Technical Report for the National Freshwater Ecosystem Priority Areas project

Report to the
Water Research Commission

by

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DISCLAIMER

This report targets a narrow technical and research audience.

It is not intended for managers and decision makers that want to use the project outputs.

The project atlas and implementation manual are more appropriate tools for communicating the project results and outputs in a less technical manner.

For further details on the broader suite of project products see Section 1.

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Input data that informed the identification of priority areas were collated and reviewed through expert workshops in six regions of the country during May and June 2009. Resulting draft priority areas were reviewed in a national stakeholder workshop in July 2010. Over 100 experts participated in these workshops and aligned meetings, representing government, private and civil society. The NFEPA project team would like to thank all participants – for a full list of those who participated in the NFEPA discussions, consult Appendix A and B. The authors would particularly like to thank the following people for their contribution to classifying the wetland ecosystem types: Nancy Job, Justine Ewart-Smith, Donovan Kotze, Nacelle Collins, Kate Snaddon, Dean Ollis, and Jenny Day.

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EXECUTIVE SUMMARY

This report targets a narrow technical and research audience. It is not intended for managers and decision makers that want to use the project outputs. The project atlas and implementation manual are more appropriate tools for communicating the project results and outputs in a less technical manner.

The Atlas of Freshwater Ecosystem Priority Areas packages the map products and provides a DVD of all NFEPA products and shapefiles. The Implementation Manual for Freshwater Ecosystem Priority Areas explains how to use NFEPA map products within the existing policy and legislation, and provides freshwater ecosystem management guidelines. Both the atlas and implementation manual are available from the Water Research Commission, or can be downloaded in electronic format from http://bgis.sanbi.org.

INTRODUCTION

The **N**ational **F**reshwater **E**cosystem **P**riority **A**reas (NFEPA) project is a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute for Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The NFEPA project aimed to:

1. Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
2. Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The NFEPA project responds to the high levels of threat prevalent in river, wetland and estuary ecosystems of South Africa (Driver et al. 2005). It provides strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as Freshwater Ecosystem Priority Areas, or 'FEPAs'. Intended key users of NFEPA products include: the national departments of Water Affairs and Environmental Affairs, catchment management agencies and their associated stakeholders, the national and provincial departments of agriculture, the Department of Mineral Resources, South African National Biodiversity Institute, South African National Parks, bioregional programmes, provincial conservation agencies, provincial environmental affairs departments, municipalities, non-governmental organisations, conservancies and environmental consultants.

The purpose of this report is to document the scientific methods and results used in generating the NFEPA map products, and describe the approach and concepts used to guide the project in developing an institutional basis for effective uptake of these maps. The report is aimed at a research audience and is not intended to communicate the results and recommendations in a user-friendly manner. The NFEPA atlas and implementation manual serve as the main communication tools in this regard.

STAKEHOLDER ENGAGEMENT PROCESS

The NFEPA outputs summarise data and on-the-ground knowledge of the freshwater ecology community in South Africa, and represents over 1000 person years of relevant ecological and planning experience. Input data that informed the identification of priority areas were collated and reviewed in a series of five regional expert workshops in May-June 2009. Resulting draft priority areas were reviewed in a national stakeholder workshop in July 2010. In addition, several meetings were held as part of the NFEPA project to stimulate awareness, and develop an understanding of how to use the NFEPA products for managing and conserving freshwater ecosystems (Appendix A). Over 100 experts participated in these workshops and meetings, representing a range of government, private and civil society stakeholders (Appendix B).

CRITERIA FOR IDENTIFYING FRESHWATER ECOSYSTEM PRIORITY AREAS

FEPAs were determined through a process of systematic biodiversity planning and involved collaboration of over 100 freshwater researchers and practitioners. FEPAs were identified based on a range of criteria:

- Representing river wetland and estuary ecosystem types;
- Representing free-flowing rivers;
- Maintaining water supply areas in areas with high water yield and high groundwater recharge;
- Identifying connected systems;
- Representing threatened fish species and associated migration corridors;
- Preferentially identifying FEPAs that overlapped with:
    - Any free-flowing river;
    - Priority estuaries identified in the National Biodiversity Assessment 2011; and
    - Existing protected areas and Department of Environmental Affairs' focus areas for protected area expansion.

SPATIAL INPUT DATA

The following GIS layers were collated by NFEPA to aid the development of NFEPA map products contained in the NFEPA atlas. Section 7 describes key data limitations.

INPUT LAYERS	DESCRIPTION
Rivers	
Sub-quaternary catchments	Sub-quaternary catchments as derived using ArcHydro, an extension to ArcGIS 9.3. They were used as planning units for identifying river and wetland FEPAs.
River network	Defined as the 1:500 000 rivers GIS layer used by the Department of Water Affairs. Smaller streams connected to estuaries in the National Biodiversity Assessment 2011 (Van Niekerk and Turpie 2011) but that were not on this GIS layer, were added to produce the river network used for planning by NFEPA.
River ecosystem types	Comprise distinct combinations of Level 1 ecoregions (Kleynhans et al. 2005), flow descriptions from Department of Rural Development and Land Reform: National Geospatial Information (DRDLR-NGI), and slope categories from Rowntree and Wadeson (1999). River ecosystem types were used for representing the diversity of rivers across the country. They can be regarded as coarse-filter surrogates of biodiversity, conserving the diversity of many common and widespread species, and their associated habitats.

INPUT LAYERS	DESCRIPTION
River condition	Combines data on present ecological state of rivers (Kleynhans 2000) and available present ecological state updates, river health data, reserve determination data, expert knowledge and natural land cover data. Rivers had to be in a good condition (A or B ecological category; Table 3.3); to be chosen as FEPAs.
Free-flowing rivers	Long stretches of rivers on the 1:500 000 river network GIS layer that have no instream dams and therefore flow undisturbed from their source to the confluence with a larger river or to the sea. Acknowledging that not all of these are likely to remain free-flowing in the light of development needs, flagship free-flowing rivers were identified based on their representativeness of free-flowing rivers across the country, as well as their importance to ecosystem processes and biodiversity value. These flagship rivers should receive top priority for retaining their free-flowing character.
Wetlands	
Wetland localities	Augments the waterbodies and wetlands from the National Land Cover 2000 (Van den Berg et al. 2008) with inland water features from Department of Land Affairs' Chief Directorate: Surveys and Mapping (DLA-CDSM). All of these have been classified as either 'natural' or 'artificial' wetlands to derive National Wetland Map 3. Wetland data layers from Mpumalanga and KwaZulu-Natal provinces, and the fine-scale biodiversity planning domains of the Cape Floristic Region have also been added.
Wetland ecosystem types	Classifies wetlands on the basis of a hydrogeomorphic approach to Level 4a of the national wetland classification system (SANBI 2010) 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.
Wetland condition	Uses the proportion of natural land cover in and around the wetland as an indicator to model wetland condition. For riverine wetlands, the condition of rivers was also taken into account. Wetland condition was used to favour the selection of wetland FEPAs, although wetlands did not have to be in a modelled good condition (similar to an A or B ecological category; Table 3.3) to be chosen as a FEPA.
Wetland ranks	Ranks wetlands according to conservation importance using a combination of special features and modelled wetland condition. Special features included expert knowledge on features of conservation importance (e.g. extensive intact peat wetlands, presence of rare plants and animals) as well as available spatial data on the occurrence of threatened frogs and wetland-dependent birds. Wetlands of high conservation importance were selected for representation first, proceeding to lower ranking wetlands only if necessary.
Wetland clusters	Groups of wetlands within 1 km of each other and embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. FEPAs were identified to represent clusters in each wetland vegetation group.
Species	
Fish sanctuaries	Fish sanctuaries were identified at the scale of sub-quaternary catchments. Fish localities from the fish database of the South African Institute for Aquatic Biodiversity (SAIAB) and Albany Museum were used to guide the choices, and were updated with expert knowledge during the regional review workshops. Five types of conservation areas were identified for each species: Fish Sanctuaries (areas required to meet fish population targets); Fish Migration Corridors (areas required for migration between required habitats, usually between mainstem and tributary habitat); Rehabilitation and Translocation Areas (areas crucial to the survival of the highly threatened fish species they support); and Upstream Management Areas (areas that need to be managed to prevent degradation of downstream Fish Sanctuaries and Fish Migration Corridors).

INPUT LAYERS	DESCRIPTION
Water supply areas	
High water yield areas	Sub-quaternary catchments where mean annual runoff is three times higher than the average for the related primary catchment. High water yield areas are not all FEPAs, but the recommendation is that they should be maintained in a good condition (A or B ecological category; Table 3.3) to support the sustainable development of water resources in each Water Management Area.
High groundwater recharge areas	Sub-quaternary catchments where groundwater recharge is three times higher than the average for the related primary catchment. High groundwater recharge areas are not all FEPAs, but the recommendation is that the surrounding land should be managed so as not to adversely impact groundwater quality and quantity.
Estuaries	
Estuary localities	The estuarine functional zone was used to depict the extent of each estuary, which was defined laterally as anything below the 5 m mean sea level contour, and longitudinally as far as tidal variation or salinity penetration, whichever goes further upstream – as per the boundaries set by the Directorate of Resource Directed Measures of the Department of Water Affairs. Where this was not known, the 5 m mean sea level contour was used as the upstream boundary.
Priority estuaries	The priority estuaries identified in the National Biodiversity Assessment 2011 (Van Niekerk and Turpie 2011), based on a systematic biodiversity planning approach. These became FEPAs and were also used to favour the selection of associated river and wetland ecosystems as FEPAs.

BIODIVERSITY TARGETS

Biodiversity targets set minimum, quantitative requirements for biodiversity conservation. They reflect scientific best judgement and will need to be refined as knowledge evolves. Quantitative biodiversity targets were set for fish species, river ecosystem types, wetland ecosystem types, priority estuaries (sensu Van Niekerk and Turpie 2011), wetland clusters and free-flowing rivers.

- Threatened and near-threatened freshwater fish species – all populations (100%) of considered to be critically endangered or endangered species, and at least ten populations of species that are in the International Union for Conservation of Nature (IUCN) vulnerable or near threatened categories and some populations of special concern (e.g. very restricted distributions in South Africa)
- River ecosystem types – 20% of total length per type
- Wetland ecosystem types – 20% of total area per type
- Wetland clusters – 20% of total area per wetland vegetation group
- Free-flowing rivers – 20% of total length per ecoregion group
- Priority estuaries (*sensu* Van Niekerk and Turpie 2011) – 100% of all priority estuaries, which already took into account biodiversity targets of 20% for estuary ecosystem types and habitat, 50% of the populations of threatened species; 40% of the populations of exploited estuarine species; 30% of the populations of all other estuarine species.

PLANNING UNIT AND BOUNDARY COSTS

Assigning a planning unit cost is one of the methods used by biodiversity planning software (MARXAN) to meet biodiversity targets while minimising costs (Ball and Possingham 2000; Possingham et al. 2000). This cost can be expressed as area of the planning unit, monetary cost (e.g. management costs or costs of foregone opportunities), or a relative measure that allows certain planning units with similar biodiversity features to be favoured over others. The cost of all planning units in a MARXAN portfolio allows an assessment of the relative cost of conserving one planning unit versus another. For selecting rivers at a sub-quaternary catchment level, we applied a relative non-monetary planning unit cost to align selection of FEPAs with terrestrial and estuarine biodiversity priority areas. Planning unit cost for identifying river FEPAs was discounted if the sub-quaternary catchment contained a high proportion of formal protected areas or if it overlapped with tertiary catchments containing a priority estuary. Planning unit cost for identifying wetland FEPAs was heavily discounted if the sub-quaternary catchment had been identified as a river FEPA.

In designing a compact network of priority areas, MARXAN allows users to allocate a boundary cost to planning units which encourages selection of connected planning units as priority areas. To help promote longitudinal connectivity in the river and wetland FEPAs selected, a boundary cost was applied to only those boundaries belonging to pass-through sub-catchments, defined as those sub-catchment boundaries that intersected a 1:500 000 river.

PLANNING PROTOCOL

A planning protocol was developed (in consultation with national and international biodiversity planning experts) for identifying FEPAs using the MARXAN biodiversity planning software (Ball and Possingham 2000; Possingham et al. 2000). This protocol involved the following steps:

1. Quantify the river biodiversity features in each sub-quaternary catchment, and load these ‘abundance’ data into MARXAN. These include presence of a fish sanctuary, length of each river ecosystem type in an A or B condition, length of each river ecosystem type in a C condition (to be used where targets cannot be achieved in A or B rivers), and length of free-flowing rivers in each ecoregion group.
2. Load the river biodiversity targets into MARXAN.
3. Load the river planning unit cost into MARXAN.
4. Assign a river boundary cost to incorporate longitudinal connectivity.
5. Pre-select, or ‘earmark’, all fish sanctuaries irrespective of river condition but only allow A or B rivers in these sanctuaries to contribute to river type targets. This forces these sub-quaternary catchments to be included as FEPAs and at the same time accounts for any A or B river ecosystem types in these fish sanctuaries.
6. Run MARXAN to achieve the remaining biodiversity targets and identify river FEPAs.
7. Use river FEPAs in the calculation of wetland planning unit cost.
8. Quantify the extent of each wetland ecosystem type and wetland cluster per sub-quaternary catchment, and load these ‘abundance’ data into MARXAN. Ecosystems of lower rank were only used to achieve targets where these could not be achieved in higher ranking wetlands.
9. Load wetland targets into MARXAN.
10. Assign a wetland boundary cost to support the selection of whole riverine wetlands.
11. Run MARXAN to achieve targets for wetland ecosystem types and wetland cluster types, and identify sub-quaternary catchments needed to achieve wetland targets.
12. Identify wetland FEPAs as any wetland systems that intersect with sub-quaternary catchments identified in Step 11, and that contribute to wetland targets (this implies that most dams intersecting the selected

planning units would be excluded because they do not contribute to wetland targets unless they have been specifically identified by wetland experts as being of known conservation importance).

13. Combine river FEPAs, wetland FEPAs and priority estuaries to derive draft FEPA maps for review at national review workshop.
14. Address stakeholder review issues (and document how they were addressed) to derive final FEPA maps as shown in Part 2 of the NFEPA atlas.

MAP PRODUCTS

An initial meeting was held with an experienced group of biodiversity planners to develop a list of potential NFEPA map products. This list was reviewed in plenary at the national stakeholder review workshop in July 2010. A consensus was reached at this workshop to develop map products that support both high-level national application and sub-national planning and decision making.

Seven formal NFEPA map products were developed:

- ***FEPA maps per Water Management Area:***
  1. Freshwater Ecosystem Priority Area maps, or 'FEPA maps' for each of the 19 Water Management Areas

- ***National maps:***
  2. Density of FEPAs by Water Management Area
  3. Density of FEPAs by sub-Water Management Area
  4. Free-flowing rivers
  5. High water yield areas
  6. High groundwater recharge areas
  7. Fish sanctuary areas.

CATEGORIES ON THE FRESHWATER ECOSYSTEM PRIORITY AREA MAPS

Maps were prepared for each Water Management Area that provided a sufficient level of detail to use in day-to-day decisions and actions that impact on freshwater ecosystems. These are the Freshwater Ecosystem Priority Area maps or 'FEPA maps', which are the main product of the NFEPA project. FEPA maps are best viewed in A3 format and are available for each Water Management Area in the NFEPA atlas or electronically on the atlas DVD or the SANBI Biodiversity GIS website (http://bgis.sanbi.org). FEPA maps are supported by information on how to use them within different legal, policy and institutional contexts, as well as guidelines for decision makers wanting to know which particular activities are appropriate for an area and which are not. Different categories are shown on the FEPA maps, each with differing management implications:

- ***River FEPA and associated sub-quaternary catchment:*** River FEPAs achieve biodiversity targets for river ecosystems and threatened/near-threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to the biodiversity goals of the country. For river FEPAs the whole sub-quaternary catchment is shown as a FEPA in dark green, although FEPA status applies to the actual river reach shown on the map within such a sub-quaternary catchment.
- ***Wetland or estuary FEPA:*** For wetlands and estuaries, only the actual mapped wetland or estuarine functional zone is shown on the map as a FEPA, indicated by a turquoise outline around the wetland. Connected freshwater systems and surrounding land that need to be managed in order to maintain these

wetlands in good condition will need to be identified at a finer scale and in management plans for individual wetland and estuary FEPAs. In some cases it may be the whole sub-quaternary catchment and in others it may be a smaller area.

- ***Wetland cluster:*** Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. In many areas of the country, wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts. On the map, an orange outline is drawn around groups of wetlands that belong to a wetland cluster. Wetlands do not have to have FEPA status to belong to a wetland cluster (although clusters with a high proportion of wetland FEPAs were favoured in identifying wetland clusters).
- ***Fish sanctuary and associated sub-quaternary catchment:*** Fish sanctuaries are sub-quaternary catchments that are essential for protecting threatened and near-threatened freshwater fish that are indigenous to South Africa. The associated sub-quaternary catchment is marked with a red or black fish symbol on the map. A red fish indicates that there is at least one population of critically endangered or endangered fish species within that sub-quaternary catchment. A black fish indicates the presence of at least one population of vulnerable or near-threatened fish species, or a population of special concern. A goal of NFEPA is to keep further freshwater species from becoming threatened and to prevent those fish species that are already threatened from becoming extinct. In order to achieve this, there should be no further deterioration in river condition in fish sanctuaries and no new permits should be issued for stocking alien invasive alien fish in sub-quaternary catchments that are fish sanctuaries. Where instream dams are unavoidable, guidelines for designing appropriate fishways should be followed (Bok et al. 2007; Rossouw et al. 2007).
- ***Fish Support Area and associated sub-catchment:*** Fish sanctuaries for rivers in a good condition (A or B ecological category) were identified as FEPAs, and the whole sub-quaternary catchment was shaded as dark green. The remaining fish sanctuaries in rivers lower than an A or B ecological condition were identified as Fish Support Areas, and the whole sub-quaternary catchment was shown in medium-green. Fish Support Areas also include sub-quaternary catchments that are important for migration of threatened fish species (these are not marked with a fish symbol). Ideally, the river condition should be improved and alien invasive fish should be removed from Fish Support Areas, so that these sub-quaternary catchments can maintain their fish populations. Where instream dams are unavoidable, guidelines for designing appropriate fishways should be followed (Bok et al. 2007; Rossouw et al. 2007)
- ***Free-flowing river:*** Free-flowing rivers long stretches of large rivers without dams or major flow alteration. These rivers flow undisturbed from their source to the confluence with a larger river or to the sea. Dams prevent water from flowing down the river and disrupt ecological functioning with serious knock-on effects for the downstream river reaches and users. Free-flowing rivers are a rare feature in our landscape and part of our natural heritage. All free-flowing rivers are shown on the map. Flagships were identified based on their representativeness of free-flowing rivers across the country, as well as their importance to ecosystem processes and biodiversity value. These flagship rivers should receive top priority for retaining their free-flowing character.
- ***Upstream Management Area:*** Upstream Management Areas, shown in very pale green, are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas. Upstream Management Areas do not include management areas for wetland FEPAs, which need to be determined at a finer scale.
- ***Phase 2 FEPA and associated sub-quaternary catchment:*** Phase 2 FEPAs were identified in moderately modified (C) rivers. The condition of these Phase 2 FEPAs should not be degraded further, as they may in future be considered for rehabilitation once good condition FEPAs (in an A or B ecological category) are considered fully rehabilitated.

LEGAL AND POLICY ASSESSMENT

This assessment was conducted for the NFEPA project in an effort to gain a comprehensive understanding of the types of instruments that can be used to facilitate uptake of FEPAs throughout the country. The assessment informed the NFEPA implementation manual, which serves to communicate how to use the FEPA maps in a variety of different contexts. Whereas the implementation manual provides a brief overview of key legal and policy instruments for promoting the management and conservation of FEPAs, its focus is more on the use of FEPAs within these different contexts. Several laws and related policy documents were explored and their relevance to NFEPA summarised. These include:

- National Water Act
- National Strategy for Sustainable Development
- Mountain Catchment Areas Act
- Working for Water and Wetlands programmes
- National Environmental Management Act (NEMA)
- National Environmental Management: Biodiversity Act
- National Environmental Management: Protected Areas Act
- The Medium-Term Strategic Framework (MTSF)
- The National Spatial Development Perspective (NSDP)
- The National Planning Commission (NPC)
- A Provincial Growth and Development Strategy (PGDS) or Framework (PGDF)
- A Provincial Spatial Development Framework (PSDF) or Plan (PSDP)
- Integrated Development Plans (IDPs)
- Spatial Development Framework (SDF)
- Mineral and Petroleum Resources Development Act of 2002 (MPRDA)
- The Restitution of Land Rights Act, 1994 (Act 22 of 1994)
- The Land Reform: Provision of Land and Assistance Act, 1993 (Act 126 of 1993)
- The Distribution and Transfer of Certain State Land Act, 1993 (Act 119 of 1993)
- The Communal Property Associations Act, 1996 (Act 28 of 1996)
- The Communal Land Rights Act, 2004 (Act 11 of 2004)
- The Land-use Management Bill (2004)
- Conservation of Agricultural Resources Act (CARA) (1983)
- National Heritage Resources Act (RSA 1999)

GUIDING CONCEPTS FOR PROMOTING UPTAKE OF FEPA MAPS

Uptake of the NFEPA products within South African organisations should not be taken for granted. No matter how good the technical products, organisations need to be receptive to them. If they are not, that receptiveness needs to be created and sustained. This section explores lessons from a variety of sources including interactions with selected future FEPA users, analysis of similar initiatives, and theory on diffusion of innovations. It distils from these key concepts to promote the institutional uptake of the FEPA products.

The ***NFEPA case studies*** sought to develop capacity at local levels for the effective implementation of FEPAs. Three case study areas were explored to understand how NFEPA products and outcomes can be implemented to influence land- and water-resource decision making processes at a sub-national level, viz.: Crocodile (West) and Marico Water Management Area ('Croc-Marico'), Inkomati Water Management Area, and Breede Water Management Area. Generic information from the NFEPA case study areas included the need for:

- High-level endorsement;
- Communication with people on the ground;
- Institutionalising FEPAs maps at a national and sub-national level;
- Incorporation into the water resource classification system;
- Aquatic ecology capacity within provincial conservation authorities and municipalities; and
- Long-term financial support.

The ***River Health Programme*** is often lauded as an example of a programme that achieved the transition from being a good technical design to becoming an operational practice. Reflecting on the successes and failures of the River Health Programme provides an opportunity to learn about the elements that are necessary for new programmes to mature into sustainable operations. Although many factors played a role in stimulating growth, dispersal and adoption of the River Health Programme, some important elements can be extracted to inform FEPA uptake (based on Strydom et al. 2006):

- Identifying core senior people who can act as ‘contagious leaders’;
- Enabling broad-based shared ownership through flexibility;
- Ensuring core messages are simple;
- Acknowledging tacit knowledge (i.e. the knowledge in the minds of FEPA experts);
- Pro-actively avoiding ‘post-project decay’; and
- Creating opportunities for feedback.

Systematic biodiversity plans have been conducted in South Africa for about fifteen years, and South Africa is considered a world leader in the field. Based on our experience, several key ingredients for designing systematic biodiversity plans that promote effective implementation have been distilled (Knight et al. 2006). Insights relevant to the development and packaging of FEPA maps and supporting information can be summarised as follows:

- Use systematic biodiversity planning as a framework;
- Clearly communicate the relevance of FEPAs;
- Address stakeholder needs in a focussed manner;
- Design a transdisciplinary project team; and
- Package the FEPA maps and supporting information to accommodate the full science-policy-implementation continuum.

Diffusion of innovation theory has provided profound insights on adoption and diffusion of new ideas (innovations). Principles that should be kept in mind by those interested in the effective and sustainable implementation of NFEPA products include:

- Acknowledging a series of well-defined uptake phases: knowledge gain, persuasion, decision, implementation and confirmation;
- Address the three kinds of knowledge: creating awareness of the innovation (awareness knowledge), explaining how it works (how-to knowledge), explaining why the innovation is needed (principles knowledge);
- Communicating clear benefits of managing and conserving FEPAs; and
- Remember that dissatisfaction with support is one of the main reasons for discontinuance.

An NFEPA study examining how to improve ***uptake of science into policy*** identified a number of challenges facing science uptake. Recommendations of this study include engaging with the political climate, understanding the needs and mental models of stakeholders, and packaging products for different users, each with different communication strategies.

KEY FINDINGS

- Tributaries are in a better condition than main rivers.
- Freshwater and estuarine ecosystems are highly threatened, respectively, 82%, 65% and 57% of estuarine, wetland and river ecosystem types are threatened (critically endangered, endangered or vulnerable).
- Only 22% of South Africa's 1:500 000 river length has been identified as FEPAs.
- There are only 62 large free-flowing rivers, representing only 4% of our river length.
- Only 18% of our water supply areas are formally protected.
- By protecting only 15% of our river length we can protect all our fish species that are on the brink of extinction.

KEY MESSAGES

- Freshwater ecosystem priority areas are a valuable national asset.
- Freshwater inputs are critical to estuarine and marine environments.
- Free-flowing rivers should be regarded as part of our natural heritage.
- Healthy tributaries and wetlands support the sustainability of hard-working rivers.
- Healthy buffers of natural vegetation mitigate the impact of land-based activities.
- Groundwater sustains river flows particularly in dry seasons.
- Mountain catchment areas play a critical role in securing our water supplies.
- Healthy freshwater ecosystems support resilience and adaptation to climate change.

KEY RECOMMENDATIONS

- Employ aquatic ecologists in provinces, Catchment Management Agencies and local municipalities to promote sustainable water development decisions.
- Set up mechanisms to support uptake of NFEPA in provincial conservation agencies and catchment management agencies.
- Use FEPAs in assessing environmental impact assessment applications and making land-use decisions.
- Use FEPAs in water resource development processes, including water resource classification, development of catchment management strategies, water use license applications, resource quality objectives, and ecological reserve determination.
- Applications for mining and prospecting in FEPAs should be subject to rigorous environmental and water assessment and authorisation processes, as mining has a widespread and major negative impact on freshwater ecosystems.
- Pilot formal mechanisms for the management and protection of FEPAs, including the use of biodiversity stewardship programmes and other fiscal incentives.
- Revive the Mountain Catchment Areas Act, which has the potential to play a much larger role in protecting our water supply areas.
- Review general authorisations of the National Water Act in relation to their impact on FEPAs.
- Strengthen and expand the scope of the River Health Programme to include wetland and to actively target FEPAs as new monitoring sites.
- Strengthen collaboration of the Department of Water Affairs and Department of Environmental Affairs around managing and conserving freshwater ecosystems.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

ACRU	Agricultural Catchments Research Unit
ARC-ISCW	Agricultural Research Council - Institute for Soil, Climate and Water
BMP	Biodiversity Management Plan
BOCMA	Breede-Overberg Catchment Management Agency
CAPE	Cape Action for People and the Environment
CARA	Conservation of Agricultural Resources Act
CARE	Comprehensiveness, Adequacy, Representativeness and Efficiency
CEC	Committee for Environmental Coordination
CEIMP	Consolidated Environmental, Implementation and Management Plan
CEM	Centre for Environmental Management
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
CSIR	Council for Scientific and Industrial Research
CWAC	Coordinated Waterbird Counts
DAFF	Department of Agriculture, Forestry and Fisheries
DCGTA	Department of Cooperative Governance and Traditional Affairs
DEAT	Department of Environmental Affairs and Tourism (now DEA)
DEM	Digital Elevation Model
DENC	Department of Environment and Nature Conservation
DoA	Department of Agriculture
DLA-CDSM	Department of Land Affairs – Chief Directorate of Surveys & Mapping (now DRDLR-NGI)
DRDLR-NGI	Department of Rural Development and Land Reform – National Geospatial Information (DRDLR-NGI).
DTEC	Department of Tourism, Environment & Conservation
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (now DWA)
DWEA	Department of Water and Environmental Affairs (now DWA & DEA)
EC	Ecological Category
ECPB	Eastern Cape Parks Board
EIA	Environmental Impact Assessment
EIP	Environmental Implementation Plan
EIS	Ecological Importance and Sensitivity
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
EMF	Environmental Management Framework
EMP	Environmental Management Plan
ESU	Evolutionary Significant Unit
EWT	Endangered Wildlife Trust
FCG	Freshwater Consulting Group
FEPA	Freshwater Ecosystem Priority Area
FS DETEA	Free State Department of Economic Development, Tourism and Environmental Affairs
GDACE	Gauteng Department of Agriculture, Conservation and Environment
GDARD	Gauteng Department of Agriculture and Rural Development
GIS	Geographic Information System
ICMA	Inkomati Catchment Management Agency
IDP	Integrated Development Plan
INR	Institute of Natural Resources
ISP	Internal Strategic Perspective
IUCN	International Union for Conservation of Nature
KZN	KwaZulu-Natal
LDO	Land Development Objective
LEDET	Limpopo Department of Economic Development, Environment and Tourism
LUMS	Land Use Management System
MAR	Mean Annual Runoff
MCA	Mountain Catchment Area
MPRDA	Mineral and Petroleum Resources Development Act
MPRDAA	Mineral and Petroleum Resources Development Amendment Act
MSL	Mean Sea Level
MTEF	Medium-Term Expenditure

	Framework
MTPA	Mpumalanga Tourism and Parks Agency
MTSF	Medium-Term Strategic Framework
MWP	Mondi Wetlands Programme
NBF	National Biodiversity Framework
NBSAP	National Biodiversity Strategy and Action Plan
NCP DENC	Northern Cape Province-Department of Environment and Nature Conservation
NDA	National Department of Agriculture
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NEMPAA	National Environmental Management: Protected Areas Act
NFEPA	National Freshwater Ecosystem Priority Area
NFSD	National Framework on Sustainable Development
NGO	Non-Government Organisation
NHRA	National Heritage Resources Act
NLC	National Land Cover
NPAES	National Protected Areas Expansion Strategy
NPC	National Planning Commission
NSBA	National Spatial Biodiversity Assessment
NSDP	National Spatial Development Perspective
NSOER	National State of Environment Report
NSSD	National Strategy for Sustainable Development
NWA	National Water Act
NWDACERD	North West Department: Agriculture, Conservation, Environment and Rural Development
NWPTB	North West Parks and Tourism Board
NWRS	National Water resource Strategy
PES	Present Ecological State
PGDF	Provincial Growth and Development Framework
PGDS	Provincial Growth and Development Strategy
PSDF	Provincial Spatial Development Framework
PSDP	Provincial Spatial Development Plan
RDM	Resource Directed Measure
RDP	Reconstruction and Development Programme
RHP	River Health Programme
RQO	Resource Quality Objective
RQS	Resource Quality Services
RSA	Republic of South Africa
SA	South Africa
SAHRA	South African National Heritage Resources Agency
SAIAB	South African Institute for Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SARVA	South African Risk and Vulnerability Assessment
SDC	Source-Directed control
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
SKEP	Succulent Karoo Ecosystem Programme
SoE	State of Environment
SoR	State of Rivers
STEP	Subtropical Thicket Ecosystem Planning Programme
UCT	University of Cape Town
UFS	University of the Free State
UKZN	University of KwaZulu-Natal
USGS	United States Geological Survey
Wits	University of the Witwatersrand
WfW	Working for Water
WfWet	Working for Wetlands
WMA	Water Management Area
WRC	Water Research Commission
WWF-SA	World Wide Fund - South Africa

SECTION 1: INTRODUCTION

1.1 BACKGROUND TO PROJECT

Freshwater ecosystems provide valuable natural resources, with economic, aesthetic, spiritual, cultural and many recreational values. Yet the integrity of freshwater ecosystems in South Africa is declining. This crisis is largely a consequence of a variety of challenges that are practical (managing vast areas of land to maintain connectivity between freshwater ecosystems), socio-economic (competition between stakeholders for utilisation) and institutional (building appropriate governance and co-management mechanisms).

In 2004 the National Spatial Biodiversity Assessment provided the first combined national assessment of terrestrial, river, marine and estuarine ecosystems. Broad priority areas for biodiversity conservation were identified for terrestrial ecosystems but not for freshwater ecosystems as some critical datasets were unavailable (Driver et al. 2005). The assessment highlighted the dire state of river ecosystems in South Africa – much worse than the state of terrestrial ecosystems (Driver et al. 2005). Urgent attention was recommended to reverse this trend, and ensure that we conserve some natural examples of the different ecosystems that make up the natural heritage of this country for now and future generations. The **N**ational **F**reshwater **E**cosystem **P**riority **A**reas (NFEPA) project responds to this need, and builds on a number of important milestones:

- As early as 1999, aquatic ecologists were exploring the potential use of systematic biodiversity planning for freshwater ecosystems of the Cape Floristic Region of South Africa (Van Nieuwenhuizen and Day 2000).

- In 2002, a World Bank-funded project addressed the need to expand the Addo Elephant National Park in a way that would conserve representative and viable biodiversity patterns and underlying processes. An integrated biodiversity plan was produced for the 'Greater Addo Elephant National Park', incorporating terrestrial, marine-estuarine and freshwater components. For the freshwater component, the use of systematic biodiversity planning principles facilitated the merging of concepts from conservation biology and aquatic ecology. This resulted in a new approach to systematically identify freshwater conservation priorities using river types as surrogates for river biodiversity (Roux et al. 2002).

- Between 2002 and 2005, the Department of Water Affairs and the Water Research Commission supported the development and refinement of basic methods for freshwater biodiversity planning. These were pilot tested in six of the 19 Water Management Areas (Kotze et al. 2006; Nel et al. 2006a; Nel et al. 2006b; Smith-Adao et al. 2006). These case studies explored ways in which freshwater biodiversity plans could be used to inform integrated water resource management processes. Sets of rivers were identified that were best suited for achieving regional conservation goals. Importantly, water resource managers and planners were involved in most of these studies. This resulted in institutional uptake and use of at least some of the plans.

- Acknowledging the precarious state of freshwater ecosystems in South Africa and the reality of overlapping and sometimes conflicting sectoral policy mandates, several government departments and national agencies agreed to participate in a series of workshops in 2006 to develop cross-sector policy for managing and conserving freshwater ecosystems. The objective of these workshops was to find synergy between respective mandates, to agree on a national goal and to advance cooperative action (Roux et al. 2006). This cross-sector policy process established a cross-sectoral consensus of ideas to use as a framework to guide the NFEPA project.

These initiatives provided both a theoretical and experiential foundation for the NFEPA project, and importantly, laid the basis for broad institutional buy-in.

1.1.1 Project aims

The NFEPA project is a multi-partner project between CSIR, South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The NFEPA project aimed to:

1. Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
2. Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim used systematic biodiversity planning (Section 3.1) to identify priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development. The second aim was divided into a national and sub-national component. The national component sought alignment between the Department of Water Affairs and Department of Environmental Affairs with regard to policy mechanisms and tools for managing and conserving freshwater ecosystems. The sub-national component used three case study areas to explore how NFEPA products should be implemented to influence land and water resource decision making processes at a sub-national level.

1.1.2 Project objectives

The following sub-objectives were identified to accomplish these aims:

- Establish criteria for identifying FEPAs and freshwater rehabilitation priorities.
- Explore the legal and institutional mechanisms for promoting the management and conservation of FEPAs, and catalyse the formal and informal processes required for cooperation.
- Develop data and maps of FEPAs at a national scale, as well as at a catchment management scale.
- Develop an atlas of freshwater biodiversity planning in South Africa, using the NFEPA map products and data.
- Develop and publish scientific advances.

The project further aimed to maximise synergies and alignment with other national level initiatives such as the cross-sector policy objectives developed in 2006 for managing and conserving freshwater ecosystems (Roux et al. 2006) and the National Biodiversity Assessment 2011.

1.1.3 Envisaged outcomes

The following were some of the envisaged outcomes of the project:

- Developing an established network of relationships among key natural resource implementing agencies.
- Building capacity among key implementing agents to understand and use the planning outputs, including:

  - Integration of FEPAs into a catchment management strategy in at least one Water Management Area.
  - Developing the capacity to use the NFEPA map products and supporting information to inform planning and management processes at sub-Water Management Area level.
  - Understanding links between FEPA maps and other spatial planning instruments e.g. water resource scenario planning, biodiversity sector plans, provincial and bioregional plans, and provincial and municipal Spatial Development Frameworks (SDFs).
- Developing capacity among young researchers to undertake freshwater biodiversity planning.
- Promoting improved management and conservation of South Africa's freshwater ecosystems and supporting sustainable use of water resources.

1.2 PURPOSE OF THIS REPORT AND ITS INTENDED USERS

This technical report is one tool in a suite of NFEPA-related products (Figure 1.1), and aims to document the technical and institutional analyses that informed the NFEPA map products, atlas and implementation manual. It also serves as a record of project execution for future reference, describing tasks undertaken and their associated outcomes, and distilling lessons for similar future endeavours. Please note that this report does not contain the FEPA maps. An example of a portion of a FEPA map is shown in Figure 3.21. For the full set of FEPA maps and other map product please consult the NFEPA atlas or NFEPA DVD (see Figure 1.1 for more on the suite of NFEPA products, which are all available from the Water Research Commission).

This report targets researchers, consultants and managers who want a deeper understanding of the science, institutional analysis and philosophy that guided the development of the NFEPA map products and supporting information. This audience may include:

- Researchers or consultants tasked with developing spatial prioritisations that take into account freshwater ecosystems. These spatial prioritisations would range from systematic biodiversity plans to strategies that inform conservation and rehabilitation programmes (e.g. Working for Water).
- Researchers and managers interested in project or programme design that integrates the value systems of science, policy and society. This report provides a guiding philosophy for creating and sustaining uptake of NFEPA products and distils lessons learnt from this project.
- Practitioners needing an overview of existing implementation mechanisms. While the implementation manual provides a brief summary of key implementation mechanisms, its main focus is on how to use the FEPA maps within these different contexts. This report provides the legal and policy analysis that informed the implementation manual.

Atlas of Freshwater Ecosystem Priority Areas

Shows **all maps developed by the NFEPA project**, including FEPA maps per Water Management Area, national map products, and maps of input data layers. A brief explanation of each map is provided.

Implementation Manual for Freshwater Ecosystem Priority Areas

Explains **how to use FEPA maps** in different sectors, and provides freshwater ecosystem management guidelines for river FEPAs and wetland FEPAs.

NFEPA DVD

Supplies **GIS shapefiles** and metadata, **A3 jpegs** of FEPA maps per Water Management Area, slide **presentations** of NFEPA, and an open-source **map viewer**. The data is also available on SANBI's Biodiversity GIS website (http://bgis.sanbi.org).

NFEPA Technical Report

Describes the **technical approach used to develop the maps**, the stakeholder engagement process, the legal and policy analysis, and guiding concepts for institutional uptake.

Figure 1.1: NFEPA products at a glance

1.3 STRUCTURE OF THIS REPORT

This report provides the detailed approach used in the technical and institutional components of the NFEPA project. It includes information describing the:

- **Stakeholder engagement process** (Section 2).
- **Technical approach.** This describes the scientific basis and approach that lead to the FEPA maps and supporting data layers (Section 3).
- **Guiding concepts for creating and sustaining uptake of FEPAs**. This section describes key principles that will stimulate and sustain the institutional uptake of the NFEPA products. It draws on the NFEPA case studies, lessons from the River Health Programme and a wealth of experience in sustainability science. These guiding principles acknowledge that natural resource planning and management occurs within complex, social-ecological systems. They pertain to planning and management of natural resources in general, not only to the uptake of FEPA products (Section 4).
- **Legal and policy assessment**. Three main sectors of relevance (water, environment, and planning) are examined as well as other possible sectors (Section 5).
- **Scientific papers published through NFEPA**. At the time of writing this report, several papers had already been submitted, accepted or published in the peer-review literature. These are listed in Section 6 with their abstracts.
- **Data limitations and research priorities** (Section 7).
- **Key findings, messages and recommendations** (Section 8).

