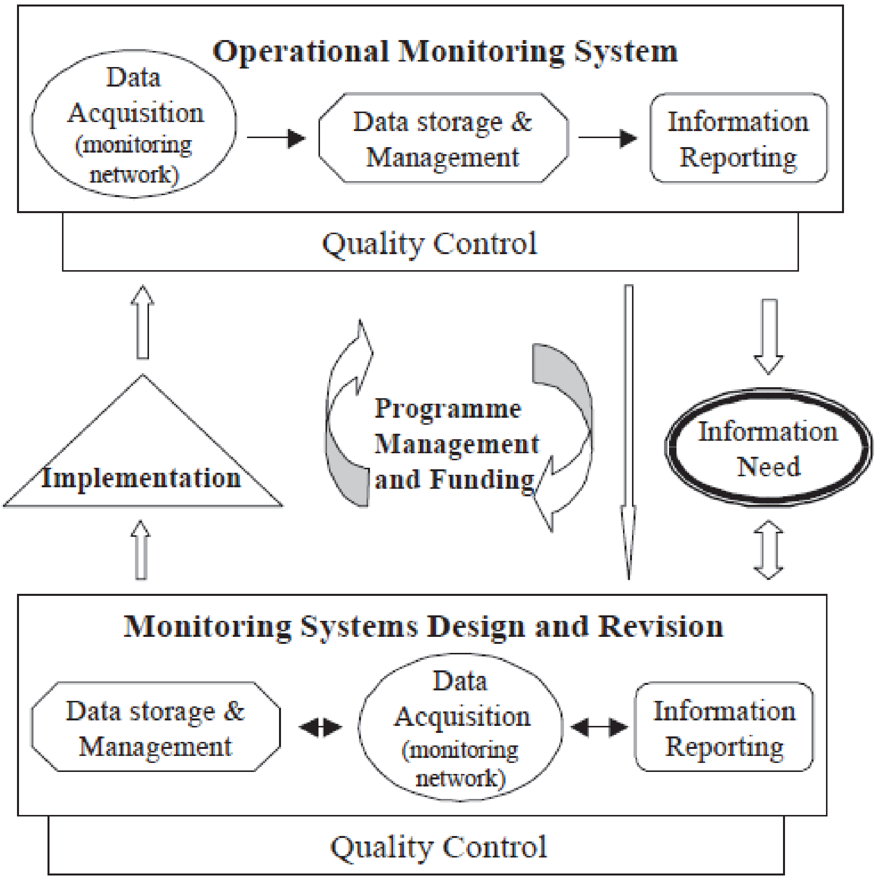

Figure 2: Illustration of the various components within a monitoring programme (Van Niekerk et al., 2002).

The design of the NWMP thus includes consideration of all the components shown in the Figure 2.

1.3 Structure Of The Report

Based on the above requirements of a monitoring programme, as well as the objectives which need to be addressed according to the Terms of Reference for the design of the NWMP, the structure of this report includes the following sections.

- Section 2: a summary review of international wetland inventory, assessment and monitoring activities and methods;
- Section 3: an overview of the current wetland institutional arrangements and environment in South Africa, including international wetland obligations, wetland-related policy, legislation and strategies; wetland organisations and current assessment and monitoring tools and guidelines available to the sector;

- Section 4: an overview of wetland inventory, assessment and monitoring initiatives currently occurring in South Africa;
- Section 5: the scope of the NWMP, the process in designing the NWMP, the NWMP framework and the relevant indicators in the NWMP. The section also provides details of indicators which were excluded, with reasons. This section outlines the assessment and monitoring SYSTEM and provides the Record of Decisions taken and agreed to during the design of the NWMP;
- Section 6: the required organisational structure, capacity, skills, funding and management requirements (i.e. governance requirements) for the successful implementation and maintenance of the NWMP. This section, together with Section 5, outlines the assessment and monitoring programme
- Section 7: recommendations for future research, including priority research needs to facilitate the implementation of the NWMP.

2 SUMMARY OF THE LITERATURE REVIEW OF INTERNATIONAL WETLAND INVENTORY, ASSESSMENT AND MONITORING INITIATIVES

The success and usefulness of a wetland inventory, assessment and monitoring system (IAMS) depends on maximising the use of resources available for the system. This includes learning from other such initiatives and applying best practice when designing and developing the system. A number of countries are a lot further than South Africa in implementing wetland IAMSs and it would have been remiss not to take advantage of their experiences.

The section below deals with

- international wetland policy initiatives
- international wetland inventories initiatives
- international wetland assessment initiatives
- international wetland monitoring initiatives

2.1 International Wetland Policies

A wetland inventory, assessment and monitoring programme is designed with the intent of reporting progress toward achieving a policy goal. For example, if the wetland policy goal of a country is management and maintenance of the 'state' of wetlands, then the IAM design would include biological, physical and chemical indicators that report on condition. If the policy goal is focussed on conserving the 'value' of wetlands, however, indicators would be focussed on the ecosystem services which these wetlands provide.

A sound policy with a strong institutional regulatory framework provides a clear roadmap to enhance compliance and enforcement of wetlands conservation and management in a country (Republic of Kenya, 2013). The need for wetland policies to achieve the appropriate management of wetlands is widely recognized, although for many governments, wetlands are not yet included in the debate about development and natural resource management; few countries have explicit wetland policies.

South Africa does not currently have a policy position or policy document related to wetlands, although the development of such a policy is under way. The review below may provide some insight into the various purposes/goals which might be adopted, and policy positions which might be applied in the South African context.

2.2 International Frameworks for Wetlands Inventory, Assessment and Monitoring

Conceptual frameworks are a key tool used in many of the more comprehensive inventory, assessment and monitoring programmes and activities. Various frameworks have been applied across the world (see Appendix B for details). Table 4 summarises the key wetland assessment and monitoring frameworks that informed the design of the NWMP.

Table 4: Summary of wetland assessment and monitoring frameworks which informed the design of the NWMP.

Framework	Description	Application in the design NWMP	Modification in application in the design of the NWMP
RAMSAR 3-way approach to monitoring wetlands (Ramsar, 2005a)	RAMSAR adopts a 3-way approachnamely, (1) inventory; (2) assessment, and (3) monitoring. Each of these components requires varying degrees of effort and scale in the application.	The NWMP will have a 3-Tier framework similar to the RAMSAR 3-way approach. that includes three spatial scales: – from national scale assessment to fine-scale	The NWMP 3-Tier Framework assesses and monitors key features of wetlands for a South-African-specific goal. The South Africa wetland assessment and monitoring goal differs from that of RAMSAR's goal of wise use (see

Framework	Description	Application in the design NWMP	Modification in application in the design of the NWMP
	Inventory, assessment and monitoring are important interactive and interlinked wetland data gathering exercises to identify key features of the ecological character of wetlands for wise use and management of these water resources.	monitoring of individual wetlands. Resource (time, cost and personnel numbers) requirements increase from Tier 1 to Tier 3 in the NWMP Framework, as does the accuracy of data and indicator reporting due to increased accuracy of methods.	Section 5.2.2. for the South Africa goal) and thus utilises different indicators and methods to those applied in the RAMSAR 3-way approach. The compilation and maintenance of a wetland inventory in South Africa informs but does not form one of the Tiers of the NWMP– as it does in the RAMSAR 3-way approach.
Environment Objective Framework for Monitoring Ecological Condition (Cairns et al., 1993)	This framework applies the goal-objectives-indicator approach to monitoring of ecological condition of wetlands. The framework is based on the principle that successful conservation, management and use of wetlands should be based on goals/objectives that in turn guide the wetland assessment and monitoring programme. The monitoring framework includes selection of explicit, generally accepted wetland conditions which should be achieved and maintained (i.e. goals/objectives). Once a goal and/or objective has been defined for the conservation, management and use of wetlands, the framework requires that indicators are selected that are useful in judging the extent to which the specific goal/objectives have been achieved. Selection of indicators is crucial in this framework, because indicators link directly to the framework goals and objectives	The NWMP was designed to address a wetland assessment and monitoring goal and strategic objectives in the country (See Section 5.2.2 for more details). This goal and objectives provided the template for the 3-Tier Framework of the NWMP and informed indicators selection.	The use of the objective framework informed only the NWMP design.
USA Environmental Protection Agency – Framework for Assessing and Reporting on Ecological Condition (EPA, 2002).	This framework logically assembles generic ecological characteristics into a few scientifically defensible categories. The information in the categories can then be used to report on a variety of environmental management goals. This framework, which is hierarchical, contains: • Goals and Objectives – the desired ecosystem conditions for wetland management, conservation and use • Six Essential Ecological Attributes – three ecological	See Environment Objective Framework for Monitoring Ecological Condition above.	See Environment Objective Framework for Monitoring Ecological Condition above.

Framework	Description	Application in the design NWMP	Modification in application in the design of the NWMP
	attributes that are primarily "patterns" (National-level Condition, Biotic Condition, and Chemical/Physical Characteristics) and three that are primarily "processes" (Hydrology/ Geomorphology, Ecological Processes, and Natural Disturbance). • Ecological Indicators – measurable characteristics related to the structure, composition, or functioning of ecological systems. • Measures – specific monitoring variables that are measured in the field and aggregated into one or more ecological indicators (or endpoints).		
Australia – Framework for the Assessment of River and Wetland Health (FARWH) (Alluvium Consulting, 2011).	The FARWH is a two-tier approach to wetland condition assessments, addressing the need for assessment to operate over a range of spatial scales to satisfy national reporting needs and to inform regional monitoring and management actions. The first tier is broad-scale assessment of the region of interest, using existing datasets and desktop assessment methods. The second tier requires detailed assessment at a wetland scale, particularly for systems that are at high risk of change or of particularly high conservation value (Alluvium Consulting, 2011). The framework is based on the conceptual model that indicators must reflect change in the condition of the wetland. FARWH is, however, a flexible process, not being prescriptive on which indices are used, with State and Territories able to include their customised wetland assessment and monitoring datasets into the FARWH (Alluvium Consulting, 2011).	The NWMP utilised the two-tiers in the FARWH as a preparatory approach for the design of the 3-Tier Framework of the NWMP	The NWMP design includes a third tier of monitoring and include prescribed indicators for each tier in the Framework.

2.3 INTERNATIONAL WETLAND INVENTORIES

Wetland inventory or mapping precedes wetland assessment and monitoring and provides a basis for guiding appropriate assessment activities. It is defined as the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.
Finlayson et al., 2001

Wetland inventories are useful in the first stages of developing effective wetland conservation, management and sustainable use programmes and assessment and monitoring of these programmes (Finlayson and van der Valk, 1995). The information collected through wetland inventories is thus regarded as a necessary prerequisite for wetland conservation and management. Strategically developed wetland inventory (or inventories) provide managers and policy-makers with key information that is required to manage individual wetland and threats to these, but also place the conservation value of wetlands within the context of broad-scale (catchment, regional or even national) priorities with regard to land-use and sustainable development (Finlayson and Spiers, 1999). Inventories are particularly valuable for assessing wetland loss and degradation, providing valuable information for creating information of the importance of wetlands and for developing targeted conservation and restoration programmes (Finlayson and Spiers, 1999). Perhaps just as important is that an inventory can demonstrate the economic value of wetlands and thus assist in decision-making related to the sustainable use of wetlands (Finlayson and van der Valk, 1995).

Once the basic information on wetland occurrence, distribution and status has been collated it is essential that it is utilised as the basis of conservation effort before it becomes dated and not seriously regarded by conservation officials (Naranjo, 1995). A wetland inventory can assist in identification of conservation priorities, establish the basis for monitoring the ecological status of wetlands, promote awareness of wetland sites and management issues, and facilitate exchange of information and comparisons between sites and regions (Garcia-Orcoyen et al., 1992). Crucially, inventories need to be updated regularly, and require central storage of, and easy access to, the data through standardised computerized formats (Finlayson and van der Valk, 1995).

Throughout the 1980s and into the 1990s there was a determined international effort to compile wetland inventories, with these efforts spearheaded by international organisations such as WWF (the World-Wide Fund for Nature), IUCN (The World Conservation Union), ICBP (now Birdlife International), and the IWRB (now Wetlands International) (Finlayson et al., 2001). Wetland inventories were compiled at a regional level for Asia (Scott, 1989), South America and the Caribbean (Scott and Carbonell, 1986), Africa (Hughes and Hughes, 1992), the South Pacific and New Zealand (Cromarty and Scott, 1995) and the Middle East (Scott, 1995).

At a national scale, countries such as the USA (Cowardin et al., 1979, Cowardin and Golet,1995, Wilen and Bates, 1995), Canada (Zoltai and Vitt, 1995) and Australia (Usback and James, 1993; ANCA, 1996) have compiled wetland inventories. More recently, in 2015, a number of southern African countries reported to RAMSAR n that a comprehensive wetland inventory had been compiled. These countries are Botswana, Kenya, Lesotho, Malawi, Mozambique and Namibia. Zambia and Zimbabwe indicated that wetland inventories were still in progress.

Appendix B provides a literature review of wetland inventories across the globe. An overview of the South African wetland inventory is provided in the Section 4.1 of this report.

2.3.1 International Wetland Assessments

*Wetland assessment is the preliminary identification of **wetland status** and **threats to present state**. This provides the first-level information from which a 'monitoring' plan is devised. Assessment describes a suite of actions relating to the evaluation of wetland health relative to a known range of conditions from wetlands across a disturbance gradient. It includes the evaluation of both the **functions** and **condition/ecological integrity** of the wetland system.*
Finlayson et al., 2001

An inventory of wetlands is in effect a type of assessment as it provides information (i.e. location; extent and type) on wetlands within the National-level. The term assessment is more commonly applied to more detailed evaluation of wetland function, value, condition, and "health" or ecological integrity (Thiesing, 2001).

Wetland assessments have been widely used, commonly to: 1) evaluate wetlands likely to be developed; 2) evaluate impacts on wetlands for planning purposes; 3) evaluate wetland restoration potential for conservation programmes; and 4) determine wildlife habitat potential for management purposes (Thiesing, 2001). A number of wetland assessment techniques have thus been developed over the years, differing in their level of detail, objectivity and repeatability of the results. There is also considerable variability in the range of wetland functions/conditions that are considered in any given technique (Thiesing, 2001).

The type of assessment is generally determined by its purpose. For example, if the purpose of an assessment is to identify the potential effects of climate change on a wetland then a risk or vulnerability assessment would be conducted. It is thus important to clearly establish the purpose of the assessment before implementing the assessment. There are generally four types of wetland assessment methods (Thiesing, 2001).

1. **Inventory and classification:** – assessments that provide information of the areal extent and/or types of wetlands within a given National-level.
2. **Rapid Assessments:** – generally low-cost assessments that gather wetland data in a short time. Rapid assessments usually focus on assessment of a single wetland or small groups of wetlands and are characterised by being qualitative and/or largely subjective (best professional judgement).
3. **Data-driven Assessments:** – mostly model-based and hence can be expensive to develop. The advantage of this type of assessment is that it provides a high degree of reproducibility.
4. **Bioindicators / Indices of Biotic Integrity**: assessments that use a selected set of variables measured across wetland types and reported separately or as indices. This type of assessment can be used to measure the condition or ecological integrity of a wetland and to identify long-term changes in the wetland.

Wetland assessments often use a combination of the above methods to determine the condition and functions of a wetland but rapid methods are, the most extensively used.

Appendix B provides a summary of wetland assessment methods across the globe. The assessment methods included in Appendix B are largely those that are applicable at a national scale.

2.4 PRIORITISATION OF WETLANDS FOR MONITORING

Since it is not possible to assess or monitor all wetlands, most countries have developed means of prioritising wetlands for management, conservation and monitoring using various methods. The method of prioritisation is usually determined by the purpose and scale of the prioritisation. For example:

- RAMSAR recommends nine criteria for prioritisation of wetlands of international importance (see Section 10.5.1)
- The Directory of Important Wetlands in Australia (DIWA) also utilises criteria to prioritise wetlands of national importance (see Section 10.5.2)
- The US EPA utilises random statistical prioritisation of wetlands for inclusion in the National Wetland Condition Assessment (see Section 10.5.3).

A summary of the various methods of prioritisation, from the literature, are provided in Section 10: Appendix B.

3 SOUTH AFRICAN'S WETLANDS: INSTITUTIONAL ENVIRONMENT AND ARRANGEMENTS

The term institution is often confused or used interchangeably with the term organisation. According to the literature an organisation is generally defined as a management structure, such as the Department of Water and Sanitation, while an institution is defined as "an organized, established, procedure" which provide the "rules[2]of the game" (Jepperson, 1991; Bandaragoda, 2000).

The key characteristics of institutions are that "they are patterns of norms and behaviours which persist because they are valued and useful" (Bandaragoda, 2000). Institutions thus define what an individual can and cannot do (compulsion or duty) in a specific situation, what they may do without interference from others (permission or liberty), what they are able to do with joint authority (capacity or right) and what they cannot expect the public influence to do on their behalf (Saleth and Dinar, 2004). Institutions thus both contain and enable behaviours (Hodgson, 2006).

According to a number of authors, an institution can be grouped into two functional segments, the **institutional environment** and the **institutional arrangements** (Davis and North, 1970; North and Thomas, 1973; Saleth and Dinar, 2004).

With regard to water, the **institutional environment** is the set of fundamental political, social, and legal rules that establish the basis for the water services institution and comprises international obligations, policy, legislation, regulations and strategies. In this section the institutional environment delimiting the wetland sector of South Africa is reviewed. It includes

- international wetland obligations;
- Wetland policy intents in environmental, water and agricultural policy;
- Wetland legislation mandates outlined in environmental, water and agricultural law;
- Wetland-related regulations; and
- Strategies that affect the wetland sector in the country.

While the institutional environment described above covers the rules of the game, the **institutional arrangements** are the governance structures that evolved from, and interact with, the institutional environment (Saleth and Dinar, 2004). This governance structure includes both the economic and the political organizations that form part of the institutional arrangements, thus provide a structure within which stakeholders – individually or collectively – cooperate or compete (Saleth and Dinar, 2004). The institutional arrangements of the wetland sector of South Africa, which is reviewed in this section, include organisations involved in the wetland sector, both from an environmental and water perspective, and wetland assessment and monitoring instruments (methods, tools, guideline, procedures and processes).

3.1 South Africa's International and National Wetland Obligations

South Africa is signatory to the United Nations Multilateral Environmental Agreements (MEA). These agreements are legally binding treaties which form the basis for international law, play a critical role in setting international norms, and strengthen co-operation among countries with different national interests (Saruchera and Mbote-Kameri, 2004). These global treaties, which include treaties for the protection of natural resources, are tools for managing resources commonly shared by states and of common concern to humankind.

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[2] *Rules,* according to Hodgson (2006) are defined as *socially transmitted and customary normative injunction or immanently normative disposition, that in circumstances X do Y* (Hodgson, 2006).

These UN treaties include the:

1. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
2. World Heritage Convention
3. United Nations Convention to Combat Desertification (UNCCD)
4. Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat
5. Convention on Biological Diversity (CBD)
6. United Nations Framework Convention on Climate Change (UNFCCC) and
7. African Convention on the Conservation of Nature and Natural Resources.

Two of these conventions, namely the Ramsar Convention on Wetlands and the Convention on Biological Diversity (CBD), directly relate to South Africa's international wetland obligations.

3.1.1 South Africa's Ramsar Commitments

The Ramsar Convention, which was ratified in 1971, binds all signatories to include wetland conservation in national policy and to promote sound wetland utilization (Kotze et al., 1995). The Convention recognises the ecological and other value of wetlands, and has the aims of stemming the loss of wetlands and promoting their 'wise use' (Kidd, 2011).

Parties to the Convention, which include South Africa, are required to designate at least one wetland of international importance (Kidd, 2011). According to South Africa's most recent Ramsar report, submitted for the 2015 COP_{12}, the country has 21 Ramsar Sites extending over 553,178 hectares (Ramsar Secretariat, 2015). The management of these Ramsar sites is carried out by the environmental authority in the region where the site is situated, generally government departments and public entities for biodiversity conservation and management in the provinces. A list of South Africa's Ramsar sites is provided in Annexure B.

Kidd (2011) considers that despite the Ramsar Convention not been directly provided for in South African law, the water and environmental legislation of the country, including the National Water Act (No. 36 of 1998) and the National Environmental Management Act (No. 107 of 1998) (South Africa, 1998a and 1998b) does provide statutes for conservation of wetlands.

Signatories to the Ramsar Convention are required to submit National Reports on their progress in implementation of the convention. These reports provide an overview of national wetland experiences, report on the monitoring of the implementation of the Convention, share information on wetland conservation measures, highlight problems, and describe potential solutions which the country has introduced. The current structure of National Report is hierarchical in nature, with a mission and 5 supporting goals (Ramsar resolution XI.3, 2012). The Convention's mission is the "conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". The five supporting goals are

- **GOAL 1. Wise Use.** To work towards achieving the wise use of all wetlands.
- **GOAL 2. Wetlands of International Importance.** To develop and maintain an international network of wetlands important for the conservation of global biological diversity and for sustaining human life.
- **GOAL 3. International cooperation.** To enhance the conservation and wise use of wetlands using effective international cooperation
- **GOAL 4. Institutional capacity and effectiveness.** To progress towards fulfilment of the Convention's mission by ensuring that it has the required mechanisms, resources, and capacity to do so.
- **GOAL 5. Membership.** To progress towards universal membership of the Convention.

The progress of signatory countries in addressing the above goals is monitored through 82 indicator questions.

3.1.2 Convention on Biological Diversity (1992)

Whilst the Ramsar Convention focusses exclusively on wetlands, the Convention on Biological Diversity (CBD) of 1992 adopts an inclusive approach to all ecosystems and biological resources (de Klemm and Shine, 1998). As a signatory to the CBD, South Africa is required (DEA, 2009a) to:

- establish a system of protected areas to conserve biodiversity;
- develop guidelines for the selection, establishment and management of protected areas;
- promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species.

Although wetlands are not directly addressed in a specific South African National Biodiversity Strategy and Action Plan (NBSAP), many of the strategic objectives (SOs) shown in Figure 3 address wetland conservation needs directly or through specific outcomes and activities linked to an SO. Conservation of wetlands is required to address the overall goal of the CBD, namely to conserve and manage terrestrial and aquatic biodiversity to ensure sustainable and equitable benefits to the people of South Africa, now and in the future (DEAT, 2005).

Figure 3: South African CBD goal and strategic objectives (DEAT, 2005)

The NBSAP is supported by National Biodiversity Assessments (NBAs) (2004 and 2011) and the National Biodiversity Framework (NBF). The primary purpose of the NBA is to provide a regular high-level summary of the state of South Africa's biodiversity, with a strong focus on spatial assessment, while the NBF addresses the requirements of the National Environmental Management: Biodiversity Act (NEM:BA). See Table 5 for wetland details included in the NBF (2008) and the NBA (2011).

Table 5: Summary of wetland components included in the NBA (2011) and NBF (2008) (Nel and Driver, 2012)

National Biodiversity Assessment (NBA) (2011)	NBA 2011 provides an assessment of South Africa's biodiversity and ecosystems, including headline indicators (i.e. ecosystem threat status and ecosystem protection level) and national maps for the terrestrial, freshwater, estuarine and marine environments. The assessment emphases spatial biodiversity information, including species and ecosystems, and lays the foundation for effective management of biodiversity and for monitoring progress against national and global targets (Nel and Driver, 2012). One of the crucial additions to the 2011 NBA is the mapping and first national assessment of wetlands. The wetland component of the NBA (2011) is based on the frameworks for classifying wetlands at the National-level scale (SANBI, 2009) and the National Freshwater Ecosystem Priority Areas (NFEPA) project, which identified Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems (Driver et al., 2012; Nel et al., 2011a and b). Key wetland findings in the NBA are (Nel and Driver, 2012): • 65% of South Africa's wetland ecosystem types are threatened (critically endangered, endangered or vulnerable). • Wetland ecosystems are more threatened than their estuarine, marine and terrestrial counterparts (44%, 59%, 41% and 40% of estuarine, coastal and inshore, offshore and terrestrial ecosystem types are threatened respectively). • Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered. • Wetlands in South Africa's make up only 2.4% of the country's area. This small area represents high-value ecological infrastructure that provides critical ecosystem services such as water purification and flood regulation. • Very few (17%) wetland ecosystems are moderately to well protected • Floodplain wetland ecosystem types are the least protected and most threatened of all the wetland ecosystem types. Over 80% of the country's floodplain wetland ecosystem types are not protected, and 60% of these are critically endangered. • FEPAs comprise only 38% of wetland area, and represent strategic spatial priorities for conserving freshwater ecosystems and supporting sustainable use of water resources. NBA recommendations related to wetlands and ecological monitoring include (Nel and Driver, 2012): • *Ecological monitoring requires quantitative data and cannot be based on expert evaluation alone* • *The present ecological status (PES) category of the Department of Water Affairs is based on an evaluation of key drivers of ecosystem modification using existing data where possible, combined with expert evaluation – Nel et al. (2011b) found that trends in present ecological status frequently had their origin in improved expert knowledge rather than being grounded in actual reality.* • *Monitoring trends in ecological condition of wetlands should be based on quantitative metrics that can be measured over time at the same site.* • *Strategic field sampling sites and metrics for wetlands should be chosen and an implementation plan (including a financing plan) for monitoring these over time should be developed and put into action.*

	• Strengthen freshwater inventorying and monitoring programmes
National Biodiversity Framework (NBF) (2008)	National Environmental Management: Biodiversity Act (NEM: BA) requires the development of a National Biodiversity Framework (NBF). The NBF, which was gazetted in 2009 (No. 32474), prioritises 33 actions for immediate attention (2008-2013). The purpose of the NSF is to provide a framework to co-ordinate and align the efforts of the many organisations and individuals involved in conserving and managing South Africa's biodiversity, in support of sustainable development (DWAF, 2009). The NBF has the aims to (DWAF, 2009): • Focus attention on the most urgent strategies and actions required for conserving and managing South Africa's biodiversity • Point to roles and responsibilities of key stakeholders, including key organs of state whose mandates impact directly on biodiversity conservation and management • *The heart of the NBF is a set of 33 Priority Actions, which provide an agreed set of priorities to guide the work of the biodiversity sector in South Africa for the next five years* (DWAF, 2009). Due to gaps in spatial data and wetland information in 2008, the NBF has little inclusion of wetland priorities and actions.

3.2 South Africa's Wetland Institutional Environment

The wetland institutional environment in South Africa encompasses policies, legislation, regulations and strategies developed by three sectors, namely the water sector, the environmental sector and the agricultural sector. Wetland-related policy, legislation, strategies, and regulations emerging from each of these sectors are outlined in the sections below.

3.2.1 South Africa's water policy, legislation, strategy, regulations and organisations relevant to wetland assessment and monitoring

South Africa's COP12 Ramsar report indicated that "South Africa does not have a specific wetland policy. Wetland issues are addressed in a range of water, biodiversity and environmental policy instruments such as the Working for Water Strategic Plan" (Ramsar, 2015). South Africa reported in the COP12 Ramsar Report that the country has "opted not to develop a stand-alone wetland policy, but to incorporate objectives relating to wetland conservation and wise use into relevant sectoral policies, including those covering environment, agriculture, biodiversity and water. The 'mainstreaming' of wetlands into those sectors with a high potential to impact on wetlands was considered to be the advantage of this approach. This made wetlands part of the business of these sectors, rather than creating a separate 'wetlands sector' whose ownership was seen to lie with a traditional wetland champion like an environmental department" (Ramsar, 2015).

3.2.1.1 Water Policy: The White Paper on National Water Policy for South Africa (1997)

A wetland or water policy sets out the sector's position or statement on a particular subject and informs the development of legislation to regulate the sector. Policy is a precursor to legislation.

For long-term effectiveness and coherence, legislation needs to be located within a consistent policy framework.

The policy which underpins the water legislation in South Africa is the White Paper on National Water Policy for South Africa (1997). This policy remains the main policy in the water sector of the country, with minor amendments having been made in the National Review of Water Policy in 2013. The policy broadly makes reference to wetlands in the context of:

- the needs for water management to take into account the complex interactions between water and the sediments, banks, animals, plants and microbes in rivers, dams and ***wetlands***;
- the reliance of humans on the healthy functioning of whole ecosystems, such as rivers, lakes, dams, ***wetlands***, estuaries and the coastal marine environment;
- **wetlands** forming an integral component of the water cycle.

3.2.1.2 Water Legislation: The National Water Act (Act 36 of 1998)

The National Water Act (NWA) requires that water resources are protected, used, developed, conserved and controlled in ways that take into account a range of needs and obligations, including the need to "protect aquatic and associated ecosystems and their biological diversity" (South Africa, 1998a).

The Act only makes direct reference to wetlands in the definition of a watercourse – deemed to include wetlands – and in the actual definition of a 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* Due to the definition of a watercourse, however, all legal mandates related to a watercourse in the act apply to wetlands as well (South Africa, 1998a).

The Act also mandates that monitoring, recording, assessing and dissemination of information on water resources, is critically important for achieving its objectives.

Sections 137 and 138 of the Act stipulate that the Minister, through the Director-General of DWS, establish national monitoring systems to facilitate the continued and co-ordinated monitoring of various aspects of water resources. These monitoring systems need to collect relevant information and data through established procedures and mechanisms from a variety of sources, including organs of state and water management institutions. The Act dictates that the national monitoring systems collect appropriate data and information to assess:

(a) the **quantity** of water in the various water resources;

(b) the **quality** of such water;

(c) the **use** of water resources;

(d) the **rehabilitation** of water resources;

(e) **compliance** with resource quality objectives;

(f) the **health of aquatic ecosystems**; and

(g) **atmospheric conditions** which may influence water resources.

The Minister is also mandated to establish national information systems for the different aspects of water resources, including. water courses. The objectives of the information system are, amongst others, to store and provide data and information for the protection, sustainable use and management of water resources (wetlands) and to provide information for the development and implementation of the national water resource strategy (including wetlands). These information systems may include, among others-

- A hydrological information system;
- A water resource quality information system;
- A groundwater information system; and
- A register of water-use authorisations.

The wetland-related and monitoring mandates of the NWA form the base for the design of the NWMP. The programme has the core intent of addressing the NWA requirement of collecting appropriate data and information to assess wetland health in the country.

3.2.1.3 Water Regulations: General Authorisation in terms of Section 21 (c) and (i) for the purpose of rehabilitating a wetland for conservation purposes

Regulations are the policy instruments through which government enforce compliance to legislative imperatives.

The General Authorisation (GA) for rehabilitating a wetland for conservation purposes (Gazette 1198 of 2009) outlines the license requirements for users wishing to impede or divert the flow of a watercourse or alter the bed, banks, course or characteristics of a watercourse for the purpose of rehabilitating a wetland for conservation purpose (DWA, 2009)

The GA requires that the water user under the regulation compile a Planning Report which includes (amongst other things) an assessment of the ecological status, importance and sensitivity (including socio-cultural and heritage value) of the wetland. The Planning Report is also required to include a monitoring and evaluation process for work to be undertaken (DWA, 2009).

Of note in the GA are that once the rehabilitation activity has been completed an active campaign of controlling new exotic and alien vegetation must be implemented and a habitat assessment study must be undertaken annually for three years. These legislative requirements can contribute to the NWMP if the results of the 3-year assessment of rehabilitated wetlands are included in the programme database. DWS, having legislative responsibility for the sustainable implementation of the NWMP, should include in the license conditions of water users the need to submit the results of these assessment to the NWMP, as well as the need of the license applicant to utilise or ensure compatibility with the methods, tools and process recommended in the NWMP for the assessment and monitoring of wetlands (see Implementation Manual for the NWMP, WRC Report xxx). Similarly, DWS should engage with the Working for Wetland programme, South Africa's premier wetland rehabilitation programme (see Section 4.2.5), to facilitate sharing of assessment and monitoring information and data.

The DWS, in November 2015, issued a call for comments on proposed revisions of the general authorisation in terms of Section 39 of the National Water Act, 1998 (act no. 36 of 1998). The draft GA amendments related to impeding or diverting the flow of water in a watercourse (section 21(c)) and altering the bed, banks, course or characteristics of a watercourse (section 21(i)) (DWS, 2015). These regulations, which will replace Regulation 1198 of 2009, apply the same definition of the extent of a watercourse but do not limit the foci of the regulation to activities for rehabilitation of wetlands for conservation purpose. The draft Regulation provides conditions for allowing the impeding or diverting the flow or altering the bed, banks, course or characteristics of a watercourse. Upon completion of the activity the regulations require that:

- a systematic rehabilitation programme must be undertaken to restore the watercourse to its condition prior to the commencement of the activity;
- all disturbed areas must be re-vegetated with indigenous vegetation suitable to the area; and
- active alien invasive plant control measures must be implemented to prevent invasion by exotic and alien vegetation within the disturbed area.

The draft Regulations further stipulate, in Section 9 (1), that the water user must establish and implement monitoring programmes to ensure that the impacts of the activity on the resource quality characteristics remain within the parameters outlined above. The draft Regulations also have the provision that "upon completion of the water use, the water user must undertake an Environmental Audit annually for three years to ensure that the rehabilitation is stable, failing which, remedial action must be taken to rectify any impacts" (DWS, 2015).

3.2.1.4 Water Strategies

Sustainable Development Goals

Sustainable Development Goals (SDGs) were adopted by the United Nations in 2015, with South Africa's commitment to achieving sustainable development requiring the country to report on progress in achieving the SDGs. A number of these SDGs relate to wetlands and to monitoring of and reporting on wetlands in the country (Table 6).

Effectively reporting, at a national level, on progress in achieving the SDGs would require a focus on monitoring and reporting wetland water quality; the effectiveness of the wetland management institution; the level of participation of local communities in wetland management; progress in conservation, restoration and sustainable use of wetlands; the degree of reduced degradation and alien invasive species in wetlands and the availability of financial resources to conserve and sustainably use wetland biodiversity and ecosystems

Table 6: Proposed water supply and sanitation SDGs (taken from United Nations, 2015)

GOAL 6 Ensure availability and sustainable management of water and sanitation for all		
Water quality	6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
Efficiency	6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
IWRM	6.5	By 2030, implement integrated water resources management at all levels, including through trans-boundary cooperation as appropriate
Water-related ecosystems	6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, **wetlands**, rivers, aquifers and lakes
Participation	6.b	Support and strengthen the participation of local communities in improving water and sanitation management
Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss		
Conservation, restoration and sustainable use		By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, **wetlands**, mountains and drylands, in line with obligations under international agreements
Reduce degradation		Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
Invasive alien species		By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species
Financial resources		Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems

South Africa's SDG reporting obligations have relevance to wetland assessment and monitoring and thus informed the NWMP design process, particularly related when selecting the goal, strategic objectives and indicators for the NWMP.

National Development Plan (NDP) (2011)

In 2012-2013 South Africa released the National Development Plan (NDP), which is to be implemented in the medium term through the Medium-Term Strategic Framework (MTSF) 2014-2019 (The Presidency, 2012). The NDP provides the development path for South Africa until 2030.

The NDP indicates that one of the challenges in a water-scarce country such as South Africa will be to pay greater attention to the management and use of water. The NDP thus envisages that, by 2030, effective management of water and the water services derived from it will support a strong economy and a healthy environment. To realise this goal the country's development will need to:

- reflect an understanding of available water resources
- ensure effective water planning that cuts across different economic sectors and spheres of government and
- ensure that natural water sources will be protected to prevent excessive abstraction extraction and pollution of water.

The NDP highlights the following challenges in the water resources and services sector.

a) Implementing broader water-resource policies that address **equitable allocation and protection** of the resource remains a challenge.
b) **Water restrictions** due to drought have been limited in recent years but the threat remains due to delays in investment in infrastructure and a failure to moderate growth in demand.
c) **Backlogs in service provision** in rural areas remain and there is pressure to upgrade urban service levels, which will require further investment.
d) There are serious concerns about the **ability of the current water administration** to cope with emerging challenges.
e) The available pool of experienced water **engineers and scientists** is shrinking rapidly.
f) **Administrative failures and the absence of enforcement** indicate that management quality was deteriorating and institutional memory was being eroded.
g) **Delays in issuing water licences** are affecting economic activity, with new farmers also affected as the administration fails to reallocate water rights in areas where demand exceeds supply, as provided for in the National Water Act (1998).

To ensure economic growth in the country, the NDP recommends managing, monitoring and protecting South Africa's water resources in a sustainable manner with effective administration, evolving water-resource management and prioritisation.

National Water Resource Strategy 2 (2013)

The National Water Resource Strategy 2 of 2013 (NWRS2) sets out the strategies, objectives, plans, guidelines and procedures of the water resource sector and institutional arrangements relating to the protection, use, development, conservation, management and control of water resources.

Key **monitoring** aspects in the NWRS-2, which will guide water resource monitoring in the next 10 years, include (taken from DWA, 2013):

- o the need to develop adequate capacity for monitoring and effective detection and adaptation to protect water and to ensure sustainable water supplies into the future;
- o acknowledgement that monitoring and collecting relevant data will not only affect the accurate assessments of the status of water resources and the magnitude of water problems, but will vastly improve planning and policy formulation processes;
- o the fact that much still needs to be done in implementation of water resource protection programmes and monitoring of ecosystem health to proactively minimise degradation of the resource, focus rehabilitation efforts and ensure compliance;
- o information is needed about the ecological state of aquatic ecosystems as well as the trajectories and rates of change that they are subjected to.
- o South Africa's Environmental Policy, Legislation, Strategy and Regulations relevant to Wetland Monitoring

Section 24 of the Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996) stipulates that all citizens have the right to an environment that is not harmful to their health or well-being and to have the environment protected for the benefit of future generations (South Africa, 1996). South Africans are compelled to take reasonable legislative and other measures to prevent pollution and ecological degradation, promote conservation, and secure ecologically sustainable development and use of natural resources (including wetlands) while promoting justifiable economic and social development.

3.2.1.5 Environmental Policy: White Paper on the Conservation and Sustainable Use of Biodiversity (No. 18163 of 1997)

The interesting and confounding aspect of wetland conservation, monitoring and management in South Africa is that it is the environmental policy, the White Paper on the Conservation and Sustainable Use of Biodiversity (No. 18163 of 1997), which provides the countries policy positions on wetlands, while the regulator of wetlands is the DWS under the ambit of the country's water policy and legislation (South Africa, 1997).

The White Paper on the Conservation and Sustainable Use of Biodiversity highlights:

- the fact that the majority of wetlands fall outside of protected areas.
- the lack of information concerning wetland losses in South Africa,
- evidence to suggest that the loss of wetlands has been high, major losses occurring in the coastal and inland margins of the country.

These constraints are still perceived to be relevant almost two decades since the promulgation of the 1997 White Paper.

The goal of the White Paper focusses on DEA imperatives, indicating that Government will *strive to conserve South Africa's biological diversity and to thereby maintain ecological processes and systems whilst providing lasting development benefits to the nation through the ecologically sustainable, socially equitable, and economically efficient use of biological resources.*

From a monitoring perspective, the White Paper indicates that monitoring and evaluation are considered by Government to be essential components of the policy. To achieve the objective, Government, in collaboration with interested and affected parties, committed to:

1. Promote and coordinate the development of international, national, regional and local monitoring programmes and strategies to assess biological trends, the impacts of human activities on biodiversity, and the successes or failures of conservation and sustainable use programmes. Monitoring programmes will, where appropriate:
    a) develop and link to the development of a national biodiversity information network;

   b) develop and implement cost-effective approaches such as the use of biodiversity indicator groups and other early warning stress indicators;
   c) update and review Red Data books, in line with appropriate international standards; and
   d) track changes in management responses to the conservation and sustainable use of biodiversity.
2. Report on biodiversity trends, as part of "State of Environment" reports.
3. Maintain and strengthen the capacities of institutions engaged in monitoring components of biodiversity, and improve coordination among such bodies.
4. Support efforts to build the capacity and draw on the knowledge of local communities and volunteers with respect to undertaking monitoring exercises.
5. Establish assessment panels or monitoring committees, comprising representatives of nongovernmental organisations, community groups, industry, the scientific community, and government.
6. Support the independent monitoring and evaluation of biodiversity conservation and sustainable use policies, programmes and projects.

3.2.1.6 Environmental Legislation: National Environmental Management Act (Act 107 of 1998)

The National Environmental Management Act (NEMA) (Act No. 107 of 1998), which is the cornerstone of environmental law in the country, was established to coordinate environmental functions exercised by various organs of state and integrating environmental management in South Africa (Figure 4) (South Africa, 1998b).

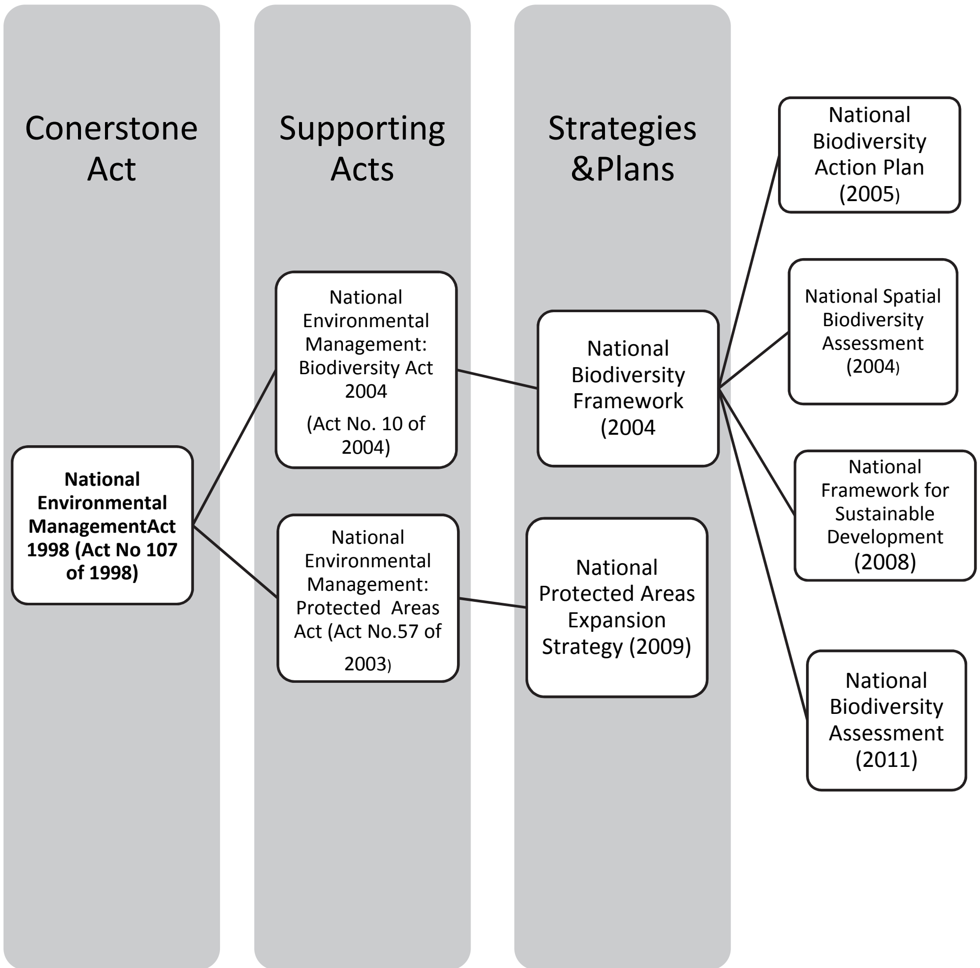

Figure 4: Hierarchy of wetland environmental monitoring-related legislation, policies and programmes

Section 2 (4)(r) of NEMA is based on the principle that sensitive, vulnerable, highly dynamic or stressed ecosystems, such as wetlands, require specific attention in management and planning procedures, especially where they are subject to significant human use and development pressure. Section 24(2) & 24(D) of the Act seeks to achieve compliance and enforcement of activities on wetlands which may not commence without environmental authorization (South Africa, 1998b).

The Act does not have any specific monitoring specifications as are found in the water legislation.

Environmental legislation most applicable to wetland monitoring is included in Table 7. In addition to these, the Department of Environmental Affair (DEA), the primary custodian of the environment in South Africa, has embarked on, as part of its law reform programme, the drafting of new legislation relevant to sustainable biodiversity use.

Table 7: South Africa's wetland-related environmental monitoring legislation

Environmental legislation	Monitoring obligations
National Environmental Management: Biodiversity Act (NEM: BA) (Act 10 of 2004)	Section 37(b) of the NEMA aims to provide for monitoring the conservation status of various components of South Africa's biodiversity. In addition, the Section 49 of this Act mandates the competent authority to designate monitoring mechanisms and to set indicators to determine the conservation status of various components of South Africa's biodiversity; including wetlands; and negative and positive trends affecting this conservation status.
National Environment Management: Protected Areas Act (NEM: PAA) (Act 57 of 2003)	The Act provides for the establishment of a national register of protected areas, and the proclamation and management of these areas, co-operative governance, public participation and matters related to protected areas. The NEM: PAA compels the minister to conduct monitoring and supervision of protected areas, including wetlands. The minister may establish performance indicators for monitoring performance with regard to the management of national, provincial, and local protected areas and the conservation of biodiversity (wetlands) in those areas. Hence, the management authority of a protected area must monitor the area against the indicators and must annually report its findings to the Minister or, as the case may be, the minister may appoint external auditors to monitor a management authority's compliance with the overall objectives of the (wetland) management plan.

3.2.1.7 Environmental Regulations: Alien and Invasive Species Regulations

DEA in 2014 published the Alien and Invasive[3] Species Regulations (R598 of 1 August 2014) under NEM: BA (DEA, 2014). The regulation divides alien and invasive species into four categories with various levels of management intervention, namely:

- Category 1a species must be **combatted or eradicated**.
- Category 1b species must be **controlled**[4].
- Category 2 species require a **permit** to carry out a restricted activity within an area specified in the Notice or an area specified in the permit, as the case may be.

[3] **invasive species"** means any species whose establishment and spread outside of its natural distribution range (South Africa, 2004)-

(a) threaten ecosystems, habitats or other species or have demonstrable potential

(b) may result in economic or environmental harm or harm to human health;

[4] **control**", in relation to an alien or invasive species, mean (South Africa, 2004)-

(a) to combat or eradicate an alien or invasive species; or

(b) where such eradication is not possible, to prevent, as far as may be practicable, the recurrence, re-establishment. re-growth, multiplication, propagation, regeneration or spreading of an alien or invasive species;

- Category 3 species are subject to **exemptions** in terms of section 71(3) and **prohibitions** in terms of section 71A of Act, as specified in the Notice.

3.2.2 South Africa's Agricultural Resources Policy, Legislation, Strategy and Regulations for Wetland Monitoring

3.2.2.1 Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)

Policy on, and regulation of, the use of wetlands falls mainly under the ambit of the water and environmental sectors of the country. In accordance with the Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983), however, there are control measures governing certain agricultural activities. The Act indicates that no land user shall allow category 2 or category 3 plants[5] to occur within 30 meters of the 1:50 year flood line of a wetland (South Africa, 1983). The definition of wetland in this Act has been amended to concur with the definition provided in the NWA.

3.2.2.2 Government Notice R280 in Government Gazette 22166

The Conservation of Agricultural Resources Act (CARA) (DoA, 1983) regulates and restricts the propagation, harbouring and sale of invasive alien plant and weed species listed in a set of Regulations published in terms of the Act. Regulation 280 is such a regulation, which outlines three categories of Invasive and Alien Plants (IAPs) (DoA, 2001):

- Category 1: These are prohibited plants, i.e. are illegal to grow or keep, and must be **controlled or eradicated**.
- Category 2: Declared invader plants with a commercial or utility value. These plants are permitted in demarcated areas under controlled conditions and in bio-control reserves. They are, however, not permitted *to occur within 30 meters of the 1:50 year flood line of a river, stream, spring, natural channel in which water flows regularly or intermittently, lake, dam or **wetland***.
- Category 3: These are primarily ornamental or 'exotic' horticultural plants that have escaped from gardens. Eradication of existing plants is not required, except *within 30 meters of the 1:50 year flood line of a river, stream, spring, natural channel in which water flows regularly or intermittently, lake, dam or **wetland***. Prevention of the spread of these species is required.

Category 2 and 3 plants are classified by the Department of Agriculture as weeds and invaders, as declared in Regulation 280. In assessing and monitoring invasive and alien plant species in the NWMP, these regulative provisions need to be recognised and incorporated.

3.3 South Africa's Wetland Institutional Arrangements

As in the case of the wetland institutional environment in South Africa, the wetland institutional arrangements encompass organisations and instruments (tools, methods, guidelines, procedures and process) in the water, environmental and agricultural sectors. These organisations and instruments are discussed in more detail below.

A number of organisations, including national and provincial water and environmental department, parastatals, NGOs, the private sector and local communities, make up the wetland conservation, management and

[5] 'category 2 plants' means plants of the kinds specified as category 2 in column 3 of Table 3 opposite the names of the respective kinds of plants;
'category 3 plants' means plants of the kinds specified as category 3 in column 3 of Table 3 opposite the names of the respective kinds of plants (South Africa, 1983)

monitoring institutional arrangements in the country. The mandates, roles and responsibilities of organisations are determined by policy and legislation.

3.3.1 The Water Sector Wetland Organisation

Schedule 4 of the NWA legislates the manner of establishment and operation of water management institutions, defined by the Act as catchment management agencies, water user associations, bodies responsible for international water management, and any persons who fulfil the functions of a water management institution in terms of the Act.

The organisations involved in the wetland sub-sector are shown in Figure 5. The key role-players are the Department of Water and Sanitation, Catchment Management Agencies, the Water Research Commission, Institutions of Higher Education, NGOs, the private sector, and citizens.

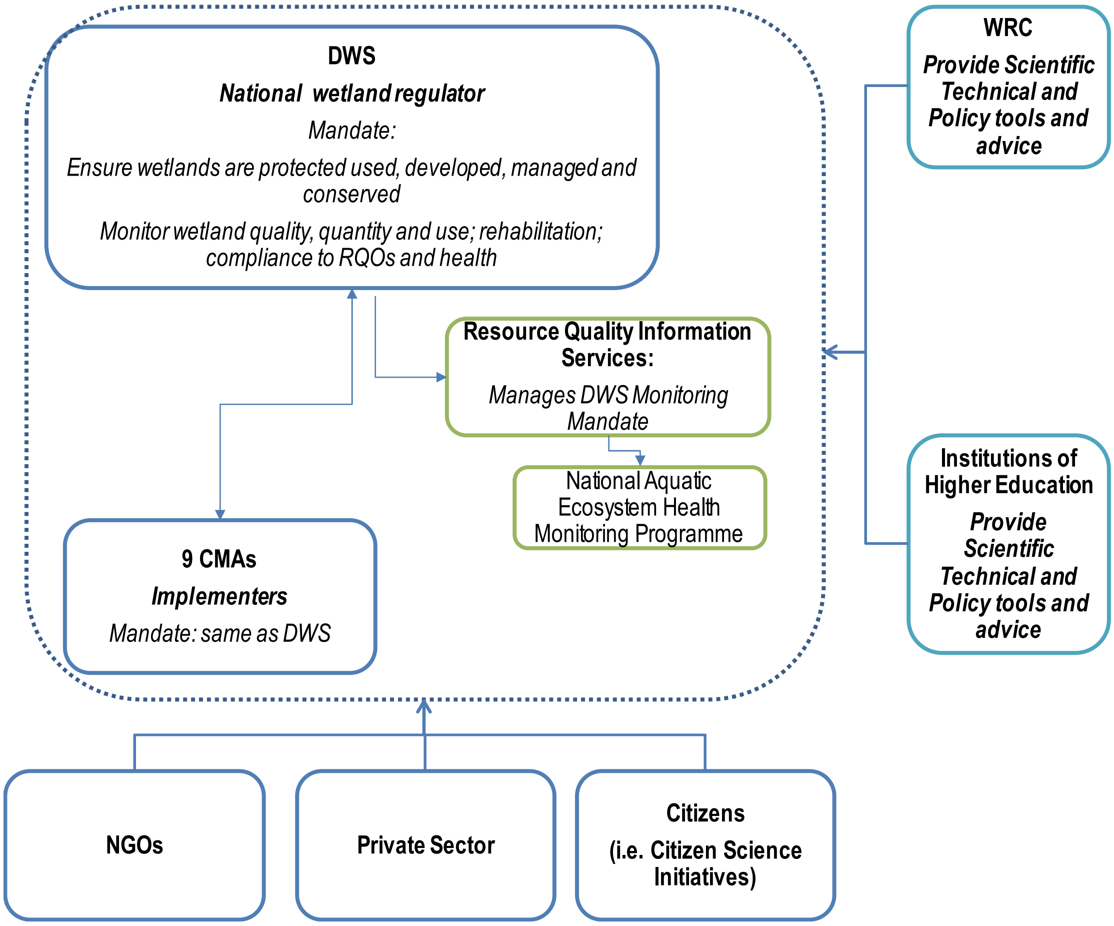

Figure 5: Water organisation's mandates, roles and responsibility in the wetland sub-sector of South Africa

The mandates of these water organisations are discussed in more detail below.

3.3.1.1 Department of Water and Sanitation Wetland and Monitoring Mandate

According to the water policy, the intention of the organisations involved in wetland protection, conservation and management should be to: intensify national management and supervision and to manage at a regional or catchment level.

DWS, as the regulator of water resources in South Africa, is responsible for ensuring that wetlands are protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner.

The 1997 National Water Policy White Paper also assigned the monitoring and information management functions to national Government, specifically to DWAF (now DWS), whose responsibilities include:

- national design and co-ordination of monitoring programmes;
- development of technology and methods to support monitoring, assessment and auditing;
- standardisation of approved methods and techniques for monitoring, analysis and assessment;
- regular review of regulations, standards, methodology and accreditation requirements;
- design, establishment and maintenance of national monitoring networks; and
- development and maintenance of information management systems.

The NWA can also be interpreted as mandating DWS to appropriate wetland data and information related to water quantity, water quantity and use, rehabilitation, compliance with RQOs and relevant atmospheric conditions (also see Section 4.2.1).

DWS is thus not only mandated to ensure that wetlands are protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner, but also to monitor the quantity, quality and use of water, rehabilitation, compliance to RQOs and the health of these wetlands.

3.3.1.2 Catchment Management Agencies (CMAs)

According to South Africa's water policy, the main responsibilities of CMAs are to manage water resources at catchment level in collaboration with local stakeholders, with a specific focus on involving local communities in the decision-making processes.

Section 80 of the NWA can be interpreted as the initial wetland functions of a CMA being-

1. to investigate and advise interested persons on the protection, use, development, conservation, management and control of wetlands in its water management area;
2. to develop a catchment management strategy that includes wetlands;
3. to co-ordinate the related activities of water users and water management institutions within its water management area; and
4. to promote community participation in the protection, use, development, conservation, management and control of the wetlands in its water management area.

Section 73. (1) of the NWA does, however, provide the Minister of Water and Sanitation with a mandate to, in consultation with the CMA, assign a power or duty of the responsibility authority to the CMA. Hence, if so mandated by the Minister, a CMA can fulfil the wetland monitoring role in their jurisdiction on behalf of DWS. DWS however, remains responsible to ensure that the national monitoring mandate is fulfilled.

CMAs may in future play a vital role in the NWMP in ensuring that the goal and objectives of the NWMP are implemented. DWS and CMAs will need to determine what this role will be, perhaps based on the capability and key imperatives of the CMA itself.

3.3.1.3 Water Research Commission (WRC)

Wetland research is a crucial component of the water sector in South Africa. The existence of the WRC is possibly the single most important assurance that necessary research can be carried out and that trained people will be available for the water sector in South Africa (DWAF, 1997).

The WRC takes its mandate from the Water Research Act (No. 34 of 1971), which has the purpose of co-ordinating, promoting, and encouraging research in respect of

1. the occurrence, preservation, conservation, utilization, control, supply, distribution, purification, pollution or reclamation of water supplies and water;

2. The use of water for agricultural; industrial purposes; or urban purposes.

The WRC thus has the mandate to facilitate research which can contribute to knowledge and capacity development in the water sector, including the wetland sub-sector. The WRC also makes available the financial resources for conducting this research.

An assessment of the research funded by the WRC on wetland management in South Africa by Phillips and Madlokazi (2011) indicates that by 2011 *the WRC has invested nearly R50 million in 67 research studies with a wetland objective. The majority (99%) of this investment was made in the last 8 years (2002-2010), and an estimated 10% of this investment was co-funded by other donors. This confirms stakeholder perception that the WRC plays a critical role in funding and guiding wetland research…. An estimated 74% (R37 million) of the investment was used to procure the services of nearly 70 research organizations and nearly 180 researchers. Approximately 70% of the projects supported career development and employment, through education and training of post-graduate students and emerging researchers.*

3.3.1.4 Institutions of Higher Education

Institutions of Higher Education play a key role in developing South Africa's wetland skills and capacity and in conducting wetland research (often through WRC funding). These institutions receive their mandate from the Higher Education Act (No. 107 of 1997). The Act mandates these Institutions to contribute *to the advancement of all forms of knowledge and scholarship, in keeping with international standards of academic quality* (South Africa, 1997b).

A rapid review of wetland research reports and publications in the country indicates that a large number of Institutions of Higher Education are involved in wetland research and capacity building in the country, including (but not limited to):

- Cape Peninsula University of Technology
- Nelson Mandela Metropolitan University
- Rhodes University
- University of Cape Town
- University of Johannesburg
- University of KwaZulu-Natal
- University of Limpopo
- University of Pretoria;
- University of South Africa
- University of the Free State
- University of the Western Cape
- University of Venda.

3.3.1.5 Citizens

Citizens can have an important role to play in the wetland sector, particularly in the monitoring of wetlands. For instance, citizens play a key role in collecting data on water birds in wetlands during Coordinated Water Counts (http://cwac.adu.org.za/about.php)

South African citizens have also been involved in monitoring river health by using a simple, low technology, biomonitoring technique to monitor water quality in rivers and streams (Graham et al., 2015). Other techniques are currently being developed for wetland monitoring.

3.3.2 The Environmental Sector Wetland Organisation

Environmental governance and institutional arrangements in South Africa are more complex than those of the water sector, partly due to a fragmented and evolving legislative framework and a lack of clarity in the division of roles and responsibilities across the three spheres of government (Middleton et al., undated). Wetland-related organisations in the environmental sector of South Africa include DEA, provincial government and agencies, SANParks, SANBI, SAEON, CSIR, local government, NGOs, institutions of higher education, citizens and the private sector (Figure 6).