1.4 THE IMPORTANCE OF HEALTHY ECOSYSTEMS

Water affects every activity and aspiration of human society and sustains all ecosystems. Rivers, wetlands, lakes and estuaries have long inspired artists and musicians, enriching the human spirit with their beauty. Freshwater ecosystems provide for many of our fundamental needs: water for drinking and irrigation, food such as fish and waterbirds, and reeds for craftsmanship. Healthy ecosystems also provide important regulating ecosystem services, such as preventing floods and easing the impacts of droughts. A healthy ecosystem supports functional communities of plants and animals that are able to remove excess nutrients and toxic substances from water, keeping it cleaner for drinking, irrigation and recreation. Healthy rivers, wetlands and groundwater systems also maintain water supply and buffer the effects of storms, reducing the loss of life and property to floods. Healthy river banks with natural vegetation help to trap sediments, stabilise river banks and break down pollutants draining from the surrounding land. Estuaries provide nursery areas for marine and estuarine animals, and supply fresh water and nutrients to the sea, which drive marine food webs and maintain important fisheries (Lamberth et al. 2009). A certain amount of water is also required to scour the mouth of most estuaries – without this scouring effect, sediments build up at the mouth and the risk of back-flooding during storms increases.

Water is also one of South Africa's most limited resources, constraining our future social and economic development. Its wise use is critical to the sustainable development of our emerging economy and the well-being of all our citizens, particularly the poorest, who depend directly on the health of natural resources for their livelihoods (Millennium Assessment 2003). Yet this valuable national asset is in crisis. Pressures arising from social and economic needs have resulted in widespread degradation of freshwater ecosystems. In many regions of the country water demand outstrips supply, and water quality has declined due to increased pollution from industry, urban expansion, mining, power generation, agriculture, forestry and inadequate sewage treatment. The National Biodiversity Assessment 2011 revealed that over half of our river, wetland and estuary ecosystem types in South Africa are threatened (Nel et al. 2011). Such widespread degradation of freshwater ecosystems inevitably compromises ecosystem service delivery and results in more costly management interventions and the loss of resilience to changing circumstances. This current situation is even more alarming when future pressures on water resources are considered – the demand for water is predicted to escalate exponentially (DWAF 2004a) and many parts of the country are expected to become drier as a result of climate change, threatening our water supplies (Schulze 2005).

A focus on sustainable development becomes crucial given these current and future pressures on water resources. It is widely accepted that social, ecological and economic systems are inextricably bound (Figure 1.2). Protection and utilisation of natural resources therefore need to work hand-in-hand to achieve sustainable development. In the context of water resource management, this means that catchments can be designed to support multiple levels of use, with natural rivers and wetlands that are minimally-used supporting the sustainability of hard-working rivers that often form the economic hub of the catchment. This concept is firmly embedded in the National Water Act, and forms the foundation of the water resource classification system (Dollar et al. 2010). Keeping some rivers and wetlands in the catchment in a natural or good condition serves a dual purpose of conserving South Africa's freshwater biodiversity, while promoting the sustainable use of water resources in the catchment. This is particularly important if we are to meet government objectives for both sustainable water resource development and freshwater biodiversity conservation. The question remains: which rivers and wetlands, and how many, should be maintained in a natural condition to support these two goals?

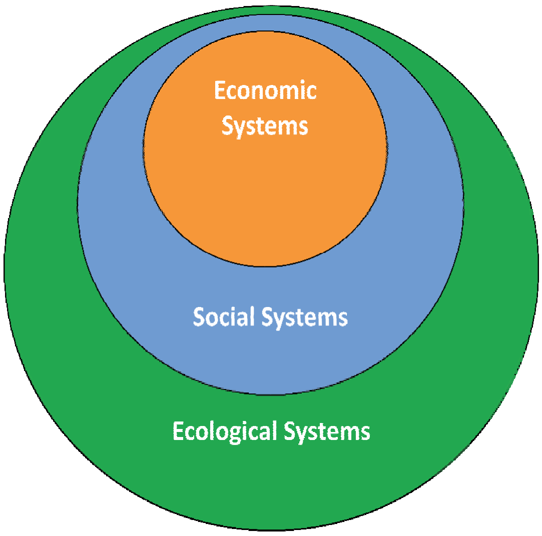

Figure 1.2: Economic, social and ecological systems are inextricably bound. The health of our ecological systems and associated natural capital underpins social and economic development.

The NFEPA project addresses this question by synthesising data and existing knowledge to identify strategic Freshwater Ecosystem Priority Areas for promoting sustainable water resource use and achieving the freshwater ecosystem goals of the country (Roux et al. 2006). The resulting maps and supporting information represent a joint effort between the water and biodiversity sectors for incorporating freshwater ecosystem goals into integrated water resource management in terms of the National Water Act.

SECTION 2: STAKEHOLDER ENGAGEMENT PROCESS

This section summarises the stakeholder engagement process followed to generate the NFEPA map products. It draws on concepts described in Section 4.

Upon project inception, several key implementing agencies and aquatic scientists were identified as stakeholders for participating in the development of FEPA maps, including provincial conservation authorities, national and catchment level water resource managers, national water resource planners, and aquatic ecologists and taxonomists. These stakeholders participated in the project inception meeting, the regional expert workshops to review input data, and the national workshop to review the draft FEPA maps. Collective experience of the stakeholders is estimated to be over 1000 person years. A summary of stakeholder attendance at these and other meetings can be found in Appendix A and B.

The ***project inception meeting*** aimed to bring together key stakeholders to help fine-tune the proposed project approach. At the meeting, several additional stakeholders were identified and subsequently asked to participate in the project. A consensus was also reached that NFEPA would be based on best available data and scientific knowledge, with a focus on desktop update of existing data, rather than gathering new data in the field. Stakeholders at the inception meeting identified the need for:

- Good communication between the project team and the broader stakeholder group;
- Review of existing data that would be used to identify FEPAs;
- Extended time on the technical component to facilitate meaningful stakeholder participation in the development of FEPA maps;
- Developing maps with multiple-use priority areas, which acknowledge that not all areas identified need to be managed in a good condition, which generally implies more restrictive use;
- A technical product that can be queried to identify individual biodiversity features within FEPAs; and
- Developing legal mechanisms to enforce NFEPA, although it was agreed that this needed to be an ongoing process that would extend beyond the scope of the NFEPA project.

Several ***specialist task team workshops*** were also held within which specialist scientists, were brought together to develop, test and agree on the most appropriate methods (given available data and constraints) for mapping river ecosystem condition, landform types, wetland ecosystem types, wetland condition and priority estuaries (held in conjunction with the National Biodiversity Assessment 2011 team).

The ***regional expert review workshops*** were held for six regions in South Africa, as identified at the project inception meeting: Western Cape, Eastern Cape, KwaZulu-Natal, Highveld, Lowveld, and Arid regions. Each workshop took place over three days between May and July 2009. The aim of these workshops was to review input information and GIS layers, as well as the methods used to construct the GIS layers. The first two days were exclusively devoted to NFEPA review. The third day was used to review NFEPA threatened fish sanctuaries as well as delineate permit exclusion zones for aquaculture and recreational fishing in terms of the alien fish species regulations of the National Environmental Management: Biodiversity Act (Act 10 of 2004)[1]. Specifically, the following NFEPA input information was reviewed:

[1] Hereafter referred to as the Biodiversity Act

- Draft criteria for identifying FEPAs, culminating in the list provided in Section 3.2. A dormant criterion was added that acknowledges the need to incorporate threatened taxa other than fish (e.g. riparian plants and macro-invertebrates) as data become available at a national level.
- Methods for identifying wetland clusters (these are clusters of wetlands embedded in natural land cover; Section 3.4.12).
- A GIS layer of river condition, adding updated data and expert opinion where it existed.
- Free-flowing rivers (methods for defining free-flowing rivers were reviewed as well as the draft GIS layer which was subsequently refined and reviewed again at the next workshop).
- Sanctuaries for conserving threatened fish species.
- Major gaps in wetland locality, with a focus on gaps in wetland systems known to be of conservation importance. In the Mpumalanga and KwaZulu-Natal provinces, and the fine-scale planning domain of Cape Action for People and the Environment (C.A.P.E.), wetland gaps were addressed through the addition of sub-national wetland localities (Section 3.4.6). In other regions, the sub-quaternary catchment within which the gaps were prevalent was identified. These were not used in identification of wetland FEPAs but should be used as priority areas for wetland mapping at a sub-national level and have been provided to the SANBI national wetland inventorying programme.
- Special features within each region comprising information for which no quantitative data existed, such as the presence of riverine rabbits, otters, intact riparian forest, intact peat wetlands, and wetlands associated with threatened species.
- Sub-national data subsequently included in NFEPA, including data on distribution of Wattled, Crowned and Blue cranes (supplied courtesy of Endangered Wildlife Trust), point localities of Mpumalanga wetlands that are associated with threatened species or intact peat wetlands, wetland localities used in the C.A.P.E. fine-scale biodiversity plans, wetland localities mapped by Mpumalanga and KwaZulu-Natal provinces.

The ***national review workshop*** was run over two days to review the proposed suite of NFEPA map products, and the draft FEPA maps and free-flowing rivers. Participants reviewed the proposed suite of NFEPA map products in plenary and reached a consensus on which free-flowing rivers would become flagship free-flowing rivers (Section 3.4.5). They were then divided into groups to review the draft FEPA maps for their respective regions. For the review of draft FEPA maps, a task team member was assigned to each region to capture review notes while the regional experts reviewed hard copy maps. The GIS layers, and a GIS operator, were also made available for querying the data layers during this process. The review notes that were captured, as well as the annotated hard copy maps, were then used to refine the draft FEPA maps. Other key issues resolved during this meeting also included the revision period for NFEPA (to be subjected to a ten-year, rather than five-year, revision) and to keep river and wetland FEPAs on the same map rather than to separate them out. The need for a point person in SANBI to support the use of NFEPA products was also highlighted.

In addition to the formal review workshops held by NFEPA, the process of knowledge dissemination and communication was enhanced by a long list of communications, in the form of ***quarterly newsletters*** and over 60 ***presentations at conferences, workshops and forums***. The list of NFEPA meetings and presentations is provided in Appendix A.

SECTION 3: TECHNICAL APPROACH

This section summarises the technical process followed to generate the NFEPA map products. For more detailed discussion on the use of the products resulting from the methods described here, please refer to the atlas and implementation manual.

3.1 INTRODUCTION

This section provides a detailed description of the methods and data used for developing FEPA maps, including a description of the:

- Criteria used for identifying FEPAs;
- Stepwise planning process;
- Input data used, including a description of the data limitations; and
- Biodiversity planning software and protocols used.

The approach for developing FEPA maps was guided by the principles of systematic biodiversity planning[2] (Box 1; Margules and Pressey 2000). Systematic biodiversity planning is a well-established field of science in which South Africa is considered a world leader (Balmford 2003). The information used to develop FEPA maps builds on previous work in South Africa on freshwater and terrestrial biodiversity planning, being based on best available data that was augmented with expert input and review. The methods also draw on recent scientific advances in systematic biodiversity planning for freshwater ecosystems (Nel et al. 2009; Linke et al. 2010), including:

- The delineation of sub-catchments as planning units thereby incorporating the need to manage the water resource of concern as well as the surrounding land (Lehner et al. 2006; Thieme et al. 2007).
- The development of a river tree-network (or river topological relationships) that can be used to assess upstream-downstream linkages and thus incorporate the consideration of longitudinal connectivity into planning (Moilanen et al. 2008).
- The use of multiple-use zonation in which different levels of protection are recommended depending on the role that sub-catchment fulfils in achieving biodiversity goals (Abell et al. 2007; Thieme et al. 2007). For example, FEPA maps show categories that are broadly based on diminishing use restrictions: *Freshwater Ecosystem Priority Areas* focus on representing natural or good examples of freshwater ecosystems, and management is therefore fairly restrictive; *Fish Support Areas* need to be maintained in a condition that supports the threatened fish populations they contain – this need not be a natural or good condition; *Upstream Management Areas* require management only to ensure that human activities do not degrade the condition of FEPAs and Fish Support Areas that occur downstream.

[2] Internationally also known as 'systematic conservation planning'

Box 1: What is systematic biodiversity planning?

Systematic biodiversity planning is a strategic and scientific approach to identifying those areas that are essential for biodiversity conservation. The key objectives of systematic biodiversity planning are to facilitate the adequate representation of biodiversity in a region, to plan for its persistence, and to do this in a way that makes efficient use of limited resources (Margules and Sarkar 2007). Three key principles underpin systematic biodiversity planning:

- The need to conserve a representative sample of biodiversity pattern, such as species and habitats (the principle of representation).
- The need to conserve the ecological and evolutionary processes that allow biodiversity to persist over time (the principle of persistence).
- The need to set quantitative biodiversity-based targets that tell us how much of each biodiversity feature should be conserved in order to maintain functioning landscapes and seascapes. Targets should ideally be based on best available science and regularly updated as new information becomes available. Targets define what resource planners and managers should aim for and provide a basis for the monitoring that is so important to good management.

Systematic biodiversity planning is also underpinned by principles that facilitate implementation. **Efficiency** strives to use the minimum of our limited natural resources to achieve conservation goals. It uses the property of *complementarity* which is the extent to which an area contributes biodiversity elements not represented elsewhere in a region (i.e. sensibly complements the choice of other areas). **Transparency** strives to document clear rationale for decisions, enabling them to be critically reviewed and updated where necessary.

Systematic biodiversity planning in South Africa is firmly embedded in both policy and practice. The Department of Environmental Afairs' National Biodiversity Framework requires provinces to develop provincial biodiversity plans. The National Protected Area Expansion Strategy is founded on systematic biodiversity principles, providing the strategy to guide the national and provincial authorities in the expansion of the country's protected areas over the next 20 years. Bioregional plans published in terms of the Biodiversity Act must use a systematic biodiversity planning approach to identify Critical Biodiversity Areas and Ecological Support Areas, and must integrate priorities for terrestrial and freshwater ecosystems. Examples of such maps can be found on the SANBI Biodiversity GIS website (http://bgis.sanbi.org).

3.2 CRITERIA FOR IDENTIFYING FRESHWATER ECOSYSTEM PRIORITY AREAS

The criteria for identifying FEPAs were based on a national cross-sectoral policy process that was undertaken in 2006 (Roux et al. 2006) in which key national government departments (including Water Affairs, Environmental Affairs, Agriculture and SANParks) agreed on a vision for managing and conserving freshwater ecosystems. The vision guided the development of a range of policy objectives and recommendations that could be shared across departments. The cross-sectoral policy process played an important role in providing a politically-accepted national biodiversity target for South Africa's freshwater ecosystems: participating departments and organisations agreed to maintain at least 20% of each major freshwater ecosystem type in South Africa in a good condition. These targets should be subject to refinement as new knowledge arises.

Criteria were reviewed in the regional expert review workshops (Section 3, Appendix B), and published in *Biological Conservation* (Nel et al. 2009). They were used to inform which GIS layers were needed for developing the FEPA maps (Table 3.2), the setting of biodiversity targets (Section 3.5), and the rules that were used in the biodiversity planning software, MARXAN (Section 3.8, Possingham et al. 2000) . Table 3.1 lists the reviewed criteria. The criteria focus on rivers, wetlands and estuaries. Groundwater was included only in terms of identifying areas of high groundwater recharge, derived using the 2005 groundwater resource assessment data, available at a resolution of 1 km x 1 km (DWAF 2005). Future refinement of FEPAs should seek to include groundwater more broadly.

3.3 STEPWISE PLANNING PROCESS

A generic, step-wise planning framework has been developed over the last decade for systematic biodiversity planning in South Africa, which draws on lessons and best practice from numerous terrestrial case studies (Margules and Pressey 2000; Margules and Sarkar 2007). This framework was adapted for planning in freshwater ecosystems and used in the NFEPA project. The three fundamental principles of representation, persistence and quantitative target setting form the basis for this planning framework. The planning framework engages an array of experts and relevant stakeholders through a series of workshops at key milestones (Section 2), in which participants are provided the opportunity to review results of previous tasks and influence the approach in future tasks. The criteria and data compiled for identifying NFEPAs were integrated into the spatial assessment framework as shown in the white boxes of Figure 3.1.**Error! Reference source not found.**

Figure 3.1: The stepwise biodiversity planning framework used by NFEPA

Steps that guided the NFEPA approach are shown in the shaded green boxes; unshaded boxes show the data that was used in each step; stakeholder workshops (shown in italic red text) were held at specific project milestones.

Table 3.1: Criteria used for identifying Freshwater Ecosystem Priority Areas.

Objective	Rationale
1. Representation of river, wetland and estuarine ecosystem types	Ecosystem types used by NFEPA share similar physical features (such as climate, flow, water chemistry and geomorphology) and, under natural conditions, are expected to share similar biological response potential and biogeographic differences. They can therefore be used as coarse-filter biodiversity surrogates, advancing freshwater conservation beyond species, to also conserve habitats and ecosystems on a systematic basis. Threatened ecosystem types should be particularly targeted since limited options remain for their conservation.
2. Representation of threatened freshwater species ▪ Delineation of fish sanctuaries	Species serve as fine-filter biodiversity surrogates for conserving representative examples of freshwater biodiversity in South Africa. Threatened species should be particularly targeted since limited options remain for their conservation. Only freshwater fish species were considered by NFEPA. Although it would be preferable to consider other freshwater taxa, this is currently not possible owing to lack of comprehensive data.
3. Representation of wetland clusters	These are clusters of wetlands embedded in a relatively natural landscape matrix through which dispersal between wetlands can occur (e.g. of frogs and invertebrates). The occurrence of threatened wetland-dependent frogs, insects and birds also guided selection of wetland clusters where choices existed.
4. Representation free-flowing rivers	Conserves representative coarse-scale processes such as natural flow regimes, erosion and sediment transport. There are very few free-flowing

		rivers left in South Africa, and several flagship free-flowing rivers have been identified as representative of free-flowing rivers remaining across the country.
5.	High water yield areas per region	Together with areas of high groundwater recharge, these are our ‘water factories’ for each primary catchment. Degradation of water supply areas can have exponentially negative impacts on ecological, social and economic well-being of the region.
6.	High groundwater recharge areas	Deleterious activities in areas that have significant recharge can have a keystone effect on the functioning of groundwater dependent ecosystems, which can be in the immediate vicinity, or far removed from the recharge area. Identifying areas of significant groundwater recharge allows for pro-active management of activities that may lower the groundwater quantity or quality in their vicinity.
7.	Preferentially select rivers connected to priority estuaries	Incorporates persistence of estuaries in the long term.
8.	Preferentially select ecosystem types from intact river systems	These systems are the ones that are most likely to support biodiversity features that persist in the long term. They also serve as reference sites.
9.	Incorporate longitudinal, lateral and vertical connectivity into planning	The persistence of all but the most isolated FEPAs depends fundamentally on management of connected systems.

3.4 SPATIAL INPUT DATA

Table 3.2 summarises the various input layers and their application in NFEPA, while the details of the derivation and review of each of these GIS layers is also described in this section. For a discussion on the degree of confidence in the data, see Section 7.

Table 3.2: Summary of input layers.
A short description of the GIS layer is provided in this table – for further detail refer to text.

INPUT LAYERS	DESCRIPTION
Rivers	
Sub-quaternary catchments	Sub-quaternary catchments as derived using ArcHydro, an extension to ArcGIS 9.3. They were used as planning units for identifying river and wetland FEPAS.
River network	Defined as the 1:500 000 rivers GIS layer used by the Department of Water Affairs. Smaller streams connected to estuaries in the National Biodiversity Assessment 2011 but that were not on this GIS layer, were added to produce the river network used for planning by NFEPA.
River ecosystem types	Comprise distinct combinations of Level 1 ecoregions, flow descriptions from Department of Rural Development and Land Reform: National Geospatial Information (DRDLR-NGI), and slope categories from Rowntree and Wadeson (1999). River ecosystem types were used for representing the diversity of rivers across the country. They can be regarded as coarse-filter surrogates of biodiversity, conserving the diversity of many common and widespread species, and their associated habitats.
River condition	Combines data on present ecological state of rivers (1999 and available updates), river health data, reserve determination data, expert knowledge and natural land cover data. Rivers had to be in a good condition (A or B ecological category; **Table 3.3**) to be chosen as FEPAs. Phase 2 FEPAs in moderately modified rivers (C ecological category) were identified for those river ecosystem types that could not achieve a biodiversity target in good condition rivers.
Free-flowing rivers	Long stretches of rivers on the 1:500 000 river network GIS layer that have no instream dams and therefore flow undisturbed from their source to the confluence with a larger river or to the sea. Dams prevent water from flowing down the river and disrupt ecological functioning with serious knock-on effects for the downstream river reaches and users. Acknowledging that not all of these are likely to remain free-flowing in the light of development needs, flagship free-flowing rivers were identified based on their representativeness of free-flowing rivers across the country, as well as their importance to ecosystem processes and biodiversity value. In examining water resource development options, these flagship rivers should receive top priority for retaining their free-flowing character.
Wetlands	
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). All of these have been classified as either 'natural' or 'artificial' wetlands to derive National Wetland Map 3. Wetland data layers from KwaZulu-Natal province and the Cape Action for People and the Environment (C.A.P.E.) fine-scale biodiversity planning domains have also been added.
Wetland ecosystem types	Classifies wetlands on the basis of a hydrogeomorphic approach to Level 4a of the national wetland classification system (SANBI 2010) 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.

INPUT LAYERS	DESCRIPTION
Wetland condition	Uses the proportion of natural land cover in and around the wetland as an indicator to model wetland condition. For riverine wetlands, the condition of rivers was also taken into account. Wetland condition was used to favour the selection of wetland FEPAs, although wetlands did not have to be in a good condition (A or B ecological category; **Table 3.3**) to be chosen as a FEPA.
Wetland ranks	Ranks wetlands according to conservation importance using a combination of special features and modelled wetland condition. Special features included expert knowledge on features of conservation importance (e.g. extensive intact peat wetlands, presence of rare plants and animals) as well as available spatial data on the occurrence of threatened frogs and wetland-dependent birds. Wetlands of high conservation importance were selected for representation first, proceeding to lower ranking wetlands only if necessary.
Wetland clusters	Groups of wetlands within 1 km of each other and embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. FEPAs were identified to represent clusters in each wetland vegetation group.
Species	
Fish sanctuaries	Fish sanctuaries were identified at the scale of sub-quaternary catchments. Fish localities from the Biodiversity (SAIAB) and Albany Museum fish database were used to guide the choices, and updated with expert knowledge during the regional review workshops. Five types of conservation areas were identified for each species: Fish Sanctuaries (areas required to meet fish population targets); Fish Migration Corridors (areas required for migration between required habitats, usually between mainstem and tributary habitat); Rehabilitation and Translocation Areas (areas critical to the survival of the critically threatened fish species they support); and Upstream Management Areas (areas that need to be managed to prevent degradation of downstream of Fish Sanctuaries and Fish Migration Corridors).
Water supply areas	
High water yield areas	Sub-quaternary catchments were identified where mean annual runoff is three times higher than the average for the related primary catchment. High water yield areas are not all FEPAs, but the recommendation is that they should be maintained in a good condition (A or B ecological category) to support the sustainable development of water resources in each Water Management Area.
High groundwater recharge areas	Sub-quaternary catchments were identified where groundwater recharge is three times higher than the average for the related primary catchment. High groundwater recharge areas are not all FEPAs, but the recommendation is that the surrounding land should be managed so as not to adversely impact groundwater quality and quantity.
Estuaries	
Estuary localities	The estuarine functional zone was used to depict the extent of each estuary, which was defined laterally as anything below the 5 m mean sea level contour, and longitudinally as far as tidal variation or salinity penetration, which ever goes further upstream - as per the boundaries set by the Department of Water Affair’s Directorate of Resource Directed Measures. Where this was not known, the 5 m mean sea level contour was used as the upstream boundary.
Priority estuaries	Those priority estuaries as identified in the National Biodiversity Assessment 2011 based on a systematic biodiversity planning approach. These became FEPAs and were also used to favour the selection of associated river and wetland ecosystems as FEPAs.

3.4.1 Sub-quaternary catchments

Sub-quaternary catchments were used as the units of selection, or planning units, for identifying priority areas. They were modelled in ArcHydro, an extension of ArcGIS 9.3, using a combination of digital elevation data and the 1:500 000 rivers used by Department of Water Affairs (Section 3.4.2). A 50 m digital elevation model (CSIR, unpublished) was used, which is an interpolation of 20 m contours and spot heights data per 1:50 000 data sheets from Department Land Affairs: Chief Directorate Surveys and Mapping (DLA-CDSM 2005-7).

Catchment boundaries were delineated around each river segment (the portion of river between each 1:500 000 river confluence; Figure 3.2) which resulted in 9 417 sub-quaternary catchments. These are roughly nested within the 1 945 quaternary catchments in South Africa (Midgley et al. 1994). The size of the sub-quaternary catchments is variable but they are on average five times smaller than quaternary catchments (mean size of 135 km^2 compared to 650 km^2 respectively).

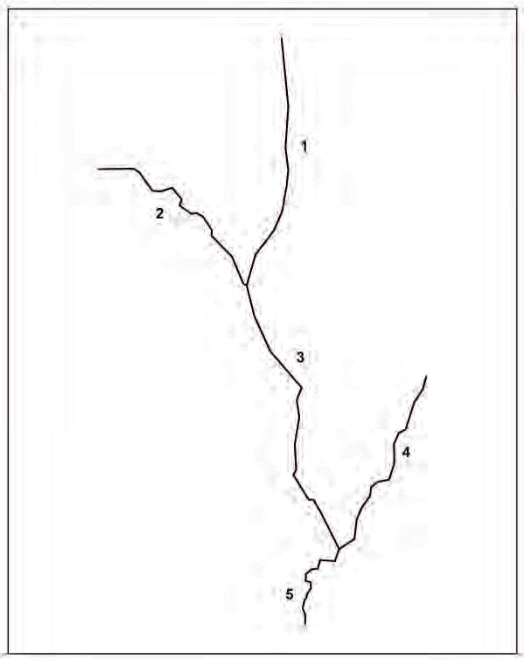

Figure 3.2: River segments and river reaches used in the GIS analyses of NFEPA
Five river segments are shown between confluences, labelled 1 to 5. These make up three river reaches – one comprised of multiple river segments labelled 1 to 3; and the remaining represented by 4 and 5. Sub-catchments were delineated around each river segment (after Nel et al. 2009).

3.4.2 River network

A rivers network GIS layer is required in order to map and classify the different river ecosystem types across the country. The Department of Water Affairs 1:500 000 river network was used as a base GIS layer for NFEPA. Ninety-seven coastal rivers from the 1:50 000 rivers GIS layer (Department Land Affairs: Chief Directorate Surveys and Mapping) were added so that all rivers associated with NFEPA estuaries were included in the analyses. This GIS layer was coded to distinguish:

- ***Quaternary catchment mainstems and tributaries***. Mainstems are rivers that pass through a quaternary catchment into a neighbouring quaternary catchment. In situations where no river passes through the quaternary catchment, the longest river system was chosen as the mainstem. All other rivers on the 1:500 000 rivers GIS layer were considered tributaries (i.e. tributaries nest within a single quaternary catchment).

- ***River segments***. The portion of river between confluences of the 1:500 000 rivers GIS layer, around which sub-quaternary catchments were delineated.

- ***River reaches***. The whole river sub-system from the headwaters to either the estuary or confluence with a major river. A river reach can be made up of a number of river segments, and may be relatively short, or as long as, e.g., the Orange River.

3.4.3 River ecosystem types

River ecosystem types were used by NFEPA for representing the diversity of river ecosystems across the country. River ecosystem types used by NFEPA are components of rivers with similar physical features (such as climate, flow and geomorphology). Under natural conditions, river ecosystem types are expected to share similar biological response potential. The goal of NFEPA is to keep at least 20% of each river ecosystem type in a good condition (A or B ecological category). River ecosystem types are an essential coarse-filter biodiversity surrogate, especially to ensure that the priority areas broadly capture the diversity of freshwater invertebrates. Preliminary investigations show that river ecosystem types are likely to capture macro-invertebrate diversity better than fish species (Roux et al. 2007). It is difficult to target freshwater invertebrates directly because of the lack of species-level data, even for macro-invertebrates, at a national level. Future revisions of NFEPA should explore the International Union for Conservation of Nature (IUCN) data released to the public in 2010 (IUCN 2007).

The NFEPA river network (Section 3.4.2) was classified according Level 1 ecoregions, flow variability and channel slope to produce 223 distinct combinations of river ecosystem types for South Africa (Figure 3.3):

- ***Level 1 ecoregions***
  Thirty-one Level 1 ecoregions classify the landscape based on topography, altitude, slope, rainfall, temperature, geology and potential natural vegetation (Kleynhans et al. 2005). Ecoregions broadly characterise the landscape through which a river flows, such that rivers in the same ecoregion share similar broad ecological characteristics compared to those in different ecoregions. For example, the Highveld is characterised by extensive flat plains with gentle meandering rivers, compared to rivers in the Eastern Coastal Belt that are often in steeply incised and confined valleys. Each river segment (Figure 3.2) on the river network was classified according the ecoregion through which it mostly flowed using zonal statistics in ArcGIS 9.3.

- ***Flow variability***
  Rivers with different flow variability can be expected to exhibit different ecological characteristics. Flow variability was broadly described using two categories: ‘Permanent’ includes both perennial and seasonal rivers and ‘Not permanent’ includes ephemeral rivers. Descriptions were based on river flow classes used in the Department of Water Affairs 1:500 000 rivers GIS layer as well as the information on the 1:50 000 rivers GIS layer from DLA-CDSM. These descriptions were originally derived from aerial photograph classification of presence/absence of water in the channel. Ideally, flow variability for the 1:500 000 rivers should be described in more than two categories. While this is accomplished by the hydrological index developed by Hannart and Hughes (2003), it is only available for mainstem

quaternary rivers. NFEPA requires a finer resolution than this. Developing hydrological indices for the 1:500 000 rivers layer should be a future focus for improving the description of river ecosystem types.

- ***Slope categories for the river channel***
  These were based on the geomorphological zones of Rowntree and Wadeson (1999), which characterise the ability of river reaches to store or transport sediment, with each zone representing a different physical template available for the biota. Moolman et al. (2002) used GIS slope profiles based on 20 m contours (DLA-CDSM) to stratify the 1:500 000 rivers according to the slope categories proposed by Rowntree and Wadeson (1999). The additional rivers added to the NFEPA rivers network (Section 3.4.2) were manually coded by eye using remotely-sensed imagery. The resulting geomorphological zones were grouped into four categories depicting ecological characteristics at a national level: mountain streams, upper foothills, lower foothills and lowland rivers. These categories can be expected to have different physical and hydrological characteristics as well as human impacts, and are likely to have distinct biota.

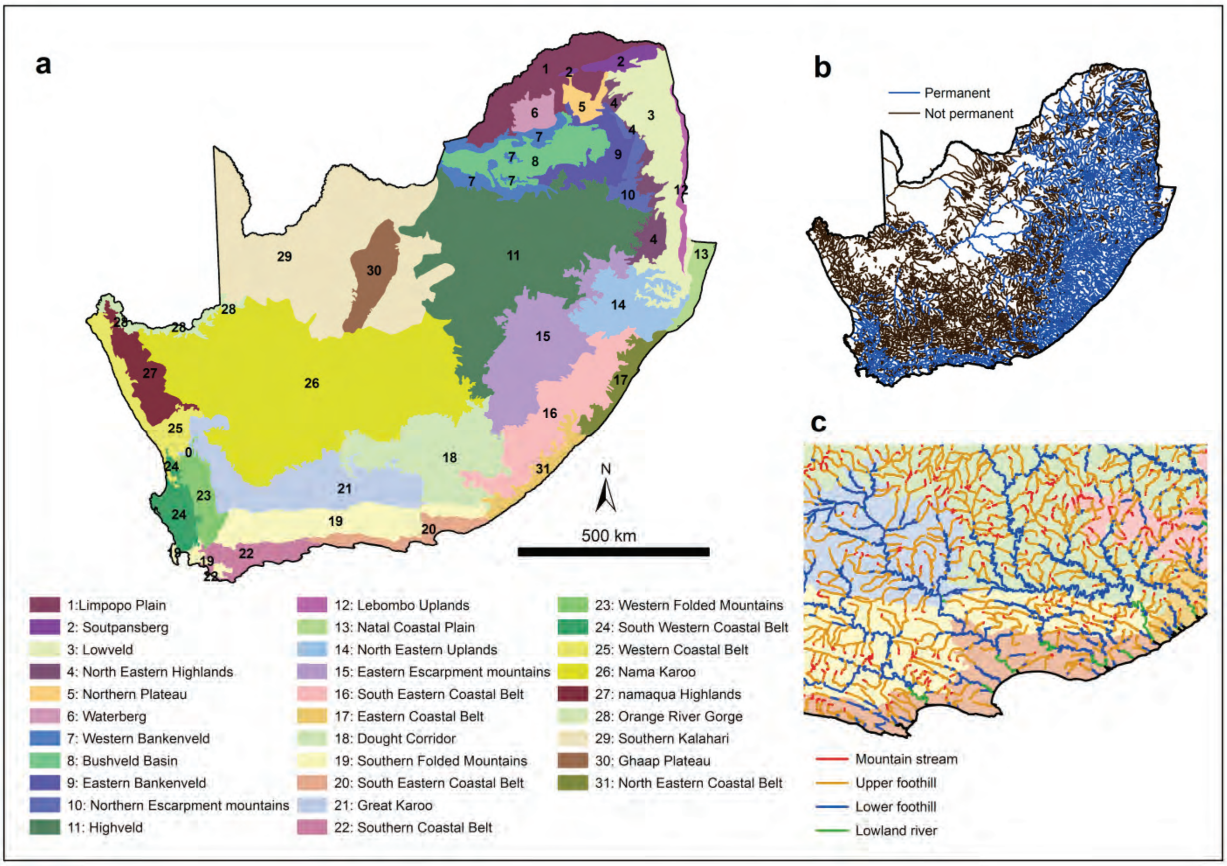

Figure 3.3: GIS layers that were combined to develop NFEPA river ecosystem types (a) Level 1 ecoregions (after Kleynhans et al. 2005), (b) flow variability (DLA-CDSM 2005-7), and (c) geomorphic zones (Rowntree and Wadeson 1999) were used to produce 223 distinct combinations of river ecosystem types.

Figure 3.4 shows the number of river ecosystem types in each Water Management Area. The Usutu to Mhlathuze, Olifants and Limpopo Water Management Areas display the highest diversity, with over 20% of the total number of river ecosystem types occurring in each of these areas. In terms of the NFEPA case study areas, the Inkomati and Crocodile (West) and Marico Water Management Areas display a relatively moderate river diversity (17% of South Africa's river ecosystem types are found here), while the Breede Water Management Area has a relatively low river ecosystem diversity (7%).

In future, descriptions and lists of dominant species should be developed for each river ecosystem types, and ideally published in a way similar to the vegetation map of South Africa, Lesotho and Swaziland (Mucina and Rutherford 2006).

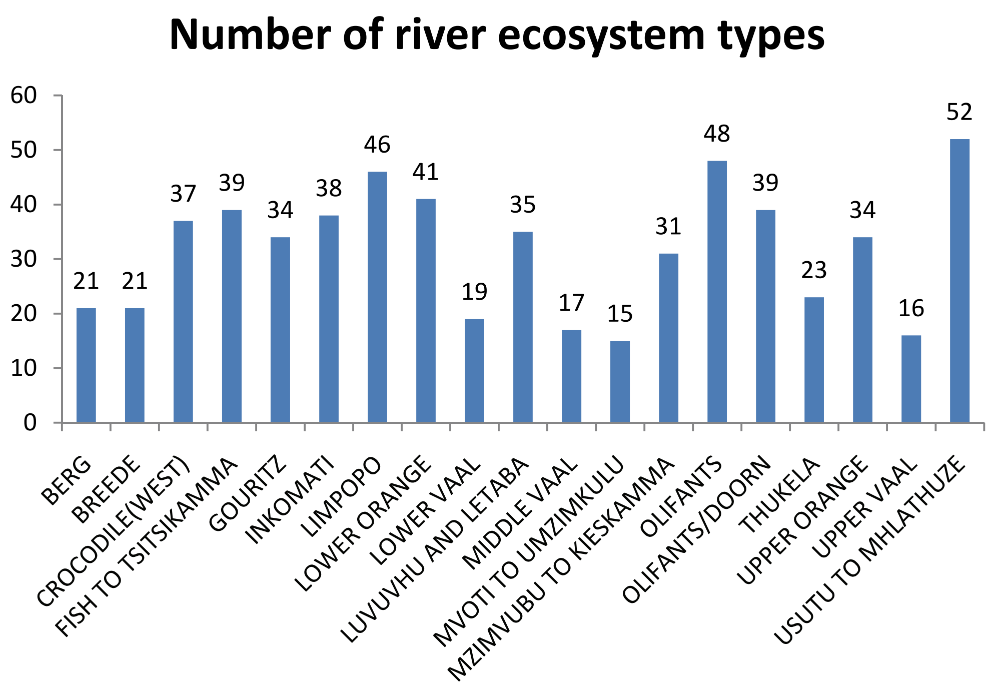

Figure 3.4: Number of river types in each Water Management Area

3.4.4 River condition

River condition describes the extent to which a river has been modified by human activity. In South Africa, river condition is often described in six ‘present ecological state (PES)’ categories ranging from natural (A) to critically modified (F) (**Table 3.3**). River condition was used to inform the selection of rivers as FEPAs and the subsequent FEPA map categories (Section 3.9.1). For example, only river ecosystems in good condition (A or B ecological category) were chosen as FEPAs because these rivers provide the best representative examples of South Africa’s freshwater ecosystems and associated biodiversity. From a practical point of view, natural ecosystems tend to be more self-sustaining, thus requiring less conservation management. The cost of rehabilitating rivers in good condition is also lower than the cost of rehabilitating modified rivers, and the likelihood of success is greater. Figure 3.5 shows a schematic of the data and process used to collate river condition data for the 1:500 000 rivers.

Table 3.3: Present ecological state (PES) categories describing condition South African rivers After Kleynhans (2000). For NFEPA, rivers in an A and B category were regarded as being in 'good condition', with the ability to contribute toward biodiversity targets.

Ecological category	Description
A	Unmodified, natural.
B	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	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions are extensive.
F	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.