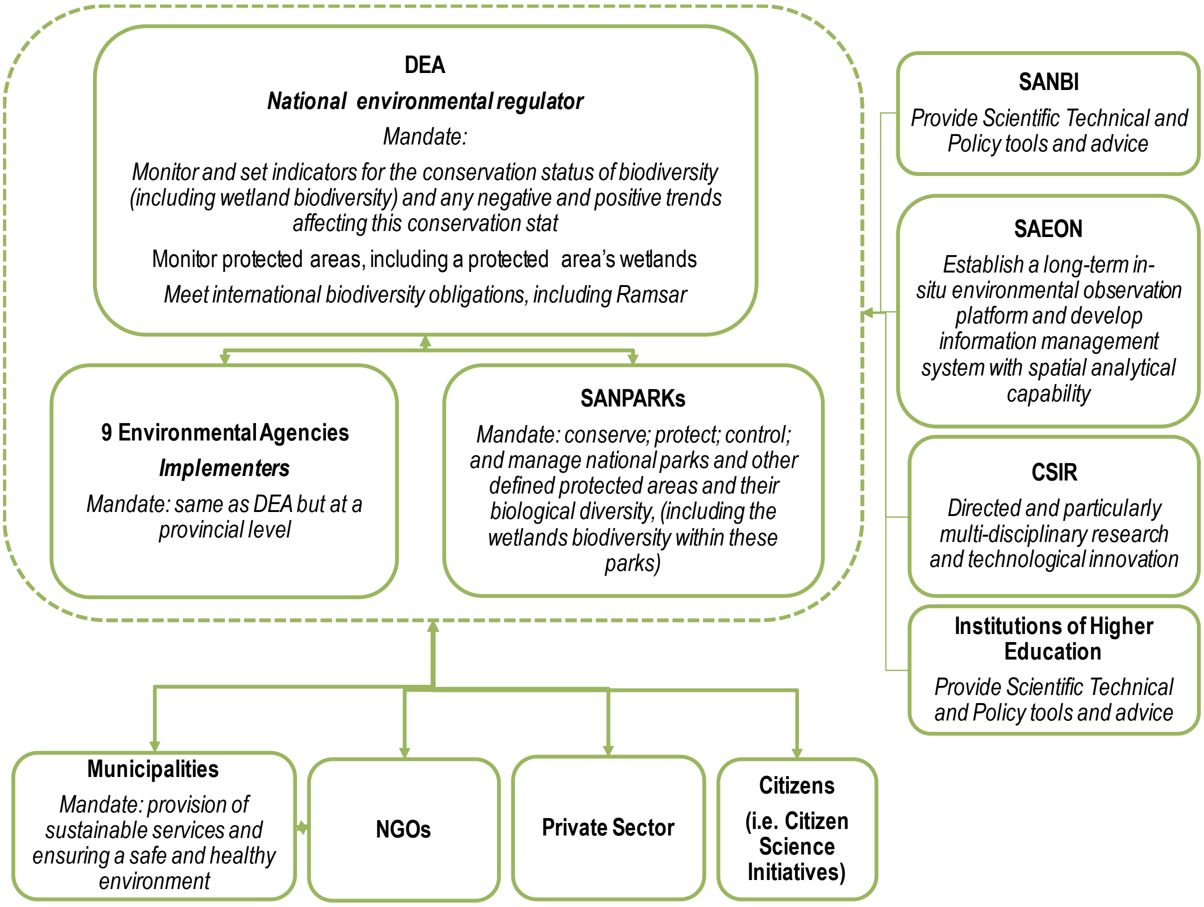

Figure 6: Environmental organisational structure of the wetland sub-sector of South Africa

3.3.2.1 Mandate of the Department of Environmental Affairs

The Constitution of South Africa entrenches the right to an environment that is protected, for the benefit of present and future generations, through reasonable legislative and other measures. This right is enacted by the environmental legislation of the country, which promotes environmental protection while pursuing sustainable development and economic growth (Stein et al., 2009). The DEA's mandate is to give effect to these aspects of the Constitution and to this end, provides leadership in environmental management, conservation and protection.

Part of DEAs responsibility, according the White Paper on Environmental Management Policy for South Africa (1998), is to provide resources for effective environmental research, monitoring and data collection in order to (DEAT, 1998):

- develop and implement information management systems
- report on the state of the environment
- measure progress in achieving sustainable development
- monitor environmental quality and environmental management

- ensure that planning for sustainable development in all sectors is based on the best science and information available.

The DEA is therefore mandated to monitor, and develop indicators for, the conservation status of biodiversity (including biodiversity of wetlands) and to monitor the protected areas of the country (including wetlands within these areas).

The Ramsar Convention on Wetlands allows for listing of wetlands of international importance as Ramsar sites. DEA is the authorised authority responsible for implementing the Ramsar Convention and thus for initiating and submitting proposals for the listing of wetlands as Ramsar sites. and for monitoring the status of Ramsar sites in the country. Management and monitoring of each Ramsar site is carried out by the authority under whose jurisdiction it falls, generally the relevant provincial departments and public entities responsible for biodiversity conservation/management, or SANParks (Netshithothole, 2012).

3.3.2.2 Provincial Environmental Authorities Wetland and Monitoring Mandates

Provincial environmental authorities have been tasked with the constitutional responsibility of ensuring that the environment is protected and sustainably utilised in their province. Several policies and Acts set out the nine Provincial Environmental Authorities' mandate to conserve and sustainably manage biodiversity.

Five provinces have established public entities (agencies or boards) with the specific mandate of planning for and managing biodiversity conservation. Entities and their mandates include:

- **Mpumalanga Tourism and Parks Agency (MTPA)** is mandated, by the Mpumalanga Tourism and Parks Agency Act of 2005, to provide conservation management of the natural resources of Mpumalanga.
- **CapeNature,** the executive arm of the Western Cape Nature Conservation Board was established in terms of the Western Cape Nature Conservation Board Act, 1998. Its mandate is to promote and ensure nature conservation in the province.
- **Ezemvelo KZN Wildlife (EKZNW)** is mandated by the KwaZulu-Natal Conservation Management Act (No. 9 of 1997), read in conjunction with the Public Finance Management Act (No. 1 of 1999), to conserve biodiversity and manage protected areas in the KZN province.
- **Eastern Cape Parks and Tourism Agency** is mandated, by the recently promulgated Eastern Cape Parks and Tourism Agency Act (Act No. 2 of 2010), to develop and manage protected areas in the Province.
- **North West Parks and Tourism Board (NWPTB) is** mandated by the North West Parks and Tourism Board Act (Act No. 3 of 1997) to regulate, plan and manage provincial Nature Reserves in the North West province.

The other four provinces fulfil their biodiversity conservation and protection mandate through a directorate within a provincial conservation authority (DEA, 2009b). The departments include:

- **Gauteng Department of Agriculture and Rural Development (GDARD)**: derives its mandate from Constitution of South Africa (South Africa, 1996). The functional responsibilities of GDARD are primarily focused on natural resource management, sustainable development and rural development. The Gauteng Nature Conservation Bill (2014) provides the mandate for protection of aquatic ecosystems and biotas.
- **Department of Economic Development, Environment and Tourism (LEDET):** although Limpopo has a Limpopo Tourism and Parks Board, established in terms of the Northern Province Tourism and Parks Board Act 8 of 2001, the mandate of the Board is limited to promoting, fostering and developing tourism to and within the Limpopo Province. LEDET has the mandate to help promote economic development and growth in the province, including through sustainable environmental management.
- **Department of Environment and Nature Conservation in the Northern Cape (DENC)**: takes its mandate from section 197 of the Constitution, read with section 7 (1) and 7 (2) of the Public Services Act of 1994.

- **Free State's Department of Economic Development, Tourism and Environmental Affairs (DETEA**): is the authority responsible for the implementation and monitoring of environmental conservation and protection efforts in the province.

3.3.2.3 Municipalities

While the Constitution of South Africa assigns concurrent responsibility to national and provincial government for the environmental mandates of the country, it assigns a number of environmental objectives to local government: to ensure the provision of services to communities in a sustainable manner and to promote a safe and healthy environment.

The Municipal Systems Act reinforces the above objectives, indicating that municipalities have a duty to strive to ensure that municipal services are provided in an environmentally sustainable manner. Municipalities must also promote a safe and healthy environment (South Africa, 1997c).

Some of the Metros in South Africa have assumed responsibility for management and monitoring of wetlands in their jurisdiction (see Section 4.2 for more details on Municipal wetland initiatives)

3.3.2.4 SanParks

SANParks is the statutory authority responsible for the management of National Parks, including parks that may also form part of declared World Heritage sites. A few national protected areas are, however, managed by authorities other than SANParks (DEA, 2009b).

SANParks exist in terms of the National Environmental Management: Protected Areas Act 57 of 2003, with the mandate to conserve, protect, control and manage national parks and other defined protected areas and their biological diversity.

3.3.2.5 South Africa National Biodiversity Institute

SANBI is a statutory body reporting through its Board to the Minister of Environmental Affairs via DEA. Several arrangements exist to facilitate co-operation with DEAT, SANParks, South African Tourism, and Provincial departments. SANBI advises and informs DEA with respect to the biodiversity elements of environment policy, and acts as its agent. South African Earth Observation Network (SAEON)

SAEON was established to function as a comprehensive and sustained South African Earth Observation Network that delivers long-term reliable data for scientific research and informs decision-making for a knowledge society and improved quality of life. Funded by the Department of Science and Technology and managed by the National Research Foundation, SAEON has the mandate to establish a long-term in-situ environmental observation platform and develop information management system with spatial analytical capability. SAEON is able to provide data sets that are necessary for compiling State of the Environment Reports, as well as providing biodiversity-related data to a number of DEA Directorates. SAEON is the major repository of biodiversity data in South Africa.

3.3.2.6 Council for Scientific and Industrial Research (CSIR)

The CSIR's mandate emanates from Section 3 of the Scientific Research Council Act (Act 46 of 1988, as amended by Act 71 of 1990), which outlines the objectives of the councils as, "through directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act".

CSIR has provided scientific and technical support to the wetland sector of the country, contributing to or leading research initiatives such as the National Biodiversity Assessments, NFEPA to name a few.

3.3.2.7 Non-governmental Organisations (NGOs)

The White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity indicates that NGOs play a crucial role in realising the goals and objectives of environmental policy, through the implementation of specific projects and programmes and through performing an independent monitoring and "watchdog" role (Sought Africa, 1997).

A number of NGOs, including organisations such as WWF; BirdLife South Africa, and the Wildlife and Environment Society of South Africa, play various roles in the wetland sector in South Africa.

3.3.2.8 Private Sector involvement in Wetland Assessment and Monitoring in South Africa

The private sector, including Mondi and SAPPI also plays a role in the wetland sub-sector of South Africa. See Section 4.2.9 for more details of activities of some of these organisations.

3.3.3 Tools, guidelines and procedures for wetland inventory, assessment and monitoring currently in use in South Africa

Various guidelines, tools and procedures are currently used by the wetland monitoring sector. Below we provide an overview of a few of the better known ones, with a particular focus on those that were considered for use in the NWMP.

3.3.3.1 Methods for Wetland Inventory and Mapping

SANBI has published guidelines, based primarily on the National Wetland Classification Scheme (NWCS), for mapping and developing inventories for wetlands (SANBI, 2009). Wetland data are documented on the basis of both spatial and non-spatial attributes, which collectively describe the location, type and function of a wetland. The level and range of spatial and non-spatial detail recorded is prescribed by the end-user's objectives. Three levels of wetland mapping objectives are defined, namely:

- basic (simple mapping of wetland presence/absence)
- intermediate (e.g. mapping in support of conservation planning) and
- detailed (e.g. mapping to support evaluation of threats).

Some details are provided in Table 8.

Table 8. The levels of wetland mapping suggested by SANBI (SANBI, 2011)

Level	Name	Description
1	BASIC (i.e. presence/absence mapping applications)	BASIC level mapping provides only a basic indication of wetland presence or absence (as well as distinguishing between natural and artificial wetlands), which can be applied at any scale or geographical extent, using primarily desktop-based mapping techniques. Note that some wetland attributes that need to be captured at this level. Can be used for developing terms of reference for commissioning simple wetland boundary delineation studies, but will not be sufficient for conservation planning and/or identification of threats.
2	INTERMEDIATE (i.e. conservation-planning and other similar applications)	INTERMEDIATE level mapping provides the *minimum* wetland data requirements for ascertaining wetland conservation value, based on defining the ecological attributes of a wetland that help in 'informing' its conservation value. Primarily a field-based activity supplemented with

Level	Name	Description
		desktop mapping. A pre-requisite for processes such as Spatial Development Frameworks (SDFs), Environmental Management Frameworks (EMFs), Conservation Plans, and other spatial planning activities such as town planning. Contain all BASIC-level attributes and others. Can be used for developing terms of reference for commissioning detailed conservation planning type studies, but not suitable for more complex applications
3	DETAILED (i.e. evaluations of threats and other similar applications)	DETAILED mapping provides the *minimum* wetland dataset requirements for ascertaining the impacts and threats to local wetlands and water resources from local land-use changes. Primarily a field-based activity supplemented with desktop mapping. Informed by the National Environmental Management Act (NEMA) and the National Water Act (NWA) legislation. A pre-requisite for formal processes such as Environmental Impact Assessments (EIAs). Contain all BASIC- and INTERMEDIATE-level attributes, and others. Can be used for developing terms of reference for commissioning detailed wetland threat studies.

A recent report (Mbona et al., 2015) describes standardised methods for ground-truthing and refining NFEPA and other spatial data. throughout the country.

This method of mapping wetlands is recommended for use in the NWMP in Section 9.2.2 of the NWMP Implementation Manual to determine, at a desktop level, the extent and developing of a preliminary map (before verification in the field) of a wetland which has been prioritised for assessment.

3.3.3.2 Methods for Wetland Assessment in use in South Africa

Wetland Index of Habitat Integrity (WETLAND-IHI) (DWAF, 2007)

The Wetland-IHI method is outlined in the *Manual for The Assessment of a Wetland Index of Habitat Integrity for South African Floodplain and Channelled Valley-Bottom Wetland Types* (DWAF, 2007). The tool was developed to allow rapid assessment of the condition of floodplain and channelled valley-bottom wetlands for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) (DWAF, 2007).

The Wetland-IHI is one of the methods used in the NWMP. See Section 9 of the NWMP Implementation Manual for details.

The Wetland-IHI tool makes use of three modules, namely hydrology, geomorphology and water quality, to assess the existing *driving processes* behind wetland formation and maintenance, and a single module, the “vegetation alteration” module, to provide an indication of the intensity of human land-use activities on the wetland itself and how these may have modified the condition of the wetland (Figure 7).

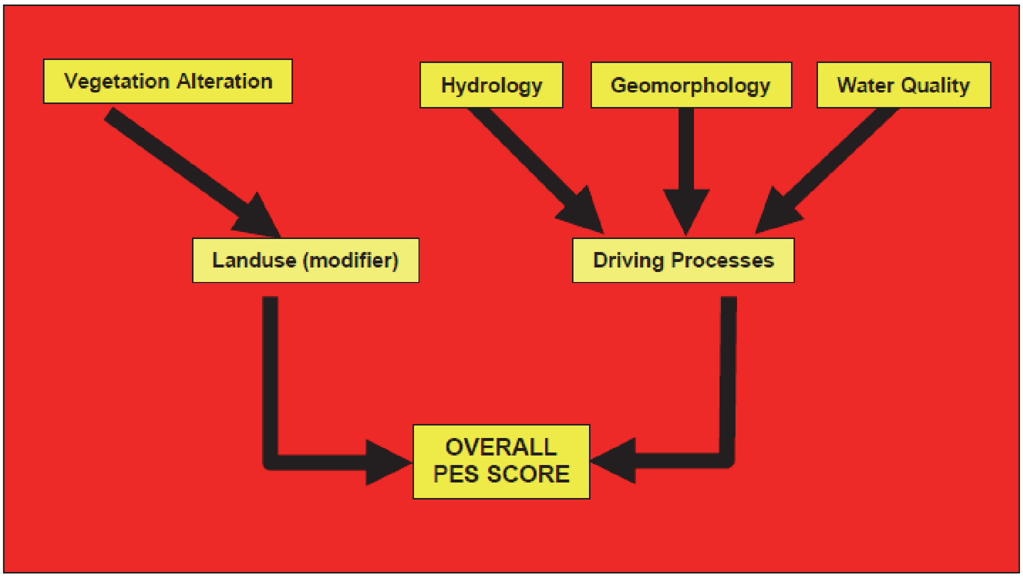

Figure 7: The four modules utilised in the Wetland-IHI to determine the Present Ecological State category for a wetland (taken from DWAF, 2007).

The integration of the scores from the assessment of these four modules provides an overall Present Ecological State (PES) score for the wetland system being examined (Table 9). The output scores from the WETLAND-IHI model are presented as standard DWAF A-F "ecological categories" (Table 9).

Table 9: Ecological categories utilised in the Wetland-IHI method (taken from DWAF, 2007)

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.

Ollis and Malan (2014) outline the gaps in and limitations of the Wetland-IHI method. A summary of these gaps and challenges are provided below (summarised from Ollis and Malan, 2014)

- The tool is only strictly applicable to floodplain and channelled valley-bottom wetlands.
- The tool is site-specific and can only accommodate the assessment of one HGM unit at a time.
- There is no version of the tool that provides for a comprehensive assessment.
- The assessment method does not make provision for an assessment of the "trajectory of change" of the various components of wetland condition.
- It is confusing, and presents a possible source of inconsistency in that certain weightings need to be entered by the assessor.
- Only four land-use activities are listed for assessment in the Vegetation Alteration module, with a number of important land-use activities excluded from this list.

- For the Hydrology module, the scoring of within-wetland effects is very confusing, as it is difficult to differentiate between the "extent" and "intensity" of the listed impacts.
- There is not enough emphasis in the Hydrology module on the potential impacts of erosion gullies on the hydrological functioning of a wetland.
- In the Geomorphology module, the presence of vegetation within a channel (and the robustness of this vegetation) is not explicitly taken into account on the ‘transport capacity’ side of the 'sediment budget' calculation.
- There is no provision for the rating of topographical alterations in the Geomorphology module.
- The overall scores for the Geomorphology module have to be entered manually in the relevant spreadsheet, with reference to a look-up table.
- For the Geomorphology module, more criteria are needed to make the rating of geomorphological impacts more robust and easier to score.
- The Water Quality module is rather rudimentary and very confusing to apply in its current form.
- The Water Quality module is very sensitive to whether an assessor enters zeros or leaves the relevant cells blank for non-applicable cells in the scoring matrix, with different mean, median and mode ratings generated in each case.
- The prescribed use of some kind of average (mean, median or mode) to derive the overall rating score for each parameter taken into consideration in the Water Quality module is potentially problematic in that it could mask water quality impacts.
- The application of the tool is dependent on the formulation of a clear “picture” of the perceived natural reference state of the wetland in the mind of the assessor, before any of the prescribed impacts can be rated.

Wet-Health (Macfarlane et al., 2009)

Wet-Health is a rapid method for assessing the ecological condition of a wetland using the impacts of human stressors on hydrogeomorphic processes and vegetation (Macfarlane et al., 2009).

Wet-Health provides two levels of assessment. Level 1 is primarily a desktop evaluation with limited field verification and thus provides information of low to moderate level of confidence, while Level 2 assessment involves structured data collection from the catchment and the wetland and thus provides information of moderate to high confidence (Macfarlane et al., 2009).

Wet-Health (Level 1) is one of the assessment methods used in the NWMP – See Section 9 of the Implementation Manual for details (Level 2 is used to monitor prioritised wetland. See Section 7 of the NWMP Implementation Manual for details.

WET-Health examines the degree to which a wetland deviates from a natural reference condition for the three components of health or condition: hydrology, geomorphology and vegetation. The method assesses the three components separately, while recognising that they are linked (e.g. geomorphological integrity affects hydrological integrity, and both affect vegetation: Kotze et al., 2012). The components of the wetland assessment include the examining of (Kotze et al., 2012):

- the quantity and timing of water inputs and the pattern of water flow through the wetland
- sedimentary inputs and outputs and geomorphic indicators of these and
- the relative abundance of plant functional groups.

WET-Health is effectively a method for rapid assessment of impacts, estimating wetland condition based on the spatial *extent* of the HGM unit that is affected by a stressor, and the *intensity* of the impact in the affected area. The extent and intensity of impact scores are combined to determine the overall magnitude-of-impact score for the component of the HGM unit (Kotze et al., 2012). The magnitude-of-impact score is in effect an *index* that reflects the extent of departure of the HGM unit from an unimpacted condition. The present ecological condition (PES), expressed as a “health class” symbol (A-F), is determined from the magnitude-of-impact score (Table 10)

Table 10: Health classes used by WET-Health for describing wetland ecological condition (Kotze et al., 2012)

Impact score	Present ecological state	Description
0-0.9	A	Unmodified, natural.
1-1.9	B	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place
2-3.9	C	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact
4-5.9	D	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred
6-7.9	E	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable
8-10	F	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota

Ollis and Malan (2014) outline the gaps and limitations of the Wet-Health method. As summary of these gaps and challenges is provided below.

- the tool is not really applicable to depressions or wetland flats.
- the tool does not include a Water Quality module.
- the integrated assessment of all the HGM units that make up a wetland, on the basis of the proportional extent of each HGM unit, can be confusing (especially to first-time users of the tool).
- The completion of a Level 2 assessment is time-consuming and complex.
- There is no explicit inclusion of a confidence rating for the assessment of the various criteria in the WET-Health score-sheets.
- For the detailed Level 2 assessment, there are certain features explicitly included and excluded that are only relevant to wetlands in certain parts of the country.
- Inclusion of a ‘changes in flow seasonality’ as a separate hydrological criterion in the hydrology module is necessary (particularly in arid areas).
- When there are several difference land-uses within a wetland there is the need for a clear explanation and additional guidance as to how the criteria for assessing changes to water distribution and retention patterns within the wetland should be scored in the hydrology module.
- The Geomorphology module is, generally, complicated and rather confusing to apply.
- The inclusion of a (indirect) diagnostic assessment and a (direct) indicator-based assessment to determine the overall geomorphological state could possibly lead to the “double-scoring” of impacts in the geomorphology module.
- The rating of a number of the criteria included in the Geomorphology module is difficult for assessors who are not expert geomorphologists, or who don’t have at least some knowledge and experience of earth science.
- A number of the criteria included in the Geomorphology module are only rated for certain specified HGM types, but the criteria are sometimes relevant to other HGM types and it is not clear whether they should be scored in such cases.

- In the Vegetation module (for a Level 1 assessment), the use of a default intensity score of 1 for 'untransformed areas' in the scoring table for disturbance classes means that a wetland that is 100% untransformed will be given a Vegetation PES of Ecological Category B, when a category of A or A/B would generally be more appropriate.
- The tool and its accompanying datasheets are not very user-friendly with a lot of cross-referencing to a multitude of tables required throughout the assessment.
- For a Level 1 assessment, it is unclear from the documentation and the score-sheets themselves whether the total extent for within-wetland hydrological and geomorphological impacts, or vegetation 'disturbance classes' can add up to more than 100%.
- At a number of points throughout the assessment (especially for Level 2), two or more scores are manually combined to derive an overall score for a particular aspect, by referring to the relevant look-up tables. This process should be automated in the relevant spreadsheets.
- The application of a Level 1 assessment is dependent on the formulation of a clear "picture" of the perceived natural reference state of the wetland in the mind of the assessor, before any of the prescribed impacts can be rated.

Decision-Support Framework for Wetland Assessment in South Africa (Ollis et al., 2014)

Noting that more than one method was available to determine the present hydrology; geomorphology; vegetation and water quality state of a wetland, Ollis et al. (2014) developed a Decision-Support Framework (DSF) for Wetland Assessments in South Africa, which consolidates all the methods into a single tool that guides the user through the assessment of a wetland using one of the) assessment methods (IHI; Wet-Health and/or Rapid Ecological Reserve Determination. Note that the DSF does not combine methods but guides the assessor as to when to apply which method.

The Framework for Wetland Assessment in South Africa (Figure 8) proposed by Ollis & Malan provides a summary of the steps required in the assessment of a wetland, utilising the various wetland assessments available (Figure 8).

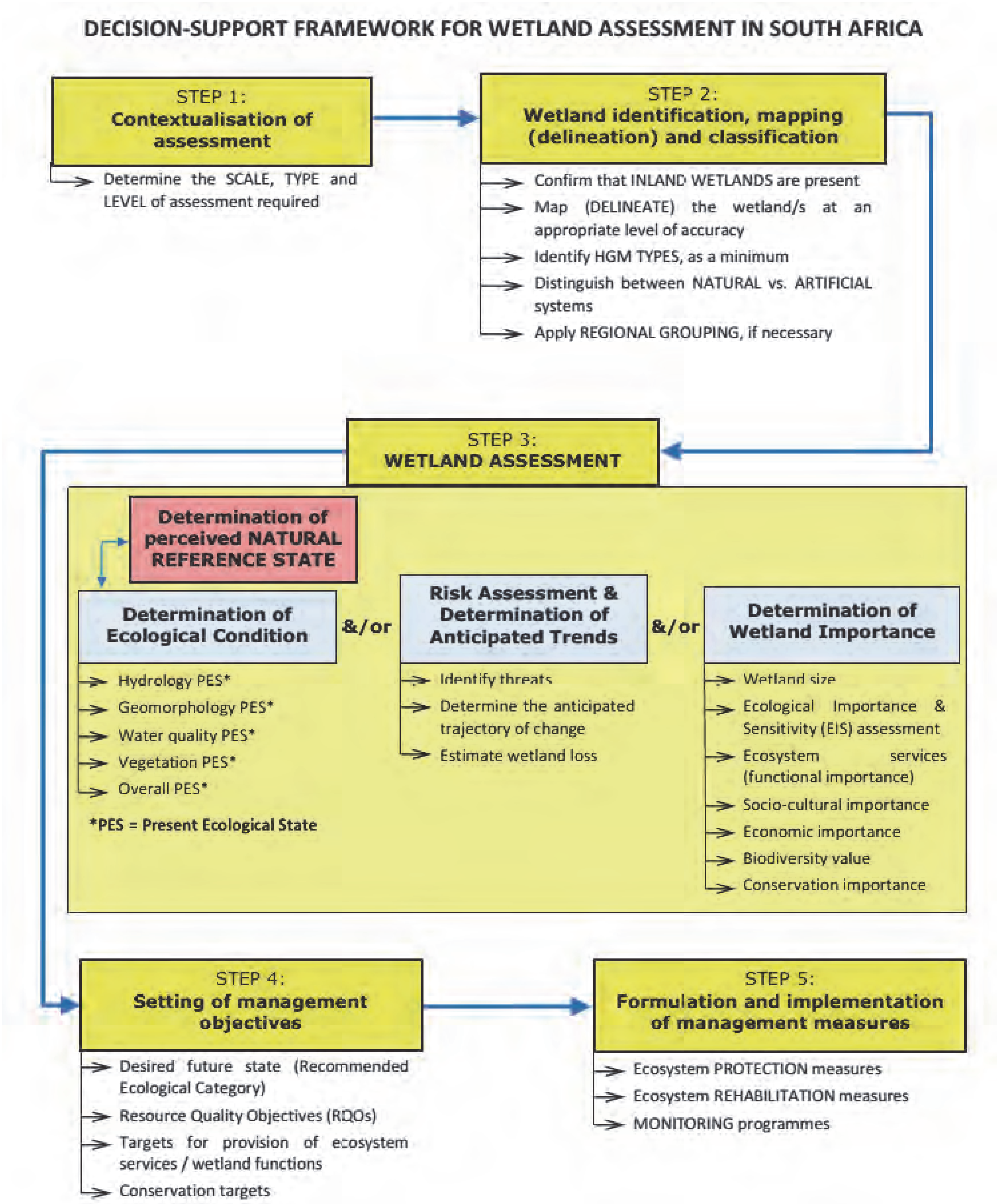

Figure 8: The proposed decision-support Framework for Wetland Assessment in South Africa (Ollis and Malan, 2014)

Linked to this Decision-Support Framework is a 'decision-support-protocol tool' (DSP tool), which includes the excel spreadsheet that needs to be completed to conduct the rapid assessment of wetlands. The separate modules from WET-Health and Wetland-IHI are explicitly included in the DSP (Ollis and Malan, 2014).

The NWMP utilises the DSF and DSP to guide the assessment of prioritised wetlands in the programme. Section 6.3.5 of the NWMP Implementation Manual provides the details as to when and how to utilise these tools, while Section 9 provides the field sheets from the DSF and DSP that need to be completed in the field when collecting the relevant data during the assessment of a prioritised wetland.

Rapid Ecological Reserve Determination (RERD) Method for Wetland Water Quality (Rountree *et al.*, 2013)

Two methods are available to determine the present water quality state of wetlands, namely the Wetland Index of Habitat and Integrity (W-IHI) for floodplains and channelled valley-bottom wetlands (DWAF, 2007) and Rapid Ecological *Reserve* Determination (RERD) Method (Rountree et al., 2013).

A land-use method (the RERD method) was developed by Malan *et al.,* as part of the Manual for Rapid Ecological Reserve Determination of Inland Wetland (Version 2) to determine the present ecological state of water quality of a wetland (Rountree et al., 2013). The overall approach of the Rapid Ecological Reserve Determination (RERD) Method is to use land-use in the catchment surrounding the wetland to infer water quality impacts on the wetland, and then to convert the impact scores to a PES category for water quality in the wetland. This takes the form of assessing the spatial extent (% of total catchment area) of various land use activities in the catchment and to combine this with the impact score for the relevant water quality constituents associated with the land use.

RERD is one of the water quality assessment methods included in the decision-support-protocol tool developed by Ollis et al. (2014) (see discussion of this tool in the previous section of the report) and is thus one of the methods used in the NWMP to identify the water quality PES category of an assessed wetland (see Section 6.4.5 and Section 9 of the NWMP Implementation Manual for details on when and how to utilise the RERD method in the NWMP).

WET-EcoServices (Kotze et al., 2009)

The WET-EcoServices tool is used to assess the goods and services that each wetland provides (Kotze et al., 2009). The tool also provides strategies for scoring the importance of wetlands. Note that this protocol specifically designed for palustrine wetlands.

The tool provides guidelines for scoring the importance of a wetland in delivering each of fifteen ecosystem services (Table 11). Once the HGM unit has been determined for a wetland, ecosystem services can be assessed at Level 1, based on existing knowledge, or at Level 2, based on a field assessment of key descriptors (Kotze et al., 2009).

Table 11: Ecosystem services included in, and assessed by, WET-EcoServices[6] (taken from Kotze et al., 2009)

Ecosystem services supplied by wetlands – Indirect benefits	Regulating and supporting benefits		Flood attenuation	The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream.
			Streamflow	Sustaining streamflow during low flow periods.
		Water quality enhancement benefits	Sediment Trapping	The trapping and retention of wetland sediment carried by runflow waters.
			Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters.
			Nitrate assimilation	Removal by wetland of nitrates carried by runoff waters.
			Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters.
			Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
			Carbon storage	The trapping of carbon by the wetland, principally as a soil organic matter.
Direct benefits			**Biodiversity Maintenance**[7]	The trapping of provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity.
	Provisioning benefits		Provision of water for human use	The provision of water extracted directly from the wetland for domestic, agriculture or other purposes.
			Provision of harvestable resources	The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
			Provision of cultivated foods	The provision of areas in the wetland favourable for the cultivation of foods.
	Cultural benefits		Cultural heritage	Places of special cultural significance in the wetland, e.g. for baptisms or gathering of culturally significant plants.
			Tourism and recreation	Sites of value for tourism and recreation in the wetland; often associated with scenic beauty and abundant birdlife.
			Education and research	Sites of value in the wetland for education or research.

Wetlands and Wellbeing: A decision support system (Kotze, 2014)

A Decision Support System (DSS), which builds on Wet-EcoServices, was developed in 2014 by Kotze for rapidly assessing ecosystem services provided to the users of inland wetlands in South Africa. The DSS is designed to generate a preliminary scoring of several ecosystem services by inference from the hydrogeomorphic (HGM) type and the structural vegetation types present in the wetland (Kotze, 2014).

The DSS (Kotze, 2014) is designed to assist with:

a) *assessing the supply of ecosystem services by a particular wetland*
b) *exploring how different use-scenarios might affect the suite of ecosystem services supplied by a particular wetland*
c) *assessing the current demand and use of the services supplied by a wetland*

[6] The wetland benefits included in the WET-EcoServices are those considered most important for South African wetlands, and which can be readily and rapidly described. This is by no means exhaustiveOther benefits include groundwater recharge and discharge and biomass export, which may all be important but are difficult to characterize at a rapid assessment level (Kotze et al., 2009).

[7] Biodiversity maintenance is not an ecosystem services as such, but encompasses attributes widely acknowledged as having potentially high value to society (Kotze et al., 2009).

d) identifying opportunities (for enhancing benefits) and risks to the provision of ecosystem services by a wetland

e) assessing the costs, particularly to local people, of a wetland, for example provision of habitat for disease vectors

f) identifying means of addressing the risks to, and costs of, a wetland and of realizing the most promising opportunities.

The Wetland and Well-being DSS is used in the NWMP to evaluate ecosystem services provided by a prioritised wetland. See Section 6.3.5 – Step 2.4.6 of the Implementation Manual for details).

The DSS uses four steps to assess the supply of ecosystem services in a wetland (Figure 9). Once the HGM type and extent and the vegetation structure type and extent have been identified and scored using the DSS tool, the HGM score and the Vegetation score are multiplied to derive an overall score using the formula (Kotze, 2014):

Overall score = HGM score x (Vegetation score/4).

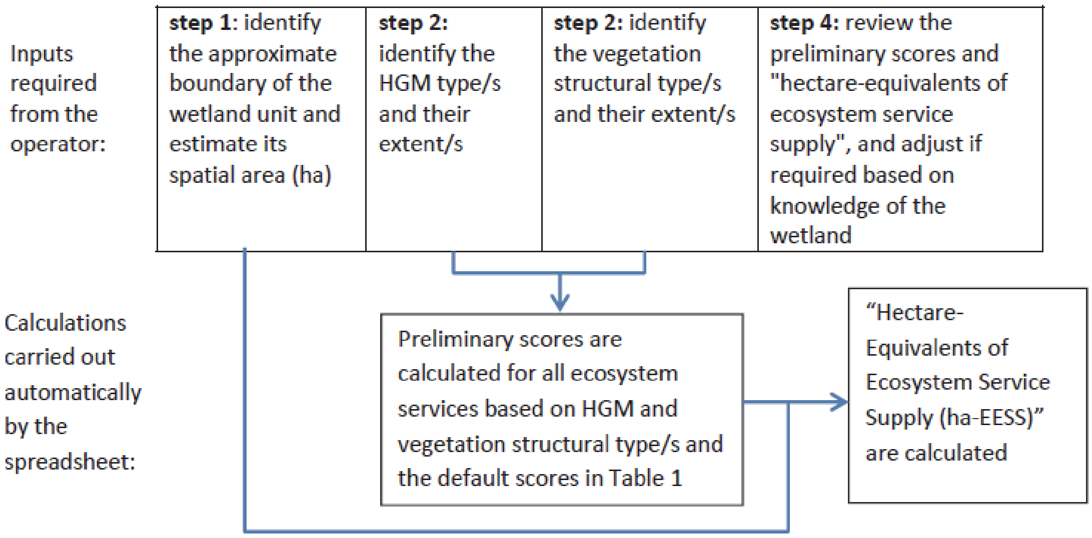

Figure 9: Steps required in the DSS to rapidly assess the ecosystem services provided by a wetland (Kotze, 2014)

Kotze (2014) indicates that the current limitations of the DSS:

- the system is not designed to assess the integrity (health) of a wetland or its importance for biodiversity conservation;
- the system is not designed to quantify in detail the specific level of impact of a current or proposed development;
- the system is not designed to provide a single overall measure of value or importance of a wetland, nor is it designed to quantify (in monetary or other terms) the benefits supplied by a wetland.

A method for assessing wetland ecological states based on land-cover type (Kotze et al., 2015)

This method assesses ecological state (PES) based on identifying and inferring impacts of land-use types in a wetland and its catchment (Kotze et al., 2015). The method advances the WET-Health Level 1 vegetation component, which uses scores for a wide range of disturbance (land-use) types to calculate the PES category for the vegetation in a wetland. In this new method, the assessment is expanded to include the impacts of land-use types on hydrology, geomorphology and water quality in order to identify a PES category for the wetland and its catchment (Figure 10). The method also includes non-land-use impacts (e.g. point-source pollution; seepages from dams into and pumping water out of wetland; fire; grazing and invasive alien plants) that may potentially affect wetlands otherwise identified as having natural land-cover.

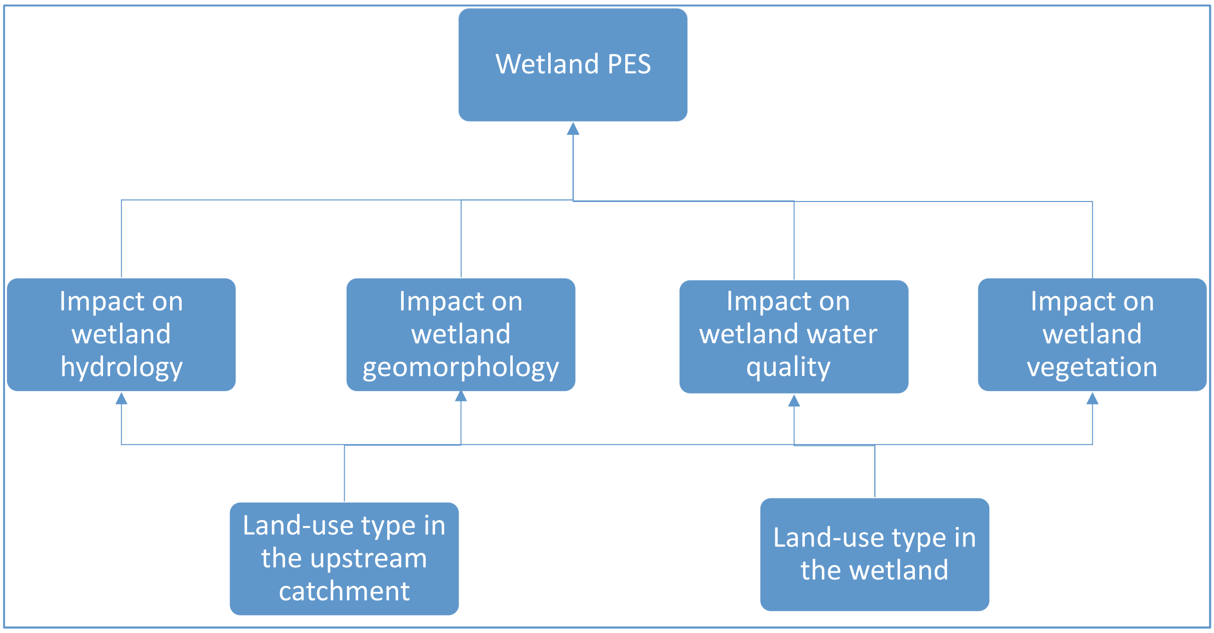

Figure 10: Components included in the methods for assessing the ecological state (PES) of a wetland based on identifying land-use types in a wetland and its catchment

According to Kotze et al. (2015) the indicator currently has the following methodological limitations:

- "The method generalizes broadly about the ecological impacts associated with particular land-covers, with little account taken of the wetland's particular features, notably its hydrogeomorphic type and ecoregion.
- The method also does not account for other site-specific features such as the erodibility of the soil, where for a given landuse, a site with a higher erodibility is likely to be subject to higher impacts.
- Although many different land-cover types were identified to try to limit the variability within each type, it is recognized that for certain types and for certain environmental impacts the impact intensity may vary quite widely from one site to the next.
- The method does not consider the degree to which the wetland is buffered (e.g. by a broad strip of intact natural vegetation around the wetland) from land-cover impacts in the wetland's upstream catchment but simply considers the extent of different land-cover types in the wetland's upstream catchment.
- The method largely avoids the issue of explicitly defining the natural reference state of the wetland being assessed.
- The method does not include point sources of pollution,
- The method does not provide guidance for interpreting satellite imagery and mapping the land-cover units identified in a wetland.
- Although a comprehensive list of land-cover types is included in the method, this is not exhaustive, and inevitably users of the method will encounter land-covers which do not fit well any of those listed.
- The method provides inadequate detail to be used in the context of Environmental Impact Assessments, which require that due consideration be given to the wetland's biotic and hydrogeomorphic features"

The method has not been extensively field-tested but it will be possible to address the methodological limitations mentioned above as the method is applied in the field.

The method is used as the PES indicator in the NWMP (see Section 6.3.5 – Step 2.4.6 of the NWMP Implementation Manual).

3.3.4 Methods and Protocols for Monitoring of Wetlands in South Africa

- There is no comprehensive monitoring system that uses a suite of indicators or outlines a comprehensive approach to monitoring wetlands in South Africa. Methods that are used focus on a few indicators, for a number of reasons, outlined below. The lack of an agreed and tested suite of indicators that can be applied to wetlands throughout the country;
- Limited knowledge of the cause-effect-response relationships between indicators and wetland condition, particularly biological indicators. Studies of the responses of South African wetland organisms to impacts are confined to a few isolated studies that focus on selected taxa; often these indicators do not demonstrate the nature of the human stressors that have contributed to the decline in condition, and therefore provide little insight into management requirements (Kotze et al., 2012).
- Limited understanding of reference conditions and the biotic features that represent them.
- The lack of monitoring indices that clearly demonstrate the present state of a wetland and a change in this state over time. The considerable variations in National-levels, climates and biomes over southern Africa has resulted a wide range of wetland types and biotas. This means that that it is extremely difficult, if not impossible, to develop reliable biotic indices which can be applied on a national scale (Kotze et al., 2012).

4 REVIEW OF WETLAND INVENTORY, ASSESSMENT AND MONITORING INITIATIVES IN SOUTH AFRICA

This section provides an overview of wetland inventory and assessment activities in South Africa. The purpose of this section is to highlight the use of wetland assessment and monitoring tools, methods and guidelines that may provide valuable data and information for the NWMP, as well as to identify activities that might potentially use the data collected and reported by the NWMP in future.

4.1 WETLAND INVENTORY IN SOUTH AFRICA

Spatial scale: National

Temporal scale: the inventory is updated on an ongoing basis

The Wetlands Conservation Programme conducted a pilot study on a national wetland inventory in the early 2000s, providing information on the extent, location and distribution of wetland systems in South Africa SANBI, 2010). A national wetland inventory (NWI) was expected to provide more detailed GIS-based maps. The South Africa database was also designed to capture attributes, functions and values of individual wetlands. The development of the national wetland inventory was closely linked to the development of a Wetland Classification System for the National Wetlands Inventory (Section 1.2.3).

South Africa embarked on the National Freshwater Ecosystem Priority Area project (NFEPA) in 2008, providing the first broad desktop inventory of rivers and wetlands of conservation importance in South Africa. The NFEPA project (Nel *et al.,* 2011): aimed to identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and to develop a basis for enabling effective implementation of measures to protect FEPAs.

The project personnel prepared maps, referred to as 'FEPA maps', for each Water Management Area in the country. They also mapped wetland clusters, which are groups of wetlands embedded in a relatively natural National-level and important for ecological processes such as migration of frogs and insects between wetlands. The key output of the NFEPA project, related to wetlands, was the final NFEPA Wetland Map 3 (Nel et al., 2011).

The input layers and their related challenges are summarised in Table 12.

Table 12: Summary of input layers into the production of National Freshwater Ecosystem Priority Area maps (Nel *et al.,* 2011)

INPUT LAYERS	DESCRIPTION
Wetland localities	Augments the waterbodies and wetlands from the National Land Cover 2000 with inland water features from Department of Land Affairs' Chief Directorate: Surveys and Mapping (DLA-CDSM). Wetlands were mapped using a combination of remotely sensed data and existing mapped localities. Sub-national data included wetland localities for: • wetlands for the entire KwaZulu-Natal Province (available from Ezemvelo KZN Wildlife); • C.A.P.E. fine-scale biodiversity planning wetlands of Saldanha/Sandveld, Riversdale plain and Upper Breede River Valley (available from http://bgis.sanbi.org); Overberg, Niewoudtville and Kamieskroon wetlands (available from http://bgis.sanbi.org); and • Selected wetlands of conservation importance in Mpumalanga Province (available from Mpumalanga Parks and Tourism Agency). Some gaps and challenges with this input layer in the NFEPA were: • There were still numerous gaps in the spatial data sets; • the pixel size was 0.02 ha, so most smaller wetlands (such as seeps), and thin longitudinal wetlands (such as valley bottoms) were not detected; • some National-levels facilitate detection of wetlands via remote sensing, hence these areas

INPUT LAYERS	DESCRIPTION
	showed fewer gaps; • spatial data was often required for more than one season
Wetland ecosystem types	In this layer the NFEPA project classifies wetlands on the basis of a hydrogeomorphic approach to Level 4a of the national wetland classification system (Ollis et al., 2009) using a GIS protocol for automation. These were then combined with groupings of the vegetation map of South Africa (Mucina and Rutherford, 2006) to derive wetland ecosystem types that were used to depict the diversity of wetland ecosystems across the country. Some gaps and challenges experienced with this input layer in the NFEPA were: • the desktop classification of wetlands still needed to be considerably refined; • wetland vegetation groups needed to be refined, for instance, grouping wetlands according to plant community analyses; • landform types, used to classify the hydrogeomorphic units of a wetland, were only 50-60% accurate; novel methods for typing wetlands using remotely-sensed images needed to be investigated.
Wetland state	Wetland condition in the NFEPA project was determined by the proportion of natural land cover in and around the wetland. For riverine wetlands, the condition of rivers was also taken into account. Some gaps and challenges experienced with this input layer in the NFEPA were: • the estimation of likely wetland condition using a GIS layer needed to be ground-truthed; • research exploring the effectiveness of indices for estimating wetland condition at a National-level level was needed for future NWI reporting.
Wetland ranks	The NFEPA project ranked wetlands according to conservation importance using a combination of special features and modelled wetland condition. Special features of conservation importance (e.g. extensive intact peat wetlands, presence of rare plants and animals) were identified by experts and available spatial data on the occurrence of threatened frogs and wetland-dependent birds were included.
Wetland clusters	This layer in the NFEPA project grouped wetlands which were within 1 km of each other and were embedded in a relatively natural National-level. Clusters were prioritised as necessary for ecological process such as migration of frogs and insects between wetlands. Some gaps and challenges highlighted with this input layer in the NFEPA were: • the understanding of the significance of distances between wetlands needed (and still needs) investigation.

NFEPA Wetland Map 3 provided the basis for National Wetland Inventory Map 4 and thus the spatial layers that underlay the current NWI for South Africa.

Nel and Driver (2011) noted that there were still gaps in mapping wetlands in South Africa at the time that the FEPAs were identified. SANBI's wetland inventory programme continues to update the NWI database and investigate means of addressing the current challenges with the inventory. For example, South Africa has a number of new spatial data sets, such as the 2013/14 Land Cover data set derived from multi-seasonal Landsat 8 imagery. Note that all the maps generated from remotely sensed data represent the probability of wetlands occurring (Geoterraimage, 2015) and ground-truthing is essential at least for a proportion of the areas identified as wetlands to provide a degree of confidence in the accuracy of the maps.

The NWMP utilises the latest NWI as the base data and map for the programme.

4.2 Water Resources and Wetland Assessments in South Africa

South Africa is already collecting a large amount of wetland data through a range of wetland assessments required to address legislative and other reporting requirements in the country. Some of these assessment initiatives are discussed in more detail below.

4.2.1 DWS: – Water Resource Directed Measures (RDM) Assessments

A national resource protection "classification" system was introduced in South Africa in 1997 by the White Paper on a National Water Policy for South Africa (South Africa, 1997). The White Paper indicates that two separate sets of measures are required for the protection of water resources (including wetlands), namely:

1. Resource-directed measures (RDM): – which are objectives for the desired level of protection for each resource. The White Paper indicates that the level of protection for a resource (including wetlands) will be decided by setting objectives for each aspect of the Reserve (water quality, quantity and assurance, habitat structure, and living organisms). This will show what degree of change or impact is considered acceptable, and unlikely to damage a water resource (wetland) beyond repair. Based on this policy requirement, wetlands will be grouped into a number of protection classes, with each class representing a certain level of protection. Where a high level of protection is required, the objectives will be strict, demanding a low risk of damage and the use of great caution. In other cases, the need for short to medium term use may be more pressing and the need for protection lower.
2. Source-directed controls (SDC): aim to control what is done to the water resources so that the resource protection objectives are achieved. The White Paper indicates that protection of water resources will be enforced through a system of source-directed measures, including the registration of sources of impact, standards for waste discharges, best management practices, permits and impact assessments. The use of directives and fines, and the ability to suspend or revoke permits and licences, are effective options for dealing quickly and effectively with cases of pollution (South Africa, 1997). The use of regulatory measures to control damage to resources other than pollution, such as habitat destruction, will be introduced where appropriate.

4.2.1.1 The National Resource Classification System (NRCS)

Spatial scale: Integrated Unit of Analysis (IUA)

Temporal scale: frequency of RQO monitoring will be determine by the catchment being managed but the DWS has indicated the intent of a 5-year plan for resource quality monitoring (DWAF, 2004a).

Chapter 3 of the NWA legitimised RQOs and SDCs, requiring the first stage in the protection of water resources in the country to be classification of the nation's water resources.

The NWA mandates that the water resource classification system be utilised to determine (1) a class and (2) resource quality objectives (RQOs) for the resource (South Africa, 1998). The purpose of the resource quality objectives is to establish clear goals relating to the quality of the relevant water resources.

In 2010 the Minister established regulations, Regulation 810, for the establishment of a Water Resource Classification System.

The Classification Process which is followed in applying the NWCS procedure, results in a Management Class (MC) and RQOs for significant water resource (watercourse, surface water, estuary, or aquifer) under consideration (DWAF, 2007b). This Management Class classifies the resource along a range from Minimally to Heavily used (Table 13) and essentially describes the desired condition of the resource, and concomitantly, the degree to which it can be utilised, i.e. the MC sets the boundaries for the volume, distribution and quality of the Reserve and RQOs (DWAF, 2007b).

Table 13: Management class in the NWRCS (taken from DWAF, 2007b)

Class I: Minimally used
The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.
Class II: Moderately used
The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition.
Class III: Heavily used
The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.

Once the Management Class has been agreed on the RQOs are decided upon and gazetted. The Management Class and RQOs are then binding on all authorities and institutions when performance a power or duty under the NWA (South Africa, 1998a). Monitoring and compliance to these entails a systematic process of measuring and managing the performance of the management of the water resource towards RQOs (DWA, 2011).

Compliance with RQOs is achieved when the resource quality is improving or is demonstrated to be in an equal or "better" condition than set by the RQOs. Numerical limits in the Classification process are generally quantitative descriptors of different components of the resource such as water quantity, quality, habitat and biota that can be used to monitor progress and compliance.

The NWMP has the potential to support this monitoring process and the RQO monitoring process has the potential to provide valuable data to the NWMP.

According to South Africa's 2015 Ramsar Report, *wetlands are being factored into the classification of water resources and development of Resource Quality Objectives*. The report indicated that in 2015 the classification of water resources and development of Resource Quality Objectives was under way in eight of the country's nine Water Management Areas.

4.2.1.2 Reserve Determination

Temporal scale: Interim, and once in 5-year cycle from start of monitoring (DWAF, 2004a)

The National Water Act legitimises the Reserve, which it defined as the quantity and quality of water required a) to satisfy basic human needs by securing a basic water supply, and b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. Reserve Determination, or ascertaining the amount of water needed to maintain a water resource (i.e. a river or wetland), is a crucial component of aquatic ecosystem management in South Africa, where the Basic Human Needs Reserve and Ecological Reserves are the only recognised water rights.

A suite of methods has been developed for determining the ecological Reserve, the particular methods to be used depending on the level of accuracy and the degree of confidence in the results required. The *Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0)* (Rountree et al., 2013) provides a systematic protocol for conducting a rapid assessment of the reserve for inland wetlands.

The wetland reserve determination protocol makes use of field assessment of focal wetland/s to determine the Present Ecological state (PES) and Ecological Importance and Sensitivity (EIS) of the wetland and also to collect data necessary for quantifying its ecological water requirements (Rountree et al., 2013).

It is important that in future these assessments use comparable methods so that the results can be included in the NWMP. Similarly, future reserve determinations may rely of NWMP data (when available).

4.2.2 DWS: – Water Use Authorisation

Spatial scale: Resource covered by the license

Temporal scale: determined within the license conditions

With water being held in public trust in South Africa, a person may only use water if authorised to do so. From a wetland perspective, a person is required to apply for a water license if s/he will be impeding or diverting the flow of water and/or altering the bed, banks, course or characteristics of a wetland. Further, any activity within 500 m of the boundaries of a wetland requires a Water Use License Application

Currently, applications submitted to DWS generally use the WET-Health assessment tool to determine the current state of the wetland, and WET-EcoServices to estimate the benefits of a wetland. There is thus complementarity between this dataset and that of the NWMP, and DWS should consider inclusion of the wetland license application results into the NWMP.

4.2.3 DEA: National Biodiversity Assessment

Spatial scale of assessment: National

Temporal scale of assessment: 5-yearly

The National Biodiversity Assessment (NBA), which follows the National Spatial Biodiversity Assessment (NSBA) of 2004, provides a summary of the state of South Africa's terrestrial, freshwater, estuarine and marine biodiversity (Nel and Driver, 2012). The NBA reports two key indicators, namely ecosystem threat status, which indicates the degree of intactness of ecosystems, and the level of protection of ecosystems (Nel and Driver, 2011).

The threat status of wetlands was based on the extent to which each wetland ecosystem had been altered from "good state, the percentage natural land cover in the wetland and over areas 50 m, 100 m and 500 m wide around the wetland used as a surrogate measure of wetland state (Table 14).

Table 14: Description of categories of wetland states (taken from Nel and Driver, 2012).

Wetland condition code	Description	Assessment criteria*
AB	Good	Percentage natural land cover ≥ 75%
C	Moderately-modified	Percentage natural land cover 25-75%
DEF	Heavily-modified	Riverine wetland associated with a D, E, F or Z ecological category river
Z1	Heavily to critically-modified	Wetland overlaps with a 1:50 000 'artificial' inland water body from the Department of Land Affairs: Chief Directorate of Surveys and Mapping (2005-2007)
Z2		Majority of the wetland unit is classified as 'artificial' in the wetland locality GIS layer
Z3		Percentage natural land cover < 25%

.

The NWMP will in future be able to provide invaluable data to the National Biodiversity Assessments, improving the accuracy of reporting of these assessments.

4.2.4 DEA: – Assessment of Management Effectiveness (METT) of Ramsar Wetlands

Spatial scale of assessment: Protected area under investigation

Temporal scale of assessment: annually

Although not a means of assessment of the state of wetlands, the Management Effectiveness Tracking Tool (METT) provides a means of determining the effectiveness of management of wetlands in the country. The internationally accepted METT was developed by the World Commission for Protected Areas (WCPA) and World Wide Fund for Nature (WWF) (Hocking et al., 2000; Stolton et al., 2003). It tracks trends in the effectiveness of management of protected areas. The METT has been widely tested across the world and has been adapted for the South African conditions, the local version being referred to as METT-SA.

The general characteristics of the METT-SA can be summarized as follows (Cowan et al., 2010).

- "It is a quick and easy self-evaluation tool applied by protected area managers to track longer term trends in management effectiveness.
- The system has 33 indicators with 10 supplementary questions.
- It relates to the National Environmental Management: Protected Areas Act, 2003.
- Includes the Department of Environmental Affairs management plan guidelines (Cowan, 2006)
- It has an automatic scoring system with automatic adjustment of scores when non applicable items are excluded
- The questions relating to the indicators have been rephrased to better reflect South African circumstances
- The scores are grouped under the elements of adaptive management, providing an indication of where priority actions are required
- It has been extensively tested and has proved to be a practical management tool especially where the evaluation is carried out by way of an interactive discussion in a multidisciplinary team".

METT-SA is already being applied in protected areas of the country and, recently, to the South African Ramsar sites (Cowan et al., 2010; Ramsar Secretariat, 2015). The METT-SA tool can potentially be adapted, in future, for use in assessment of management effectiveness of wetlands within the NWMP.

4.2.5 DEA: – Working for Wetlands (WfW) Programme

Spatial scale of assessment: Programme Level Assessment

Temporal scale of assessment: as required by programme

The WfW programme, initiated in 2000, is a joint initiative of the departments of Environmental Affairs (DEA), Agriculture, Forestry and Fisheries (DAFF) and Water Affairs (DWA), housed at the DEA. The programme is implemented in partnership with the Department of Public Works, Small Enterprise Development Agency (SEDA), Construction Industry Development Board (CIDB) and provincial agencies such as Gauteng Enterprise Propeller (GEP) and Limpopo Business Support Agency (LIBSA) provides assistance to Small Medium & Micro Enterprises (SMMEs) utilised by the programme with regards to training and business support (DEA, undated)

WfW uses a poverty-relief-driven approach to its core business, the implementation of large-scale wetland rehabilitation projects, which focus on the rehabilitation, wise use and protection of wetlands (Dini, undated). The WfW programme seeks to maximises employment creation, creates and supports small businesses and transfers relevant and marketable skills to beneficiaries.

According to DEA, the benefits accruing from the wetlands rehabilitated by Working for Wetlands include:

- Improved livelihoods,
- Protection of agricultural resources,

- Enhanced biodiversity,
- Cleaner water,
- Reduced impacts from flooding and
- Sustained base-flows in rivers.

The WfW programme uses the Wet-Tool methodologies to assess wetlands. For instance, the assessment of the impacts and threats within each wetland system is done to establish the current 'health' of the wetland.

In the first fourteen years the programme (DBSA, undated):

a) invested more than R724 million (approximately USD 79 million) in rehabilitation;
b) rehabilitated 906 wetlands;
c) improved or secured the health of more than 70,000 hectares of wetland area (DBSA, undated);
d) provided 18,463 employment opportunities; and
e) provided 193,780 days of training in both vocational and life skills.

The NWMP and Working for Wetland Programme need to ensure that methods and tools which are utilized in assessment of wetlands are compatible, ensuring data and information sharing between the programmes. This will maximize benefits from the resource inputs of both programmes.

4.2.6 DEA: – Environmental Impact Assessments (EIA) in South Africa

Spatial scale of assessment: Area of environmental authorisation

Temporal scale of assessment: determined by the Record of Decision

Environmental Impact Assessment became a legal requirement in South Africa in 1997 with the promulgation of regulations under the Environment Conservation Act (Act 73 of 1989) (ECA). This was followed by the promulgation of NEMA and the gazetting of new EIA Regulations in terms of Chapter 5 of NEMA, in 2006 and amended in 2014. The regulations require that any activity listed in Listing Notice 1, 2 or 3 the EIA Regulations is subject to environmental authorisation. Regulation 982 defines a watercourse as including wetlands, making extensive reference to activities which require environmental authorisation if impacting on or within a specified distance from a watercourse (thus a wetland).

The EIA process is relevant to the NWMP in that the methods currently being used to conduct the EIA assessment of wetland condition are complementary. EIA environmental assessment practitioners make use of WET-Health to assess the current state of a wetland. Hence, EIA data could make valuable contributions to the NWMP if this dataset is included in the NWMP database. This will require engagement between DWS and DEA on the capture and sharing of this data.

4.2.7 Provincial Environmental Authorities: – Provincial Spatial Biodiversity Plans

Spatial scale of assessment: Provincial

A provincial spatial biodiversity plan has two main goals (SANBI website):

- *To guide conservation agencies in terms of protected area expansion by identifying priority areas for protected area expansion and consolidation, including priority areas for stewardship contracts with private and communal landowners.*
- *To guide land-use planning and decision-making in other sectors by identifying critical biodiversity areas crucial for conserving a representative sample of biodiversity and maintaining ecosystem functioning.*

Provincial spatial biodiversity plans utilise a range of biological features to determine Critical Biodiversity Areas in the provinces.

4.2.7.1 Gauteng C-Plan (Gauteng Department of Agriculture and Rural Development, 2014)

Gauteng C-Plan v3.3 is based on the systematic conservation planning approach of Margules and Pressey (2000). The main aims of Gauteng Conservation Plan Version 3.3 (GDARD, 2014) are to:

- "serve as the basis for biodiversity inputs into land-use planning processes in the province;
- serve as the basis for biodiversity inputs into bioregional plans for municipalities within the province;
- serve as the primary informant for the biodiversity component of the Basic Assessment and Environmental Impact Assessment (EIA) processes;
- guide protected area expansion and biodiversity stewardship programmes in the province".

Input layers into Gauteng C-Plan v3.3 included data on important aquatic features including pans, unique aquatic biodiversity features and best-condition quaternary catchments, and priority areas for climate change adaptation (GDARD, 2014).

4.2.7.2 Mpumalanga Biodiversity Conservation Plan (MBCP) (Farrar and Lotter, 2006)

The MBCP used a Systematic Biodiversity Planning approach (Farrar and Lotter, 2006). The plan makes use of the latest mapping and remote sensing data on vegetation, land use and water resources, which are combined and subjected to sophisticated analyses. Approximately 500 biodiversity features were used in the MBCP, 340 terrestrials and 157 aquatic features, including wetlands. The MBCP also provides guidelines for the management of wetlands.

4.2.7.3 Eastern Cape Biodiversity Conservation Plan (ECBCP)

The ECBCP make use of expert knowledge and expert mapping to develop conservation plans for the province. No spatial information on critical wetlands was available at the time of development so these were not included in the plan but would ideally be included in later revisions (Berliner and Desmet, 2007). Like other conservation plans, the ECBCP includes wetlands as a part of the spatial planning process. Since there was no accepted priority ranking system for wetlands at the time of development of the ECBCP, the plan utilised a 50 m buffer be set for all wetlands.