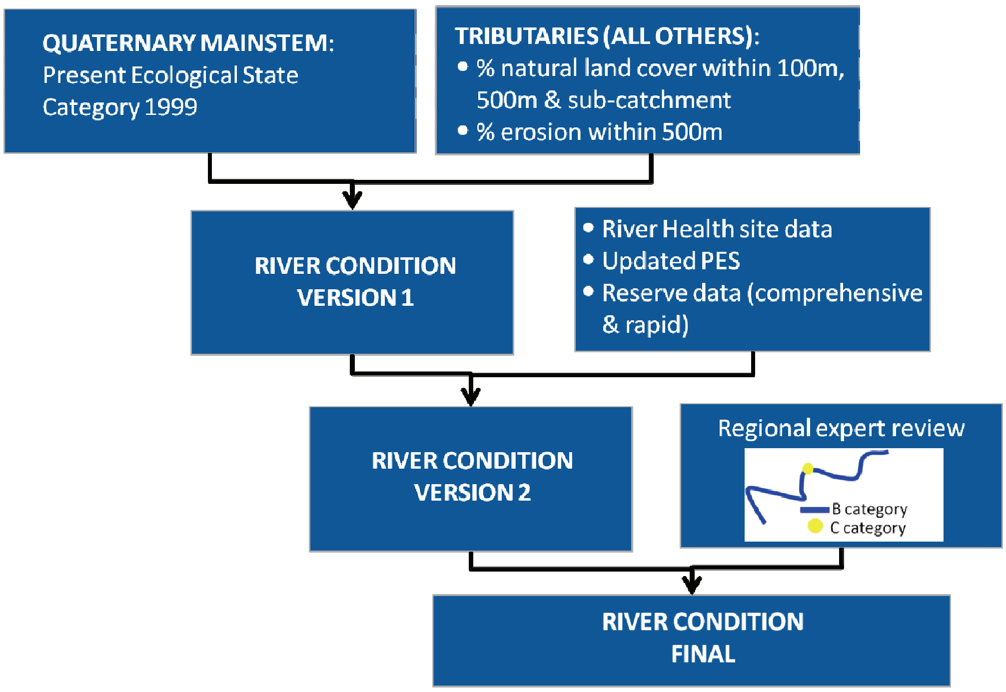

Figure 3.5: Process and data used to collate river condition data for all 1:500000 rivers

River condition version 1

An initial GIS layer for river condition was compiled by combining the 1999 present ecological status categories for quaternary mainstem rivers with modelled categories for all other tributaries. The present ecological status categories range from A (natural) to F (heavily modified) and were collected through a series of sub-national workshops with river scientists and practitioners throughout the country between 1998 and 1999 (Kleynhans 2000). The categories were based on an expert assessment of the modification of six attributes from their natural condition (flow, inundation, water quality, stream bed condition, introduced instream biota, riparian or stream bank condition), and were informed by existing data where possible. For NFEPA, quaternary mainstem rivers were considered to be in a good condition if in an A or B ecological category, moderately-modified if in a C category, and largely-modified if in D to F categories.

Lack of data necessitated the modelling of tributary condition using natural land cover as an indicator of condition. This was based on studies that suggest that where no direct data exist, land cover is the most useful factor to infer information about ecological integrity of freshwaters (Allan 2004; Linke et al. 2007). We used the 30 m resolution 2009 SANBI ‘Mosaic National Land Cover’, which updates the National Land Cover 2000 GIS layer (Van den Berg et al. 2008) with more recent and improved provincial land cover data where it exists. Transformed land classes included cultivated, urban, degraded and eroded land, as well as plantations, mines and quarries. Inland water bodies at a 1:50 000 scale (DLA-CDSM 2005-7) were also used to distinguish natural and artificial waterbodies, where the latter included all dams, fish farms, large reservoirs, purification plants, sewerage works and water tanks. The remaining land cover classes were considered natural. Only two condition categories were assigned to tributaries: ‘good condition’ (equated to the A or B ecological categories of mainstem rivers), or ‘not in good condition’ (assigned to a category of Z). Tributaries were considered to be in a good condition if the minimum value for the percentage of natural land cover within the sub-catchment, 500 m and 100 m buffer of a river segment was ≥ 75% AND the percentage erosion within a 500 m buffer of a river segment was ≤ 5%; remaining tributaries were regarded as not in good condition. Elevating the impact of erosion was considered important in accounting for the inaccuracy of the land cover data in detecting land degradation (Thompson et al. 2009), which is especially problematic in the drier regions where subsistence grazing often causes disproportionate degradation to rivers, altering the riparian vegetation and causing bank erosion.

River condition version 2

River condition data for several catchments in the country have been collected since the collation of the 1999 present ecological status data, mainly through the River Health Programme, updated present ecological status for selected Water Management Areas and reserve determination studies. These sub-national data were collated in GIS as a means of guiding review of the river condition version 1 GIS layer (Figure 3.5).

Site collection data from the River Health Programme were initially drawn from the Department of Water Affairs rivers database, extracting sites with coordinates. Although the rivers database contains indices relevant to the River Health Programme (e.g. various macro-invertebrate scores), it makes no provision for translating these indices into a single summary score to describe the overall present ecological category. The same situation was found with the older State of River Reports – although they provide a desired ecological category, they do not give an indication of overall present ecological category. Confounding this problem was that most State of River Reports were not accompanied by the required technical reports, which made it difficult to access the original data. Fortunately, a more recent project reviewing the River Health Programme (Strydom et al. 2006) had collated data from its provincial champions in a spreadsheet which had made provision for indicating the overall present ecological category. By relating these site numbers back to the original rivers database, we were able to access coordinates and develop a spatial map for overall present ecological category at 582 sites (estimated as less than 50% of all River Health Programme sites). It is recommended that the rivers database be updated with the information contained in the Strydom et al. (2006) and that an effort is made to synthesise indices into an overall present ecological category.

Updated present ecological status data for seven of the 19 Water Management Areas were obtained from the Resource Quality Services Directorate of the Department of Water Affairs. These data used expert assessment methods (Kleynhans et al. 2005) to develop a present ecological status category (or 'ecostatus' category) for a total of 204 quaternary catchments within the selected Water Management Areas. Because the data were at a quaternary catchment resolution, they were only used for updating the quaternary mainstem data in the river condition version 1 GIS layer.

Ecological reserve determination data were obtained from Department of Water Affairs' surface water reserve requirements database. All ecological reserve data were treated similarly no matter whether the reserve determination techniques were desktop, rapid, intermediate or comprehensive. Although the database contained the most recent data, a large number of sites (457 of 1021, or 45%) had no coordinates attached rendering them useless for mapping purposes. We relied on expert input at the workshop for providing reserve determination knowledge for these sites, which is not ideal. The need for clear and accurate site coordinates is a major issue given the investment that goes into reserve determinations. It is recommended that this aspect be quality-controlled more strictly in taking receipt of deliverables of future reserve determination studies.

Once the sub-national data had been collated, they were compared to the river condition version 1 GIS layer to identify discrepancies. The more recent present ecological status updates for selected Water Management Areas took precedence over the 1999 version – any discrepancies were addressed by adopting the most recent present ecological category. Discrepancies between the river condition version 1 GIS layer and the site-specific data from the River Health Programme and the reserve determination studies were flagged for debate by experts during the regional review process.

River condition final version

During the regional review workshops, experts reviewed the river condition of their regions based on their knowledge, and debated discrepancies between site-specific data and river condition version 2. Experts were asked to review whether the discrepancies were a result of localised or landscape level impacts. The present ecological status category was only updated if the difference was deemed significant at a landscape scale. In addition, experts were asked to estimate a present ecological status category for any tributaries that they knew, particularly those that had been modelled as 'not in good condition'. These refinements resulted in the final version of river condition used by NFEPA (Figure 3.6).

A previous assessment showed that only a third of the country's main rivers are in a good condition (A or B ecological category; Nel et al. 2007). The NFEPA assessment, which included both main rivers and their 1:500 000 tributaries, showed clearly that tributaries are generally less heavily impacted than main rivers. Nearly half of the rivers are in good condition if main rivers and tributaries are considered together, compared with about a third when considering main rivers alone (Figure 3.7). This emphasises the important role that healthy tributaries play in keeping our heavily impacted main rivers functioning.

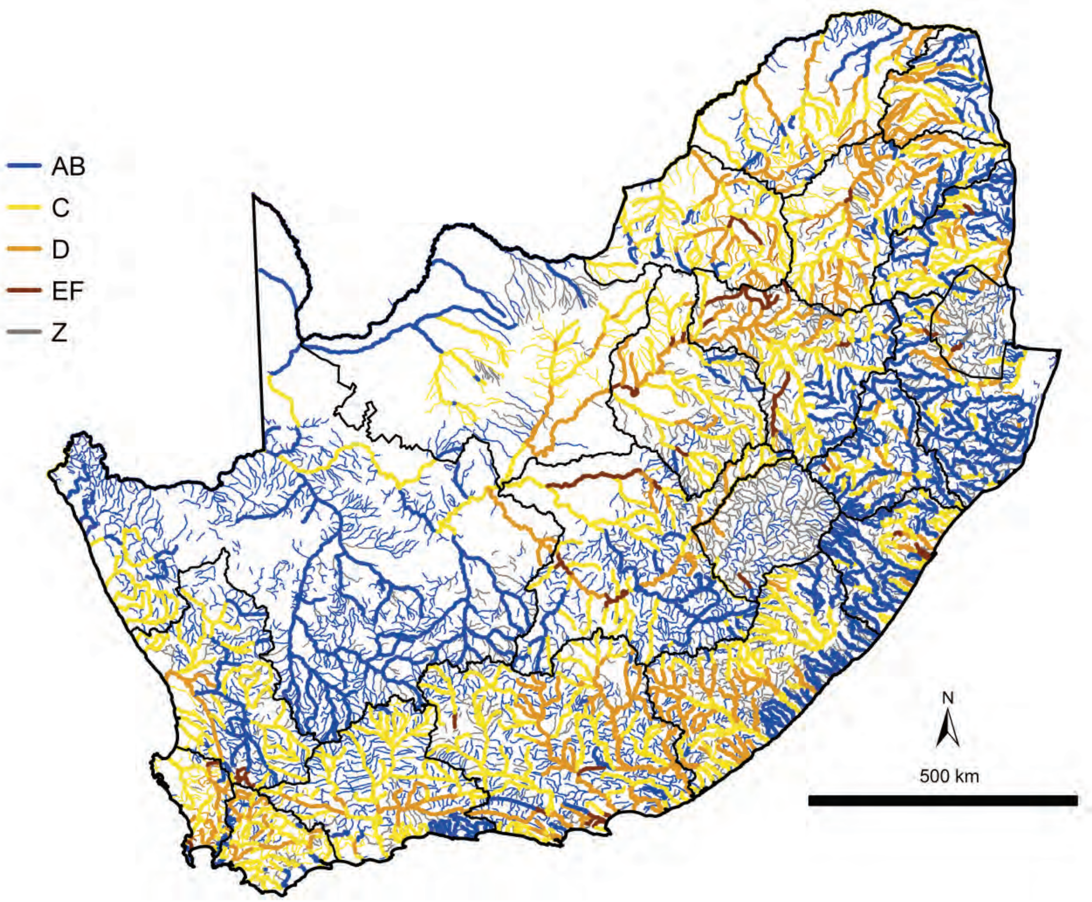

Figure 3.6: NFEPA river condition
Quaternary mainstem rivers are drawn thicker than tributaries.

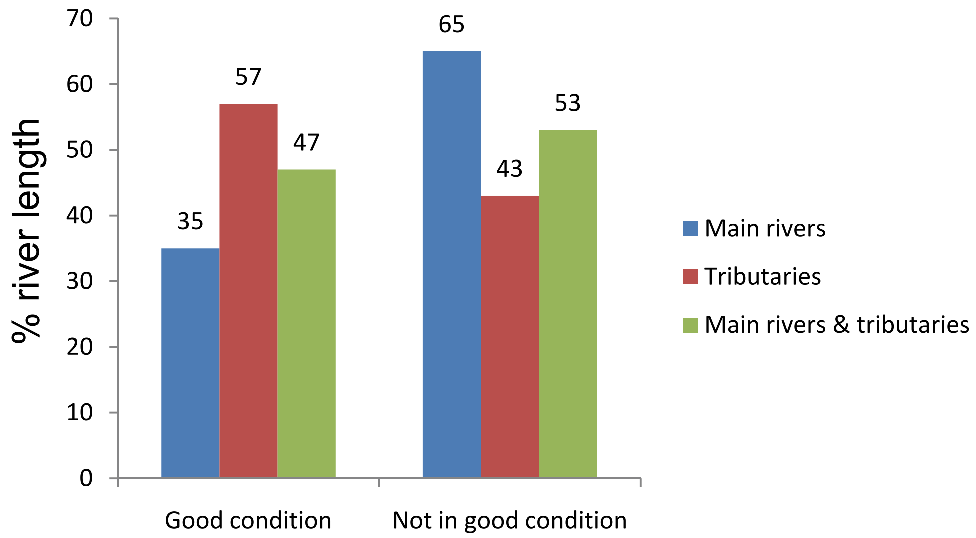

Figure 3.7: Number of river types in each Water Management Area

3.4.5 Free-flowing rivers

A free-flowing river is a long stretch of a relatively large river that has not been dammed or does not experience major flow alteration. It flows undisturbed from its source to the confluence with another large river or to the sea. Dams prevent water from flowing down the river and disrupt ecological functioning with serious knock-on effects for the downstream river reaches and users. Today there are very few large rivers that remain dam-free, or ‘free-flowing’. Free-flowing rivers are rare features in our landscape and an important part of our natural heritage. Opportunities for conserving free-flowing rivers are fast disappearing with the growing demand for development of water resources. While acknowledging the importance of water resource development, there is also an urgent need to identify some free-flowing rivers that can serve as a representative set our country’s last remaining free-flowing rivers, and to maintain their free-flowing character.

A draft list of free-flowing rivers was compiled for expert review, by identifying river reaches (Figure 3.2) satisfying all of the following requirements:

- Permanent or seasonally flowing rivers. Rivers that do not necessarily flow every year (‘ephemeral rivers’) were not considered.
- In good condition (A or B ecological category).
- No instream dams throughout the length. The Upper Vaal and Upper Marico rivers were special cases where the long stretch of river flowing freely from source to dam was considered free-flowing.
- Length ≥ 50 km for inland rivers, with no length threshold for coastal rivers.

River ecosystem types and river condition were used to identify reaches qualifying under the first two criteria. The 1:50 000 farm dams (DLA-CDSM 2005) were used as the dams GIS layer. Data constraints prevented consideration of farm dams built after 2005, as well as weirs. The 1:50 000 farm dams GIS layer (DLA-CDSM 2005) was used to identify instream dams. To account for spatial inaccuracies between the 1:500 000 rivers and the 1:50 000 dams, the dams were buffered by 50 m. Any buffered dam that intersected a river was then assumed to be an instream dam. This produced a draft list of free-flowing rivers, which were then reviewed by experts during the series of regional review workshops (Section 2; Appendix A and B) to produce a final list of free-flowing rivers of South Africa.

There are 62 free-flowing river reaches in South Africa, of which only 25 are longer than 100 km (Table 3.4; Figure 3.8). Acknowledging that not all of these are likely to remain free-flowing in the light of development needs and objectives, 19 of the 62 free-flowing rivers (Table 3.4) were identified as flagship free-flowing rivers at the final national review workshop (Section 2; Appendix A and B). These flagships were identified based on their representativeness of free-flowing rivers across the country, as well as their importance to ecosystem processes and biodiversity value. These flagship rivers should receive top priority for retaining their free-flowing character.

The Eastern Cape and KwaZulu-Natal provinces have the highest number of free-flowing rivers in the country (Table 3.4; Figure 3.8). Many of these rivers will undoubtedly lose their free-flowing status as these provinces are in urgent need of water resource development to improve water supply to households and agriculture. Flagship free-flowing rivers should receive top priority for maintaining their dam-free status. The provinces of Gauteng and Free State have no remaining free-flowing rivers. Rivers of the Free State are characteristically dry rivers that can go for years without flowing; thus, the lack of free-flowing rivers for this region is natural. The lack of free-flowing rivers in the Gauteng province (Table 3.4; Figure 3.8) is indicative of rivers working hard to meet the demands the largest economic hub of the country – representation of freshwater ecosystems within this region needs to be sought outside Gauteng in the North West Province.

This emphasises the immense importance of the Upper Groot-Marico River, which is the only free-flowing river representative of the entire north-western region of the country.

Table 3.4: Free-flowing rivers, or rivers without dams, in South Africa
Those in bold italics are flagship free-flowing rivers that are top priority for retaining their free-flowing character.

NORTHERN CAPE	**EASTERN CAPE**	**KWAZULU-NATAL**
Upper Sak, Klein- Sak & tributaries*	Riet	***Mzimkhulu****
	Kap	Mzumbe
WESTERN CAPE	Mpekweni	Mpambanyoni*
Doring & tributaries*	Mgwalana	aMahlongwa
Klaas Jaagers	***Kobonqaba***	aMahlongwana
Rooiels	iNxaxo	Mkomazi & tributaries*
Touws	Qhorha & tribuntaries*	***Mkuze & tributaries****
Karatara-Hoogekraal	Shixini	***Nsuze* tributary of Thukela***
Homtini	***Nqabarha****	Matigulu & tributaries*
Knysna	Ntlonyane	***Black Mfolozi & tributaries****
Bietou-Palmiet	Xora*	Nsonge
Groot (Garden Route)	Mncwasa	Nondweni
Bloukrans	Mdumbi	Ngogo
	Mtakatye*	Mfule*
LIMPOPO	Mnenu	Nyalazi*
Mutale-Luvuvhu*	Sinangwana	
Mohlapitse	Mngazana	**MPUMALANGA**
	Mntafufu	***Ntombe tributary of Phongolo***
NORTHWEST	Mzintlava	Hlelo*
Upper Groot-Marico	Mkozi	Upper Vaal*
	Msikaba*	***Elands****
	Mtentu*	Mbyamiti
	Sikombe	Nwanedzi-Sweni*
	Mpahlane	
	Mzamba*	
	Mtamvuna & tributaries*	
	Kraai & tributaries*	

* Free-flowing rivers longer than 100 km

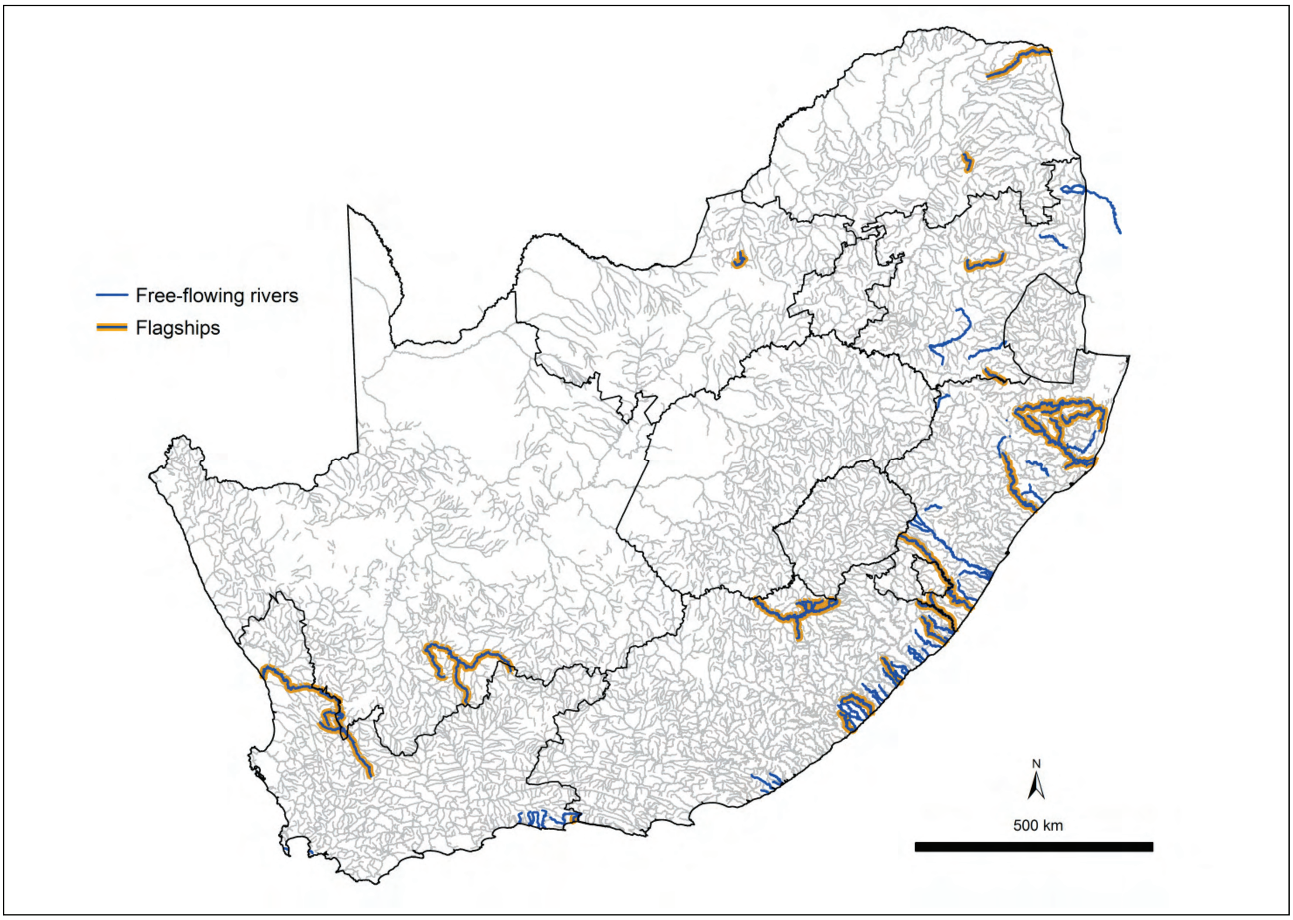

Figure 3.8: Free-flowing rivers in South Africa

3.4.6 Wetland locality mapping

It is necessary to map wetlands so that they may be classified into the different wetland ecosystem types across the country. Figure 3.9 shows a flow diagram of the data that were used to derive the NFEPA wetland localities map. SANBI's National Wetland Map 1 was used as the base GIS layer. This layer was derived from the National Land Cover 2000 GIS layer (Van den Berg et al. 2008), 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, National Wetlands Map 1 was combined with the 1:50 000 inland water features (DLA-CDSM 2006), to derive National Wetland Map 2 that was divided into three 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 locality maps from other biodiversity planning initiatives were added to the National Wetland Map 3 to derive the final NFEPA Wetland Map 3. 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).

The locality mapping was 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.

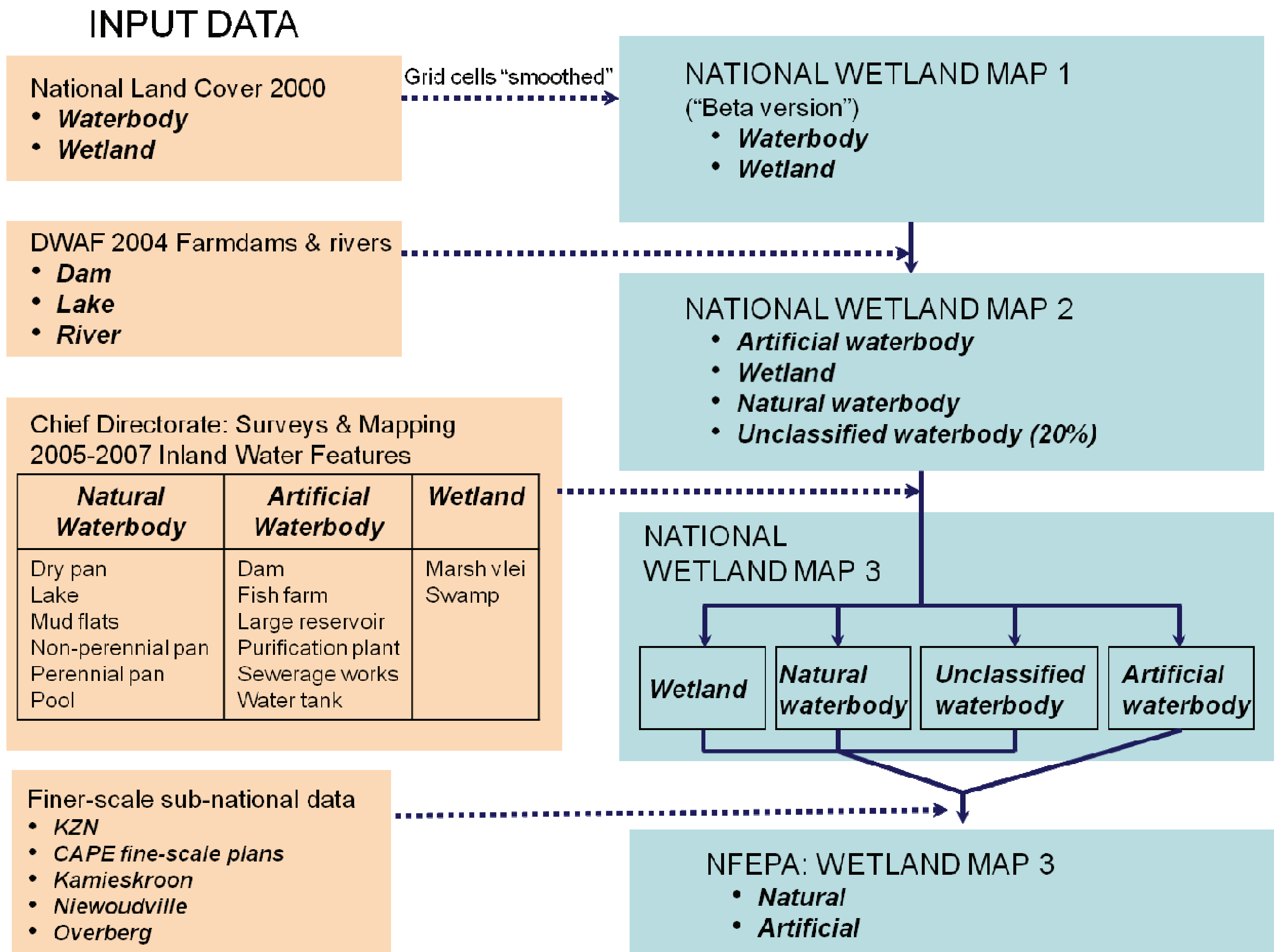

Figure 3.9: Flow diagram of the input data used to map NFEPA wetland localities

3.4.7 Wetland ecosystem types

Wetland ecosystem types were used by NFEPA as coarse-filter surrogates for representing the diversity of wetland ecosystems across the country. Wetlands in the same wetland ecosystem types are expected to share similar broad functionality and ecological characteristics. A goal of NFEPA is to ensure that at least 20% of each wetland ecosystem type is managed in a natural or near-natural state. This serves to conserve many common species and communities, and the habitats in which they evolve. Wetland ecosystem types were supplemented with information on Ramsar status, known threatened frog and waterbird occurrences, and expert knowledge on biodiversity importance (Section 3.4.11), to help identify wetland FEPAs.

The national wetland classification system (SANBI 2010) was used to classify wetland ecosystem types. It is a hierarchical classification framework consisting of six levels, with each level requiring increasing levels of detail about the wetland. Level 1 separates wetlands into inland, marine and estuarine systems. Levels 2 to 4 identify broad groups of wetlands sharing similar regional context, landform and broad hydrology. Levels 5 and 6 describe site characteristics such as hydroperiod, geology, vegetation, substratum, salinity, pH and naturalness.

NFEPA automated the classification procedure using GIS, to Level 4a of the national wetland classification system:

- At ***Level 1***, wetlands were identified either as estuaries or as inland wetlands using the NFEPA wetland map (Section 3.4.6). Only inland wetlands were classified into distinct wetland ecosystem types, because estuaries were classified as part of the National Biodiversity Assessment 2011 (Section 3.4.16).

- At ***Level 2***, the GIS layer of wetland vegetation groups (Section 3.4.8), which characterises the regional context within which wetlands occur, was used to classify wetlands. Each wetland (polygon in the NFEPA wetlands map, Section 3.4.6) was assigned the wetland vegetation group that occupied the majority of its area.

- At ***Level 3***, the landforms GIS layer (Section 3.4.9) was used to classify wetlands according to four broad landform types (slopes, benches, valley floors and plains). Wetlands smaller than 100 ha were not divided by landform type, but rather assigned the landform type that occupied the majority of its area. Larger wetlands were divided according to landform type using a GIS overlay.

- ***Level 4a*** describes seven wetland hydrogeomorphic types (Table 3.5). Wetlands were classified according to this level using four GIS layers: Level 3 classifications of wetlands into broad landform types, 1:50 000 pans (DLA-CDSM 2006), the NFEPA river network (Section 3.4.2) and the NFEPA river ecosystem types (Section 3.4.3). Using a sequential step-wise process of elimination, polygons were classified according to Level 4a (Figure 3.11 Figure 3.11):

    i. *Depressions* for all four landform types were identified based if their centre points coincided the 1:50 000 pans (DLA-CDSM 2006).
    ii. *Floodplains* for Level 3 wetlands classified as valley floors and plains were identified by selecting the remaining inland wetlands which were within 100 m from river ecosystem types classified as lowland rivers.
    iii. *Valleyhead seeps* were identified by selecting remaining inland Level 3 wetlands identified as 'U-shaped valleys' from the original ten default categories of the ArcGIS 9.3 landform tool (see Table 3.6).
    iv. *Channelled valley-bottom wetlands on valley floors* were identified by intersecting the remaining inland valley-floor wetlands with the 1:50 000 river lines (DLA-CDSM 2006).
    v. Remaining inland wetlands on valley floors were then classified as *Unchannelled valley-bottom wetlands on valley floors*.
    vi. Remaining inland wetlands on plains that intersected with the 1:50 000 river lines (DLA-CDSM 2006) were classified as *Unchannelled valley-bottom wetlands on plains*, as they show association with alluvial processes even though these wetlands are not associated with channels.
    vii. Remaining inland wetlands on plains were the classified as *Flats on plains*.
    viii. Remaining inland wetlands on benches were the classified as *Flats on benches*.
    ix. Remaining inland wetlands on slopes were then classified as *Seeps.*

The GIS layers classifying each level of the national wetland classification system were finally combined to derive NFEPA wetland ecosystem types. GIS layers of inland wetlands (Level 1) classified according to wetland vegetation group (Level 2) were combined with the seven hydrogeomorphic wetland types (Levels 3 and 4a) to produce 792 distinct combinations that were considered as NFEPA ecosystem types for inland wetlands. No further grouping of these 792 wetland ecosystem types was done, however potential exists for grouping at least some of these, for example:

- 40 wetland ecosystem types are represented by one wetland only.
- 29 wetland ecosystem types have a total area of less than 10 ha.
- Examining total area of wetland belonging to NFEPA wetland vegetation groups shows that only five wetland vegetation groups have a total area of less than 10 ha. This suggests that the wetland vegetation groups each contain a substantial number of wetlands to warrant their existence.
- In classifying wetlands according to Level 3 (see above), wetlands smaller than 100 ha were not divided by landform type, but rather assigned the landform type that occupied the majority of its area.

Table 3.5: Geomorphic types as defined by Level 4a of the national wetland classification system For more detailed definitions, discussion and photographs the reader is referred to SANBI (2010).

Level 4a geomorphic type	Definition
Seep	A wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Water inputs are primarily from subsurface flow that enters the wetland from an up-slope direction.
Valleyhead seep	A gently-sloping, typically concave wetland area located on a valley floor at the head of a drainage line, with water inputs mainly from subsurface flow (although there is usually also a convergence of diffuse overland water flow in these areas during and after rainfall events.
Unchannelled valley-bottom	A mostly flat valley-bottom wetland area without a well-defined stream channel running through it, characterised by an absence of distinct channel banks and the prevalence of diffuse flows, even during and after rainfall events. Water inputs are typically from an upstream channel, as the flow becomes dispersed, and from adjacent slopes (if present).
Channelled valley-bottom	A mostly flat wetland area on a valley floor (see valley floor) that is dissected by and typically elevated above a well defined stream channel (see channel). Dominant water inputs to these areas are typically from the channel (when it overtops or from sub-surface discharge) and from adjacent valley-side slopes.
Floodplain	The mostly flat or gently-sloping wetland area adjacent to and formed by a lowland or upland floodplain river, which is subject to periodic inundation by overtopping of the channel bank. Water and sediment input to these areas is mainly via overspill from a river channel during flooding.
Flat	As relates to Level 4A of the classification system, a near-level wetland area (i.e. with little or no relief) with little or no gradient, situated on a plain or a bench in terms of landscape setting. The primary source of water is precipitation, with the exception of flats along the coast (usually in a plain setting) where the water table may rise to the surface or near to the surface in areas of little or no relief because of the location near to the base level of the land surface represented by the presence of the ocean. Dominant hydrodynamics are vertical fluctuations.
Depression	A landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations. Depressions may be flat-bottomed (in which case they are often referred to as ‘pans’) or round-bottomed (in which case they are often referred to as ‘basins’), and may have any combination of inlets and outlets or lack them completely.

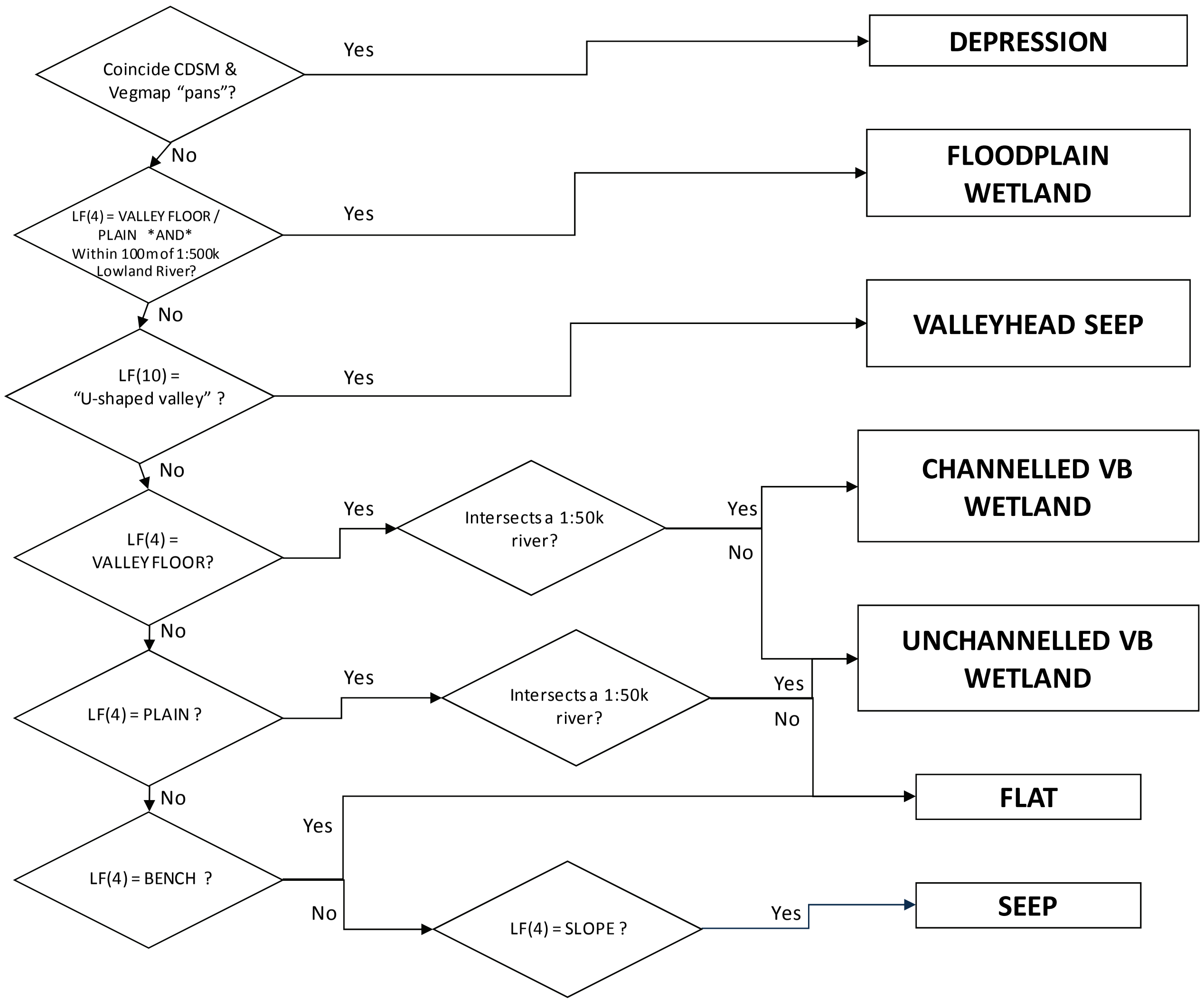

Figure 3.10: Process used for desktop classification of wetlands into seven geomorphic types
Definitions for the seven geomorphic types are provided in Table 3.5. This is equivalent to Level 4a of the national wetland classification system (SANBI 2010). Lowland rivers were defined using the slope categories identified for river ecosystem classification (Section 3.4.3). 'CDSM' refers to the Chief Directorate: Surveys and Mapping, and 'VB' refers to valley-bottom.

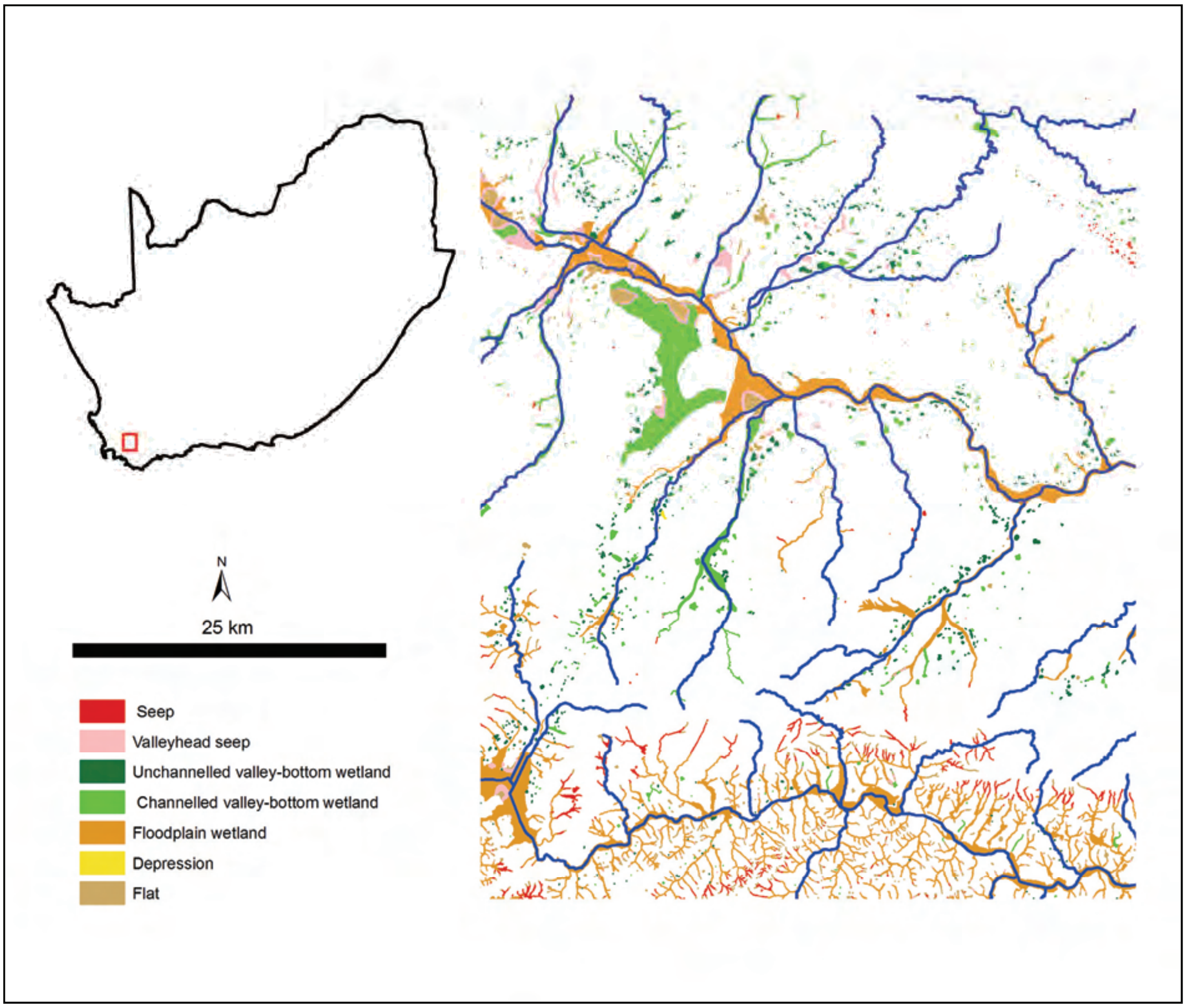

Figure 3.11: Seven wetland geomorphic types used to classify wetland ecosystem types

3.4.8 Wetland vegetation groups

A GIS layer of wetland vegetation groups was used to classify wetlands according to Level 2 of the national wetland classification system (SANBI 2010), which characterises the regional context within which wetlands occur. The assumption here is wetlands in a particular vegetation group are likely to be more similar to one another than to wetlands in other vegetation groups. Broad vegetation groupings reflect differences in geology, soils and climate, which in turn affect the ecological characteristics and functionality of wetlands.