4.2.7.4 North West Province Biodiversity Conservation Assessment)

The North West Province Biodiversity Conservation Assessment (CBA) included an *integrated wetland layer for the province, mapping nearly 12000 wetlands. It incorporates all previous wetland products plus the new land cover* (North West Department of Agriculture, Conservation, Environment and Rural Development, 2009). The plan indicates that since no information on the ecological status or health of the wetlands was available, a proxy for the Present Ecological Status Category (PESC) was developed using the level of terrestrial transformation/degradation immediately surrounding a wetland. For the area of 500 m around a wetland, the percentage transformation was calculated, the assumption being that the less the degree of transformation, the better the condition of the wetland. The ecological states of the wetlands were then used to categorize wetlands into critical and important wetlands for the CBA map, with those in a better ecological state prioritised for conservation (North West Department of Agriculture, Conservation, Environment and Rural Development, 2009).

4.2.8 KZN Ezemvelo Wildlife: – KZN Biodiversity Status Assessment Report 2011

Spatial scale of assessment: Wetland (chiefly prioritised wetlands)

Temporal scale of assessment: 5-yearly

KZN Ezemvelo Wildlife, as part of the KZN Biodiversity Status Assessment report, conducted an assessment of Biodiversity Asset: Integrity of Priority Wetlands which indicated that the objective of prioritised wetlands in the province was to *ensure that a representative sample of the inland wetlands of KwaZulu-Natal is maintained in a state that allows viable samples of the provinces aquatic biodiversity to be conserved in perpetuity* (Goodman, 2012).

Linked to this objective are two goals, still under discussion, namely:

- No net decline (from present) of overall wetland integrity in the province
- At least 20% of KZN's important wetlands should be maintained in a pristine state (Present Ecological State Category A), no less than an additional 30% of KZN's important wetlands should be in a slightly impacted (Present Ecological State Category B) and the remaining 50% or less should be in an impacted (Present Ecological State Category C) or better state.

An assessment of 24 prioritised wetlands in the province was carried out in 2011 to determine the integrity status of the wetlands and trends in this status. The PES of these wetlands, in 2011, varied from unmodified (A) 20.8%, to largely natural (B) 12.5%, moderately modified (C) 45.8%, largely modified (D) 16.7% and seriously modified (E) 4.2%.

The results of the assessment demonstrated that the present ecological state of KZN's priority wetlands was below the desired target and guided management actions related to these wetlands.

This assessment of prioritised wetland in the province used some of the methods and tools recommended for use in the NWMP (see NWMP Implementation Manual for more details). Hence the NWMP could in future provide value information for the province's assessments, and *vice versa*.

4.2.9 Private Sector: the Mondi Wetlands Programme (MWP)

Spatial scale of assessment: Wetlands

Mondi was one of the first commercial landowners to realize the importance of wise management of wetlands in South Africa. In 1991, the Mondi Wetland Programme was established. MWP is a collaboration between Mondi, WWF South Africa, the Wildlife and Environment Society of South Africa (WESSA), and the Mazda Wildlife Fund.

The programme uses a number of strategies to ensure that wetlands are managed in an environmentally acceptable manner. For example, the MWP promotes the rehabilitation and wise use of wetlands among key government agencies and private wetland users. The overall management objective for the programme is to minimize the impact of all forestry and other operations on wetlands, by applying best management practices and promoting and facilitating the sustainable utilization of Mondi's wetlands.

In 2011, the MWP conducted "state of wetlands" assessments on Mondi land holdings. The selection of wetlands for assessment was informed by the systematic conservation plans of freshwater ecosystems in KwaZulu Natal (Ezemvelo KZN Wildlife) and in Mpumalanga (Mpumalanga Tourism and Parks Board). Areas of high conservation value were used to prioritise wetland areas for assessment (Walter et al., 2011). Wetlands were selected across the whole Mondi management area (Walter et al., 2011) and the Wet-Health and Wet-Ecoservices tools were used to assess the health and functionality of the wetlands.

As a result of the assessment of the state of Mondi wetlands, the programme is able to report the extent; the vegetation type and status (endangered, vulnerable, etc.); the HGM type; the health (Present Ecological State category) and ecosystem services provided by the Mondi wetlands (Walter et al., 2011).

This assessment of Mondi wetlands used some of the same methods and tools as recommended for the NWMP (see NWMP Implementation Manual for more details). Hence the NWMP could in future provide valuable information for the Mondi assessments, and *vice versa*.

4.2.10 Parastatal: Eskom Wetland Assessment

Eskom is one of the biggest industrial water users in South Africa, accounting for about 2% of national water requirements in the year 2000 (DWAF, 2004b). Despite recognition of this water use being of strategic importance to the country, water used by Eskom is subject to the same efficiency criteria and water-demand management requirements as applied to other uses (DWAF, 200b). Eskom is also signatory to the UN CEO Water Mandate, designed to assist companies in the development, implementation, and disclosure of water sustainability policies and practices (UN CEO Water Mandate, undated). Hence, Eskom is committed to the maintenance of water resources within the catchments within which it operates, particularly ensuring that the ecosystems and wetlands under their jurisdiction are maintained in a healthy ecological state (Venter and Mitchell, 2015).

Eskom recognises the importance of wetlands within the area of its jurisdiction and is legally obliged to conserve these (Venter and Mitchell, 2015). To address this need, Eskom has developed the Eskom Wetland Classification and Risk Assessment Index Field Guide (Oberholster et al., 2014) and the development of a GIS-supported wetland inventory of Eskom properties (Venter and Mitchell, 2015).

The Eskom assessment of wetlands uses tools currently available for assessing the PES of wetlands and may thus, in future, benefit the NWMP and *vice versa*.

4.3 WATER RESOURCE AND WETLAND MONITORING

4.3.1 National Aquatic Ecosystem Health Monitoring Programme (NAEHMP)

The NAEHMP was implemented in 1994 by the Department of Water Affairs and Forestry (DWAF). Initially, the NAEHMP was named the National Aquatic Ecosystem Bio-monitoring Programme (NAEBP), which aimed at addressing the health of aquatic ecosystems in South Africa. The national custodian of the NAEHMP is the Department of Water and Sanitation, managed by Resource Quality Services with support from the Commission, the CSIR and various regional and provincial authorities.

The focus of the NAEHMP is primarily the ecological state of aquatic systems (DWAF et al., undated).

A total of eleven water-resource-quality monitoring programmes fall under the NAEHMP (Table 15) but the chief focus of the programme has largely been riverine ecosystems (DWAF, 2004). The main purpose of these monitoring programmes is to assess the status of the water resources and to track trends in water quality. Table 15 shows the various programmes under the NAEHMP, the indicators monitored by the programme and the type and frequency of reporting.

Table 15: National monitoring programmes (DWAF, 2004)

	Monitoring Programme	Indicators/Measures	Type of Report	Frequency of Reporting
1	National Microbial Monitoring Programme (NMMP)	microbes (*E. coli*, Faecal coliform)	Microbial Status Report	• Bi-monthly • Annually
2	River Health Programme (RHP)	fish, invertebrates; vegetation	State of Rivers Report	Annually
3	National Chemical Monitoring Programme (NCMP)	Numerous water quality variables	Assessment and Planning Reports	Variable
4	National Eutrophication Monitoring Programme (NEMP)	P and N compounds, Chlorophyll, Algae, Cyanobacteria	Eutrophication Status Reports	Annually
5	National Radioactivity Monitoring Programme (NRMP)		Radiological Water Quality Status Report	Regularly
6	National Toxicity Monitoring Programme (NTMP)	Toxicants and toxicity	Toxicological Water Quality Status Report	Regularly
7	Ecological Reserve Determination and Monitoring		Ecological Status Report	Intermittent
8	Hydrographic Surveys for sedimentation		Reservoir Volume and Sedimentation	Every 20 years per dam
9	Dam walls (dam safety)		Coordinates and diagrams	Bi-annually
10	Hydrological Monitoring Programme (HMP)	• Continuous surface water levels at gauging stations, canals, and dams and flow	• Flow and Dam Records, • Total Flow Regime, • Evaporation and rainfall	• Continuous, • daily, • monthly,

	Monitoring Programme	Indicators/Measures	Type of Report	Frequency of Reporting
		rates in pipelines • Rainfall and evaporation	records	• annually
11	Geohydrological Monitoring Programme (GMP)	• Rainfall depth and chemical character, • EC and temperature, • Groundwater level, • Isotope, • Trace elements	• Groundwater balance, Geochemical trends and spatial changes, • Geohydrological Reports	• Hourly readings of groundwater levels, • Bi-annual sampling of quality.

According to the National Water Resource Strategy of 2013, a number of databases in major national water monitoring programmes are in progress, and 11 of these are operated by DWS. These include:

- Surface water data (including streamflow, rain, evaporation and reservoirs) in the HYDSTRA database
- Groundwater data in various databases, including NGA, WARMS, GRIP, HYDSTRA and Hydrogeological maps
- Fitness-for-use data in the National Microbial Water Quality Monitoring Programme, National Eutrophication Monitoring Programme, National Toxicity Monitoring Programme, Rivers database, WMS, NGA/REGIS, HYDSTRA and geographical information systems (GIS)
- Water-use data captured by the DWA in the Water Registration Management System (WARMS)
- Compliance and performance data in the Regulatory Performance Management System
- Gauged rainfall data, primarily in the South African Weather Service (SAWS) database, but also available from others such as the Agricultural Research Council (ARC), water boards, local and district municipalities, WUAs, etc.

The best -known component of the National Aquatic Ecosystem Health Monitoring Programme is the RHP.

4.3.1.1 DWS: – River Health Programme (RHP)

The RHP is a nation-wide programme aimed at using biological indicators, in conjunction with the traditional physical and chemical indicators, to assess and monitor the health of South Africa's rivers. It was implemented in 1995, with the aim of monitoring and conserving the health of South African rivers.

Data representing the state of the rivers of South Africa has been collected and stored in a Rivers Database for identifying trends, patterns, etc. The RHP uses standardised procedures such as the South African Scoring System (SASS) method to monitor invertebrates (insect larvae, snails, crabs, etc.) (Chutter, 1994; Dickens & Graham, 2002) and the overall condition of the in-stream river ecosystem.

The RHP was designed to meet the following objectives (DWAF et al., undated):

- measure, assess and report on the state of aquatic ecosystems;
- detect and report on spatial and temporal trends in the state of aquatic ecosystems;
- identify and report emerging problems regarding aquatic ecosystems;
- ensure that all aquatic ecosystem health reports provide scientifically relevant information for the management of aquatic ecosystems; and
- create capacity and environmental awareness.

In the RHP, reference sites or reference conditions are utilised against which the PES of sites, reaches or rivers are assessed within an ecoregion (DWAF et al., undated). Ecoregion boundaries are used in the process of selecting reference sites.

The River Health Programme uses the biological monitoring component of the EcoClassification process to assess biological response data in terms of the severity of biophysical changes (Kleynhans and Louw, 2007). EcoClassification – the term used for the Ecological Classification process – is defined as *the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers* *relative the natural or close to the natural reference condition* (Kleynhans and Louw, 2007). The purpose of the EcoClassification process, according to Kleynhans and Louw (2007) is to develop an understanding of the causes and sources of the deviation of the PES of biophysical attributes from the reference condition.

The PES of a river is expressed in terms of various components, namely **drivers** (physio-chemical, geomorphology, hydrology) of change and **biological responses** (fish, riparian vegetation and aquatic invertebrates) to change (Kleynhans and Louw, 2007 and Figure 11). The PES categories for these components are integrated in the EcoStatus, representing the ecologically integrated state for the river (Kleynhans and Louw, 2007). The approach taken in monitoring the health of rivers in South Africa is to determine the biological fitness and survival (biological responses) in an aquatic ecosystem through the drivers of the processes in the rivers. The direct assessment of biological responses (such as the SASS system) indicates ecosystem functions that may have been impaired, and may sometimes point to the causes of impairment (Beechie *et al*., 2003). This is the framework that was used to develop the conceptual approaches and assessment models within which the current project was carried out.

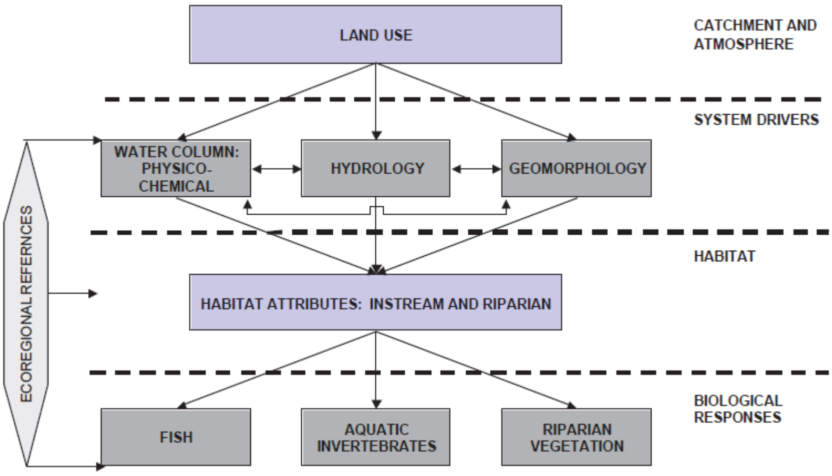

Figure 11: Framework underpinning the EcoStatus determination of rivers (from Kleynhans and Louw, 2007)

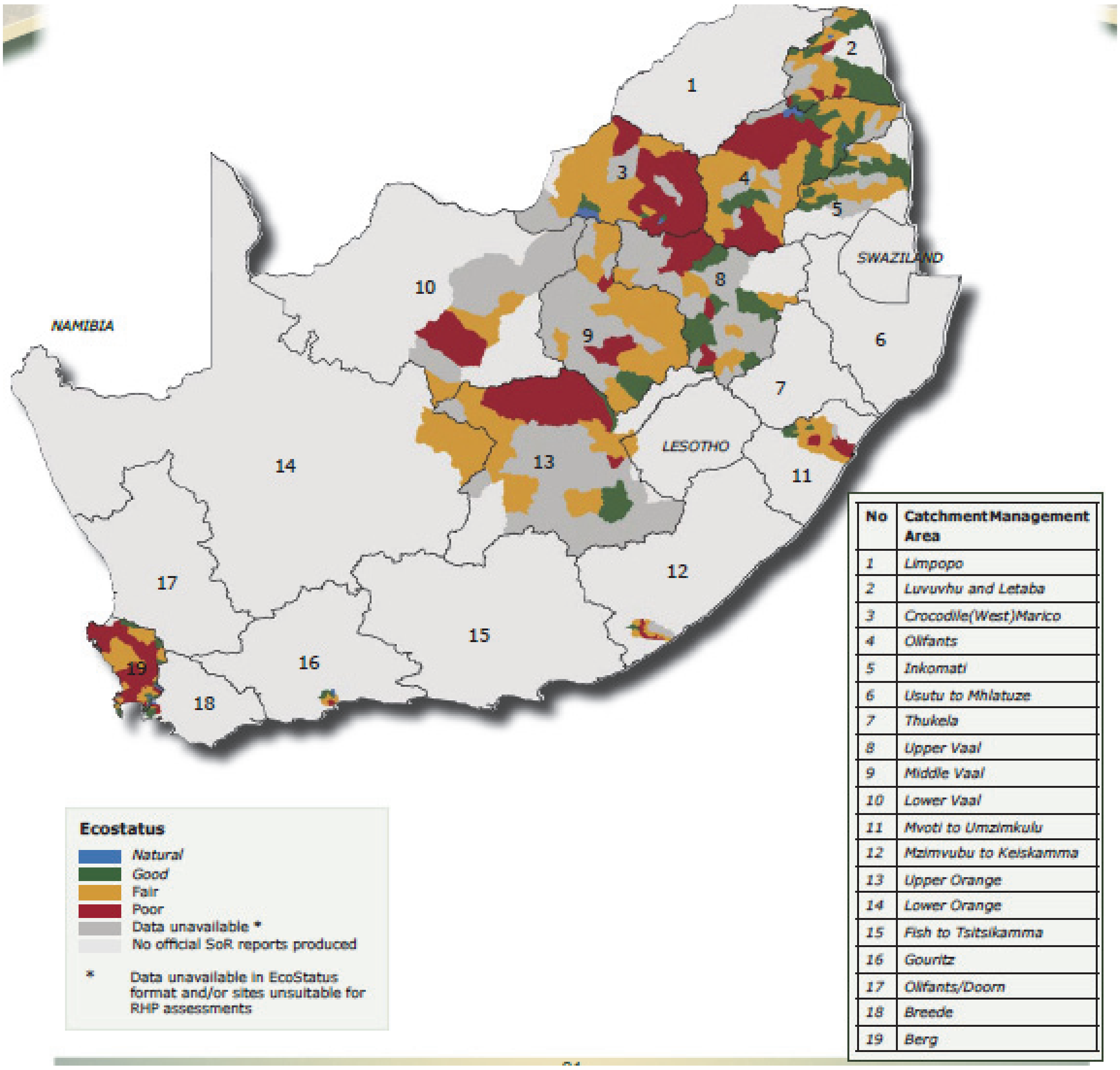

Figure 12: Ecostatus of rivers from RHP reports between 2000 and 2005 (taken from DWAF et al., undated)

The individual indices are also report for each river which has been assessed (Figure 13).

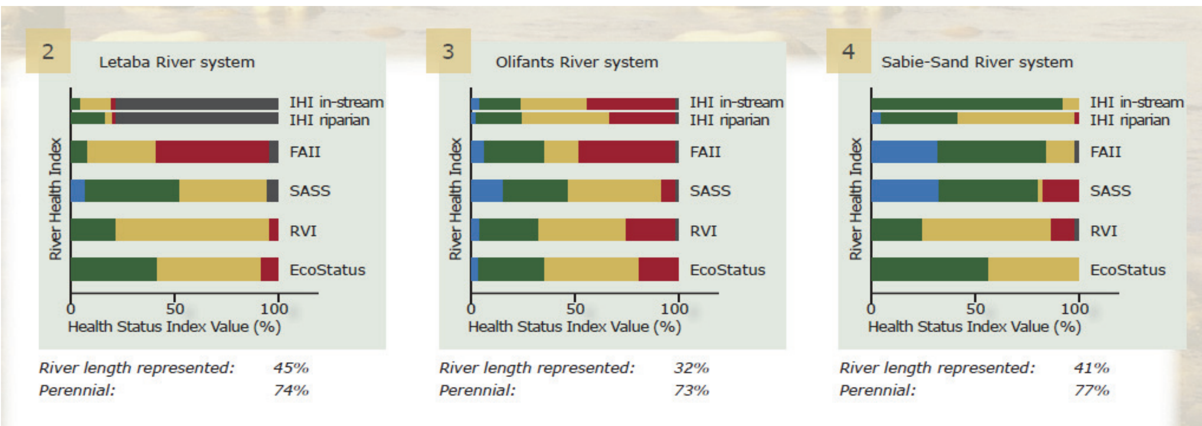

Figure 13: Example of reporting of individual indices for a river in the RHP (taken from DWAF et al., undated)

In a review of the RHP after 10 years of implementation, the following were highlighted as requiring urgent attention in 2004 (DWAF et al., undated)

- The management Classification System needed to be finalised and implemented

- The need for setting of the Reserve and resource quality objectives (RQOs) and implementation of in-stream flow requirements
- Continued monitoring of compliance with control measures
- Expanding the capacity and expertise RHP base through support, training and guidance
- Regional refinement and implementing of the RHP indices
- Clarification of roles and responsibilities between DWAF and other government departments in the RHP, particularly were overlaps exist in the management of wetlands, estuaries and groundwater
- Providing manager support, particularly in allocations of budgets and resources
- The need for continued communication and awareness creation to facilitate management action based on RHP monitoring results
- Expanding the RHP and continuing River Health Monitoring and Reporting to be more nationally representative

Driver and Nel (2011) made the following comments on the RHP: "...s*everal river health monitoring nodes have already been established under the auspices of the River Health Programme. These nodes should be reassessed, refined and supplemented according to an explicit set of criteria that also includes consideration of wetlands and other new information, e.g. FEPAs. In addition to the refinement of this monitoring network, there needs to be substantial investment into implementing repeated monitoring at these nodes – the River Health Programme sites have themselves rarely been re-visited due to funding, coordination and human capacity constraints (Strydom et al. 2006)".*

4.3.1.2 DWS: National Estuaries Monitoring Programme (NEsMP)

The National Estuaries Monitoring Programme (NEsMP) was established in 2008 by the then DWA with the purpose of monitoring long-term trends and changes in the condition of South African estuaries. Trends and change are monitoring using water quality, physio-chemical and biological monitoring. The NEsMP falls under the ambit of the NAEHMP.

The NEsMP is designed on a 3-Tiered framework, based on the intensity of monitoring required. The three Tiers in the Framework include (Figure 14):

Tier 1 – collection of basic abiotic data

In this tier the most basic data are collected, with the following objectives in mind:

1. long term trend analysis of water quality in a specific estuary, for local, regional and national water quality situation analysis;
2. facilitation of future ecosystem health reporting;
3. facilitation of future understanding of a system for reserve determination purposes;
4. facilitation of further scientific research on a system.

Tier 2 – collection of more detailed abiotic data in line with Reserve Determination

In tier 2, more detailed data are collected, making use of the RDM Monitoring protocol with the following objectives in mind:

1. long term trend analysis of water quality in a specific estuary, for local, regional and national water quality situation analysis;
2. report on regional and national estuarine health;
3. preliminary and comprehensive reserve determination;
4. audit the success of reserve implementation.

Tier 3 – event-driven monitoring to support management intervention in response to factors such as fish kills, pollution incidents and development pressure

In tier 3, situation-specific information is collected with the following objectives in mind:

1. proactive conservation planning;
2. surveys for comprehensive reserve determination purposes;
3. reactive investigation of specific human induced impacts, e.g. artificial mouth breaching, pollution incidents, fish kills, etc.;
4. reactive audit of the success of remediation actions;
5. reactive investigations of natural phenomena, e.g. floods, droughts, etc.

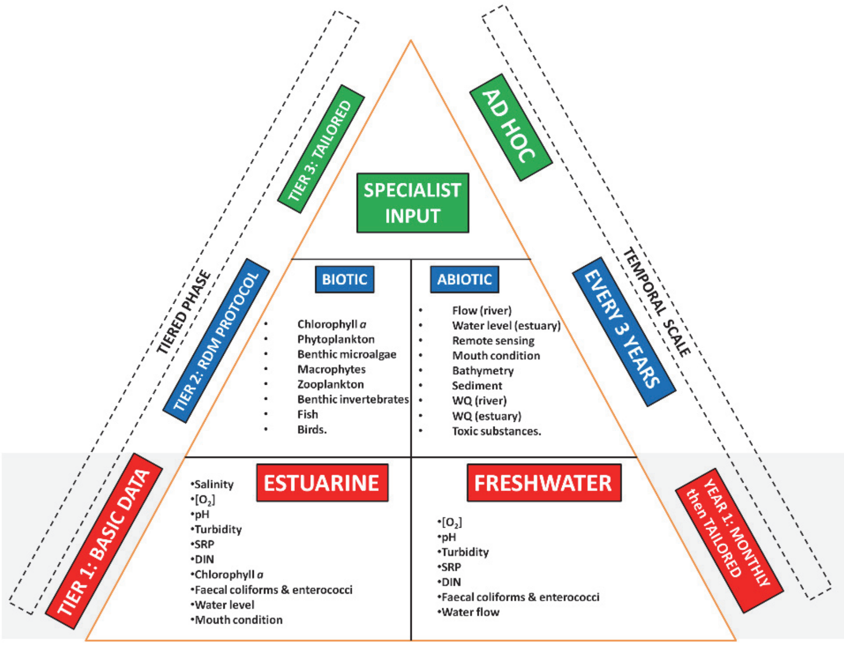

Figure 14: Tiers of the NEsMP (taken from https://www.dwa.gov.za/iwqs/rhp/nesmp/Estuary_tiers_s.png)

4.3.2 DEA: – State of Environment Reporting

The National State of the Environment Report (2009) was South Africa's first national assessment of the state of the environment. The SOE system is maintained by the DEA, reporting 9 datasets with 20 indicators of environmental sustainability. The purpose of these indicators is to provide information on our ability to protect our environment.

The SOE system currently reports only a single wetland indicator, namely number of sites designated as Wetlands of International Importance (i.e. Ramsar sites), and the area occupied by each

4.3.3 NGO: Coordinated Waterbird Counts (CWAC)

The Animal Demography Unit (ADU) of the University of Cape Town launched the Coordinated Waterbird Counts (CWAC) project in 1992 as part South Africa's commitment to International waterbird conservation. CWAC is implemented through regular mid-summer and mid-winter censuses monitoring of over 400 wetlands in the country. All the counts are conducted by volunteers, using standards protocols and data processing. Once field data have been collected, assessors can submit results electronically to CWAC for processing. The output of CWAC is species counts for sites which have been monitoring, as well as counts of specific species (e.g. Figure 15).

Google Roodeplaat Dam (25382821)	
Gauteng	
CWAC status	REGISTERED-COUNTED REGULARLY
Authority	Gauteng Department of Agriculture, Conservation and Environment
Management status	PROVINCIAL GAME/NATURE RESERVE
Conservation status	PROTECTED
IBA information	
Ramsar information	
Heritage information	
View Cards	Click here

Information
Date_registered
1998/07/25
Brief_description
Infestation of Water Hyasinth is a major problem in this dam.

Spp	Common name	Taxonomic name	Min	Avg	Max	IBA	Subregional IBA	RAMSAR
269	Avocet, Pied	Recurvirostra avosetta	2	3.50	5			
66	Bittern, Dwarf	Ixobrychus sturmii	2	2.00	2			
67	Bittern, Little	Ixobrychus minutus	1	2.50	7			
212	Coot, Red-knobbed	Fulica cristata	7	528.61	2165			
50	Cormorant, Reed	Phalacrocorax africanus	8	141.79	461			
47	Cormorant, White-breasted	Phalacrocorax carbo	9	156.42	495			130
203	Crake, Black	Amaurornis flavirostris	1	14.25	68			
52	Darter, African	Anhinga rufa	3	62.58	191			
95	Duck, African Black	Anas sparsa	1	2.69	6			
10006	Duck, Domestic	Anas platyrhynchos	1	1.67	3			
10005	Duck, Hybrid	Anas hybrid	1	2.33	4			
10015	Duck, Hybrid Mallard	Anas hybrid	1	1.00	1			
103	Duck, Maccoa	Oxyura maccoa	1	1.00	1			
1016	Duck, Mallard	Anas platyrhynchos	1	4.73	10			
1017	Duck, Mandarin	Aix galericulata	1	1.50	2			
10003	Duck, Muscovy	Cairina moschata	2	2.00	2			
10014	Duck, Unidentified	N/A N/A	1	1.67	3			
100	Duck, White-faced	Dendrocygna viduata	1	71.76	552			
96	Duck, Yellow-billed	Anas undulata	1	99.00	431			
61	Egret, Cattle	Bubulcus ibis	1	18.35	100			
58	Egret, Great	Egretta alba	1	3.22	11			
59	Egret, Little	Egretta garzetta	1	12.47	50			
60	Egret, Yellow-billed	Egretta intermedia	1	3.57	15			
149	Fish-eagle, African	Haliaeetus vocifer	1	1.33	3			
86	Flamingo, Greater	Phoenicopterus ruber	2	2.00	2			
10004	Goose, Domestic	Anser anser	1	2.50	6			
89	Goose, Egyptian	Alopochen aegyptiacus	2	69.82	256			
88	Goose, Spur-winged	Plectropterus gambensis	1	1.67	5			
4	Grebe, Great Crested	Podiceps cristatus	1	7.90	32		25	
6	Grebe, Little	Tachybaptus ruficollis	1	51.22	129			
263	Greenshank, Common	Tringa nebularia	1	1.00	1			

Figure 15: Example of site bird counts which emanate from the CWAC programme (taken from http://cwac.adu.org.za/sites.php?sitecode=25382821)

CWAC is one of the largest and most successful citizen science programmes in Africa, providing much needed data for waterbird conservation around the world.

The goal of CWAC is the effective long-term waterbird monitoring, benefiting conservation efforts worldwide.

4.3.4 SANBI: – National Alien Species Monitoring Programme

South Africa does have a significant suite of data related to alien invasive plants in the country. SANBI and DEA are tracking alien invasive on an ongoing basis and are able to report some of this detail for the quaternary catchments of the country (Figure 16).

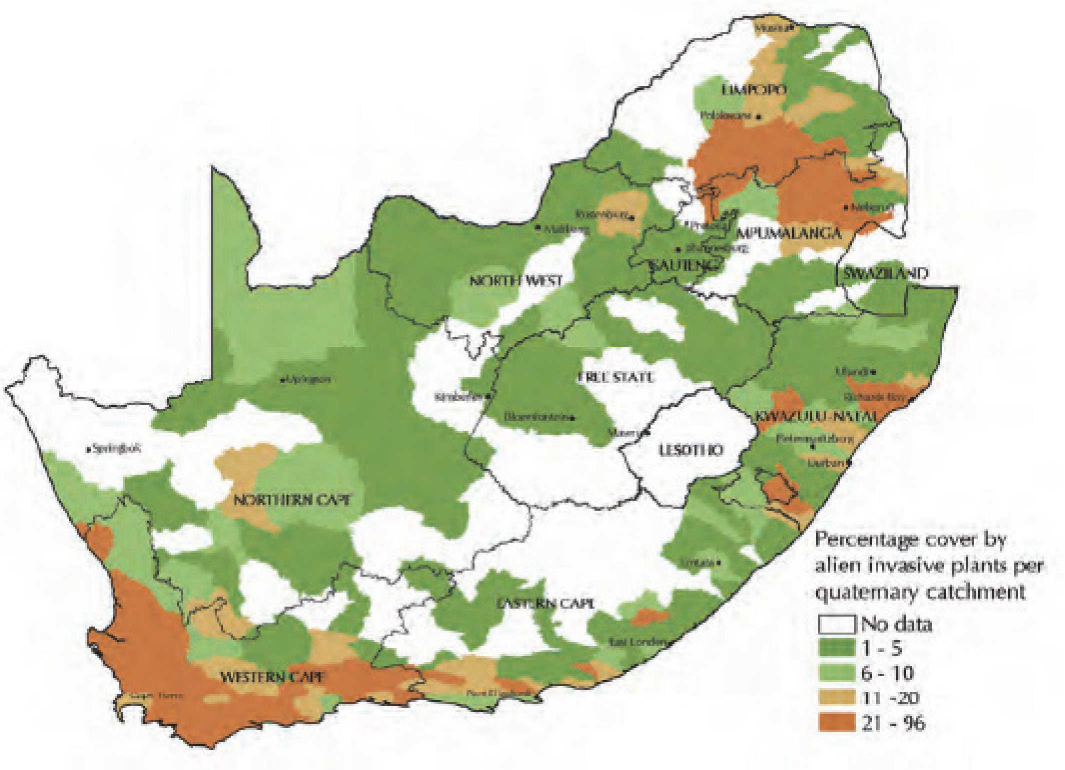

Figure 16: Percentage cover by alien invasive plants per quaternary catchment (Driver et al., 2004)

SANBI, through a national co-ordinator of the Invasive Species Programme, is responsible for the implementation and management of the institutional arrangements of the Early Detection and Rapid Response programme at national and regional level. The objective of the programme are (taken from SANBI, 2014):

- develop and co-ordinate early detection surveillance of new or emerging invasive alien plants and waterweeds;
- develop capacity and systems to allow for rapid and accurate identification and verification of invasive alien plants;
- harness and develop capacity and ensure optimum institutional cooperation to facilitate risk assessment and rapid response of each new or emerging invasive plant in South Africa;
- co-ordinate the organization of rapid response teams to respond when invasions;
- develop and co-ordinate effective information management systems;
- initiate and execute relevant research on early detection, risk assessment and rapid response;
- plan and implement an advocacy and awareness raising programme;
- design and implement a monitoring and evaluation programme to assess effectiveness of the above programmes and to recommend improvements.

The programme makes use of both experts and observers to recognise and survey invasive plants. Plant specimens gathered by the spotters and by regional co-ordination units are identified, confirmed and verified by taxonomists at the National Herbarium in Pretoria, the KwaZulu-Natal Herbarium in Durban and the Compton Herbarium in Cape Town (SANBI, 2014). An Invasive Plant Assessment Panel, linked to the programme, provides the recommended course of action for dealing with a newly detected invasion, which is then implemented by a regional eradication, follow up and management plan (SANBI, 2014).

5 DESIGNING THE NATIONAL WETLAND MONITORING PROGRAMME

As highlighted in Section 1.2, the monitoring system includes:

- a logical monitoring Framework (see Sections 5.2 and 5.3);
- SMART (simple, measurable, applicable, relevant/repeatable and timeous) indicators (see Section 5.6);
- instruments to collect and capture indicator data (see Sections 5.7);
- formulae or methods to consistently analyse indicator data (see Section 5.6).

The operational component provides the aspects of a monitoring programme necessary for sustainable operation and maintenance, including:

- data storage mechanisms (See Section 5.8)
- communication tools which display indicators in a simple, user-friendly manner (see Section 5.9) and
- a management plan to detail data and indicator update frequencies and requirements (See section 5.6).

A monitoring programme also includes an implementation plan which outlines a skills plan detailing the expertise required to ensure a sustainable system (see Section 6).

Finally, a monitoring programme requires a plan for management of the system and details of the ongoing funding of the programme (See section 6 for management plant/governance plan). Overarching the various components of the programme is quality control.

A successful and sustainable monitoring programme that forms an integral part of management, assessment and monitoring, reporting and verification requirements would involve (Bosch *et al.,* 1996):

1. clearly articulated wetland management goals and target;
2. monitoring tools to assess and interpret the outcomes of implementing management actions;
3. guidelines for consistent indicator management and reporting;
4. indicator alignment with national/programme imperatives;
5. high standards of data collation and analysis (quality);
6. availability of a knowledge base which is easily accessible and provides useful knowledge to respond to monitoring outcomes; and
7. the ability to be updated with new data and information, i.e. adaptive management approach.

The design of the NWMP acknowledges the requirements for a sustainable monitoring programme, addressing each requirement at the various stages of the design process.

5.1 Approach to the Design of National Wetland Monitoring Programme

The approach taken in designing the NWMP included:

- **Minimising duplication of effort** One of the greatest advantages of designing the NWMP at this time is that there have already been significant efforts to map wetlands and develop methods and tools for assessment. The previous sections of this report indicate that a National Wetland Inventory is already in place and being updated, that there are currently nationally applied methods for the resource classification, reserve determination, classification of wetlands, delineation and condition assessment of wetlands and that a number of assessments of wetlands have already been completed through EIA and water-use licensing applications. One of the underlying principles in the design of the NWMP has been to use these efforts to inform the programme. This firstly ensures maximum use of current resources; secondly it ensures alignment and relevance of the programme with wetland sector needs; and finally it minimises duplication of efforts.

- **Requisite simplicity** South Africa has limited resources for assessing, monitoring and reporting on its wetlands. The NWMP is designed to minimise resource use, while maximising outputs of any wetland assessment or monitoring initiative. The design is thus based on simplicity: application of current methods and tools, while also ensuring legislative relevance and scientific credibility in these efforts.
- **Prioritisation** Because of the large number of wetlands in South Africa, not all of them can be assessed or monitored. The NWMP provides methods for selecting suitable wetlands for assessing and monitoring.
- **Adaptive management approach** The NWMP needs to be embedded in an adaptive management approach. Adaptive management is a process, which couples scientific and social values to promote sustainable management of natural systems (Holling, 1978; Thomas, 1996). For the best results in sustainable use of natural resources, scientific information should be coupled to holistic management at appropriate scales (Haney and Power, 1996). Adaptive management is a process of "learning by doing", which begins with the compiling of initial baseline information for the indicators/indices in the monitoring system. This is followed by continued reviewing, refining, updating, and changing where necessary, indicators/indices with each iteration of the monitoring system. In other words, the monitoring system adapts as the wetland sector 'learns by implementing' the NWMP.
- **Maximum stakeholder engagement and participation** The wetland sub-sector of South Africa has many -stakeholders and is multi-organisational. The design of the NWMP recognised this and included extensive stakeholder engagement at all stages in the design process (see Appendix A for stakeholders who participated in the various engagements). The end result of this research is a NWMP which is stakeholder accepted.

5.2 The Process followed in Designing the NWMP

The process followed in designing the NWMP was largely stakeholder driven. Stakeholders were engaged through:

- focus group discussions (i.e. with DEA and DWS wetland and monitoring personnel)
- interviews with key individuals
- workshops with stakeholders, each workshop having a specific purpose (e.g. to agree on a goal and framework, selection of indicators,).
- workshops at forums such as the National Wetland Indaba and Water Institute of South Africa Conference

Table 16 lists the stakeholder engagements conducted during the design of the NWMP:

Table 16: Stakeholder engagement in support of the design of the NWMP

Date	Session	Purpose
6 June 2013 -	Meeting with National and Provincial DWS National Aquatic Ecosystem Health Monitoring Programme (NAEHMP)	To determine the wetland monitoring requirements and aspirations of the NAEHMP
22 Oct 2013 -	NWMP Wetland Indaba Workshop	To communicate the initial concepts of the NWMP and gather stakeholder inputs
26 March 2014 -	NWMP Goal Workshop with wetland stakeholders in Pretoria	To determine and agree on the goal and strategic objectives of the NWMP
29 April 2014 -	NWMP Goal Workshop with wetland stakeholders in Cape Town	To determine and agree on the goal and strategic objectives of the NWMP
25 May 2014 -	WISA 2014	To communicate the initial NWMP Framework and gather stakeholder inputs
2 July 2014 -	Internal Team Working Session	To determine wetland indicators
28 & 29 July	DWS/DEA/SANBI/Team Working Session 2014	To determine wetland indicators

Date	Session	Purpose
2014 -		
12 Sept 2014 -	DEA Workshop	To communicate the NWMP framework and indicators and gather DEA inputs
25 Sept 2014 -	Goal/indicator workshop KZN 2014	To communicate the NWMP framework and preliminary indicators to KZN stakeholder
20 Oct 2014 -	Wetland Indaba 2014	To communicate the NWMP framework and indicators and gather stakeholder inputs
13 Nov 2014 -	River Health Programme Symposium Presentation	To communicate the preliminary NWMP
23 April 2015 -	Interdepartmental Inland Water Ecosystem Liaison Committee Meeting	To communicate the preliminary NWMP
13 May 2015 -	Water quality discussion meeting May 2015	To address water quality indicators
14 May 2015 -	Indicator and Manual Workshop May 2015	To finalise and agree on NWMP indicators
15 May 2015 -	Team meeting May 2015	To finalise and agree on NWMP output
1 July 2015 -	SASAQS Conference	To communicate the preliminary NWMP
20 Oct 2015-	Wetland Indaba 2015	To communicate the NWMP
20 Nov 2015 -	Meeting with DWS specialists	To communicate the NWMP

5.2.1 Determining the Scope of the NWMP

National assessment and monitoring of wetlands can have many purposes, including reporting on the extent of wetlands in a country; reporting on the condition/health of wetlands; reporting on the value and benefits of wetlands or for a single purpose such as reporting on a single indicator such as an Index of Biological Integrity. Assessment and monitoring of wetlands might also be used for assessing the impacts of an activity on a wetland (EIAs); the effectiveness of conservation and management interventions on a wetland (performance monitoring); the effectiveness of rehabilitation on a wetland (performance monitoring); or to meet legislative requirements such as maintaining wetland water quality (regulatory monitoring).

The purpose of the assessment and monitoring programme will determine the scope and thus the type of framework, methods, tools, indicators and reporting required.

In the case of the NWMP, the purpose and scope of the NWMP was clarified through three activities (Table 17):

- Review of the recommendations of the Day et al. (2012) document on *Soliciting ideas towards the development of terms of reference for the design of a National Wetlands Monitoring Programme. Proceedings of A Workshop held on 29th March, Water Research Commission, Pretoria;*
- Recommendations made by the Reference Group Meeting of Wetland Experts linked to NWMP design research project on 16 May 2013;
- Recommendations from a meeting with National and Provincial DWS National Aquatic Ecosystem Health Monitoring Programme (NAEHMP).

Table 17: Documents and workshop outputs used to define the scope and purpose of the NWMP

Source	Recommendation related to the scope and purpose of the NWMP
Workshop on Soliciting ideas towards the development of terms of reference for the design of a National Wetlands Monitoring Programme (Day et al., 2012)	• the programme will depend on the objectives, and that these may differ from site to site, from time to time, and according to the requirements of different users. • The scope of the NWMP should include: o The ability to understand at a national scale the trends of wetland condition in addition to the smaller scale, site-specific monitoring issues o The ability to track the efficacy of wetland rehabilitation projects; o The ability to monitor wetland loss/degradation and associated loss of ecosystem services; and o The ability to estimate and monitor changes in the socio-economic value of wetlands.

Source	Recommendation related to the scope and purpose of the NWMP
	o The ability to measure the contribution that wetlands make to human well-being – in other words, to monitor ecosystem services as well as bio-physical aspects. o The ability to understand, at a broad scale, how wetlands are changing in response to environmental pressures such as climate change. o An adaptive management framework. • The NWMP needs to recognise South Africa's responsibilities in terms of international agreements such as the Ramsar Convention require a monitoring programme. • The implementation of management actions should be a primary objective of the programme, not just the collecting of data.
WRC Reference Group Meeting	The Reference Group recommended that the programme consider both monitoring the ecological aspects of wetlands as well as the socio-economic value/benefits of wetlands. DWS reiterated that socio-economic factors are important to Government and thus important in such a programme.

Meeting with National and Provincial DWS National Aquatic Ecosystem Health Monitoring Programme (NAEHMP)	The DWS team indicated the potential uses of a NWMP might be:
	• as a decision-making tool for license authorisation requests related to wetland areas
	• as a decision-making tool for protection of a wetland
	• as a decision-making tool to inform municipal developments/EIAs/planning (i.e. a GIS tool for municipal decision-making and planning)
	• for assessing current state of all wetlands
	• to assess trends in the functional health of wetlands
	• to assess wetland ecosystem health.
	The DWS team further indicated that the following should be considerations in the design of the NWMP.
	• the need to include all wetlands, but with monitoring sites to be prioritised;
	• consideration of wetland:
	  • characteristics
	  • position in landscape
	  • drivers of change
	  • responses to drivers according to habit and biodiversity
	  • functionality;
	• consider the characteristics of wetlands which are currently being monitored in the WQ Monitoring Programme (i.e. wetlands play a key function in maintaining water quality); prioritising of wetlands for protection/intervention based on the NWMP is critical;
	• standardised data collection methods are needed, with simple methods for assessment and more comprehensive options for certain wetlands or 'red flagged' issues in a wetland;
	• consider links between the NWMP and licence reporting and the latest ISO standards (includes reporting on biodiversity and ecosystem services): these reporting requirements might to feed into the NWMP.

Through the above engagements it was decided that the scope of the NWMP should include assessment and monitoring of the ecological condition of wetlands in the country, and of the ecosystem services they provide. The NWMP thus includes both bio-physical and socio-economic assessment and monitoring.

Assessment and monitoring of the ecological condition of a wetland should include assessment of both the drivers of habitat change in the wetland (i.e. the hydrology; geomorphology and vegetation of the wetlands) and of the fauna and flora to reflect the integrity of the system (Kleynhans and Louw, 2007).

The PES of wetlands in South Africa, based on current wetland assessment methods, is expressed by the **drivers** (geomorphology, hydrology, vegetation and water quality) of the wetland. Ideally, the **biological responses** (fish, aquatic invertebrates, etc.) should also be assessed and monitored to provide an integrated state for a wetland (Kleynhans and Louw, 2007). Trends in wetland condition can be determined by the directional change in the attributes of the drivers and the biota (as a response to drivers) at the time of assessment or monitoring, namely unchanged (close to reference state or stable); negative (moving away from reference state) or positive (moving toward a more natural state) (Kleynhans and Louw, 2007). The extent of change in a biota due to a change in a driver will depend on the type of modifications and the sensitivity of the biota to such driver changes (Kleynhans and Louw, 2007).

The current methods of assessment of wetland condition in South Africa have focussed on inferring the condition based on the drivers of change. Methods of biological assessment and monitoring of wetland condition are available but have not been widely tested and the links between cause (drivers), response (habitat) and condition have not been demonstrated. These links need to be understood for all wetland HGM types in the country in order to be able to relate a change in some aspect of the biota to a change in the condition of the wetland.

Assessment and monitoring of the value/benefits of a wetland is reflected by the ecosystem services it provides and indeed, the benefits it provides are a measure of its importance to society. Understanding many of the relationships within wetlands and thus the indicators in the national monitoring systems is based on the Millennium Ecosystem Assessment (MEA) ecosystem services (MEA, 2003). Ecosystem services are defined in the MEA as the *benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits* (Figure 17) (MEA, 2005). The conceptual framework for the MEA places human well-being as the central focus for assessment, while recognizing that biodiversity and ecosystems also have intrinsic value and that people take decisions concerning ecosystems based on considerations of wellbeing as well as intrinsic value (MEA, 2005).

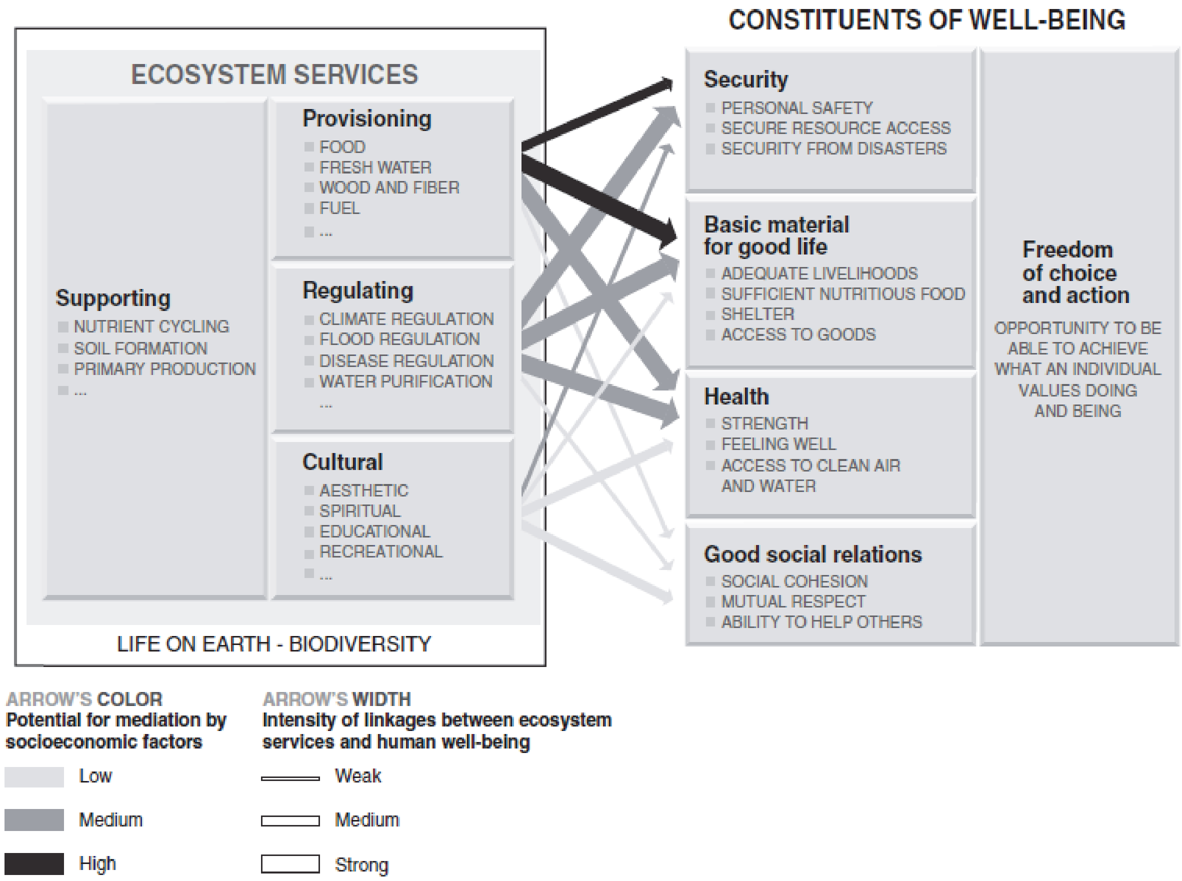

Figure 17: A framework for the wise of wetlands (UN MEA, 2005)

Describing wetlands using the MEA framework in Figure 17 provides a structured manner for understanding the cause-effect relationships between various components within a wetland and provides details of the drivers of changes in wetlands, as well as ecosystem services which need to be considered and.

The NWMP needs to enable South African decision-makers, stakeholders and academics to:

- meet international wetland reporting and monitoring obligations (i.e. Ramsar wetlands);
- uphold national wetland legislative monitoring and reporting obligations as mandated;
- assess, monitor and report on the general condition and functioning of wetlands (i.e. "state of the wetlands");
- monitor the provision of wetland ecosystem services;
- support the estimation of changes in the socio-economic value of wetlands;
- provide data to support timeous intervention or corrective action; and
- guide and inform future wetland conservation and rehabilitation initiatives.

These requirements were taken into account when determining the goal and Strategic Objectives (SOs) of the NWMP.

5.2.2 Setting a Wetland Assessment and Monitoring Goal and Strategic Objectives

A goal is defined as *an observable and measurable end result, which has one or more objectives to be achieved within a fixed timeframe* (Business Dictionary)

The scope of the NWMP outlined in Section 5.2.1 was a key aspect to be addressed when defining the objectives of the NWMP. The stakeholder workshop (Day et al., 2012)

indicated that *monitoring is of little use without a clear and unambiguous definition of the reasons for the monitoring and the objectives that it will satisfy. The objectives of a monitoring programme should, in turn, be guided by the requirements of the end-users of the information that is to be generated and disseminated* Furthermore, it is imperative to take into account the needs of stakeholders in formulating the objectives.

A monitoring programme is generally designed with hierarchal structuring of a goal or goals, SMART strategic objectives and targets, and demonstration of the relationships between these. The Strategic Objectives (SOs) demonstrate the objectives required in order to achieve the overall goal of the programme. Each SO is linked to one or more indicator/indices, which demonstrate progress in achieving the SO. Indicators are captured and reported using one or more measures related to the indicator, i.e. measures of water quality indicators would be turbidity; pH, etc.

The use of a hierarchical structure in the design of the NMWP had a number of advantages.

1. It facilitates the capturing and reporting of the "big picture" of protection, use, development, conservation, management and control of wetlands in South Africa This 'big picture' needs to be complemented by intensive studies of individual wetlands in local environments using the site-specific monitoring system discussed in Section 5.3.3 below (Noss, 1992).
2. It facilitating the recognition that the effects of environmental stresses can be expressed in different ways at different levels of wetland biological organization, namely the effects at one level in the hierarchy can be expected to resonate through the other levels of the framework, often in unpredictable ways.
3. Perhaps most importantly, it facilitates the linking of goals with -SOs and indicators, ensuring that each level is relevant and reports to the higher level (i.e. indicators related directly to the SOs and the SOs relative to the goal). This ensures that the SOs and indicators are selected to address the goal and thus the scope and purpose of the wetland assessment and monitoring programme. The hierarchical structure of the programme also facilitates the selection of indicators that represent the many aspects of wetlands that warrant attention in a wetland monitoring and assessment programme.

5.2.2.1 Determining the NWMP Goal

Ideally, South Africa would have a National Wetland Strategy or Policy that would determine the national wetland assessment and monitoring goal, strategic objectives and targets required for the hierarchy of the national NWMP monitoring system. In the absence of a National Wetland Strategy or Policy, goals, SOs and targets had to identified in order to guide the design of the NWMP. Stakeholder workshops were held for this purpose in Pretoria, KZN and the Western Cape (see Appendix A for a list of participants in these workshops).

The agreed goal for wetland assessment and monitoring in South Africa is *to* ***assess and monitor the change in, and threats to, the extent, present ecological state of and ecosystem services provided by wetlands in the country***

The term **wetland condition** is often used synonymously with 'ecosystem health' or 'ecosystem integrity'. The NWMP provides a framework for assessing and monitoring the state of wetlands in the country and thus uses the term "wetland condition". The term condition was selected to avoid confusion between the wetland assessment tools (i.e. Wet-Health) and the indicators of wetland condition in the NWMP. The NWMP adopts the definition of wetland condition as the *state of the physical, chemical, and biological characteristics of the wetland, and the processes and interactions that connect them*.

Condition of wetlands in the NWMP is measured using wetland PES indicators that report condition on a scale ranging from pristine (i.e. in the natural state) to completely impaired. Ecological condition thus describes the extent to which a given wetland system departs from full ecological integrity (if at all). Methods best suited to assess wetland condition reflect this by providing a quantitative measure describing where a wetland lies on the continuum ranging from full ecological integrity (i.e. the least impacted or reference condition) to highly degraded (poor condition: Fennessy et al., 2007). A single numerical score, for instance of Present Ecological State, for each indicator is the result. This score is not meant to measure absolute value or have intrinsic meaning, but rather provides a comparison between wetlands relative to some reference condition.

Similarly, Thiesing (2001) defines **wetland values** as attributes of wetlands that are perceived as valuable to society. Recognition of the value of wetlands to society can be demonstrated through the ecosystem services that they provide. The NWMP therefore includes an indicator that assesses and monitors wetland ecosystem services.

The NWMP goal is in line with the need for both bio-physical and value/benefit assessment and monitoring of wetlands in the country, namely the purpose and scope of the NWMP.

5.2.2.2 Determining Strategic Objectives (SOs) for the NWMP

The selecting of SOs for the design of the NWMP followed the approach that:

- ✓ Strategic Objectives (SO) need to be precisely stated, specific, realistic and achievable. This would ensure SMART objectives which can be measured and thus progress tracked over time. It is important to be able to know when an objective has been achieved, i.e. the end-point of an SO.
- ✓ If more than one objective is identified, prioritisation is necessary in order to make the best use of time and resources.
- ✓ The SOs will determine the nature of the NWMP framework, the wetland sampling design, the selection of assessment and monitoring indicators and sampling methods, field deployment, quality assurance, data analysis, data management, reporting, and the cost of wetland monitoring activity.

- ✓ The SOs for the national monitoring system should follow recommendations from the Ramsar strategic objectives related to Wise Use and the prescripts by the NWA for monitoring of water resources[8].

Figure 18 shows that through an extensive process of stakeholder engagement, three SOs were agreed for the NWMP, including the need for a wetland inventory in the country (SO1), the need to assess the condition, function and use of wetlands and the need to monitor wetlands in the country (SO3).

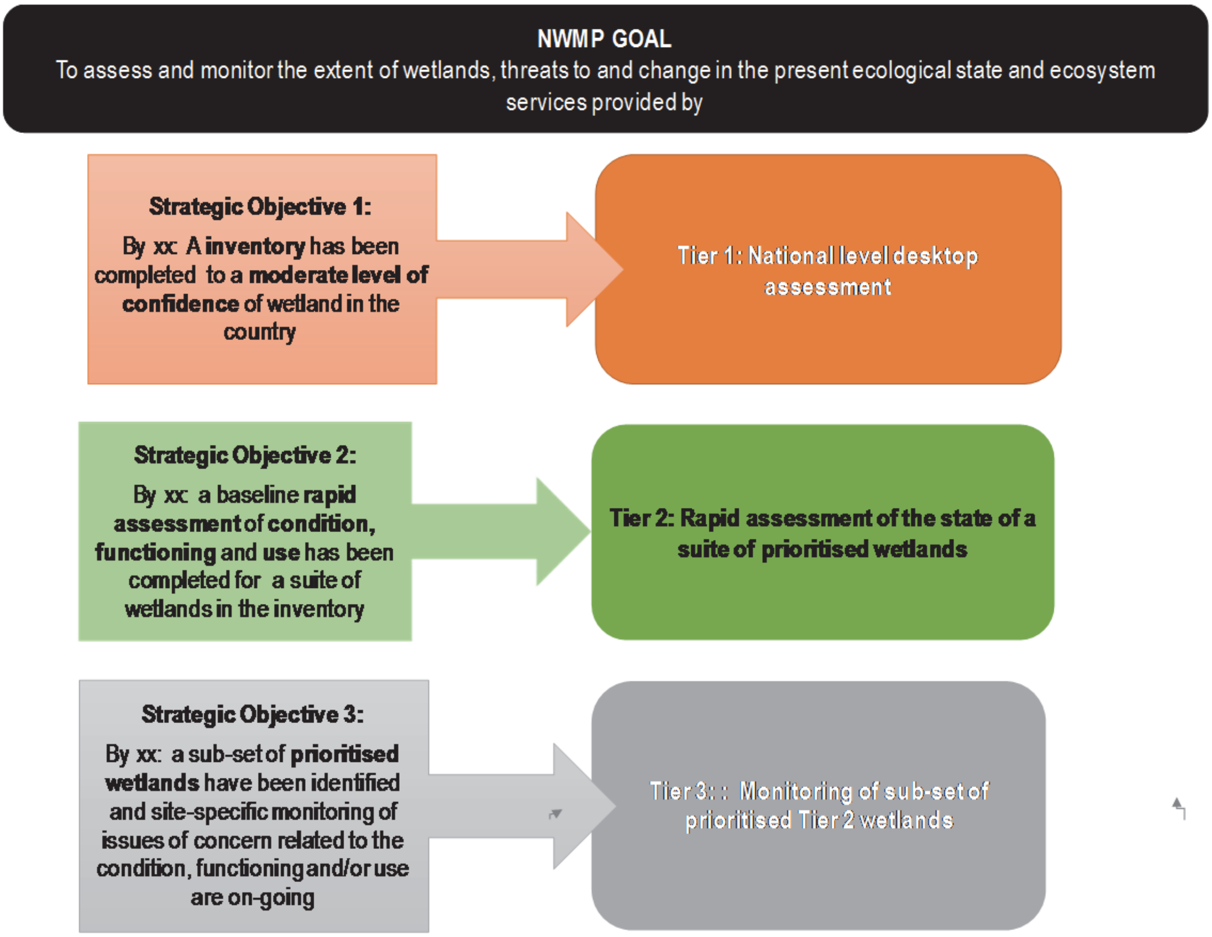

Figure 18: Stakeholder determined Goal and Strategic Objectives for the NWMP shown on the left and linkages with the 3 Tiers in the NWMP shown on the right

The monitoring and assessment of SOs progress required various scales of assessment and various levels of resource (skills, financial, time) to address the objective. The hierarchical design of the NWMP, using a goal and SOs, suggested that wetland assessment and monitoring would occur at multiple spatial and temporal scales. A 3-tier Framework for was thus developed for the NWMP.

5.3 THE 3-TIER FRAMEWORK FOR THE NWMP

The 3-Tier Framework of the NWMP translates the three strategic objectives into a 3-Tier monitoring system:

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[8] According to the NWA (Act No. 26 of 1998) the minister is required to establish national monitoring systems on water resources which provides for the collection of appropriate data and information necessary to assess, among other matters-
(a) the quantity of water in wetlands;
(b) the quality of wetlands;
(c) the use of wetlands;
(d) the rehabilitation of wetlands;
(e) compliance of wetlands management with resource quality objectives;
(f) the health of wetlands ecosystems; and
(g) atmospheric conditions which may influence wetlands.

- Tier 1: National-level desktop assessment
- Tier 2: Rapid assessment of a series of prioritised wetlands
- Tier 3: Monitoring of a subset of the Tier 2 wetlands

The 3-tiered hierarchical framework assesses and monitors wetlands at spatial scales from national to individual wetlands.

What is a wetland assessment?	What is monitoring of a wetland?
A wetland assessment is the field-investigation of the extent, state and threats to a wetland using the suite of indicators in the NWMP framework. This provides the first-level information from which a sub-set of wetland is prioritised for Tier 3 monitoring and for which a monitoring plan is devised	Monitoring of a wetland is the ongoing measurement of wetland characteristics for a specific purpose using specific indicators from Tier 3 of the NWMP. Only a sub-set of Tier 2 wetlands will be prioritised for monitoring.

5.3.1 Tier 1 – National-level assessment of wetlands

Tier 1 is a National-level assessment of wetlands throughout the country, using existing datasets and desktop assessment methods. Tier 1 predominately relies on GIS and mapping datasets (Land Cover, National Wetland Inventory) rather than direct measurement at a wetland scale.

The purpose of Tier 1: National-level level desktop assessment of wetlands, is twofold, namely to:

1. to report on the National-level indicators using GIS and desktop assessment methods (see Section 5.6 for details of these indicators) and
2. to provide information for the wetlands identified for site-specific rapid assessment in Tier 2.

The basic data for this tier is the National Wetland Inventory (NWI). The starting point for Tier 1 is therefore for the NAEHMP to acquire the NWI dataset from SANBI. The NWI should be used on an ongoing basis to update the NWMP database and vice versa.

5.3.2 Tier 2 – Rapid Assessment of Prioritised Wetlands

Tier 2 of the NWMP framework involves the rapid assessment of prioritised wetlands (see Section 5.5 on prioritising wetlands). Tier 2 is designed in line with the RHP field assessment process, namely field assessors spending approximately 4-8 hour at each site. Assessors will need some time prior to the field visit to collect preliminary data on the wetland and after the field visit to capture, analyse and report on the field results to the NWMP management unit.

The purposes of Tier 2 are to:

(1) ensure that, over time, an increasing number of wetlands in the country has undergone a rapid assessment of the change in, and threats to, the extent, present ecological state of, and provision of ecosystem services;
(2) verify the desktop information provided from Tier 1 for each of the prioritised wetlands;
(3) determine the baseline conditions for each wetland and identify specific issues of concern;
(4) identify a sub-set of wetlands for monitoring in Tier 3 (see Section 5.5.1 for how to prioritize wetlands for monitoring).

The definition of the *assessment area* is important as it influences how the data are collected and how the results are reported (e.g. by area of wetland resource, by wetland), understood, and used. The ‘‘wetland assessment area’’ or the ‘‘scoring boundary” is determined by the indicator methods used in the programme. The methods used to determine Tier 2 indicators are chiefly hydrogeomorphic units, with the results combined to provide a result for the entire wetland. The assessment area in the NWMP is thus a) HGM units and b) the entire wetland.

5.3.3 Tier 3 – Monitoring of Prioritised Wetlands

Tier 3 is wetland-specific monitoring of prioritised wetlands and primarily has two objectives. The first is to monitor issues of concern highlighted during the assessment of the wetland for Tier 2. The results of the Tier 2 assessment will determine whether the wetland requires further monitoring, which will be identified if a particular indicator or combination of indicators from Tier 2 show that there is a continuing an issue/concern.

What is wetland monitoring?

Monitoring is defined as the ongoing measurement of wetland indicator(s) for a specific purpose

The second objective is to build a body of knowledge of wetlands throughout the country. We have limited understanding of the links between attribute such as the assemblages of frogs, fish and birds and the state and usefulness of wetlands. It is therefore necessary to build a knowledge base that will allow the wetland sector to use changes in wetland attributes to infer changes in wetland condition. The purpose of Tier 3 monitoring is thus to contribute to the body of knowledge on wetlands and on the links between attributes and state and usefulness of the wetland.

5.4 Prioritisation of Wetlands in the NWMP

The report provides a guide to prioritising Tier 2 and 3 wetlands, supported by an Excel template for carrying out the necessary calculations.

The use of a rule-based model for prioritisation of wetlands in the NWMP was recommended. Qualitative rule-based models are particularly useful in data-poor situations as they are based on empirical logic, use logical inference as a format for the structuring of knowledge, and can provide an indication of the type of data required to improve confidence in the model predictions (Mackenzie et al., 1999).

Mackenzie et al. (1999) indicate that rule-based models "force scientists and managers to think about the problem to be solved, the decisions to be made, the components of the system, how they relate to each other and interact with one another". While modelling is possible without data, Mackenzie et al. note that the availability of data improves the level of confidence that both developers and users of the model have in its results. The designers of rule-based models should therefore attempt to source the most relevant and accurate data available during the design process. The use of rule-based, pragmatic models promotes inclusion of only relevant information and a structure that reduces ecological complexity without loss of meaningful output (Mackenzie et al., 1999).

The first direct step in developing rule based models, and possibly the most important, is to clearly define the objective of the model in terms of the goal. Once the goal of the model has been set, the components can be defined and related to one another. Rules in the model then take the form of "IF-THEN or ELSE" statements, which apply certain responses depending on which of the conditions have been met. In this way, relevant data are converted into rules.

The NWMP is designed to prioritise wetlands at two levels (Figure 18). The NAEHMP will therefore need, on an annual basis and in conjunction with experts and partners, to identify the wetlands to assign to Tiers 2 and 3.

Prioritisation of wetlands in the NWMP uses a criteria-rule-based approach and expert opinion. The criteria are adapted from those recommended by stakeholders. Each recommended criterion was reviewed during the testing of the Implementation Manual and related to the data and information available for the prioritisation process.

The prioritisation process in the NWMP is based on the following assumptions:

- it is more effective to maintain a wetland in good condition than to rehabilitate it;
- decision-makers (i.e. provincial reps; national reps; CMAs; municipalities) carrying out the prioritisation process in future will have a thorough knowledge of the areas to undergo assessment and monitoring;
- an adaptive management approach is adopted – the prioritisation process will be reviewed annually;
- the prioritisation process will include a representative sample of assessments and monitoring across ecoregions, sub-quaternary catchments and HGM types, decisions-makers to decide what this representative sample is.

5.5 Prioritisation of Wetland for Assessment in Tier 2

The philosophy behind Tier 2 of the NWMP is to facilitate, over the years of the programme, a rapid field assessment of as many of South Africa's wetlands as possible within the human, financial and resource constraints that affect aquatic health assessment and reporting in the country. Maximising returns and outputs from NWMP wetland assessments is crucial, allowing limited resources to be strategically directed at the prioritised wetlands in order to maximise the desired outcomes.

The reasons for needing to sample only a subset of the country's wetlands are threefold:

a) there are too many wetlands in the country for all of them to be assessed in the field;

b) there is a need to decide on the sequence of systems to be assessed;

c) there is a range of wetland types and ecoregions throughout the country.

The report provides a guide for identifying wetlands suitable for Tier 2 rapid assessment, using a rule-based model and expert opinion. Mackenzie et al. (1999) indicate that rule-based models *force scientists and managers to think about the problem to be solved, the decisions to be made, the components of the system, how they relate to each other and interact with one another*. The criteria chosen for the prioritisation exercise are adapted from those recommended by stakeholders at an NWMP design workshop held in Gauteng in May 2015. Each criterion was reviewed during the testing of the NWMP Implementation Manual to ensure that appropriate data and information would be available for the prioritisation process.

The prioritisation process in the NWMP is based on the following assumption:

- the decision-makers (i.e. personnel from provincial and national departments, CMAs and municipalities) carrying out the prioritisation process in future will have a thorough knowledge of the wetlands in their jurisdiction that will undergo assessment and monitoring;
- an adaptive management approach is useful – the prioritisation process will be reviewed annually;
- the prioritisation process will include a representative sample of wetlands across ecoregions, and local decisions-makers will decide which wetlands to choose.

The NWMP stakeholder recommended a suite of criteria be utilised to prioritise wetlands in Tier 2. These criteria should be utilised, in conjunction with expert opinion, to prioritised wetland to undergo Tier 2 wetlands. Criteria include:

1. categories of wetland types (HGMs)d
2. ecoregions which should be prioritised for wetland assessment.
3. management units within ecoregions which should be prioritised for Tier 2 wetland assessments.
4. important attributes of wetlands that should be considered in Tier 2 prioritisation of wetlands for assessment, including:

- conservation status including threatened ecosystem, i.e. vulnerable; critically endanger; centre of endemism; biological threats, i.e. red data species; Ramsar site and critical biodiversity areas
- ecosystem service provided by the wetland which can be inferred from the HGM types of the wetland (Table 18).

Table 18: Preliminary rating[9] of the ecosystem services[10] potentially supplied by a wetland based upon HGM type (taken from Kotze, 2014)

Regulatory services:	Flood attenuation	Erosion control	Sediment trapping	Phosphate assimilation	Nitrate assimilation	Toxicant assimilation
Floodplain[11] wetland	4	3	3.5	4	2	2
Valley-bottom wetland, channelled	2	3	3	3	2	2
Valley-bottom wetland, unchannelled	2.5	4	4	3	3	4
Seep with channelled outflow	1.5	4	1	1	4	4
Seep without channelled outflow	1.5	4	1	1	4	3
Depression, exorheic	1.5	1	1	1	2	2
Depression, endorheic	1.5	1	1	1	2	2

Provisioning services:	Water supply	Grazing	Plants for crafts	Medicinal plants	Indigenous/ wild foods	Cultivated foods	Tourism & recreation
Floodplain wetland	3	4	3	2	3	4	4
Valley-bottom wetland, channelled	3	3	3	4	2	3	3
Valley-bottom wetland, unchannelled	3	3	4	3	2	3	3
Seep with channelled outflow	4	3	3	4	2	3	2
Seep without channelled outflow	2	3	2	3	1	3	2
Depression, exorheic[12]	3	3	2	1	4	2	3
Depression, endorheic	1	2	1	1	4	1	3

- threat to the wetland from land use activities based on data collected in Section 5.3 of the Implementation Manual
- importance of the wetland as a reference wetland based on expert opinion

Once wetland have been preliminary prioritised based on the above criteria, the NWMP management needs to determine what the reasonable number of wetlands are that can be dealt with by the programme and provincial environmental agencies.

Taking the pragmatic view of the number of Tier 2 wetlands to undergo assessment on an annual basis, and the minimum number of representative wetlands within each criteria category can be determined. For example, the NWMP and experts may decide to target 5 or 6 wetlands in each combination of HGM type, ecoregion, conservation status, ecosystem services provided and reference condition, perhaps in each CMA or each of the main drainage regions in the country. Selection of the individual wetlands to undergo the Tier 2 assessment from each of these categories can be determined by the NWMP and provincial agencies. Appendix F however, does provide a guide for the NWMP or provincial agencies to prioritisation these Tier 2 wetlands at a sub-quaternary

[9] *The same range is scores from 0 to 4 is used as is applied by WET-EcoServices level 1 assessment.*
[10] *Although streamflow regulation has been omitted from Kotze (2014), the report indicates that scores for water supply is likely to provide some indication of this service.*
[11] *Kotze (2014) indicates that a floodplain wetland is taken as typically comprising predominantly floodplain flat with floodplain depressions contained within the flat. If a particular floodplain unit is characterized by the very limited extent of depressions, then this unit is probably best treated as a channelled valley bottom unless it is particularly wide (i.e. >500 m)*
[12] *Kotze (2014) indicates that exorheic depressions generally experience flushing, which prevents the accumulation of solutes. However, under arid conditions this flushing will often be inadequate to prevent such accumulations, and therefore under arid conditions these depressions may need to be treated as endorheic in terms of water supply.*

catchment (referred to as broad-scale management units) and fine-scale prioritisation of individual wetlands within the sub-quaternary catchment. Note: this guide of broad-scale and fine scale prioritisation of Tier 2 wetlands requires further testing at a national scale, once the NWMP database has been developed.

Expert inputs should be sought in the prioritisation process, especially in the provinces (i.e. Agencies; CMAs, etc.).

5.5.1 Prioritisation of wetlands to be monitored in Tier 3

The philosophy of Tier 3 of the NWMP is that some of the wetlands assessed in Tier 2 will be selected for monitoring, based on a number of key criteria related to the wetland. They are: (1) the ecological importance and sensitivity of the catchment in which the wetland occurs and the conservation importance of the area, based on provincial/local conservation plans; (2) the important ecosystem services provided by the wetland as determined by the indicator of ecosystem service provided by the assessed wetland in Tier 2; and (3) the value of wetlands in reference condition, to allow the accumulation of hard data on the structure and functioning of the different types of wetland in the country.

At this point, indicator and spatial data generated from Tiers 1 and 2 should be available in the database and, together with the information in Table 19, will provide the basic information needed for selecting wetlands for Tier 3 monitoring.

Table 19: Criteria utilised for selection of wetlands for monitoring

Criterion	Why the criterion is important	Categories	Data source
Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS)	**Ecological** *importance* of a wetland is an expression of its importance in maintaining biological diversity and functioning at local and wider scales. Ecological *sensitivity* (or fragility) refers to the system's ability (or rather, lack of ability) to resist disturbance. *Resilience* refers to the system's ability to recover from disturbance once it has occurred. Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity of aquatic ecosystems. The modus operandi followed by DWS's Directorate: Resource Directed Measures (RDM) for rivers is that, if the EIS is high the aim should be to improve its condition, although improvement may not always be realistic. The assumption made in this document is that if the EIS of the sub-quaternary catchment is high, then wetlands in this Sub-Quaternary Reach should be considered for monitoring.	Low=1; Medium=2; High = 3	https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx
Provincial spatial biodiversity plans	A provincial spatial biodiversity plan has two main goals (SANBI website): - to guide conservation agencies by identifying priority areas for expansion and consolidation of protected areas - to guide land-use planners and decision-makers in other sectors by identifying critical biodiversity areas (CBAs) critical for conserving representative samples of biodiversity and maintaining ecosystem functioning.	• CBA (Irreplaceable) = 3; • CBA (Important) =2 • Ecological support area = 1	The following five provinces have completed provincial biodiversity plans: • Gauteng (C-Plan version 3.3) • Mpumalanga (Mpumalanga Biodiversity

Criterion	Why the criterion is important	Categories	Data source
	To identify CBAs, provincial spatial biodiversity plans use a range of data which may include: • land-cover map • availability of land-cover classes • vegetation map • threatened species • plants • birds • invertebrates • mammals • reptiles / amphibians • important aquatic features • unique features and pans • near-pristine conditions • features related to climate change.		Conservation Plan) • Eastern Cape (Eastern Cape Biodiversity Conservation Plan) • KwaZulu-Natal (KwaZulu-Natal Biodiversity Conservation Plan) • North West (North West Biodiversity Conservation Assessment)
FEPAs, FEPA clusters and Ramsar sites	FEPAs are South African rivers and wetlands that have been identified as being of particular conservation importance. FEPA *clusters* of wetlands are found in relatively natural landscape matrices that allow for important ecological processes such as migration of frogs and insects between wetlands. SANBI's goal is that at least 20% of the wetland cluster areas identified for each wetland vegetation group (Nel, 2011). "Ramsar wetlands" have been identified internationally as being important for biodiversity conservation.	• Cluster=2; • Individual wetland = 1; • Ramsar = 3	http://bgis.sanbi.org/nfepa/project.asp
Ecosystem Services	In all Millennium Assessment scenarios, actions taken to increase the supply of provisioning ecosystem services such as food and water result in reductions in the supply of supporting, regulating, and cultural services (MEA, 2005). Hence, prioritization of wetlands for monitoring based on biodiversity and regulating services score is crucial.	• Biodiversity Regulation = 3 • Regulating Services = 3; Provisioning Services =2; • Cultural Services =1	Data will emanate from the Tier 2 assessment of prioritised wetlands
	Change in landcover	In certain areas of the country, wetlands may be prioritised for monitoring based on the land-cover and land-use within and around the wetlands (for instance, major changes in either are expected, the wetland may be prioritised for monitoring).	
	Biome	In certain areas of the country, wetlands may be prioritised for monitoring based the biome in which they are found, i.e. fynbos biome wetlands	
	EcoRegion	In certain areas of the country, wetlands may be prioritised for monitoring based the EcoRegion in which they are found	

Wetlands with all condition indicators categorised as A (or sometimes B) may be potential Reference Condition sites and so should therefore be considered, in consultation with wetland experts, for Tier 3 monitoring.

Certain wetlands may be prioritised for monitoring irrespective of the above prioritisation. Some examples are

1. wetlands to be monitored to address current gaps in wetland knowledge;
2. provincially prioritised wetlands;
3. wetlands that already have good baseline data; and
4. wetlands that are deemed by experts as a 'must' for monitoring for various reasons.

In summary, wetlands will be selected for Tier 3 monitoring for a variety of reasons and by a variety of management authorities and wetlands scientists. In the long run, the number of sites chosen will depend on logistic and financial constraints as well as conservation or socioeconomic value.

5.6 INDICATOR SELECTION IN THE NWMP

The development and use of indicators is designed to assess temporal patterns in the status and trends of ecosystems, habitats and species, the pressures and threats they face, and the responses made to address these pressures and threats. Such indicators are not designed to provide a complete and comprehensive assessment of all aspects of wetland ecosystems and their dynamics: rather they are intended to give a series of related pictures of these patterns, in order to guide further design and the focusing of decision-making for addressing unwanted change (Ramsar, 2010a).

The overall purpose of wetland assessment and monitoring is to assess the degree of change in the extent, state and use of a wetland, based on the objectives in the national monitoring system framework discussed above. The NWMP uses a variety of indicators to do this.

According to Noss (1990 and 1992,) ideally, indicators should be:

(1) specific: unambiguously associated with the key attribute of concern and not significantly affected by other factors;
(2) measurable by some procedure that produces reliable, repeatable, accurate information;
(3) sufficiently sensitive to detect changes that can provide an early warning of change;
(4) timely: able to detect change in the key ecological attribute quickly enough that project managers can make timely decisions on conservation actions;
(5) comprehensive: able to detect changes across the entire potential range of variation in the key ecological attribute, from best to worst condition;
(6) technically feasible: amenable to implementation with existing technologies without great conceptual or technological innovation;
(7) distributed over a broad geographical area, or otherwise widely applicable;
(8) capable of providing a continuous assessment over a wide range of stress;
(9) relatively independent of sample size;
(10) cost-effective: able to provide more or better information per unit cost than the alternatives, and easy and cost-effective to measure, collect, assay, and/or calculate;
(11) partner-based: compatible with the practices of key partner institutions in the conservation effort, or based on measurements they can or already do collect;
(12) able to differentiate between natural cycles or trends and those induced by anthropogenic stress; and
(13) relevant to ecologically significant phenomena.

Since no single indicator will have all of these properties, a suite of complementary indicators is often required. Two approaches to determining these complementary indicators are applied in the monitoring sector, namely SPICED and SMART. These acronyms stand for Subjective, Participatory, Interpreted and communicable, Cross-checked and compared, Empowering, and Diverse and disaggregated (SPICED indicators) and Specific, Measurable, Achievable (or acceptable), Relevant (or reliable) and Time-bound (SMART indicators). The two approaches differ in that the SMART approach requires indicators to be rigorous and, while recommending stakeholder inputs in selecting indicators, the level of involvement may be minimal and the process of selection may not be completely transparent. Literature (Larson and Willams, 2009) reveals that the SPICED approach addresses some of the criticism of the SMART approach, placing greater emphasis on developing indicators that stakeholders can define and use directly for their own purposes. In addition, the SPICED framework challenges the traditional assumptions that the only valid and 'rigorous' indicators are those that are 'objective', 'independent' and deal with 'facts' rather than 'perceptions' of the facts Larson and Willams, 2009). The main advantage of participatory approaches is that they can provide qualitative information that is locally meaningful, readily useful and context specific. Ideally, the SMART criterion approach of indicator selection can be used to assess the ***suitability*** of the indicators, whereas SPICED guidelines can ensure that the users get the ***most value*** out of the suite of indicators (Larson and Willams, 2009). Both approaches were applied in the selection of indicators for the NWMP.

A major question in the design of the NWMP was, "what should we monitoring or assessing, and why?" The following key considerations were applied when selecting indicators.

1. The indicator must provide information on the extent, state or use of wetlands in the country.
2. The indicator needs to demonstrate a driver-response relationship, showing change in the extent, condition or use of wetlands through changes in drivers or a change in a response to a driver.
3. The indicator needs to be measurable at a scale appropriate to each tier of the framework. Thus Tier 1 indicators need to be GIS-based, while Tier 2 and 3 indicators need to be collected on the ground. In selecting site-specific indicators, the definition of the ecological condition of a wetland and its emphasis on the biological, chemical and physical components of the ecosystem need to be considered. In addition, site-specific indicators need to address ecosystems services.
4. The key manner in which indicators were selected in the NWMP was that of the SPICED approach. Recommendations from stakeholder workshops, and expert opinion, were the primary criteria applied in the selection of indicators.
5. Once an indicator had been recommended in the stakeholder engagement process, SMART criteria were applied. Excluded indicators either did not relate directly to the scope, purpose, goal or strategic objectives of the programme, or were not currently measurable (either the method not being currently available or cause-and-effect relationships not being well understood).

Based on the above criteria, a number of indicators have been recommended:

- 4 National-level-level indicators for Tier 1 objectives
- 8 site-specific wetland assessment indicators for Tier 2 objectives
- 8 site-specific wetland monitoring indicators and 5 monitoring protocols for Tier 3 objectives (note that all indicators will be monitored for each Tier 3 wetland (Figure 19).

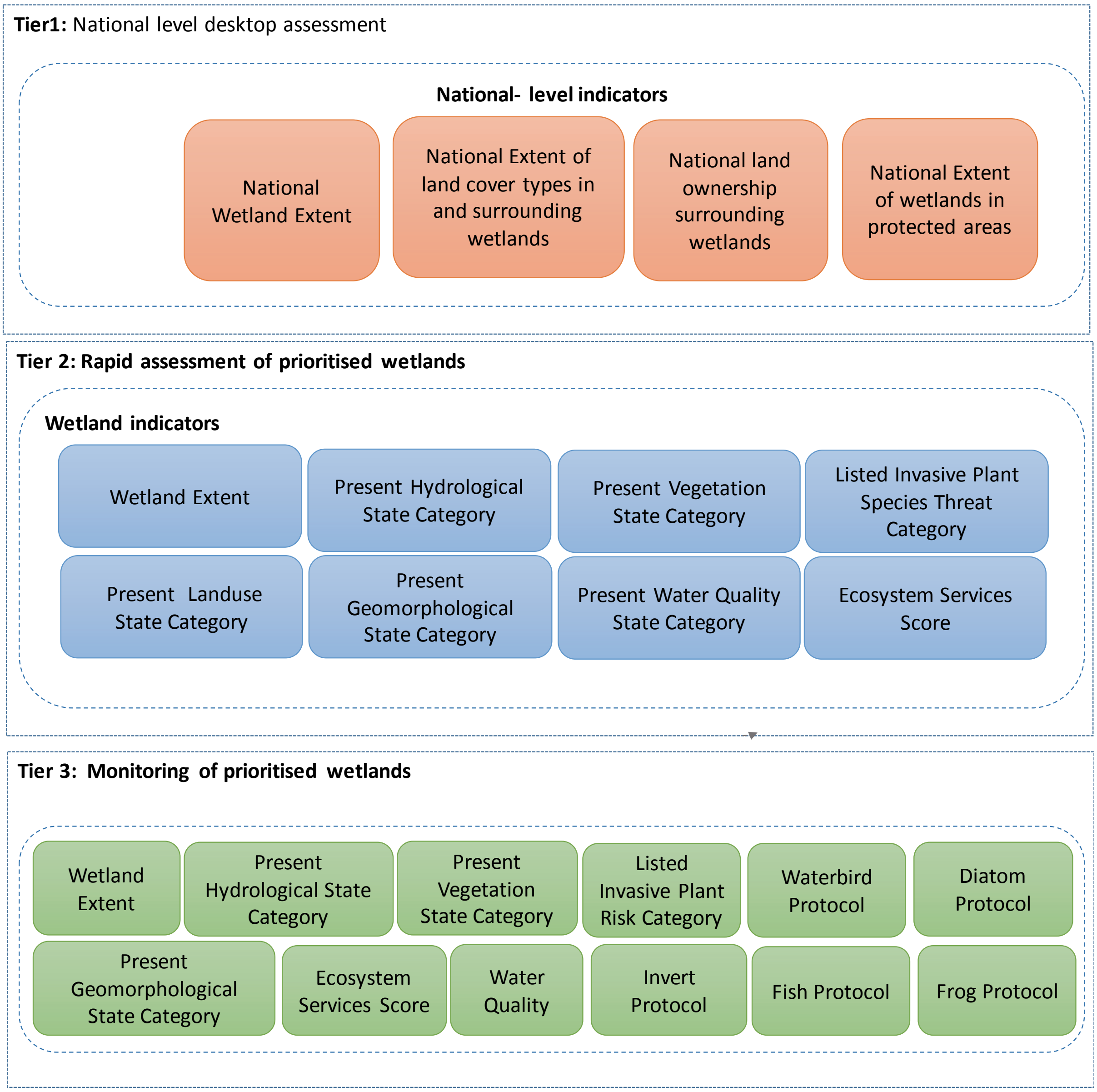


Figure 19: Indicators in each of the Tiers of the NWMP

The selected indicators include both stressor/driver and response indicators. Wetlands are subject to human activities that stress the system and degrade its condition (Fennessy et al., 2007). Stressor/driver indicators (e.g. land-use) directly affect wetland condition and function, and are reflected in a response – i.e. a change in wetland condition, such as increased cover of invasive alien plants. Methods that use stressor indicators are valuable because they provide information on the effects of the pressure on the state or use of the wetland. These indicators may also be valuable in deciding what measures might be needed to improve its state or usefulness. Note, however, that it is assumed that wetlands respond predictably to a given stressor (Fennessy et al., 2007).

The following section of the report discusses each of the indicators in the NWMP and the metadata required for measuring the indicator. Appendix C provides an indicator of indicators which were excluded from the NWMP and the reason for exclusion. There were however very limited as the selection of indicators was largely stakeholder drive.

5.6.1 Indicators selected for the NWMP

5.6.1.1 Indicators for Tier 1 – National-level Assessment of Wetland

The key purpose of Tier 1 is to report on National-level indicators using GIS and desktop assessment methods. Four National-level-level indicators are reported, namely:

- National extent of wetlands;
- National extent of land cover types in and surrounding wetlands;
- National extent of land ownership surrounding wetlands; and
- National extent of wetlands in various categories of protection

The outcome of Tier 1 will be that the NAEHMP can report, at a national scale, the extent of wetlands in the country, what land-cover types can be found in and surrounding wetlands, the categories of land ownership of the land surrounding our wetlands, and the extent of protected wetlands in the country. This tier thus places wetlands into context at a national scale, in terms of size, potential threats, accessibility and protection. These indicators largely relate to 'threats' to wetlands in the country, in that a change in the indicator demonstrates that there may be an increased or decreased 'threat' to wetlands.

An essential component of this tier of the framework is the estimate of Wetland Extent (see Section 5.1 of the NWMP Implementation Manual for description of Wetland Extent and indicator/measurement thereof).

A comprehensive 'how to' guide for the development and reporting of Tier 1 indicators are provided in Section 5 of NWMP Implementation Manual. The Implementation Manual provides details of data required, methods and procedures for report the Tier 1 indicators of the NWMP. The Section below thus only address the metadata components of the Tier 1 indicators which are NOT included in the Section 5 of the NWMP Implementation Manual.

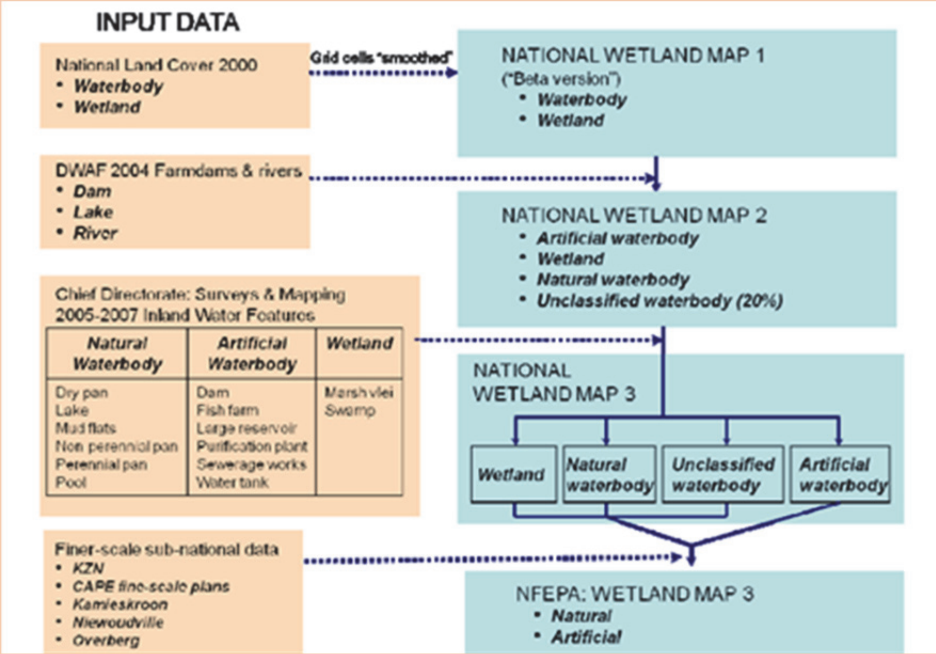
The NWMP will report each of these indicators at specific intervals, to demonstrate trends (changes) in the indicator over time.

Each of these National-level indicators is described in more detail in the section below. See Section 5 of the NWMP Implementation Manual for details of the method used to report each of the National-level level indicators.

Indicator: National extent of wetlands

Metadata	Description
Name:	Surface area of wetlands
Definition:	This indicator assesses the extent, in hectares, of wetlands in the country. The indicator could be disaggregated to report the surface area by wetland type, by ecoregion or by catchment: • total surface area of wetlands in each HGM type • total surface area of wetlands in each ecoregion • total surface area of wetlands in each catchment, etc.
Units:	Hectares
Relevance:	First and foremost, it is necessary to understand, on an ongoing basis, the extent of wetlands in the country. The extent of wetlands in turn informs wetland management, conservation, assessment and monitoring efforts. Wetland mapping is a pre-requisite for other NWMP reporting. Over time, the indicator will need to ensure that methods address the high natural variability of South Africa's wetland environments (i.e. is a change in wetland extent due to natural variability or to other impacts?) and be appropriately linked with other indicators in the NWMP, particularly those in Tiers 2 and 3.
Why was the indicator selected for the NWMP	The indicator was recommended by stakeholders-and is of relevance to wetland assessment and monitoring. It is currently measurable using standardised GIS and mapping methods; it uses data updated by SANBI on an ongoing basis; and provides a clear proxy for the state of wetlands in the country. The assumption can be made that a reduction in the extent of wetlands in the country would reflect a deterioration in the state of wetlands in the country.
Drivers and Pressures:	The major driver of change in wetland extent is change in land-use – urban expansion due to population growth and immigration to cities and towns, infrastructure developments such as roads and drainage, industrial expansion and expansion of crop cultivation and mining. Global warming is likely to lead to a reduction in wetland extent. Loss of wetland area may affect the state of the remaining wetlands, as well as reducing ecosystems services that a particular wetland would normally deliver, and negatively affecting the well-being of people who depend directly on the wetland.
Potential means of reporting the indicator	More recent literature reveals that in substantial parts of the country outright loss of wetlands is estimated to be more than 50% of the original wetland area (Driver *et al.*, 2012). Approximately 300 000 wetlands remain, making up only 2.4% of South Africa's surface area (Driver *et al.*, 2012). Trends in wetland extent will provide details on whether South Africa has had a loss or gain of wetland extent over time but these gains and losses must be assessed in a scientifically accurate manner which would address change due to improvement in data capture, technology improvement, improved methods, and new wetland area captured. One means of verification of this change over time would be report this indicator in conjunction with the indicator on the *Extent of land cover types in and surrounding wetlands in the country* – where the relative proportion of transformed land cover of wetland is reported (see next indicator in the report)

Metadata	Description
Data required:	National Wetland Inventory shapefile, taken from the SANBI Biodiversity-Geographical Information System (bGIS) website (http://bgis.sanbi.org)
Method to be used:	The method for reporting this indicator is provided in Section 5 of the NWMP Implementation Manual. The methods applied by SANBI in the development of the NFEPA wetland delineations, which underpin the NWI, included (taken from SANBI, undated). "The flow diagram below shows the data that were used to derive the NFEPA wetland delineations. SANBI's Wetland Map 1 was used as the base GIS layer. This layer was derived from the National Land Cover 2000, in which wetland polygons are described as "Wetland" or "Waterbody". The waterbody category does not distinguish between natural or artificial waterbodies. To overcome this problem, SANBI's National Wetlands Map 1 was combined with the 1:50 000 inland water features from Chief Directorate Surveys and Mapping (DLA-CDSM, 2006), to derive National Wetland Map 2 that was divided into 3 GIS layers: wetland, natural waterbody and artificial waterbody. To derive National Wetland Map 3, the wetland and natural waterbody GIS layers were combined to produce a natural waterbody GIS layer. This was then combined with the artificial waterbody GIS layer to produce the National Wetland Map 3, in which wetland polygons have been described as either "natural" or "artificial" waterbodies. Finally, existing sub-national wetland delineations from other biodiversity planning initiatives were added to the National Wetland Map 3 to derive the final NFEPA wetland map. Sub-national data included wetland delineations for: • Wetlands for the entire KwaZulu-Natal Province (available from Ezemvelo KZN Wildlife); • C.A.P.E. fine-scale biodiversity planning wetlands of Saldanha/Sandveld, Riversdale plain and Upper Breede River Valley (available from www.bgis.sanbi.org); • Overberg, Niewoudtville and Kamieskroon wetlands (available from www.bgis.sanbi.org); • Selected wetlands of conservation importance in Mpumalanga Province (available from Mpumalanga Parks and Tourism Agency). The delineations were based largely on remotely-sensed imagery and therefore did not include historic wetlands lost through drainage, ploughing and concreting. Irreversible loss of wetlands is expected to be high in some areas, such as urban centres".

Metadata	Description
	 The assumption is that a similar method will be applied by SANBI in updating the NWI in future.
Limitations:	The limitations of this indicator relate to the current limitations in the NWI and Map 1 emanating from the NFEPA project (Section 4.1 above), namely: • numerous gaps still exist in the spatial data sets of the NWI; • the minimum wetland size for Map 1 was 0.02 ha, so smaller wetlands (e.g. seeps and temporary ponds), or thin longitudinal wetlands (such as valley-bottoms) were not detected; • some National-levels facilitate better detection of wetlands via remote sensing, so gaps in spatial data sets may be higher in certain National-levels (e.g. forests) than others;
Responsibility	SANBI is responsible for managing and updated the dataset required to report this indicator. DWS and SANBI will need to facilitate an agreement on the sharing of the data. The agreement should also include the sharing of the NWMP spatial and other data with the NWI.
Frequency of reporting the indicator	5 yearly or when the NWI spatial data has been updated
Frequency of data update for the indicator	5 yearly

Indicator: National extent of land cover types in and surrounding wetlands

Metadata	Description
Name:	Land-cover in and surrounding wetlands
Definition:	This indicator reports the extent, in hectares, of various land-cover types within, and within a 100 m[13] buffer around, wetlands, using National Landcover data. See Appendix E for a literature review of buffer size around wetlands.
Units:	Hectare
Relevance:	Wetlands are the most threatened of South Africa's ecosystems, with at least 48% of wetland ecosystem types critically endangered and 65% wetland ecosystem types being endangered or vulnerable (Nel and Driver, 2012). Threats stem from anthropogenic activities such as urban expansion, agriculture, mining and forestry, and global warming. Change of land-cover within and surrounding a wetland, due to removal of natural vegetation during excavating drains, for cultivation, and for road construction, etc. can lead to widespread wetland degradation. Such degradation can result in the reduction and loss of wetland functional effectiveness and ability to deliver ecosystem services or benefits to humans and the environment (Kotze *et al.,* 2009). Depending on the kind of change, changes in land-cover can also affect the timing and amount of runoff flowing into a wetland, and the pattern and residence time of water flowing through it, affecting the hydrological "health" of wetlands (Macfarlane *et al.,* 2009). Tracking land-cover in and around wetlands is critical to conservation, management, assessment and monitoring of wetlands in the country. Furthermore, the indicator can provide guidance when making decisions related to water license applications, environmental impact assessments and other requests for land-use change.
Why was the indicator selected for the NWMP	The indicator was recommended by stakeholders and is of relevance to wetland assessment and monitoring. It is currently measurable; it uses data updated between 2000 and 2012/13 and thus can show trends; and provides a clear proxy for the state of wetlands in the country. The assumption can be made that a change in land-cover in and surrounding a wetland will reflect a deterioration in the state of wetlands in the country.
Drivers and Pressures:	Change in land-cover in and around a wetland can result in a change in the drivers of wetland geomorphology, hydrology and vegetation and therefore in wetland state and use. It is thus an indicator of pressure on wetlands.

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[13] The NWMP currently recommends a 100 m buffer zone to determine land-cover around the wetlands – this may change in future due to the current regulations for GENERAL AUTHORISATION IN TERMS OF SECTION 39 OF THE NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998) which defines the "extent of a watercourse" to include (for wetlands and pans) the area "within a 500 m radius from the boundary (temporary zone) of any wetland or pan" (when the temporary zone is not present then the seasonal zone are delineated as the wetland boundary)

Metadata	Description
Potential means of reporting the indicator	See Section 5.2 of the NWMP Implementation Manual
Data required:	See Section 5.2 of the NWMP Implementation Manual
Method to be used:	See Section 5.2 of the NWMP Implementation Manual
Limitations:	The limitations of this indicator are currently the same as those of the previous indicator. The 2012/13 Land Cover dataset does address some of the limitations found in the NFEPA project Map 2, however, and thus the NWI, in that the dataset has been derived from multi-seasonal Landsat 8 imagery. The dataset was developed using operationally proven, semi-automated modelling procedures developed specifically for the generation of this dataset, based on repeatable and standardised modelling routines (Geoterraimage, 2015). Depending on the available image acquisition dates per frame, the wetland extent in the 2012/13 land-cover dataset was modelled using either a dual- or a single-image acquisition process (Geoterraimage, 2015). The single-date approach used the best "wettest" image date, while the dual-date approach utilised the difference between wettest and driest image dates. The single (wettest) date modelling was used only when data did not provide suitable seasonal differences for the dual date, wet-dry-date approach. Both approaches generated a dataset that represented the likelihood of wetlands occurring in the National-level in order to best represent actual wetland extent (Geoterraimage, 2015).
Responsibility	The most recent land-cover map and dataset was produced by GeoTerra for the Department of Environmental Affairs and is available to the public. DWS will need to engage with the various department responsible or producing land-cover data to update this indicator in future, however.
Frequency of reporting	10 yearly – or linked to an update of the National Land-cover Map
Frequency of data update	When the National Lan-cover Map and data is updated

Indicator: National extent of land ownership surrounding wetlands

Metadata	Description
Name:	Wetland land ownership
Definition:	This indicator reports the extent, in hectares, of land ownership of wetlands throughout the country. Land ownership includes the 100 m border surrounding wetlands.
Units:	Hectares
Relevance:	This indicator reports the extent, in hectares, of wetlands in the country which are under

Metadata	Description
	various land ownership. Although not reflecting the 'state' of wetlands in the country, the indicator does reflect the state of tenure of the land on which these wetlands are located and to some extent would influence considerations in determining intervention and management of the wetlands.
Why was the indicator selected for the NWMP	The indicator was recommended by stakeholders as a proxy for the nature of management that might be achievable and required for a wetland: ownership of the land surrounding a wetland determines responsibility and to some extent what interventions might or should occur. The type of land tenure can also provide insight on what permission may be required to access a wetland during Tier 2 and 3 field assessments The indicator is currently measurable.
Drivers and Pressures:	n/a
Potential means of reporting the indicator	See Section 5.3 of the NWMP Implementation Manual
Data required:	See Section 5.3 of the NWMP Implementation Manual
Method to be used:	See Section 5.3 of the NWMP Implementation Manual
Limitations:	Limitation with the NWI dataset as outlined in the indicator related to the Extent of Wetlands in the country. There may be cost associated with the latest cadastral data for South Africa. The cadastral data has large areas of 'unknown' land ownership, particularly in urban areas.
Responsibility	The National Land Surveyor General (NLG) is responsible for management and maintenance of the cadastral data for South Africa. DWS will need to engage with the NLG to obtain the relevant dataset for updating this indicator.
Frequency of reporting the indicator	5 yearly – or linked to an update of the other National-level indicators.
Frequency of data update for the indicator	5 yearly – or linked to an update of the other National-level indicators.

Indicator: national extent of wetlands in various categories of protection

Metadata	Description
Name:	Protected wetland area
Definition:	This indicator reports the extent, in hectares, of wetlands which fall within protected areas of the country. This indicator can be disaggregated in future by the type of protection such

Metadata	Description
	as national park; nature reserve; stewardship area, etc.
Units:	Hectare
Relevance:	The indicator provides evidence of the extent of protection of wetlands in the country, as the assumption could be made that if the wetland is in a protected area it would be managed for conservation and be at low risk from changes in land ownership, land-cover and/or land use. The purpose of the National Water Act is to ensure that the nation's water resources are **protected**, used, developed, conserved and controlled in ways that take into account a range of needs and obligations. Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered (Driver et al., 2011). The indicator will provide data regarding the State's commitment to promote the establishment of a National System of Protected Wetlands as part of the protected area system (White Paper on the Conservation and Sustainable Use of Biodiversity, no. 18163 of 1997). As a member of the Convention on Biological Diversity, South Africa has also committed, in the 20 years 2008-2028, to expand the protected areas network by 10.8 million hectares. Such a move would, of course, also offer greater protection to some of the country's wetlands.
Why was the indicator selected for the NWMP	This indicator was recommended as important by stakeholders at the May 2015 workshop. The indicator has significant relevance for South Africa's commitment to the CBD and to the country's environmental imperatives. The indicator is measurable, uses current data (maintained by DEA and SANBI); and complements national, provincial and municipal wetland conservation imperatives.
Drivers and Pressures:	This is largely a response-driver indicator, since declaration of a system of protected wetlands would be a response to change in the extent of wetlands in the country. Expansion of the system of protected wetlands would be a positive driver of change and can be expected to have a positive effect on the state of wetland state and possibly usefulness.
Potential means of reporting the indicator	See Section 5.4 of the NWMP Implementation Manual
Data required:	See Section 5.4 of the NWMP Implementation Manual
Method to be used:	See Section 5.4 of the NWMP Implementation Manual
Limitations:	Limitations of the NWI dataset as outlined in the indicator related to the Extent of Wetlands in the country.
Responsibility	DEA is responsible for maintaining the protected areas network database. SANBI is responsible for maintaining the NWM DWS will need to engage with these organisations for the latest datasets to be able to report this indicator
Frequency of reporting the indicator	5 yearly – or linked to an update of the other National-level indicators
Frequency of data update for the indicator	5 yearly – or linked to an update of the other National-level indicators

5.6.1.2 *Indicators for Tier 2 – Rapid Assessment of Prioritised Wetlands*

Tier 2 is at the level of assessment of selected individual wetlands. Tier 2 requires the collection, capturing, analysis and reporting of eight indicators of the state and use of the wetlands (Figure 20).

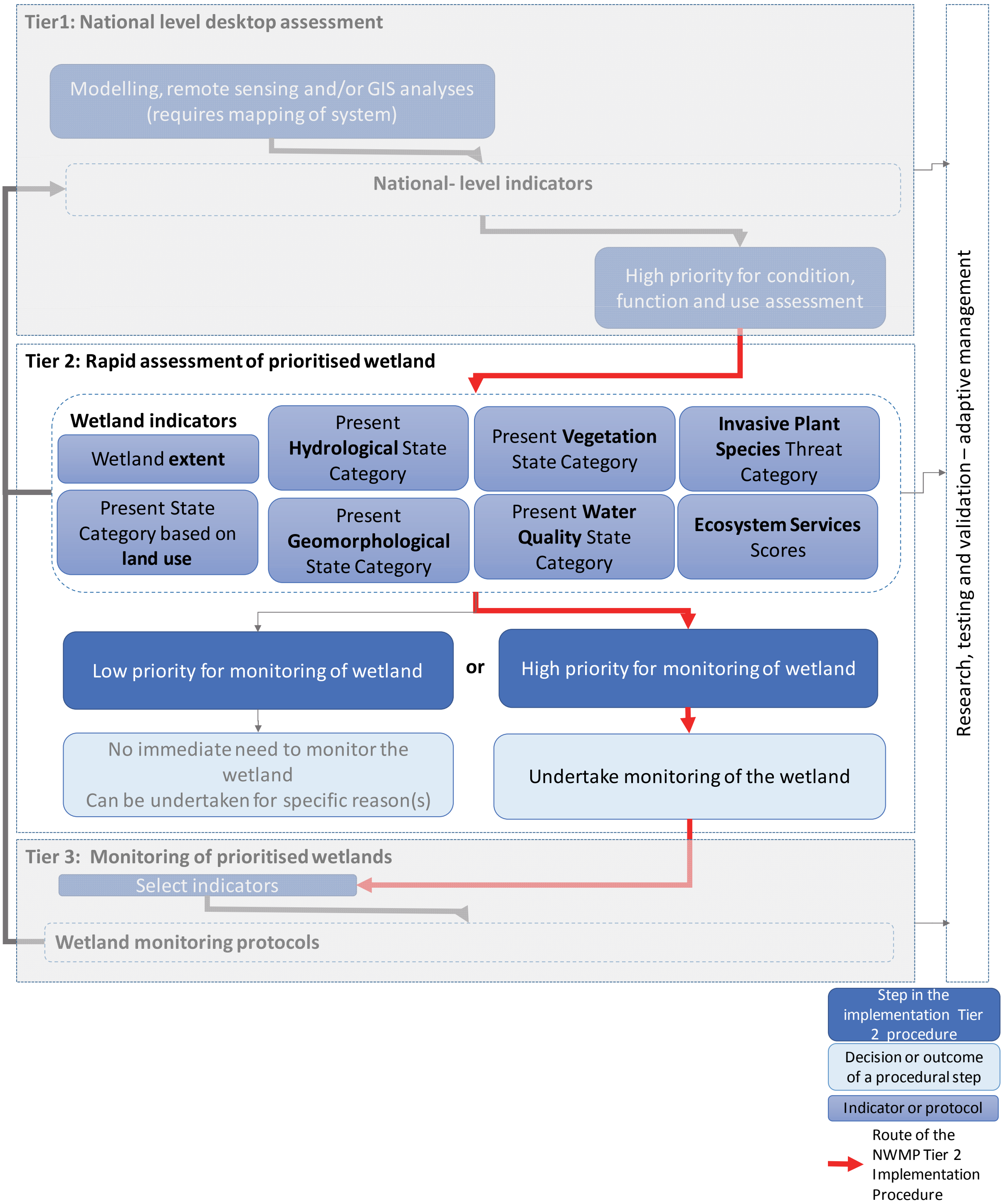


Figure 20: Process to follow to implement Tier 2 of the NWMP.

The state of a wetland is measured in the NWMP using a combination of ecological state indicators. Establishing the Present Ecological State of a wetland is a concept that is a crucial part of setting Resource Quality Objectives (RQOs) for South Africa's water resources, as required by the NWA (South Africa, 1998a; Kleynhans and Louw, 2007). Hence, estimating the Present Ecological State (PES) in the NWMP can assist in setting RQOs for water resources, while existing PES data can feed into the NWMP.

Several assessment methods have been developed in South Africa for some of the indicators to be incorporated in Tier 2 of the NWMP. The methods include:

- the **Wetland Index of Health (IHI)** (DWAF, 2007), which provides a method for estimating the Present Ecological State (for hydrology; geomorphology; vegetation and water quality) for floodplain and channelled valley bottom wetlands;
- **Level 1 WET-Health** (Macfarlane et al., 2009), which also provides a method for estimating the present state of hydrology; geomorphology and vegetation state for most wetland types;
- **Rapid Ecological Reserve Determination (RERD) Method** (Rountree *et al.,* 2013), which provides a method for estimating the present state of water quality wetlands;
- **Wet-EcoServices (Kotze et al., 2009),** which provides a method for estimating the value of ecosystem services provided by a wetland;
- **Wetlands and Wellbeing: A Decision Support System** (Kotze, 2014), which provides a decision-support system for rapidly assessing, in the context of resilient social-ecological systems, the ecosystem services provided by wetlands to the users of inland wetlands in South Africa;
- **Method for assessing wetland ecological state based on land-cover type** Kotze (2015)**,** which utilises wetland vegetation and land use to estimate a present ecological state for the wetland.

Noting that more than one method is available in South Africa for estimating the present hydrological, geomorphological, vegetation and water quality states of a wetland, Ollis & Malan (2014) have developed a Decision-Support Framework (DSF) that allows assessors to choose the most appropriate tool for a particular assessment operation. Linked to the DSF is a 'decision-support-protocol tool' (DSP tool), which includes the Excel spreadsheets that need to be completed for the rapid assessments of prioritised wetlands. The Present Ecological State indicators (i.e. hydrology; geomorphology, water quality and vegetation) in Tier 2 of the NWMP utilised the DSF to collect, capture and analyse the data for these indicators (see NWMP Implementation Manual for details). Each of the eight indicators used in Tier 2 is discussed in more detail in the section below.

Indicator: Extent of the Wetland

Metadata	Description
Short Name:	Wetland Extent
Definition:	This indicator reports the extent, in hectares, of the prioritised wetland.
Units:	Hectares
Relevance:	See Tier 1 indicator on the Extent of Wetlands in the Country
Why was the indicator selected for the NWMP	A prerequisite for assessing and monitoring of any prioritised wetland in the country is the mapping of the extent of the wetland under investigation. This indicator is selected as it is fundamental requirement of all the wetland assessment methods which have been developed in South Africa.

Metadata	Description
Drivers and Pressures:	See Tier 1 indicator on the Extent of Wetland in the Country
Data required:	A preliminary desktop map of the extent of the wetland
Method to be used:	The purpose of this step is to ensure that the wetland meets the requirements of the national definition of a wetland (see glossary for definition) and to map the prioritised wetland. The Preliminary Desktop Map is the map which was generated in Tier 1 above (See Section 5.6.1.1). The most reliable indicators of wetlands are the redoxymorphic soil features[14], which develop due to prolonged saturation of the area (DWAF, 2008a). These features can be used to indicate permanently, seasonally or temporarily inundated or saturated zones in the wetland (DWAF, 2008a). See Section 5.7 of the WRC NWMP Implementation Manual for the method for this indicator.
Limitations:	None
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS. The NWMP of DWS is responsible for storing the data and reporting on the indicator.
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

Indicator: Present Ecological State based on Land Use

Metadata	Description
Short Name:	Present Ecological State category derived from land use
Definition:	This indicator identifies present state (category A-F) based on **land use** within the wetland and its upstream catchment (Kotze et al., 2015).
Units:	Category A-F

[14] physical and chemical changes in the soil due to (1) in the case of gleying, a change from an oxidizing (aerated) to reducing (saturated, anaerobic) environment; or (2) in the case of mottling, due to switching between reducing and oxidizing conditions (especially in seasonally waterlogged wetland soils) (DWAF, 2008a).

Metadata	Description
Relevance:	This indicator estimates a Present Ecological State of the wetland based on land-use within the wetland and its upstream catchment (Kotze *et al.,* 2015). **What is landuse?** Land-use means what it says: how people use the landscape – whether for development, conservation, or mixed uses. Land-use within a wetland and in the upstream catchment can directly and indirectly affect the hydrology, geomorphology, vegetation and water quality of a wetland, resulting in changes in the PES indicators of the prioritised wetland.
Why was the indicator selected for the NWMP	This indicator was recommended by stakeholders. It is measurable using the methods provided in Kotze et al. (2015) and has relevance as a direct indicator of change in one of the key pressures on wetlands.
Drivers and Pressures:	Land-use change is a driver of change in wetlands since it can result in a change in the state of geomorphology, hydrology, vegetation and water quality, all of which can affect the wetland state and usefulness.
Data required:	Wetland delineation Wetland classification Results from the field assessment
Method to be used:	The method for determining the present state based on land use can be found in Kotze et al., (2015) *Method for assessing wetland ecological condition based on land-cover type. Part 2: The user manual.* For this indicator the detailed-map option should be applied. See Section 6.3.5 – Step 2.4.6 of the WRC NWMP Implementation Manual for the method related to this indicator.
Limitations:	According to Kotze et al. (2015) the indicator currently has the following methodological limitations: o "The method generalizes broadly about the ecological impacts associated with particular land-covers, with little account taken of the wetland's particular features, notably its hydrogeomorphic type and ecoregion. o The method also does not account for other site-specific features such as the erodibility of the soil, where for a given landuse, a site with a higher erodibility is likely to be subject to higher impacts. o Although many different land-cover types were identified to try to limit the variability within each type, it is recognized that for certain types and for certain environmental impacts the impact intensity may vary quite widely from one site to the next. o The method does not consider the degree to which the wetland is buffered (e.g. by a broad strip of intact natural vegetation around the wetland) from land-cover impacts in the wetland's upstream catchment but simply considers the extent of different land-cover types in the wetland's upstream catchment.

Metadata	Description
	o The method largely avoids the issue of explicitly defining the natural reference state of the wetland being assessed. o The method does not include point sources of pollution, o The method does not provide guidance for interpreting satellite imagery and mapping the land-cover units identified in a wetland. o Although a comprehensive list of land-cover types is included in the method, this is not exhaustive, and inevitably users of the method will encounter land-covers which do not fit well any of those listed. o The method provides inadequate detail to be used in the context of Environmental Impact Assessments, which require that due consideration be given to the wetland's biotic and hydrogeomorphic features" The method has not been extensively field-tested and may be adapted over time as field testing occurs. A number of the above limitations may be reduced as the method is applied in the field and refined.
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS. The NWMP of DWS is responsible for storing and reporting on the indicator.
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

Indicator: Present Hydrological State

Metadata	Description
Name:	Present hydrological state
Definition:	This indicator reports on the present hydrological state of a wetland, inferring that if the present state is close to the natural reference state then the hydrology of the wetland is in good order. **What is hydrology?** Wetland hydrology can be defined as the movement of both surface and sub-surface water into, through and out of a wetland (Macfarlane *et al.,* 2009). Hydrology is the driving force behind wetlands and their important processes, including waterlogging of soils, the availability of nutrients and solutes, and sediment fluxes, which in turn influence the wetland fauna and flora (Macfarlane *et al.,* 2009).

Metadata	Description
Units:	Category (A-F)
Relevance:	This indicator reports on the present hydrological state of a wetland. Hydrological condition or integrity is inferred from an analysis of catchment and/or on-site activities that have an impact on wetland hydrology (Macfarlane et al., 2009). Changes in hydrology can affect the overall structure of, and the biophysical processes taking place in, a wetland (Macfarlane et al., 2009). The hydrology of a wetland can be altered by human or natural modifications, which in turn alter the distribution and retention patterns of water within the wetland (Venter and Mitchell, 2015). Hydrological patterns can also be affected by local climate characteristics and water inflow into the wetland (Macfarlane et al., 2009). Similarly, the hydrological conditions in a wetland can affect important processes, such as the development of anaerobic conditions in the soil (waterlogging), availability of nutrients and other solutes, and sediment fluxes, all of which can influence the fauna and flora of the wetland. Reporting on this indicator is important not only for assessing the health of the wetland, but also for biodiversity conservation and for identifying wetlands that can be used as reference sites for hydrological condition. It is important to estimate the proportion of wetlands that approach a reference hydrological condition, as this would allow conservation authorities to consider conserving a representative sample of wetlands in relatively good hydrological condition (Dr D. Kotze, University of KwaZulu-Natal, *pers. comm,* 2014).
Why was the indicator selected for the NWMP	Wetlands, by definition, are characterized by three parameters: hydrology (e.g. hydroperiod, mean water depth), the presence of hydric soils, and the resulting biotic communities, particularly the presence of hydrophytic vegetation (Fennessy et al., 2007). The indicator was highly recommended by stakeholders participating in the NWMP design process. In South Africa the indicator is particularly relevant in that it is currently used in legislative processes such as Reserve Determinations, EIAs and water licensing. The indicator is measurable using standardised methods and is one of the key characteristics that affects the state, function and thus usefulness of wetlands.
Drivers and Pressures:	Drivers and pressure on the hydrology of wetlands may include (Macfarlane *et al.,* 2009) • human modifications of wetlands which affect the quantity and timing of water entering the wetland; • geomorphological modification that can alter the distribution and retention patterns of water within the wetland.
Data required:	Wetland delineation Wetland classification Results from the field assessment
Method to be used:	The overall approach to rapidly estimating the present hydrological state of a wetland is to use either the IHI or WET-Health assessment method, which quantify the impacts of human activity or clearly visible impacts on wetland hydrology, and then convert the impact scores to a Present Hydrological State score.

Metadata	Description
	See Section 6.3.5 – Step 2.4.2 of the WRC NWMP Implementation Manual for the method to ascertain this indicator.
Limitations:	• All current methods used in assessing hydrological state of a wetland have limitations (see Section 4.1). • There is currently no field assessment tool to facilitate the easy collection of data required to complete the DSP/IHI or Wet-Health worksheets, which are necessary to calculate the present hydrological state category for the wetland. • It is currently unclear whether the indicator would be sufficiently sensitive to demonstrate change in hydrological state of a wetland over time – this will only be demonstrated through repeated assessment of a wetland using the recommended methods. • It is critically important that the reference state used in each hydrological assessment of a wetland be the same, and documentation of the assumed reference state is vital for future assessments.
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS The NWMP of DWS is responsible to store the data and report the indicator
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

Indicator: Present Geomorphological State

Metadata	Description
Name:	Present geomorphological state
Definition:	This indicator reports on the category of present geomorphologic state of a wetland. Geomorphology in this context refers to the distribution and retention patterns of sediments within a wetland (Macfarlane *et al.,* 2009).
Units:	Category (A-F)
Relevance:	This indicator reports on the present geomorphologic state of the prioritised wetland. Geomorphic processes shape and control wetland structure. Wetlands are characterised by the temporary storage or net accumulation of sediment (Macfarlane *et al.,* 2008). Gullying and erosion in a wetland can lead to increases in the outputs of sediments from the wetland, which can threaten the natural structure and functioning of the wetland (Macfarlane et al., 2009).