Wetland vegetation groups were derived by grouping the 438 national vegetation types of South Africa, Lesotho and Swaziland (Mucina and Rutherford 2006) into groups thought to reflect the turnover of wetland biodiversity at a national level. The expert knowledge of regional wetland ecologists was used to do the grouping, deriving a map of 133 wetland vegetation types. Future research should focus on improving these groupings using ordination or cluster analysis techniques of representative surveys across the country. For most of the vegetation types in Mucina and Rutherford (2006), this was a simple exercise of deciding which vegetation types belonged in which groups. However, there were a few vegetation types where the landscape context of individual vegetation type patches (represented as polygons in the GIS layer) had to be considered:

- The ‘Azonal’ category of the national vegetation types was not used in deriving wetland vegetation groups as it is inconsistently mapped across the country. Instead, the ‘Azonal’ category was incorporated into whichever vegetation type was surrounding that ‘Azonal’ polygon.
- The ‘Forest’ category was incorporated into whichever vegetation type was surrounding that ‘Forest’ polygon.
- Polygons in the national vegetation types GIS layer identified as ‘Northern KwaZulu-Natal Shrubland’ that were surrounded by ‘Ithala Quartzite Sourveld’ or ‘KwaZulu-Natal Highland Thornveld’ were included in a different wetland vegetation group (Sub-Escarpment Grassland Group 2) than if they were surrounded by any other vegetation type (in which case, they were included in Sub-Escarpment Grassland Group 4).

Using these vegetation grouping rules, a map of 133 wetland vegetation groups was derived from the SANBI vegetation map (Figure 3.12). This was then used, in combination with the landform GIS layer, to classify wetland ecosystem types (Section 3.4.7).

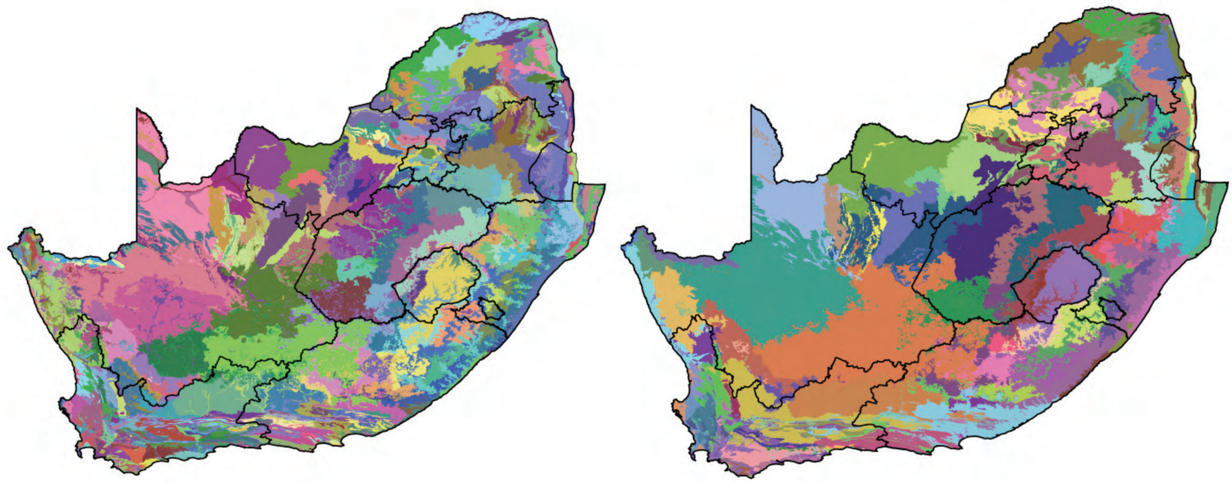

Figure 3.12: Vegetation types (left map) were grouped into wetland vegetation groups (right map) The 438 vegetation types (Mucina and Rutherford 2006) shown in (a) were grouped into 133 wetland vegetation groups that were used to characterise the regional context within which wetlands occur (Level 2 of the National Wetland Classification framework).

3.4.9 Landform types

A GIS layer of landform types was used to classify wetlands according to Level 3 of the national wetland classification system (SANBI 2010). Landforms describe the topography of a land surface in the context within which it occurs, identifying a range of landform types such as valley floors, slopes and benches, or hill tops. Landforms provide a framework for the role the landscape plays in processes related to geology, hydrology and ecology. Four general landform types are defined at Level 3 of the national wetland classification system for the geomorphic classification of the wetlands: slopes, benches, valley floors and plains (Table 3.6).

Table 3.6: Definition of the four landform types used in the national wetland classification system The relationship of each landform type with the ten default types of the landform tool is also shown. For further detail refer to text

Landform class (SANBI 2010)	Landform class definition	Landform Tool classes (Jenness 2006; Dilts 2009)
Valleys	An elongated, relatively narrow region of low land between ranges of mountains, hills, or other high areas (such as sand dunes), often having a river or stream running along the bottom	1. Canyons, deeply incised streams
Slopes	An inclined stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley (includes scarp slopes, mid-slopes and foot-slopes).	2. Midslope drainages, shallow valleys 3. Upland drainages, headwaters 4. U-shaped valleys 6. Open slopes 7. Upper slopes 9. Midslope ridges, small hills in plains
Plains	An extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land. This includes coastal plains (bordering the coastline), interior plains, and plateaus (areas of low relief but high altitude occurring at the edge of the escarpment). Plains are differentiated from valley floors on the basis that they are not located in between two side-slopes (typical of mountain ranges, hills, or other uplands).	5. Plains
Ridges / benches	An area of mostly level or nearly level high ground (relative to the broad surroundings), including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately perpendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope on one side and a down-slope on the other side in the same direction).	8. Local ridges / hills in valleys 10. Mountain tops, high ridges

Landforms for the country were generated using a 50 m resolution digital elevation model generated from 20 m-interval contours and spot height data per 1:50 000 data sheets (Van Deventer et al. in review). The ArcGIS 9.3 landform tool (Weiss 2001; Jenness 2006; Dilts 2009) was used, which identifies landform types using the standard deviation from the average elevation in a specified search area. An important feature of the landform tool is that it offers the opportunity of defining a small and large search area, or 'neighbourhood'. The small neighbourhood takes account of the landform within a local context and a large neighbourhood to reflect the regional context within which the landform occurs. Taking into account the regional context is important in a country such as South Africa with its complex geology, geomorphology and climate which produces diverse landform patterns (Figure 3.13).

- The ***small neighbourhood*** reflects the landform within a local context. Whereas previous published methods have set a standard small neighbourhood across the entire area of interest, NFEPA used a variable small neighbourhood distance across the country, depending on the 34 geomorphic provinces in South Africa (Partridge et al. 2010). In delineating geomorphic provinces, Partridge et al. (2010) calculated valley widths for a selection of large rivers characteristic to each geomorphic province. The maximum valley width for each geomorphic province was used as the small neighbourhood, with an additional distance of 1 km added to ensure that the edge of landform change was incorporated.

- The ***large neighbourhood***, which reflects the regional context within which the landform occurs, used catchment boundaries to calculate large neighbourhood distances. This is because in most landform applications it is generally accepted that catchments form ridge boundaries. Tertiary catchment boundaries were used as a starting point for calculating large neighbourhood distances. Primary and secondary catchments (mean size approximately 58 000 km^2 and 8 500 km^2 respectively) were considered mostly too large to obtain a meaningful regional context, while quaternary catchments (mean size approximately 670 km^2) provide a more local context. Tertiary catchment boundaries were first refined to reflect NFEPA improvements to catchment boundary delineation, by grouping the sub-quaternary catchments (Section 3.4.1) into their respective tertiary catchments. Where the refined tertiary catchment and its neighbourhood distance was too large to process (e.g. large neighbourhood above 20 km and surface area > 20 000 km^2), the area was divided according to smaller groupings of the sub-quaternary catchments. The maximum width of the resulting tertiary catchments was then calculated to derive the large neighbourhood distance (Figure 3.14), and 10 km was added to ensure that the drainage divide of the watershed was encountered by the landform tool.

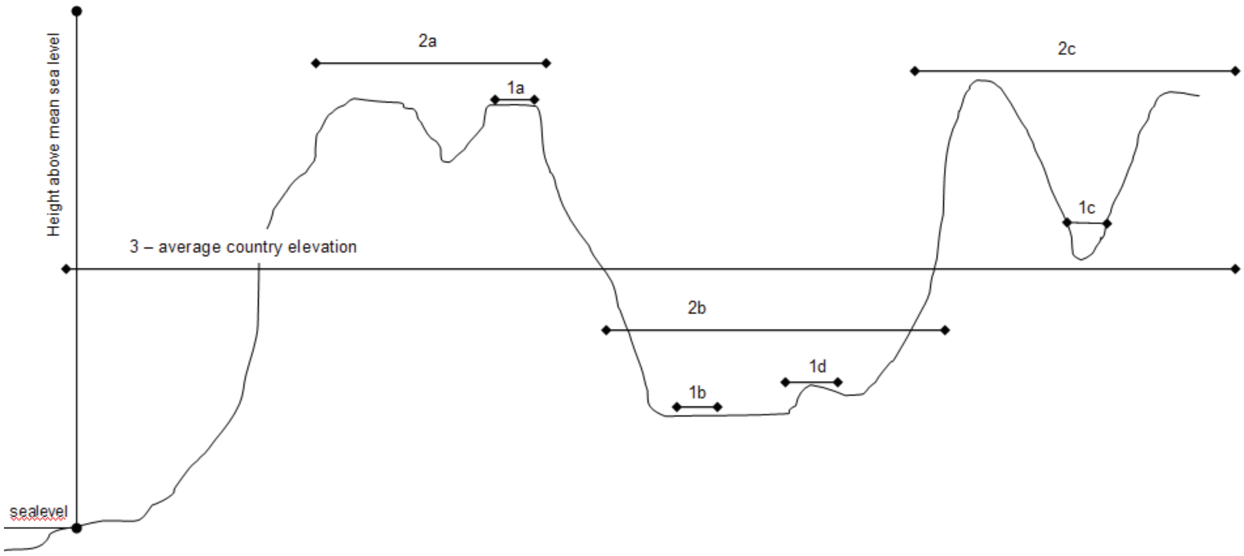

Figure 3.13: Importance of regional context in selecting neighbourhoods and thresholds of slope (i) When comparing 1 a – c it is clear that high slopes are not necessarily associated with benches and valleys. Some mountains have a relatively low slope at their summits and some valleys have deeply incised streams. (ii) In comparing 1 and 2 it is evident that the neighbourhood distance can be selected too low to identify the geomorphologic feature (e.g. 1a or 1b) – the right distance is often difficult to determine. (iii) The importance of regional context is well demonstrated showing that when 1c and 2c are combined, the landform is recognised as a mountain valley, as well as when recognising 1d is a hillock within the 2b valley. (iv) Errors may result from selecting a neighbourhood distance that would calculate the average of a region or country. Even when using a high resolution digital elevation model, valleys in mountains and hillocks in valleys would not be identified and the majority of the landforms above the average elevation would be classified as crests, and below the average elevation as valleys.

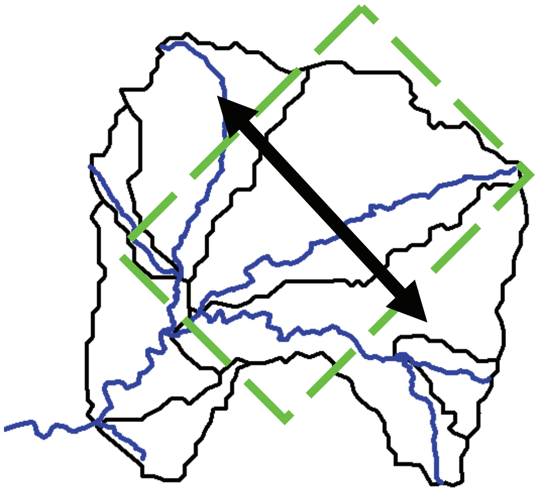

Figure 3.14: Large neighbourhood calculation using tertiary catchment width

Computer processing limitations prevented the processing of the whole country at once using the landform tool. South Africa was therefore divided into 280 tertiary catchments (refined where necessary to sub-quaternary catchment boundaries) and landforms were calculated according to the assigned small and large neighbourhood distances using the default circle-search shape option of the landform tool. A maximum of five computers (on average 2 Gb RAM computer with 100 Gb free space) were used over a period of six months to process the data. The results were combined into a single GIS layer for South Africa. The ten default landform types provided by the landform tool were reclassified to the four landform types as described by Level 3 in the national wetland classification system (Table 3.6).

The results were compared to 260 random points that were classified manually using Google Earth imagery and topographical maps, and showed a 50-60% overall accuracy (Van Deventer et al. in review). The landform tool by default tended to overestimate benches and valleys, and underestimate slopes. This level of congruency suggests that the NFEPA landform GIS layer are suitable for coarse-scale national application, but will have to be further refined for use at local levels.

3.4.10 Wetland condition

Wetland condition describes the extent to which a wetland has been modified by human activity. There are many field approaches to assessing wetland condition. However, in the absence of field survey data for most wetlands across the country, wetland condition was modelled by NFEPA to serve as a relative measure that would inform choices in selecting wetland FEPAs. Wetlands with known special features were selected as the first choice for achieving wetland ecosystem type targets; thereafter wetland condition was considered for achieving targets first in wetlands of good condition, proceeding only if necessary to wetlands of progressively modified condition. Wetland FEPAs did not have to be in a good condition (A or B ecological category) to be chosen as a FEPA, but those wetland FEPAs currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.

Several data sources were used to assign a condition category (Table 3.7) to each wetland. A category of ‘Z1’ was assigned to all wetland polygons that overlapped with a 1:50 000 artificial inland water body (dams, fish farms, large reservoirs, purification plants, sewerage works and water tanks) obtained from DLA-CDSM

(2005-2007). There is a high confidence that these wetlands are artificial or have been heavily modified and in the subsequent biodiversity planning process 'Z1' wetlands were excluded from consideration unless they had been specifically identified by regional experts as being of conservation importance.

There are mapping inaccuracies between the 1:50 000 water bodies GIS layer and the NFEPA wetland map, resulting in spatial slivers when combining the two GIS layers. For example, a dam polygon surrounded by natural slivers may in reality be a dam surrounded by fringe vegetation, or it may merely reflect the inevitable spatial discrepancies from combining two different GIS layers. To account for spatial slivers, modelling the condition of the remaining wetlands (i.e. those not coded as 'Z1') calculated the area of the wetland unit coded as natural vs. Artificial. A wetland unit was defined as a contiguous spatial unit which may be made up of several polygons. Those wetland units that had the majority of their area coded as artificial inland water body were assigned a 'Z2' condition category. In the subsequent biodiversity planning process majority natural wetlands took precedence over ones that were coded as majority artificial.

For the remaining wetlands (i.e. those not coded as 'Z1' or 'Z2'), the percentage natural land cover in and around the wetland was used as a surrogate measure of wetland condition. The same land cover data as used for modelling condition of tributaries was applied (see Section 3.4.4). Percentage natural land cover was calculated within four areas: the wetland itself, and the wetland surrounded by GIS buffers of 50, 100 and 500 m from the delineated wetland polygon. The minimum of these four percentages was used to guide the condition category of the wetland, using the following rules:

- Non-riverine wetlands were considered in good, moderately modified or heavily modified condition if the minimum percentage natural land cover was ≥ 75%, 25-75% or < 25% respectively. These wetlands were coded 'AB', 'C' and 'Z3' respectively.
- Riverine wetlands associated with a heavily modified NFEPA river (i.e. in a D, E or F ecological category) were assigned the condition category of that river irrespective of the surrounding natural land cover.
- Wetlands associated with natural or only moderately modified NFEPA rivers (i.e. in an A, B, or C ecological category) were assigned a condition based on the minimum percentage natural land cover rule used for non-riverine wetlands because the surrounding land use is more likely to be a driver of ecosystem degradation than the moderate condition of the associated river.
- Several riverine wetlands are associated with rivers too small to be included in the NFEPA rivers network GIS layer – in these instances, the river condition was unknown and the wetland was assigned a condition based on the natural land cover rule alone.

Approximately 45% of our remaining wetland area in South Africa is in a heavily or critically modified condition, owing to human impacts of damming, draining and bulldozing of wetlands. This is of immense concern given the important regulating ecosystem services that healthy wetlands provide, such as their filtering ability, and their role in drought mitigation and flood attenuation. The belt of heavily modified wetlands is particularly prevalent in Gauteng, along the escarpment and in the Western Cape province (Figure 3.15). The contribution wetlands perform to drought mitigation and flood attenuation in these areas is likely to have eroded. This is particularly concerning from the viewpoint of ecosystem-based adaptation to changes in land cover and climate, as the prediction is that there will be an increase in the frequency of droughts and storm events respectively in the Western Cape and Gauteng provinces.

Table 3.7: Description of NFEPA wetland conditions categories
PES equivalent describes a condition category broadly equivalent to that used by Department of Water Affairs to describe present ecological state. Percentage of total area in each condition category is also provided.

PES equivalent	NFEPA condition	Description	% of total wetland area*
Natural or Good	AB	Percentage natural land cover ≥ 75%	47
Moderately modified	C	Percentage natural land cover 25-75%	18
Heavily to critically modified	DEF	Riverine wetland associated with a D, E, F or Z ecological category river	2
	Z1	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)	7
	Z2	Majority of the wetland unit is classified as ‘artificial’ in the wetland locality GIS layer	4
	Z3	Percentage natural land cover < 25%	20

** This percentage excludes unmapped wetlands, which includes those that have been irreversibly lost due to draining, ploughing and concreting*

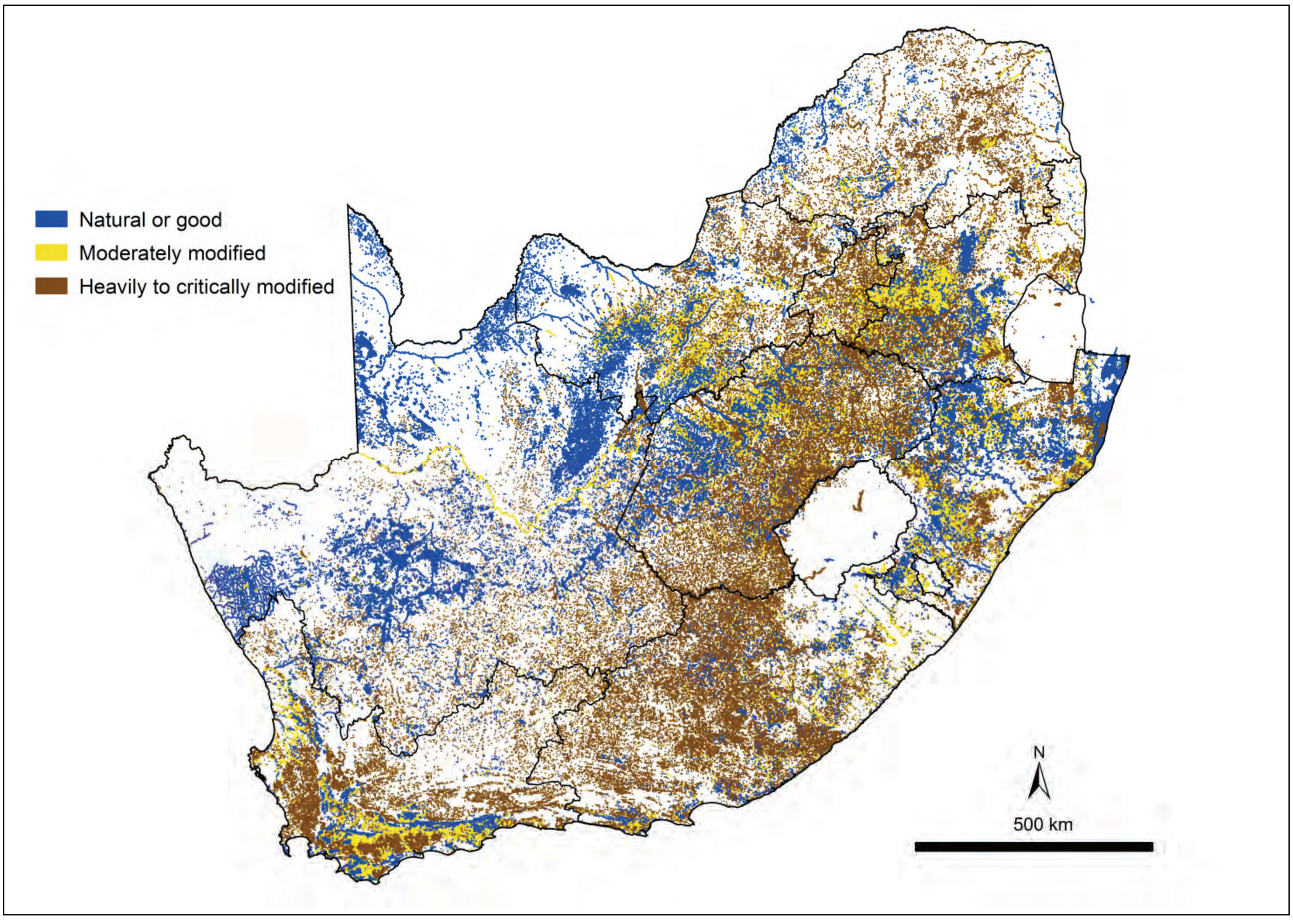

Figure 3.15: NFEPA wetland condition
The outlines around wetland polygons have been accentuated for visual purposes.

3.4.11 Wetland ranks

Wetland ranks were applied in the biodiversity planning process to favour selection of certain wetlands over others in instances where choices existed for achieving representation of wetland ecosystem types. Data were collated at different scales to use as criteria to rank wetlands, ranging from expert knowledge at a sub-quaternary catchment level to point locality data for threatened species (Table 3.8). Ranking was done at the level of the wetland unit, which represents the entire wetland system and can comprise several wetland ecosystem types or wetland conditions. For criteria with point locality data, ranks were applied to specific wetland units irrespective of wetland condition. For criteria mapped at the level of the sub-quaternary catchment wetland condition was also considered. The following criteria were used:

- ***Sub-national biodiversity priority data*** included GIS data from three existing sub-national data sources:
  - Coordinates of important wetlands in Mpumalanga Province provided by Mpumalanga Tourism and Parks. These wetlands are considered of high biodiversity value owing to rare and endangered wetland-associated bird species, high rare bird species richness and presence of intact peat wetlands. These point data were used to identify specific wetlands that should receive a high rank, regardless of their condition. All point data provided were associated with a wetland (i.e. there were no gaps identified in the NFEPA wetlands map for these point localities).
  - A wetland prioritisation exercise in northern KwaZulu-Natal (Begg 1986) was used to identify sub-quaternary catchments containing important wetlands in this region. Begg (1986) focussed on large wetlands, and so for the NFEPA review process experts made a concerted effort to consider representation of smaller systems. All wetlands within the sub-quaternary catchments identified by Begg (1986) were selected regardless of their wetland condition.
  - The Cape Action Plan for People and the Environment (C.A.P.E.) fine-scale biodiversity planning for freshwater ecosystems had already ranked wetlands in three areas of the Cape Floristic Region. These wetland ranks, ranging from 1 to 7, were developed for the same wetlands contained in the wetland locality GIS layer using finer-scale methods (Snaddon et al. 2008) which considered wetland and landscape condition, size of wetland, location with regard to springs and groundwater recharge or discharge areas, proximity to other wetlands or rivers in good condition and C.A.P.E. priority estuaries, and presence of threatened fish or amphibian species. Wetlands ranking 6 or 7 as per Snaddon et al. (2008) were ignored because these were ranked using desktop data on which NFEPA improves. Wetlands ranked 1 to 5 as per Snaddon et al. (2008) used finer-scale methods and we therefore replaced the NFEPA ranks for these wetlands with the Snaddon et al. (2008) ranks.

- ***Ramsar sites*** of 2004 were obtained from the Department of Environmental Affairs GIS layer to identify specific wetland units that had the majority of their range overlapping with a Ramsar site, irrespective of wetland condition.

- ***Threatened frog species*** were drawn from frog collection data of the Animal Demography Unit with permission from the Bloemfontein National Museum and Transvaal Museum. These data comprised almost 42 500 records at a quarter degree scale, with just over 17 000 (40%) of the records having point coordinates. Only the latter records were used to identify specific wetlands with threatened species associations. Critically endangered, endangered and vulnerable species were classified according to the 2004 frog IUCN red data listing (Minter et al. 2004). Any wetland within 500 m of one of these threatened species records was considered to have a threatened frog species association, regardless of its condition.

- ***Threatened waterbird species*** along with associated IUCN species status were drawn from the waterbird locality data of the Coordinated Waterbirds Counts (CWAC) (http://cwac.adu.org.za/cwac_map.php?Pv=GP). Any wetland within 500 m of one of these threatened species records was considered to have a threatened waterbird species association, regardless of its condition.

- ***Crane species*** are considered to be extremely sensitive to wetland condition and their presence is generally indicative of healthy wetland systems. Sub-quaternary catchments containing records of breeding and sighting localities for Wattled Cranes (critically endangered), Grey Crowned Cranes (vulnerable) and Blue Cranes (vulnerable) were obtained from the Endangered Wildlife Trust. Wetland units with the majority of their area coded as 'Z1', 'Z2' or 'Z3' (Section 3.4.10) were excluded from consideration. All other wetlands with the majority of their area located in these sub-quaternary catchments were then selected as important for Cranes.

- ***Association with other wetlands*** examined both riverine and non-riverine wetlands (unlike wetland clusters which only consider non-riverine wetlands; see Section 3.4.12). Wetland association was afforded to a wetland if it formed part of a group of ≥ 3 wetlands within 1 km of each other, regardless of its condition.

- ***Expert knowledge*** was drawn from information captured at the regional review workshops, in which experts had systematically reviewed their region of interest guided by both electronic and hard copy maps. They recorded important wetlands and reasons for their importance at a sub-quaternary catchment level. Incorrect coding of individual wetlands was also noted (e.g. where dams were coded 'natural') and the GIS layer was refined accordingly. Expert notes were then coded into four categories to help rank wetlands:
    - ➢ Very important sub-quaternary catchments identified by experts as containing wetlands of exceptional biodiversity with very sound reasons. Wetland units within these sub-quaternary catchments with the majority of their area coded as 'Z1', 'Z2' or 'Z3' (Section 3.4.10) were excluded from consideration *unless* associated with a Ramsar site, or threatened frog or waterbird species.
    - ➢ Sub-quaternary catchments containing good natural examples of wetlands in the region. To qualify under this criterion, wetlands in the sub-quaternary catchment had to have the majority of their condition in an A, B or C condition category (Section 3.4.10).
    - ➢ Sub-quaternary catchments identified as important but reasons provided were unclear. Wetland units within these sub-quaternary catchments with the majority of their area coded as 'Z1', 'Z2' or 'Z3' (Section 3.4.10) were excluded from consideration *unless* associated with a Ramsar site, or threatened frog or waterbird species.
    - ➢ An existing or proposed Working for Wetland site that is not known to be of exceptional biodiversity importance and is often impacted. No qualifying rules for wetland condition were set for this criterion.

The above criteria were then considered in ranking each wetland unit according to the ranks and rules in Table 3.8. Rank-1 wetlands represent the best choices for selecting wetlands to achieve targets. The biodiversity planning software (MARXAN) was set up to first achieve biodiversity targets in Rank-1 wetlands. If the targets could not all be met by selecting Rank-1 wetlands, MARXAN proceeded to Rank-2 wetlands, then to Rank-3 and so on.

Table 3.8: Criteria used to rank wetlands

CRITERION	RANK
Wetlands that intersect with a Ramsar site	1
Wetlands within 500 m of a IUCN threatened frog point locality	2
Wetlands within 500 m of a threatened waterbird point locality	2
Wetlands (excluding dams) with the majority of its area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of exceptional biodiversity importance, with valid reasons documented	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands that are good, intact examples from which to choose	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of biodiversity importance, but with no valid reasons documented	3
Wetlands (excluding dams) in A or B condition AND associated with more than three other wetlands (both riverine or non-riverine wetlands were assessed for this criterion)	4
Wetlands in C condition AND associated with more than three other wetlands (both riverine or non-riverine wetlands were assessed for this criterion)	4
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing impacted Working for Wetland sites	5
Any other wetland (excluding dams)	6

3.4.12 Wetland clusters

Wetland clusters are groups of wetlands within 1 km of each other and embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. A goal of NFEPA is to ensure that at least 20% of the wetland cluster area identified for each wetland vegetation group is managed in a way that supports dispersal between wetlands within the cluster, ideally associated with a natural or near-natural condition. Biodiversity targets for representing wetland clusters were set *in addition* to those for representing wetland ecosystem types. Because the biodiversity planning software (MARXAN) strives for meeting as many biodiversity targets in the same area, the clusters selected as FEPAs often contained wetland FEPAs selected for achieving wetland ecosystem type targets.

During the regional expert review workshops, a range of proposed methods and their respective results were reviewed, to come to a consensus on how wetland clusters would be identified. Several key recommendations were incorporated into the final methods:

- The need to be very explicit about the aim of wetland clusters. The primary aim is to support migration of wetland-dependant plant and animal populations through the landscape matrix. A secondary benefit may be that this target improves the regulatory ecosystem services that wetlands provide (e.g. flood attenuation, drought mitigation or water purification processes), but this should not detract from the primary aim. Another secondary benefit is that the clustering technique may capture unmapped seeps within the wetland cluster; however, addressing gaps and inaccuracies in wetland mapping is not the primary focus.
- A recommendation was to focus wetland clusters on maintaining lateral connections in the landscape matrix. As such, only non-riverine wetlands were used to identify wetland clusters (channelled valley-bottom wetlands, floodplain wetlands and valleyhead seeps were excluded in the cluster identification process). Unchannelled valley-bottom wetlands were treated as non-riverine wetlands.
- A discussion on whether to nest wetland clusters within primary, secondary, tertiary, quaternary or sub-quaternary catchments lead to the recommendation that wetland clusters should be allowed to straddle any catchment boundary.
- In identifying wetland clusters, the importance of setting variable distances between wetlands to cater for different levels of wetland connectivity was considered. This was based on the premise that wetlands in topographically diverse regions are less connected (and therefore require smaller distances) than those in the relatively flat, arid interior (e.g. panveld), where occasional floods connect wetlands over a very large distance. The final recommendation through specialist scientist consultation was to use the same distance throughout the country (i.e. wetlands should be within 1 km of each other). The reason for not increasing the distance in the arid interior was that natural dispersal cannot occur without floods in the harsh arid climate. This should be refined in future using movements of invertebrates, frogs and wetland dependent birds.
- Consideration was given to removing artificial wetlands (e.g. dams) from the cluster identification process. It is undesirable to have a wetland cluster comprised solely of dams. However, some artificial wetlands have natural fringe vegetation that supports a variety of biodiversity. The final recommendation was to allow some artificial wetlands in the cluster, as long as the area of natural wetlands exceeded that of the artificial wetlands.
- The number of wetlands required to make up a wetland cluster was debated, against the possibility of using a size threshold instead. The decision was to use a number threshold (i.e. minimum number of wetlands required to make up a wetland cluster). Two main reasons for this were that (i) large wetland clusters may be the result of only a single large wetland (often a dam); (ii) using size of cluster biases against seep clusters which are often comprised of small, but many, wetlands.
- Methods were discussed for ranking of wetland clusters for preferential selection during the biodiversity planning process. The recommendation eventually was that wetland clusters did not need to be ranked.

Because the biodiversity planning software (MARXAN) strives for meeting as many biodiversity targets in the same area, the clusters selected as FEPAs often contained wetland FEPAs selected for achieving wetland ecosystem type targets, and these were preferentially selected from high ranking wetlands.

To generate the initial clusters, all non-riverine wetlands were buffered by 500 m in GIS to collapse individual wetlands within 1 km of each other. These initial clusters were also assigned a wetland vegetation group (Section 3.4.8) that occupied the majority of their area. Initial clusters only qualified as a final NFEPA wetland cluster if it satisfied all of the following criteria:

- Comprised of three or more wetlands;
- Area of natural wetlands, compared to that of artificial wetlands, is 50% or more; and
- The majority of the wetland cluster area (i.e. ≥ 50%) is under natural land cover, as determined using the same land cover as that used for modelling condition of tributaries (Section 3.4.4). Three wetland vegetation groups could not achieve wetland cluster targets in clusters where the area of natural land cover was ≥ 50% (Mesic Highveld Grassland Group 7; Southern Shale Band Vegetation and Eastern Fynbos-Renosterveld Shale Renosterveld). For wetland clusters in these wetland vegetation groups, the natural land cover threshold of 50% was lowered to a threshold of 25%.

In many areas of the country (notably Gauteng and Western Cape provinces), wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts (Figure 3.16). The potential for identifying smaller wetland clusters at a finer scale of planning should be investigated in these areas, similar to the work that has been done for the City of Cape Town wetlands.

3.4.13 Fish sanctuaries

Fish sanctuaries are sub-quaternary catchments that are essential for protecting threatened and near-threatened freshwater fish that are indigenous to South Africa (Table 3.9). They were used by NFEPA as species biodiversity surrogates to supplement the representation of river ecosystem types. A goal of NFEPA is to keep further freshwater species from becoming threatened and to prevent those fish species that are already threatened from becoming extinct.

The International Union for Conservation of Nature (IUCN) red list of threatened fish species (http://www.iucnredlist.org/initiatives/freshwater) was used as a starting point for identifying threatened fish species in South Africa, which included those that are critically endangered, endangered, vulnerable and near threatened. Unique populations of those species classified according to IUCN criteria as data deficient, but deemed threatened by South African fish biologists who participated in the regional workshops, were also included. In addition, some species are in the process of taxonomic revision that will split them into several species, e.g. *Galaxias zebratus* may well be split into more than ten species. These were considered as separate lieages and fish biologists across the country assigned them a preliminary conservation status that was guided by the IUCN criteria. This resulted in a list of 66 freshwater fish species or subsets of species (‘evolutionary significant units’, *sensu* Moritz (1994)) that were considered to be threatened or near-threatened for which sanctuaries were identified. Table 3.9 shows the IUCN list of threatened or near threatened fish species, including those which contain distinct lineages for which fish sanctuaries were also delineated. The NFEPA metadata show the 66 species or species lineages for which fish sanctuaries were delineated, named according to fish biologist terminology (no formal taxonomic nomenclature exists for the lineages).

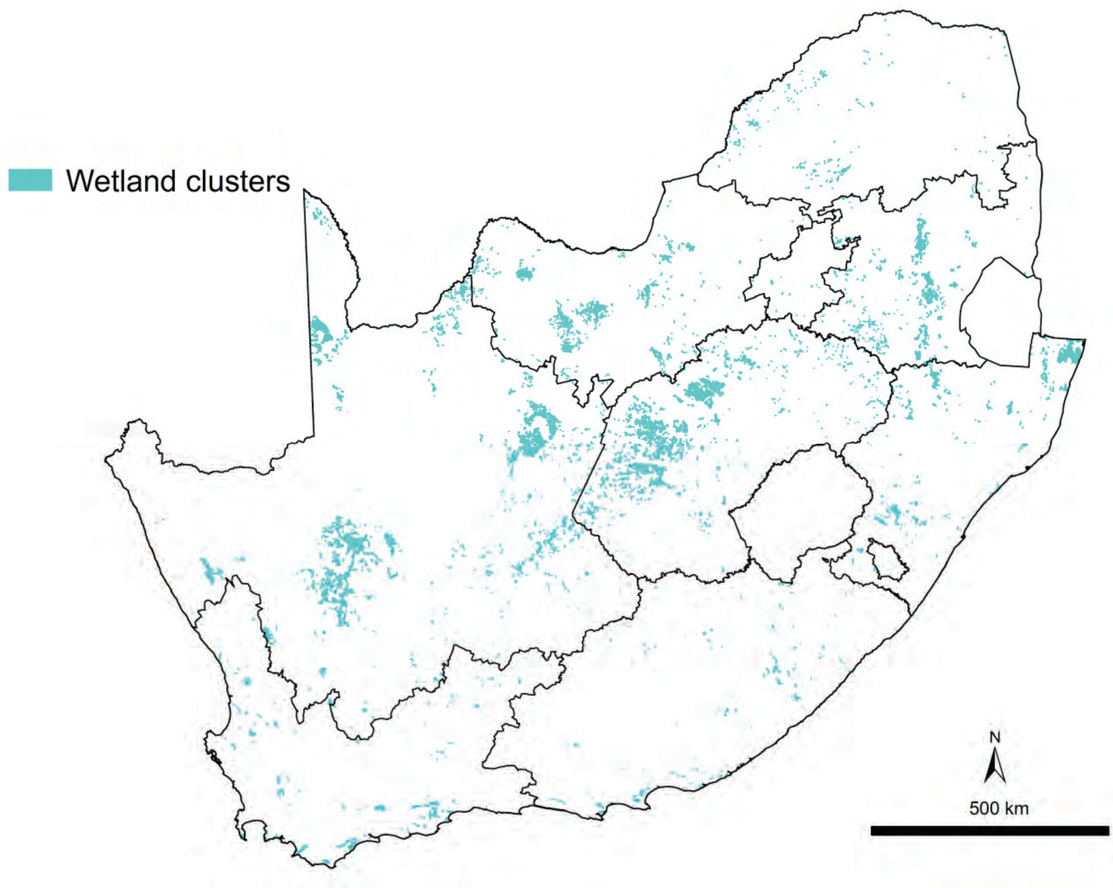

Figure 3.16: NFEPA wetland clusters.
Representative samples of wetland clusters in each wetland vegetation group (Section 3.4.8) were chosen as FEPAs. The outlines of the wetland cluster polygons have been accentuated slightly for ease of viewing.

Fish sanctuaries were identified manually on a species-by-species basis at the scale of sub-quaternary catchments. This was technically feasible because there are relatively few threatened freshwater fish species and options for conserving these species have diminished so much that few choices are available for consideration. The distribution of each threatened fish species was examined, using fish point locality data from the South African Institute for Aquatic Biodiversity (SAIAB) and the Albany Museum. These data were supplemented with expert knowledge from experienced fish biologists in different regions of the country. Historical records deemed no longer valid (owing to local extinctions) were excluded from consideration. As far as possible, known 'viable' populations of fish were chosen as fish sanctuaries, defined as self-recruiting populations. In addition, confirmed localities that were not in the original data, but that were known by regional fish biologists were considered. River condition was used to guide decisions where choices existed, but it was not used as a driving factor because in many cases options only exist for conserving these species in modified rivers (habitat degradation is one of the main drivers affecting conservation status).