Why was the indicator selected for the NWMP	The indicator was strongly recommended by stakeholders participating in the NWMP design process. The indicator is relevant in that it is currently used in legislative processes such as the Reserve determination, EIAs and water licensing. The indicator is measurable using standardised methods and is applicable to the NWMP framework in that it is an indicator of one of the key characteristics (i.e. geomorphology, hydrology, vegetation and water quality) of wetlands: a change in geomorphology is likely to affect state and usefulness of a wetland.
Drivers and Pressures:	A key pressure on wetland geomorphology in the southern Africa region is gully erosion (Kotze et al., 2012).
Data required:	Wetland delineation Wetland classification Results from the field assessment
Method to be used:	Like the indicator of present hydrological state, the indicator of present geomorphological state can be estimated using either the Wetland-IHI or the WET-Health method. The overall present geomorphic state can be calculated using the intensity and magnitude of erosional, depositional and organic material (Venter and Mitchell, 2015). See Section 6.3.5 – Step 2.4.3 of the WRC NWMP Implementation Manual for the method to ascertain this indicator.
Limitations:	• All current methods utilised in assessment of geomorphological state of a wetland have limitations (see Section 4.2 for more details). • There is currently no field assessment tool to facilitate the easy collection of data required to complete the DSP/IHI or Wet-Health worksheets needed to calculate the category of the present geomorphological state for a wetland. • It is currently unclear whether the indicator would be sufficiently sensitive to demonstrate change in geomorphological state of a wetland over time: this can only be demonstrated through repeated assessment of a variety of wetlands using the recommended methods. • It is critically important that the reference state used in each geomorphological assessment of the wetland should be the same. Furthermore, without documenting the reference conditions used to assess the present geomorphological state, a comparative assessment cannot be conducted in future to demonstrate change.
Responsibility	Data is collected and captured by field assessors and results submitted to the NWMP at DWS. The NWMP of DWS is responsible for storing the data and reporting on the indicator.
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

Indicator: Present Vegetation State

Metadata	Description
Name:	Present state of vegetation
Definition:	This indicator reports on the category of the present state of vegetation in a wetland.
Units:	Category (A-F)
Relevance:	The condition and characteristics of the vegetation are sensitive measures of the effects of human activities on wetland ecosystems. Furthermore, the vegetation has an important influence on wetland functioning, for instance by affecting the pattern and rate of water-flow through the wetland. In addition, the vegetation provides habitat for other taxa, including vertebrates, invertebrates and microbes. A decline in the extent of natural vegetation can potentially affect both the condition of the wetland and the ecosystem services it provides.
Why was the indicator selected for the NWMP	The indicator was strongly recommended by stakeholders participating in the design process. The indicator is relevant in that it is currently used in legislative processes such as Reserve determination, EIA and water licensing. in the country. Vegetation is measurable using standardised methods and is an indicator of one of the key characteristics of wetlands: a change in vegetation is likely to affect state, functioning and usefulness of a wetland.
Drivers and Pressures:	A wide range of driving forces may contribute to the loss of natural vegetation in wetlands. These include • conversion to cultivated lands, pastures, lawns or other introduced vegetation; • deep flooding under dams; • infilling and infrastructural development; and • direct destruction by opencast mines, urban developments and so on. Some institutional driving forces, linked to those above, include strong economic incentives for conversion of natural vegetation to agricultural land: • inadequate consideration given to the full range of ecosystem services supplied by wetlands under natural vegetation; • a lack of adequate governance systems protecting natural wetland vegetation. Driving forces that may reduce the rate of loss of natural wetland vegetation include • provision of alternative sources of income (e.g. through social grants) and • incentives (e.g. through the Forestry Stewardship Council) for maintaining and restoring natural wetland areas.
Data required:	Wetland delineation Wetland classification Results from the field assessment

Metadata	Description
Method to be used:	Like the hydrological and geomorphological indicators, the state of the vegetation can be estimated using either the Wetland-IHI or WET-Health method. The criteria used by the two methods for assessing the category of vegetation state have different focuses, with the IHI making use of land use *activities* in the wetland, while the WET-Health method is based on land-use *categories* (not activities) in the wetland. The DSP tool should be consulted when deciding which of the two methods to use. See Section 6.3.5 – Step 2.4.4 of the WRC NWMP Implementation Manual for the method to ascertain this indicator
Limitations:	See indicators of present hydrological and geomorphological state.
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS. The NWMP of DWS is responsible for storing the data and reporting on the indicator.
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

Indicator: Water Quality

Provided by Dr Jenny Day (University of Cape Town)

Metadata	Description
Name:	Water quality (WQ)
Definition:	Water quality refers to the suitability of the chemical and physical conditions in water relative to the requirements of users, who may be humans or other organisms. The idea of water quality takes into account a number of important physical properties (e.g. temperature, dissolved gases) and the concentrations of numerous substances (e.g. common salt, nutrients, toxins) dissolved in the water.
Units:	For this qualitative indictor, Category (A-F)
Relevance:	Water has attributes such as temperature, and dissolved chemical substances such as nutrients (N and P compounds) and salts, that affect the ability of living organisms to survive. For this reason, the South African NWA requires the water quality of aquatic ecosystems, including wetlands, to be assessed (Rountree *et al.,* 2013). The physical and chemical attributes of water are affected by numerous physical and chemical factors such as hydrology, the nature of the sediments of a wetland, the vegetation in and around it, its position in the landscape, and the

Metadata	Description
	climate, as well as the extent of influence ground water. In addition, water quality of wetlands is affected by human activities, particularly those that cause materials to enter a wetland. Examples include • agriculture, which increases levels of nutrients and other agrichemicals (e.g. pesticides, antibiotics, hormones); • effluents from urban areas, which include human waste or purified sewage effluents containing nutrients and numerous other chemical substances; • industrial effluents, which may contain acids or alkalis, oils and greases, or toxic by-products, and may also be saline; • mining, which produces various cocktails of chemicals, some of which are likely to be very toxic, and defunct mines, which may produce acid mine drainage; • construction activities, which may result in silt and sediment entering a wetland • extreme events such as storms and floods, which move sediments that may contain phosphates, toxic metals and pathogens. Dallas and Day (2004), Malan and Day (2012) and Day and Dallas (2014) provide a useful background to the effects of various constituents and attributes of water on wetlands and the organisms that live in them.
Why was the indicator selected for the NWMP	A change in virtually any aspect of water quality is likely to affect the condition, functioning and usefulness of a wetland. Developing an indicator of water quality was therefore strongly recommended by stakeholders participating in the design process because WQ is relevant to current legislative processes such as Reserve determinations, EIAs and granting of water licences. The indicator is measurable using standardised methods and is applicable to the NWMP framework.
Drivers and Pressures:	Water quality is affected by land-use activities in and around a wetland. One of the commonest causes of alterations in wetland condition is the introduction of the plant nutrients phosphorus (P) and nitrogen (N). Even relatively small increases in concentration of these nutrients can result in eutrophic conditions, in which algae may "bloom" uncontrollably. Day and Malan (2012) provide a useful table showing the drivers of change in key water quality variables, and their effects, in wetlands. See Table 20 below for a summary.

Table 20: Common contaminants in diffuse pollution, sources and their impacts on the aquatic environment

Pollutants	Sources	Effect on aquatic environment
Nitrogen and phosphorus ("nutrients")	agriculture: livestock (especially from feedlots) and crop cultivation (especially irrigated); commercial forestry; organic waste, sewage and purified sewage effluents; septic tanks; informal settlements; atmospheric deposition (N); wash-off from urban areas; various industrial processes	eutrophication: increased growth of algae, blue-greens and macrophytes, leading to changes in (biological) community structure
Suspended sediments	construction activities and any other disturbance of the soil surface; livestock and crop cultivation; commercial logging; wind over shallow waters; bioturbation of the sediments, for instance by bottom-feeding fishes	sedimentation encourages encroachment of vegetation; sediments may carry nutrients and toxins
Salts (increasing salinity)	crop cultivation (especially irrigated, in arid areas); mining; sewage purification	salinization, leading to changes in (biological) community structure

Metadata	Description		
	Oils and other hydrocarbons	car maintenance, disposal of waste oils; handling and storage spills; traffic emissions; wash-off from urban areas; industrial effluents	toxicity and physical oiliness
	Biodegradable organic wastes	manure from livestock (especially from feedlots) and human settlements (from informal settlements to cities); crop and forestry residues; wash-off from urban areas; sewage, soak-away and septic tanks	increased oxygen demand (may lead to fish-kills), eutrophication
	Water-borne pathogens	human excrement: wash-off from urban areas, informal settlements, failure of septic tanks and waste-water treatment plants; livestock (especially from feedlots)	health risks to humans and livestock
	Toxic metals	wash-off and effluent from urban and industrial areas; mining	toxicity
	Biocides	cultivation of crops and livestock; storage of food products; municipal and residential areas, particularly gardens	toxicity; some forms may cause disruption of endocrine systems in vertebrates
	Acids	mining (acid mine drainage); power generation (acid rain); industrial effluents	acidification of soil and water bodies; certain metals (e.g. aluminium) become toxic
Data required:	Wetland delineation Wetland classification Results from the field assessment		
Method to be used:	Estimating the PES for wetland water quality should involve measuring the chemical and physical attributes of samples of water taken from the wetland. These procedures are time-consuming and expensive, however, so proxy methods are used for a first approximation of water quality for Tier 2 assessments. Such methods are not adequate replacements for actual measurements of water quality variables and are useful *only* for rapid estimation of a water quality PES. Two proxy methods are available, namely the Wetland Index of Habitat and Integrity (W-IHI: DWAF, 2007), which is designed specifically for floodplains and channelled valley-bottom wetlands, and the Rapid Ecological Reserve Determination (RERD) Method of Rountree *et al. (*2013). The RERD was developed by Malan and *et al.,* as part of the *Manual for Rapid Ecological Reserve Determination of Inland Wetlands because* WET-Health Level 1 does not assess water quality. The RERD Method uses the spatial extent (% of total catchment area) of various land-use activities in the area surrounding the wetland to infer perturbations to water quality, and then converts impact scores for the relevant water quality constituents associated with each land-use to derive a total score for Present Water Quality Condition. See the DSP for guidance as to use of the RERD or IHI method. Note that all assessments of water quality condition in a particular programme *should use the same method* so that results are comparable. It is recommended that the assessor take water samples for analysis while conducting the rapid field assessment of any wetland. We have a very poor understanding of the direct links between each water quality constituent and the condition of a wetland, so it is necessary to start building a body of data from which the links can be examined. **Rapid field assessments (i.e. Tier 2) should include the collection of water quality data.** The magnitudes of the relevant attributes (pH, electrical conductivity, dissolved oxygen, temperature, turbidity) can be measured using standard field-based instruments. It is also extremely useful to take measurements of chlorophyll in the field using one of the newly-developed chlorophyll meters. In addition, it is strongly recommended that water samples be collected for analysis of nutrients (and perhaps other		

Metadata	Description
	variables) by the RQS laboratory of DWS. (See table 21 and also note that arrangements will need to be made with the RQS laboratory before samples are collected.) Note that in certain cases the method for assessing WQ in rivers (https://www.dwaf.gov.za/iwqs/report.aspx) is more appropriate than either the IHI or RERD. These cases are highlighted in Table 21 below.

Table 21: Recommendations for water quality sampling in wetlands (from Rountree *et al.*, 2013)

Wetland type	Method to apply (river or wetland method)	Where to sample
Floodplain	If over-bank flooding occurs less than once per year, use the rivers method. If more frequent, use the wetland methods (RERD or IHI for Tier 2 assessment)	Sample about 200 mm below the water surface, if possible, at inflow, outflow and middle of wetland
Valley bottom (with channel)	If the average width of the fringing wetland is **less than twice** the channel width, use the rivers method for the channelized section of the wetland. If more than this, use the wetland methods (RERD or IHI for Tier 2 assessment).	Sample about 200 mm below the water surface, if possible, at both inflow and outflow of wetland.
Valley bottom (without channel)	Use wetland methods	Sample about 200 mm below the water surface, if possible, at both inflow and outflow of wetland.
Seep	Currently no WQ method available. Use vegetation to assess ecological condition	Take water samples from any free-standing water
Depressions	Use wetland methods (RERD or IHI for Tier 2 assessment).	Sample free-standing exposed water, at a depth of 200 mm if possible, at the edge of the water

Limitations:

- All current methods utilised in assessment of water quality condition of a wetland have limitations (see Section 4.2).
- Wetland water quality data are limited in South Africa. In addition, the natural water quality of wetlands varies greatly from one wetland to the next, particularly in terms of certain aspects such as salinity. Understanding the significance of variations in the data, on nutrients, for example, requires the development of a long-term series of data on wetlands of different types throughout the country. This is currently not happening. Furthermore, the guidelines given in Malan and Day (2012) are preliminary and require validation.
- The current IHI and RERD methods are rough proxies for water quality and have not been validated. It is questionable, too, if any method that does not actually measure key WQ constituents will be adequate for all wetlands and all types of impairment of WQ. Furthermore, it is currently unclear whether the existing indicators are sufficiently sensitive to demonstrate a change in water quality over time; this can be demonstrated only through repeated sampling using physical and chemical methods.
- There is currently no field assessment tool for completing the DSP/IHI or RERD worksheets, which are necessary for calculating the category of "present water quality condition" for a wetland. The most detailed set of WQ data for wetlands is to be found in the database associated with the WRC-funded projects of Malan & Day (2005a, b).
- It is critically important that the same WQ reference conditions are used in each assessment of a wetland, and for all wetlands in a particular area. Without documenting the reference conditions used to assess current water quality, comparisons with future assessments will be invalid.

Metadata	Description
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS. The NWMP of DWS is responsible for storing the data and reporting on the indicator.
Frequency of reporting	After completion of the assessment of the wetland.
Frequency of data update	Annually

Indicator: Listed Invasive Plant Species Threat Score

Metadata	Description
Name:	Listed Invasive Plant Species Threat Score
Definition:	This indicator reports on the cover by and recruitment of listed invasive plant species (in according with NEM:BA) as a threat score. Listed invasive plant species should include terrestrial, and aquatic plant which are listed as invasive in NEM:BA and which are found in the prioritised wetland
Units:	Score
Relevance:	The occurrence of listed invasive alien plants in wetlands is of great relevance to the condition of a wetland in that invasive plants may out-compete the indigenous plants and in severe cases of invasion, the indigenous vegetation may be almost entirely lost. Where transpiration rates of invasive plant species are higher than those of the native vegetation, the hydrology of the wetland may be affected. And where the invasive species are less effective in binding soil than the native vegetation is (e.g. Back Wattle, *Acacia mearnsii*, compared with palmiet, *Prionum serratum*) then erosion may increase. A loss of biodiversity may also occur.
Why was the indicator selected for the NWMP	The indicator was strongly recommended by stakeholders participating in the NWMP design process. The indicator has relevance to the requirement of the NEM:BA and the Alien and Invasive Species Regulations (2014), that management authorities of all protected areas, and all organs of state (e.g. municipalities), draw up an "invasive species monitoring, control and eradication plan" for land under their control". DEA has developed guidelines for development of Invasive Species Monitoring, Control and Eradication Plans which address the legal requirements of the Act, requiring the inclusion of: (a) a detailed list and description of any listed invasive species occurring on the relevant land; (b) a description of the parts of that land that are infested with such listed invasive species; (c) an assessment of the extent of such infestation; (d) a status report on the efficacy of previous control and eradication measures. The DEA published Regulation 599 of 1 August 2014 which provides Alien and Invasive Species Lists under NEM:BA (DEA, 2014), providing lists of terrestrial and freshwater plant, mammal, bird, reptile, amphibian, microbial and freshwater fish and invertebrate species that fall within a number of different categories and are thus prohibited (DEA, 2014). The Regulations do not

Metadata	Description
	specify the habitat or geographic area in which the species would most commonly be found.
Drivers and Pressures:	Driving forces likely to have contributed to invasive plant species in wetlands include the following: • historical disturbance of wetlands, which increases their vulnerability to invasion; • inadequate measures taken to prevent the introduction and spread of alien invasive species in South Africa; and • inadequate prioritization, planning and allocation of resources to control of invasive alien plants within the quaternary catchment.
Data required:	Wetland delineation Wetland classification Results from the field assessment
Method to be used:	The method for determining listed alien invasive species in wetlands is provided in Section 6.3.5 – Step 2.4.7 of WRC NWMP Implementation Manual. The method requires the documenting of all Listed Invasive Plant Species within and 50 meters around the wetland. A 50-meter buffer zone is included because this will determine the category of each listed species
Limitations:	• The method requires refinement and testing on a large scale. • The indicator currently considers only listed alien terrestrial and aquatic plants, although the other invasive taxa may be important in some wetlands. • The current Regulation 599 lists all alien invasive species, without details of region or habitat where each species is most likely to occur. A field guide to alien invasive species which are likely to be found in wetlands, by EcoRegion, would be most useful.
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS The NWMP of DWS is responsible for storing the data and reporting on the indicator
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

Indicator: Ecosystem Services Scores

Metadata	Description
Name:	Ecosystem services scores

Metadata	Description
Definition:	This indicator provides a score (1-4) for 15 ecosystem services provided by wetlands.
Units:	Score
Relevance:	The capacity of an ecosystem to deliver different services is related to its condition. A "healthy" ecosystem may provide more, and a more sustained flow of, a variety of services compared to an ecosystem that is managed to provide a maximum amount of only one specific service, such as fish, crops or timber. **What are ecosystem services?** "Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services ("goods") such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth" (Millennium Ecosystem Assessment, 2005) Good wetland management benefits both ecosystem and human health, affecting people in all social, economic and geographic categories. As well as increasing pressures on wetlands in South Africa, there is an increasing demand for ecosystem services particularly ensuring water quality in a transformed and transforming landscape (Hay et al., 2014). Healthy wetlands provide an array of services that are used in everyday life and that reduce vulnerability, particularly of the poor, to floods, drought, crop failure and disease (Wetland International, 2008). This indicator provides information to decision-makers about those wetlands and ecoregions where ecosystem services are especially important, particularly to poor and indigent households. The indicator can identify areas where decision-makers need to consider the value of these services when considering applications to use or modify a wetland.
Why was the indicator selected for the NWMP	The value of wetlands to humans has been recommended as an indicator during almost all stakeholder engagements during the design of the NWMP. The indicator is measurable, it is thus highly relevant in a developing country such as South Africa, and it is applicable to the NWMP Framework.
Drivers and Pressures:	The major drivers of change in the provision of ecosystem services by, and state of, a wetland are increasing economic development and demographics: human encroachment into wetland areas, with environmental pressures primarily created by activities such as urbanization, mining, industrial development, etc. Activities such as cultivation of wetlands for food production are accompanied by a myriad of stressors such as pollution and eutrophication. If crop yield supported by fresh water services from a wetland s compromised due to land degradation, for instance, this in turn has a detrimental effect on the condition and wellbeing both to people dependant on particular ecosystem services, and wetland state.
Data required:	Wetland delineation Wetland classification Results from the field assessment

Metadata	Description
Method to be used:	The Wetland and Well-being Decision Support System (DSS) of Kotze (2014) is used to estimate the ecosystem services provided by a wetland. The DSS allows for a preliminary assessment of ecosystem services, inferred from the HGM type and the structural types of vegetation in the wetland (Kotze, 2014). See Section 6.3.5 – Step 2.4.8 of the WRC NWMP Implementation Manual for the methods to ascertain this indicator.
Limitations:	Kotze (2014) indicates that the current limitations of the DSS: • the system is not designed to assess the integrity (health) of a wetland or its importance for biodiversity conservation; • the system is not designed to quantify in detail the specific level of impact of a current or proposed development; • the system is not designed to provide a single overall measure of value or importance of a wetland, nor is it designed to quantify (in monetary or other terms) the benefits supplied by a wetland.
Responsibility	Data are collected and captured by field assessors and results submitted to the NWMP at DWS. The NWMP of DWS is responsible for storing the data and reporting on the indicator.
Frequency of reporting the indicators for the wetland	After completion of the assessment of the wetland.
Frequency of data update in the NWMP database	Annually

5.6.1.3 Indicators for Tier 3: Monitoring of Prioritised Wetlands

South Africa has, and will in future, have limited resources for monitoring its wetlands.

Note that sampling of Tier 3 wetlands should repeat data collection and analysis of those wetland attributes highlighted as being threatened or those issues of concern identified in the Tier 2: Rapid Assessment of the wetland.

Wetlands included in Tier 3 in the NWMP will have been prioritised for monitoring through various processes (see Section 5.5 for prioritisation process).

A primary objective of monitoring Tier 3 wetlands is to build a data set of physical, chemical and biological features of for the country as a whole. We know very little about the natural ranges of biophysical features of wetlands, let alone about the links between a change in a particular wetland attribute (such as the assemblage of frogs, fish or birds) and the change in the state of the wetland. It is necessary to build a knowledge base which will allow the wetland sector, in future, to use a change in a wetland attribute to indicate a change in the state of the wetland. A number of the Tier 3 wetlands can be considered to be Reference Wetlands, chosen specifically to record a wide variety of physical, chemical and biological attributes over time.

Wetland Monitoring Plans

Day et al., 2012 indicated that "monitoring should provide feedback to managers and conservators, allowing them to modify their activities in a suitable way. An appropriate social learning process needs to be built into the monitoring programme, to bridge the gap between the generation of monitoring results/data and action on the ground. This needs to be part of the programme right from the beginning. This critical aspect is often left out of monitoring programmes, which is why there is often no action on the ground: awareness on its own does not result in action".

It should be noted that some wetlands will be prioritised for monitoring in order to address knowledge gaps, as reference sites and to add to existing environmental data. Where monitoring is carried out for management purposes, however, a monitoring plan is crucial. Although there is no prescriptive design, a monitoring plan should adopt an adaptive management approach (see Section 4.4 of the WRC NWMP Implementation Manual for more details on adaptive management and monitoring plans).

The development and implementation of monitoring plans will generally be the responsibility of institutions such as the provincial environmental agencies (wetlands in protected and conservation areas); DEA (Ramsar sites); the private sector (corporates, commercial farmers, etc.) or organisations such as Eskom.

Deciding what to monitor

Often the Ecosystem Services score from Tier 2 can guide the selection of indicators for monitoring in Tier 3. Table 22 provides some recommendations as to which Tier 3 indicators/protocols might be chosen. If the wetland has a high score for biodiversity maintenance, for example, then indicators/protocols related to biodiversity should probably be included in the monitoring plan.

Table 22: Recommendation for indicators and/or protocols to monitor in Tier 3 wetlands based on ecosystem service scores (Tick denote which indicator/protocol should be monitored when a particular ecosystem services is provided by the wetland).

Ecosystem services supplied by wetlands					Wetland Geomorphological State	Wetland Hydrological State	Wetland Vegetation State	Wetland Water Quality State	Present State based on Land use	Listed Invasive Plant Risk Score	Ecosystem Services Scores	Water Quality Determinant Monitoring Protocols	Diatom Monitoring Protocol	Waterbird Monitoring Protocol	Invertebrate Monitoring Protocol	Fish Monitoring Protocol	Amphibian Monitoring
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits		Flood attenuation		√			√								
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits		Streamflow		√			√								
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Water quality enhancement benefits	Sediment Trapping	√				√								
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Water quality enhancement benefits	Phosphate assimilation	√	√	√	√	√			√	√				
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Water quality enhancement benefits	Nitrate assimilation		√	√	√	√			√	√				
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Water quality enhancement benefits	Toxicant assimilation		√		√	√			√	√				
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Water quality enhancement benefits	Erosion control	√		√		√								
Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits		Carbon storage		√			√								
Direct benefits	Biodiversity Maintenance[15]				√	√	√	√	√	√	√			√	√	√	√
Provisioning benefits				**Provision of water for human use**		√		√	√		√	√	√				
Provisioning benefits				Provision of harvestable resources			√		√	√	√						
Provisioning benefits				Provision of cultivated foods			√		√	√	√						
Cultural benefits				Cultural heritage					√		√						
Cultural benefits				Tourism and recreation					√		√						
Cultural benefits				Education and research					√		√						

Indicators to be considered in monitoring of wetlands in South Africa

The indicators which are currently recommended for monitoring of wetlands in the country are shown in Figure 21. Two types of monitoring components are included in NWMP wetland monitoring procedure:

Monitoring Indicators

Monitoring indicators have been selected for inclusion in the NWMP where methods are currently available, are in use, and are included as indicators for Tier 2 assessments. Repeated use of the indicators in Tier 3 wetlands, following the same processes, methods and approach outlined for Tier 2 wetlands (Section 6 of the NWMP Implementation Manual), should ensure consistency of results.

[15] *Indicators to monitor biodiversity change in a wetland will largely depend on the particular issue of biodiversity concern which will need to be monitored*

A limitation of Tier 2 indicators is that they are usually based on expert judgement and not on quantitative data. It is therefore unclear whether the methods are sufficiently sensitive to demonstrate change. This limitation can be addressed only through the implementation of more detailed monitoring components, as outlined below.

Monitoring Protocols

Monitoring protocols are included in the NWMP as future or 'potential' indicators. Stakeholders have indicated that it is important to monitor certain wetland characteristics for which indicators do not currently exist, or are untested. 'Potential indicators' demonstrate the limitations outlined by Kotze et al., (2012): "*South Africa is still a long way from using biotic indices that account for its diversity of wetland types and biota. In addition, biota can also be time consuming to describe, and require a high level of specialist input. Furthermore, once described, the biotic indices often do not indicate the nature of the human stressors that have contributed to the decline in ecological condition, and therefore provide little insight into management requirements*."

Monitoring protocols are thus provided in the NWMP as standardised approaches for collecting and analysing data for six wetland characteristics: water quality, fish, diatoms, invertebrates, birds and frogs. If a wetland monitoring plan requires information on any of these characteristics, protocols are therefore available. Ideally, over time, experts can use these data to develop biotic indices for wetland types, to demonstrate relationships between each of the biotic characteristics and Tier 2 wetland indicators, and to demonstrate relationships between these wetland characteristics and a changes in wetland state, function or usefulness.

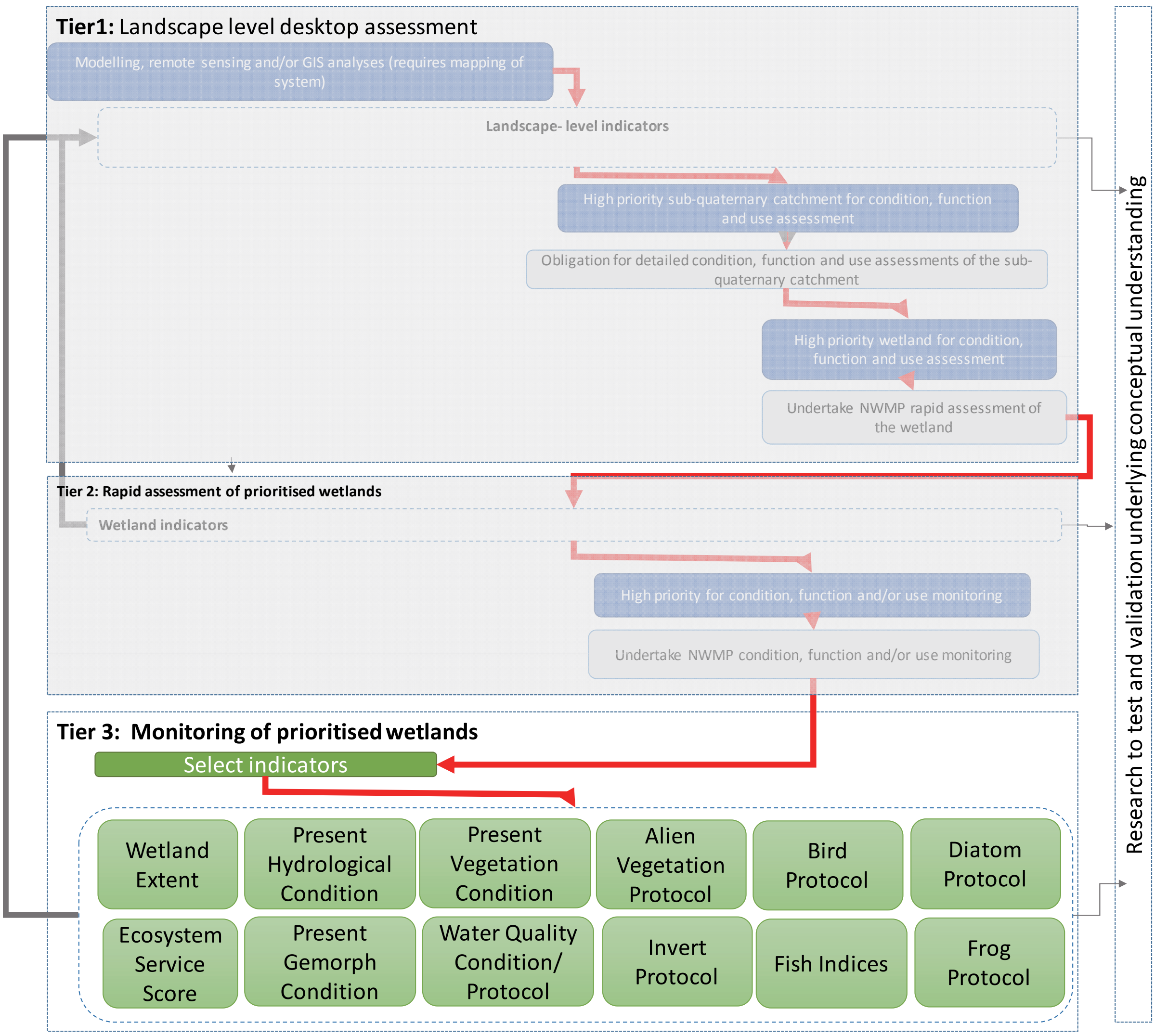


Figure 21: Indicators recommended for monitoring of wetlands in the NWMP.

5.7 DATA CAPTURE INSTRUMENTS

Since the indicators selected for inclusion in the NWMP are largely based on standardised, nationally tested methods, the assumption can be made that data-capture instruments (e.g. Excel spreadsheets) are already available for each indicator. This is not the case for all of the monitoring protocols, and some data-capturing instruments still need to be developed. Based on the above assumption, it is recommended that initially all the NWMP indicator data be collected manually, using various paper field data collection tools and templates, or electronic field sheets based on these.

Given the historical problems with timely submission of data from the field, and the large margin of error with paper data collection, it is recommended that the NWMP move, in the long-term, to adopting a system of Electronic Data Capture (EDC). Once such a system has been procured, paper formats can be converted into digital apps (e.g. using cell-phones) and all data entry, and transmission to the data storage system can be done electronically. Electronic data capture has been demonstrated to have numerous advantages over paper data collection. It should be relatively simple and inexpensive to convert paper data collection into electronic format and develop an application to capture this data.

5.8 NWMP DATA MANAGEMENT SYSTEM

5.8.1 Responsibility for the Data Management System

A crucial component of the design of the NWMP has been who will develop a data-management system (including a database), and who will manage and curate the data.

Three organisational options were considered when designing the NWMP, namely:

1. Option 1 Housed and managed at DWS, following the current RHP structure where data are collected by DWS provincial personnel during field trips, captured and stored by DWS and communicated through the State of Rivers Reports. Alternatively, data may be collected by a variety of agents but captured and housed by DWS.
2. Option 2 Housed at SANBI/SAEON with the NFEPA and National Wetland Inventory but remain the legislated responsibility of DWA. Data may still be captured in a similar manner as option 1.
3. Option 3 Housed at DEA with the Ramsar data set. DWA remain legal custodian of the data.

In fact, due to the legislative responsibility of DWS to monitor and report on the health of aquatic ecosystems in the country, legal responsibility for the management and maintenance of the NWMP will belong to DWS. This is an important decision as the organ of state with the mandate for the NWMP needs to be the lead organisation in requesting budgetary allocations from the National Treasury. The budget request should be collaborative, however, led by DWS in partnership with such organisations as DEA and SANBI, which organisations ought to play a crucial role in wetland assessment and monitoring.

The NWMP is designed on the premise that the management and maintenance of the National Wetland Inventory remains the responsibility of SANBI and the management and maintenance of the protected areas database and Ramsar wetland assessment and monitoring requirements remain with DEA.

The DWS has the opportunity to engage SAEON to manage and implement their data management system for monitoring programmes throughout the country because SAEON has the ability to manage large datasets, ensuring the security of this data while allowing access to the relevant users.

5.8.2 Format of the NWMP Data Management System

The large range of potential users of the NWMP, as demonstrated by the range of organisations involved in the wetland sub-sector, clearly indicates that there is a need for a mechanism to facilitate communication and data sharing. The NWMP data need to be easily captured and shared by a range of organisations and stakeholders. A centralized Data Management System (DMS) is thus required (DWAF, 2004). Indeed, stakeholders in the wetland sector should be able to share an IT platform related to data acquisition, data management and storage, and information generation and dissemination (e.g. assessment tools such as statistical methods, mathematical models, etc.). At least in the first phase of the implementation of the programme, the DMS must be able to accept data files prepared using standardized data templates compatible with Microsoft Excel and other spreadsheet software, and to store the data. It must also be possible download the data files and use them as needed (see Appendix D for a guide on the data field which may be needed in the database).

It should be noted that DWS has recently initiated a review and development of the database for the RHP, with the specification that a new or updated database be usable also for the Estuaries and NWMP datasets. A database is therefore likely to be available for NWMP data in the near future.

DWS personnel in the NAEHMP indicated that DWS currently makes use of a number of data management systems, including Excel-based, customised web-based, and open-source systems. The advantage and disadvantages of different types of DMS are outlined in Table 23 below..

Table 23: Advantages and disadvantage of various data management options for the NWMP (taken from http://learnitanytime.com/4031/know-the-advantages-and-disadvantages-of-microsoft-access-2/)

Data Management System	Advantages	Disadvantage
Excel-based DMS	• *Familiar and easy to use:* Excel is a tool that very familiar to users and is easy to use. Because of the average person's knowledge of Excel, it takes very little time to open a new spreadsheet, define columns, and begin entering data.	• It is difficult for external individuals to upload data • Datasheets can be modified easily and will often require locking to prevent this. • It is difficult to secure the data. • Excel has limited line numbers and cells, placing artificial limits on how data must be stored. • Having to manage data across multiple sheets is error prone. • Excel lacks version control. • Excel does not handle relational data.
Access-based DMS	• *Easy to install and use* — Access gives data managers a fully functional, relational database management system in minutes. • *Ease to integrate* – Access works well with many of the developing software programs based in Windows. It also can be used in the front-end as back-end tables with products like Microsoft SQL Server and non-Microsoft products like Oracle and Sybase. • *.NET-friendly* – Access is a go-to choice for users who plan to develop software using .NET linking to Access database. • *Widely popular* — Microsoft Access is the most popular desktop database system in the world. • *Saves you money* — Microsoft Access is hundreds of dollars more economical than other larger systems; offering the same functions and usage. • *Convenient storage capacity* – A Microsoft Access database can hold up to 2 GB of	• *Finite* – Microsoft Access is limited to storage of 2 GB of data. • *Structure Query Language (SQL)* — SQL for MS Access is not as robust as MS SQL Server or Oracle, for instance • *One file* — All the information from your database is saved into one file – limits options on data utilization; speed of reporting and queries, etc. • It is difficult to publish files apart from static files. • *Multi-user limited* — Technical limit is 255 concurrent users, but real world limit is 10 to 80 (depending on type of application).

Data Management System	Advantages	Disadvantage
	data. • *Multi-user support* – About ten users in a network can use an Access application. • *Importing data* — Microsoft Access makes it easy to import data.	
Web-based DMS	See Table 24	

Based on the above advantages and disadvantages, it is recommended that the NWMP employs a web-based DMS. However, this DMS should be open-source and not license-dependent or customised. The RHP database has demonstrated the disadvantages of using a customised system, which requires ongoing input from the developer and can become expensive.

With this in mind, a summary of the advantages and disadvantages of two of the most common means of monitoring system data storage, namely on a server or on the Cloud, is provided in Table 24.

Table 24: Advantages and disadvantages of data storage using a server and the Cloud (taken from http://www.clouddrive.com.au/download/www.clouddrive.com.au-WhitePaper.pdf)

Data storage	Advantage	Disadvantage
Cloud	✓ Cheap, virtually unlimited electronic data can be storage in remotely hosted facilities ✓ It is accessible via the internet or a Wide Area Network (WAN) ✓ Does not require specialist installation ✓ Does not require a backup and recovery system ✓ Does not require energy to power the system	✓ Performance is limited by bandwidth (WAN speeds are typically 10 to 100 times slower than LAN speeds) ✓ Availability of cloud storage is a serious issue – relies on network connectivity between the LAN and cloud data storage provider. ✓ Incompatible interface – cloud data storage providers use proprietary networking protocols which are often not compatible with normal file services on the LAN ✓ Accessing cloud data storage often requires *ad hoc* programmes to create a bridge due to difference in protocols ✓ Lack of standards – different interfaces need to be created to access different cloud data storage providers ✓ Swapping or choosing between providers is complicated as protocols are incompatible
High capacity electronic storage devices (LAN) (SAN)	✓ High-capacity electronic storage devices such as servers, Storage Area Networks (SAN) and Network Attached Storage (NAS) do provide high performance, high availability data storage accessibility	✓ Storage of large quantities of data is expensive ✓ The device is generally expensive to purchase ✓ Device generally has a limited life-span ✓ Require back-up and recovery systems ✓ Server needs to be placed in a position with particular environmental conditions, e.g. a cool, dry area ✓ Require personnel to manage ✓ Requires power to run

In effect, decisions related to data storage will often hinge on:

- ✓ the needs of the monitoring system;
- ✓ cost of the storage option;
- ✓ access to reliable internet of a sizable bandwidth;

- ✓ the data storage device(s) currently being used (e.g. as the Rivers database for RHP in South Africa).

5.8.3 Data Quality Considerations

The NWMP is all about data, its collection and its reporting in a meaningful and accurate manner. These data tell the story of wetlands in the country and highlight the threats to and pressures on our wetlands. The credibility of the NWMP rests on the quality of the data that is produced. If NWMP data is not credible, we will be unable to manage and conserve wetlands in an effective and efficient manner, and the value of the NWMP will be lost.

There are a number of ways to ensure that the data produced by the NWMP meet the quality requirements to produce scientifically credible results. Perhaps the most crucial of these is the expertise and skills of the people involved in the sustainable operation and maintenance of the NWMP, particularly the skill and expertise of the individuals who carry out field assessments and monitoring. Although, legislatively, the DWS is responsible for the NWMP, the programme is designed in a manner that private sector and other governmental institutions involved in wetland management, conservation and reporting can also contribute data to the NWMP. The skills and expertise of the wetland sector as a whole is thus crucial to the quality of data within the NWMP.

Field assessors in the NWMP should have undergone training and should be accredited in the NWMP methods, which are not new methods but rather methods which are already being applied in the wetland sector. In addition, the NWMP recommends that teams of at least 2 assessors carry out the assessment and monitoring of wetlands. A manner of minimising bias in indicator results is for the specialist (led) assessor to compare the indicator results of the two assessors and use their best judgement to determine the final indicator results, i.e. although one may assume that the led assessor would have the most accurate indicator results, the comparing of results will assist the led assessor in determining gaps/omissions in their dataset and indicators results.

One of the other means of ensuring excellent data quality in the NWMP is ensuring scientifically credible design of a method. Methods must also be repeatable (i.e. produce comparable results) under two different scenarios (DWAF, 2008):

- When different people apply the same method to the same wetland; and
- When the same person repeats the same method at the same wetland.

Linked to repeatable methods in the NWMP is the need to ensure that the Reference Condition utilised in the assessment clearly documented. This will ensure that future assessments and monitoring utilise the same reference against which to determine the indicators in the NWMP.

Data assurance can also be achieved by ensuring that specialist analysis of data is conducted by individuals and organisation which meet all proficiency requirement, i.e. laboratories that have SANS accreditation for the analysis methods.

Good record keeping is also an essential part of quality assurance. Original datasheets should be kept. Data must be collected and captured in a standardised manner using metadata fields outline for each indicator in the NWMP.

It is also vital that transcription of data from data sheets to electronic format is accurate. Back-checking of a representative sample should be done at certain intervals in the NWMP.

The manner in which data is managed and stored can also contribute to quality assurance of data. Efficient and effective management and storage of the NWMP data are an essential pre-requite for successful assessment and monitoring of wetlands in the country. Data management and storage must be standardised and follow a rigorous procedure to ensure high quality and reliable data.

With the NWMP being a public sector initiative, data quality in this programme needs to adhere to South Africa's *Data Quality Policy 001: Policy on Informing Users of Data Quality Feb 2006.* This policy defines data quality in terms of "*fitness for use*". Whether data and statistical information are fit for use depends on the intended use and on the characteristics of the data or information.

The following eight dimensions apply to data quality in the NWMP:

- The relevance of statistical information reflects the degree to which it meets the real needs of users.
- Accuracy: – the degree to which the information correctly describes the phenomena it was designed to measure.
- Timeliness: to the delay between the reference point to which the information pertains, and the date on which the information becomes available.
- Accessibility: – the ease with which they can be obtained
- Interpretability: – the ease with which users can understand statistical information through interpreting the available metadata.
- Coherence: – the degree to which it can be successfully brought together with other statistical information within a broad analytic framework and over time.
- Methodological soundness: – the application of international standards, guidelines, and agreed practices to produce statistical outputs.
- Integrity: – maintain the confidence users have in the agency producing statistics and ultimately, in the statistical product.

To ensure the quality of mapping and a standardisation of process utilised in the mapping of wetland in South Africa, the SANBI mapping guideline is utilised in the NWMP.

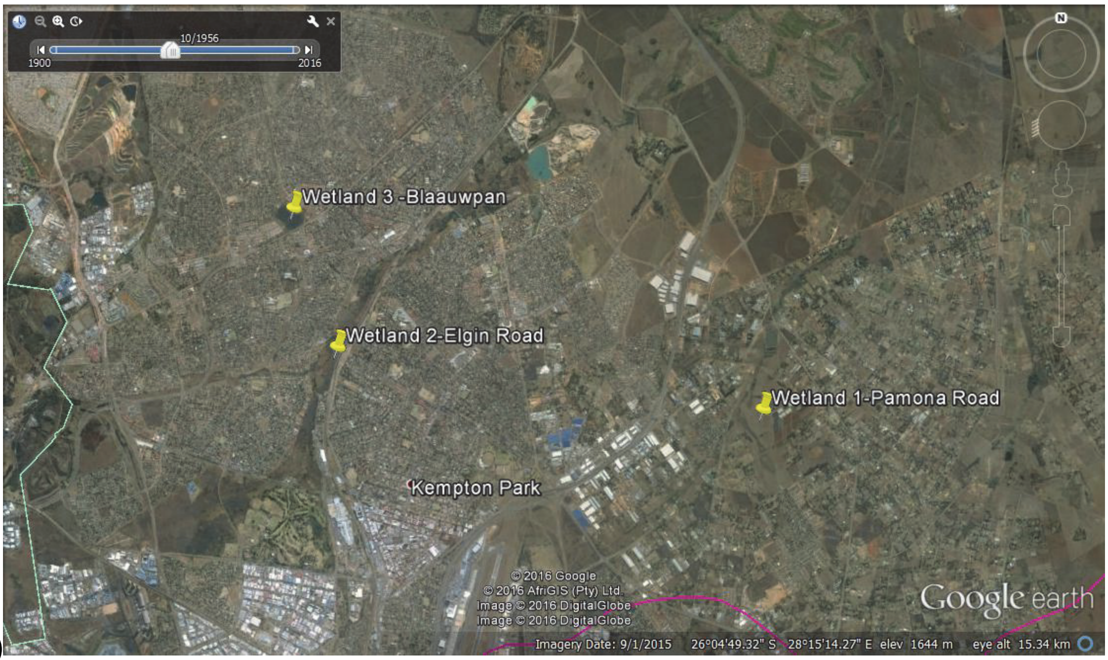
5.9 INDICATOR COMMUNICATION TOOLS WHICH DISPLAY INDICATORS IN A SIMPLE, USER-FRIENDLY MANNER

Even a well design monitoring program would have little value if the information that is collected is not utilised or does not influence the management process. The usefulness of the NWMP information has already been outlined in the previous sections of the report, including in the EIA process; for water licensing, for Reserve Determination, etc.

Only well-developed indicators can provide clear messages for communication. A well-developed set of indicators will provide a range of results which can be interpreted to generate clear messages specific to different target audiences (BIP, 2010). It is often necessary to simplify information in order to convey useful messages to a wide audience, but also maintain scientific credibility of the information.

5.9.1 Testing of the NWMP Implementation Manual (IM)

The NWMP Implementation Manual was tested in four wetlands in the Gauteng Province. The purpose of the testing was largely to determine whether it was possible to collect all the relevant data for the wetland within 4-8 hours, as envisaged in the NWMP. This section of the report provides the results of the assessment as an example of the outcomes of the NWMP reporting. The four wetlands were assigned the names, Wetland 1-Pomona Road; Wetland 2-Elgin Road; Wetland 3-Blaauwpan and Wetland 4-Blesbokspruit. Figures 22 shows the position of each wetland relative to the nearest suburb or town. A short overview of each wetland is provided below.

a) 

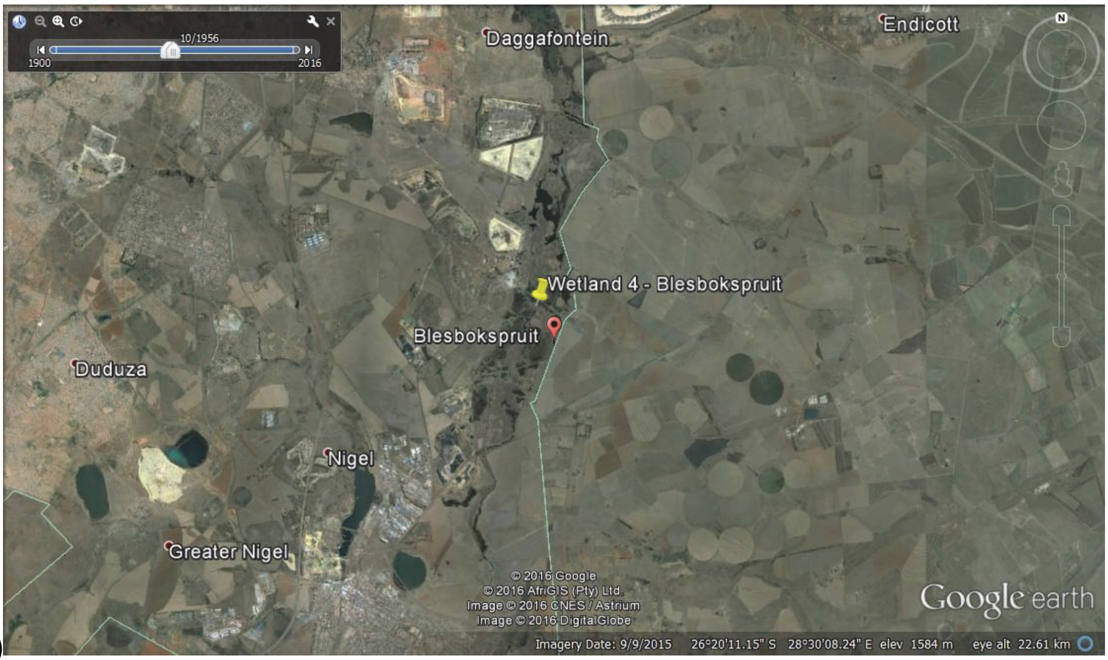
b) 

Figure 22: a) location of wetland 1-3 in the Kempton Park suburb and b) location of the Blesbokspruit near Nigel.

A short overview of each wetland is provided below.

Short Overview of Wetland 1 – Pomona Road; Wetland 2-Elgin Road and Wetland 3-Blaauwpan

All three of these wetlands were situation in Kempton Park of the Ekurhuleni Metro of Gauteng. The wetlands are situated in Drainage Region C – Vaal River which ultimately drains into the Orange River (source: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx). The wetlands are situated on the Rietvlei headwater which drains into Rietvlei Dam (Quaternary catchment A21A).

Wetland 1-Pamona Road is a channel valley bottom wetland which is situated in the Pomona Agricultural Holdings (AH). The upper catchment includes agricultural lands and the Serengeti Golf and Wildlife Estate. The wetland receives surface runoff from the urban development of the Pomona AH on the western edge and Bridle AH and Rietfontein on the eastern edge (Figure 23)

Figure 23: Location of Wetland 1-Pamona Road wetland

Wetland 2-Elgin Road is a channel valley bottom wetland situated between the Aston Manor (east) and Van Riebeeck Park (west) suburbs of Kempton Park (Figure 24). The wetland area is listed as a critical biodiversity area in the Gauteng C-Plan.

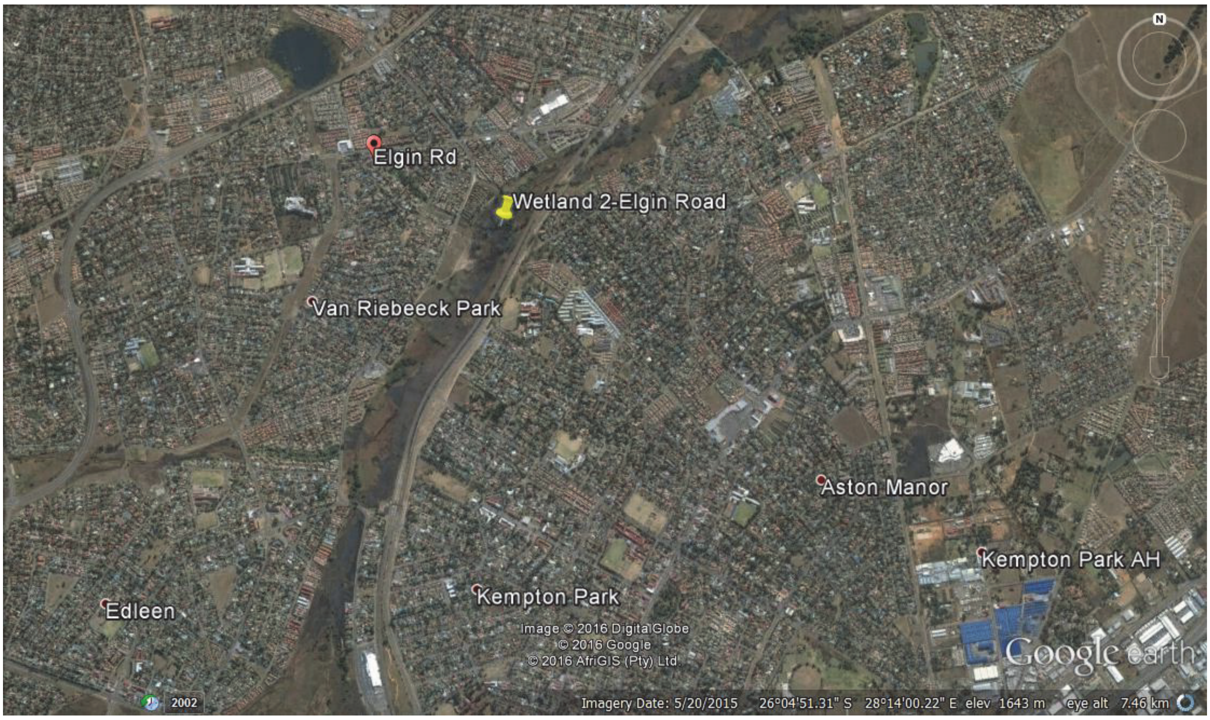


Figure **24: Location of the Elgin Road wetland**

Blaauwpan is an endorheic system situated on the Continental Divide within 400 meters of the headwaters of the Vlei which drains past Pomona, past the Serengeti Golf Estate and the Hartbeesfontein Waste Water Treatment Works (WWTW). Where the marginal buffer has been disturbed (e.g. digging for the sewer) there is a very heavy infestation of invasives, mainly blackjacks (Figure 26b). The pan receives surface runoff from the urban development immediately surrounding it although the catchment is limited. Figure 25 shows the position of the Blaauwpan wetland using Google Earth, while Figure 26 provides a picture of the wetland.

Figure 25: Blaauwpan, showing the line of manholes for the sewer that goes into the Elgin Street wetland just across the road to the North. The yellow lines is 100 m

a)b)

Figure 26: a) Blaauwpan wetland and b)complete coverage by *Azolla filiculoides* over the area that was dry when we visited it.

Short Overview of Wetland 4 -Blesbokspruit

The Blesbokspruit Ramsar area is situated in Gauteng in the Blesbokspruit River. The Ramsar area was declared as a Ramsar protected wetland in 1986 but has since been placed on the Montreaux record. The Blesbokspruit was historically mainly a meandering highveld stream with an associated floodplain (Compaan, 1995). Mining development resulted in the construction of roads and embankments that led to the formation of large areas of shallow water that led to the formation of the Blesbokspruit as it is seen today

The extent of the Blesbokspruit has been changing ever since it was first established due to mining runoff. The extent is also changing due to present impacts in terms of hydrology; however, current land use is fairly stable and not much room is available for the wetland to significantly increase the extent (Malherbe, 2016). The Ramsar Information Sheet of the Blesbokspruit indicates that it is between 1400 and 1800 ha in size (Swart, 1991) while the Gauteng C Plan (Version 3) indicates that it is approximately 2111 ha in size. Figure 27 indicates the current Ramsar boundary of the Blesbokspruit compared to the NFEPA wetlands data for wetlands in South Africa. It is evident that additional wetland habitat exists outside of the protected areas of the Ramsar boundary (Malherbe, 2016).

Regionally, NFEPA wetlands layer indicated that wetlands within Gauteng comprises around 36000 hectares, hence Blesbokspruit is relatively small in the overall picture although it fulfils an important role within the Gauteng province (Malherbe, 2016).

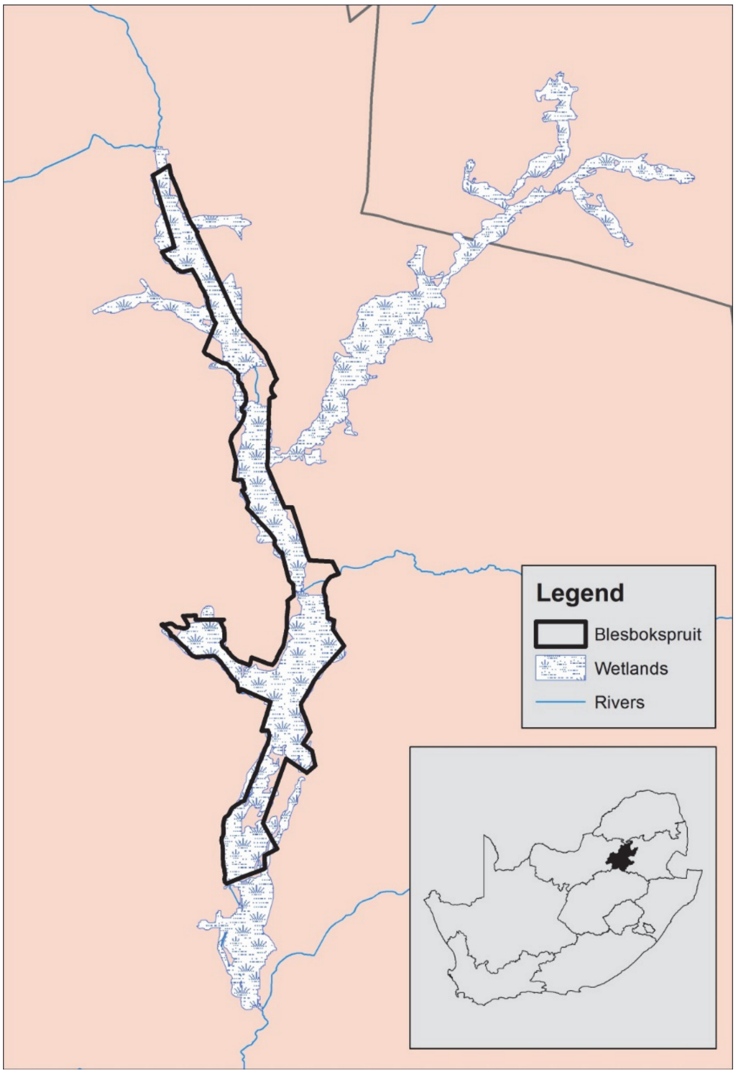


Figure 27: Map of the Blesbokspruit wetland indicating the present Ramsar boundary and the extent of wetlands in the surrounding environment.

Land cover surround Blesbokspruit is mostly mining and cultivation with small areas of natural vegetation potentially still present. Outside of the boundary of the Ramsar site some urban built-up areas also exist in close proximity of the wetland. Numerous bridges also cross the wetland at various points. 100 % of the area is covered with these land covers (Malherbe, 2016).

There are three different protected areas that can be defined for the Blesbokspruit. The majority of the wetland falls within the Ramsar protected wetland site which ensures some level of protection (Malherbe, 2016). The Marievale Nature Reserve in the south comprises 1 400 ha that are managed by the Gauteng government. The northern section is protected by the Springs Bird Sanctuary (Groot Valley Conservancy) and comprises approximately 200 ha. In between these two protected areas no other protection status apart from the Ramsar protection are present. Many sections of the wetlands are located outside of the wetland or Ramsar boundary and are thus more impacted by the surrounding community (Malherbe, 2016).

5.9.1.1 Results from testing of Tier 1 of the IM on the four wetlands

The information generated from Tier 1 of the NWMP for the four wetlands is largely background information based on GIS and other electronic data sources, and a preliminary desktop map for each of the sites (Figure 28). Table 25 shows the background data for each of the wetlands, as provided by the Tier 1 GIS and electronic data set.

Table 25: Summary of result of the Tier 2 assessment of four wetlands in the Gauteng Province (data collected using the NWMP Attributes Spreadsheet – see WRC NWMP Implementation Manual for a copy of the Attributes Spreadsheet)

	Wetland 1 - Pomona Road	Wetland 2 – Elgin Street	Wetland 3 – Blaauwpan	Wetland 4 – Blesbokspruit	source
Landownership	GDARD	GDARD	GDARD	Ramsar Site	Indicator National Extent of Land Ownership Surrounding Wetlands – Section 5.3 of the NWMP Implementation Manual
Province	GP	GP	GP	GP	Implementation Manual Attributes Table – Section 9.2.2
Closest Town	Edenvale	Edenvale	Edenvale	Nigel	Implementation Manual Attributes Table – Section 9.2.2
Municipality	City of Ekurhuleni	City of Ekurhuleni	City of Ekurhuleni	City of Ekurhuleni	Implementation Manual Attributes Table – Section 9.2.2
EcoRegion 1	Highveld	Highveld	Highveld	Highveld	https://www.dwaf.gov.za/iwqs/gis_data/ecoregions/get-ecoregions.aspx
Water Management Area	Vaal	Vaal	Vaal	Vaal	www.dwaf.gov.za
Secondary Catchment	A2	A2	A2	A2	Wet-Health GIS (available on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Wet-Health/Catchment CD*)
Quaternary catchment	A21A	A21A	A21A	A21A	Wet-Health GIS (available on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Wet-Health/Catchment CD*)
Vegetation Type	Mesic Highveld Grassland	Mesic Highveld Grassland	Mesic Highveld Grassland	Mesic Highveld Grassland	http://bgis.sanbi.org/vegmap/map.asp
Rainfall Region	Summer	Summer	Summer	Summer	

Prior to conducting the field assessment of each of the wetlands, a preliminary desktop map can be generated (see Figure 28)

Figure 28: Examples of preliminary desktop map generated from Google and GIS data in Tier 1 for (a) Wetland 1 – Pomona Road (b) Wetland 2 – Elgin Road (c) Wetland 3 – Blaauwpan and (c) Wetland 4 – Blesbokspruit

5.9.1.2 Results from testing of Tier 2 of the NWMP Implementation Manual

The NWMP requires that field assessors collect data and report on eight indicators for the Tier 2 wetlands, namely:

1. Extent of the wetland
2. HGM type(s) for the wetland
3. Reference condition utilised in the assessment
4. Present Hydrological State category (A-F) for the wetland
5. Present Geomorphological State category (A-F) for the wetland
6. Present Vegetation State category (A-F) for the wetland
7. Present Water Quality State category (A-F) for the wetland and results for pH, temp, EC and DO
8. Present Ecological State category (A-F) of the wetland based on landuse
9. Invasive Plant Species Threat Level (low-high) for the wetland
10. Ecosystem Service Scores (0-4) for the wetland

To collect the data for the above indicators, the NWMP follows a stepwise procedure for Tier 2 (shown in Figure 29)

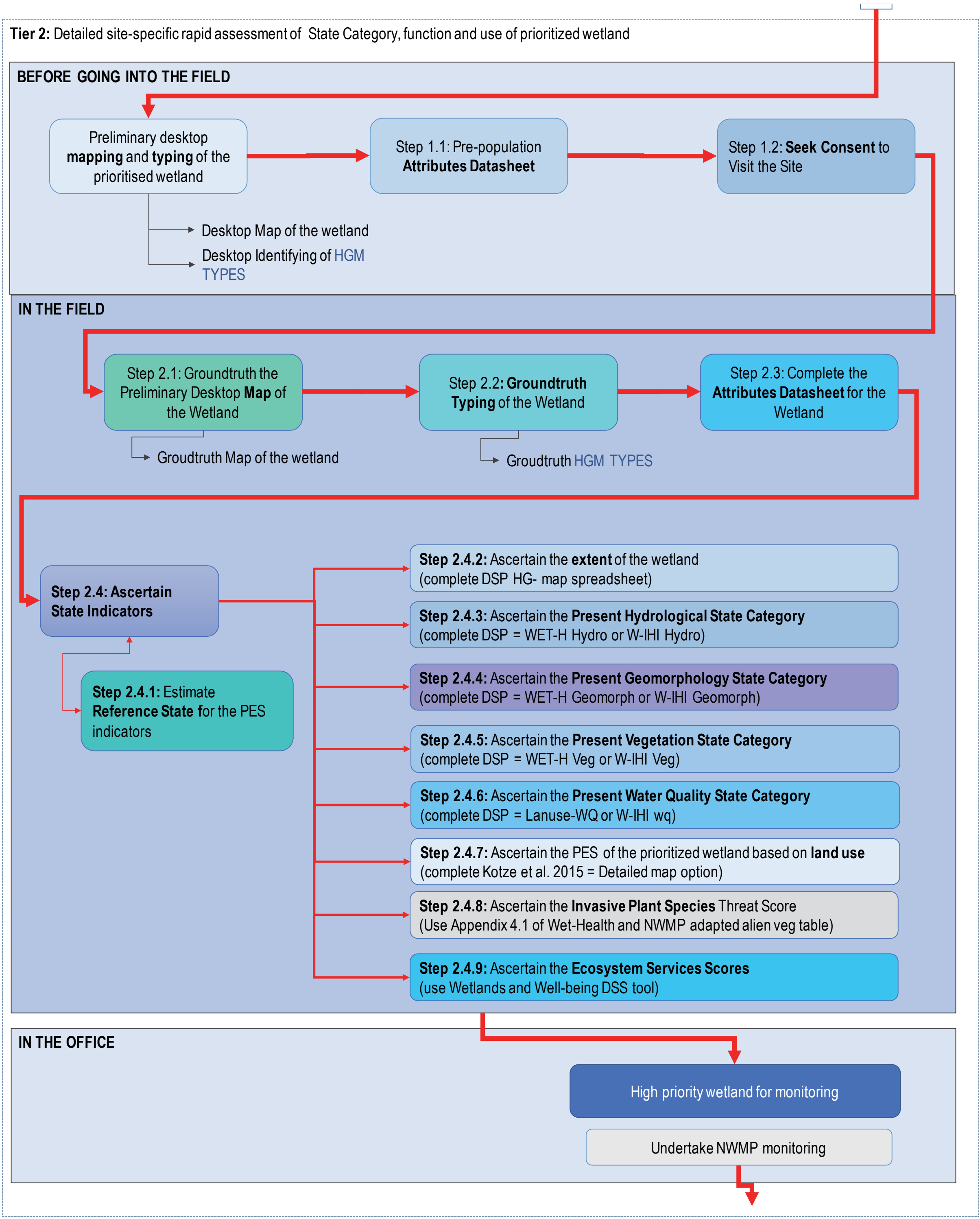


Figure 29: Stages and steps required to complete a rapid, field assessment of a prioritised wetland in Tier 2 of the NWMP.

5.9.2 Step 2.1: Ground-truthing the Preliminary Desktop Map of the Prioritised Wetland

The purpose of this step in the NWMP process is to ensure that the Tier 2 wetland meets the requirements of the national definition of a wetland (see glossary for definition) and to verify the preliminary desktop map boundaries of the wetland. The Preliminary Desktop Map is the map which was generated in Tier 1 (See Section 5.7 of the NWMP Implementation Manual).

The most reliable indicators of wetlands are the redoxymorphic soil features[16], which develop due to prolonged saturation of the area (DWAF, 2008). These features can be used to indicate permanently, seasonally or temporarily inundated or saturated zones in the wetland (DWAF, 2008). A preliminary map, (from Tier 1 – see Section 5.7 of the NWMP Implementation Manual) will be provided to the field assessor, who should use the Rapid Assessment Datasheet (Table 29 of Section 9.2.2 of the NWMP Implementation Manual), developed by Mbona et al. (2015), to rapidly ground-truth the boundaries of a wetlands. The mapped extent can be confirmed in the field by taking GPS positions points using vegetation as a guide, and taking soils samples if time allows. Table 26 provides an example of ground-truthing the extent of Wetland 1-Pomona Road wetland.

Table 26: Example of the mapping and data which should be inserted into the electronic DSP tool spreadsheet called HGM type

Use the map showing HGM Units and "assessment units" within the wetland to fill in the following table:								
Insert sketch map of wetland, showing approximate delineation of HGM Units making up the wetland and selected "assessment units"	**HGM Unit**	**HGM Type**	**Artifical system?***	**Assessment unit**	**Approximate extent (Ha)**		**Proportional extent (%) of assessment units**	
							relative to HGM Unit	**rel. to entire**
	1	**Unchannelled VB wetland**	N	**HGM 1a**	**28,0**	**28,0**	**100%**	**100%**
				HGM 1b			**%**	
				HGM 1c			**%**	
				[total must = 100%]				

Figure 1: GPS points of the boundary of the Elgin Street Wetland

Figure 2: Ground-truthed map for the Elgin Street wetland

Section 6.3.2 – *Step 2.2: Ground-truth the Type of the Prioritised Wetland*; Section 6.3.3 – *Step 2.3: Complete the Attributes Datasheet for the Wetland* and Section 6.3.4 – Step 2.4*: Assessment of the Condition Indicators* of the NWMP Implementation Manual were utilised to collect the data for the indicators:

[16] physical and chemical changes in the soil due to (1) in the case of gleying, a change from an oxidizing (aerated) to reducing (saturated, anaerobic) environment; or (2) in the case of mottling, due to switching between reducing and oxidizing conditions (especially in seasonally waterlogged wetland soils) (DWAF, 2008).

1. HGM type(s) for the wetland
2. Reference condition utilised in the assessment
3. Present Hydrological State category (A-F) for the wetland
4. Present Geomorphological State category (A-F) for the wetland
5. Present Vegetation State category (A-F) for the wetland
6. Present Water Quality State category (A-F) for the wetland and results for pH, temp, EC and DO
7. Present Ecological State category (A-F) of the wetland based on landuse
8. Invasive Plant Species Threat Level (low-high) for the wetland
9. Ecosystem Service Scores (0-4) for the wetland

Table 27 provides the results of collecting the data for these indicators at the four wetlands which were assessed during the testing of the NWMP. It should be noted that ecosystem services were assessed in the field testing using the Wet-Ecosystem Services methods, while the updated NWMP Implementation Manual recommends (after the testing) the use of the Wetlands and Well-being Decision Support System tool.

Figure 30 provides an example of how the indicator results provided in Table 27 could be communicated in a user-friendly manner to the public, i.e. web.

Name	Extent (ha)	Type	Present Hydrological State Category	Present Geomorphic State Category	Present Vegetation State Category	Present Water Quality State Category	PES Category based on Land Use	Threat Level from Listed Invasive Plants	High Value Ecosystem Services (i.e. score 4)
Pamono Road	28	Channel Valley Bottom	D	A/B	B	B	D	L	None

(a)

(b)

Name	Extent (ha)	Type	Present Hydrological State Category	Present Geomorphic State Category	Present Vegetation State Category	Present Water Quality State Category	PES Category based on Land Use	Threat Level from Listed Invasive Plants	High Value Ecosystem Services (i.e. score 4)
Elgin Road	5,3	Channel Valley Bottom	D/E	B	F	N/A	D	H	None

(c)

Name	Extent (ha)	Type	Present Hydrological State Category	Present Geomorphic State Category	Present Vegetation State Category	Present Water Quality State Category	PES Category based on Land Use	Threat Level from Listed Invasive Plants	High Value Ecosystem Services (i.e. score 4)
Blaauwpan	24	Pan	n/a	n/a	E	A	C	NONE	Seidement trapping Phosphate assimilation Nitrate assimilation Toxicant assimilation

Name	Extent (ha)	Type	Present Hydrological State Category	Present Geomorphic State Category	Present Vegetation State Category	Present Water Quality State Category	PES Category based on Land Use	Threat Level from Listed Invasive Plants	High Value Ecosystem Services (i.e. score 4)
Blesbokspruit	2111	Channel Valley Bottom	F	B	F	E	C	N/A	NONE

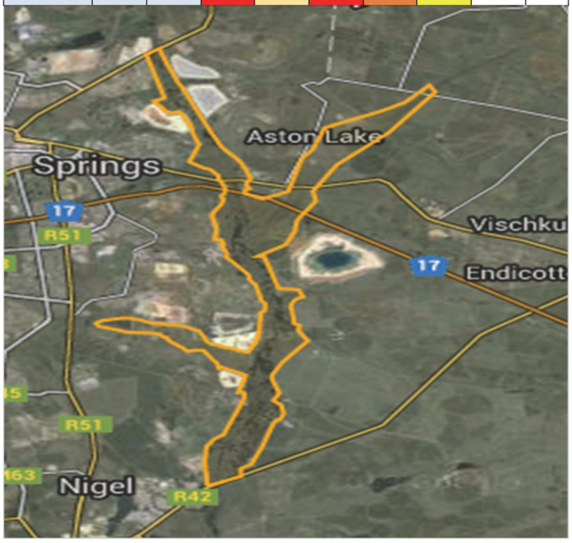
(d) 

Figure 30: Examples of reporting indicator results for NWMP Tier 2 assessment of (a) wetland 1 – Pomona Road (b) wetland 2 – Elgin Road (c) wetland 3 – Blaauwpan and (4) wetland 4 – Blesbokspruit.

Table 27: Sample of data which is collected during the field testing of the NWMP Implementation Manual

Wetland Indicator	Wetland 1 - Pomona Road	Wetland 2 – Elgin Street	Wetland 3 – Blaauwpan	Wetland 4- Blesbokspruit	SOURC	Method Used
Extent (ha)	28	5,3	24	2111	Step 2.1: Ground-truthing the Preliminary Desktop Map of the Prioritised Wetland – Section 6.3.2 of the NWMP Implementation Manual	Mbona et al. (2015)
Type	Channel Valley Bottom	Channel Valley Bottom	Pan	Channel Valley Bottom	Step 2.2: Ground-truth the Type of the Prioritised Wetland – Section 6.3.3 of the NWMP Implementation Manual	Ollis et al. (2013)
Present Hydrological State Category	D	D/E	**Neither** WET-Health nor Wetland IHI is applicable	F	Step 2.4.2: Ascertain the Present Hydrological State of the Prioritised Wetland – Section 6.3.5 of the NWMP Implementation Manual	Wet-Health in the DSP tool (Ollis et al. (2014)
Present Geomorphological State Category	A/B	B	**Neither** WET-Health nor Wetland IHI is applicable	B	Step 2.4.3: Ascertain the Present Geomorphological State of a Wetland – Section 6.3.5 of the NWMP Implementation Manual	Wet-Health in the DSP tool (Ollis et al. (2014)
Present Vegetation State Category	B	F	E	F	Step 2.4.4: Ascertain the Present Vegetation State of a Wetland – Section 6.3.5 of the NWMP Implementation Manual	Wet-Health in the DSP tool (Ollis et al. (2014)
Present Water Quality Condition Category	B	No visible water	A	E	Step 2.4.5: Ascertain the Present Water Quality State of a Wetland – Section 6.3.5 of the NWMP Implementation Manual	PERD in the DSP tool (Ollis et al. (2014)
Present Condition Category based on Land Use	D	D	C	C	Step 2.4.6: Ascertain the Present Ecological State of a Wetland based on Landuse – Section 6.3.5 of the NWMP Implementation Manual	Kotze (2015)
Listed Invasive Alien Threat Category	L	H	None	Extent limits assessment	Step 2.4.7: Ascertain the Threat posed by Listed Invasive Plant Species – Section 6.3.5 of the NWMP Implementation Manual	NWMP Method – Section 9.2.5 of the NWMP Implementation Manual
Ecosystem Service Score						
Flood attenuation	1,8	1,7	0	2,3	Step 2.4.8: Ascertain ecosystem services provided by the wetland – Section 6.3.5 of the NWMP Implementation Manual	Wet-Ecosystem Service Methods was used
Streamflow regulation	1,6	1,6	0	2,3		
Sediment trapping	3,2	2,2	4,0	1,5		
Phosphate assimilation	2,4	2,3	4,0	2,2		

Wetland Indicator	Wetland 1 - Pomona Road	Wetland 2 – Elgin Street	Wetland 3 – Blaauwpan	Wetland 4- Blesbokspruit	SOURC	Method Used
Nitrate assimilation	2,1	2,3	4,0	2,1		
Toxicant assimilation	2,6	2,1	4,0	2,6		
Erosion control	2,4	2,4	0	2,7		
Carbon storage	1,7	1,3	2,5	3,0		
Biodiversity maintenance	1,3	1,25	3,0	1,5		
Provision of water for human use	0,5	0,5	0	2,1		
Provision of harvestable resources	0	0	0	1,0		
Cultivated foods	0	0	0	1,8		
Cultural heritage	0	0	0	1,0		
Recreation	0,3	0	3,0	3,0		
Education and research	0,8	1	2,0	1,3		

5.9.3 Lessons Learnt form testing of the NWMP Implementation Manual

This section of the Implementation Manual outlines some of the lessons learnt from testing of the implementation of the manual.

Lessons learnt from the implementation of the NWMP manual have largely been included as case studies and examples in the manual. Additional lessons learnt include:

5.9.3.1 Tier 1: Issues faced through GIS Analysis

- The use of Geographic Information Systems (GIS) is integral to effective wetland assessment and monitoring. However, various drawbacks to the process have been identified. Data requirements for criteria representation are extensive which proved to introduce the following issues.
  - The nature of data required varied greatly across the sectors. This meant that data is found in a multitude of locations with a variety of processes needed to obtain it. For example, much of the biological data could be easily obtained online however cadastral data needed to be requested for and purchased.
  - The goal of obtaining the latest data exacerbated the already problematic task of searching for the appropriate data. At times the data for the specific criteria was available however it was outdated and more recent data was available through other sources.
  - Various criteria identified as integral to the process were not readily available. For example, spatial data on threatened species distribution. This data could be found but relied on already constructed databases which were vulnerable to becoming outdated (i.e. NFEPA wetland layer).
- The key issues faced during the dataset analysis and utilisation process arose from the need for technical expertise and appropriate system requirements and wetland expert knowledge.
  - The process requires technical skills appropriate for GIS operation.
  - The processing of datasets, especially for the national extent, required a computational system with a high processing capability.
  - Expert knowledge is crucial for prioritisation.

5.9.3.2 Tier 2: Rapid Field assessment of Wetland State, Function and Use

The indicators utilised in Tier 2 of the NWMP are based on methods which have largely been field-tested in the country and which are currently being utilised in many processes and activities, such as EIAs and water use licensing applications. Hence, major changes and lessons learnt in collecting, analysing and reporting these indicators were not expected. However, lessons learnt from field testing of Tier 2 of the NWMP did highlight:

- A field-guide for Listed Invasive Plants in Wetlands is required – a field guide of plants which are predominate found in wetlands, by wetland EcoRegion, would be most useful. The field guide would highlight, with photographs, the most common listed invasive plant species which can be expected to be found in the various EcoRegions of the country.
- Stakeholders, during the testing of the Implementation Manual, suggested the addition of a biodiversity indicator in Tier 2 of the NWMP. This indicator should build on the monitoring information and data collected in Tier 3 to determine an indicator or indices such as an Indices of Biological Integrity (IBI) which could be utilised in Tier 2. This biodiversity indicator could demonstrate a response of a wetland to the drivers of change, i.e. change in geomorphology, hydrology. Inclusion of such an indicator should be considered as a future indicator for inclusion in the NWMP.
- Data collection, analysis and reporting of Tier 2 level indicators requires a relatively high level of wetland assessment skills. It does not seem that it will be possible to follow the RHP process of training internal DWS personnel in the methods and then expect these personnel to carry out the assessments. Hence,

emanating out of the testing of the Implementation Manual and from discussions with DWS personnel (who have indicated a serious lack of wetland skills and capacity in the department) a number of options need to be considered in the implementation of the NWMP (See Section 6.2 for more detail)

- Testing of the manual highlighted the need for the NWMP to consider simple, electronic field sheets which can capture the data in the field, with verification and finalisation on return to the office. It is however, recommend that initially data be collected manually using various data collection tools and templates – this will facilitate for the verification and testing of field sheets before development of the electronic systems is operationalised. Given the historical problems with timely submission of data from the field, the recommendation is that the NWMP strive to adopt a system of Electronic Data Collection (EDC) as soon as possible. Once a system has been procured, the paper formats would be converted into digital apps and all data entry and transmission would be electronic. The use of applications (apps) that run on smartphones running Android 2.0+ software has been proved to be cost effective and efficient in monitoring.
- The consideration in designing data storage for the NWMP is to ensure that the data storage options compatible with other systems, now and in future.

5.9.3.3 Tier 3: Monitoring of Prioritised Wetlands

Although Tier 3 of the NWMP was not field-tested as monitoring of prioritised wetlands will be site-specific and unique to each wetland – based on the wetland monitoring plan (see Section 5.5.1 for more details) However, reviewers of the Implementation Manual did make the recommendation of inclusion, in future, of a sediment (perhaps toxicity) monitoring indicator.

6 GOVERNANCE STRUCTURE AND IMPLEMENTATION PLAN FOR THE NWMP IN SOUTH AFRICA

Day et al., 2012 recommended that *Right from the design phase of the NWMP, it is important to decide who (scientists or technicians) will be implementing the different aspects of the programme (collecting data, interpreting data, report writing, formulation and implementation of management actions, etc.).*

6.1 PROPOSED WETLAND MONITORING INSTITUTION

One of the considerations for the NWMP is the consideration of whose legal responsibility it is to monitor wetlands and what the mandates of different government departments (e.g. DWA, DAFF, DEA, provincial and local authorities) and organisations (e.g. SAEON, SANBI) are with regard to the NWMP (Day et al., 2012).

6.1.1 Partnership Implementation

Partnerships among national, provincial, local, private and NGO agencies will be imperative to ensure the success of implementing the NWMP. The public wetland sector, consisting of national DWS, CMAs and local water management institutions (whichever form these take in future) and national DEA, provincial environmental agencies and municipalities, are responsible for satisfying various wetland monitoring mandates

Overall responsibility of the NWMP lies with the Department of Water and Sanitation (DWS). DWS, CMAS and local water management institutions are mandated to monitoring the health of aquatic ecosystems in the country and thus collectively are responsible for the implementation of the NWMP at a national, regional and local level. DWS is however, the legal custodian of water resources and primary water management agency in South Africa. Its mandate as specified in the National Water Act (Act No. 36 of 1998), is to monitor water resources. The responsibilities of DWS include:

- National design and co-ordination of the NWMP;

- Development of technology and methods to support the NWMP;
- Standardisation of approved methods and techniques in the NWMP;
- Regular review of regulations, standards, methodology and accreditation requirements of the NWMP;
- Design, establishment and maintenance of the NWMP; and
- Development and maintenance of the NWMP information management systems.

However, wetlands by their structure and position in the National-level are natural resources that fall within the mandate of several government departments and within the development boundary of several mining, forestry and infrastructure operations. The varied nature of these stakeholders requires different monitoring outputs and as such would require the concerted efforts of several different government agencies and private institutions.

The Minister, in the NWA, also has the power to delegate certain powers to CMAs. One of these powers which may be delegated to CMAs should be the monitoring of aquatic ecosystems, including the assessment and monitoring of wetlands within their jurisdiction.

DEA and provincial environmental agencies have been mandated to monitor wetland biodiversity; Ramsar wetlands and wetlands in protected areas of the country. According the White Paper on Environmental Management Policy for South Africa (1998) DEA has the responsibility to provide resources for effective environmental research, monitoring and data collection in order to:

- Develop and implement wetland information management systems
- Report on the state of the environment including the state of wetlands
- Measure progress in achieving sustainable development
- Monitor environmental quality and environmental management
- Ensure that planning for sustainable development in all sectors is based on the best science and information available

DEA is thus co-custodian of the NWMP and is responsible to provide political support to the programme, strategic guidance and to co-fund certain inputs and outputs of the NWMP, i.e. RAMSAR monitoring and State-of-Wetlands Reports

There is a need for Memorandum of Understanding (MoU) between these various public institutions to facilitate the implementation of the NWMP. A MoU describes a bilateral or multilateral agreement between two or more parties. It expresses a convergence of will between the parties, indicating an intended common line of action (Wikipedia, 2014). Government departments, companies and government agencies use MoU to define a relationship between them. A signed MoU or Memorandum of Agreement between the government departments and collaborating organisations clearly defines the roles, functions and responsibilities that each department or organisation agree to undertake within the wetland monitoring sector. These MoUs can be a useful document in contributing to the successful implementation and maintenance of NWMP.

SANBI is the legal organization reporting through its Board to the Minister of Environmental Affairs via DEA. SANBI has a mandate under the National Environmental Management: Biodiversity Act (NEM: BA) (Act No 10 of 2004) to lead and manage South Africa's biodiversity. SANBI advises and informs, scientifically, DEA with respect to the biodiversity elements of environment policy, and acts as its agent in the ways stipulated in its mandate.

Municipalities, through their biodiversity/conservation spatial plans, are require to monitoring and report on critical biodiversity areas and protected areas under their jurisdiction. A key component of these plans is to inventory and report (thus monitor) wetlands within their jurisdiction.

Private sector and NGOs have an important role to play in the assessment and monitoring of wetlands in the country as these organisations, for various purposes, are utilising the various tools and reporting the indicators which are recommended in the NWMP. These data will be useful additions to the NWMP.

The private sector, including private landowners, have a crucial role to play in conserving, managing and sustainability utilising wetlands in the country. This role can be extended to monitoring wetlands under their jurisdiction – using instruments such as stewardship agreements; water licensing conditions; EIA records of decision, etc.

The contribution of NGOs to the wetland sub-sector has been significant. Partnerships with and support from these NGOs will be essential to the process of implementing the NWMP.

6.2 IMPLEMENTATION OF THE NWMP

6.2.1 Personnel

From initial discussions with NWMP stakeholders, it is envisioned that the NAEHMP personnel assume responsibility for the implementation of the NWMP. At this stage the capabilities of the NAEHMP is extremely limited with no specialist wetland expertise at a national level and limited wetland expertise in the regions. Hence, it will necessary in future for DWS to develop the capacity to implement the NWMP or to utilise innovative implementation mechanisms. The various personnel and budget Models for implementation of the NWMP are outlined below.

6.2.1.1 NWMP Management Unit

The implementation of the NWMP will require a NWMP Management Unit be set up at the NAEHMP of DWS. The recommendation is that the NWMP Management Unit be composed of a manager and two technical staff (Table 28). Due to the complex nature of wetland assessment and monitoring in the country, and the need to understand the methods which are utilised in the NWMP, it is highly recommended the manager of this NWMP Management Unit be a wetland specialist. The responsibility of the technical personnel will be to co-ordinate the programme, support the field assessors, capture data where necessary and engage with stakeholders.

Table 28. Preliminary staff requirements for the NWMP Management Unit

NWMP Management Unit			
OSD Post	**Number Required**	**Salary Notch on 1st April 2013 (Rand/annum)**	**Total (Rand/annum)**
Scientific Manager (Grade A)	1	R 607 338,00	R 607 338,00
Scientific Technician (Production) (Grade A)	2	R 206 844,00	R 413 688,00
Sub-total	**R**		**1 021 026,00**

6.2.1.2 Tier 1 Staffing Requirements

The successful development and implementation of Tier 1 of the NWMP can be seen as the bedrock on which developmental decisions regarding wetlands can be made. The current National Wetland Inventory housed and populated by SANBI is a crucially important component and can also be considered as an integral component of the final NWMP.

The implementation of Tier 1-National-level Assessment of NWMP can be undertaken by the NWMP management unit at the DWS. The responsibility of the consolidation of the meta-database for Tier 1 would thus be the responsibility of this management unit. A suite of other organisation will need to provide crucial input into the Tier of the NWMP, including SANBI; NLG and DEA.

The initial timeframes envisioned for the first reporting of Tier 1 of the NWMP would be one year. Indicators in this tier of the NWMP can be reported immediately by the personnel and other resources are available for the NWMP. The personnel required to report the indicators in Tier 1 will require GIS and mapping expertise. The envisaged personnel cost to implement Tier 1 of the NWMP is just over R 200 000 per annum.

It should be noted that the GIS and mapping database linked to the NWMP will require technology with significant memory capacity and the ability to process large amounts of data at a relatively high speed. Specification for such technology may include:

- RAM: for GIS software such as ArcGIS software at least 8GB of RAM but preferably 16GB or higher is required.
- CPU Speed: GIS software systems recommend at least "2.2 GHz minimum; Hyper-threading (HHT) or Multi-core".
- Hard Drive Storage: – large geographic area or are using high resolution satellite imagery require 1GB or larger.
- 64-bit Processing: at least a 64-bit operating system is required.
- Graphics Card: for 3D GIS work a graphic card capable of handling 3D display is required.

Software such as ArcGIS would also be required.

6.2.1.3 Tier 2 Rapid Assessment and Tier 3 Monitoring of Prioritised Wetland

The second level of wetland data and information required for the NWMP is that of a wetland assessment. The NWMP Tier 2 Rapid Assessment of a wetland has been designed to be conducted by 2 individuals collecting data in the field within a 4-hour period, an addition 4 hours for pre-field visit preparation and 4 hours' post-field visit to capture and analyse the indicator data in the office – hence a total of a 2 day to report the indicators for a prioritised wetland.

The assumption is also made that the assessment of a prioritised wetland will be conducted by assessors which are situated in the province/Ecoregion/catchment area in which the wetland is situated. Hence travel would not include any air travel and will not take more than 3 hours to reach a site (i.e. 6 hours for return travel).

It is highly recommended, like other assessment in DWS (i.e. Blue Drop; Green Drop; No Drop), that the entire national Tier 2 wetland assessment team meet on an annual basis to refresh their knowledge and expertise in conducting the NWMP assessments.

The assumption is also made that the individuals conducting the rapid assessment of a prioritised wetland will be skilled in the methods which are utilised to collect and capture the indicator data. The requirement will be that:

1. The assessor will be certified in the various methods from one of the accredited courses which are offered in South Africa (See Section 6.2.2)
2. At least one of the assessors will have completed at least 5 assessments utilising the methods recommended for Tier 2
3. Assessors will have been certified, during the national NWMP assessment workshop held annual, on the NWMP assessment process (i.e. Blue Drop and Green Drop assessors have to qualify as assurors by writing an exam at the end of the training workshop – the NWMP should consider a similar requirement of their assessors).

Tier 2 monitoring is estimated as take individuals two days per annum per wetland.

The assumption is made that the NWMP could reasonably be able to conduct Tier 2 rapid assessment of 40 prioritised wetlands per annum and monitoring of 10 wetlands per year. This number is a number which was suggested in the May 2015 NWMP workshop, based on the RHP experience. It should be noted that this number is only provided as a guide, and would not limit the number of wetland assessments and monitoring which would occur in a year. These number were effectively being determine by resources, human and financial, available for the implementation of the NWMP. The more resources available, the greater the number of wetlands which can be assessed and monitored. The personnel and budget estimated outline in the section below is however, based on 40 wetland assessments and 10 monitored wetlands per annum (note, the number of wetlands being monitored will increase annually).

Based on the criteria and assumptions outlined above, 3 Models are provided for the personnel structure and costing for the implementation of Tier 2 and Tier 3 of the NWMP. If should be noted that all three Models assume the existence of a NWMP Management Unit (See Section 6.2.1.1) and the Tier 1 personnel requirements and costs. The 3 Models provided are:

- The RHP Aligned Model
- The DWS Capacity Development Model
- The Specialist Model

6.2.1.4 RHP Aligned Model

In this Model, the Tier 2 rapid assessments and the Tier 3 monitoring are conducted by DWS national and provincial personnel. All personnel are thus DWS staff and fall under the DWS salary bill.

Advantage of this Model

- DWS assumes responsibility for the personnel, hence personnel salaries are allocated on an annual basis from the DWS personnel budget.
- Lines of reporting are clear and personnel management is a direct responsibility of DWS
- DWS will (over time) build wetland assessment and monitoring capacity.

Disadvantage of this Model

- DWS will have to go through an extensive process of recruiting relevant personnel which can be costly, extremely time-consuming and constrained by internal processes and constraints
- DWS will have to spend extensive financial resources to source wetland assessment and monitoring training for these individuals
- The assessors within the programme will require time to build their experience in wetland assessment – this may also be difficult to do without internal wetland assessment specialist (hence the need for the NWMP Management Unit manage to be a wetland specialist)
- Turn-over of staff within the programme would require the repeating of the bullets above to ensure qualified assessors in the NWMP
- Specialist monitoring skills may not be available as DWS personnel may not have all the skills require to monitoring the wide range of wetland indicators, across all the wetland types in the country.

The personnel cost of this Model for the NWMP, shown in Table 29, is estimated to be just under R5 million.

Table 29: Personnel and Professional costs associated with the RHP Aligned Model for the NWMP

OSD Post	Number Required	Salary Notch on 1st April 2013 (Rand/annum)	Total (Rand/annum)
NWMP Management Unit			
Scientific Manager (Grade A)	1	R 607 338,00	R 607 338,00
Scientific Technician (Production) (Grade A)	2	R 206 844,00	R 413 688,00
Sub-total			**R 1 021 026,00**
Tier 1 National-level Assessment			
GIS Technician (Production) (Grade A)	1	R 206 844,00	R 206 844,00
Sub-total			**R 206 844,00**
Tier 2: RHP Aligned Model (DWS Staff Only)			
Scientific Technician (Production) (Grade A)	2/province	R 206 844,00	R 3 723 192,00
Sub-total			**R3 723 192,00**
Tier 3: RHP Aligned Model (DWS Staff Only)			
No additional requirements as the assumption is that the Scientific Technicians will perform this function			
ANNAUL COST OF NWMP (DWS personnel)			**R4 951 062,00**

6.2.1.5 DWS Capacity Building Model

In this Model, the Tier 2 rapid assessment and Tier 3 monitoring of prioritised wetlands will follow the model used by other DWS programmes such as the Blue Drop; Green Drop and No Drop. In these models, assessor teams are a combination of DWS personnel and external consulting specialists. The model requires that at least one of the assessors, referred to as the Lead Assessor, is a specialist in the field of wetland assessment. The role of the Lead Assessor is to manage the rapid assessment and monitoring of the prioritise wetland, as well as to assist with the building of the capacity of the other assessor.

Advantage of this Model

- DWS salary cost will be lower.
- DWS will (over time) build highly skilled wetland assessment and monitoring capacity, through in-field training and capacity building by wetland assessment specialist
- Wetland assessment and monitoring will be led by wetland specialists, who will also be familiar with the wetlands in the assessment area, i.e. specialist familiar with the provincial/Ecoregion/catchment wetlands should be utilised
- Loss of personnel, due to normal staff-turnover will have less of an impact on the programme, as compared to the RHP Align Model.
- Tier 3 monitoring can utilises wetland specialists to address the specification of the monitoring plan which needs to be developed for the wetland, i.e. if the focus of monitoring is water quality, a wetland water quality specialist can be contracted to led the monitoring efforts.

Disadvantage of this Model

- DWS will still need to recruit relevant personnel which can be costly, extremely time-consuming and constrained by internal processes and constraints. However, fewer personnel will be require when compared to the RHP Align Model.
- DWS will still need to allocate financial resources for wetland assessment and monitoring training for these individuals. However, training costs will be lower as compared to the RHP Align Model.
- DWS will, on an annual basis, have to source funding to contract external consulting experts
- DWS will expend extensive time on contract management – however this may also be an advantage as less time is spent on ongoing management of personnel.
- The cost of this Model will be higher than that of the RHP Aligned Model

The cost of this Model, shown in Table 30, is estimated to be in the region of R 8,63 million.

Table 30: Personnel and Professional costs associated with the DWS Capacity Building Model for the NWMP

NWMP Management Unit			
OSD Post	Number Required	Salary Notch on 1st April 2013 (Rand/annum)	Total (Rand/annum)
Scientific Manager (Grade A)	1	R607 338,00	R 607 338,00
Scientific Technician (Production) (Grade A)	2	R206 844,00	R 413 688,00
Sub-total			**R 1 021 026,00**
Tier 1 National-level Assessment			
GIS Technician (Production) (Grade A)	1	R 206 844,00	R 206 844,00
Sub-total			**R 206 844,00**
Tier 2: DWS Capacity Building Model (DWS Staff + External Consulting Specialist)			
Scientific Technician (Production) (Grade A)	1/province	R 206 844,00	R 206 844,00
Consulting Specialist	1/province		R 5 760 000,00
Sub-total			**R5 966 844,00**
Tier 2: DWS Capacity Building Model (DWS Staff + External Consulting Specialist)			
Consulting Specialist	1/province		R 1 440 000,00
Sub-total			**R 1 440 000,00**
ANNAUL COST OF NWMP (DWS personnel and professions fees)			**R 8 634 714,00**

6.2.1.6 *Specialist Model*

In this Model all the Tier 2 wetland assessments and Tier 3 monitoring is conducted by wetland specialists based in the region (province; EcoRegion; catchment) within which the wetland is found.

Advantage of this Model

- DWS salary cost is lower than the other two Models.
- Wetland assessment and monitoring will be led by wetland specialists, who will also be familiar with the wetlands in the assessment area, i.e. specialist familiar with the provincial/Ecoregion/catchment wetlands should be utilised. Assessment and monitoring should thus have greater accuracy.
- Staff turn-over at DWS will have limited impact on the implementation of the NWMP.
- Tier 3 monitoring can utilises wetland specialists to address the specification of the monitoring plan which needs to be developed for the wetland, i.e. if the focus of monitoring is water quality, a wetland water quality specialist can be contracted to led the monitoring efforts.

Disadvantage of this Model

- DWS will not be building internal wetland assessment and monitoring capacity.
- The cost of this Model is significantly higher than the other two Model (i.e. greater precision in the NWMP has a cost associated with it)
- DWS will need to focus resources on contract management, which is not usually a strength of the organisation. The DWS procurement and contracting process can have a significant impact on the NWMP as these processes, while extremely necessary, are often slow and laborious. The other assessment programmes in the department outsource the management responsibility to an Implementing Agent, which has an additional cost.

The cost of this option, shown in Table 31, is estimated to be in the region of R 15,62 million.

Table 31: Personnel and Professional costs associated with the Specialist Model for the NWMP

NWMP Management Unit			
OSD Post	**Number Required**	**Salary Notch on 1st April 2013 (Rand/annum)**	**Total (Rand/annum)**
Scientific Manager (Grade A)	1	R607 338,00	R 607 338,00
Scientific Technician (Production) (Grade A)	2	R206 844,00	R 413 688,00
Sub-total			**R 1 021 026,00**
Tier 1 National-level Assessment			
GIS Technician (Production) (Grade A)	1	R206 844,00	R 206 844,00
Sub-total			**R 206 844,00**
Tier 2: Specialist Model (External Consulting Specialist)			
Consulting Specialist	2/prov		R 11 520 000,00
Sub-total			**R11 520 000, 00**
Tier 3: Specialist Model (External Consulting Specialist)			
Consulting Specialist	2/pro		R 2 880 000,00
Sub-total			**R 2 880 000,00**
ANNAUL COST OF NWMP (DWS personnel and professions fees)			**R 15 627 870,00**

6.2.1.7 Implementation of Personnel and Budget Models.

Based on the 3 Models outline above and the need to urgently initiate wetland assessment and monitoring in the country, it is recommended that the NWMP is implemented in a phase manner using the 3 Models outline above (Figure 31).

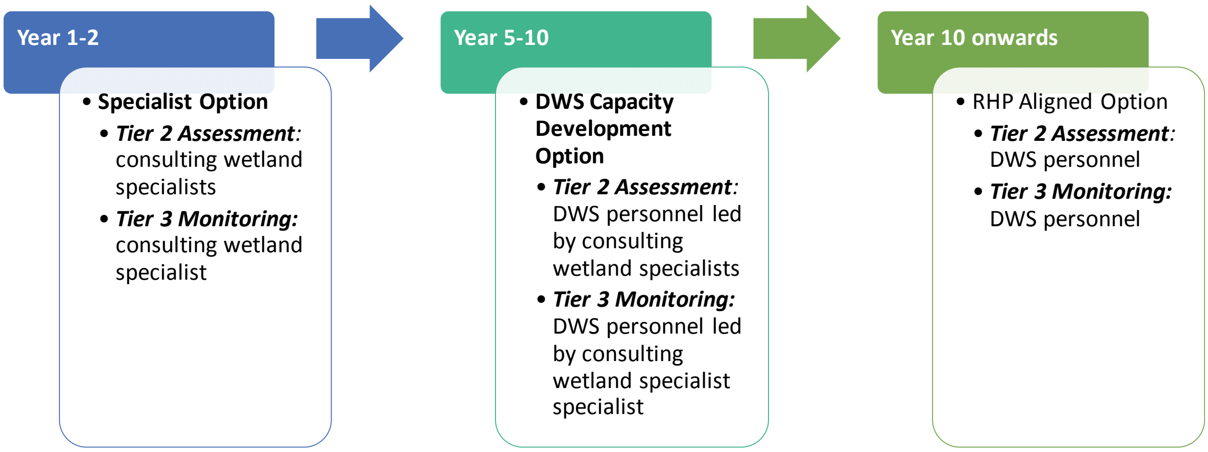


Figure 31: Recommended resource Models for the implementation of the NWMP.

The programme could in the initial stages of implement, apply the Specialist Model in conducting the Tier 2 assessments and Tier 3 monitoring. This will allow the programme to be rapidly initiated and will ensure that specialists wetland assessors are involved in conducting the first rounds of assessments and monitoring. This will also ensure that precision, skills and capacity would not be a limitation to the first phase of implementation of the NWMP. Implementation in this manner will also provide DWS the time to source and appoint the wetland personnel requires to sustainably operate and maintain the NWMP.

Once the NWMP Management Unit and other personnel have been appointed, the Tier 2 assessments and Tier 3 monitoring could be conducted utilising the DWS Capacity Development Model. This Model supports the capacity development of DWS assessor.

If the DWS develops a highly specialist team of assessors in sufficient numbers during phase 2 of implementation, the department may choose to apply the RHP Align Model in conducting the Tier 2 assessment and Tier 3 monitoring.

6.2.2 Capacity Development for the Implementation of the NWMP

The OECD (2006) defines capacity development as the *process whereby people, organisations and society as a whole unlock, strengthen, create, adapt and maintain capacity over time*. There are various levels of capacity development required to implement the NWMP.

6.2.2.1 Individual Capacity Development

The NWMP implementation requires assessors which have extensive knowledge of South Africa's wetland and the wetland assessment methods which are currently utilised in the country. It is not sufficient for an assessor to have attended a wetland assessment and monitoring course. They will need to be experienced in actually utilising these methods in the field, preferably with the support of a wetland assessment specialist. Section 6.2.1 above provides an implementation Model, the DWS Capacity Building Model, for the building of DWS internal capacity to conduct the Tier 2 and Tier 3 assessment and monitoring of prioritised wetlands in the NWMP. This Model would require three capacity development activities for DWS assessors included in the NWMP:

- The assessor will need to have attended and been certified in the assessment methods which are utilised in the NWMP Tier 2 Assessment;
- The assessor will need to have been accompanied by a wetland assessment specialist in the first 5 field assessment they conduct for the NWMP

- The assessor will need to have passed the NWMP test which is conducted at the annual NWMP method and process workshop

Wetland Consulting Specialists and DWS Professionals which are chosen to lead assessors in the NWMP will require certain credential. There are three basic qualifications that environmental professionals must exhibit:

1. A degree or diploma in the field of biology, zoology, environmental science or ecology, or a Masters or Doctorate degree in one of these fields.
   a) Ecological knowledge of the wetlands for the areas to be assessed, including proven professional work experience in these wetlands, or
2. A minimum of one certification or registration – SACNASP certification is a pre-requisite

6.2.2.2 Organisational capacity development

The NWMP is designed to be implemented through partnerships between the various organisation with the wetland sector. There is already extensive wetland capacity and skills in the sector, which should be acknowledge and utilised in the implementation process. Organisation which will need to consider developing wetland assessment and monitoring capacity, as ring-fencing resources for this purpose, include:

1. DWS: the department will need to develop a capacity development plan to build the NWMP Management Unit as well as to ensure the correct capacity and skills to implement the 3 Tiers of the NWMP. The DWS should however focus, if they choose to build the internal capacity, on developing capacity for implementation of Tier 1 and Tier 2 of the programme. Tier 3 specialist's expertise should be drawn from the various other organisations involved in the wetland sector, particularly from NGO specialist programme such as CWAC and WWF; from research organisation such as SANBI (invasive species programme) and CSIR (conservation planning) and from private sector (specialist of wetland characteristics). Capacity which would be required include:
   a. GIS and mapping
   b. Wetland research
   c. Wetland assessment and monitoring methods
   d. Fieldwork and data capture
   e. Stakeholder engagement
2. DEA: the department will need to develop a capacity development plan, particularly focussed on monitoring (Tier 3) and assessment (Tier 2) of protected and conservation areas and Ramsar sites. Capacity development should focus on development of the provincial agencies expertise and skills – the provincial environmental agencies have an important role to play in the NWMP
3. SANBI: the parastatal needs to ensure that the capacity is available to manage and maintain the NWI.
4. NGOs and private sector: participation of NGOs in the NWMP is important, particularly in their role of specialist monitoring in Tier 3. Experience has demonstrated however, that NGOs and private sector, when recognising a capacity or skill need, will develop this capacity over time.
5. Community organisation: the use of communities and individuals in the monitoring of wetlands within their jurisdiction should be encouraged. The citizen science initiatives can contribute to the NWMP; however, the local capacity will need to be developed for these local contributions. Capacity can be developed through:
   a. Training days
   b. Ongoing mentorship

   Methods and guidelines will need to be developed to support community/local monitoring in the NWMP. Local/community monitoring would not preclude the need for wetland experts in this Tier of the NWMP, but rather these local communities/individuals can assist with the ongoing collection of data which is required in the Wetland Monitoring Plan.

6.2.2.3 Wetland system and processes capacity development

South Africa has well established water and environmental policies and legislation. However, the country is currently reviewing both policy and legislation related to these sectors. This provides the opportunity to review the wetland policy and legislation positions, particularly to clarify overlaps and confusion related to the mandates, roles and responsibility of the various organisations within the wetland institution, i.e. DWS, DEA and DAFF; national and provincial organs of state; municipalities.

The wetland sector could also benefit from a Wetland Management Strategy or Policy for the country (DWS has recognised this need and is currently developing a Wetland Policy for the country). The Strategy/Policy should provide guidance to the NWMP particularly related to management, conservation and protection objectives and targets for the country.

6.2.2.4 Capacity development of the South Africa wetland institution

Capacity development at a national scale largely focusses on increasing societies knowledge and understanding of wetlands in the country. This can be facilitated through:

- User-friendly communication of the NWMP results
- Awareness and promotion campaigns
- Publication in popular genre
- Publication of scientific data (for knowledge sharing with the South Africa scientific community)

7 RESEARCH NEEDS

The nature of the design of the NWMP is that the programme could be implemented in the very near future. Similarly, the selection of indicators was stakeholder driven, hence very few indicators which were recommended by stakeholder were excluded from the programme. As a result, research needs to be able to implement the NWMP and report indicators in the NWMP are limited. There are, however, a limited number of research needs that are required (1) to implement the NWMP and (2) to conduct wetland assessment and monitoring in the country.

7.1 NWMP Research Needs

High Priority: Further information about indicators

- Listed Alien Invasive Plants Indicator: development of a field guide of listed alien species potentially to be found in South Africa, with likely geographical localities
- Research is needed to see if the currently used qualitative indicators used in Tier 2 are adequately sensitive to change in wetland condition, or if quantitative methods are needed for any of them.
- Research is needed on all aspects of Reference Wetlands or Reference Conditions for wetlands. A priority is a tool to for capturing the fine detail of the Reference Conditions against which an indicator is assessed in Tier 2. Further, key Reference Sites need to be identified for each EcoRegion, wetland type, etc. A guideline of Reference Conditions would be very useful.
- Improved resolution of inventory: currently the National Wetland Inventory does not include wetlands <0.02 ha in area, it has data gaps (see Section 5.8.1.1. and Section 4.1 for details) and it has only partly been ground-truthed. Research is required to determine a process for reducing these limitations, for instance by incorporating local data generated outside of formal state institutions.

High Priority: Methods

- There is a need to develop methods for assessing PES where WET-Health, IHI and other NWMP-recommended methods cannot be used (e.g. depressions and seeps).
- Further research is needed on natural variations in water chemistry across wetland types, ecoregions, etc. and their responses to influent pollutants. Water quality is currently assessed inappropriately by reference to land-use at Tier 2, and no adequate methods are available for using water chemistry data to generate useful indicators at Tier 3. Part of the reason is that we have very inadequate understanding of wetland water chemistry, particularly with reference to nutrients. Continued research on Reference data for water chemistry, and suitable indicators of water quality issues such as eutrophication, are urgently needed.
- There is an urgent need to develop simple, user friendly combined field data collection tools for Tier 2 indicators – these should be developed in a paper format initially, while keep in mind that in future electronic data collection should be considered, i.e. data capture on Android Smart Phones or iPads. Currently, common practice in conducting Wet-Health assessment is that specialists visit the site, visually assess the area and take a large number of photographs of the components required to report hydrology, geomorphology and vegetation. The Wet-Health spreadsheets are completed once the specialist returns to the office. This process of conducting a Wet-Health assessment may work for specialist wetland assessors who are familiar with the criteria required to conduct the assessment, but does to assist new entrants into the Wet-Health assessment process. Consolidated field datasheets to capture the criteria of the Wet-Health assessment would offer these new assessors guidance on which data and information is required to be collected in the field to report the present hydrological, geomorphological and vegetation condition of the prioritised wetland.

- There is an urgent need to combine or rework the IHI and Wet-Health methods into a single, standardise assessment method. Indications are that this activity is already underway.
- The gaps and limitations of highlighted by Ollis and Malan (2014); Kotze et al. (2009) and Kotze et al. (2014) should be addressed
- Guidelines are required for the development of Wetland Monitoring Plans.
- The method of prioritisation of wetlands in Tier 2 and Tier 3 of the NWMP requires testing at a national scale and refinement based on this testing. The baseline NWMP database will need to be developed to facilitate this testing.

7.2 Wetland assessment and Monitoring Research Needs

- There is a need to continue research into the use of plants and microbes as biological indicators for monitoring wetlands. Indices need to be able to track trends (i.e. be sensitive to change). (Note that some work has already been done on wetland plants and invertebrates as indicators: plants look promising, but invertebrates do not).
- Research is needed on the wetland characteristic which are monitored using the Tier 3 protocols to refine these into indicator (if possible) which demonstrate a response to a change in a wetland stressor (i.e. landuse change; cultivation; mining).
- Other indicators that should be examined in future include:
    - Hydroperiod indicator
    - Fauna (small vertebrate) indicator.

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9 APPENDIX A: LIST OF STAKEHOLDERS WHICH PARTICIPATED IN THE DESIGN OF THE NWMP

Name & Surname	Company
Willem Lubke	SEF
Peter Ramollo	DENC
Bismark Mashau	GDARD
Ramogale Sekwele	DWS
Lucia Motaung	DEA
Metthew Bird	NMMU
Nadene Slabbert	DWS
Makgauthe Maleka	DEA
Mthobisi Wanda	DEA
Jackie Jay	DWS
Siyabonga Buthelezi	DWS-KZN
Elliot Weni	DWS-EC
Ashla Gohell	GDARD
Tebogo Nkadimeng	GDARD
Skhumbuzo Kubheka	EKZNW
Tanya Smith	EWT
Wietsche Roets	DWS
Siyanda	DWS
Dean Oilis	FCG
Mandisa Nduma	DWS
Miki Lebelo	DWS
Anda Galasha	DWS
Sipiwo Xongo	DWS
Lungile Gaulana	DWS
Salunathi Sakwe	DWS
Zanele Nyamende	DWS
Jenny Day	UCT/FRC
Pete Goodman	Pvt
Doug Mackfarlane	Eco-Pulse
Boyd Escott	KZNWW
Tanya Smith	EWT
Jeanne Tarrant	EWT
Doug Bordet	DUCT
Samele Vilukazi	DUCT
Craig Cowden	GroundTruth
Ayanda Gosa	DAFF-LUSM
Khumbuno Kubleka	KZN WW`
Heidi Neihwoudt	SANBI
Nancy Job	Private
I Bredin	INR
G Cillers	DWS

C Thirion	DWS
LM Motanug	DEA
F Mbeda	DWA

10 APPENDIX B: LITERATURE REVIEW OF INTERNATIONAL WETLAND INVENTORY, ASSESSMENT AND MONITORING INITIATIVES

The success and usefulness of a wetland inventory, assessment and monitoring systems (IAMS) is to maximise the resources available for the system. This includes learning from other such initiatives and applying best practice when designing and development of IAMS. A number of countries are a lot further than South Africa in implementing IAMS and it would have been remiss for this NWMP assignment not to review these initiatives to determine what could and cannot be applied to a programme in this country.

The section below separates the review of wetland into the following IAMS components:

- International Wetland Inventories Initiatives
- International Wetland Assessment Initiatives
- International Wetland Monitoring Initiatives

10.1 Literature Review of International Frameworks for Wetlands Inventory, Assessment and Monitoring

Conceptual frameworks are a key tool used in many of the more comprehensive inventory, assessment and monitoring programmes and activities.

10.1.1 RAMSAR 3-way approach to monitoring wetlands

RAMSAR adopt a 3-way approach to monitoring of wetlands (Figure 32), namely, (1) wetlands inventory; (2) assessment of wetlands, and (3) monitoring of wetlands. Each of these components applies varying degrees of effort and scale in the application.

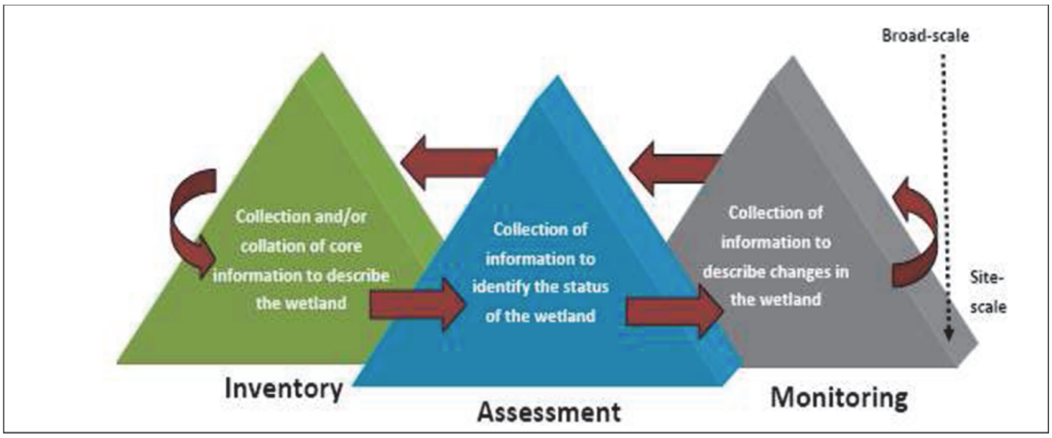

Figure 32: The general purposes of and relationships between wetland inventory, assessment and monitoring (taken from Finlayson and Pollard, undated)

Inventory, assessment and monitoring are important interactive and interlinked wetland data gathering exercises to identify key features of the ecological character of wetlands for wise use and management of these water resources. Ramsar defined the components shown in Figure 32 as (Ramsar, 2005):

- **Wetland Inventory:** is the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities. A wetland inventory provides the baseline record of the ecological character of the wetland. Although a wetland inventory may be repeated, this does not constitute wetland monitoring as outlined in the subsequent statement below.

- **Wetland Assessment:** is the identification of the status of environmental condition of wetlands and threats to provision of ecosystem services. It provides baseline data which can inform specific monitoring activities.
- **Wetland Monitoring:** is the collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. The collection of time-series information that is not hypothesis-driven from wetland assessment is termed surveillance rather than monitoring.

The triangular shape shown in Figure 32 represent the greater level of information and detail that is likely to be collected at the site-scale compared to the broad national-scale.

10.1.2 Environment Objective Framework for Monitoring Ecological Condition

This framework applies the goal-objectives-indicator approach to monitoring of ecological condition of wetlands (Figure 33). Developing this framework for a monitoring programme usually initiate with the selection of explicit, generally accepted wetland conditions which should be achieved and maintained (i.e. wetland goal/objectives) (Cairns et al., 1993). Since wetland ecosystems are complex, multivariate systems which are continuously exposed to a multitude of natural and anthropogenic stresses, successful conservation, management and use of wetland in the country should be based on a wetland goal/objectives, which would in turn guide the wetland assessment and monitoring programme.

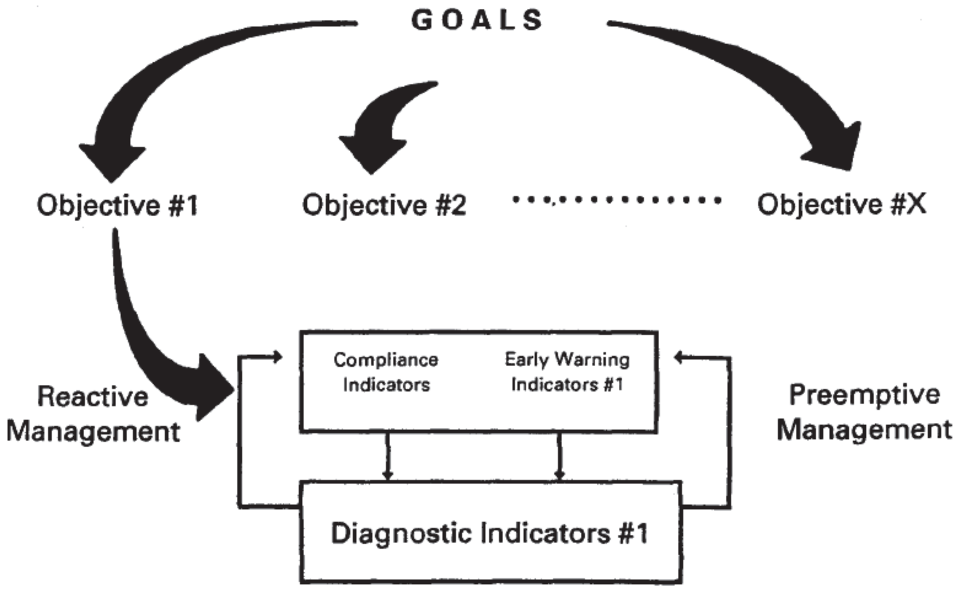

Figure 33: General framework for indicator selection for biological monitoring of ecological condition (taken from Cairns et al., 1993)

Once a goal and/or objectives have been defined for the conservation, management and use of wetlands, the framework requires that indicators are selected that are useful in judging the extent to which the specific goal/objectives have been achieved (Cairns et al., 1993).

In every situation of environmental assessment and monitoring of ecosystems there are a vast number of indicators which could be included in an assessment and monitoring programme. However, the requirement to collect and assimilate a vast amount of information to report a large number of indicators of wetland condition is not an effective or an efficient use of limited resources. Hence, this framework requires that environmental parameters or 'indicators' must be selected that are useful in judging the degree to which specified environmental conditions have been achieved or maintained. Since the number of potential indicators is virtually infinite, the selection of the few 'best' indicators from this vast array is by no means a simple exercise (Cairns et al., 1993). The importance of indicator selection in a framework cannot be overemphasized (Cairns et al., 1993). Hence, such a framework needs to facilitate indicator selection to ensure that these indicators link directly to assessment and monitoring of wetland condition goals and objectives in the country.

This framework is based on the ecosystem approach, which views 'man-within-the system' as opposed to 'the ecosystem-external-to-man.' Indicators can take many forms in the framework, including diagnostic, early warning and compliance indicators. One or more indicators are identified that are used directly to judge attainment and maintenance of some desired condition state, for maintaining the desired condition or to determine management required to fulfil objectives (Cairns et al., 1993).

10.1.3 USA Environmental Protection Agency – Framework for Assessing and Reporting on Ecological Condition

Recognising an information gap in the assessment of integrity of ecological systems in a systematic way across regions of the USA, the Environment Protection agency (EPA) focussed attention on developing a systematic framework for assessing and reporting on ecological condition (EPA, 2002). The framework has the purpose of ensuring that required information is measured systematically by the Agency's programs; provides a template for assembling information across Agency programs and from other agencies; and provides an organizing tool for synthesizing large numbers of indicators into a scientifically defensible, yet understandable, report on ecological condition (EPA, 2002).

The US EPA proposes a *framework in which information about generic ecological characteristics can be logically assembled, then synthesized into a few, scientifically defensible categories* (EPA, 2002). The information in the categories can then be used to report on a variety of environmental management goals. This framework contains the following major elements (Figure 34) (EPA, 2002):

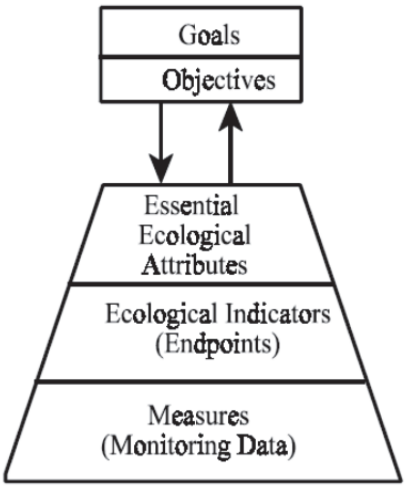

Figure 34: The US EPA Proposed Architecture for Assessing and Reporting on Ecological Condition (EPA, 2002).

- Goals and Objectives – articulates the desired ecosystem conditions that will determine wetland management, conservation and use
- Essential Ecological Attributes – six Essential Ecological Attributes (EEAs) (Figure 35). The EEAs include three ecological attributes that are primarily "patterns" (National-level Condition, Biotic Condition, and Chemical/Physical Characteristics) and three that are primarily "processes"

(Hydrology/Geomorphology, Ecological Processes, and Natural Disturbance). The processes create and maintain patterns, which consist of the elements in the system and the way they are arranged; these patterns in turn affect how processes are expressed[17] (EPA, 2002).

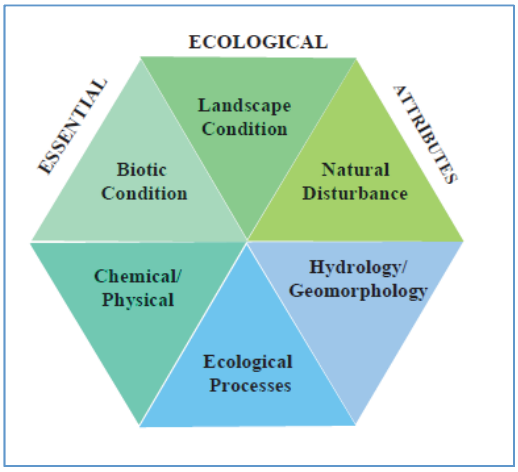

Figure 35: Essential Ecological Attributes and Reporting Categories (taken from US EPA, 2002)

- Ecological Indicators – ecological indicators (also called ecological endpoints) are measurable characteristics related to the structure, composition, or functioning of ecological systems. Multiple indicators may be associated with each subcategory in the EEA hierarchy.
- Measures – specific monitoring variables that are measured in the field and aggregated into one or more ecological indicators (or endpoints).

The relationship between the various levels of the proposed framework is that measures (monitoring data) are aggregated into ecological indicators and indicators are aggregated into the subcategories of the hierarchy of EEAs (EPA, 2002). The framework demonstrates the links between monitoring data or indicators and the overarching conclusions that can be drawn about the condition of various important ecological attributes (EPA, 2002).

10.1.4 USA Environmental Protection Agency – 1, 2, 3 Level Approach to Assessment of Wetland Condition

In recognition that an intensive assessment is not always practical or desirable, the U.S. Environmental Protection Agency (USEPA) has proposed a three-tiered approach to monitoring and assessment, termed Level 1-2-3 or “three-level framework” (USEPA 2006; Stein et al., 2009). The framework breaks assessment procedures into three levels which vary in the degree of effort needed and the scale of application. The levels range from broad, National-level assessments using readily available data (Level 1 methods), to rapid field methods (Level 2), to intensive biological and physical-chemical measures (Level 3) (Fennessy et al., 2007).

[17] The distinction between processes and patterns often is a temporal one. Processes (e.g. transfers of matter through ecosystems, community dynamics) may follow an element of pattern (chemicals, numbers of species) through time. Because of this relationship, patterns sometimes are measured as surrogates for processes, which often are more difficult to measure directly. For example, the biomass of invertebrates over space and time (a pattern) may be measured as an indicator of secondary production (a process).

10.1.5 Australia – Framework for the Assessment of River and Wetland Health (FARWH)

Australia has structured their river and wetland health assessments in the National Framework for the Assessment of River and Wetland Health (FARWH) (Figure 36). The need for a framework for river and wetland health assessment was identified in the baseline assessment of Australia's water resources, with this baseline indicating that the lack of an assessment framework was a barrier to water resource decision-making in the country (Alluvium Consulting, 2011). The framework utilises broadscale monitoring supplemented with more targeted assessment at a finer spatial and temporal scale (Alluvium Consulting, 2011).