Fish sanctuary maps were identified for each species, with five possible categories listed here from the highest to lowest level of protection required:

- ***Fish sanctuaries:*** These are sub-quaternary catchments required to meet fish population targets. Fish sanctuaries in a good condition (A or B ecological category) were selected as FEPAs, and the remaining ones became Fish Support Areas. Fish sanctuaries are depicted on the FEPA maps using a fish symbol (see FEPA maps in Part 2 of the NFEPA atlas). A red fish denotes a fish sanctuary that contains at least one critically endangered or endangered population; the remaining fish sanctuaries are shown with a black fish.

- ***Fish rehabilitation areas:*** Sub-quaternary catchments which are highly suitable for the re-introduction of threatened fish species that once occurred there, but have since been extirpated, were identified as fish sanctuaries. All of these require some level of habitat rehabilitation and/or the eradication of alien fish species before re-introduction can take place. Fish rehabilitation areas were treated in the same way as fish sanctuaries in the planning process and are depicted on the FEPA maps using the fish symbols as explained in the previous bullet point.

- ***Fish translocation areas:*** Sub-quaternary catchments where threatened fish species have already been translocated to, outside the known indigenous range. These populations were only selected if the translocation formed part of a conservation intervention and only when the intervention is still seen as a valuable contribution to the conservation of the species. Fish translocation zones were treated in the same way as fish sanctuaries in the planning process and are depicted on the FEPA maps using the fish symbols as explained in the previous bullet point.

- ***Fish migration corridors:*** Provide links between certain habitats (usually between mainstem and tributary habitat) necessary for the migration of threatened migratory fish species. Fish migration corridors are shown as Fish Support Areas on the FEPA maps, but differ from fish sanctuaries, and fish rehabilitation and translocation areas in that they do not contain a fish symbol (see FEPA maps in Part 2 of the NFEPA atlas). Fish migration corridors were considered to be lower priority areas compared to fish sanctuaries, and fish rehabilitation and translocation areas, but higher than fish upstream management areas.

- ***Fish upstream management areas:*** These are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream fish sanctuaries, fish rehabilitation and translocation areas, and fish migration corridors. All fish upstream management areas became Upstream Management Areas on the FEPA maps, although some of the fish upstream management areas were subsequently identified as FEPAs to represent river ecosystem types. Fish upstream management areas were considered the lowest priority areas for the conservation of fish species.

The different areas for the conservation of threatened fish were combined for all species. This resulted in some sub-quaternary catchments containing a mixture of fish sanctuaries, fish rehabilitation and translocation areas, fish migration corridors, and fish upstream management areas for different species. In instances where a sub-quaternary catchment containing more than one fish species had such mixture, it was coded as the category with the highest level of protection. The sub-quaternary catchment area necessary to conserve South Africa's threatened freshwater fish species is 13% (
Table **3.10**).

The combined GIS layer for fish sanctuary maps was used with river condition (Section 3.4.4) to divide fish sanctuaries, and fish rehabilitation and translocation areas into FEPAs and Fish Support Areas (see FEPA maps in Part 2 of the NFEPA atlas), where fish sanctuaries in a good condition (A or B ecological category) were selected as FEPAs, and the remaining ones became Fish Support Areas. This split helped to simplify the message for FEPAs ("FEPAs are in a good condition and need to remain so"). It resulted in a roughly 50:50 split at a country-wide level in terms of area and number of sub-quaternary catchments (
Table **3.10**). However, the sub-national ratios differ across the country – for example, the ratio of fish FEPAs to Fish Support Areas is high in north-eastern part of the country corresponding to the Inkomati, Usutu to Mmhlathuze and Thukela Water Management Areas (Figure 3.17).

Table 3.9: Threatened freshwater fish species indigenous to South Africa

Species marked with an asterisk require taxonomic updating as recent research shows that they contain several distinct lineages, many of which are threatened. IUCN status was based on the 2007 IUCN assessment (Darwall et al. 2009). For this study, the IUCN status was further refined by regional fish biologists to include new taxonomic information on different lineages within species. All IUCN species listed as threatened – those that are critically endangered (CR), endangered (EN) and vulnerable (VU) – were included. Species classified as data deficient (DD) by IUCN, but which contain several distinct lineages that are considered threatened were also included, as well as near threatened species (NT) – fish sanctuaries for each distinct lineage considered threatened or near threatened were also mapped, to bring the final list to 66 mapped fish species or subsets of species.

Genus	Species	Common name	IUCN Status	Genus	Species	Common name	IUCN Status
Amphilius	*natalensis**	Natal mountain catfish	DD	*Clarias*	*theodorae*	Snake catfish	LC
Austroglanis	*barnardi*	Spotted rock catfish	EN	*Galaxias*	*zebratus**	Cape Galaxias	DD
Austroglanis	*gilli*	Clanwilliam rock catfish	VU	*Hydrocynus*	*vittatus*	Tigerfish	LC
Austroglanis	*sclateri*	Rock catfish	LC	*Kneria*	*auriculata*	Southern kneria	CR
Barbus	*amatolicus*	Amatole barb	VU	*Labeo*	*seeberi*	Clanwilliam sandfish	EN
Barbus	*andrewi*	Witvis	EN	*Labeo*	*umbratus*	Moggel	LC
Barbus	*anoplus**	Chubbyhead barb	DD	*Labeobarbus*	*capensis*	Clanwilliam yellowfish	VU
Barbus	*brevipinnis*	Shortfin barb	NT	*Opsaridium*	*peringueyi*	Southern barred minnow	LC
Barbus	*calidus*	Clanwilliam redfin	VU	*Oreochromis*	*mossambicus*	Mozambique tilapia	NT
Barbus	*erubescens*	Twee River redfin	CR	*Pseudobarbus*	*afer**	Eastern Cape redfin	NT
Barbus	*hospes*	Namakwa barb	LC	*Pseudobarbus*	*asper*	Smallscale redfin	EN
Barbus	*lineomaculatus*	Line-spotted barb	VU	*Pseudobarbus*	*burchelli**	Burchell's redfin	CR
Barbus	*motebensis*	Marico barb	VU	*Pseudobarbus*	*burgi**	Berg River redfin	EN
Barbus	*pallidus**	Goldie barb	DD	*Pseudobarbus*	*phlegeton**	Fiery redfin	CR
Barbus	*serra*	Sawfin	EN	*Pseudobarbus*	*quathlambae**	Maloti redfin	EN
Barbus	*sp. "Banhine"*	Banhine barb	CR	*Pseudobarbus*	*tenuis**	Slender redfin	NT
Barbus	*sp. "Ohrigstad"*	Ohrigstad barb	DD	*Sandelia*	*bainsii*	Eastern Cape rocky	EN
Barbus	*sp. "Waterberg"*	Waterberg barb	NT	*Sandelia*	*capensis**	Cape kurper	DD
Barbus	*treurensis*	Treur River barb	EN	*Serranochromis*	*meridianus*	Lowveld largemouth	EN
Barbus	*trevelyani*	Border barb	EN	*Silhouetta*	*sibaya*	Sibayi goby	EN
Chetia	*brevis*	Orange-fringed river bream	EN	*Varicorhinus*	*nelspruitensis*	Incomati chiselmouth	NT
Chiloglanis	*bifurcus*	Incomati suckermouth	EN				

Table 3.10: The number and extent of sub-quaternary catchments required for fish sanctuaries The area of all fish sanctuaries amounts to 13% of the total area of South Africa

	Number of sub-quaternary catchments	Area (km^2)
Fish FEPA	623	75 946
Fish Support Area	631	90 457
Total	1254	166 403

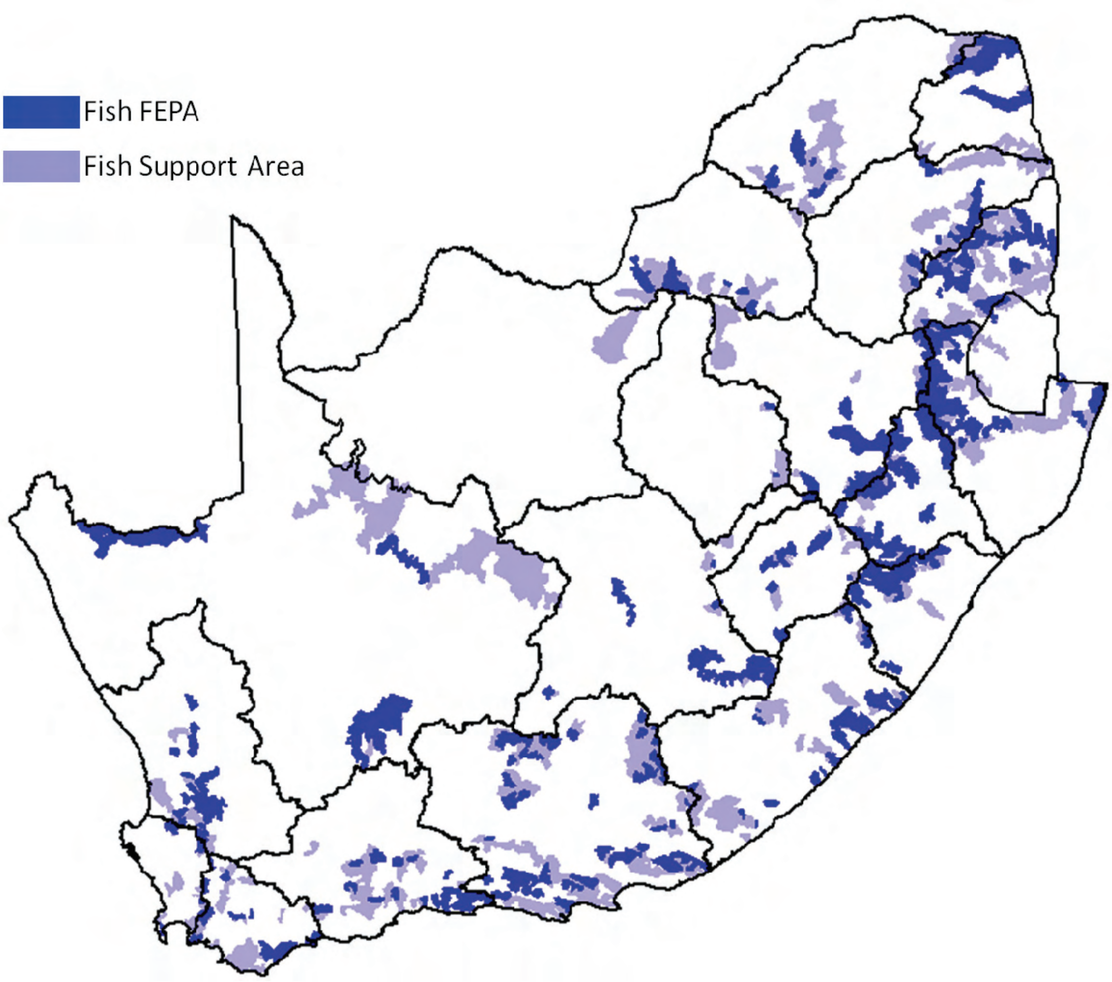

Figure 3.17: Fish sanctuary areas
Those in rivers of good condition (A or B ecological category) became FEPAs, with the remaining being allocated to Fish Support Areas

3.4.14 High water yield areas

High water yield areas were considered to be those sub-quaternary catchments where mean annual run-off (mm per year) is at least three times more than the average for the related primary catchment. Mean annual run-off is the amount of water on the surface of the land that can be utilised in a year, which is calculated as an average (or mean) over several years. High water yield areas are important because they contribute significantly to the overall water supply of the country. They can be regarded as our 'water factories', supporting growth and development needs that are often a far distance away. Deterioration of water quantity and quality in these high water yield areas can have a disproportionately large adverse effect on the functioning of downstream ecosystems and the overall sustainability of growth and development in the regions they support.

The map of high water yield areas was derived using mean annual rainfall data at a 1 x 1 minute resolution for the entire country. This was converted into mean annual runoff using the rainfall-runoff relationships established in South Africa's 1990 Water Resource Assessment (Midgley et al. 1994):

$$MAR = (MAP-B+3) + (C / \exp((MAP-A)/C))$$

Where:

- MAR = Mean Annual Runoff (mm per year)
- MAP = Mean Annual Precipitation (mm)
- exp = e to the power of
- A = 75 + 45Z
- B = 225 + 135Z
- C = 150 + 90Z
- Z = climate-related zone number, ranging from 1 to 9.

As a cross-check, the average mean annual runoff per quaternary catchment was calculated using the derived data and compared to Water Affairs' quaternary catchment mean annual runoff (Midgley et al. 1994). The result was found to compare favourably (Figure 3.18).

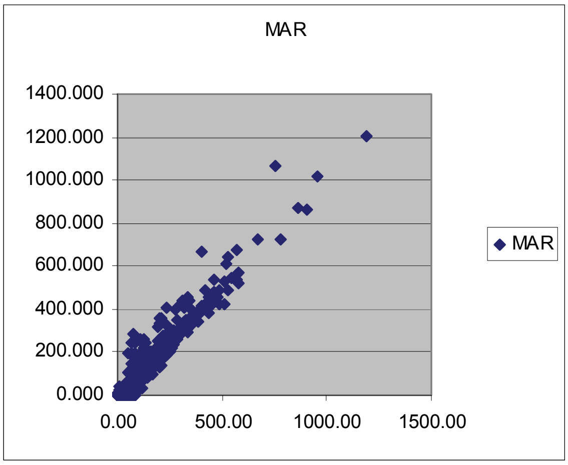

Figure 3.18: Relationship between mean annual runoff of NFEPA and that for the quaternary catchments of Department of Water Affairs

MAR refers to Mean Annual Runoff (in mm per year). NFEPA 1' x 1' data are summarised according to the average MAR per quaternary. Department of Water Affairs quaternary catchment MAR is from Midgley et al. (1994).

High water yield areas were identified by expressing mean annual runoff for each sub-quaternary catchment as the percentage mean annual runoff for that primary catchment. The mean annual run-off for both sub-quaternary and primary catchments was calculated as an average of all 1' x 1' grid cells in the respective catchment. Areas where mean annual runoff was at least three times more than that of the primary catchment were identified as high water yield areas (Figure 3.19).

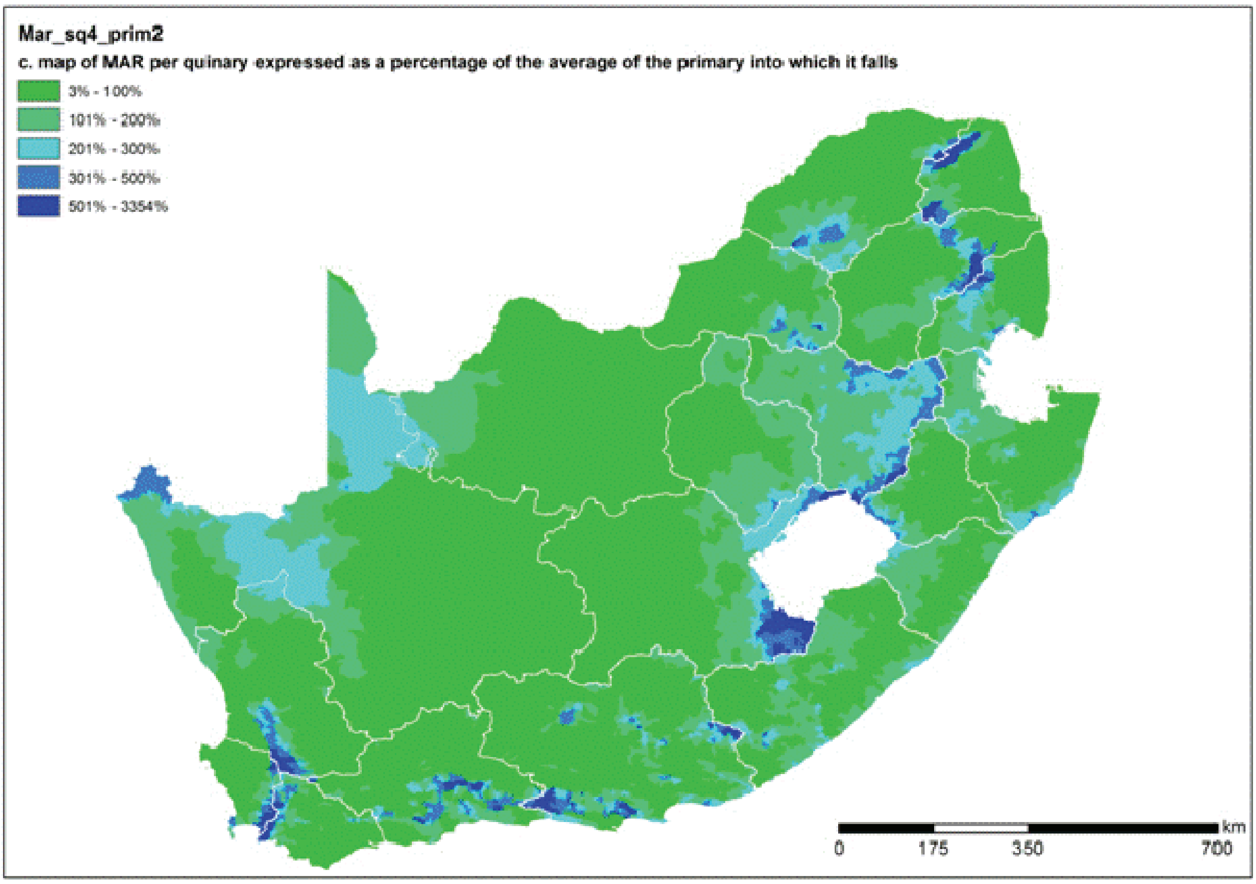

Figure 3.19: High water yield areas
High water yield areas are sub-quaternary catchments where mean annual runoff is at least three times more than that of the primary catchment (shown on the map as > 300%).

3.4.15 High groundwater recharge areas

This map shows those sub-quaternary catchments where groundwater recharge is at least three times more than the average for the related primary catchment. Groundwater recharge is the process by which rain water seeps into groundwater systems, and is calculated as an average over several years. Groundwater recharge is dependent mainly on rainfall and geological permeability, and different areas vary in their ability to recharge groundwater. High groundwater recharge areas can be considered as the 'recharge hotspots' of the region. Keeping natural habitat in these areas intact and healthy is critical to the functioning of groundwater dependent ecosystems, which can be in the immediate vicinity, or far removed from the recharge area. For example, recharge in the Groot Winterhoek mountains of the Olifants/Doorn Water Management Area is believed to sustain coastal aquifers over 100 km away, which in turn support high value crops (potatoes). Activities that should be prevented or controlled in these areas include groundwater abstraction, maintenance of natural vegetation cover, and clearing invasive alien plants.

The map of high groundwater recharge areas was derived using the 2005 groundwater resource assessment data, available at a resolution of 1 km x 1 km (DWAF 2005). This method of determining groundwater recharge was based on the Chloride Mass Balance (Lerner et al. 1990). A GIS model was then established, which replicates natural processes of direct groundwater recharge (DWAF 2005). The model was calibrated and refined according to known recharge values at several sites across the country, as well as expert knowledge (DWAF 2005).

Groundwater recharge (mm per year) for each 1 km x 1 km cell was expressed as a percentage of the mean annual rainfall (mm per year) for that cell. This gives a relative idea of where the proportionally highest recharge areas are in the country, compared to using absolute numbers (mm per year). Percentage recharge for each sub-quaternary catchment was expressed as the percentage recharge for the relevant primary catchment to identify areas where groundwater recharge is at least three times more than that of the primary catchment (Figure 3.20).

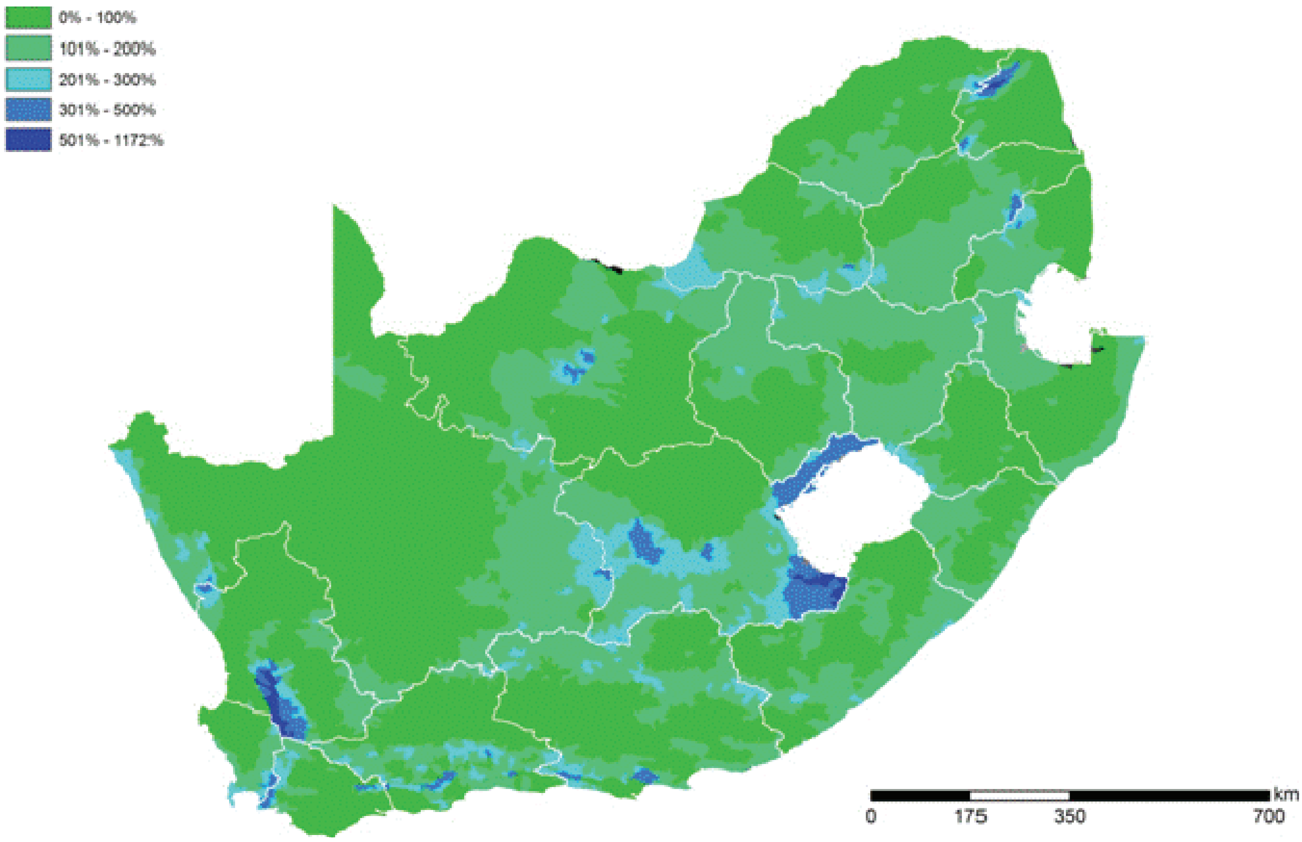

Figure 3.20: High groundwater recharge areas

High groundwater recharge areas are sub-quaternary catchments where groundwater recharge is at least three times more than that of the primary catchment (shown on the map as > 300%).

3.4.16 Priority estuaries

Timelines of the NFEPA project were designed explicitly to align with a related study on identifying priority estuaries at a national level as part of the National Biodiversity Assessment 2011. The identification of these priority estuaries used a systematic biodiversity planning approach (Van Niekerk and Turpie 2011). Input GIS layers used to identify the priority estuaries included the estuarine functional zone, estuary ecosystem types, estuary habitat types, estuarine-dependent species, and estuary condition. Detailed methods for the derivation of these GIS layers can be found in Van Niekerk and Turpie (2011). The mapping of the estuarine functional zone (which includes open water area, estuarine habitat and floodplain area) enabled biodiversity planning to be undertaken using the full extent of the estuary rather than treating the estuary as a point on a map. This planning process resulted in the identification of 119 priority estuaries in South Africa, amounting to about 40% of estuaries and 80% of estuarine area, to be zoned at varying levels of use (Van Niekerk and Turpie 2011).

NFEPA used the estuary data developed by the National Biodiversity Assessment 2011 in three ways:

1. All estuarine functional zones were incorporated into the GIS layer of NFEPA wetland localities. The estuarine functional zone is defined by the 5 m topographical contour as indicative of 5 m above mean sea level. It includes open water area, estuarine habitat (sand and mudflats, rock and plant communities), and floodplain area. In some cases, the estuarine functional zone goes beyond the 5 m contour, for one or more of the following reasons:
    - In deeply incised floodplains, where the river/estuary bed may be metres below the mapped floodplain area, tidal action and/or back-flooding may be detected further upstream than indicated by the 5 m contour as indicated on the topographical map. This is an artefact of the mapping process and may need site-specific data to correct.
    - For some narrow, deeply incised estuaries with very large catchments the 1:10 year flood line may be above the 5 m contour (little floodplain area versus significant flood volume), e.g. Mzimkulu estuary. In such cases, it is recommended that a detailed topographical survey be conducted and a flood line estimate be done following engineering principles to demarcate more dynamic areas and indicate flood risk on a more local scale.
    - The littoral active zones adjacent to an estuary can stretch beyond the 5 m contour, e.g. dune field next to the Duiwenhoks and Sundays estuaries, and should be incorporated into the estuarine functional zone in site specific cases.

2. In selecting FEPAs, preference was given to sub-quaternary catchments upstream of priority estuaries. This was achieved by discounting the planning unit cost of all sub-quaternary catchments associated with priority estuaries (Section 3.6). While it is favourable to align priority estuaries and FEPAs in such a manner, sub-quaternary catchments associated with priority estuaries were not all automatically selected as FEPAs because they do not necessarily all need to be managed in an A or B condition to support the conservation of its priority estuary. A related reality is that river and estuary condition do not always coincide – poor condition rivers can be connected to relatively good condition estuaries and vice versa. For example, tidal flushing may make some estuaries, particularly the large open estuaries, more resilient than their associated rivers; conversely, local and marine effects may have a much more negative influence on an estuary's condition than that of the associated rivers.

3. In finalising the FEPA maps, every priority estuary became a FEPA, shown on the maps in the same way as wetland FEPAs (see Part 2 of the NFEPA atlas).

3.5 BIODIVERSITY TARGETS

Biodiversity targets[3] set minimum, quantitative requirements for biodiversity conservation. This allows an evaluation of whether or not existing conservation efforts adequately represent the biodiversity of a region while providing guidance for planners who are balancing a number of competing demands for natural resources in a region. Furthermore, targets provide agencies responsible for water resource management and biodiversity conservation with common quantitative measures for which to aim (Groves 2003). Targets reflect scientific best judgement and will need to be refined as knowledge evolves – a very recent WRC project explored the setting of more scientifically defensible biodiversity targets for rivers and should be incorporated into future systematic biodiversity plans for rivers (Rivers-Moore 2010). The NFEPA biodiversity targets adopted to achieve representation of South Africa's freshwater ecosystems and associated biodiversity are described below.

3.5.1 Fish species

Fish sanctuaries were identified for threatened freshwater fish species (Table 3.9). For critically endangered or endangered species, a target of 100% of all confirmed existing populations was set. For other threatened and near threatened species, the target was specified as a minimum of ten populations (or maximum confirmed existing populations), coinciding wherever possible with sub-catchments selected for critically endangered and endangered species. This target of ten populations was derived from the Union for Conservation of Nature (IUCN) criteria for threatened status which specifies that as soon as a species drops below ten populations it becomes vulnerable (http://www.iucnredlist.org/initiatives/freshwater).

3.5.2 River ecosystem types

Targets were calculated as 20% of the total length of each river ecosystem type. Any river ecosystem type that had less than this amount remaining in a good condition (A or B ecological category) was considered threatened and the biodiversity planning software (MARXAN) automatically selected sub-quaternary catchments containing the remaining examples of these good condition ecosystem types. In line with criterion 8 (Table 3.1), only rivers in good condition (A or B ecological category) were able to contribute towards achieving this 20% representation. For those river ecosystem types where < 20% of their total length is in A or B condition, 'Phase 2 FEPAs' were identified, providing options for rehabilitation once all FEPAs have been secured for conservation. 'Phase 2 FEPAs' were identified by creating a rule in the biodiversity planning software (MARXAN) so as to first achieve targets in A or B rivers and only proceeded to moderately modified rivers (C ecological category) where necessary. Ecological categories lower than a C (i.e. D, E, F or Z; Section 3.4.4) were not considered suitable for rehabilitation back to a near natural condition. This assumption is based on an analysis of Department of Water Affairs' 1999 Best Attainable Ecological Management Class (Kleynhans 2000) in which regional river experts estimated that only 18% of D-category rivers could be rehabilitated back to at least a B-category, compared to almost 70% of C-category rivers.

3.5.3 Wetland ecosystem types

Targets were calculated as 20% of the total area of each wetland ecosystem type. Any river ecosystem type that had less than this amount remaining in a good condition (A or B ecological category) was considered threatened and the biodiversity planning software (MARXAN) automatically selected sub-quaternary catchments containing the remaining examples of these good condition ecosystem types. Ecological

[3] Also known as 'conservation targets' or 'biodiversity thresholds'

condition was not used as a single criterion for selecting representative wetland ecosystem types, as it was for river ecosystem types. This was because wetland condition was entirely modelled data and our level of confidence in the data was not as high as it was for river condition. Instead, wetlands were ranked according to condition as well as several other criteria (Table 3.8) to provide the biodiversity planning software (MARXAN) with information that would favour the selection of certain wetlands over others. Wetlands were selected first from wetlands with the highest importance ranks, proceeding to wetlands with lower importance ranks only where it was still necessary to achieve the residual targets for wetland types. Dams were excluded from being able to contribute to wetland ecosystem type targets except in instances where they were included in a wetland intersecting with a Ramsar site or known locality of a threatened waterbird species.

3.5.4 Estuary ecosystem types, habitats and associated species

All 119 priority estuaries from the National Biodiversity Assessment 2011 (Van Niekerk and Turpie 2011) were included as FEPAs. In addition, the sub-quaternary catchment within which the priority estuary occurs was given preference for achieving all other NFEPA biodiversity targets. Priority estuaries were based on achieving the following estuarine biodiversity targets (Van Niekerk and Turpie 2010):

- Estuary ecosystem types: 20% of the total area of each type.
- Estuary habitat types (including sand and mudflats, rock and several plant communities): 20% of the total area of each type, except for mangroves and swamp forest habitats where targets were set at 100% of estuaries that contained > 5 ha of these habitats.
- Species targets: set for estuary dependent fish and bird species (84 and 35 species, respectively) based on numbers of individuals per species, as follows: 50% of the population for red data species, 40% for exploited species and 30% for the rest.
- Ecosystem and landscape level processes were accommodated by ensuring that the protected area set had a good geographic spread, included large as well as small estuaries, and favoured healthier estuaries. Alignment with existing and/or proposed terrestrial and marine protected areas was also taken into consideration.

3.5.5 Wetland clusters

Targets were based on achieving representation of wetland clusters across all 133 wetland vegetation groups (Section 3.4.8), calculated as 20% of the total area of clusters within each wetland vegetation group.
Wetland clusters were not ranked, but the individual wetlands making up the cluster were. Because the biodiversity planning software seeks to maximise efficiency by achieving targets in the same sub-quaternary catchments wherever possible, the ranks of individual wetlands drive the selection of wetland clusters to a large extent.

3.5.6 Free-flowing rivers

A stand-alone product for free-flowing rivers in South Africa was developed, showing all free-flowing rivers in the country, and highlighting which of these are the flagship free-flowing rivers deemed the most suited for representing the last remaining free-flowing rivers in South Africa. Selection of flagship free-flowing rivers was based on achieving representation across ten ecoregion groups in South Africa (Table 3.11). A target was set to choose flagship free-flowing rivers to represent at least 20% of the number of remaining free-flowing river systems in each ecoregion group. At the national review workshop (Section 2; Appendix A and B), experts were asked to identify the flagship free-flowing rivers to qualify within each ecoregion group, based on size, importance as an ecological corridor (e.g. inputs to the marine environment which drive marine ecosystems and commercial fisheries, eel migration corridor) and evenness of spatial spread within the ecoregion group (to incorporate concepts around ecological gradients and climate change adaptation). Explicit targets for free-flowing rivers were also incorporated into the biodiversity planning software (MARXAN). Targets were set at 20% of the total length of free-flowing river per ecoregion group (Table 3.11). The primary aim of this target was to favour achievement of other NFEPA biodiversity targets in free-flowing rivers wherever possible, rather than to select whole free-flowing river systems as FEPAs. Sensitivity analyses suggested that 30-40% targets started to select sub-quaternary catchments for the sole purpose of fulfilling free-flowing river targets, rather than favouring their selection for other targets and were therefore too high to achieve this primary aim.

Table 3.11: Ecoregion groups allocated to remaining free-flowing rivers
Ten ecoregion groups were identified, based national Level 1 ecoregions (Kleynhans et al. 2005).

Ecoregion group	Level 1 Ecoregions
Southwestern Coastal Belt & Uplands	Western Folded Mountains
	South Western Coastal Belt
Southern Coastal Belt & Uplands	Southern Folded Mountains
	Southern Coastal Belt
Southeastern Coastal Belt & Uplands	South Eastern Coastal Belt
Eastern Coastal Belt & Uplands	North Eastern Highlands
	Natal Coastal Plain
	North Eastern Uplands
	South Eastern Uplands
	Eastern Coastal Belt
Karoo	Drought Corridor
	Great Karoo
	Western Coastal Belt
	Nama Karoo
	Namaqua Highlands
	Orange River Gorge
Highveld & Escarpment	Northern Escarpment Mountains
	Highveld
	Eastern Escarpment Mountains
Lowveld	Lowveld
	Lebombo Uplands
Limpopo Mountains	Soutpansberg
	Waterberg
	Western Bankenveld
	Bushveld Basin
	Eastern Bankenveld
Limpopo Plains	Limpopo Plain
	Northern Plateau
Kalahari	Southern Kalahari
	Ghaap Plateau

3.6 PLANNING UNIT COST

Assigning a planning unit cost is one of the methods used by the biodiversity planning software (MARXAN) to meet biodiversity targets while minimising costs (Ball and Possingham 2000; Possingham et al. 2000). This cost can be expressed as area of the planning unit, monetary cost, or a relative measure that allows certain planning units with similar biodiversity features to be favoured over others. The cost of all planning units in a MARXAN portfolio allows an assessment of the relative cost of conserving one planning unit versus another. For selecting rivers at a sub-quaternary catchment level, we applied a relative non-monetary planning unit cost to align selection of FEPAs with terrestrial and estuarine biodiversity priority areas.

3.6.1 Rivers

Terrestrial biodiversity priority areas were defined by combining the existing formal protected areas in South Africa[4] with the areas identified as focus areas for protected areas expansion (DEA 2008). Planning units with terrestrial biodiversity priority areas were 'discounted' according to the following equation:

[Riv1PU_Cost] = [PU_Area] – [TBP_Area] + C

Where:

- [Riv1PU_Cost] = Initial planning unit cost for rivers, which includes terrestrial biodiversity priority areas
- [PU_Area] = Area of planning unit
- [TBP_Area] = Area of terrestrial biodiversity priority within that planning unit
- C = a constant of 100 was used as a minimum planning unit cost to ensure that every planning unit had a cost.

Priority estuaries from the National Biodiversity Assessment 2011 (Van Niekerk and Turpie 2010) were used to further 'discount' planning units surrounding priority estuaries. A decaying discount was used, which decreased progressively the further upstream the planning units were from the priority estuary. This was achieved using the Water Affairs' quaternary catchments nested within each primary catchment (Midgley et al. 1994), coding the first level of quaternary catchment from the estuary mouth, the second level of quaternary catchments, and then remaining quaternary catchments in that primary. The final river planning unit cost, [Riv2PU_Cost], was then assigned using the following rules:

- [Riv2PU_Cost] = [Riv1PU_Cost] *0.50 if planning unit falls within the first level; else
- [Riv2PU_Cost] = [Riv1PU_Cost] *0.25 if planning unit falls within the second level; else
- [Riv2PU_Cost] = [Riv1PU_Cost]

This decaying discount ignores the influence of activities in the catchment as a whole on the estuary (which can sometimes be profound), but acknowledges the recovery potential offered by major healthy tributaries close to the mouth of the river, or estuary.

[4] As defined under the National Environmental Management: Protected Areas Act (Act No. 57 of 2003), hereafter referred to as the 'Protected Areas Act'

3.6.2 Wetlands

The initial idea was to achieve biodiversity targets for rivers and wetlands simultaneously. However, sub-quaternary catchments are relatively large to use as planning units for wetlands. The combined river and wetland biodiversity algorithm resulted in the selection of many large sub-quaternary catchments solely for the purpose of achieving wetland biodiversity targets, with unrealistically large spatial requirements. To address this problem, sub-quaternary catchments were selected first to achieve river biodiversity targets (river FEPAs). These were then used to inform a separate biodiversity planning process to select sub-quaternary catchments needed to achieve wetland biodiversity targets (wetland FEPAs), strongly favouring selection of sub-quaternary catchments that were identified as river FEPAs. Whole wetland systems that intersected with the sub-quaternary catchments thus selected were identified as wetland FEPAs if they contributed to wetland targets (i.e. most dams intersecting the selected planning units would be excluded; see Section 3.5.3).

A relative non-monetary planning unit cost was also applied for selecting wetlands, to align with terrestrial and river biodiversity priority areas, such that:

[WetPU_Cost] = [PU_Area] – MAX{ [TBP_Area] and [RBP_Area] } + C

Where:

- [WetPU_Cost] = Planning unit cost for wetlands
- [PU_Area] = Area of planning unit
- [TBP_Area] = Area of terrestrial biodiversity priority within that planning unit, calculated as the combined extent of formal protected areas and focus areas for protected area expansion in the same way as was done for river planning unit cost (Section 3.6.1)
- [RBP_Area] = Area of river biodiversity priority for that planning unit, calculated as 0.75*[PU_Area] for planning units that have been identified as river FEPAs or Fish Support Areas (Section 3.4.13), and [PU_Area] for the remaining
- MAX{ [TBP_Area] and [RBP_Area] } is the maximum value of [TBP_Area] and [RBP_Area]
- C = a constant of 100 was used as a minimum planning unit cost to ensure that every planning unit had a cost

3.7 BOUNDARY COST

Because rivers are longitudinal systems, preference was given to achieving targets on the same system before moving to another river system. This longitudinal connectivity was achieved by applying a boundary cost only to those boundaries belonging to pass-through sub-catchments, defined as those sub-catchment boundaries that intersected a 1:500 000 river. All boundaries were assigned a uniform boundary cost of 200 (irrespective of length of boundary). This value was derived using a series of MARXAN scenarios to test the sensitivity of the selections to different boundary penalties: setting the boundary penalty too low produced a relatively scattered solution, while setting the boundary penalty too high resulted in the selection of many connected sub-catchments that did not contribute toward biodiversity targets (e.g. sub-catchments in which river systems were not intact). For wetlands, a boundary cost was also applied to those boundaries belonging to pass-through sub-catchments. The boundary cost was set in a similar way, through sensitivity analyses.