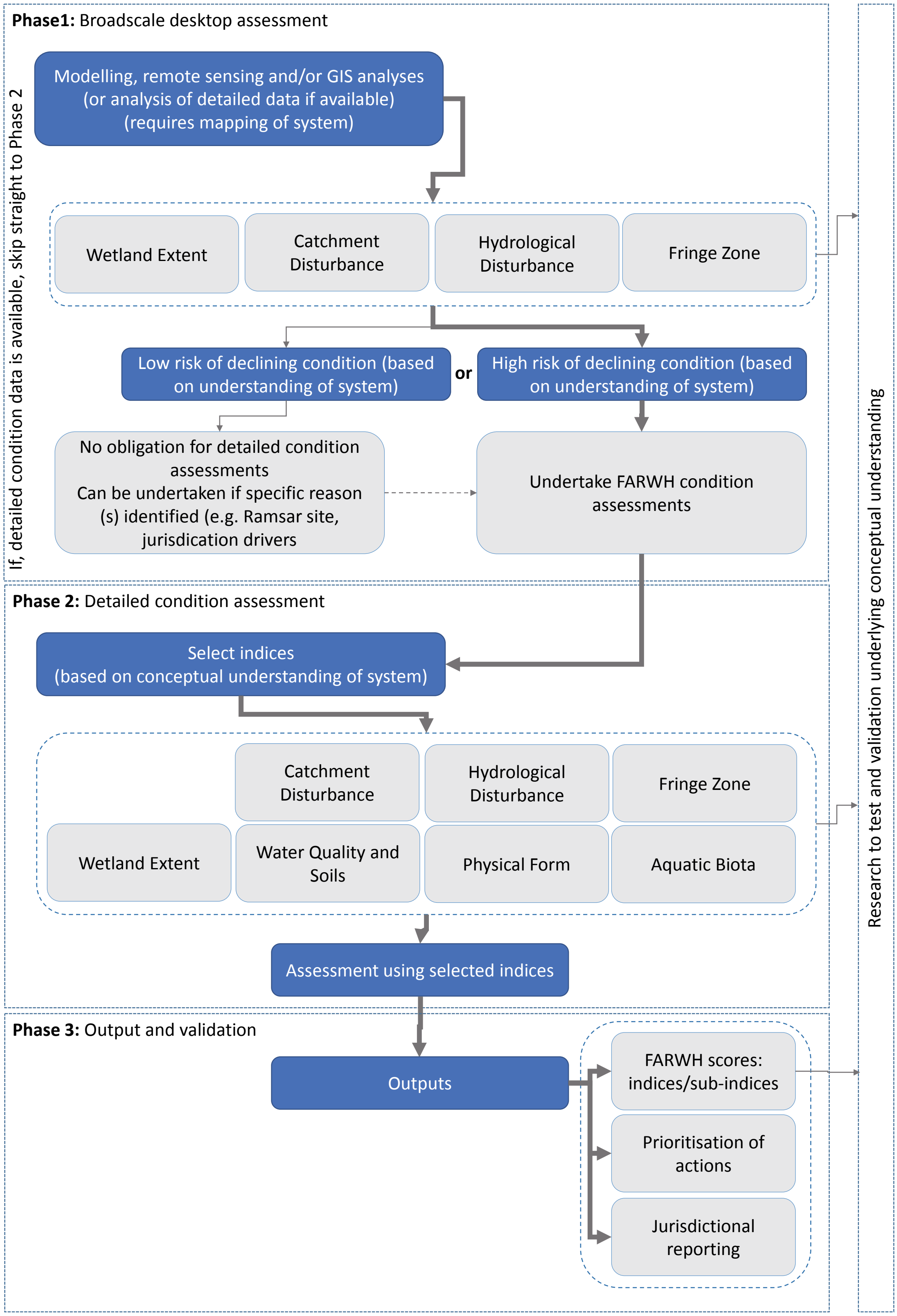

Figure 36: The Australian National Framework for the Assessment of River and Wetland Health (FARWH) (taken from Alluvia Consulting, 2011)

The NARWH is a two-tier approach to wetland condition assessments, addressing the need for assessment to operate over a range of spatial scales to satisfy national reporting needs and to inform regional monitoring and management actions (Alluvium Consulting, 2011). The first tier in the framework (Figure 36) is broadscale assessment of the region of interest, using existing datasets and desktop assessment methods. An essential component of all tiers of the framework is Wetland Extent (Alluvium Consulting, 2011). The broadscale desktop assessment predominately relies on threat-based datasets (Catchment Disturbance, Hydrological Disturbance) rather than direct measures of condition (Alluvium Consulting, 2011).

The second tier of the framework requires detailed assessment at a wetland scale, particularly for systems that are at high risk of change or of particularly high conservation value (Alluvium Consulting, 2011). For these high risks wetlands (sites) a suite of FARWH indices are assessed, although not all indices may be applicable to all sites, i.e. if the extent of wetland has been adequately capture in the first tier it is not necessary to capture it in the second tier. The FARWH uses six key components which represent ecological integrity to assess river and wetland health (National Water Commission, 2007):

1. Physical form
2. Water quality and soils
3. Aquatic biota
4. Hydrological disturbance
5. Fringing zone
6. Catchment disturbance

The framework is based on the conceptual mode that indicators must reflect change in the condition of the wetland. The approach was informed by the links between catchments, river and wetland habitats and aquatic biota, with the development of a hierarchical model in which broad-scale catchment characteristics affect local hydrology (water regimes), hydraulics, habitat features, and water and soil quality, which in turn influence the river and wetland biota (Australian Government Water Fund, 2007). The Australian FARWH assessments methods have taken the interesting Model of being a flexible process, not being prescriptive on which indices are used to report the six key components discussed above (National Water Commission, 2007). State and Territories, which in the Australian situation may have already been assessing, monitoring and reporting on the wetlands within their jurisdiction for many years (i.e. AusRivAS, the Victorian Index of Stream/Wetland Condition, the Tasmanian Conservation of Freshwater Ecosystem Values Project, the Queensland Wetland Program, and the Lake Eyre Basin Rivers Assessment), are able to include these datasets from their assessment and monitoring programmes in the FARWH (National Water Commission, 2007).

Assessments of each component of the Framework is however, based on departures from reference conditions, where reference conditions have been set by using minimally disturbed sites, historical data, modelling of past conditions and professional judgement (National Water Commission, 2007).

10.2 Literature Review of International Wetland Inventories

Why are wetland inventories important to assessment and monitoring of wetlands in a country?

Wetland inventories are useful in the first stages of developing effective wetland conservation, management and sustainable use programmes and assessment and monitoring of these programmes (Finlayson and van der Valk, 1995). The information collected through wetland inventories is thus regarded as a necessary prerequisite for wetland conservation and management. Strategically developed wetland inventory (or inventories) provide managers and policy-makers with key information that is require to manage individual wetland and threats to these, but also place the conservation value of wetlands within the context of broadscale (catchment, regional or even national) land use and sustainable development priorities (Finlayson and Spiers, 1999). Inventories are particularly valuable for assessing wetland loss and degradation, providing valuable information for creating information of the importance of wetlands and for developing targeted conservation and restoration programmes (Finlayson and Spiers, 1999).

Once the basic information on wetland occurrence, distribution and status has been collated it is essential that it is utilised as the basis of conservation effort before it becomes dated and not seriously regarded by conservation officials (Naranjo, 1995). A wetland inventory can thus assist in identification of conservation priorities, establish the basis for monitoring the ecological status of wetlands, promote awareness of wetland sites and management issues, and facilitate exchange of information and comparisons between sites and regions (Garcia- Orcoyen et al., 1992).

Perhaps just as important is that an inventory can demonstrate the economic value of wetlands and thus assist in decisions-making related to the sustainable use of wetlands in a country (Finlayson and van der Valk, 1995).

Crucial to the value of an inventory is the need to regularly update these, requiring storage of data centrally and easy access to the data through standardised computerized formats (Finlayson and van der Valk, 1995).

Throughout the 1980s and into the 1990s there was a determined international effort to compile wetland inventories, with these efforts spearheaded by international organisations such as WWF (World Wide Fund for Nature), IUCN (The World Conservation Union), ICBP (now Birdlife International), and IWRB (now Wetlands International) (Finlayson et al., 2011). Wetland inventories were compiled at a regional level for Asia (Scott, 1989), South America and the Caribbean (Scott and Carbonell, 1986), Africa (Hughes and Hughes, 1992), the South Pacific and New Zealand (Cromarty and Scott, 1995) and the Middle East (Scott, 1995).

Similarly, at a national scale, countries such as USA (Cowardin et al., 1979; Cowardin and Golet, 1995; Wilen & Bates, 1995), Canada (Zoltai & Vitt, 1995) and Australia (Usback & James, 1993; ANCA, 1996) complied wetland inventories.

More recently, a number of southern Africa countries reported to RAMSAR in 2015 that a comprehensive wetland inventory had been compiled, including Botswana, Kenya, Lesotho, Malawi, Mozambique and Namibia. Zambia and Zimbabwe indicated wetland inventories were still in progress.

Finlayson et al. (2001) indicated that despite these international and national efforts to compile wetland inventories, the activities have been plagued by a number of common problems, including:

- Information is required at a number of geographical scales, ranging from local (site) to national and global scales, that result in non-comparable results.
- The scattered nature of the information has prevented accurate assessment of the size and extent of wetlands.
- It has not always been possible to corroborate the accuracy of some information.

Given past difficulties with obtaining inventory data in many locations it was proposed that a minimum data set sufficient to describe the wetland(s) was established, including the location and size of the wetland and those features that provide value and benefits to humans (Finlayson et al., 2001). The minimums inventory dataset proposed by Finlayson et al. (2001) is shown in Table 32.

Table 32: Essential core data elements and recommended additional information categories identified for wetland inventory and assessment (taken from Finlayson et al., 2001)

Essential core data
Area and boundary (size and variation, range and average values)*
Location (coordinates, map centroid, elevation)*
Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region)*
General description (shape, cross-section and plan view)
Soil (structure and colour)
Water regime (periodicity, extent of flooding and depth)
Water chemistry (salinity, pH, colour, transparency)
Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)
Recommended additional information
Landuse — local and in the catchment
Impacts and threats to the wetland — within the wetland and in the catchment
Land tenure and administrative authority — for the wetland parts of the catchment
Conservation and management status of the wetland — including legal instruments and social or cultural factors
Climate — zone and major features
Groundwater features — noting that catchment boundaries may not correspond with those of groundwater basins
Management and monitoring programs — in place and planned

* These features can usually be derived from topographic maps or remotely sensed images, especially aerial photographs

The following section of the report provides a snap-shot summary of some of the wetland inventories which have been compiled across the world, based on a review of international scientific literature. An overview of the South African wetland inventory is provided in the Section 4.1 of the report.

10.2.1 RAMSAR Wetland Inventory

Contracting Parties to the Ramsar Convention commit to compile an inventory as part of the process of developing and implementing a national wetland policy for the wise use of all wetlands in their territory. According to RAMSAR (2005) a wetland inventory can be defined as *the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities*. Wetland inventories are not limited to national scale inventories but can also be carried out at a regional scale to determine specific wetland types; at a local scale to determine characteristics of individual wetlands; and at a site-specific scale to report variability within individual wetlands (RAMSAR, 2005).

The RAMSAR Convention recognises that some wetland inventory methodologies, notably the Mediterranean Wetland Inventory and the Asian Wetland Inventory (AWI), are appropriate for application for a variety of purposes (RAMSAR, 2005). Depending on particular local, national and regional needs and priorities, they can be implemented at one or more scales, and their methods may be applied also to other regions of the world. The key feature of the AWI is the production of hierarchical and map-based outputs with a progression in scale from river basins to individual sites (Figure 37).

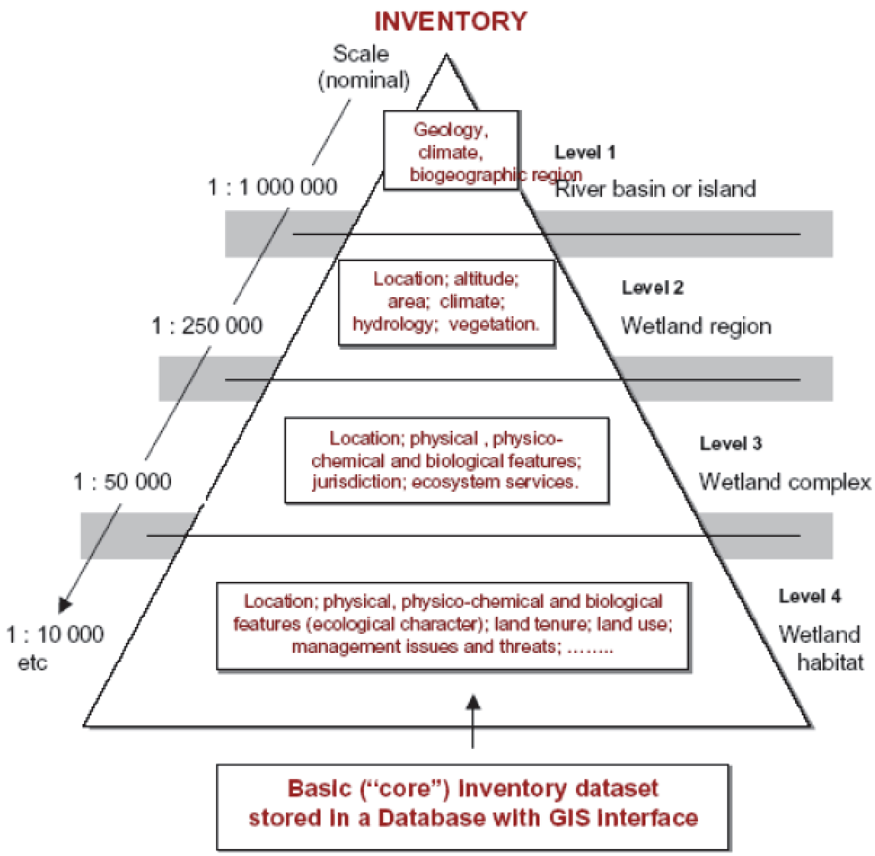

Figure 37: The hierarchical approach to wetland inventory. Data fields most appropriate for each level are shown with the most data being collected at level 4 (shown at the base of the triangle) (taken from Ramsar, 2005).

The RAMSAR *Framework for Wetland Inventory* utilises a 13-step structured framework for conducting a wetland inventory. These steps are:

1. State the purpose and objective
2. Review existing knowledge and information
3. Review existing inventory methods
4. Determine the scale and resolution
5. Establish a core or minimum data set
6. Establish a habitat classification
7. Choose an appropriate method
8. Establish a data management system
9. Establish a time schedule and the level of resources that are required
10. Assess the feasibility & cost effectiveness
11. Establish a reporting procedure
12. Establish a review and evaluation process
13. Plan a pilot study

The *Framework for Wetland Inventory* also provides a minimum set of data fields, biophysical and management features of wetlands, that need to be collected in each inventory, depending on the specific purpose of the inventory (Table 33) (RAMSAR, 2005).

Table 33: Core (minimum) data fields for inventory of biophysical and management features of wetlands (taken from RAMSAR, 2005)

Biophysical features	Management features
Site name (official name of site and catchment)	Land use – local, and in the river basin and/or coastal zone
Area and boundary (size and variation, range and average values)	Pressures on the wetland – within the wetland and in the river basin and/or coastal zone
Location (projection system, map coordinates, map centroid, elevation) *	Land tenure and administrative authority – for the wetland, and for critical parts of the river basin and/or coastal zone
Geomorphic setting (where it occurs within the National-level, linkage with other aquatic habitat, biogeographical region) *	Conservation and management status of the wetland – including legal instruments and social or cultural traditions that influence the management of the wetland
General description (shape, cross-section and plan view)	Ecosystem benefits/services derived from the wetland – including products, values, functions and attributes (see Resolution VI.1) and, where possible, their relevance to human well-being (see Resolutions VI.23 and VII.8)
Climate – zone and major features	Management plans and monitoring programs – in place and planned within the wetland and in the river basin and/or coastal zone (see Resolutions 5.7, VI.1, VII.17, and VIII.14)
Soil (structure and colour)	
Water regime (periodicity, extent of flooding and depth, source of surface water and links with groundwater)	
Water chemistry (salinity, pH, colour, transparency, nutrients)	
Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)	

* These features can usually be derived from topographical maps or remotely sensed images, especially aerial photographs.

The *Framework* also stresses that an inventory should contain a clear statement of its purpose and objective; should identify the habitats that will be considered, the range of information that is required, the time schedule, and who will make use of the information (RAMSAR, 2005).

Although RAMSAR has developed a number tools and methods to assist countries in developing wetland inventories, RAMSAR (2005) indicates there were still gaps in these tools and methods related to:

- development and testing of a hydro-geomorphically-based system of classification of wetland types;
- further development of the Web-based wetland inventory meta-database;
- a review of data and information needs for Ramsar sites and other wetlands, including guidance for the description of the ecological character of wetlands, and harmonisation of the Information Sheet on Ramsar Wetlands (RIS) with the wetland inventory core data fields and the description of ecological character;
- advice on delineating and mapping wetlands (in conjunction with the description of ecological character.

RAMSAR recommends that countries prioritise the conducting of a national wetland inventory, if they have not done so already. The inventory should focus on collecting a basic set of data (as outline in Table 33). Once these baseline data have been collected and stored in the inventory, more management-oriented information on wetland threats and uses, land tenure and management regimes, benefits and values should be added (RAMSAR, 2005). When such assessment information is recorded, it should be accompanied by clear records that describe when and how the information was collected and its accuracy and reliability.

10.2.2 MedWet Inventory

The aims of the MedWet inventory program were: (1) to assess the status of existing wetland inventories in the Mediterranean region in order to identify gaps and review the adequacy of methods in use, and (2) to prepare a standard methodology for carrying out inventories of Mediterranean wetlands (Costa et al., 2001). Due to the diverse nature Mediterranean region and the resources available, a flexible inventory methodology was developed to address an array of needs and situations. The methodology was based on four main features: it should be (a) standardised to allow consistent use throughout the region and to allow comparisons between inventories, (b) comprehensive, to include all relevant information, (c) flexible, to allow use by entities with diverse resources, and (d) compatible, to assure comparisons and exchange of information with ongoing programs, such as the Ramsar database (Costa et al., 2001).

The MedWet Inventory utilises three levels of information: the catchment area, the wetland site and the habitat. Information collected at the catchment level avoids repetitive inputting of data common to every site within the catchment. The site level includes essential information to be collected at each wetland, while the habitat level entails recording detailed data and provides a baseline for site management and monitoring (Costa et al., 2001). At all levels the following five main components are identified (1) site selection, (2) wetland identification, (3) classification system, (4) data collection and storage, and (5) the mapping procedure (Costa et al., 2001).

The mapping method for wetlands consists of four phases: (1) collection, screening and evaluation of existing data, (2) fieldwork, (3) photointerpretation and production of the final wetland habitat description map, and (4) digital map production using GIS. The work is based on information captured from aerial photographs combined with ground data and pre-existing data (Costa et al., 2001).

Inventory data is entered into the MedWet Database (MWD), which allows the storage, analysis and presentation of the inventory information and possible compilation of information at a Mediterranean level. The MedWet Web Information System (MedWet/WIS) is the latest version of the MedWet Database. It is the result of a number of successive and gradually improving versions that have been developed since 1996. The MedWet/WIS was developed in order to adopt new database and web technologies, integrate GIS tools and web service facilities and address new demands in data access and reporting requirements (Katsaros et al., 2008).

The MedWet inventory, assessment and monitoring initiative, now operates as just one part of a much broader, and expanding Mediterranean wetlands program being implemented under the support of the Ramsar Convention on Wetlands. The MedWet Inventory identify where wetlands occur in Mediterranean countries and ascertain which are priority sites for conservation; identifies the values and functions for each wetland; provides a baseline for measuring future change; and provides a tool for planning and management and permit comparisons between sites (RAMSAR, 2010b).

10.2.3 Asian Wetland Inventory (AWI)

A mechanism to determine the status of Asian wetlands for the 21st century and to develop a comprehensive Asian Wetland Inventory (AWI) was developed under the auspices of the Wetland Inventory and Monitoring Specialist Group (WIMSG) and the international non-governmental organisation (NGO) Wetlands International (Finlayson et al., 2002). Since its initiation in 1999, a number of outcomes have been achieved through the AWI, including (Finlayson et al., 2002):

1. *Increased awareness on the importance of wetlands and the need for a standardised inventory among relevant national government agencies across Asia.*
2. *A dynamic and standardised Geographical Information System (GIS) integrated database providing core data/ information on Asian wetlands to guide and support planning and conservation efforts by national governments, international Conventions, NGOs and others.*
3. *A strengthened network of trained personnel in techniques and skills required for implementation of the AWI at national and local level.*
4. *Established national inventory programmes and databases in all participating nations.*
5. *Established network of regional training programmes in wetland inventory*
6. *A monitoring programme for regular revision and updating information on wetlands of national and international importance in Asia*

10.2.4 USA Fish and Wildlife Services – National Wetland Inventory

As early as 1974, the US Fish and Wildlife Service gave its Office of Biological Services the mandate to *develop and disseminate a technically sound, comprehensive data base concerning the characteristics and extent of the Nation's wetlands* (Wilen and Bates, 1995). To address this mandate state-of-the-art principles and methodologies for compiling a national wetland inventory were assimilated and developed and in 1979 the National Wetlands Inventory (NWI) Project was operational (Wilen and Bates, 1995). Before implementing the NWI Project, a wetlands classification system (Cowardin et al., 1979) was developed for the USA and was adopted on the 1st October 1980 (Wilen and Bates, 1995). Researchers determined, due to the magnitude of performing an inventory covering the entire geographic area of the United States, that a remote sensing technique would be the best method to inventory wetlands in the country (Wilen and Bates, 1995). The remote sensing technical choice was between high-altitude photography and satellite imagery (Landsat), with the conclusion being that Landsat's could not provide the needed data for classification detail and wetland determinations within the desired accuracy requirements and that the NWM would therefore be conducted using mid-and high-altitude colour infrared aerial photography (Wilen and Bates, 1995). The Fish and Wildlife Services, in 1995, employed a small, full time staff of 40 persons that include biologists, photo interpreters, cartographers, computer technicians and computer analysts to manage and compile the NWI (Wilen and Bates, 1995). The budget for NWI was $8 million annually, with $5 million spent on wetland mapping and the remaining $3 million spent on wetland status and trends work (Wilen and Bates, 1995).

The operational phase of the NWI, initiated on 1 October 1979, involves two main efforts: (1) wet lands mapping, and (2) wetlands status and trends analysis (Wilen and Bates, 1995).

10.2.5 Australia – National Wetland Inventory

In 1995, Spier and Finlayson (1995) indicated that an inventory of Australian wetlands did not exist, although a national overview of wetlands was provided in the 1980s. It was recommended at the time that a national approach to wetland inventory be developed and implemented, using standardised techniques to systematically collect, collate, store and disseminate data and information and provide mechanisms for identifying priorities for national funding (Spier and Finlayson, 1995). Spier and Finlayson (1995), in outlining the Protocols for an Australian national wetland inventory, indicated that the National Wetland Inventory would be compiled from existing datasets and inventory projects where possible. A series of wetland inventories have been completed at regional scale in South Australia and a number are currently underway.

10.3 LITERATURE REVIEW OF INTERNATIONAL WETLAND ASSESSMENTS

Why is wetland assessment important and necessary?

An inventory of wetlands is in affect a type of assessment of wetlands as it provides information (i.e. location; extent and type) of wetlands within the National-level. However, the term wetland assessment is more commonly applied to more details evaluation of wetland function; value; condition; health or ecological integrity (Thiesing, 2001).

Wetland assessments have been widely used in the sector, the most common use of these being to: 1) evaluate wetlands for development; 2) evaluate impacts on wetlands for planning purposes; 3) evaluate wetland restoration potential for conservation programs; and 4) determine wildlife habitat potential for management purposes (Thiesing, 2001). A number of wetland assessment techniques have thus been developed over the years, differing in their level of detail, objectivity and repeatability of the results. There is also considerable variability in the range of wetland functions/condition that are considered by any given technique (Thiesing, 2001). Some wetland assessment methodologies are narrowly focused and may only consider a single or a small related group of condition and functions such as fish habitat, bird habitat, wildlife habitat, flood storage, while other assessment methods may assess a broader range of wetlands functions concurrently, such as flood storage capacity, sediment stabilisation, nutrient uptake, primary production export and fish and wildlife habitat (Thiesing, 2001). Some techniques also have components to consider wetland values as well as functions.

The assessment which is applied to a wetland is generally determined by the purpose of the assessment. For example, if the purpose of the assessment is to determine the potential effects of climate change on a wetland then a risk or vulnerability assessment would be conducted. It is thus critically important to clearly establish the purpose of the assessment before implementing the assessment. There are generally four types of wetland assessment methods (Thiesing, 2001):

5. **Inventory and classification:** – assessments which provide information of the areal extent and/or types of wetlands within a given National-level.
6. **Rapid Assessments:** – generally low-cost assessment technique which gather wetland data in a short period of time. Rapid assessment usually focusses on assessment of a single wetland or small groups of wetland and are characterised as being a completely qualitative assessment or being largely subjective (best professional judgement)
7. **Data-driven Assessments:** – mostly rely on model-based assessment of a wetland and hence can be expensive to develop. The advantage of these types of assessment is that they provide a high degree of reproducibility.
8. **Bioindicators/Indices of Biotic Integrity**: – assessment which use a selected set of variables measured across wetland types and reported separately or as a multimetric indices. These types of assessments can be used to measure the condition or ecological integrity of a wetland and identify long-term changes in the wetland. They do not however, provide a reliable assessment of functional capacity.

Wetland assessment often utilise a combination of the above methods to determine the condition and function of a wetland. Rapid assessment methods are however, the most extensively used methods used to assessment wetlands.

Rapid Assessments, which are a swift assessment for a specific purpose, generally providing initial data on the wetland such as baseline assessment, change assessment, indicator assessments, species assessment or resource assessments. Rapid assessment may be conducted for various purposes, may take various forms and may collect various data, shown in Table 34.

Table 34: Purpose, type of assessment and data which is gathering from various rapid assessments (taken from Ramsar, 2005b)

General purpose	**Biodiversity baseline**		**Disturbance and ecosystem health**		**Resource sustainability and economics**
Specific purposes	Baseline inventory; prioritization; conservation; identification	Conservation of specific species; status of alien species	Change detection	Overall ecosystem health or condition	Sustainable use of biological resources
Assessment type	**Baseline inventory**	**Species-specific assessment**	**Change Assessment**	**Indicator assessment**	**Resource assessment**
Types of data and analyses possible	1. Species lists/inventories. 2. Habitat type lists/inventories. 3. Limited data on population size/ structure, community structure and function, and species interactions	1. Status of a focal species: distribution, abundance, population size/ structure, genetic, health, size, species interactions, nesting, breeding and feeding	1. Monitoring data. Effects of an activity or disturbance on habitat/species/ communities: diversity loss, genetic issues, habitat changes or loss. 3. Monitor impacts.	1. Data on health or condition of inland water systems. 2. Water quality data. 3. Hydrological information. 4. Biological parameters. 5. Biotic indices.	1. Presence, status and condition of economically, culturally, nutritionally, and socially important species. 2. Information on sustainability of use of a species. 3. Limited monitoring data: stock

General purpose	Biodiversity baseline		Disturbance and ecosystem health		Resource sustainability and economics
	4. Abundances, distribution patterns, and ranges. 5. Genetic information. 6. Important species: threatened, endangered, endemics, migratory, invasive alien species, other significance: cultural, scientific, economic, nutritional, social. 7. Diversity indices. 8. Water quality data. 9. Hydrological information.	information. 2. Ecological data on focal species; habitat, symbionts, predators, prey, etc. 3. Threats to focal species and habitats. 4. Life history table. 5. Water quality data. 6. Hydrological information.	4. Determine changes in ecological character. 5. Impact reduction options. 6. Biotic indices. 7. Habitat indices. 8. Water quality data. 9. Hydrological information. 10. Early warning indicators.		assessment data, habitat status. 4. Limited information relevant to resource management. 5. Water quality data. 6. Hydrological information.

Assessments are often conducted to determine effects of human activities and natural disturbance of the ecological character on a wetland area (Secretariat of the Convention on Biological Diversity and the Secretariat of the Convention on Wetlands, 2006). These assessments can be prospective (such as in an EIA) or retrospective, which assess the actual disturbances or alterations on wetland ecological character.

Retrospective assessments are difficult without baseline data against which a comparison but can be made to determine trends and change over time (taken from Secretariat of the Convention on Biological Diversity and the Secretariat of the Convention on Wetlands, 2006) by:

a) Comparing two or more different sites at the same time;
b) Comparing the same site at different times (trends);
c) Comparing the impacted site to a reference site; and
d) Comparing the observed status to environmental quality standards.

Most existing rapid assessment methods are designed for this purpose; some of these (either biological, physical-chemical or eco-toxicological) may also be used as “early warning indicators”

It should be noted however, that the *“cause-effect”* relationships are not always clearly understood or defined. Although a particular indicator may demonstrate change in a particular ecological characteristic, the relevance of the indicator to demonstrates the link between the ecological impact and an observed response/effects at an individual level, let alone the population, community or ecosystem level may not necessary exist.

The sections below outline the purpose and process of some the wetland assessment methods developed and implemented in various countries. The assessment methods which are included in the report are largely focussed on those which are applicable at a national scale.

10.3.1 US Rapid Assessment Methods

The majority of wetland assessment methods have the purpose of assessing wetland functions (i.e. “ecosystem services” such as flood prevention and water quality improvement) and values (Ollis and Malan, 2014). Only a few of these assessment methods related to assessing wetland ecological condition.

10.3.1.1 US Fish and Wildlife Services – Wetland Status and Trends Reporting

The US Fish and Wildlife Service is required to update the status of wetlands in the USA and show trends in this status at 10 year intervals (Dahl, 2011). There have been five national wetland and trends reports completed so far.

This Wetland Status and Trends study is designed to provide information of the current status and extent of wetland resources in the United States and to assess change in those resources over time. It is a quantitative measure of the area extent (status) of all wetlands, showing only the wetland acreage gained or lost annually, where the greatest gains and losses are occurring, and what wetland types are most vulnerable to loss.

A statistically random sample of wetlands stratifies the 48 (excl Alaska and Hawaii) states and identifies primary wetlands by remote sensing imagery of vegetation, visible hydrology, and geography to select 5042 sample plots (Dahl, 2011). Each plot is four square miles (2,560 acres or 1,040 ha) in area. Data is ground-truthed by inspection of an addition 898 (18%) supplemental sample plots (Dahl, 2011). Sampling included all types of wetlands (fresh and saltwater).

The selected sample plots are examined, with the use of remotely sensed data in combination with field work, to determine wetland change (Dahl, 2000).

The Cowardin et al. (1979) wetland definition and classification of wetland types is adopted as a standard for this assessment (Dahl, 2011). This has provided consistency and continuity in the defining of the biological extent of wetlands between the various status and trends reports.

Dahl (2000) indicated that the limitation of this assessment were"

- That certain habitats were excluded from this study because of the limitations of aerial imagery as the primary data source to detect wetlands.
- the estuarine wetlands of California, Oregon and Washington occur in discontinuous pockets, with their patchy distribution precluding establishment of a coastal stratum and no statistically valid data could be obtained.
- Ephemeral wetlands are not recognized as a wetland type by Cowardin et al. (1979), and were not included in the assessment.

10.3.1.2 EPA National Wetland Condition Assessment (NWCA) -USA Rapid Assessment Method (USA-RAM)

The Environmental Protection Agency of the USA has implemented a national survey of the condition of the wetlands in the country referred to as the National Wetland Condition Assessment (NWCA) (Kentula et al., 2011). The NWCA, part of the National Aquatic Resource Survey (NARS) programme, is a collaboration among the US EPA and State, Tribal, and other Federal partners (US EPA, in review). The NWCA was accomplished by analysing data collected across the conterminous USA, designed to complement the US Fish and Wildlife Service's National Wetland Status and Trends Program (S&T) (see Section 2.4.1.2).

The NWCS utilises the USA Rapid Assessment Method (USA-RAM) to assess the wetland condition in a short timeframe, with the objectives to:

- Determine the ecological integrity of wetlands at regional and national scales.
- Build state and tribal capacity for monitoring and analyses.
- Promote collaboration across jurisdictional boundaries.
- Achieve a robust, statistically-valid set of wetland data.
- Develop baseline information to evaluate progress.

Due to their traceable and cost-effectiveness, the NWCA uses ecological indicators to estimate condition of the wetland resource (Jackson et al., 2000, Dale and Beyeler, 2001). Indicators included in the assessment include (Table 35 provides more details on each indicator):

a) Wetland Vegetation
b) Wetland Soils
c) Wetland Hydrology
d) Wetland Water Chemistry (where standing water)
e) Algae

The choice of NWCA field methods and indicators was influenced by considerations of timing and the resources required, in particular, the need to complete travel and sampling for a site typically in one day by teams of 4-6 persons (Kentula and Cline, 2004; Kentula et al., 2011). The size of the assessment areas ranged from 0.1 to 0.5ha and had to be at least 20 m wide to accommodate the plots for sampling vegetation. The wetland assessment area and the area immediately adjacent to the assessment area were surveyed, to provide information on the stressors on the wetland (Kentula et al., 2011).

Table 35: Indicators used in the NWCA of the EPA (adapted from US EPA, 2011).

Indicator	Motivation	Method	Data
Wetland Vegetation	Vegetation is a major component of biodiversity found in wetlands and is habitat for a myriad of organisms. The composition and abundance of plant species is both reflective of, and may influence, the hydrology, water quality, and soil characteristics of a wetland. Plants respond to, and reflect, physical, chemical, or biological disturbances and stressors (Selinger-Looten et al., 1999, Rayamajhi et al., 2006). The presence and abundance of alien plant species often reflect degraded or declining quality. In addition, plant data can be used to derive a numerous metrics or indicators that are useful descriptors of ecological integrity or stress (e.g. USEPA, 2002a; Bourdaghs et al., 2006; Magee et al., 2008; Mack and Kentula, 2010).	Collect plant data in five 100-m2 Vegetation Plots systematically placed across the assessment area	• Species composition and abundance • Native species • Alien species • Floristic quality • Guild composition • Community composition • Vegetation structure
Soils	Soils cycle nutrients, store pollutants, mediate groundwater and provide habitat for microorganisms, invertebrates, and other more complex organisms (Richardson and Vepraskas, 2001). Biogeochemical processes characteristic of hydric soils directly influences wetland condition and the delivery of associated ecosystem services. Soil structure and chemistry can indicate water quality and hydrology (Hargreaves et al., 2003; Mitsch and Gosselink, 2007).	Data is collected in four soil pits and includes an on-site description of the soil profile. Four types of soil samples (chemistry, bulk density, soil enzymes and stable isotopes) are also collected for laboratory analysis.	• Soil profile description • Hydric soil field indicators • Soil chemistry.
Hydrology	Wetland hydrology is the primary driver of wetland formation and persistence. Hydrology impacts soil geochemical dynamics, plant productivity, nutrient cycling, and accretion and erosion of organic and inorganic materials in wetlands (Mitch and Gosselink, 2007; Tiner, 1999).	Data includes an assessment of hydrologic sources and connectivity, indirect evidence of hydroperiod, estimates of hydrologic fluctuations, and documentation of hydrology alterations or stressors.	• Degree of saturation • Degree of inundation • Types of hydrologic alteration.
When standing water is present at a wetland assessment area, water chemistry	Total nitrogen and phosphorus reflect the trophic state of the wetland, providing crucial information on possible eutrophication (Keddy, 1983). Anthropogenic disturbances such as	Samples are taken and analysed for general surface water conditions, various chemical analysis, and evidence of disturbance.	•

Indicator	Motivation	Method	Data
	hydrologic modifications and land use changes are known to alter water quality variables (Lane and Brown, 2007; Reiss and Brown, 2005).		
Algae	Algae respond rapidly to ecological change in wetlands and have been widely used as indicators of wetland condition because of their rapid reproduction rates, short life cycles, and broad distribution (McCormick and Cairns, 1994). More notably, because nutrients such as nitrogen and phosphorus are limiting factors to most types of algae, they respond quickly to excess nutrients. In addition, diatom species can provide insights into past hydrology such as recent flooding, standing water, or droughts (Lane and Brown, 2007; USEPA, 2002; McCormick and Cairns, 1994).	Samples are collected from substrates (substrate samples) and from the surface of vegetation stems and leaves (epiphytic samples), and, if water is present, from water (planktonic samples).	Data on species composition and abundance, including guilds, and the presence of algal toxins are collected.

The NWCA is designed to produce detailed information on wetland quality by wetland type and region of the country, providing insight into the implications of the changes in area. The survey is also designed to determine and rank the main stressors which determine the condition of wetlands and has a capacity building component, with the design and conducting of the assessment intended to help build capacity to monitor wetlands. Stressors provide details on factors which affect the condition of the wetland (EPA, 2011).

NWCA field sampling started on April 4, 2011, where 55 field crews sampled 1,179 sites across the country. Each crew was trained to use standard protocols outlined in a NWCA Field Operations Manual (FOM) to sample vegetation, soils, hydrology, algae, water quality, and the wetland buffer at each site. Multiple laboratories analysed more than 20,000 samples collected during the NWCA field season (EPA, 2011).

A key component of the NWCA is to produce a report which communicates wetland ecological condition in a scientifically valid manner but can easily be understood by a variety of audiences (e.g. ay people, policy makers, and resource managers, as well as scientists) (Kentula et al., 2011).

Since the NWCA is still in process and a very new initiative, there are as yet not lesson learnt document related to this assessment.

10.3.1.3 US Fish and Wildlife Services – Habitat Evaluation Procedure (HEP)

The US Fish and Wildlife Services has developed the rapid Habitat Evaluation Procedure (HEP) which is used to evaluate fish and wildlife habitats within a given ecological community (Thiesing, 2001). HEP was originally developed to assess the number of habitat units per acre (for each species) on land which was being consider for acquisition for management of wildlife (Thiesing, 2001). It provides information for two wildlife habitat comparison; (1) relative value of different future points in time and (2) the relative value of the same area at future points in time (US FWS, undated). HEP thus assesses both the existing and future condition of the wetland, based on ecological characteristics of the species which have been reported in the literature. A Habitat Suitability Index (HIS) is calculated for the species in the habitat, which is multiplied by the habitat area to provide Habitat Units (i.e. Habitat area x Habitat quality (HSI) = Habitat units (HUs)) (US FWS, 1980; Schamberger and Krohn, 1982)) (see Table 36 for example of HEP results). The Table 36 example indicates that Sites 1 and 3 contain habitat of the highest relative quality, and sites 2 and 4 have the lowest habitat quality (Schamberger and Krohn, 1982). Decision-makers could, based on this information, select sites 2 or 4 for development due to the lower habitat value (HSI score) for wildlife and select Site 1 and/or 3 for wildlife management due to the higher HSI score.

Table 36: Hypothetical example of the results from an HEP (taken from Schamberger and Krohn, 1982)

Study site	Area/acres	HSI	HU
1	1,000	1.0	1,000
2	1,000	0.2	200
3	10,000	0.9	9,000
4	10,000	0.4	4,000

HEP also accommodates modification of models to regional differences in the habitat use of the species (Thiesing, 2001).

The procedure is reported to have some bias on the part of the field evaluators, particularly related to the way in which species are selected for assessment and in terms of the weights assigned to the habitat features (Thiesing, 2001)

10.3.1.4 US Army Corps of Engineers – Wetland Evaluation Technique (WET 2.0)

The US Army Corps of Engineers' Wetland Evaluation Technique or WET 2.0 was used to make wetland permit decisions (Adamus et al., 1987; Adamus et al., 1991). The WET method utilised the presence or absence of a large set of physical, chemical and biological characteristics as correlative predictors of wetland functions. It assigns wetland values to the characteristics that are valuable to society. The following functions are assigned values by WET:

- Ground-water recharge
- Ground-water discharge
- Floodflow alteration
- Sediment stabilization
- Sediment/toxicant retention
- Nutrient removal/transformation
- Production export
- Wildlife diversity/abundance
- Aquatic diversity/abundance
- Recreation
- Uniqueness/heritage

The WET thus evaluates functions and values in terms of effectiveness, opportunity, social significance, and habitat suitability. It was designed to be applied by any environmental professional and provides a balance between costly, site-specific studies and the "best professional judgment" approach (Novitzki et al., undated). WET require that information be obtained from the wetland, the area surrounding the wetland, and the area downstream from the wetland to answer a series of questions related to the wetlands watershed, topography, vegetation, and other features (Novitzki et al., undated). By progressing the data through a series of flow charts (or an available computer software package), an evaluation can assign a probability rating of "high," "moderate," or "low" to each of the functions listed above (except for recreation) (Adamus, 1988; Novitzki et al., undated)). WET is thus not a quantitative measure of wetland function but rather is a predictive tool of the *qualitative likelihood* (high, medium or low) that a wetland performs given functions, to an unspecified degree (Thiesing, 2001). It does not estimate the degree or magnitude to which a function is performed (Novitzki et al., undated). Recreation is not evaluated because no scientific basis exists for making an objective assessment without extensive data collection at the site (Novitzki et al., undated).

Although the WET approach has been applied to almost every wetland type in the various state of the USA, the need to be so widely applicable has led to the method being unwieldy to use (Novitzki et al., undated). Despite its shortcomings, WET continues to be used by those who are familiar with it. Although WET provides a procedure for rapid screening of different alternatives which would affect wetlands in a National-level, it is not suitable for assessing the actual extent of wetlands impacts, or the type, location, or amount of mitigation that would be necessary to compensate for functions lost due to impacts.

10.3.1.5 Hydrogeomorphic Classification Method (HGM)

The Hydrogeomorphic Classification Method (HGM) was developed by Brinson (1993) and Smith et al. (1995) to measure a large suite of wetland functions in a quantifiable, consistent manner across a large geographic region (Thiesing, 2001). The HGM approach characterises a specific wetland relative to the characteristics of a group of wetlands (reference wetlands) in the region to determine the degree to which the individual wetland is performing selected functions (Novitzki et al., undated). The method classifies wetlands into subclasses based on hydrology and geomorphic setting and then, using experts, an assessment protocol is established for measuring functions across a set of wetlands of the same hydrogeomorphic subclass within a geographic region (called the reference domain) to determine the range of performance, for those functions in wetlands within the National-level (Thiesing, 2001).

Wetland characteristics which are evaluated by the HGM are regionally specific, i.e. different characteristics are identified and evaluated for different hydrogeomorphic settings (Novitzki et al., undated). This regional specificity is determined by wetland scientists or managers identifying the functions that are performed by wetlands in a specific hydrogeomorphic setting and identifying the wetland characteristics (indicators) of these functions (Novitzki et al., undated). These functional profiles are used to develop functional indices (Thiesing, 2001).

The wetland assessment provided by the HGM approach is a "site profile" that lists the site characteristics that are related to identified wetland functions (Novitzki et al., undated).

The site profile is compared with characteristics of the reference wetlands in order to rank the site (Novitzki et al., undated). Reference standards in the Hydrogeomorphic Method are defined as the *conditions under which the highest sustainable level of function is achieved across the suite of functions performed by wetlands of that subclass* (Thiesing, 2001).

The HGM provides an objective means by which functional performance can be measured, objectively compared across geographic areas and evaluated (Thiesing, 2001). The advantage of this method is that the model development is an iterative process, which allows for refinement and validation based on data and expert review. The method is also both objective, using reference wetlands for objective comparison, and quantitative. The method is also relatively rapid, consistent, and reproducible. The disadvantage of this method is that the cost of the model development is high and the results of the assessment and the functions measured are complex. The methods also do not assess highly impacted wetlands (Thiesing, 2001).

10.3.1.6 Bioindicators or Indices of Biotic Integrity

The bioindicators, or Indices of Biotic Integrity (IBIs) rapid method of wetland assessment was developed to assess wetlands across large geographic National-levels (Thiesing, 2001). Originally developed for rapid assessment of the condition of streams and open water, the method was later adapted for assessing wetland conditions. Bioindicators or IBIs does not assess the function of a wetland, but rather utilises a characteristic of a specific set of environmental conditions as indicator of condition and overtime, impacts on the wetlands, i.e. species which are sensitive to degradation would act as indicator of wetlands with high quality condition (Thiesing, 2001).

These methods of wetland assessment do not assess the functional capacity but rather ecological condition of a wetland. This is a useful tool in cases where wetland management is the foci, where assessment of condition will assume increasing importance (Thiesing, 2001). The disadvantage of the use of Bioindicators or IBI rapid assessment is that it takes considerable time and data to develop a reliable suite of indicators (Thiesing, 2001).

10.3.1.7 State-specific Rapid Assessment Methods – California Rapid Assessment Method (CRAM) and the Ohio Rapid Assessment Method (ORAM)

Apart from the national and generic rapid methods discussed in the sections above, individuals States in the USA utilised situational specific rapid assessment methods to assess their wetlands. Two of these methods are the California Rapid Assessment Method (CRAM) and the Ohio Rapid Assessment Method (ORAM).

To support the need to be able to monitor the state of wetlands in California, a consortium of local, state and federal authorities has been developing tools, guided by the three-level framework for surface water monitoring and assessment issued to the state by the USEPA (CWMW, 2013a). Level 2 of the framework consists of rapid assessment of wetland condition in relation to the broadest suite possible of ecological and social services and beneficial uses. California has developed the California Rapid Assessment Method (CRAM) as a cost-effective and scientifically defensible Level 2 method for monitoring the conditions of wetlands throughout California (CWMW, 2013a).

CRAM is designed to enables two or more trained practitioners to assess the health of a wetland in half a day, using the best-fit set of narrative descriptions of observable conditions ranging from the worst commonly observed to the best achievable for the type of wetland being assessed. The basic design of CRAM includes wetland attributes and metrics that describe each wetland attribute. Thus, each CRAM attribute is represented by a set of metrics (Table 37), and each metric is represented by a set of mutually exclusive narrative descriptions of alternative states. (CWMW, 2013a).

Table 37: CRAM attributes, metrics and submetrics (taken from CWMW, 2013a)

Attributes		Metrics and Submetrics
Buffer and Landscape Context		Aquatic Area Abundance or Steam Corridor Continuity
		Stream Corridor Continuity (Bar-built estuaries only)
		Aquatic Area in Adjacent Landscape (Bar-built estuaries only)
		Marine Connectivity (Bar-built estuaries only)
		Buffer:
		Percent of AA with Buffer
		Average Buffer Width
		Buffer Condition
Hydrology		Water Source
		Hydroperiod or Channel Stability
		Hydrologic Connectivity
Structure	Physical	Structural Patch Richness
		Topographic Complexity
	Biotic	Plant Community:
		Number of Plant Layers Present or Endemic Species Richness (vernal pools only)
		Number of Co-dominant Species
		Percent Invasion
		Horizontal Interspersion
		Vertical Biotic Structure

CRAM yields an overall score for each assessed area based on the component scores for the attributes and their metrics (CWMW, 2013a).

CRAM also provides guidelines for identifying stressors that might account for low scores (CWMW, 2013). The stressor checklist allows researchers and managers to explore possible relationships between condition and stress, and to identify actions to counter stressor effects (CWMW, 2013a).

10.3.2 Australian Rapid Assessment Methods for Wetland

10.3.2.1 Wetland Assessment Techniques

The Australian Wetland Assessment Techniques provides a method for wetland managers to assess and monitor the health of wetlands. It is designed for use by individuals with various levels of knowledge of wetlands, but knowledge of the local area in which the assessment is being conducted and potential impacts in the area are necessary.

The method assesses wetland health by calculating indices, with some indices common to all wetland types and others based on the properties and functions of the wetland type. Indices which are included in the assessment area include:

- Connectivity index.
- Human disturbance index.
- Acid sulphate soils index.
- Vegetation index.
- Habitat index.
- Indexes relevant to wetland type.

Indices are combined into a health index for the wetland under assessment.

A Management Options Section is provided with prompts to identify activities which will improve wetland health. These can be used as a basis for more detailed management planning.

The advantage of the method is that is does not require extensive knowledge of plant species; is easy to follow and can be specific to a wetland type. Limitations of the method is that it cannot currently be applied to all wetland types and guidance is not give on the sampling methodology.

10.3.2.2 Index of Wetland Conditions

The Index of Wetland Condition (IWC) is a method developed in Victoria, Australia for rapid assessment of wetland condition. It is based on the state of the biological, physical and chemical components of the wetland ecosystem and their interactions. The method aims to differentiate natural from human induced changes in wetland condition. The IWC is based on the following principles (Victorian Government, 2005):

1. suitable for use at all naturally occurring, non-flowing wetlands without a marine hydrological influence in Victoria.
2. a tool for the surveillance of wetland extent and condition over a 10-20-year timeframe.
3. suitable for use at a wetland at any time of year.
4. designed to assess wetland condition in a single visit.
5. a rapid assessment tool.
6. simple, straightforward and inexpensive.
7. easy to interpret.
8. based on the key ecological components of the wetland and its catchment.
9. be sufficient to determine significant human-induced change in the state of the wetland.
10. The reference benchmark for condition assessment is the wetland unmodified by human impact associated with European settlement.

The IWC takes the form of a hierarchical index, with six sub-indices based on the characteristics that define wetlands: wetland catchment, physical form, hydrology, soils, water properties and biota (Table 38) (Victoria Government, 2005). The components within each characteristic form the basis for the determination of possible measures to include in the IWC.

Table 38: Hierarchical index of the IWC (taken from Victoria Government, 2005)

IWC sub-index	Key ecological component	Measure	Measure type
Wetland catchment	Wetland catchment	Percentage of land in different land use intensity classes adjacent to the wetland	Threat
	Wetland buffer	Average width of the buffer	Component
		Percentage of wetland perimeter with a buffer	Component
Physical form	Area of the wetland	Percentage reduction in wetland area	Component
	Wetland form	Percentage of wetland where activities (excavation and landforming) have resulted in a change in bathymetry	Threat
Hydrology	Water regime	Severity of activities that change the water regime	Threat
Water properties	Macronutrients (such as nitrogen and phosphorus)	Activities leading to an input of nutrients to the wetland	Threat
	Electrical conductivity (salinity)	Factors likely to lead to wetland salinisation • input of saline water to the wetland • wetland occurs in a salinity risk area	Threat
Soils	Soil physical properties (structure, texture, consistency and profile)	Percentage and severity of wetland soil disturbance	Impact
Biota	Wetland plants	Wetland vegetation quality assessment based on: • critical lifeforms • presence of weeds • indicators of altered processes • vegetation structure and health	 Component Impact Impact Component

The advantage of the IWC rapid assessment method is that it is continually tested and developed; is designed, as far as possible to meet objectives; is simple, straightforward and inexpensive and is easy to interpret. However, the limitations of the method are that is required systematic use and testing as part of a continuing process of development; that some key ecological components, e.g. wetland catchment, pH and turbidity, are not measured and there is lack of knowledge of reference conditions.

10.4 Literature Review of International Wetland Monitoring

Environmental monitoring, including monitoring of wetlands, has received increasing attention in recent years (Finlayson, 1999). Concern over loss and degradation of wetlands has directed greater attention and effort on developing effective wetland management processes and responses (Finlayson, 1999). To ensure wetland management process and responses are effective, relevant information of the problem, cause of the problem and effectiveness of addressing the problem are necessary, hence effective monitoring programmes are required.

Monitoring of wetlands facilitates the reporting of change or lack of change through time and at particular places (Finlayson, 1999). Monitoring by definition, is conducted to address a specific target of goal. A survey, on the other hand, is conducted without any preconception of what the findings may be and surveillance is a time series surveys to determine the change, variability and/or range of values of a particular parameters (Finlayson, 1999). Thus monitoring is effectively surveillance which collects data or information over time with a specific reason for collecting the data or information (Finlayson, 1999).

Ideally, a wetland or assessment area which is prioritised for monitoring should have a wetland management plan. A well-designed monitoring programme would have little value and will thus not likely be implemented if the information that is collected is not utilised to manage the site. A management plan provides a means for responding to information collected from the monitoring programme, but also provide guidance and a reason for collecting the data or information in the monitoring programme. Essentially, monitoring provides the means of measuring the output of the management procedure – that is, it provides the means of measuring the (observed) state of the environment and the extent to which it may have been altered (Finlayson, 1999)

10.4.1 RAMSAR Wetland Monitoring

The Ramsar Convention Framework for designing wetland monitoring, shown in Figure 38, follows a 10-step process. The site-specific process also demonstrates a number of iterative, feedback loops which provide the means of reassessing the effectiveness of the preferred method in achieving the objective of site specific monitoring. Typically, the collection of specific information for management purposes is done in response to this hypothesis. A hypothesis is defined as a concept that is not yet verified but that, if true, would explain certain facts or phenomena (Western Australian Department of Environment and Conservation, undated).

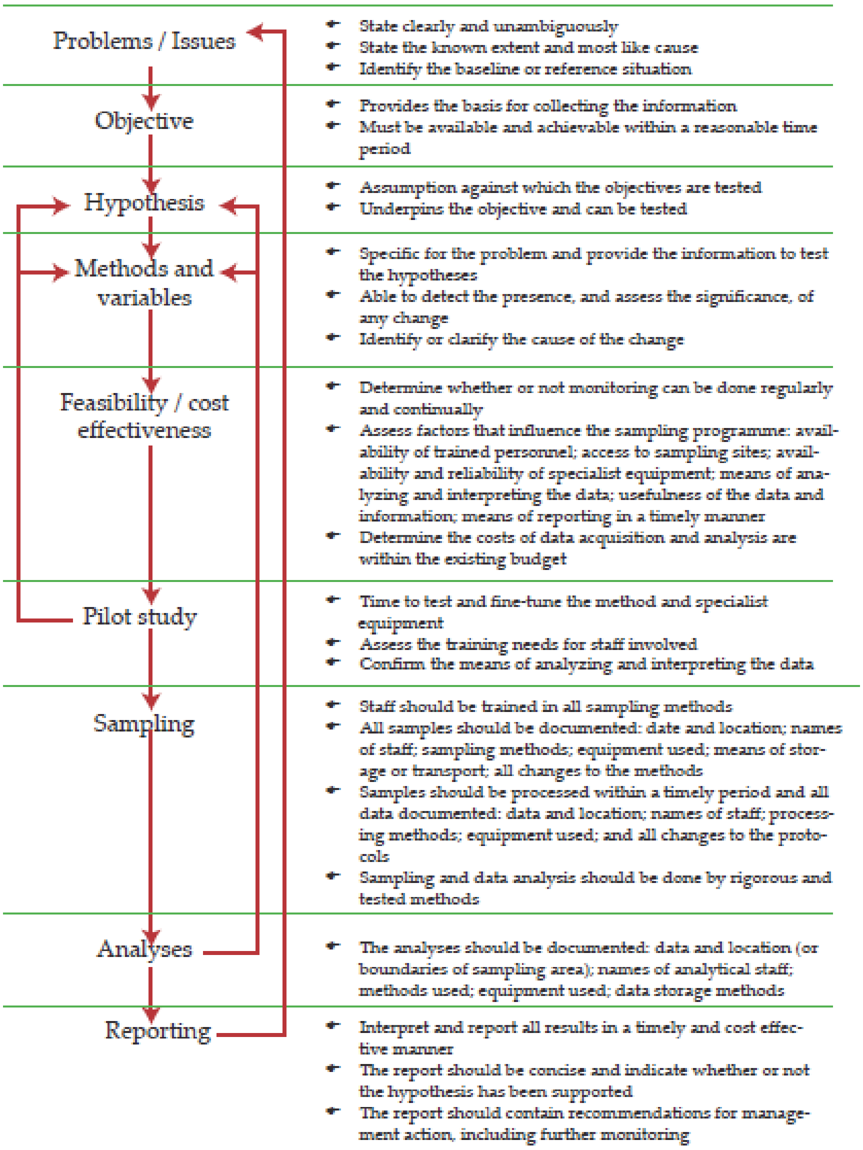

Figure 38: The recommended Ramsar Convention Framework for designing a wetland monitoring programme and for site-specific monitoring (taken from Ramsar, 2010)

Regardless of the approach adopted for the site-specific monitoring system the following four questions must be answered when planning a monitoring program (Western Australian Department of Environment and Conservation, undated):

• What is the hypothesis to be tested?

• How much confidence is required in the answer?

• Which indicators will be measured?

• How will the collected data be analysed?

Defining the hypothesis is probably the most important step in the design of a site-specific monitoring system. Without a meaningful question to answer, it will be difficult to know what to measure or how to measure it and data that are collected will lack context and may not inform management of the site (Western Australian Department of Environment and Conservation, undated).

The monitoring hypothesis for the site will clearly identify the issue being investigated, the change that is expected in the ecological character of the site and the timeframe for the observed change to occur (Western Australian Department of Environment and Conservation, undated). A hypothetical example is shown in Table 39.

One of the key aspects to be discussed and agreed for the site-specific monitoring system will be to decide whether a hypothesis will:

- ✓ Be developed for each wetland?
- ✓ Be developed for each wetland type?
- ✓ Be developed for all wetlands?

The review of current available data and information for wetlands will determine whether the purpose of the monitoring can be achieved from existing data and information or whether further field survey is required to meet the requirements of the monitoring system (Ramsar, 2005b).

Table 39: A hypothetical example to a programme to monitor changes in a wetland (taken from DEC, undated)

A hypothetical example of a programme to monitor changes in wetland area, water regime and sedimentation and unwise use of natural resources. In this example it is assumed that adequate baseline data on the extent of wetland exists prior to monitoring commencing. Furthermore, this example excludes the explanation of the rationale behind the choice of objectives, methods, etc. but it is reiterated that the designers need to make decisions and record the reasons and detail on which these are based.	
General problem or issue	a) Changes of wetland area b) Changes in water regime and sedimentation c) Unwise use of natural resources
Specific problem/ issue	a) Monitor the extent of threatened habitat type b) Monitor lake water level, sedimentation, duration of flooding c) Monitor grazing pressure and fisheries production
Hypothesis	a) The area of threatened habitats will not decrease significantly from the current area b) The lake water level will not exceed above the threshold from the Mean Sea Level Max flooding will not exceed a specified period. Sedimentation will not exceed the average of the past specified period (10 years). c) Grazing pressure, and fishing will not exceed the average of the last specified period (10 years)
Assessment Indicators, Methods and variables	a) Identify means of mapping the wetland area from aerial photography b) Field verification/ ground truth every specified period (5 years) c) Daily records of lake water level. Surveys for sedimentation. Duration for flooding at specific plots. d) Population surveys for birds e) Records of grazing animals and fish production

Feasibility/ cost effectiveness	a) Establish the availability of the equipment, the suitability of the photographs, ground inspection techniques and mapping techniques, etc. b) Determine the cost of obtaining and interpreting the photographs and assessing data and ground surveys c) SANBI will provide baseline information (if available) d) Identify statistical limits on the data
Pilot Study	a) Test equipment under field conditions and check reliability of data interpretation methods, statistical procedures, etc. b) Ground truthing may be necessary to confirm reliability of data c) Train staff in collecting and interpreting the data and statistical analysis
Sampling	a) Collect aerial photographs, interpret and store data b) Undertake ground surveys (Every 5 years) (Daily & monthly records to lake water levels)
Sample Analysis	a) Statistical comparison with baseline information
Reporting	a) Statistical analysis and interpreted and reported identify to whom and within what time period with conclusions and recommendations for management action and/further monitoring b) Annual reporting
Program Evaluation	a) Stop monitoring if/when it is shown that the changes have stopped occurring b) Evaluate to check if the framework is effective.

Ramsar has also developed a number of monitoring indicators, including eight effectiveness indicators which may have one or more sub-indicators. A further five indicators are recommended by Ramsar for further consideration and development. The initial eight indicators are:

Indicator	Sub-indicator(s)
A. The overall conservation status of wetlands	i. Status and trends in wetland ecosystem extent ii. Trends in conservation status – qualitative assessment
B. The status of the ecological character of Ramsar Sites	i. Trends in the status of Ramsar Site ecological character – qualitative assessment
C. Trends in water quality	i. Trends in dissolved nitrate (or nitrogen) concentration ii. Trends in Biological Oxygen Demand (BOD)
D. The frequency of threats affecting Ramsar Sites	i. The frequency of threats affecting Ramsar Sites – qualitative assessment
E. Wetland sites with successfully implemented conservation or wise use management plans	i. Wetland sites with successfully implemented conservation or wise use management plans
F. Overall population trends of wetland taxa	i. Trends in the status of waterbird biogeographic populations
G. Changes in threat status of wetland taxa	i. Trends in the status of globally-threatened wetland-dependent birds ii. Trends in the status of globally-threatened wetland-dependent amphibians
H. The proportion of candidate Ramsar sites designated so far for wetland types/features	i. Coverage of the wetland resource by designated Ramsar sites
E. Wetland sites with successfully implemented conservation or wise use management plans	i. Wetland sites with successfully implemented conservation or wise use management plans

10.4.2 Australia Wetland Monitoring Methods

10.4.2.1 Finlayson Monitoring Framework

Spiers and Finlayson (1999) recommends a framework for designing a monitoring program, based on the MedWet Mediterranean wetland program (Finlayson, 1996a) and the Ramsar International Wetland Convention

(Finlayson, 1996b). The framework can be applied to all forms of monitoring (e.g. changes in the area of a wetland, the ecological health of a wetland, or the underlying reasons behind the loss of wetlands). The framework is effectively a series of steps that can assist those charged with designing a monitoring program to make decisions suitable for their own situation.

Finlayson (1999) recommends that the development of a monitoring programme for a site or assessment area should be a cooperative process between managers (who make decisions) and scientists (who provide expert advice and interpret data). The managers would outline the need for a monitoring program and the scientists recommend the most appropriate techniques and, by an iterative process, an approach that has both scientific rigour and meets the management objectives will be developed.

The monitoring framework provides a systematic, structure way of designing the monitoring programme using 10 steps (Figure 39). The framework is not prescriptive and therefore, not all steps may be given equal attention. Managers and designers will make their own decisions based on local circumstances – the framework provides a guide to assist them in making these decisions (Finlayson, 1999).

Figure 39: Finlayson (1999) recommended framework for design of a wetland monitoring programme (taken from Finlayson, 1999)

10.4.3 New Zealand – Wetland Monitoring Project

The Environmental Performance Indicators (EPI) Programme is being coordinated by the NZ Ministry for the Environment. The purpose of this programme is to build on existing information and monitoring efforts to develop a core set of national environmental performance indicators for use throughout New Zealand and to support improved policy decisions. The project began in 1998 and involved development of New Zealand wetlands classification system and a method for monitoring change in wetland extent.

The focus of the New Zealand wetlands monitoring project was on estuarine (coastal wetlands semi-enclosed by land and dominated by effects of saline water) and palustrine (dominated by shallow freshwater with attached/rooted vegetation) wetlands.

The New Zealand wetland monitoring project made use of two indicators, soil and vegetation. Studies had identified that these indicators were the most important indicators of wetland condition, simply because they are not mobile and can be sampled in most of the estuarine and palustrine wetlands (Cowardin et al., 1979; Faulkner et al., 1989; Tiner, 1991, 1999).

The monitoring showed that more information was required to encompass the full range of geographical and altitudinal range, size, class, vegetation composition and structure, and degree of modification inherent in wetlands throughout New Zealand. Therefore, a national wetland database was recently established to utilise the monitoring data collected from the 15 wetlands visited during indicator development.

Overall, the information obtained from the wetland database will be used mainly to assist in progressive indicator development and in determining critical limits that can be used for setting goals and measuring performance in New Zealand.

10.4.4 USA – Dakota Wetland Health Evaluation Program (WHEP)

WHEP was initiated in 1997 as a volunteer monitoring program for monitoring of wetlands in Dakota County, Minnesota, USA (Fortin Consulting, 2015). The aim of the program is to monitor changes in the health of approximately 169 wetlands across the Country. The program further assists decision makers, engineers, resource managers, in identifying the highest quality wetland resources.

WHEP uses vegetation and micro-invertebrates as indicators:

- Vegetation is samples using a standard 100 square metre plot representing vegetation type found in the wetland.
- Micro-invertebrates are sampled using a dipnet and bottletrap samples from each wetland site. The dipnet sample provides the widest number of species, while the bottletrap sample, collected by submerging two litre designed bottle mounted on a dowel, allows the volunteers to catch the actively swimming predators.

WHEP uses the vegetation and micro-invertebrates to estimate an Index of Biological Integrity (IBI), a scoring process to interpret the condition of wetlands. The Index of Biotic Integrity (IBI) (poor, moderate, excellent) provides an estimate of the health of each wetland (Fortin Consulting, 2015).

Volunteers are trained to collect this wetland data on macroinvertebrates and vegetation (Fortin Consulting, 2015). In 2014, 95 Dakota County WHEP volunteers (ten of which helped two or more teams) donated more than 1,630 hours in training, sample collection and sample identification in completion of this wetland monitoring initiative (Fortin Consulting, 2015).

Results from the 2014 WHEP assessment, shown in Figure 40, indicate and the majority of wetland which were monitored had a moderate invertebrate and vegetation score.

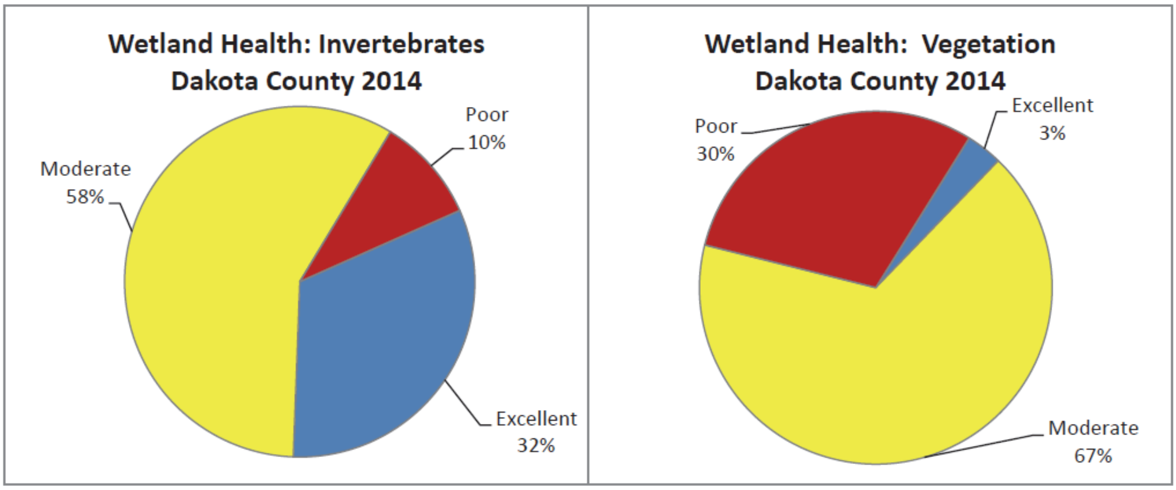

Figure 40: Percent of wetland in Dakota County with poor, moderate and excellent invertebrates and vegetation IBI scores (taken from Fortin Consulting, 2015)

The 2014 monitoring of wetland was also subjected to trend analysis. Results, shown in Figure 41, showed that 34 percent of wetlands demonstrated improved invertebrate IBIs, with none of the wetland demonstrating a decline in score. A smaller percent of wetlands had improved vegetation IBI scores, but 13% showed a decline in these scores (Fortin Consulting, 2015). The monitoring programme also attempted to identify some of the causes of wetland health conditions, however, no significant relationships were found between IBI scores and wetland alterations (Fortin Consulting, 2015).

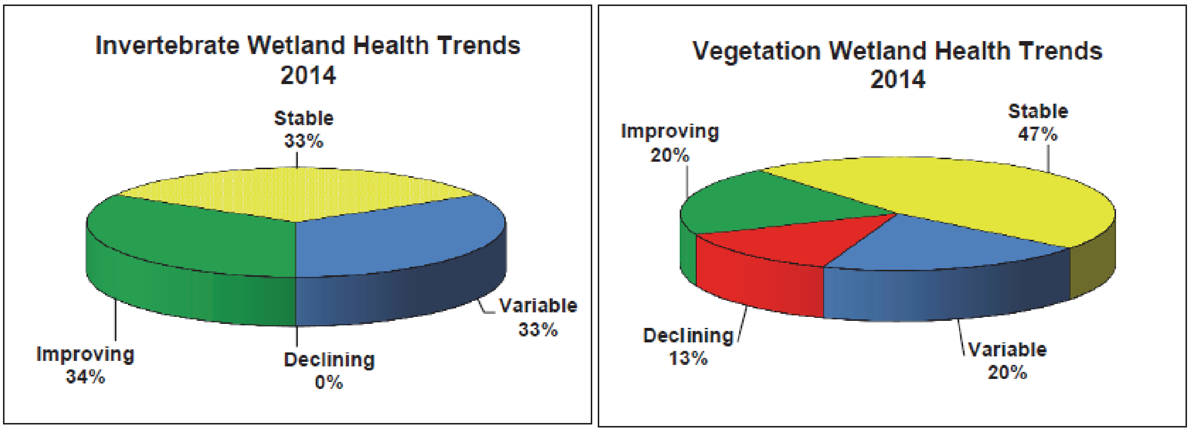

Figure 41: Trends in wetland IBI scores as an indication of wetland health Dakota County (taken from Fortin Consulting, 2015)

The disadvantage of this method of wetland monitoring is that biological data can be difficult to interpret and that the WHEP methods are designed for one to identify wetland health conditions, not addressing the cause of poor wetland condition. It is essential that stressor, including the surrounding land use and other potential stressors, be assessed.

10.5 Wetland Prioritisation

Most countries recognise that it is not possible to assess or monitor all wetlands. Countries have thus developed means of prioritisation of wetlands for management, conservation and monitoring using various methods. The methods of prioritisation is usually determined by the purpose and scale of the prioritisation. For example:

- RAMSAR recommends 9 criteria for prioritisation of wetlands of international importance (see Section 10.4.1)

- The Directory of Importance Wetlands in Australia (DIWA) also utilises criteria to prioritise wetlands of national importance (see Section 10.4.2)
- The US EPA utilises random statistical prioritisation of wetlands for inclusion in the National Wetland Condition Assessment (see Section 10.4.3).

A summary of the various methods of prioritisation, from literature, are provided below.

10.5.1 RAMSAR Wetlands of Importance

An important obligation under the Ramsar International Wetland Convention is for each Contracting Party to 'designate suitable wetlands within their territory for inclusion in a List of Wetlands of International Importance'. The Convention provides a suite of criteria for identifying wetlands of international importance, including that wetland can be considered as international important if it:

- Criterion 1: contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Criterion 2: supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
- Criterion 3: supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- Criterion 4: supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
- Criterion 5: regularly supports 20,000 or more waterbirds.
- Criterion 6: regularly supports 1% of the individuals in a population of one species or subspecies of waterbirds.
- Criterion 7: supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
- Criterion 8: is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
- Criterion 9: regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

An important component of inclusion of a wetland into the List of Internationally Important Wetlands is the need the obligation to inform the Ramsar Bureau 'if the ecological character of any wetland in their territory and included in the List has changed, is changing, or is likely to change as the result of technological developments, pollution or other human interference' (Ramsar Convention). A framework for designing a wetland monitoring programme was adopted by COP6 (Resolution VI.1) in 1996.

10.5.2 Australian prioritisation of nationally important wetlands

Australia has prioritised wetland of national importance and included these in a Directory for the country. The Directory of Importance Wetlands in Australia (DIWA) is intended to augment the list of wetlands of international importance under the Ramsar Convention. Eligibility of wetlands for inclusion in the Directory of nationally important wetlands is determined based on criteria which were agreed by the ANZECC Wetlands Network in 1994. If a wetland meets at least one of the following criteria they may considered nationally important (Australian Government, Department of Environment):

1. A good example of a wetland type occurring within a biogeographic region in Australia.
2. Plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.

3. Is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.
4. Supports 1% or more of the national populations of any native plant or animal taxa.
5. Supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.
6. Is of outstanding historical or cultural significance.

Australia Government, Department of Environment indicated that there was a degree of subjectivity when applying certain of the criteria at the individual wetland sites, as each investigator may evaluate the site different again a particular criterion – hence different degree of significance would be obtained by the different investigators. Similarly, gaps in data related to certain criteria may affect the determination of the significance of the site. To address some of the limitations with the use of criteria for prioritisation, Australia has adopted a bioregional approach to listing sites in the Directory, minimising the difficulty in applying the criterion related to system's uniqueness or representativeness.

Australia has 65 RAMSAR sites and 800 wetlands of nationally important wetlands.

10.5.3 Prioritisation of Wetland in the US EPA Wetland Condition Assessment

The selection of the sites to be included in the NWCA was completed in two steps (EPA, in review)

a) the approximately 5,000 4-square mile plots from the US Fish and Wildlife Service's Status and Trends (S&T) database were used to identify wetlands in the first step. The S&T survey is an area frame design stratified by state and physiographic region (Dahl and Bergeson,2009; Dahl, 2011). This step results in the aerial imagery interpretation of land cover types focused on S&T Wetland Categories within each 2-mile by 2-mile plot selected (S&T sample size is 5,048 plots).
b) a Generalized Random Tessellation Stratified (GRTS) survey design (Stevens and Olsen 121, 1999; Stevens and Olsen, 2004) for an area resource was applied to the S&T wetland polygons. This step was stratified by state with unequal probability of selection by seven ***NWCA Wetland Types*** based on a subset of the S&T Wetland Categories.

The NWCA sample size was 996 (900 sites + 96 revisited sites) sites for the conterminous 48 states, with the following sample size for wetland types (EPA, in review):

Wetland type	Sample	Max Sample per State
Estuarine intertidal emergent	*128*	*13* (coastal states)
Estuarine intertidal forested and shrub	127	13 (coastal states)
Emergent wetlands in palustrine, shallow riverine, or shallow lacustrine littoral settings	129	10
Shrub-dominated wetlands in palustrine, shallow riverine, or shallow lacustrine littoral settings	129	10
Forested wetlands in palustrine, shallow riverine, or shallow lacustrine littoral settings	129	10
Farmed wetlands in palustrine, shallow riverine, or shallow lacustrine littoral settings; subset that was previously farmed, but not currently in crop production	129	10
Open-water ponds and aquatic bed wetlands	129	10

The minimum number of sites for a state was 8. The NWCA did accommodate modification of sampling, etc. by the states – for example (EPA, in review):

- Wisconsin chose to intensively study the Southeastern Plains till region in addition to the sites sampled for the national estimates as part of the NWCA.
- Ohio decided to base their survey design on a current digital map of wetlands in the state.
- The Wetland Status and Trends Monitoring Program survey design was the basis for the Minnesota NWCA design.

11 APPENDIX C: INDICATORS EXCLUDED FROM NWMP

Indicator	Reason for Exclusion
Faunal Indicator (small inverts)	There is currently no protocol or method to report this indicator.
Soil Erosion Indicator	The linked between soil erosion as a stressor and wetland condition; function and use still needs to be scientifically demonstrated for wetlands in South Africa.
Biological Index	*South Africa is still a long way from using biotic indices that account for its diversity of wetland types and biota. In addition, biota can also be time consuming to describe, and require a high level of specialist input. Furthermore, once described, the biotic indices often do not indicate the nature of the human stressors that have contributed to the decline in ecological condition, and therefore provide little insight into management requirements* (Kotze et al., 2012)
Hydroperiod Indicator	Indicator under investigation – however, not currently measurable
Biological Assessment Indicator	See biological index above

12 APPENDIX D: GUIDE TO DATA FIELD REQUIRED FOR THE NWMP DATABASE

Data Field Name	Description
Wet_Unit_ID	The identifier for a HGM unit
WetlandName	Name of the wetland (if available)
HGM type	Wetland Hydrogeomorphic Types from Ollis et al. (2013).
WMA	Water management area name (source
Ecoregion 1	Name of Ecoregion 1 (source DWA www
Ecoregion 2	Name of Ecoregion 2
Quinary_Number	Sub-quaternary number (source NWI or DWA sub-quaternary data set)
Quinary_Area_msq	Sub-quaternary area (m3) (calculate using field calculator)
Quinary_Area_ha	Sub-quaternary area (ha) (calculate using field calculator)
Wet_Unit_AREA_msq	Area of HGM unit (m3) (source NWI)
Wet_Unit _Area_ha	Area of HGM unit (ha) (source NWI)
Landcover	Hectare of landcover types surround the wetland unit (source: Section 5.2 of the NWMP Implementation Manual)
Landownship	Landownership surrounding wetland unit (source: see Section 5.3 of WRC NWMP Implementation Manual)
Prot_Site_Type	Type of protected area in which the wetland unit is located (source: see Section 5.4 of the NWMP Implementation Manual)
Rainfall Region	Data collected using Attributes Tables see Appendix 1 of the NWMP Implementation Manual)
Landuse in Catchment (visible at site)	Data visually collected using Attributes Table (see Appendix 1 of the NWMP Implementation Manual)
CLUSTERID	NFEPA cluster (source: NWI)
WETVEGGRP	Mucine and Rutherford veg group in which the wetland unit is located (source: NWI)
Protection_level	NBA ecosystem protection level which indicates the protection level of ecosystems (see Section 4.2.3) (source: NWI)
Threat_Status	NBA ecosystem threat status which provides the degree of intactness of ecosystems (see Section 4.2.3) (source: NWI)
Center of Endemism	
MAR_Class	
Name of strategic water area	
Assessment Status	Shows whether a NWMP assessment has already been conducted at the unit (Yes/No)
Assess_Date	Provides the date on which the NWMP assessment was conducted
Name_Assessor	Provides the name of the assessor
Affil_Assessor	Provides the organisaiton/institution of the assessor
Assessor_cert	Shows the credentials of the assessor (i.e. SACNASP number/NWMP certification)
Landowner_name_contact	Provides the name and contact of the landowners of the site
Province	Provides the province in which the site is located
Political_region	Provide the municipality in which the site is located

Closest_town	Provides the town closes to the site
Altitude	Altitude of the HGM unit – determined with GPS
Mean_Annual_Preception (MAP)	Data collected using Attributes Tables
Long/lat	Determine at site with GPS
Approximate size of wetland unit	(source: see 5.1 and 5.8 and section 6.3.2 of the NWMP Implementation Manual)
Approximate size of area assessed unit	(source: see 5.1 and 5.8 and section 6.3.2 of the NWMP Implementation Manual)
Urban/rural area	Location of the HGM unit (rural are or urban area) (see Appendix 1 of WRC the NWMP Implementation Manual)
Presence/evidence of:	Data collected using Attributes Tables (see Appendix 1 of WRC Report xxx: NWMP Implementation Manual)
Ass_Geomorph PES	(source: see Section 2.4.4 of the NWMP Implementation Manual)
Ass_Hydro PES	(source: see Section 2.4.3 of the NWMP Implementation Manual)
Ass_Veg PES	(source: see Section 2.4.5 of the NWMP Implementation Manual)
Ass_Alien Risk Score	(source: see Section 2.4.8 of the NWMP Implementation Manual)
Ass_PES based on Landuse	(source: see Section 2.4.7 of the NWMP Implementation Manual)
Ass_EcoServices	(source: see Section 2.4.9 of the NWMP Implementation Manual)
Provincial Conservation Strategy Status	Demonstrates the conservation status of the wetland (source: BGIS)
NWI_Frog	NBA frog layer (source: NWI)
NWI_CWAC	NBA CWAC layer (source: NWI)
NWI_CRANE	NBA CRANE layer (source: NWI)
Mon_Geomorph PES	(source: see Section 7.2 of the NWMP Implementation Manual)
Mon _Hydro PES	(source: see Section 7.2 of the NWMP Implementation Manual)
Mon _Veg PES	(source: see Section 7.2 of the NWMP Implementation Manual)
Mon _Alien Risk Score	(source: see Section 7.11 of the NWMP Implementation Manual)
Mon _PES based on Landuse	(source: see Section 7.4 of the NWMP Implementation Manual)
Mon_Amphibians	(source: see Section 7.7 of the NWMP Implementation Manual)
Mon_Waterbirds	(source: see Section 7.8 of the NWMP Implementation Manual)
Mon_Invert	(source: see Section 7.5 of the NWMP Implementation Manual)
NWI_EcoService	(source: see Section 7.3 of the NWMP Implementation Manual)
Mon_Diatoms	(source: see Section 7.6 of the NWMP Implementation Manual)
Mon_Fish	(source: see Section 7.10 of the NWMP Implementation Manual)

13 APPENDIX E: LITERATURE REVIEW OF WETLAND BUFFER REQUIREMENTS

One of the key considerations in the NWMP is the size of the buffer area around a wetland which should be included in a number of indicators (i.e. landuse around the wetland and landownership around the wetland). Hence, this section of the report provides a review of the literature of international norms related to this issue.

Scientific research published since the 1970s has documented the value of establishing, maintaining, and enhancing vegetated buffers along wetlands (City of Boulders and Biohabitats, 2007). In the literature, the discussion around buffer zones for wetland related largely to buffer size necessary to protect a wetland. Since landuse activities around and in a wetland can impact the health of the wetland, common practice is to maintain a buffer zone around the wetland (Castelle et al., 1994). Terrestrial habitats surrounding wetlands are critical for the management of water and wildlife resources (Semlitsch and Bodie, 2003). Buffers are defined by Castelle et al. (1994) as *vegetation zones located between natural resources and adjacent subject to human alteration.* The efficacy of the buffer depends on various factors, including buffer width, slope, soil type, condition and type of vegetation, and buffer strips can act as sources as well as sinks of runoff, chemicals and sediment (Endreny and Wood, 2003).

Although most would agree that a buffer zone is necessary to protect a wetland, there is often little agreement of the degree of buffering required (Castelle et al., 1994). A buffer which is too small may not protect the resource, while a buffer which is overly large may impact on landuse and ownership around the resource. Castelle *et al*. (1992) suggest four criteria for determining adequate buffer sizes for aquatic systems:

1. *resource functional value (i.e. ecosystem function and ecosystem service perspective)*
2. *intensity of adjacent land use*
3. *buffer characteristics (e.g. slope, soil type, nature (natural versus artificial barrier, etc.)*
4. *specific buffer functions required (e.g. sediment/nutrient removal, species diversity, etc.)*.

Wetland buffers provide a number of functions, which can be utilised to determine the buffer zone (Table 40 and Figure 42). Literature indicates that a terrestrial buffers or riparian strips 30-60 m wide was effective to protect water resources (Semlitsch and Bodie, 2003).

Table 40: Recommended buffer zone widths for wetland/riparian ecosystems (taken from ANPC, 2012)

Aspect	Objective	Recommended buffer width*
Temperature	Water temperature moderation/ shade	12 – 30 m
		20 m[a]
	Maintain microclimate gradient	45 m
Nutrients	Reduce nutrient inputs (removal)	100 m[b]
		200 m (sandy soils)
	(reducing nitrate)	30 m
		30 – 48 m
	(removal of phosphorus)	9 – 30 m
	(removal of nitrogen)	30 – 48 m
Pollution	Reduce pollution (heavy metal) input	100 m[b]
		200 m (sandy soils)
	Reduce pollution (pesticide removal)	> 15 m
Sediment	Reduce sedimentation (removal)	9 – 30 m
		30 m
		10 – 65 m
		100 m[a]
Water quality	Improving/protection of water quality	5 – 30 m
		≥ 6 m[c]
	Protection from land use	30 - 60 m
Ecological processes	Maintain ecological processes/major food webs	10 – 30 m
	(carbon flow)	20 – 50 m[d]
	(large woody debris and organic litter)	30 – 50 m
Bank stability	Protect bank stability	20 – 30 m
Biodiversity	Protect biodiversity (species diversity)/ wildlife/ habitat	30 – 90 m
		3 – 120 m
		> 100 m
		100 – 170 m
	Bird habitat	40 – 500 m
	Reptile/amphibian habitat	30 – 1000 m[e]
	Mammal habitat	> 50 m
	Maintain benthic invertebrates in streams adjacent to logging	32 m
Insects	Nuisance insects	100 – 800 m[f]
Groundwater	Protection of inflowing groundwater quality	2000 m[g]
	Minimise groundwater drawdown	[h]35 – 170 m
Salinity	Protection from rising salinity	250 m

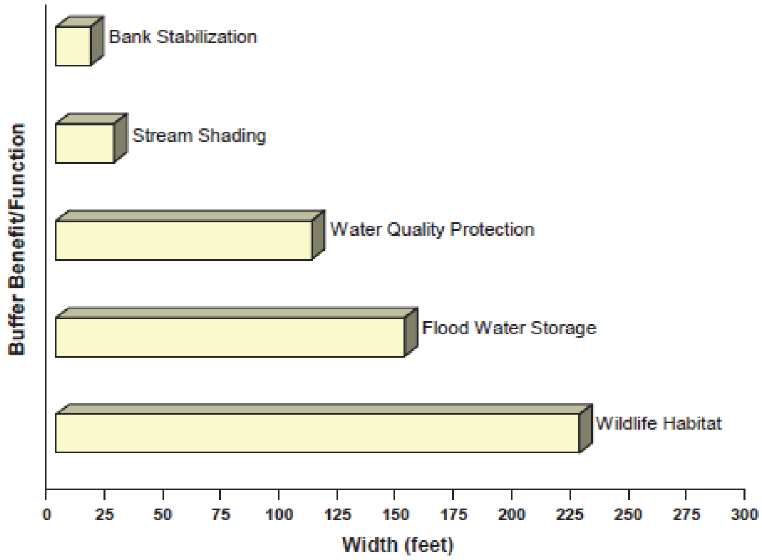

Figure 42: Aquatic Buffer Width Correlated to Ecological Function (taken from City of Boulders and Biohabitat, 2007)

Several studies suggest larger wetland buffer widths, such as 200 to 500 m, are more effective for protecting fauna such as birds and reptiles, or reducing heavy metal pollution. Semlitsch and Bodie (2003) indicates that the terrestrial habitats surrounding wetlands are important for more than just the protection of water resources, including the conservation and management of semiaquatic species. As a result, Semlitsch and Bodie (2003) propose that stratification should include three terrestrial zones adjacent to core aquatic and wetland habitats (Figure 43):

1. *"a first terrestrial zone immediately adjacent to the aquatic habitat, which is restricted from use and designed to buffer the core aquatic habitat and protect water resources;*
2. *starting again from the wetland edge and overlapping with the first zone, a second terrestrial zone that encompasses the core terrestrial habitat defined by semiaquatic focal-group use (e.g. amphibians); and*
3. *a third zone, outside the second zone, that serves to buffer the core terrestrial habitat from edge effects from surrounding land use (e.g. 50 m; Murcia, 1995)".*

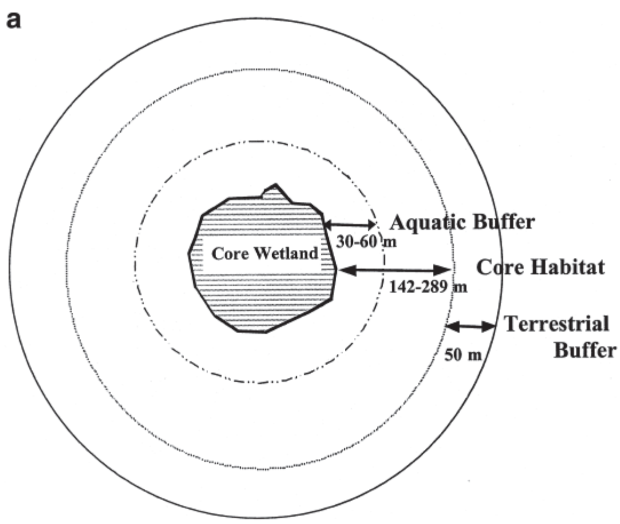

Figure 43: Zones of protection of wetlands as proposed by Semlitsch and Bodie (2003). Both core habitat and aquatic buffer requirements are met within the second zone, which may range from 142 to 289 m to meet the needs of amphibians and reptiles and. An additional 50-m buffer is recommended to protect core habitat from edge effects (Murcia, 1995) (taken from Semlitsch and Bodie (2003)).

Similar to international experiences, South Africa has no stipulated required wetland buffer size. The *Wetland offsets: a best-practice guideline for South Africa* (Macfarlane et al., 2014) does however, utilise a buffer zone of 500 m around the wetland. This guide is utilised to determine the relative proportion of different landuses within a 500 m delineated buffer of the wetland and to mapped and assess these according to the relative ability of the landuse to support wetland dependant species (Macfarlane et al., 2014). This buffer zone is utilised to determine off-set requirements for a wetland.

From a regulatory perspective, CARA stipulates that no Type 2 or 3 listed species should be within 30 meters of a wetland, while the recent GENERAL AUTHORISATION IN TERMS OF SECTION 39 OF THE NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998), which are currently out for public comment, defines the "extent of a watercourse" to include (for wetlands and pans) the area "within a 500 m radius from the boundary (temporary zone) of any wetland or pan" (when the temporary zone is not present then the seasonal zone are delineated as the wetland boundary).

The NWMP thus recommends the use of 100 m buffer around wetlands for determining the extent of landuse and landownership surrounding wetland in the country. This buffer size may however, have to be adjusted with regulatory change.

14 APPENDIX F: GUIDE TO PRIORITISATION OF TIER 2 WETLANDS

The size of the NMWP and the nature of available data sets, requires that the prioritisation process be split into two scales:

- a broad scale that prioritises wetlands in specified management units, and
- a fine scale that identifies assessment units within management units.

Data required for the Tier 2 prioritisation process are indicated in table 41.

Table 41: contains spatial data required for the Tier 2 prioritisation process.

Data	Source	Assumed Web address
Broad scale		
Latest national wetland inventory dataset	SANBI	bgis.sanbi.org
Latest sub-quaternary catchment dataset		
Latest national land cover dataset	SANBI	bgis.sanbi.org
Latest national protected areas dataset	DEA	egis.environment.gov.za
Latest provincial conservation plan maps dataset	SANBI	bgis.sanbi.org
Fine Scale		
Latest wetland clusters dataset	SANBI	bgis.sanbi.org
Provincial Biodiversity Conservation Plans dataset	SANBI	bgis.sanbi.org

14.1.1 Broad-scale management unit prioritisation (sub-quaternary catchments)

The broad-scale management units are represented by sub-quaternary catchments. Sub-quaternary catchments are recommended as the first level of prioritisation in the NWMP based on the fact that:

- the RHP has indicated a need for PES, EIS and ES categories to be identified for rivers at a sub-quaternary catchment level (specifically priority hydrological data inputs are needed at a sub-quaternary catchment level);
- the River Data Integration Model of the RHP utilises a sub-quaternary catchment scale (Dr Kleinhans, DWS, *pers. comm.*);
- the desktop mapping of Mpumalanga Highveld Wetlands found this scale as a useful scale for mapping of wetlands (Mbona et al., 2015);

The goal of prioritisation of wetlands for Tier 2 Assessment at a broad scale is thus *to determine a sample of sub-quaternary which display a range of trajectories of change in threats, vulnerability, protection and conservation importance to their wetlands*

Four criteria were used to prioritise these broad scale management units (sub-quaternary catchments):

1. **Threat to wetlands in the sub-quaternary catchment relative to the national extent of wetland**: the land-cover threat to wetlands in the sub-quaternary catchment are placed within the context of the national extent of wetlands. For example, in a sub-quaternary catchment with a large extent of wetlands which has a high percentage of mining within the 100 m area surrounding the wetlands, the assumption is that wetlands in this sub-quaternary catchment are a high threat in the context of the national extent of wetlands in the country and thus there is a need to prioritise this sub-quaternary catchment
2. **Vulnerability of wetlands in the sub-quaternary catchment:** the vulnerability of wetlands in the sub-quaternary is scored based on the extent of land-cover types within a 100 meter around the wetlands in the sub-quaternary catchment. The assumption is made that the lower the level of land-cover change in this 100 m area surrounding the wetlands in the sub-quaternary, the more vulnerable the wetlands in the sub-

quaternary catchment are to potential change. Therefore, there is a need to prioritise this sub-quaternary catchment for wetland assessment

3. **Level of protection of wetland in the sub-quaternary catchment:** this criterion utilises the level of protection of the wetland extent in the sub-quaternary catchment. The assumption made is that the lower the extent of wetlands in the sub-quaternary catchment which have protection, the greater the threat to change in the wetlands in the sub-quaternary catchment. Thus there is a need to prioritise this sub-quaternary catchment for wetland assessment.
4. **Conservation priority level of wetlands in the sub-quaternary catchment**: this criterion utilises the extent of wetland area in the sub-quaternary catchment which has been prioritised for conservation in provincial biodiversity conservation plans. The assumption is made that if a sub-quaternary catchment has a large extent of wetlands which have been prioritised for biodiversity conservation, there is a need to prioritise this sub-quaternary catchment for wetland assessment.

All the above criteria need to be segregated into these management units (sub-quaternary catchments) and placed in a database. Once all the required criteria are in the databased, the criteria must be weighted, scored and ranked to obtain the desired prioritisation of management units. The process to be followed is described below.

14.1.1.1 Developing the broad-scale database

Basedata: Extent

The relative extent of all wetlands within each management unit (sub-quaternary catchment) needs to be determined. This can be done by determining the area of sub-quaternary catchments and the wetlands within them. Overlay the latest wetland inventory layer with the sub-quaternary catchment layer. There are various wetland polygons which overlap sub-quaternary boundaries. This makes the extent determination within each sub-quaternary catchment problematic. These layers must thus be "Unionised", meaning they must be joined into a single shapefile. The sub-quaternary catchment layer must first be converted into lines to achieve the desired result.

The purpose of this is to split all wetland polygons, which may overlap sub-quaternary catchments, based on the boundaries of sub-quaternary catchments. Wetlands will thus fall perfectly into the management units chosen. This splitting of wetland polygons makes the extent determination process possible and provides the platform on which all other criteria will be incorporated into the database.

Once wetland polygons have been split, all wetland polygons found within each management unit must be attributed to their corresponding management unit. In other words, wetlands found within a management unit will be classified as belonging to that sub-quaternary catchment. This can be done by joining the attribute tables of the two layers, based on the location of the polygon within each layer (Join attributes by location). Please note, do not remove records which do not have a matching record – select the option which does not remove the sub-quaternary polygons which do not contain wetlands.

The extent (area) of wetlands within each management unit can be calculated by creating a new area field in the attribute table (using the field calculator).

The area of each sub-quaternary catchment must also be determined. This will allow for the calculation of relative extent of wetlands within each management unit. The area can be calculated using the field calculator.

This constructed sub-quaternary dataset will be the platform which shall be built on by incorporating the remainder of the required criteria. The "join attributes by location" function will be utilised extensively to include additional criteria into this database.

Criteria: Threat to national wetland extent and Vulnerability of Wetlands in the Sub-Quaternary Catchment

The threat from landcover within each management unit to the national extent of wetlands is determined by the land cover types within a 100 m area surround wetlands in the sub-quaternary catchment.

The land cover types can be determined by using the latest land cover vector data. Land cover within a 100 m area surround wetland within a sub-quaternary catchment can be determined by following the methods outlined in Section 5.2 of the WRC Report: NWMP Implementation Manual at a sub-quaternary spatial scale. This is done by clipping the 100 m buffer (obtained from the latest wetland inventory) from the latest land cover layer.

Once land cover 100 m buffer polygons have been split, all land cover polygons found within each management unit must be attributed to their corresponding management unit. In other words, land cover found within a management unit will be classified as belonging to that sub-quaternary catchment. This can be done by joining the attribute tables of the two layers, based on the location of the polygon within each layer (Join attributes by location). Please note, do not remove records which do not have a matching record – select the option which does not remove the sub-quaternary polygons which do not contain wetlands.

To determine the extent (Area) of land cover within each management unit, the sum of the area of each land cover polygon within each sub-quaternary catchment must be calculated. This can be done by calculating the area and editing the layer within the attribute table. The corresponding area of land cover within each management unit can be summed using the field calculator.

Criterion: Level of Protection of Wetlands in the Sub-Quaternary Catchment

The degree of protection is determined by overlaying the latest national protected areas dataset with the constructed sub-quaternary dataset (with now included wetland extent) and joining the attributes by location (this will join the attribute tables based on where features in the wetland layer are situated in relation to features in the protected area layer, allowing the type of protection for each wetland feature to be seen).

This added dataset will allow for determining the percentage extent (determined in a previous step) of features which are protected and not-protected found within specific sub-quaternary catchments.

Criterion: Conservation importance of wetland in the sub-quaternary catchment

The degree of conservation importance is determined much like the level of protection described above. Overlay the latest national protected areas dataset with the constructed sub-quaternary dataset (with now included wetland extent) and join the attributes by location (this will join the attribute tables based on where features in the wetland layer are situated in relation to features in the conservation importance layer, allowing the conservation importance for each wetland feature to be seen).

This added dataset will allow for determining the percentage extent (determined in a previous step) of features which have and do not have official conservation importance within specific sub-quaternary catchments.

14.1.1.2 Utilising the database to prioritise

Scoring of Individual Criteria

The database for prioritisation will, at this stage, have generated a percentage of wetland extent in sub-quaternary catchment within each of the scoring categories (Table 42). A score is recommended for each category for the various criteria (Table 42)

Table 42: Score and motivation for scores for criteria which are broad scale management units (sub-quaternary catchments) prioritisation in the NWMP.

Criterion	Score	Motivation for Score	Scoring of Criterion
Risk of wetlands in the sub-quaternary catchment to national extent of wetland			
Scoring categories			
Natural and waterbodies	0	Score zero as 100 m areas surround wetlands in the sub-quarterly are natural	Higher score (4) = Higher threat due to surrounding land cover types Lower score (0) = Lower threat due to surround land cover types
Degraded Natural	1	Low score as 100 m areas surround wetlands in the sub-quarterly are natural but degraded	
Cultivated/plantation	2	Moderate score as 100 m surround sub-quaternary wetlands are cultivated/plantation	
Mines and quarries	4	High score as 100 m areas surround wetlands in the sub-quarterly are mined, quarried, urban or built-up	
Urban/ Built-up	4		
Vulnerability of wetlands in the sub-quaternary catchment			
Scoring categories			
Natural and waterbodies	0	Same as above	Higher score (4) = Higher vulnerability of wetlands due to surrounding land cover types Lower score (0) = Lower risk due to surround land cover types
Degraded Natural	1		
Cultivated/plantation	2		
Mines and quarries	4		
Urban/ Built-up	4		
Level of protection of wetland in the wetlands in the sub-quaternary catchment			
Scoring categories			
Not protected	0	Wetlands in the sub-quaternary are not protected	Higher score (4) = Higher protection of land surround wetlands Lower score (0) = Low protection of land surround wetlands
National Park	4	High score as protected is legislated in NEM: PAA (South Africa, 2003)	
World Heritage Site	4	High score as protected is legislated in the World Heritage Convention Act (South Africa, 1999)	
Botanical Garden	2		
RAMSAR	4	High score as protected under international RAMSAR Convention	
Special Nature Reserve	4	High score as protected is legislated in the World Heritage Convention Act (South Africa, 1999)	
Protected Environment	4	High score as protected is legislated in the World Heritage Convention Act (South Africa, 1999)	
Natural Reserve	4	High score as protected is legislated in the World Heritage Convention Act (South Africa, 1999)	
Marine Conservation Area	4	High score as protected under the Marine Living Resource Act (South Africa, 1998b)	

Criterion	Score	Motivation for Score	Scoring of Criterion
Forestry Nature Reserve	4	High score as protected under the Forests Act (South Africa, 1998c)	
Biosphere Reserve	2		
Stewardship site	2	Moderate score as protected under contract law	
Conservation importance of wetland in the sub-quaternary catchment			
Scoring categories			
Critical biodiversity area	4	Prioritised in the provincial spatial plan for protection and conservation	Higher score (4) = High wetland area prioritised as Critical Biodiversity Area Lower score (0) = Low wetland area prioritised as Critical Biodiversity Area
Biodiversity Importance	3	Prioritised in the provincial spatial plan for conservation	
Ecological Support Area	2	provincial spatial plan for support provided to CBAs	
No prioritisation	0	Not prioritised for protection and conservation	

Formula utilised to score a criterion for a sub-quaternary catchment are recommended as follows:

Threat to national wetland extent

For this criterion the % of land cover types surround wetlands in the sub-quaternary catchment are placed in the context of the total extent of wetland in the country, i.e. the hectares of each land cover type surround wetlands are divided by the national extent of 100 m area around each wetland (including the wetland within).

This assumes that sub-quaternary catchments with a higher extent of wetlands will have a higher score if these wetlands are chiefly surrounded by mining, quarries, urban and built up areas. This criterion follows a similar assumption made in the National Biodiversity Assessment (Nel and Driver, 2011b) which assumed that wetlands with high percent of natural land cover would be in good condition and the converse for wetlands which had a low percent of natural land cover (i.e. areas around the wetland were dominated by other land cover types) (Table 43).

Table 43: Description of wetland conditions categories (taken from Nel et al., 2011b))

Wetland condition code	Description	Assessment criteria*
AB	Good	Percentage natural land cover ≥ 75%
C	Moderately-modified	Percentage natural land cover 25-75%
DEF	Heavily-modified	Riverine wetland associated with a D, E, F or Z ecological category river

The threat to national wetland extent score for a sub-quaternary catchment is then calculated using the formula:

Threat Score (RS) or Vulnerability Score (VS) = (((n*0) +(w*0) +(nd*1) +(cp*2) +(mq*4) +(ub*4)))/4

n = % area surround wetlands which is natural

w = % area surround wetlands which is waterbodies

nd = % area surround wetlands which is natural degraded

cp = % area surround wetlands which is cultivation or plantation

mq = % area surround wetlands which is mining or quarries

ub = % area surround wetlands which is urban or built-up

Vulnerability of Wetlands in the Sub-Quaternary Catchment

For this criterion the % of land cover types surround wetlands in the sub-quaternary catchment are calculated, i.e. the percentage of each land use type within the 100 m area around the wetland within a sub-quaternary:

% land cover type = area of land cover type 100 m around wetlands in the sub-quaternary catchment/total area of wetlands in the sub-quaternary catchment

This criterion is based on the assumption that sub-quaternary catchments with a higher extent of wetlands areas surrounded by mining, quarries, urban and built up areas would be more vulnerable and thus should be prioritised. This criterion follows a similar assumption made in the National Biodiversity Assessment (Nel and Driver, 2011) which assumed that wetlands with high percent of natural land cover would be in good condition and the converse for wetlands which had a low percent of natural land cover (i.e. areas around the wetland were dominated by other land cover types) (Table 43).

The vulnerability score for wetlands in the sub-quaternary catchment is calculated using the same formula as is utilised for the above mentioned criterion.

Level of Protection of Wetlands in the Sub-Quaternary Catchment

For this criterion the % of wetland protected area types surrounding wetlands in the sub-quaternary catchment are calculated:

% protection type = area of protection type 100 m around wetlands in the sub-quaternary catchment/total area of wetlands in the sub-quaternary catchment

The criterion is based on the assumption that a sub-quaternary catchment with high extent of wetlands in protected areas is less likely to be at threat from land cover change.

The level of protection score for a sub-quaternary catchment is then calculated using the formula:

Protection Level Score (PLS) = ((nd*0) +(np*4) +(whs*4) +(bg*2) +(Ramsar*4) +(snr*4) +(pe*4) +(nr*4) +(mca*4) +(fnr*4) +(br*4) +(ss*4))/4

nd = % area surround wetlands which is not protected

np = % area surround wetlands which is national park

whs = % area surround wetlands which is World Heritage Site

bg = % area surround wetlands which is botanical garden

RAMSAR = % area surround wetlands which is Ramsar

snr = % area surround wetlands which is special nature reserve

pe = % area surround wetlands which is protected environment

nr = % area surround wetlands which is nature reserve

mca = % area surround wetlands which is marine conservation area

fnr = % area surround wetlands which is forest nature reserve

br = % area surround wetlands which is biosphere reserve

ss = % area surround wetlands which is stewardship site

Conservation importance of wetland in the sub-quaternary catchment

For this criterion the % of area surrounding wetlands which has been prioritised for conservation in the sub-quaternary catchment are calculated:

% conservation status = area of wetlands in the sub-quaternary catchment by conservation priority/total area of wetlands in the sub-quaternary catchment

Biodiversity conservation importance is utilised various spatial layers and information to prioritise areas for conservation. For example, (but not limited to):

- Land Cover Map
- Availability of Land Cover Classes
- Vegetation Map
- Threatened Species
- Plants
- Birds
- Invertebrates
- Mammals
- Reptiles
- Important Aquatic Features
- Unique Features and Pans
- Near-Pristine Quaternary Catchment
- Climate Change Related Features
- Priority Areas to Represent All Bioclimatic Zones
- Carbon Sequestration

Hence, these criteria would have already been applied to the provincial spatial conservation planning process.

The wetland conservation status score for a sub-quaternary catchment is then calculated using the formula:

Conservation Priority Score (CPS) = ((cba*3) +(bi*4) +(ess*4) +(np*2)/4

cba = % area of wetlands in the sub-quaternary catchment which is critical biodiversity area

bi = % area of wetlands in the sub-quaternary catchment which is of biodiversity importance

ess = = % area of wetlands in the sub-quaternary catchment which is of ecological supporting services

np = = % area of wetlands in the sub-quaternary catchment which is no prioritised

14.1.1.3 Combining Criteria Score for a Sub-Quaternary Catchment Score

To prioritised wetland sub-quaternary catchments for Tier 2 wetland assessment the score of individual criteria area combined in the following manner:

Sub-quaternary Score = NRS + VS + PS + (CPS*3)

NRS = normalised risk score

VS= vulnerability score

PS = Protection Level Score

CPS = Conservation Priority Score

The Critical Biodiversity Area score was modelled to be the most influential criterion and thus this criterion is assigned a higher weight (50%).

14.1.1.4 Rules for Prioritisation

Noting that the goals of this broad-scale management unit prioritisation process is to *determine a sample of sub-quaternary catchments which display a range of trajectories of change in threats, vulnerability, protection and conservation importance to their wetlands* the following rules are recommended to prioritise:

If the Sub-quaternary catchment score tends toward 6 (normalised) then the wetland area in the sub-quaternary has a high landcover threat of affecting the national extent of wetlands; has a high extent of their wetlands which are vulnerable to land cover activities; has a high level of wetland area in protected areas and has a high area of wetlands which have been prioritised as critical biodiversity areas – hence this sub-quaternary catchment should be prioritised.

At the other end of the spectrum, if the sub-quaternary catchment score tends toward 0 then the wetland areas in the sub-quaternary catchment do not pose a high risk of affecting the national wetland extent; are not vulnerable to land cover activities; has little or no areas surround wetlands which are protected and has little or no areas of wetland which have been prioritised as critical biodiversity areas – hence this sub-quaternary catchment would not be immediately be prioritised for Tier 2 wetland assessments.

Prioritisation can take two routes:

- the sub-quaternary catchments with the highest scores are prioritised to undergo Tier 2 wetland Assessment; OR
- To ensure a range of trajectories of change is captured in the sample, prioritisation could include the selection of a random sample of sub-quaternary catchments, across Ecoregions, with scores between 3-6 (Table 44). This will provide a suite of sub-quaternary catchments with a range of criterion scores.

Table 44: Criteria combinations which are recommended for prioritisation of a sample of sub-quaternary

Criteria	Score						
Normalised Land cover threat to the National Wetland Extent	High	Low	High	Low	Low	High	Low
Vulnerability of wetland in the sub-quaternary	High	High	High	Low	Low	High	High
Level of protection of wetlands in the sub-quaternary	High	High	Low	Low	High	High	Low
Area Wetlands of Prioritised for Conservation	High	High	High	High	High	Low	High
Total Score	**6**	**5**	**5**	**3**	**4**	**3**	**4**

Fine-scale function unit prioritisation (sub-quaternary catchments)

The above prioritisation process will provide a suite of sub-quaternary catchments which should be prioritised for NWMP wetland assessment. Once the criteria have been applied, the list of prioritised sub-quaternary catchments should be validated with wetland and assessment experts in the country. Once agreement is reached on the prioritised sub-quaternary catchments, the NWMP will need to prioritise assessment units within the selected sub-quaternary catchments.

The goal of fine-scale function unit prioritisation within sub-quaternary catchments is to *determine a sample of functional unit within each prioritised sub-quaternary catchment which should undergo a rapid assessment.*

The fine scale prioritisation will prioritise wetland functional units within chosen sub-quaternary catchments. These units will be determined during a pre-fine scale prioritisation desktop wetland delineation.

A similar approach should be taken when determining functional units where, in general, functional units will be separated based on the location of the confluence of tributaries with the NFEPA river stretch (i.e. the NFEPA river dataset).

14.1.2 Fine-scale functional unit prioritisation

The following steps should be followed to determine the wetland functional units within a sub-quaternary catchment. It is advised that this process be done in consultation with an expert in wetland functioning.

14.1.2.1 Developing the find-scale functional units

Desktop river/stream delineation

At this point a desktop wetland delineation must be done utilising existing land cover maps, wetland inventories as well as the most recent Landsat imagery (i.e. Google Earth™). The resulting dataset must then be used as a platform to determine wetland functional units. The functional units must be derived through use of existing wetland cluster data, river and contour datasets, expert knowledge of wetland functioning and local knowledge of the catchment.

Wetland functional units need to be determined within the prioritised sub-quaternary catchment. Note that the development of the sub-quaternary catchment dataset was based on the NFEPA Rivers dataset. Each sub-quaternary catchment contains one stretch of the NFEPA river layer, either from its source to the first confluence or else between two confluences.

Utilising the most recent Landsat imagery (i.e. Google Earth™) together with a contour dataset (appropriate contour class will depend on topography) for the region and NFEPA rivers dataset and latest wetland inventory layer, all streams and waterways must be determined within the prioritised sub-quaternary catchment. The determination of this dataset will require the creation of a new vector layer containing streams and rivers which join with the NFEPA river stretch (See Example in Figure 44). Any finer scale spatial data which is available should also be included in the determination of functional units as this would potential improve the accuracy of the prioritisation process.

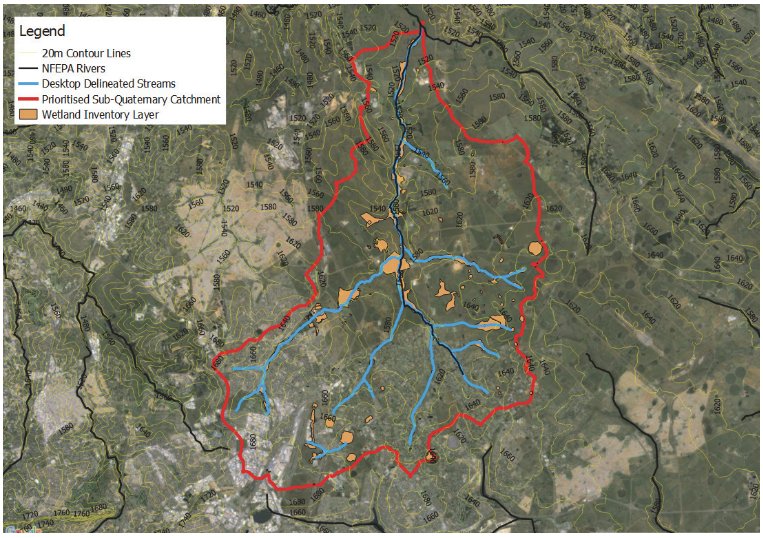

Figure 44: Example of management unit with inclusion of contour, NFEPA rivers, NWI and streams spatial layers

Functional Unit Delineation

Functional units must then be delineated based on the location of streams and wetlands in relation to confluences with the main stream all the time taking into consideration the gradient of the topography using the contour layer as a guide (Figure 45). Again, it is very important that this step be done together with expert advice (i.e. Hydrologist, hydro-geologist, geomorphological specialist other associated fields). The delineation of functional units must be done with the approach of determining the sub-sub-quaternary catchments or rather the sub-quaternary catchments.

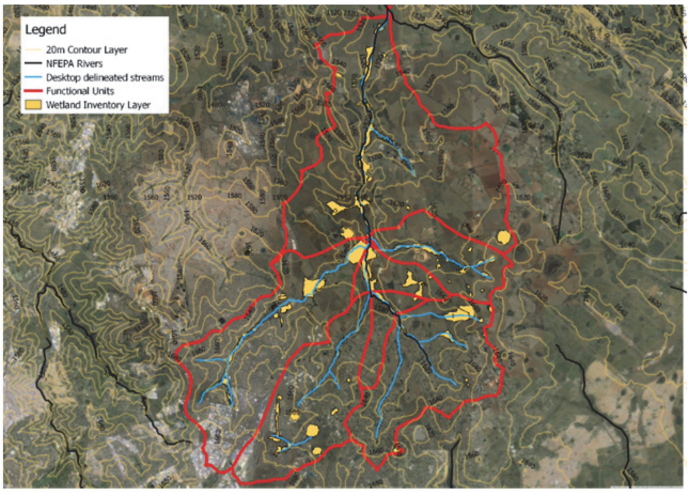

Figure 45: Example of management unit which as be delineated into function units

Basedata: Wetland Extent in the Function Unit

The relative extent of all wetlands within each functional unit (sub-quaternary catchment) needs to be determined. This can be done by determining the area of functional units and the wetlands within them.

The total extent of wetlands within each wetland functional unit must be determined and placed in the fine scale database.

Criteria: Extent of NFEPAs clusters in the Function Unit

The presence of a NFEPA cluster must be determined by overlaying the NFEPA cluster layer with the delineated functional unit layer. Attributes must be joined into one table to determine the presence of a cluster within each functional unit.

Criteria: HGM Types in the Function Unit

The diversity of HGM type must be determined for each functional unit. This will be done by using the total extent of each HGM type as well as the number of HGM types present. The prioritisation process should focus on function units which have the highest number of HGM types as well as the greatest extent of these (termed the diversity of HGM types).

A modified Shannon index should be explored for this purpose (see example below):

Variables:

H	HGM Diversity Index
S	total number of HGM types in the function unit (richness)
p_i	proportion (area) in the function unit made up of each *HGM type*
E_H	equitability (evenness)

The following formula could be utilised:

The resulting product is summed across HGM types, and multiplied by -1:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Shannon's equitability (E_H) can be calculated by dividing H by H_{max} (here H_{max} = ln$S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

$$E_H = H / H_{max} = H / \ln S$$

14.1.2.2 Rule for Prioritisation of Function Units within a Sub-Quaternary Catchment

The prioritisation of a function unit to undergo Tier 2 assessment can be determine based on the following rules:

Scenario 1:

1. If there are wetlands present in the function unit;
   AND
2. The function unit has NFEPA clusters:

   THEN

   The function unit should be considered for Tier 2 wetlands assessments.

Scenario 2:

1. If there are wetlands present in the function unit;
   AND
2. The function unit has no NFEPA clusters:

   THEN

   The functional unit with the higher HGM evenness score should be considered for Tier 2 wetlands assessments.

Again it will be important to utilise the above criteria in conjunction with expert opinion. Expert inputs should be sought, especially in the provinces (i.e. Agencies; CMAs, etc.), to assist with the prioritisation of sub-quaternary catchment and assessment units for the rapid field assessment in the country.

15 APPENDIX G: GLOSSARY OF TERMS

The definitions of terms provided below are applicable to the NWMP and have been adapted for the programme.

Assessment	In the NWMP is the act of estimating the condition of wetland indicators at Tier 2 of the framework. This provides the first-level information from which a monitoring plan can be devised for wetlands considered in Tier 3 of the NWMP.
Afforestation/plantation	The establishment of forests by natural succession or by the planting of tress on land where they did not formerly grow, e.g. establishment of monoculture of pines, eucalypts or wattle (DEA SoE Glossary)
Attribute	A characteristic feature or component of a wetland
Buffer	A strip of land surrounding a wetland
Condition	Wetland condition refers to its current state, compared to reference or best state, for physical, chemical, and biological characteristics (EPA)
Biodiversity hotspot	An area that is identified as a conservation priority because it contains a large number of species, many endemic or otherwise of importance (DEA SoE Glossary)
Catchment	The area from which water flows towards a common point. The surface and subsurface catchment areas may not coincide. The extent of catchment areas is defined by hydrological divides.
Conservation	The maintenance of environmental quality and functioning (DEA State of the Environment Glossary of Terms)
Degradation	Deterioration of the ecological infrastructure or productivity of an area (DEA SoE Glossary)
Delineation (of a wetland)	Defining the boundary of a wetland based on soil, vegetation, and/or hydrological indicators (Duthie, 1999)
Communal land	Land that is owned and managed communally, generally by traditional authorities (DEA SoE Glossary)
Diatom	Microscopic alga with a silicon "shell" in two separate halves
Ecosystem	The dynamic complex of animals, plants and micro-organisms and their non-living environment (soil, water, climate and atmosphere) interacting as a functional unit (DEA SoE Glossary)
Ecosystem services	The beneficial functions such as water quality regulation, nutrient cycling, soil fertility maintenance, regulation of the concentration of atmospheric gases and cultural and recreational opportunities provided by ecosystems (DEA SoE Glossary)
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 Eco Classification 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). (DWAF, 2007)
EcoRegion	"*Ecoregions are areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources* (US EPA (DWAF, 2007)
EcoStatus	The overall Present Ecological State (PES) or current state of the resource. It represents the totality of the features and characteristics 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)
Endorheic	of closed drainage (e.g. a pan) (Duthie, 1999)
Endemic	A plant or animal species that occurs naturally in and is restricted to a particular geographical region.

Eutrophication	A process of nutrient enrichment of aquatic ecosystems, mainly by nitrates and phosphates, which stimulates excessive algal growth. (DEA SoE Glossary)
Floodplain	A wetland inundated when a river overtops its banks during flood events, resulting in the soils being saturated for extended periods of time (Duthie, 1999)
Hydrogeomorphic (HGM) Classification	A wetland classification system based on the position of a wetland in the landscape (geomorphic setting), dominant sources of water, and the flow and fluctuation of water once in the wetland.
HGM unit	A type of aquatic ecosystem distinguished primarily on the basis of, (i) landform (which defines the shape and localised setting of the ecosystem); (ii) hydrological characteristics (which describe the nature of water movement into, through and out of the ecosystem); and (iii) hydrodynamics (which describe the direction and strength of flow through the ecosystem) (Ollis et al., 2013).
Hydrology	The science of dealing with the properties and circulation of water both on the surface and under the earth
Impacts	Positive and negative, primary and secondary, directly or indirectly, intended or unintended long-term effects on the extent, health and ecosystem services provided by a wetland (adapted from OCED, 2002).
Indicator	A quantitative or qualitative factor or variable that provides a simple and reliable means of reflecting the changes in extent, health and ecosystem services provided by a wetland (adapted from OCED, 2002). A measure that helps to assess the extent of the success with which goals are being achieved. Based on complex information or data, indicators are often used to measure how resources are being managed (DEA SoE Glossary)
Indigenous species	Species native to a particular area
Invasive alien plant	Alien plants are non-natives; invasive plants have a tendency to spread to a degree that is detrimental to the environment in which they occur.
Land cover	The physical land type such as forest or open water.
Monitoring	In the NWMP, defined as the ongoing measurement of wetland characteristics for a specific purpose
National park	State land set aside for the protection of plants, animal and scenery and for human enjoyment (DEA SoE Glossary)
Present Ecological State (PES)	The current ecological condition of natural ecosystem, assessed as the degree of deviation from the Reference State [insert reference].
Prioritised wetlands	In the NWMP are those wetlands which undergo Tier 2 Rapid Assessment and Tier 3 Monitoring.
Quaternary catchment	All the land area from mountaintop to seashore which is drained by a single river and its tributaries. Each catchment in South Africa has been subdivided into secondary catchments, which in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These subdivided catchments provide the main basis on which catchments are subdivided for integrated catchment planning and management [reference to be inserted].
Redoxymorphic	a property of wetland soils associated with wetness and resulting from reduction and oxidation
Rapid assessment	evaluation of the state of a wetland characteristic that takes only a few hours
Reference state/condition	The natural or pre-impacted condition of an ecosystem.
Reference Site	A minimally impaired site that is thought to be representative of the natural conditions of other sites of the same type and region
Red data species	Threatened or endangered species that appear on a Red Data list

Wetland	Defined in the National Water Act as the *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* (South African; 1998)
Surface water	Water found on the surface of the land