3.8 PLANNING PROTOCOL

A planning protocol was developed (in consultation with national and international biodiversity planning experts) for identifying freshwater ecosystem priority areas based on the criteria and data that NFEPA has developed. CLUZ (Smith 2005) and MARXAN (Ball and Possingham 2000; Possingham et al. 2000) biodiversity planning software were used to assist with the initial selection of sub-quaternary catchments. Several scenarios were examined to test the sensitivity and selection frequency of the MARXAN outputs. The following steps were used:

1. Quantify the river biodiversity features in each sub-quaternary catchment, and load these 'abundance' data into MARXAN. These include presence of a fish sanctuary, length of each river ecosystem type in an A or B condition, length of each river ecosystem type in a C condition (to be used where targets cannot be achieved in A or B rivers), and length of free-flowing rivers in each ecoregion group.
2. Load the river biodiversity targets into MARXAN (Sections 3.5.2 and 3.5.6).
3. Load the river planning unit cost into MARXAN (Section 3.6.1).
4. Assign a river boundary cost to incorporate longitudinal connectivity (Section 3.7).
5. Pre-select, or 'earmark', all fish sanctuaries irrespective of river condition but only allow A or B rivers in these sanctuaries to contribute to river type targets. This forces these sub-quaternary catchments to be included as FEPAs and at the same time accounts for any A or B river ecosystem type in these fish sanctuaries.
6. Run MARXAN to achieve the remaining biodiversity targets and identify river FEPAs.
7. Use river FEPAs in the calculation of wetland planning unit cost (Section 3.6.2).
8. Quantify the extent of each wetland ecosystem types and wetland cluster per sub-quaternary catchment, and load these 'abundance' data into MARXAN. Ecosystems of lower rank were only used to achieve targets where these could not be achieved in higher ranking wetlands (Sections 3.5.3 and 3.5.5.).
9. Assign a wetland boundary cost to support the selection of whole riverine wetlands (Section 3.7).
10. Run MARXAN to achieve targets for wetland ecosystem types and wetland cluster types, and identify sub-quaternary catchments needed to achieve wetland targets.
11. Identify wetland FEPAs as any wetland systems that intersects with sub-quaternary catchments identified in Step 11, and that contribute to wetland targets (i.e. most dams intersecting the selected planning units would be excluded; see Section 3.5.3).
12. Combine river FEPAs, wetland FEPAs and priority estuaries to derive draft FEPA maps for review at national review workshop.
13. Address stakeholder review issues (and document how they were addressed) to derive final FEPA maps as shown in Part 2 of the NFEPA atlas.

3.9 MAP PRODUCTS

> ***Box 2: Summary of NFEPA map products.***
>
> - *Maps per Water Management Area:*
>
>   1. Freshwater Ecosystem Priority Area maps, or 'FEPA maps'
>
> - *National maps:*
>
>   2. Density of FEPAs by Water Management Area
>   3. Density of FEPAs by sub-Water Management Area
>   4. Free-flowing rivers
>   5. High water yield areas
>   6. High groundwater recharge areas
>   7. Fish sanctuary areas

The outputs produced by the planning process in Section 3.8 were interpreted to meet the needs of a wide range of implementers, including water resource planners and catchment managers, land-use planners and decision makers, and those involved in conservation and rehabilitation. An initial meeting was held with an experienced group of biodiversity planners to develop a list of potential NFEPA map products. This list was reviewed in plenary at the national stakeholder review workshop in July 2010. A consensus was reached at this workshop to develop map products that support both high-level national application and sub-national planning and decision making. The final list of NFEPA map products is shown in Box 2. An overview of each of these map products is provided below; their application and features are also described and disseminated in the NFEPA atlas.

3.9.1 Categories on the Freshwater Ecosystem Priority Area maps

Maps were prepared for each Water Management Area that provided a sufficient level of detail to use in day-to-day decisions and actions that impact on freshwater ecosystems. These are the Freshwater Ecosystem Priority Area maps or 'FEPA maps', which are the main product of the NFEPA project (Figure 3.21). FEPA maps are best viewed in A3 format and are available for each Water Management Area in the NFEPA atlas or electronically on the atlas DVD or the SANBI Biodiversity GIS website (http://bgis.sanbi.org). FEPA maps are supported by information on how to use them within different legal, policy and institutional contexts, as well as guidelines for decision makers wanting to know which particular activities are appropriate for an area and which are not.

Different categories are shown on the FEPA maps, each with differing management implications. A sub-quaternary catchment code is also provided on the FEPA maps. This code can be used to look up further information on the biodiversity features in each FEPA and Fish Support Area. This additional look-up information is useful for developing site specific management plans, and is available in an Appendix of the NFEPA implementation manual, or electronically on the atlas DVD or the SANBI Biodiversity GIS website (http://bgis.sanbi.org).

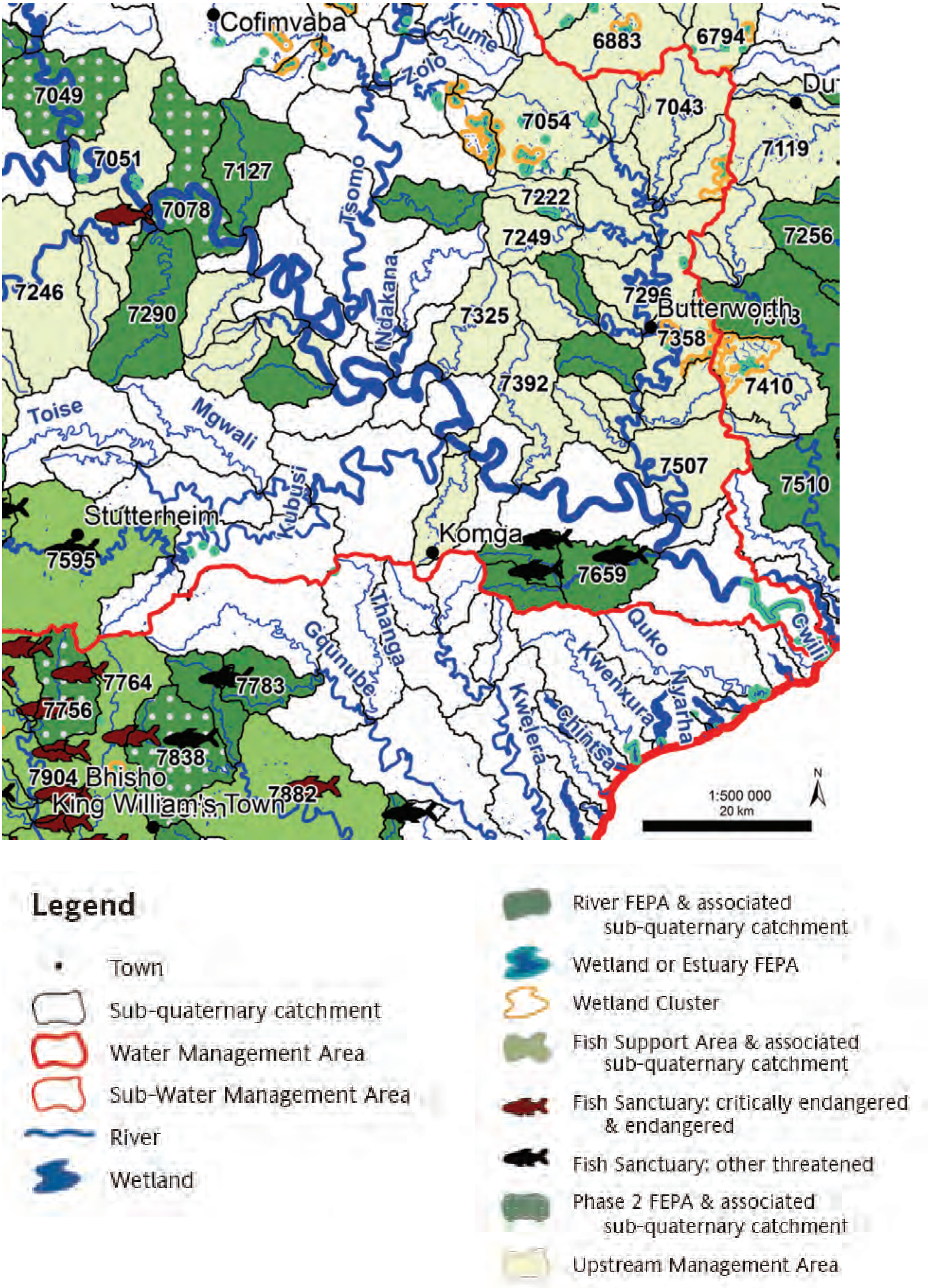

Figure 3.21: Example of a FEPA map, showing a portion of the Mzimvubu Water Management Area

FEPA map categories are as follows:

- ***River FEPA and associated sub-quaternary catchment:*** River FEPAs achieve biodiversity targets for river ecosystems and fish species, and were identified in rivers that are currently in a good condition (A or B ecological category; **Table 3.3**). Their FEPA status indicates that they should remain in a good condition in order to contribute to the biodiversity goals of the country. For these FEPAs the whole sub-quaternary catchment is shown as a FEPA in dark green, although FEPA status applies to the actual river reach shown on the map within such a sub-quaternary catchment. The shading of the whole sub-quaternary catchment indicates that the surrounding land and smaller stream network needs to be managed in a way that maintains the good condition of the river reach (A or B ecological category). It is important to note that river FEPAs currently in an A or B ecological category may still require some rehabilitation effort, e.g. clearing of alien plants and/or rehabilitation of river banks. From a biodiversity viewpoint, rehabilitation programmes should therefore focus on securing the ecological structure and functioning of FEPAs before embarking on rehabilitation programmes in Phase 2 FEPAs (see map category description below).

- ***Wetland or estuary FEPA:*** For wetlands and estuaries, only the actual mapped wetland or estuarine functional zone is shown on the map as a FEPA, indicated by a turquoise outline around the wetland. Connected freshwater systems and surrounding land that need to be managed in order to maintain these wetlands in good condition will need to be identified at a finer scale and in management plans for individual wetland and estuary FEPAs. In some cases it may be the whole sub-quaternary catchment and in others it may be a smaller area. Although wetland condition was a factor in selection of wetland FEPAs, wetlands did not have to be in a good condition (A or B ecological category) to be chosen as a FEPA. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition. Estuary FEPAs are the national priority estuaries identified as part of the National Biodiversity Assessment 2011 (Van Niekerk and Turpie 2011). Functional zones for all estuaries are shown on the map, which includes the open water area of the estuary as well as the zone to which the estuary may expand during flood (this was guided largely by the 5 m coastal contour line). Estuary FEPAs are shown on the map in the same way as wetland FEPAs, with turquoise outlines. Recommended ecological category for priority estuaries is listed in Van Niekerk and Turpie (2011).

- ***Wetland cluster:*** Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. In many areas of the country, wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts. On the map, an orange outline is drawn around groups of wetlands that belong to a wetland cluster. Wetlands do not have to have FEPA status to belong to a wetland cluster (although clusters with a high proportion of wetland FEPAs were favoured in identifying wetland clusters).

- ***Fish sanctuary and associated sub-quaternary catchment:*** Fish sanctuaries are sub-quaternary catchments that are essential for protecting threatened and near threatened freshwater fish that are indigenous to South Africa. The sub-quaternary catchment is marked with a red or black fish symbol on the map. A red fish indicates that there is at least one population of critically endangered or endangered fish species within that sub-quaternary catchment. A black fish indicates the presence of vulnerable or near threatened fish populations. A goal of NFEPA is to keep further freshwater species from becoming threatened and to prevent those fish species that are already threatened from becoming extinct. In order to achieve this, there should be no further deterioration in river condition in fish sanctuaries and no new permits should be issued for stocking alien invasive alien fish in farm dams within fish sanctuaries. Fish management plans need to be developed in all fish sanctuaries to protect the fish they contain, with an urgency given to those fish sanctuaries containing critically endangered or endangered fish species (denoted by the red fish symbol on the map). These plans should address issues such as management of a particular stretch of the river habitat within the sub-quaternary catchment, the construction of weirs to keep invasive alien fish species to a minimum (following approval from an environmental impact assessment), and managing aquaculture and angling communities regarding policy on aquaculture and recreational fishing. Where instream dams are unavoidable, guidelines for designing appropriate fishways should be followed (Bok et al. 2007; Rossouw et al. 2007).

- ***Fish Support Area and associated sub-catchment:*** Fish sanctuaries for rivers in a good condition (A or B ecological category) were identified as FEPAs, and the whole sub-quaternary catchment was shaded as dark green. The remaining fish sanctuaries in rivers lower than an A or B ecological condition were identified as Fish Support Areas, and the whole sub-quaternary catchment was shown in medium-green. Fish Support Areas also include sub-quaternary catchments that are important for migration of threatened fish species (these are not marked with a fish symbol). These areas should be managed to support the conservation of the threatened or near threatened fish populations they contain. This will include developing management plans that address similar issues to those recommended for fish sanctuaries (see above).

- ***Free-flowing river:*** Free-flowing rivers are rivers without dams. These rivers flow undisturbed from their source to the confluence with a larger river or to the sea. Dams prevent water from flowing down the river and disrupt ecological functioning with serious knock-on effects for the downstream river reaches and users. Free-flowing rivers are a rare feature in our landscape and part of our natural heritage. All free-flowing rivers are shown on the map. Flagships were identified based on their representativeness of free-flowing rivers across the country, as well as their importance to ecosystem processes and biodiversity value. These flagship rivers should receive top priority for retaining their free-flowing character. Flagship free-flowing rivers are not explicitly shown on the FEPA map, but are listed in the atlas and Table 3.4, and coded in the river shapefile.

- ***Upstream Management Area:*** Upstream Management Areas, shown in very pale green, are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas. Upstream Management Areas do not include management areas for wetland FEPAs, which need to be determined at a finer scale.

- ***Phase 2 FEPA and associated sub-quaternary catchment:*** Phase 2 FEPAs were identified in moderately modified (C) rivers. The condition of these Phase 2 FEPAs should not be degraded further, as they may in future be considered for rehabilitation once good condition FEPAs (in an A or B ecological category) are considered fully rehabilitated.

3.9.2 Maps to support national planning and decision making

These maps were considered as nationally useful tools, either summarising the FEPA maps or presenting an extra layer of information that has been collated for this project.

- ***Density of FEPAs by Water Management Area:*** This map shows the percentage of the total area for that Water Management Area that has been identified as a FEPA, calculated for each Water Management Area using the following equation:

  Density of FEPA = (R + W) / WMA

  Where:
  - WMA = area of the respective Water Management Area
  - R = area of river FEPA and associated sub-quaternary catchment
  - W = area of wetland FEPAs that do not overlap with river FEPAs and their associated sub-quaternary catchments

  This map is intended to convey the message to national level planners and decision makers that the custodianship of freshwater biodiversity is not evenly distributed across the country. Some Water Management Areas have more FEPAs to look after than others (which will make them darker in colour on the map). However, lighter coloured areas still have FEPAs to prioritise, just not as many. An important policy question is how we can support Water Management Areas with a high proportion of FEPAs in achieving our national freshwater ecosystem goals.

- ***Summary of FEPAs by sub-Water Management Area:*** This map shows the percentage of the total area for that sub-Water Management Area that has been identified as a FEPA, calculated for each sub-Water Management Area using the following equation:

  Density of FEPA = (R + W) / sWMA

  Where:
  - sWMA = area of the respective sub-Water Management Area
  - R = area of river FEPA and associated sub-quaternary catchment
  - W = area of wetland FEPAs that do not overlap with river FEPAs and their associated sub-quaternary catchments

  This map is intended to convey to catchment managers that the custodianship of freshwater biodiversity is not evenly distributed within their respective Water Management Area. In allocating resources within the Water Management Area, it is important to bear this in mind.

- ***Free-flowing rivers, fish sanctuaries, high water yield areas, and high groundwater recharge areas:*** The development and use of these four map products is described respectively in Sections 3.4.5, 3.4.13, 3.4.14, and 3.4.15.

SECTION 4: GUIDING CONCEPTS FOR PROMOTING UPTAKE OF PROJECT OUTPUTS

This section explores lessons from a variety of sources including interactions with selected future FEPA users, analysis of similar initiatives, and theory on diffusion of innovations. It distils from these key concepts to promote the institutional uptake of the FEPA products.

4.1 INTRODUCTION

Natural resources such as water and biodiversity are embedded in social systems characterised by a range of stakeholders with very different values, expectations and time horizons. As the impacts of use and abuse of these resources have become more apparent, we have come to better appreciate the dynamic interconnected nature of social-ecological systems. Whereas in the past we might have been satisfied to understand the direct relationship between cause and effect, we now appreciate that causes and effects often tend to be connected across spatial and temporal scales in non-linear relationships, or they can be so widely separated in time and space that predictions are inherently uncertain. Such non-discreet issues are not amenable to the simple solutions often proposed by discipline-based research projects. Researchers now have to seek answers and integrate concepts from across natural and social science disciplines. Furthermore, to successfully address diverse stakeholder values, an acceptable solution may not be in the form of ‘the right answer’ but rather in the form of a negotiated outcome.

Accordingly, scientists are expanding their research approaches to social-ecological issues in order to increase their effectiveness in society as a whole. New approaches seek to produce new knowledge, new alliances and new understanding that will influence the longer term management and governance of a particular resource. Effective research programmes require us to build knowledge systems that span disciplinary, research, policy, and operational domains, and to achieve co-evolution of understanding, alignment of purpose and harmonised action across these domains. This takes much more time and requires patient persistence and more investment in social capital than that typically afforded by research projects. Strategies to promote such systems require a sufficiently long-term perspective that takes into account the generally slow diffusion of new ideas and scientific information in practice.

The development and envisaged uptake and application of the FEPA products falls within this social-ecological context. Uptake of the NFEPA products within South African organisations should not be taken for granted. No matter how good the technical products, organisations need to be receptive to them. If they are not, that receptiveness needs to be created and sustained. This section analyses various sources for key concepts that will guide the institutional uptake of the FEPA products.

4.2 INSIGHTS FROM PROJECT CASE STUDIES

The NFEPA project combined the fairly technical aspect of identifying FEPAs with an effort to develop a basis for effective implementation. It is helpful to acknowledge that there are at least two components to this second aim. The first national component is focussed on aligning the Department of Environmental Affairs’ and Department of Water Affairs’ policy mechanisms and tools for conserving freshwater ecosystems and supporting sustainable use of water resources. The second component examines existing legal and policy mechanisms for promoting uptake of FEPAs by implementing agencies (Section 5), translating these into practical recommendations on how to use FEPA maps and supporting information within specific relevant legal and policy contexts (as set out in the NFEPA implementation manual). The second component strives to develop capacity at local levels for the effective implementation of FEPAs, and is dealt with in this section of the report. Three case study areas were explored to understand how NFEPA products and outcomes can be implemented to influence land- and water-resource decision making processes at a sub-national level. The three case study areas were deliberately chosen to represent different institutional circumstances and ecological characteristics:

1. **Crocodile West Marico Water Management Area ('Croc-Marico')**: This overlaps the North West, Gauteng and Limpopo provinces. The project team has a long-standing relationship with key individuals in the area around freshwater biodiversity planning and management. A Catchment Management Agency has not yet been established.
2. **Inkomati Water Management Area**: This falls entirely within Mpumalanga Province. The project team has an established relationship with members of the Inkomati Catchment Management Agency (ICMA), the first Catchment Management Agency to be established in South Africa. A catchment management strategy was produced at the time the NFEPA project was running.
3. **Breede Water Management Area**: This resides entirely within Western Cape Province. The Breede-Overberg Catchment Management Agency (BOCMA) is the responsible authority. Their catchment management strategy is currently under development.

Workshops were held in each area in the first half of 2010 and again in the latter part of the year. During the course of the project, a number of stakeholders within these regions were also consulted and interviewed face-to-face or in small group sessions (e.g. in the analysis of improving the science-policy interface, see Sections 4.6 and 6.6). This stakeholder engagement process focussed on the draft FEPA maps, with the objective to:

- Provide background information on the cross-sector policy objectives and the need for cooperation;
- Present and discuss the NFEPA project and the provisional outputs;
- Allow each agency to respond on how NFEPA's link to their responsibilities and mandates;
- Facilitate a joint exploration of how existing capacity and legislation can be used to implement NFEPAs; and
- Explore and design the way forward.

Main points from each of the workshops are summarised below.

4.2.1 Croc-Marico stakeholder inputs

- **High-level endorsement.** Visible and clear endorsement by the national Department of Water Affairs and Department of Environmental Affairs was seen as very important for empowering and motivating lower-level managers and practitioners to adopt FEPAs. Some commented that this is seriously lacking in other contexts.
- **Private consultants**. Private consultants were regarded as a useful vehicle to disseminate FEPA information and products. They often provide guidance long before issues reach government departments.
- **Must institutionalise**. Uptake of FEPA products must not only rely on champions ('someone's pet project'). Use of FEPAs must become integrated into processes.

  - In Department of Water Affairs, Resource Quality Objectives and water resource classification were suggested as important mechanisms for integrating FEPAs and spatial planning;
  - Need a Memorandum of Understanding between Department of Water Affairs and Department of Environmental Affairs to clarify roles and responsibilities;
  - At provincial level, Environmental Implementation Plans are the most important;
  - At local level, Environmental Management Frameworks are the most important.
- **Need operational best practices**. Need these, even for consultants, especially related to what ‘biodiversity’ and ‘conservation’ means. Need to keep things simple. Must create behaviour change. Need something you can take to the developers “or even show to the bulldozer driver”.
- **Targeting on-the-ground practitioners**. It was considered important that people on the ground were familiar with the FEPA products so that they could help promote the main messages.
- **Potential uses of FEPAs**. The information provided by FEPAs could help focus river health monitoring in these priority areas. They could also be used to inform responses to environmental impact assessments.
- **Potential barriers to FEPA uptake**: There are currently many major projects in the Water Management Area. FEPAs would be much more readily adopted if they could be integrated into these other initiatives. The point was made that “managers don’t read manuals, but they do read directives” (although the latter are only used when someone has done something wrong, i.e. the damage has been done).
- **Top management must understand the importance of monitoring**. This is important because capacity on the ground is seriously lacking.
- **Lack of capacity**. This was described as a “crisis” at provincial and municipal levels. A specific recommendation was made that provincial departments must have an aquatic scientist, ecologist or someone with a natural science background.

4.2.2 Inkomati stakeholder inputs

- **FEPAs are an enriching layer**. All thought the FEPA products would make their lives easier. The SANParks representative, in particular, noted that FEPAs provide a very important contextual planning layer to decision making. They want to know about neighbouring FEPAs and will help to engage with them.
- **Conservation Management Sub-strategy template for Catchment Management Strategies**. The implementation manual should contain a template for a conservation management sub-strategy in a catchment management strategy. Conservation authorities should proceed with development of this strategy even if a Catchment Management Agency does not yet exist. A suggested template for a conservation management strategy, prepared for the Breed-Overberg Catchment Management Agency, is provided in Appendix C of this report.
- **FEPAs and the Protected Areas Expansion Strategy**. FEPAs can potentially inform a strategy for expanding protected areas for the good of freshwater ecosystems. To date protected areas have focussed largely on terrestrial ecosystems, and FEPAs offer a means for considering freshwater ecosystems in strategies dealing with protected area expansion.
- **Awareness and education**. This is needed to help spread the word. For example, each representative would need to pass on the FEPA-related information to many others in their organisations. They need help and resources to do this. An easily accommodated resource is to provide slide presentations of NFEPA and its products, which should target at least two distinct groups of users: politicians and decision makers that need to understand the benefits that use of FEPAs can add, and key messages of the project; and scientists and on-the-ground managers who

are interested in the technical detail behind the FEPAs. The NFEPA project has produced such slide presentations that will be made available on SANBI Biodiversity GIS website (http://bgis.sanbi.org).

- **Need to understand biodiversity planning**. Need to know what it is and how it relates and contributes to land-use planning. Currently, biodiversity guidelines for land-use planning only indirectly cater for freshwater ecosystems.
- **Need to understand background to FEPA maps**. There was general acknowledgement that:
    - This knowledge is important to ensure proper use of the maps; and
    - There is a need for post-project interaction with the FEPA development team.
- **Long-term support**: Need an identified support person for technical and other support.
- **Regional FEPA 'home'**. There is a need to identify a natural home for FEPAs in the regions. SANBI's role of support within the Freshwater Programme is national, and a clear need for a regional home was identified. The most obvious home would likely be in the provincial conservation authority, as the custodian of conserving freshwater biodiversity.
- **Dealing with local data**. There is a need for clarity on how to use FEPAs when there is perhaps more detailed or more recent local data available.

4.2.3 Breede-Overberg stakeholder inputs

- **Use for FEPA maps**: The Breede-Overberg Catchment Management Agency viewed the FEPA maps as potentially useful in the identification of critical monitoring sites and as input into their catchment management strategy. A suggested template for a conservation management strategy, subsequently prepared for the Breed-Overberg Catchment Management Agency, is provided in Appendix C of this report.
- **High-level endorsement**. It was noted that high-level endorsement is essential, particularly in Department of Water Affairs.
- **Incorporation into the water resource classification system**. FEPAs were seen as particularly helpful to incorporating environmental concerns into the classification system.
- **Importance of provincial conservation authorities**. CapeNature was seen critical to championing the use of FEPA products.
- **Level of technical detail**. FEPA users may not have sufficient technical knowledge. Simple maps with appropriate guidelines were deemed necessary. The need for aquatic ecologists and/or biodiversity specialists on teams that develop catchment management strategies and water resource classification was noted.
- **Challenges to FEPAs**. It was acknowledged that there will be land owners who will disagree with FEPAs and that they have a right to challenge them. The need for a strong biodiversity representative in Department of Water Affairs' processes was therefore identified.
- **Lack of capacity**. This was described as a 'crisis' at provincial and municipal levels. A specific recommendation was made that provincial departments must have an aquatic scientist, ecologist or someone with a natural science background.
- **Long-term support**. There needs to be a mechanism to allow continued dialogue between FEPA users and FEPA developers after the project, perhaps through a helpdesk.

4.2.4 Insights relevant to uptake of project outputs

On the whole, a very high level of receptiveness was evident in each of the workshops to the proposed FEPA maps. However, a few common insights can be distilled from the above that should be specifically addressed at least in the associated implementation manual:

- **High-level endorsement**. This issue was raised in each workshop and was seen as particularly important in Department of Water Affairs.
- **Communication with people on the ground**. FEPA maps and supporting information should also communicate with those who face freshwater ecosystem and biodiversity conservation issues on a daily basis.
- **Need to institutionalise FEPAs**. There need to be specific efforts aimed at incorporating the use of FEPA into organisation procedures and practices. There should not only be a reliance on individual champions.
- **The need for a national and sub-national 'home' for FEPAs**. There is a definite need for an identified central contact person or organisation for ongoing (post-project) FEPA-related support. The SANBI Freshwater Programme will serve as such a national body to support the uptake of FEPAs and ensure that the products of NFEPA are used appropriately. However, a need was also identified for support at a sub-national level, and such explicit support is not yet in place. Ideally, this support should be considered as a formal role of the provincial conservation authority and resources should be made available for such a role. In some cases, this role may be taken up by regional officials from Department of Water Affairs.
- **Incorporation into the water resource classification system**. This was seen as very important by all three groups, and was one example of institutionalisation. The Nel et al. (2011) paper on integrating environmental flows and biodiversity planning (see abstract, Section 6.2) provides technical recommendations for including products such as FEPAs into water resource classification.
- **Lack of capacity**. This was seen by many as a serious obstacle to FEPA uptake in government departments, especially at provincial and local level. FEPAs need to make the job of overburdened staff members easier, and not add an extra layer of complication into their day-to-day activities.
- **Long-term financial support**: There needs to be ongoing investment from the national and provincial level to sustain the uptake of FEPAs. This financial report may take the initial form of funding provincial authorities to attend Department of Water Affairs' meetings, especially around water resource classification. It should also investigate more long term issues such as the establishment of financial incentives for the implementation of FEPAs, both at the Catchment Management Agency level, as well as at the level of land owners, or water user associations.

4.3 LESSONS FROM THE RIVER HEALTH PROGRAMME

4.3.1 Good design to operational practice

Until the late 1980s, water quality managers relied almost entirely on information gained from the monitoring of chemical and physical water quality variables. Such 'stressor monitoring' focuses on the stressors that are likely to cause pollution or ecological change. However, a predictive ability is only possible where a known cause-effect relationship exists between the concentration of a specific stressor and the responses within a receiving ecosystem. Although the effects of a single substance on a single species under controlled conditions can be determined with reasonable confidence in a laboratory, the extrapolation of such effects to complex ecosystems is fraught with problems.

Acknowledging the limitations of a stressor only approach, water resource managers from the Department of Water Affairs started to consider response monitoring as a complementary approach. Response monitoring entails the use of biological or ecological indicators to characterise the response of the environment to a stressor or disturbance. The response-oriented approach is diagnostic, in that it indicates how well an ecosystem is functioning given the degree to which it is subjected to multiple stressors.

While response monitoring made sense conceptually, it represented a completely new approach to water resource management. Water resource managers had to be convinced of its practicality and value. The national River Heath Programme started as a small initiative directed by the then Hydrological Research Institute (later renamed as the Institute for Water Quality Studies and more recently to Resource Quality Services). Through a number of small demonstration projects, the River Health Programme gradually won support among water resource managers at Department of Water Affairs – most of whom had engineering backgrounds. Buy-in to the programme was expanded to the Department of Environmental Affairs and the Water Research Commissions, and these three organisations became the national custodians of this development.

The programme was initially called the National Aquatic Ecosystem Biomonitoring Programme (NAEBP). An early focus on river ecosystems led to the establishment of the River Health Programme as a sub-programme of the NAEBP. The first objectives for the NAEBP still apply, namely 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 in South Africa; and
- Ensure that all reports provide scientifically sound and management-relevant information for national aquatic ecosystem management (Roux 1997).

Realising that the national departments do not have the competencies and capacity required for implementing a national biomonitoring programme, the national custodians sought the support of provincial implementation agencies. During a consultation planning meeting that was held in 1996, provincial champions were nominated to lead clusters of provincial departments and agencies in implementing the River Health Programme across the country.

Parallel with the development of provincial implementation capacity, the national custodians provided funding to stimulate the development of various biological indices and protocols for selecting monitoring sites, deciding on monitoring frequency, processing data and reporting information. An effort was made to create a sense of inclusive ownership, both among research organisations and implementation agencies. A number of organisations participated:

- Scientists from University of Cape Town were prominent in developing spatial classification of rivers and protocols for the selection of monitoring and reference sites;
- Scientists from Rhodes University played a prominent role in reviewing and recommending ecological indicators for use in the programme;
- The CSIR was responsible for developing an invertebrate-based biological index of water quality (the South African Scoring System or SASS);
- Development of a habitat assessment index and a fish-based index of river integrity came from the Institute for Water Quality Studies; and
- Quality assurance procedures were led by scientists from Umgeni Water.

An impressive series of technical reports were produced and made available to assist agencies with sound implementation of the River Health Programme. However, no matter how sound the underlying principles or technical design, the intended merit of a new program can only be realised once it is effectively implemented. During the late 1990s and early 2000s, a key priority was to promote adoption of the River Health Programme by provincial agencies and implementation teams. As more and more provincial government agencies experimented with implementing the programme, valuable lessons regarding successes and mistakes were shared with other provinces. At the same time, new developments funded by the national custodians had to be communicated to provincial implementation agencies. Mechanisms to facilitate communication horizontally between provinces and vertically between provincial and national agencies included annual meetings of all role players, technical reports, a newsletter and a dedicated website (www.csir.co.za/rhp).

The River Health Programme is often lauded as an example of a programme that achieved the transition from being a good technical design to becoming an operational practice. Over a period of nine years (1994 to 2003), the River Health Programme had grown from a mere idea into a national operation. This is especially significant when considering that adoption and implementation of the River Health Programme is largely voluntary and that programme implementation is taking place in an environment characterised by limited financial resources, a multitude of competing social and economic priorities and general scarcity of appropriately skilled people.

Reflecting on the successes and failures of the River Health Programme provides an opportunity to learn about the elements that are necessary for new programmes to mature into sustainable operations. Although many factors played a role in stimulating growth, dispersal and adoption of the River Health Programme, three elements in particular appear to be critical drivers in developing and maintaining the capacity required for implementation of this monitoring programme. The three elements are contagious leaders, flexible governance through shared ownership, and creative packaging and dissemination of key messages. The following is a brief explanation of each of the three critical drivers (based on Strydom et al. 2006).

4.3.2 Contagious leaders

In his book The Tipping Point, Malcolm Gladwell writes that ideas, products, messages and behaviours spread just like viruses. If a virus finds appropriate carriers and connects with sufficient recipients, it becomes an epidemic. If we would like to see a new programme spread like an epidemic, the most important investment that we can make is to find and support the natural carriers of our ‘virus’. Contagious leaders are characterised by:

- **Deep philosophical and theoretical understanding** of their messages, not only in terms of ‘what’ needs to be done, but also ‘why’ it is important;
- **Shaping an enduring vision and core purpose** that capture people’s imagination and resources;
- **An ability to balance vision with action**; while it is important to provide direction at the strategic level, it is equally important to maintain focus and give effect to the vision through advances at the operational level;
- **Instigating strategic (and face-to-face) conversations** with stakeholders to develop a shared understanding of the objectives and challenges; and
- **Regular reflection** to allow adaptation of strategies and methods to ensure relevance in a changing world.

One of the most critical success factors in creating uptake and dispersing the River Health Programme vision was that a number of committed leaders took ownership of the message. Collectively, these leaders had influence in government, the academia, and conservation agencies, and their direct communication and endorsement were critical to gathering wider support for the program. The influence of opinion leaders started with pre-existing personal networks, extending outward to motivate other key groupings to get involved and allocate priority time and funding to the associated work.

4.3.3 Flexible governance through shared ownership

The provincial scale was selected for deploying the programme, primarily due to the presence of agencies with relevant expertise and equipment that operate at these levels. During a consultative planning meeting held in 1996, provincial champions were elected to act as hubs for implementation activities. Since no single organisation in any province could boast to have all the expertise required for effective implementation of the River Health Programme, it was up to the champions to establish inter-organisational implementation networks.

Provinces that participated successfully in the River Health Programme usually evolved through three distinct maturation phases, namely:

- **Phase 1 – Individual enthusiasm**: In most instances, provincial champions started off armed only with enthusiasm for the task ahead. The primary reason why they have agreed to champion their provincial initiative is because they care about rivers and believe that the River Health Programme would help them to generate information that would contribute to sound river management. Their lobbying for team members was based on the need for certain basic skills as well as for having the representation of key organisations.
- **Phase 2 – Informal networking**: Individuals join the informal network of River Health Programme practitioners based on their perception of the value that the initiative holds for them and their organisations. True to their operational environment, 'joining' is associated with participation in river surveys rather than registration or attendance of meetings. The ability to collectively accomplish something that cannot be accomplished separately is commonly cited as a reason for joining the provincial network.
- **Phase 3 – Organisational endorsement**: Either before or after joining the provincial network, individual members would request approval from their organisations to get involved in River Health Programme activities. Their case is strengthened if they can show examples of what the programme produces and demonstrate how this relates to their organisational mandates. Endorsement may be in the form of incorporating River Health Programme objectives as part of the job description of staff members and/or their organisational business plan.

4.3.4 Creative packaging and dissemination of key messages

With an ultimate goal of changing the behaviour of the recipients of information, river health practitioners had to rethink the formats used for packaging information as well as the strategies used for disseminating information. Three main lessons emerged from efforts to improve the effectiveness of communicating river health messages, namely to:

- **Reduce the complexity of scientific messages**: The River Health Programme has made huge advances in simplifying the 'front end' for communicating river health while retaining the rigour of the biological assessment process in the background. As an example, a river health classification scheme has been developed where different health classes are simply referred to as natural, good, fair and poor.
- **Develop a flagship communication product**: A significant contributor to the popularity and visibility of the River Health Programme can be ascribed to the development of the State of Rivers reporting concept. These reports or posters comprise semi-standardised formats for the packaging of river health information. The State of Rivers reports always portray a distinct River Health Programme brand yet reflect dynamic development over time.
- **Uncover and utilise tacit knowledge**: Data and information that can be found in databases and reports provide important content for compiling a credible State of Rivers report. However, these sources cannot convey context. To enrich content with context, we have to turn to tacit knowledge, which includes the

concepts, images, beliefs, viewpoints, value sets and guiding principles that are based on personal experience and reside in individuals. Engagement of local scientists, farmers and community members in discussions provided valuable context regarding the history and features of a particular river.

In communicating key messages, a recent reflection on the impact of the River Health Programme (Strydom et al. 2006) also highlighted a few weaknesses or shortcomings. Two points may be particularly informative for efforts promoting FEPA uptake:

- **Continuity and commitment of national support over the long-term**: One of the primary objectives of the State of Rivers reporting initiative is to provide information on the ecological state of South Africa's rivers to enable resource managers to make informed decisions and take appropriate action. This information must furthermore show whether previous decisions were successful or failed to improve river health. For this to happen, monitoring and reporting must be repetitive to reveal trends and to establish whether appropriate management actions have taken place and have been successful. State of Rivers reports are available for several catchments across the country and a frequency of reporting every three years is recommended. However, none of the catchments has been revisited for full follow-on surveys and reporting. It is therefore not possible to say with certainty whether the health of these rivers has improved or declined. Due to loss of key champions or otherwise, it seems as if the initial enthusiasm is waning. The initial surveys and State of Rivers reports were facilitated with national assistance (both technical and financial) and were received with enthusiastic support from the regional agencies. The intention was that regions should be able to initiate and lead their own follow-on reporting. However, this has not happened. A lesson is to seek some ongoing investment from the national level, as this could lead to significant returns.

- **Influencing management decisions and environmental outcomes**: It seems that the River Health Programme has successfully facilitated a progression from a mindset of monitoring for the sake of monitoring (Strydom et al. 2006) to a mindset of monitoring for the sake of reporting. A further step, of monitoring for the sake of influencing management decisions and environmental outcomes, is still largely lacking. It is therefore important to explicitly give attention to the establishment of functional feedback loops between the information arising from monitoring data and decision making. The latter should cover both operational and policy levels.

4.3.5 Insights for the River Health Programme relevant to uptake of project outputs

If the above insights were to be directly translated into the FEPA context, then achieving a high degree of uptake would require:

- **Identifying core senior people who can act as 'contagious leaders'**. They would need to have the ability to think strategically and be able to galvanise others into action.
- **Enabling broad-based shared ownership through flexibility**. Given the significant differences in ecological diversity and institutional circumstances throughout South Africa, a flexible institutional approach to enabling FEPA uptake will be essential. It will not be 'one-size-fits-all'.
- **Ensuring core messages are simple**. These messages may range from those related to managing and conserving biodiversity to those dealing with how to use a FEPA map in a specific context. The NFEPA atlas and implementation manual serve as initial tools for communicating these messages.
- **Acknowledging tacit knowledge**. While manuals and reports can contain a wealth of useful data and information, there can be equally important knowledge in the minds of FEPA experts, whether they are new users or the FEPA developers. Mechanisms must exist for tapping into this knowledge.

- **Pro-actively avoiding 'post-project decay'**. Thought must be given to mechanisms and funding sources for ensuring continuity of the enormous national momentum that has been created during the NFEPA project. It should not be assumed that sustained uptake will just happen.
- **Creating opportunities for feedback**. Mechanisms must be created, like annual workshops or even conferences, to allow FEPA users to present their experiences.

4.4 LESSONS FROM SPATIAL BIODIVERSITY PLANNING

It is all too easy for a biodiversity plan to end up being simply a technical or academic exercise that does not result in management and conservation action on the ground. There are several possible approaches to biodiversity planning. The approach used most often in South Africa, and one advocated in biodiversity policy is referred to as systematic biodiversity planning (see Box 1). Systematic biodiversity planning helps to provide a basis for constructive interaction with other socio-economic sectors by focusing on priority areas, recognising competing land uses and development needs, and setting defensible, transparent, data-driven biodiversity targets. Systematic biodiversity plans have been conducted in South Africa for about fifteen years, and South Africa is considered a world leader in the field. Based on our experience, several key ingredients for designing systematic biodiversity plans that promote effective implementation have been distilled (Knight et al. 2006). These are directly relevant to promoting the uptake of FEPAs and are summarised below.

4.4.1 Use systematic biodiversity planning principles

There are several ways to conduct spatial biodiversity plans, ranging from entirely expert driver, to scoring and ranking of ecosystems, to systematic biodiversity plans. The last of these has had over three decades of research and practice in the terrestrial and marine realm, and has recently been successfully applied to freshwater ecosystems, in South Africa and abroad. Indeed an entire special issue is dedicated to systematic biodiversity planning for freshwater ecosystems, the contents of which are summarised in Linke et al. (2011). Systematic biodiversity planning is considered the most scientifically rigorous way to identify spatial priorities for managing and conserving biodiversity. Over the 30 years of its development, scientifically robust methods have been developed for integrating expert input with quantitative data and for creating an enabling environment for uptake of the biodiversity plans. Systematic biodiversity planning is also firmly embedded in both environmental policy and practice in South Africa.

4.4.2 Make the case for biodiversity

In Section 4.5.1, it is noted all three kinds of knowledge need to be recognised in promoting diffusion of innovation – awareness knowledge, how-to-do-knowledge and principle knowledge. Principle knowledge essentially makes a case for why you need the innovation (e.g. what benefits can be derived from using the innovation, and what are the consequences of not using the innovation). The need for principle knowledge is encapsulated in this key ingredient of effective systematic biodiversity planning.

Making the case for healthy ecosystems, and hence the need for managing and conserving ecosystems and their associated biodiversity should be an integral part of stakeholder collaboration. Promoting conservation as a valid land use that contributes to development, rather than preventing development, is useful. Biodiversity planning is not just about establishing formal protected areas but should inform land-use planning and decision making in all social and economic sectors. Compelling local or regional examples of nature's central role in maintaining flows of ecosystem goods and services can be powerful.

4.4.3 Identify key stakeholders up front, their needs and the goals of the process

Important questions to ask before embarking on a biodiversity planning exercise include: Who wants or needs this plan? Who will inherit the planning outcomes and what will they be used for? What is the organisational and institutional capacity for implementation? What are the likely implementation mechanisms? If there are not clear answers to these questions, the biodiversity plan is probably a supply-driven plan that will end up sitting on a shelf. Demand-led plans are needed with clear aims that take implementation opportunities and constraints into account.

The aim of a biodiversity plan will inform who is commissions the plan and oversees its development, who inherits the plan so that products can be tailored accordingly (Section 4.4.6), the data that needs to be collected and the spatial scale at which the plan is conducted.

4.4.4 Pay attention to project design and recruiting an appropriate project team

It is worth investing time and resources in a consultative project design process that involves key stakeholders. Important recommendations relevant to this key ingredient include:

- ***Select scale of planning appropriate to the project goals:*** Plans at different scales answer different questions and can be applied in different ways. Spatial error of data inputs and intended planning outputs and their interpretation and application on the ground are critical considerations affecting implementation. Broad-scale plans (e.g. 1:250 000 scale) identify broad priority areas for entire regions. Fine-scale plans (1: 50 000 or finer) are usefully undertaken within these broad priority areas to design protected area networks and to inform land-use planning and decision making outside protected areas. This gives us a nested system of broad-scale and fine-scale biodiversity plans that complement each other.

- ***Collect data that is useful to achieving the project goals:*** Not all spatial data are useful, so the utility of data should be carefully considered before investing time and resources acquiring or developing them. Different information is useful in different planning contexts. For example, in areas where habitat transformation is prevalent, investment in a recent and accurate land cover map is likely to be the best investment of data collection resources. From a biodiversity planning perspective, it makes more sense to invest data collection resources in mapping spatial components of ecological processes, ecosystem types and habitat transformation (including restorable habitat), than in collecting and curating species distribution data.

- ***A dedicated project coordinator is essential:*** A dedicated coordinator is more effective than combining coordination and specialist functions in one person. The coordinator does not necessarily need to have formal biological training, but must understand or be willing to learn the basics of systematic biodiversity planning. The coordinator should understand the planning process, be able to respond to stakeholder requests and provide regular communication and feedback between the project team and its stakeholders. An experienced and effective project coordinator brings a great deal of trust and credibility to the project process.

- ***Recruit a transdisciplinary project team:*** Apart from the dedicated coordinator, the project team include specialists with a combination of high-level analytical GIS skills, assessment expertise, regional natural history and biogeographic knowledge, and a sound knowledge of the institutional context within which the plan is conducted. Implementing agencies need to be closely involved in the planning process, ideally as part of the project team. If this is not possible then, at a minimum, key staff from the implementing agencies should be kept fully informed of the planning process through regular update sessions. The team should be governed by an advisory group of experienced, respected people who can provide guidance, credibility, and a forum for reporting on progress.

4.4.5 Involve stakeholders in a focused way that addresses their needs and interests

A great deal of time and resources can be wasted on poorly conceived, unfocused stakeholder involvement programmes. Recommendations for getting extra mileage from stakeholder participation include:

- ***Identify key stakeholders up front and understand their needs:*** This sets the foundation for implementation. Key stakeholders should be relevant, important, or influential, and include local- and high-level stakeholders. Different stakeholders possess distinct mental models, which necessitates managing multiple realities.

- ***Design a stakeholder participation programme with clear objectives:*** Different stakeholders should be involved in different aspects of the process, such as building awareness, gathering information, building consensus on a vision and priority actions, building capacity and establishing institutions to implement the planning outcomes. Each of these aspects requires different levels of information – for many stakeholders, detailed technical information is often not necessary or constructive. Key high-level stakeholders, implementing organisations, and key experts with specialised ecological or socioeconomic knowledge of the planning region, may be valuable contributors to the design of the process because of their political or institutional knowledge or influence.

- ***Avoid holding broad participatory workshops for the sake of it:*** Focused, face-to-face and one-on-one interactions, or small-group sessions with key stakeholders, that address their specific needs are often more effective. Geographically decentralised workshops may be useful for a broad-scale plans that cover a large area. If large workshops are held, they should be well planned and coordinated. Caution is required with participating stakeholders that often deal with practicalities of land use – they can get understandably frustrated when planning occupies significant time and resources with no perceived link to action.

4.4.6 Interpret and promote uptake of project outputs

Outputs from a systematic biodiversity plan are usually technical, complex, and often meaningless to implementers. Time and resources should be allocated for tailoring these products to the needs of key implementers. Project outputs need to be interpreted to support both high-level policy uptake and uptake reflected in local day-to-day decisions and actions. Interpretive legal, policy and ecosystem management guidelines should accompany maps that provide explanations for the use of maps within different legal, policy and institutional contexts, as well as guidelines for decision makers wanting to know what particular activities are appropriate for an area.

4.4.7 Insights relevant to uptake of project outputs

All the above points are directly applicable to the development and packaging of FEPA maps and supporting information. They can be summarised as follows:

- ***Use systematic biodiversity planning as a framework***. This is not only accepted as the most widely-accepted means of identifying spatial biodiversity priorities, but is also endorsed by formal legislation in terms of the Biodiversity and Protected Areas Act. It is also supported by a cross-sector policy approach for managing and conserving freshwater ecosystems (Roux et al. 2006).
- ***Communicate relevance of FEPAs***: Awareness of the FEPA maps and how to apply them is insufficient if it is not supported with a clear message to decision makers that justifies the importance and benefit of using the products.
- ***Address stakeholder needs*** and design a stakeholder engagement process in which these needs can be understood and addressed.
- ***Design a transdisciplinary project team*** which should include a credible and dedicated project coordinator, ideally staff members from the relevant implementing agencies and an advisory group of experienced scientists and practitioners.
- ***Package the FEPA maps and supporting information to accommodate the full science-policy-implementation continuum.*** This will require technical products, as well as products that serve as communication tools for using the NFEPA products. These communication tools should target both high level decision makers (e.g. politicians and their advisors) and local level decision makers and managers (e.g. catchment managers, provincial agencies, land-use planners and municipal officials). They should be specific to the context within which the end-user operates, and communicate the science as simply as possible.

4.5 DIFFUSION OF INNOVATION

4.5.1 The theory

Over a period of more than four decades, the theory on the diffusion of innovations has provided profound insights on adoption and diffusion of new ideas (innovations). FEPA products represent such an innovation, and in this section we list a number of principles that should be kept in mind by those interested in the effective and sustainable implementation of NFEPA products.

First, a few definitions:

- **Innovation** is an idea, practice, or object that is perceived as new by an individual or other unit of adoption.
- **Diffusion** is the process in which an innovation is communicated through certain channels over time among the members of a social system, where communication is a process in which participants create and share information with one another in order to reach a mutual understanding.
- A **social system** is a set of interrelated units that are engaged in joint problem solving to accomplish a common goal.

The more similar individuals of a social system are in attributes such as belief, education and socioeconomic status (homophily – 'love of the same', often expressed as 'birds of a feather flock together'), the more likely effective communication is to occur, with associated effects in terms of knowledge gain, attitude formation and change, and behaviour change.

Over time, an individual or other decision making unit will pass through a number of phases from first learning about the new idea to potential adoption and implementation (**Table 4.1**).

1. **Knowledge is gained** when the decision making unit learns of the innovation's existence and gains some understanding of how it functions.

2. **Persuasion** takes place when the individual forms a favourable or unfavourable attitude towards the innovation.
3. **Decision** occurs when the individual or unit engages in activities that lead to a choice to adopt (a decision to make full use of an innovation as the best course of action available) or reject the innovation.
4. **Implementation** takes place when an individual or unit puts an innovation into use. Some re-invention might occur.
5. **Confirmation** occurs when an individual seeks reinforcement of an innovation-decision that has already been made, but may reverse this previous decision if exposed to conflicting messages about the innovation.

The first phase (to have knowledge of) could include:

- **Awareness knowledge** (what is the innovation). So-called change agents, often through 'technology transfer' initiatives, commonly concentrate on creating awareness knowledge.
- **How-to knowledge** (how does it work). The innovation-decision is more likely to be positive if significant effort is concentrated on creating how-to knowledge because clients/agencies will only be able to make a proper adoption if they know how to use the innovation themselves.
- **Principles knowledge** (why does it work or why is it necessary). This commonly falls outside the ambit of technology transfer projects and may not be perceived as necessary by the adopter. However, it is in fact an important determinant of, and positively correlated with, sustained adoption.

Subsequent to an adoption, an adopter may choose to discontinue use of the innovation. There appears to be two main reasons for such discontinuance:

- **Replacement of the innovation with a better innovation**.
- **Rejection of the innovation because of dissatisfaction with its performance**. Such dissatisfaction may come about because the innovation is inappropriate for the individual/group or it does not result in a perceived advantage. Dissatisfaction is more likely when the innovation is not compatible with the existing knowledge and past experiences of the individual/group. Dissatisfaction could also result from a lack of ongoing technical support that might be required to use the innovation properly. Some adopters may simply find that they do not have the resources (human and financial) to use the innovation on a sustainable basis. The latter is more common amongst relatively late adopters.

  An idea is not securely adopted before it has been fully integrated into the ongoing routines and operations of the adopter. It should be kept in mind that adoption of a new idea almost always means discontinuing a previous idea. Time is required to phase out old routines and habits and reallocate budget to the implementation of the new idea. Some adopters may find this a frustrating and tricky process and external facilitation might be required to guide adopters through the required steps.

  From the initial diffusion of an idea to its widespread use may take several years. For example, in the 12 years from the initial diffusion of the internet to 2002, approximately 71% of adult Americans adopted the Internet. It may be unrealistic to expect that 100% of potential adopters will end up using the new idea. Key factors that determine the rate of adoption are:

- The degree to which an innovation is perceived as advantageous by the unit of adoption;
- The degree to which the innovation is perceived to be consistent or compatible with the existing values, past experiences and needs of potential adopters;
- The degree to which the innovation is perceived to be relatively difficult or 'complex' to use;
- The degree to which potential adopters may experiment with an innovation on a limited basis; and

- The degree to which the results of an innovation are visible to others, e.g. through communicating the results of a pilot project.

4.5.2 Insights relevant to uptake of project output

Points of particular importance are the following:

- **Acknowledge all uptake phases**. The diffusion of innovations such as the FEPA maps will involve a series of well-defined phases. Knowing what phase an individual or organisation is currently in will help focus interactions with them because (a) the general needs of that person or unit are understood and (b) possible pitfalls are known. **Table 4.1** suggests actions and approaches when interacting with people in the various phases. A core feature is a degree of monitoring that can feed into reflection and learning on FEPA uptake so that it is not only sustained but improved from lessons learned. It will be important to acknowledge and understand the many likely phases of FEPA uptake and not make rash assumptions about the real degree of uptake in specific circumstances at any particular time.
- **Address the three kinds of knowledge**. The first two kinds of knowledge (creating awareness of the innovation and explaining how it works) are specific though more obvious aims. However, the importance of principles knowledge (why the innovation is needed) should also be explicitly addressed. This will be especially important in making a clear case for why it is important to manage and conserve FEPAs, and communicating clear benefits of implementing measures to manage and conserve FEPAs. Ideally, these messages should also be framed within the context of existing legal and policy mechanisms that promote the conservation and management of FEPAs.
- **Remember that dissatisfaction with support is one of the main reasons for discontinuance**. This will require giving special attention to: (1) providing a clear, user-friendly description on how to use the NFEPA products; (2) outlining the limits of applicability; (3) ensuring ongoing support is available.

Table 4.1: Guidelines offered by diffusion of innovation theory for interacting with FEPA users

When addressing people in this diffusion phase ...	... do the following:
1. Gaining knowledge (of FEPAs and FEPA maps and why each are useful)	1. Clearly and simply describe what FEPAs are, what the maps show, and generally how they can be used. Be guided by the FAQs in this document. 2. If the person is a likely practitioner, offer to initially send them the atlas and Management Guidelines. 3. If the person may be able to help with institutional uptake, offer to send them the atlas and implementation manual. 4. Follow up (a) ensuring these were received and (b) asking whether any further information can be provided. 5. Record any strong opinions, positive or negative, as input for future reflection.
2. Persuasion (attitudes towards FEPA maps, for or against, are being formed)	1. Emphasise the scientific soundness of the maps by summarising the technical process that produced the maps (e.g. mention the principles of systematic biodiversity planning). 2. Emphasise their practical application by providing specific examples of how FEPAs can be used, tailoring the choice of examples as much as possible to their circumstances. 3. Offer to send them the atlas and technical report (for more technical detail). 4. Offer to send them the actual maps for a trial run. 5. Follow up (a) ensuring these were received and (b) asking whether any further information can be provided and (c) offering help if necessary. 6. Record any strong opinions, positive or negative, as input for future reflection.
3. Decision (the user is engaging in activities that will lead directly to the choice to adopt or reject the use FEPA maps)	1. Make a special effort to (a) address concerns, (b) improve the depth of understanding of the FEPA maps and their ultimate purpose, (c) solve specific technical problems, and (d) convey the kind of ongoing support that will be available. 2. If the person rejects the use of FEPAs, try to respectfully understand why that decision was made. 3. Record any strong opinions, positive or negative, as input for future reflection.
4. Implementation (FEPA maps are actually being used)	1. Explore the nature and extent of any problems that have been encountered. 2. Offer to solve these problems, if this is feasible. 3. If the person sounds enthusiastic about FEPA maps, establish the extent to which they, or their applications, can be used for marketing purposes for others who are still in previous phases. (Can the person become a 'contagious leader'?) 4. Record any strong opinions, positive or negative, as input for future reflection.
5. Confirmation (the user is re-examining a previous decision – positive or negative - relating to using the FEPA maps)	1. Ensure you understand exactly why confirmation is being sought. 2. Probe for possible misconceptions and address them clearly, ensuring that the person understands why the misconception arose in the first place and providing the correct explanation. 3. Whether or not the person reverses a previous decision, record the misconceptions, their cause(s), and their consequences as input for future reflection.

4.6 LESSONS FROM WORKING AT THE SCIENCE-POLICY INTERFACE

Policy-making debates take place between official policy-makers, who are mandated to make and implement policy, and non-government actors, who influence policy. Bridging actors serve as a 'go between' mediating and/or supporting communication between government and other actors in society. This policy-making context was used to examine the NFEPA project and formulate a framework to to encourage the uptake and use of science recommendations and products in everyday practice in a South African context.Challenges that hamper the uptake of science in government departments were explored, and several recommendations were made on how to address these challenges with a view to improving the uptake and use of science products in general, and NFEPA in particular. The challenges facing uptake of science products in South Africa are presented below, along with some recommendations. For further detail, the reader is referred to Funke and Nienaber (in press), the abstract of which is provided in Section 6.6.

There are several key challenges to the uptake of science products such as the NFEPA products:

- ***Government priorities:*** Governments are constantly under pressure to meet multiple needs and demands and tend to prioritise certain issues over others. The South African government, in particular, tends to prioritise development (e.g. water service delivery, mining and tourism) over environmental concerns. This means that strategic priorities and choices do not always emphasise the environment, making it difficult for government scientists and resource managers to promote a balance between conservation and development when advising their strategic managers and decision makers at the higher levels of government.

- ***Compliance with national legislation:*** While good legislation exists to manage the environment and other sectors, compliance with this legislation is often not rigorously enforced and monitored. Industry actors, such as mining companies and developers, often do not understand the role of government in regulating their sector, and are unable to communicate the required information clearly. Also, the turn-around time to take decisions between different government departments regarding development is very slow. A related challenge is that of enforcing the national environmental legislation – some developers would prefer to pay a fine, rather than follow the required environmental authorisation process.

- ***Capacity challenges in government departments:*** Most government departments and sub-units are understaffed, making it difficult for government employees to carry out their day-to-day operations. There are also bureaucratic problems around complicated intra-departmental processes, which include a lack of communication between chief directorates, inaccessibility of information, an overload of rules and regulations and a lack of funding in certain areas. These issues limit the capacity of governmen*t* employees to absorb and use new science products and tools, given the already stressful work environment within which they function.

Recommendations for promoting improved uptake of science products include:

- ***Targeting end-user audiences:*** There are four types of end-users for science products such as NFEPA:
    - All tiers of government (national, provincial and local)
    - Various levels of the political hierarchy within each of these governmental tiers (strategic decision makers as well as their advisors)
    - A wide range of government departments across sectors
    - A range of actors that are not part of government but interact with the environmental or water policy discourse (e.g. consultants, science organisations, academic institutions, major donor partners and bridging organisations)

Strategies for reaching these target audiences should include: regular updates, attention to information exchange between equals (avoiding a patronising tone), tapping into existing networks such as management meetings and seminars, using a variety of media (e.g. brochures and websites aimed at laypersons, a clip on an environment-focused television documentary such as ‘50/50’, articles in environmental newsletters and policy briefs). Strategies engaging high-level users (top-down strategies) are needed in combination with strategies that target on-the-ground decision makers (bottom-up strategies).

- ***Packaging and communicating the products:*** It is important to tailor the science products in a way that supports the work of the end user. Critical ingredients for doing this include: (1) ensuring that the products are timely because ‘re-work’ is unlikely, (2) providing explanations on how to use the products within the legislative and policy context in which the users operate; (3) providing a products that is of high quality and reliability; (4) packaging the information into a user-friendly and user-inspired format; (5) providing end-users with ongoing support needed to use the products most effectively and easily.

- ***Recognising politics and political process:*** It is critical to engage with the political leadership of the government departments. Decision makers are juggling multiple inputs at once and are influenced by broader political priorities, agendas and trends. There is a need to seek political advisors that are trusted and can convey information in a way that is digestible to strategic mangers and decision makers. Products need to suit the political climate in which decision makers work, present politically correct or appropriate solutions, and be accessible enough for decision makers to take ownership of them. A bridging or intermediary actor, is very useful to access political decision makers (e.g. via Parliamentary briefs and personal meetings).

4.6.1 Insights relevant to uptake of project output

Points of particular importance are the following:

- Engage with the political circumstances: There is a need to communicate the importance of the products and the benefits of using them in a politically attractive manner. Seeking political advisors to help package this message correctly is helpful in this regard. At a more operational level, the project needs to acknowledge that the FEPA maps will most often be implemented within poorly resourced, understaffed contexts – they should therefore be easy to use and should not add to the work of overburdened staff members.
- Understanding the needs and mental models of stakeholders is essential.
- Packaging and communicating needs to address a wide range of users and each will require different media strategies. Three main means of communication are: policy products, technical products and outreach products.

4.7 INCORPORATION OF INSIGHTS INTO PROJECT DESIGN AND PROCESS

4.7.1 Project design

- ***Coupled science and implementation goals:*** NFEPA aims (Section 1.1.1) have a technical component for identifying FEPAs and an implementation component focussed on developing a basis for effective uptake of FEPA maps.

- ***Multiple partners:*** Several key organisations were included as NFEPA partners even at the proposal development stage, comprising scientists (CSIR and SAIAB), implementers (DWA, DEA, SANPArks), bridging organisations and civil society (SANBI, WWF). These organisations represent the full science, policy, implementation continuum. This not only helped to ensure a strong buy-in amongst a wide range of organisations, but it is likely to have contributed more to the credibility of the project, than a project run by a single organisation.

- ***Inclusion of key implementers at the proposal development stage:*** This helped to ensure that the proposed products would meet their needs. Obtaining explicit funding from the two key government departments (Department of Water Affairs and Department of Environmental Affairs) also facilitated strong ownership and buy-in to project outputs.

- ***Stakeholder-informed project design:*** Before the project began, key stakeholders were identified through email networks of the project team, and invited to a project inception workshop (Appendix A). At the inception workshop, several options around the project approach were discussed and stakeholders were able to provide their perspectives and guidance on these approaches. The decisions that were made jointly at this workshop were then incorporated into the final project design.

- ***An approach underpinned by strong science making use of tacit knowledge:*** The technical component is based on best available data and uses a widely-accepted scientific planning framework for identifying FEPAs (Sections 3 and 4). A decision at the stakeholder inception meeting was to use existing empirical data at a national scale and improve this wherever possible with expert knowledge through expert workshops. This was conducted in a scientific manner within a systematic biodiversity planning framework.

- ***Transdisciplinary project team:*** Project team members included scientists and bridging agents, with strong links to implementing agencies. In addition, the project team had regular consultations with implementers (Appendix A). The project team coordinator had good networks and experience in River Health Programme management. This contributed significantly to the trust people put in the project process.

- ***Building capacity within the project team:*** The NFEPA project approach was underpinned by a philosophy of building the skills and capacity across South Africa to better manage and conserve freshwater ecosystems. Each component was provided with a mix of very experienced senior scientists/practitioners and emerging young researchers/practitioners. Task teams were created for each of the GIS layers developed, with a mixture of emerging and experienced scientists from different organisations that could learn together. Such inter-organisational capacity development is a very good strategy in a country and field where human skills are scarce (it serves to create a bigger pool of senior scientists to combine with younger scientists across organisations). A tremendous growth in expertise was experienced in the project team over the three years, both collectively and individually. The inter-organisational involvement had an additional benefit of greatly enhancing the credibility, institutional buy-in, and dissemination of knowledge.
- ***Creating and sustaining project team momentum:*** Several strategies were used to create and maintain group cohesion and progress on the project. Because the project team was geographically dispersed, an effort was made to hold a ‘work retreat’ in the varying centres at least three times a year. In the initial stages of the project, and for at least a year thereafter, a project team telephone conference was scheduled for the first Friday of every month to discuss progress and issues encountered. Such interaction helped substantially in developing a common understanding, language and vision and long lasting relationships for future collaboration.

4.7.2 Stakeholder engagement

- ***Garnering the support of 'contagious' leaders:*** The project team and its networks dedicated an explicit task to enthusing leaders in the field of freshwater ecology and strategic planning for water resources. At a national level, the project engaged director-level support in the national Departments of Water Affairs and Environment Affairs (in particular the Directorate: Resource Directed Measures and Directorate: Strategic Planning in Department of Water Affairs) – these directorates are responsible for water resource protection and development in South Africa. Support was also garnered among provincial conservation agencies and catchment managers that would serve as local champions for implementing the products. Their support of the project brought credibility to the project, and helped to spread the NFEPA networks.

- ***Allowing the time to engage meaningfully with stakeholders:*** During the project inception phase, concern was raised about the time realistically required for regional experts (many of whom are governmental officials juggling multiple responsibilities), to have meaningful input into the review of input GIS layers and the subsequent priority areas identified. Projects that require such a level of mass collaboration take more time, commitment and patience than thought. The 2.5 year project duration was lengthened to three years to accommodate meaningful stakeholder engagement. The slower pace of the project also enhanced co-learning in workshops, small group sessions and individual interviews.

- ***Combined top-down and bottom-up approach:*** Stakeholder engagement occurred at a national level as well as at more local levels. The national governance component sought to engage top officials of Department of Water Affairs, Department of Environmental Affairs and the National Planning Commission through one-on-one interviews, and presentations at ministerial committees (MinTech and MinMec; Appendix A). At a more at a local level of decision making, case studies (Section 4.2) were selected with the aim of developing the understanding, capacity and guidelines required to use the project outputs.

- ***Focussed workshop sessions with clear objectives:*** Sufficient time was provided for five three-day geographically decentralised review workshops, gathering inputs from over 100 aquatic scientists and practitioners around the country. These workshops served as hands-on GIS and map collation sessions, and also developed the capacity of aquatic scientists and practitioners on applying systematic biodiversity planning to freshwater ecosystem sustainability. The workshops considerably strengthened people's confidence and enthusiasm in the project, and to a large extent many of the participants have become local champions of the products. A national review workshop was also held with an extended group of participants a year later to review the draft FEPA maps and proposed map products. This national workshop was designed in a series of plenary and break-away sessions, to make best possible use of time for debating overarching issues that needed group consensus, and then regional review.

- ***Focussed individual and small group sessions:*** These took place in case studies, expert interviews and consultation with scientists and managers at all levels of governance (local, provincial and national).
- ***Quarterly newsletters:*** At the project inception workshop, a strong need was expressed for wide-reaching communication of project progress and milestones. The team accomplished this in a quarterly newsletter. The newsletter also supplied the contact details of the project coordinator who made sure that subsequent queries about the project were addressed.

- ***Stimulating awareness knowledge:*** The wide networks collectively formed by the project team members and 'contagious' leaders were the first method of stimulating awareness knowledge amongst potential users of the NFEPA products. In addition to this, the project team targeted presentations of the NFEPA project at national political processes (e.g. DEAs MINMEC which comprises the Minister, Deputy

Minister and provincial MECs for environment) and key local environmental forums such as the Grasslands Forum, Fynbos Forum, Biodiversity Planning Forum, National Wetlands Indaba, Western Cape Wetlands Forum (Appendix A). During the final stages of the project, two types of PowerPoint presentations were developed to provide for stakeholders that are interested in promoting the use of NFEPA products within their own networks. Both presentations are available on the SANBI Biodiversity GIS website (http://bgis.sanbi.org). The first of these presentations targets a scientific audience and the second focuses more policy and implementation.

4.7.3 Packaging and dissemination

- ***Tailoring products to stakeholder needs:*** Careful consideration was given to the packaging of the map products and their implications. Final NFEPA map products were developed in collaboration with stakeholders participating in the national review workshops and the case study workshops. The NFEPA atlas serves as a packaging tool for disseminating these map products and supporting information. An implementation manual was also developed to accompany the map products. The manual describes how to use the map products in different legal and policy contexts, and provides freshwater ecosystem management guidelines for each of the FEPA map categories (Section 3.9.1). The atlas and implementation manual explicitly address the need for reducing scientific detail (e.g. as contained in this technical report). A series of key findings and recommendations, as well as headline policy messages has also been constructed (Section 8).

- ***Making the case for using FEPA maps:*** The NFEPA atlas and implementation manual not only provide practical guidance on the use of FEPAs, but also highlight the benefits of using the maps framing them within the current political context (addressing the principles knowledge of understanding why it is necessary to use an innovation).

- ***Use of different dissemination tools:*** The NFEPA products are provided using a variety of electronic and hard copy dissemination tools (Figure 1.1), each with slightly different purposes. At the most basic level, A3 PDF files of FEPA maps can be downloaded for each Water Management Area. The NFEPA atlas packages the maps and supporting information into a user-friendly, hard copy product. It includes FEPA maps for each Water Management Area, national map products, and maps of input data. It also provides a DVD of all NFEPA products and shapefiles available in hard copy and electronic copy. It is available in hard copy from the Water Research Commission. The atlas DVD provides shapefiles and metadata that explain the different map categories. It also contains an easy-installation map-viewer that allows the user to zoom into a region of interest and click data layers on and off. This map-viewer is very easy to operate and does not require extensive computer specifications. All shapefiles, maps and supporting information can be downloaded from the SANBI Biodiversity GIS website (http://bgis.sanbi.org). This website also offers a similar map-viewing option that is user-friendly, allowing users to zoom into a region of interest and click data layers on and off.

4.7.4 Post project support

SANBI co-lead this project and is in a position to serve as a bridging institution mandated by government that could catalyse and maintain implementation activities beyond the life of the project. In addition, WWF is an institution that represents civil society and which has a large and active freshwater programme to support the implementation of the NFEPA products beyond the life of the project. However, institutionalisation at the sub-national level remains an unresolved issue, which needs to be addressed to sustain future uptake and updates of FEPA maps (Section 4.7.5).

4.7.5 Unresolved issues

There are two project related issues that are critical to harnessing the full impact of science to implementation innovation change. The first is the need to find appropriate sub-national homes for the FEPA maps and supporting information. Although SANBI can help coordinate the use of FEPA maps at the national level, a strong sub-national champion is required to make sure that FEPA maps are used in planning and decision making processes related to water resources and land use. Ideally, the FEPA maps should be institutionalised within provincial conservation authorities who need to be appropriately resourced for this responsibility (in terms of staff and operational budget). This is problematic because many provincial conservation authorities do not even have a qualified aquatic ecologist on their staff.

The second issue relates to establishing an evidence-base for how FEPAs are influencing decisions and shaping environmental outcomes. A suite of indicators should be developed and implemented to monitor the effectiveness of FEPA uptake, from its early stages into policy, to action on the ground. Suitable feedback to improving future updates, or similar initiatives should also be established.

SECTION 5: LEGAL AND POLICY ASSESSMENT

This section describes existing legal frameworks and general administrative arrangements, with the intention of informing the contents of the NFEPA implementation manual.

5.1 OVERVIEW

Responsibilities for the management and conservation of freshwater ecosystems and their associated biodiversity fall across a number of South African sectors and government departments. This multi-sectoral situation creates particular challenges for the uptake, embedding and consistent use of FEPA maps and products in South Africa. It is inevitable that mandates and responsibilities overlap. There is widespread concern about this fragmentation and the effectiveness of enforcement and implementation. This is in spite of the fact that there are at present more mechanisms for enforcement than ever before (Kidd 2008).

This legal and policy assessment was conducted for the NFEPA project in an effort to gain a comprehensive understanding of the types of legal instruments that can be used to facilitate uptake of FEPAs throughout the country. The assessment informed the NFEPA implementation manual, which serves to communicate how to use the FEPA maps in a variety of different contexts (Figure 1.1). Whereas the manual provides a brief overview of key legal and policy instruments for promoting the management and conservation of FEPAs, its focus is more on the use of FEPAs within these different contexts. This section of the technical report provides a more thorough description of the actual legal and policy tools, and aims to:

- Identify current legislation, mechanisms and associated responsibilities relating to FEPAs;
- Identify specific contexts in which FEPAs can either:
  - Provide sound scientific input; or
  - Will contribute to formal institutionalisation of FEPAs which will embed their use in organisational practices and procedures.
- Provide a reference for government officials that describe the most relevant FEPA-related legislation and mechanisms in:
  - Their own departments; and
  - Other departments with which they may need to work. This is done in the interests of creating a better understanding of respective roles and responsibilities, which in turn should facilitate better cooperation.

For more detail on the specific use of FEPAs within the legal and policy mechanisms described below, the reader is referred to the NFEPA implementation manual.

5.2 CURRENTLY-USED ECOSYSTEM MANAGEMENT GUIDANCE

In order to understand the needs of target users, it is useful to examine the decision making contexts appropriate to each user group with specific reference to managing and conserving freshwater ecosystems. Table 5.1 shows these target groups, their decision making contexts and where they obtain their ecosystem management guidance (a useful reference for this section is Cadman et al. 2010).

The target users represent a wide diversity of professionals, politicians, landowners and civil society. Similarly, there is a range of documents readily available as reference material to guide the management and conservation of freshwater ecosystems. There is a good deal of agreement in terms of the objectives of ecosystem management and the means by which this can be achieved. The level of detail, however, differs markedly between sources.

Table 5.1. Potential target user groups, their decision making contexts and currently used guidance.

User group	Decision making context	Current guidelines, protocols or frameworks
Government: National	Formulating or updating legislation, guidelines and policies Protection of natural resources National water resource classification Reserve determination Mining and prospecting applications Listing threatened ecosystems / species Environmental public works programmes	National environmental legislation National Environmental Sector Plan National Biodiversity Framework, National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy National Environmental Sector Plan Climate Change Response Strategy Preliminary ecological reserve determinations Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans River Health indices / State of River reports List of threatened ecosystems / species System-specific management guidelines (e.g. WetHealth and WetEcosystem Services for wetland assessment).
Government: Provincial, District	Water use applications / registration Spatial development and land-use planning Reserve determination Environmental impact assessment Biodiversity planning Biodiversity offsets	Provincial environmental legislation Provincial/District Spatial Development Frameworks (SDFs) Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans Land-use guidelines River Health indices / State of River reports List of threatened ecosystems / species Provincial development guidelines, e.g. KZN Department of Agriculture and Environmental Affairs Guidelines for Development Activities that may affect Wetlands (DAEA 2002)
Government: Local	Spatial development and land-use planning Environmental impact assessment Biodiversity planning Biodiversity offsets	Provincial environmental legislation Provincial/District/Local Spatial Development Frameworks (SDFs) Local guidelines and policies (e.g. City of Cape Town's Floodplain and River Corridor Management Policy) Land-use guidelines River Health indices / State of River reports List of threatened ecosystems / species

User group	Decision making context	Current guidelines, protocols or frameworks
National parastatals	Co-ordination and undertaking biodiversity-related research Monitoring and reporting on the state of biodiversity Biodiversity planning and policy advice Knowledge networking and information management Conservation management and tourism Coordination of programmes of action involving civil society and other stakeholders	River Health indices / State of River reports List of threatened ecosystems / species National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans
Catchment management agencies	Preparation of catchment management strategies	River Health indices / State of River reports List of threatened ecosystems / species National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans catchment management strategy
Conservation agencies (e.g. implementation, funding)	Protected Areas expansion strategies Biodiversity stewardship Prioritisation of conservation effort / funding Providing comments on environmental impact assessments	National, provincial and local legislation River Health indices / State of River reports List of threatened ecosystems / species National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans
Environmental Assessment Practitioners	Understanding national biodiversity value Environmental impact assessment Biodiversity offsets	National, provincial and local legislation River Health indices / State of River reports List of threatened ecosystems / species Biome-specific ecosystem guidelines (e.g. Fynbos Forum ecosystem guidelines (De Villiers et al. 2005)
Biodiversity specialists and researchers, and biodiversity planners	Understanding national biodiversity value Environmental impact assessment Assessing ecological importance and sensitivity Biodiversity planning Biodiversity offsets Prioritising research focus	National, provincial and local legislation River Health indices / State of River reports List of threatened ecosystems / species National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans Biome-specific ecosystem guidelines (e.g. Fynbos Forum ecosystem guidelines)

User group	Decision making context	Current guidelines, protocols or frameworks
Rehabilitation practitioners	Prioritisation of rehabilitation effort / funding/ programmes Implementation of rehabilitation programmes	River Health indices / State of River reports List of threatened ecosystems / species Biome-specific ecosystem guidelines (e.g. Fynbos Forum ecosystem guidelines) Rehabilitation guidelines, e.g. WET-Rehab (Russell 2009), Working for Wetlands best management practices guidelines, Alien Plant Control guidelines for landowners, MONDI guidelines
Landowners, farmers, developers, irrigation boards, industry	Property investment Biodiversity stewardship Small-scale conservation Sustainable production Implementation of the ecological reserve Biodiversity offsets	National, provincial and local legislation River Health indices / State of River reports List of threatened ecosystems / species National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans Sector-specific best practice guidelines (e.g. Biodiversity and Wine Initiative biodiversity guidelines, Sustainable Sugarcane Farm Management System, GreenChoice Living Farms Reference, MONDI guidelines (Braack et al. 2004; Kotze 2004), eco-labelling and certification guidelines Biome-specific ecosystem guidelines (e.g. Fynbos Forum ecosystem guidelines)
Legal profession and estate agents	Settling of disputes Property evaluation and sales Biodiversity offsets	List of threatened ecosystems / species National Biodiversity Strategy and Action Plan (including the National Spatial Biodiversity Assessment), National Protected Areas Expansion Strategy Bioregional plans, biodiversity sector plans (incorporating maps of Critical Biodiversity Areas and Ecological Support Areas and associated guidelines), biodiversity plans
Civil society organisations	Knowledge networking and information management Programmes of action involving civil society and other stakeholders Education	River Health indices / State of River reports List of threatened ecosystems / species Biome-specific ecosystem guidelines (e.g. Fynbos Forum ecosystem guidelines)

5.3 WATER SECTOR

5.3.1 Introduction

The South African National Water Policy (DWAF 1997) and National Water Act (Act 36 of 1998) are explicit about the need to protect aquatic ecosystems in order to allow for sustainable achievement of social and economic benefits from these systems. A balance is required between protecting such systems and achieving economic development.

5.3.2 National Water Act

The National Water Act is the primary legislation dealing with the protection of water resources in the country and sets the framework for how these resources must be managed. A number of fundamental principles (DWAF 1997), which reflect certain prominent themes, underpin the Act, namely that:

- Government must be the custodian of water resources;
- The equitable access of water by all South Africans must be attained;
- The hydrological cycle is a single system and that water for the environment is crucial for the healthy operation of the cycle; and
- The international dimensions of South Africa's water resources and the rights of neighbouring countries are recognised.

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. Importantly in the current context, these include the need to "protect aquatic and associated ecosystems and their biological diversity". Contrary to the previous Act (Act 54 of 1956) (RSA 1956), no private ownership of water is now possible: the only rights to water are for basic human needs and the quantity and quality required to protect aquatic ecosystems "…in order to secure ecologically sustainable development and use" of water resources (RSA1998a).

5.3.2.1 Policies, legislative tools and mechanisms

> The water resource classification system and the associated Resource Quality Objectives may be the single most important context in which the use of FEPAs should be institutionalised. This will also clearly demonstrate Department of Water Affairs' high-level endorsement of the importance of FEPAs.

- **Resource-directed measures (RDMs)**. These focus on the quality of the resource itself and set clear objectives for the desired level of protection of the resource (DWAF 1997). They comprise:
  - *A water resource classification system* which must provide a standard set of rules and procedures to determine the class of water resources. The classification system provides a definition of the classes that are to be used and a step-wise procedure to be followed in order to recommend a class. The class outlines those attributes society requires of different water resources and consists of a combination of the requirements of water users within the catchment and the ecological requirements for the resource (DWAF 2006).
  - *The determination of the Reserve.* The Reserve is the quantity and quality of water required to satisfy basic human needs and to protect aquatic ecosystems. The Reserve is the only right specified in the Act and consists of two aspects: a basic human needs reserve and an ecological reserve. Water for basic human needs has the highest water allocation priority in the country

followed by the ecological reserve. The purpose of the ecological reserve is to secure water to protect the structure and function of aquatic ecosystems in such a form that they can continuously provide the desired set of socio-economic goods and services to society.

- T*he setting of Resource Quality Objectives (RQOs)*. Resource Quality Objectives are clear goals relating to the "quality of the relevant water resources" and these are set in accordance to the class specified for the resource in question. These are specific objectives for controlling impacts on the water resource, through regulatory measures such as the licensing of water use (DWAF 2006). The National Water Act also makes provision for the setting of a preliminary ecological reserve and resource quality objectives for water resources before the formal classification system has been established.

- **Source-directed controls (SDCs)**. These are measures to control water use in order to limit impacts to acceptable levels so that the Resource Quality Objectives set by the Department of Water Affairs, are achieved (Reed and de Wit 2003). These controls include principles for regulating water use, such as water quality standards for waste water, waste water discharges, pollution prevention, and waste minimisation technologies. The Department of Water Affairs furthermore encourages progressive implementation of self-regulation while economic incentive mechanisms are also implemented (DWAF 1997). The authorisation of a water use is an important source-directed control mechanism. A water use must be authorised before it may be exercised and can be one of three kinds:

  - A *Schedule I authorisation*, which includes amongst others the taking of water from a water resource to which a person has lawful access, for reasonable domestic use, small gardening (not for commercial purposes), and watering of livestock (not feedlots). There are no charges or tariffs associated with a Schedule I use.
  - A *general authorisation*, by which a water use is authorised for a group or groups of water users, as long as certain minimum requirements (currently set out in Regulation 1191 of 1999) (DWAF 1999) are met.
  - A *water use license*, for which an individual water user must apply to the relevant licensing authority, currently Department of Water Affairs. The application is evaluated according to the criteria of section 27 of the Act. Water use is authorised with a range of conditions attached that include the requirement to use water efficiently, and to pay all relevant charges relating to the water use. Failure to comply with conditions attracts sanctions and penalties that could include withdrawal of the authorisation. There are eleven different kinds of uses that are listed in Section 21 of the Act and that require formal authorisation.

- **National Water Resource Strategy**. The National Water Resource Strategy (DWAF 2004a) is intended to set out 'the strategies, objectives, plans, guidelines and procedures of the Minister as well as the institutional arrangements relating to the protection, use, development, conservation, management and control of water resources within the framework of existing relevant government policy. The strategy is an indicative multi-year programme for implementing the national water policy, and an indicative quantification of government's proposed investments in all aspects of water resource management, including investments in new infrastructure. It also provides the framework within which water will be managed at regional or catchment level in the 19 defined Water Management Areas.

> Revisions of the National Water Resource Strategy should reference FEPAs explicitly. This will be another important way in which the Department of Water Affairs formally endorses their use.

The national water resource strategy should be reviewed at intervals of not more than five years. The first strategy was published in 2004 and is currently being reviewed to be published in 2011.

- **Catchment Management Strategies**. The National Water Act provides for the progressive development of Catchment Management Strategies. Catchment management must be carried out in accordance with the National Water Resource Strategy. The catchment management strategy must set out the strategies, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of water resources in the Water Management Area. It must be done with the cooperation and agreement of stakeholders and interested persons (Abernethy 2001). In those Water Management Areas in which there is not yet a Catchment Management Agency, the Department of Water Affairs' internal strategic perspectives (ISPs) are essentially integrated water resource management plans and are considered to be the forerunners of catchment management strategies.

> Explicit mention in a catchment management strategy of the importance of FEPAs in general, and identifying specific FEPAs within the Water Management Area, will be the most important mechanism for institutionalising FEPAs at catchment (regional) level. This promoted their consideration at lower (municipal) levels.

- **National monitoring and information systems**. The National Water Act provides the policy framework for water resource assessment. It requires the establishment of national monitoring systems and national information systems to address the monitoring, recording, assessing and dissemination of information on water resources. The River Health Programme is one of several national monitoring programmes of Department of Water Affairs and was initiated in response to the need for information regarding the ecological state of aquatic ecosystems (Roux 1997). The purpose of the programme is to measure, assess and report on the general state of rivers at a national level.

> FEPAs can inform monitoring system design by (a) prioritising the location of monitoring points (e.g., within, upstream and downstream of FEPAs) and (b) indicating potentially appropriate monitoring variables.

5.3.2.2 Administration and implementation

There is a complex set of institutional relationships that govern the water sector, involving numerous organisations fulfilling different roles and functions. Problems and challenges experienced in the sector are in part a consequence of these multiple institutional layers and the associated risks of performance failure by any one party (DWA 2009).

Department of Water Affairs is the lead agent and national custodian of water resources in the country. The National Water Act allows for the establishment of various organisations such as catchment management agencies, water user associations, advisory committees and water tribunals for conflict and dispute resolution. Each has particular roles to play regarding water management and achieving the purpose of the National Water Act.

5.3.3 Other mechanisms

5.3.3.1 National Strategy for Sustainable Development

Section 8 of Agenda 21 calls on countries to adopt national strategies for sustainable development that "should build upon and harmonise the various sectoral economic, social and environmental policies and plans that are operating in the country." Department of Environmental Affairs and the Department of Foreign Affairs have been tasked with the responsibility of coordinating South Africa's response to the outcomes of the World Summit on Sustainable Development and are the lead government departments for the development of a National Strategy for Sustainable Development (DEA 2010c). The first phase of this process culminated in the adoption by the Cabinet in June 2008 of the National Framework on Sustainable Development. Amongst other things, this framework spells out South Africa's vision of a sustainable society as follows:

"*South Africa aspires to be a sustainable, economically prosperous and self-reliant nation state that safeguards its democracy by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration*."

The National Strategy for Sustainable Development addresses the need to pursue and assess the key stated objective of increased economic growth via environmental integrity, social equity and economic development. It intends to address issues such as water quality and quantity, climate change, waste management, soil loss and pollution, food production and strategic biodiversity management, while attending to development priorities associated with addressing poverty and basic human needs.

5.3.3.2 Mountain Catchment Areas Act

The purpose of the Mountain Catchment Areas Act (Act 63 of 1970) (RSA 1970) is to:

- Provide for the conservation, use, management and control of land situated in mountain catchment areas;
- Encourage conservation and use, management and control of mountain catchment areas;
- Manage mountain catchment areas to maintain sustained yields of quality stream flow, nature conservation, fire hazard reduction, aforestation, grazing, tourism and recreational opportunity; and
- Put the onus on owners of the designated land to manage that land through prevention of soil erosion, removal of exotic vegetation and fire protection.

However, there is lack of clarity about the status of the Act, and no consensus on its administration or on the responsible regulating authority for mountain catchment areas. A key recommendation of NFEPA is that the Mountain Catchment Area Act be revitalised, that clarity on responsibility for its implementation be achieved, and that further mountain catchment areas be proclaimed. High water yield areas identified by NFEPA (see atlas) should be considered priorities for declaration as mountain catchment areas, given the vital role they play in water provision. The National Protected Area Expansion Strategy 2008 (Government 2010) notes that the status of the Mountain Catchment Areas Act is an important matter to resolve, given the significant contribution that mountain catchment areas make to protected area targets and their important role in providing ecosystem services.

5.3.3.3 Working for Water and Wetlands programmes

South Africa has in recent years seen the development of many control programmes aimed at conserving and rehabilitating ecosystems and their biodiversity. These programmes often involve different governmental departments and organisations and contribute to education, community empowerment, capacity building and employment (NSOER 2010).

> The Working for Water and Working for Wetlands programmes can promote their objectives of improved ecological functioning through using FEPAs to prioritise their efforts.

The fight against invasive alien plants is spearheaded by the Working for Water (WfW) programme that is administered through Department of Water Affairs. It works in partnership with local communities to whom it provides jobs, and also with government departments including the national departments of Environmental

Affairs, Agriculture, Forestry and Fisheries, Trade and Industry, as well as the provincial departments of agriculture, conservation and environment, research foundations and private companies (WfW 2010).

The Working for Wetlands Programme (WfWet) relies on collaboration between Department of Environmental Affairs, Department of Water Affairs, Working for Water, the Mondi Wetlands Project, LandCare (Department of Agriculture, Forestry and Fisheries) and the Water Research Commission (WfWet 2010). It aims to facilitate the conservation, rehabilitation and sustainable use of wetland ecosystems, while at the same time fulfilling functions such as poverty alleviation, job creation, training and empowerment (DEAT 2005).

WfWet is managed by SANBI on behalf of the departments of the Department of Environmental Affairs, the Department of Agriculture, Forestry and Fisheries, as well as the Department of Water Affairs. It also forms part of the government's expanded public works programme which seeks to draw unemployed people into the productive sector of the economy.

5.4 ENVIRONMENTAL SECTOR

5.4.1 National Environmental Management Act (NEMA)

The National Environmental Management Act (Act No. 107 of 1998) (RSA 1998b) is the cornerstone of environmental law in South Africa. It is regarded as 'framework legislation' which "aims to define overarching and generic principles in terms of which sectoral-specific legislation is embedded, as well as to enhance the cooperative environmental governance amongst fragmented line ministries" (Kidd 2008). New legislation that has been developed under the National Environmental Management Act is more specialised and addresses particular resource issues such as biodiversity (Section 5.4.2) and protected areas (Section 5.4.3).

The Act contains an extensive list of principles of which the following two reflect the core values (RSA 2004a):

- Environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably.
- Development must be socially, environmentally and economically sustainable.

The Act also gives effect to the overarching principles of cooperative government contained in Section 3 of the Constitution. This is significant, since the 'environment' is designated in the Constitution as an area of concurrent national and provincial legislative competence, with the result that both national and provincial authorities are responsible for the administration of laws protecting the environment (Kidd 2008).

5.4.1.1 Policies, legislative tools and mechanisms

- **Environmental implementation plans and environmental management plans**. The National Environmental Management Act provides the basis for cooperative governance through the system of Environmental implementation plans and environmental management plans (EIPs and EMPs respectively):
  - ➢ An environmental implementation plan must be prepared by every national department listed in Schedule 1 (i.e. the departments of Environmental Affairs; Land Affairs; Agriculture; Housing; Trade and Industry; Water Affairs; Transport; and Defence) in exercising functions which may affect the environment as well as every province, and

- An environmental management plan must be prepared by every national department listed in Schedule 2 (i.e. the departments of Environmental Affairs; Water Affairs; Minerals and Energy; Land Affairs; Health; and Labour) in exercising functions which involve the management of the environment.

The purpose of these plans is to provide for cooperative environmental governance, more specifically to coordinate and harmonise the environmental policies, plans, programmes and decisions of the various national departments and of provincial and local spheres of government, in order to (a) minimise the duplication of procedures and functions and (b) promote consistency in the exercise of functions that may affect the environment. While these plans have to be updated every four years, the National Environmental Management Act also requires national departments and provinces to report annually to the Committee for Environmental Coordination (CEC) on the implementation of their environmental implementation plan and environmental management plan commitments.

Department of Water Affairs, Department of Environmental Affairs and the Department of Rural Development and Land Reform (previously Department of Land Affairs) are listed in both Schedule 1 and 2 because they have both impacting and managing functions. These departments have to develop a single Consolidated Environmental, Implementation and Management Plan (CEIMP). The importance of these plans lies in the fact that every organ of state must exercise every function that may significantly affect environment substantially in accordance with the environmental implementation plan and environmental management plan commitments. The intention is to include biodiversity in such plans and so enable their mainstreaming into decision making. This appears to be a sensible system for ensuring coherent environmental policy from all government departments. However, it has to date not been very successful and biodiversity considerations at the strategic level remain marginalised and narrow (Wynberg 2002; Kidd 2008).

- **Environmental Management Frameworks (EMFs)**. Environmental management frameworks are strategic region-based planning mechanisms which aim to facilitate the compilation and consideration of applications for environmental authorisation as well as to guide future planning. An environmental management framework is described as “a study of the biophysical and socio-cultural systems of a geographically defined area to reveal where specific land uses may best be practiced and to offer performance standards to maintain appropriate use of such land”. Until recently, environmental management frameworks formed part of the 2006 Environmental Impact Assessment Regulations. However the new amendment to the Act now recognises environmental management frameworks as an environmental instrument in its own right. This has resulted in standalone Environmental Management Framework regulations which came into effect on 2 August 2010.

- **Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs)**. The National Environmental Management Act requires that specific activities, before commencing, be authorised on the basis of an Environmental Impact Assessment (Kidd 2008). The primary purpose of an Environmental Impact Assessment is to determine and evaluate the environmental implications of development to inform decision making at the project level (DEA&DP 2009). The nature of the proposed development determines whether a basic assessment process or a scoping and full Environmental Impact Assessment process, as indicated in the listing notices, should be performed. Legislation has been substantially amended (Act 8 of 2004 (RSA 2004b); Act 62 of 2008 (RSA 2008a) and provides for other tools such as Strategic Environmental Assessments (SEAs). A Strategic Environmental Assessment refers to a process that integrates sustainability considerations into the formulation, assessment and implementation of higher-level policies, plans and programme (DEAT 2007). Where Environmental Impact Assessments focus on positive and negative impacts of a specific development project, SEAs allow determination of the most suitable development type for a particular area, before development proposals are formulated (DEAT 2004a).

- **State of Environment reporting**. The National Environmental Management Act guarantees access to information on the state of the environment and threats to it and allows for access by the public to all environmental management and implementation plans. The Department of Environmental Affairs reports on a number of themes which include biodiversity, inland water, marine and coastal ecosystems (NSOER 2010). The reports are produced at national, provincial and local level for the various sectors.

5.4.1.2 Administration and implementation

At the national level, the Department of Environmental Affairs is the custodian of the environment. The Department's mission is to lead the sustainable development of South Africa's environment by:

- Conserving the country's natural resources;
- Protecting and improving the quality and safety of the environment; and
- Promoting a global sustainable-development agenda (DEAT 2005).

This responsibility is shared with many other institutions that exist at several levels of governance. Provincial conservation agencies are major role players and independent statutory organisations such as South African National Parks (SANParks) and the South African National Biodiversity Institute (SANBI) are valuable partners. National and provincial governments have concurrent legislative competence for environmental management (that is, both spheres are constitutionally responsible for it).

The National Environmental Management Act also makes provision for the establishment of institutions for environmental management (Kidd 2008) which includes:

- **The National Advisory Forum**, consisting of 12-15 stakeholder representatives and domain experts, appointed by the Minister, to inform and advise the Minister on fulfilling the objectives of the Act which include matters concerning environmental management and governance.

- **The Committee for Environmental Coordination (CEC)**, consisting of Director Generals from relevant departments, provincial heads of department, and persons co-opted by the Minister. One of the main functions of the Committee for Environmental Coordination is to promote the implementation of environmental implementation plans (EIPs) and environmental management plans (EMPs). The Committee for Environmental Coordination has to scrutinise the plans once they are submitted and either approves them or, in the event of any inconsistencies, refers them back for resubmission. To assist the Committee for Environmental Coordination in the performance of its function, sub-committees on law reform and biodiversity have been established, as well as on environmental management plans and implementation plans. The National Environmental Management Act also requires national departments and provinces to report annually to the Committee for Environmental Coordination on the progress of their environmental implementation plans and environmental management plans for monitoring purposes.

5.4.2 National Environmental Management: Biodiversity Act ('Biodiversity Act')

South Africa's policy and legislative framework for biodiversity is well developed and provides a strong basis for the conservation and sustainable use of biodiversity.

National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (RSA 2004a) gives effect to multilateral agreements of which the Convention on Biological Diversity is particularly important. The objectives of the Act are to provide for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act. The Biodiversity Act also provides direction and mechanisms for consistent implementation of biodiversity policy across the country. This should ultimately contribute to resolving the fragmented nature of biodiversity-related legislation and consolidation of different laws to give effect to the principle of cooperative governance (DEAT 2005; Kuntonen-van't Riet 2007).

5.4.2.1 Policies, legislative tools and mechanisms

Systematic biodiversity planning is an important element of several of the legal tools and mechanisms described in the Act (Biodiversity Advisor 2010). Relevant tools and mechanisms include the following:

- **National Spatial Biodiversity Assessment**. This is a national assessment of spatial priorities for conservation action, integrating terrestrial, freshwater, estuarine and marine ecosystems. It uses systematic biodiversity planning techniques to determine the ecosystem threat status of these ecosystems and to identify national priority areas for conservation action and more detailed planning (Driver et al. 2005). It provides a spatial picture of the location of South Africa's threatened and under-protected ecosystems, and focuses attention on geographic priority areas for biodiversity conservation. There is a particular emphasis to mainstream biodiversity priorities throughout the economy and to make links between biodiversity and socio-economic development. The development of the National Spatial Biodiversity Assessment 2004 was commissioned by the Department of Environment Affairs and led by SANBI in partnership with several organisations and was the first ever comprehensive spatial assessment of biodiversity throughout the country. The National Biodiversity Assessment is updated every five years.

- **National Biodiversity Strategy and Action Plan (NBSAP)**. This sets out a comprehensive long-term strategy for the conservation and sustainable use of South Africa's biodiversity. The National Biodiversity Strategy and Action Plan was compiled partially in response to the Convention on Biological Diversity (1995) but also in order to satisfy Section 3 of the Biodiversity Act which calls for the development of a National Biodiversity Framework, which it feeds into. South Africa's first National Biodiversity Strategy and Action Plan was developed by Department of Environmental Affairs and completed in 2004 (DEAT 2004b).

- **National Biodiversity Framework (NBF)**. The Biodiversity Act required the Minister to prepare a National Biodiversity Framework within three years of promulgation of the Act. The purpose of the framework is to provide for an integrated, coordinated and uniform approach to biodiversity management by organs of state in all spheres of government, non-governmental organisations, the private sector, local communities, other stakeholders and the public; and identify priority areas for conservation action and the establishment of protected areas. The National Biodiversity Framework (DEAT 2007) rests on the National Biodiversity Strategy and Action Plan and National Biodiversity Assessment.

> The NBF has a number of 'Priority Actions' directly relevant to the use of FEPAs and institutional arrangements like the establishment of a Freshwater Programme.

- **Biodiversity plans**. A biodiversity plan is a direct extension of the National Biodiversity Assessment and the National Biodiversity Strategy and Action Plan as it gives effect to the statutes at provincial level (Kidd 2008). It provides the main building block in planning for sustainable development and a comprehensive biodiversity strategy. It is essentially a comprehensive environmental inventory and spatial plan aimed at informing land-use planning processes (see Section 5.5.2).

- **Bioregional plans and biodiversity plans**. The Biodiversity Act calls for the declaration of bioregions and the publication of bioregional plans. This forms part of a suite of legislated planning tools to assist with the management and conservation of South Africa's biodiversity at a national and provincial scale. Ultimately, the aim is a coherent series of nested management plans at various levels, covering larger bioregions, threatened ecosystems, protected areas and species. Such plans are not limited to formal protected areas and include land outside of the protected area network (DEAT 2004c).

  The purpose of a bioregional plan is to provide a map of biodiversity priorities with accompanying land-use planning and decision making guidelines to inform land-use planning, environmental assessment and authorisation and natural resource management by a range of sectors whose policies and decisions impact on biodiversity (DEA 2009). Bioregional plans are usually the outputs of a systematic spatial conservation assessment of the region, identifying areas on conservation priorities and constraints as well as opportunities for implementation (NSOER 2010). This method of planning incorporates conservation priorities into proactive planning guidelines allowing for efficient and suitable selection of sites for conservation management. Bioregional plans are intended to inform multi-sectoral planning and assessment processes such as environmental management frameworks, environmental management plans, spatial development frameworks (SDFs), strategic environmental assessments (SEAs) and environmental impact assessments (EIAs), and must be updated every five years and monitored for compliance on a regular basis (DEA 2009).

  Bioregional plans must align with administrative boundaries in order to make them usable. They can be developed for district municipalities, groups of local municipalities, or metros (Biodiversity Advisor 2010). The format for bioregional plans as well as the process for publishing a bioregional plan is set out in the recently gazetted 'Guideline Regarding the Determination of Bioregions and the Preparation of and Publication of Bioregional Plans' (DEA 2009). Examples of bioregional plans include: Cape Action for People and the Environment (C.A.P.E.); Succulent Karoo Ecosystem Programme (SKEP) and Subtropical Thicket Ecosystem Planning Programme (STEP) (DEAT 2005).

  In some provinces biodiversity sector plans have been developed which are precursors to bioregional plans. These biodiversity sector plans do not have the legal weight of a bioregional plan but can be used in the interim until a bioregional plan has been published.

- **Biodiversity management plans**. These may be developed by any person, organisation or organ of state desiring to contribute to biodiversity management of ecosystems and indigenous species in need of protection.

> It is recommended that biodiversity management plans be developed for special biodiversity features (e.g. red data species, rare habitats, etc.) that occur in FEPAs.

- **Threatened ecosystems and species**. The Biodiversity Act aims to ensure sustainable use of biodiversity, by providing for the protection of threatened ecosystems and species through a national (and/or provincial) listing mechanism which lists those ecosystems and species in need of protection. The lists have four categories: critically endangered, endangered, vulnerable and protected (DEAT 2005; Kidd 2008). The purpose is primarily to reduce the rate of ecosystem and species extinction. This includes preventing further degradation and loss of structure, function and composition of threatened ecosystems. The Minster may also identify threatening processes in listed ecosystems which will be regarded as a ‘specified activity’ in terms of the National Environmental Management Act and which cannot be carried out without authorisation.

FEPAs provide a natural input into the National Protected Areas Expansion Strategy, helping to highlight those areas most in need of protection, and hence possible formal inclusion in the National Protected Areas System.

- **National Protected Areas Expansion Strategy**. South Africa’s protected area network not only is biased towards the protection of certain ecosystems, but currently also falls far short of sustaining biodiversity and ecological processes (DEA 2010b).

  The National Protected Areas Expansion Strategy, which was commissioned by Department of Environmental Affairs, serves as a national framework for an integrated, coordinated and uniform approach to the expansion and consolidation of the national protected areas system. The goal of the strategy is to achieve cost effective protected area expansion for ecological sustainability and increased resilience to climate change (DEA 2010b). Using systematic biodiversity planning tools, the strategy identifies priority areas where protected area expansion would contribute to meet national biodiversity targets. It highlights how to be more efficient and effective in allocating the scarce resources available for protected area expansion. It sets targets for protected area expansion, provides maps of the most important areas for protected area expansion, and makes recommendations on mechanisms for protected area expansion. Provincial spatial biodiversity plans provide the basis for the development of provincial protected area expansion strategies. These provincial spatial biodiversity plans are also crucial for provinces wanting to develop stewardship programmes as they guide the identification of stewardship sites.

  The primary implementers of the National Protected Areas Expansion Strategy are protected area agencies, including provincial conservation authorities, SANParks, World Heritage Site Authorities and the Marine and Coastal Management Branch of Department of Environmental Affairs. Each should develop an agency-specific protected area expansion implementation plan based on the strategy targets and focus areas.

- **Biodiversity stewardship**. Biodiversity stewardship is an element of the National Protected Areas Expansion Strategy and has been implemented in South Africa over the past few years. It has gained importance as a key mechanism to secure priority biodiversity on land outside of state-owned protected areas, i.e. on privately/communally owned land where the landowner/user is willing to enter into an agreement. Biodiversity stewardship is voluntary and cannot be forced upon a landowner/user (DEA 2010b). Its implementation has occurred from the bottom up through partnerships between landowners, conservation NGOs and conservation agencies. There are different categories of stewardship which afford different levels of conservation protection which trigger certain fiscal incentives for the landowners/users.

  The key advantages of biodiversity stewardship are (DEA 2010b):

  - It provides a cost effective conservation mechanism for expanding protecting over important biodiversity areas without taking land out of agricultural production;
  - It contributes to national targets for protecting threatened ecosystems, maintaining the diversity and integrity of natural systems and landscapes, and the provision of vital ecosystem goods and services; and
  - It provides political, social, economic and environmental benefits.

- **Permitting**. Much of the Biodiversity Act revolves around the permitting of activities, whether in respect of threatened species and activities relating to them, aliens species, listed invasive species or bioprospecting. The Biodiversity Act sets out the procedural aspects of the application (as well as appeals against permitting decisions), including the requirement of an independent risk assessment where appropriate. The national Minister or other organs of state (at national, provincial and local levels) are all regarded as an 'issuing authority'. It would seem that only the Minister will be responsible for bioprospecting, while other permitting functions may be delegated to other organs of state.

5.4.2.2 Administration and implementation

The Biodiversity Act provided for the establishment of the South African National Biodiversity Institute (SANBI) and gives it a mandate in regards to the monitoring, advising and coordination of biodiversity issues in South Africa (DEAT 2005). The functions of SANBI include reporting on the status of South Africa's biodiversity, the dissemination of information concerning biodiversity and the coordination of programmes to include civil society in the conservation and sustainable use of biological resources. Biodiversity is also an important function of other national departments such as Department of Water Affairs, the Department of Agriculture, Forestry and Fisheries (DAFF) and a number of other institutions, public and private at national, provincial and local level.

The Inter-Departmental Liaison Committee on Freshwater Initiatives is a newly established committee currently including Department of Water Affairs, SANParks, SANBI and Department of Environmental Affairs. However, it can include any organ of state that has an interest in freshwater management. This committee was previously a Department of Water Affairs-SANParks liaison committee and was broadened to include SANBI and Department of Environmental Affairs.

5.4.3 National Environmental Management: Protected Areas Act

This Act (Act No. 57 of 2003) (RSA 2003a) aims to consolidate and rationalise all the protected areas legislation in South Africa. It provides for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; and for intergovernmental cooperation and public consultation in matters concerning protected areas.

All protected areas, other than those established in terms of the National Forestry Act, will be catered for in terms of this Act. There are four types of protected areas that may be declared:

- **Special Nature Reserves** which are declared to protect highly sensitive, outstanding ecosystems, species, geological or physiological features and which are to be made primarily available for scientific research or environmental monitoring.
- **National Parks** which are declared to protect areas of national or international significance, a viable representative sample of South Africa's natural systems or scenic areas, or the ecological integrity of one or more ecosystems. The purpose of declaring an area a National Park is to exclude exploitation or occupation that is inconsistent with such protection and to provide a foundation for spiritual, scientific, educational, recreational and tourism opportunities that are environmentally compatible.
- **Nature Reserve**s which are declared to supplement the system of National Parks in South Africa.
- **Protected Environment**s which are declared to provide a buffer zone from undesirable development adjacent to National Parks or Nature Reserves.

The Act furthermore provides for the continued existence, governance and functions of the South African National Parks (SANParks), and for intergovernmental cooperation and public consultation in matters concerning protected areas.

5.4.3.1 Policies, legislative tools and mechanisms

The Department of Environmental Affairs' Directorate of Biodiversity Conservation administers the Protected Areas Act (DEAT 2005). A register of protected areas has to be maintained that must contain a list of the entire system of protected areas, including those declared in terms of legislation other than the Protected Areas Act. The Minster is further empowered to prescribe norms and standards and indicators for the compliance or achievement of any of the objectives of the Act.

5.4.3.2 Administration and implementation

Department of Environmental Affairs, as the lead agent, provides for continued existence of SANParks and the National Parks Land Acquisition Fund and establishes management authorities for protected areas, which may include provinces, local authorities and communities. Provincial conservation agencies include:

- CapeNature (Western Cape);
- Eastern Cape Parks Board (ECPB);
- Ezemvelo KwaZulu-Natal Wildlife (EKZNW);
- Mpumalanga Tourism and Parks Agency (MTPA); and
- North West Parks and Tourism Board (NWPTB).

CapeNature and Ezemvelo KwaZulu-Natal Wildlife have a mandate to work throughout the province concerned, inside and outside protected areas while the other three have a mandate to work only within protected areas. Conservation agencies responsible for protected areas and the conservation of biodiversity outside of protected areas vary in institutional character and structure across the nine provinces (DEAT 2005).

It is emphasised that this Act must be read in conjunction with both the National Environmental Management Act and the National Environmental Management: Biodiversity Act, where the controls on the management and utilisation of species are established.

5.5 PLANNING SECTOR

5.5.1 Introduction

The concepts of 'harmonisation', 'coordination', 'integration' and 'alignment', although somewhat elusive, are often associated with the collective concept of intergovernmental development planning. However, they need to be understood within the context of the three 'distinctive, interdependent and interrelated' spheres of government (local, provincial and national), each of which has its own set of sector functions or departments (Oranje and van Huyssteen 2007).

The Reconstruction and Development Programme (RDP) aimed at having national government drive the reconstruction and transformation while provinces and municipalities would pay supporting, ancillary roles. The Development Facilitation Act (1995) put in place a set of normative guidelines to guide all planning and land development actions. It also provided for municipal strategic planning in the form of Land Development Objectives (LDOs).

The Reconstruction and Development Programme office closed in 1996 but the ideal of a ‘Developmental State’ remained. The new priorities became decentralised development planning and the policy imperative of ensuring collaboration, coordination and integration in and between the different spheres of government. This meant that local government was endowed with a new ‘developmental’ role and was to become the main planning arm of government (Oranje and van Huyssteen 2007).

The White Paper on Local Government (1998) establishes the basis for a system of local government which is focused on involving local citizens and communities in finding sustainable ways to meet their needs and improve the quality of their lives. This is done in the context of redressing the socio-economic inequities inherited from the apartheid era (RSA 1998c). It provides three approaches: (i) integrated development planning and budgeting; (ii) performance management; and (iii) working together with local citizens and partners. It emphasises the potential of integrated development planning as a mechanism for enabling prioritisation and integration in municipal planning processes, and strengthening links between the development and institutional planning processes (RSA 1998c).

5.5.2 Policies, legislative tools and mechanisms

5.5.2.1 National

- **The Medium-Term Strategic Framework (MTSF)** sets out government’s priorities to meet national development challenges over a period of five years (van Huyssteen 2009). It is a statement of intent which is elaborated on in the Medium-Term Expenditure Framework (MTEF), which sets out government’s associated resource allocation. The Medium-Term Strategic Framework and Medium-Term Expenditure Framework combined provide a framework of development objectives and funding commitments in term of which national and provincial line departments, provincial government and municipalities have to do their planning and budgeting (Oranje and van Huyssteen 2007). It is overseen by the Presidency (van Huyssteen 2009). The Medium-Term Strategic Framework for 2004-2009 did not contain any mention of the ‘biodiversity’ nor ‘environment’ (where it refers to the natural environment). While this is of some concern, Strategic Priority no. 9, namely “Sustainable resource management and use”, in the current Medium-Term Strategic Framework (2009-2014) does refer to South Africa’s vulnerability to “biodiversity loss and diminishing water resources”.

- **The National Spatial Development Perspective (NSDP)** provides a guiding framework for all forms of prioritisation, allocation of resources and implementation. It is overseen by the Presidency (van Huyssteen 2009). The 2006 National Spatial Development Perspective contains a sub-section on biodiversity. It refers to the National Spatial Biodiversity Assessment (NSBA) and notes the “increasing – and largely negative – impact” of human activities on ecosystems. It does not address freshwater ecosystems explicitly. However, it does say that “water-resource management and existing policy emphasis on water-resource protection, conservation, water-demand management and improved efficiency of use should be intensified”.

- **The National Planning Commission (NPC)** was established to improve government’s long-term planning efforts and to mobilise society around a common set of objectives and priorities to drive development over the longer term. The first planned output for the National Planning Commission is to draft a Vision 2025 document and a long-term strategic plan. The Vision 2025 document will be an articulation of the kind of society that all South Africans would want to see in about 15 years time. The long-term strategic plan would be the plan that would need to be followed to achieve the vision. The purpose behind formulating a vision and long-term strategic plan is to mobilise society around a commonly agreed set of long-term goals; to achieve greater coherence in government's work between departments and across spheres; to provide for more certainty and to improve the quality of decision making for all parts of government; and to provide a basis for trade-offs between competing objectives. The National Planning Commission would concern itself mainly with high-level national strategic planning, which would take into account and influence operational sector plans (RSA 2010).

5.5.2.2 Provincial

- **A Provincial Growth and Development Strategy (PGDS)** or **Framework (PGDF)** must take into account the priorities identified in the National Spatial Development Perspective and Medium-Term Strategic Framework (above). It must also get input from municipalities and subsequently guide their Integrated Development Plans (IDPs). The Provincial Growth and Development Strategy take a long-term strategic view and provides and implementation, monitoring and evaluation plan. It is required in terms of guidelines as set out by The Presidency and is overseen by the Office of the Premier (van Huyssteen 2009).

- **A Provincial Spatial Development Framework (PSDF) or Plan (PSDP)** assists in the preparation of the Provincial Growth and Development Strategy, provincial sector and departmental strategic plans. It illustrates the current situation in terms of urban and rural development, the space economy, the environment, etc. It also provides a spatial frame of reference for deliberating investment options and projects and provides a platform for coordinated investment in the province. The Provincial Spatial Development Framework or Provincial Spatial Development Plan is typically overseen by the Office of the Premier, the Department of Development Planning or the Department of Local Government and Housing (van Huyssteen 2009).

5.5.2.3 Municipal

- **Integrated Development Plans (IDPs).** The Municipal Systems Act (RSA 2000) requires all local authorities in all provinces to prepare Integrated Development Plans. As the Integrated Development Plan is a legal requirement, it supersedes all other plans that guide development at the local government level (RSA 2000). An Integrated Development Plan is a comprehensive five-year plan (revised annually) for an area that gives an overall framework for development. It aims to coordinate the work of local and other spheres of government as well as different sectors (e.g. health, environment, housing) in a coherent plan to improve the quality of life for all the people living in an area. It takes into account the existing conditions and problems and resources available for development. The plan considers economic and social development for the area as a whole. It sets a framework for how land should be used, what infrastructure and services are needed and how the environment should be protected (RSA 2000).

- **Spatial Development Framework (SDF)**. A Spatial Development Framework is a compulsory core component of an Integrated Development Plan, both of which must take into account the priorities identified in the Medium-Term Strategic Framework. The Spatial Development Framework must guide and inform land development and management by providing future spatial (land development) plans for a municipal area. It could also include specialist studies/reports for the municipal area, specifically in terms of physical infrastructure and project specific information. The Spatial Development Framework is typically overseen by the Development/Town/Forward Planning Unit (van Huyssteen 2009).

- **Land Use Management System (LUMS).** The National Land Use Management Bill requires each municipality to have a Land Use Management System. It should be provided for by the Spatial

Development Framework. Land Use Management Systems promote coordinated, harmonious and environmentally sustainable development.

5.5.3 Administration and implementation

The Department of Cooperative Governance and Traditional Affairs (formally the Department of Provincial and Local Government) derives its mandate from the Constitution (RSA 1996a). The main function of the department is to develop national policies and legislation that govern the operations of provincial and local government. The other function is to support provincial and local governments in fulfilling their duties and service delivery-related obligations (DCGTA 2009).

The key objectives of the department are centred on meaningful local development, credible service delivery through forging and enabling better vertical and horizontal relationships between the three spheres of government and all sectors. Beyond government, the department aims to find creative and innovative ways of mobilising communities, stakeholders and organs of civil society to become development partners with government in matters of governance and service delivery. In most local areas, there are many different agencies that contribute towards the development of the area, such as national and provincial government departments, parastatals such as Eskom and Spoornet, trade unions, community groups and private sector organisations. Local government seeks to provide leadership and coordinate the efforts of all those who have a role to play in achieving local economic development (DCGTA 2009).

5.6 MINING SECTOR

5.6.1 Introduction

Mining activities in South Africa are regulated by legislation from the mining, water and environmental sectors. The Mineral and Petroleum Resources Development Act of 2002 (MPRDA) notes that the principles set out in Section 2 of the National Environmental Management Act apply to all prospecting and mining operations (RSA 1998b; RSA 2002). This means that social, economic and environmental factors must be integrated into the planning and implementation. The National Environmental Management and the National Water Act stipulate that a party responsible for a mining operation has to take all reasonable measures to prevent pollution or degradation from taking place (RSA 1998a). According to the Mineral and Petroleum Resources Development Act, the holder of a mining right or permit is responsible for, and must make financial provision for, any environmental damage and pollution and the rehabilitation of the environment affected by mining to its natural state until a closure certificate has been issued (RSA 2008a).

The Mineral and Petroleum Resources Development Amendment Act of 2008 (MPRDAA) seeks to address some of the shortcomings of the 2002 Mineral and Petroleum Resources Development Act by making the Minister of Mining responsible for environmental matters in terms of the National Environmental Management Act. This in theory should alleviate some uncertainty with regard to who the responsible authority is in cases where both mining and environmental legislation apply. The transition from the Mineral and Petroleum Resources Development Act environmental authorisation system to the system of the National Environmental Management Act environmental authorisations is to take place within 18 months of the Mineral and Petroleum Resources Development Amendment Act coming to force (PMG 2008; RSA 2008b).

5.6.2 Policies, legislative tools and mechanisms

According to Section 5 of the Mineral and Petroleum Resources Development Amendment Act (RSA 2008b), no person may conduct a reconnaissance mission, prospect, remove, mine, explore and produce any mineral without having 1) an approved environmental authorisation in place and 2) the appropriate permission or permit in place as well as giving the landowner or lawful occupier of the land in question at least 21 days written notice (RSA 2002).

- **Environmental authorisations.** An environmental authorisation as granted by the Minister of Mineral Resources is a condition that needs to be in place prior to the issuing of a permit or the granting of a right in terms of the Mineral and Petroleum Resources Development Act (RSA 2008b). An environmental management programme must be requested where an Environmental Impact Assessment is necessary. This should contain baseline information on the affected environment, evaluate the impacts of the proposed activities and describe any necessary mitigation measures.

  The Minister of Mineral Resources may not grant an environmental authorisation unless he/she has taken into consideration any recommendations by the Regional Mining Development and Environmental Committee. In addition, anyone issued with an environmental authorisation is responsible for monitoring and auditing compliance with the requirements of the environmental management programme (RSA 2008a).

- **Mine closure.** The holder of any mining-related right remains responsible for any environmental liability until the Minister of Mineral Resources has ordered a closure certificate in terms of the Mineral and Petroleum Resources Development Act (RSA 2002). However, the holder may outsource the handling of environmental problems to another entity. No closure certificate may be issued unless the Chief Inspector and each government department in charge of any law that relates to any matter affecting the environment have confirmed in writing that all environmental issues have been adequately dealt with.

- **Water management and pollution control.** The provisions of the National Water Act apply to the water management and pollution control. An assessment of the water-related impacts must form part of the environmental impact assessment report and the environmental management programme (DME 2004). All water use associated with mining operations has to be authorised by Department of Water Affairs. This means that mining operations can only start once both Department of Mineral Resources and Department of Water Affairs have issued the relevant authorisations (Godfrey et al. 2007).

  Residue stockpiles and residue dumps as defined in the Mineral and Petroleum Resources Development Amendment Act are considered to be waste under the National Water Act because of the potential they have of polluting water resources (Godfrey et al. 2007). The National Water Act requires reasonable measures to prevent any such pollution. The relevant Catchment Management Agency is the responsible authority.

5.6.3 Administration and implementation

The Department of Mineral Resources is the custodian of the country's mineral resources and is therefore responsible for ensuring the sustainable development of these resources within a framework of national environmental policy, norms and standards, while at the same time promoting economic and social development (Godfrey et al. 2007). The Mineral Regulation Branch of the Department is responsible for regulating the mining and minerals industry to achieve transformation and contribute to sustainable development.

5.7 LAND AND DEVELOPMENT SECTOR

5.7.1 Introduction

The White Paper on Land Policy notes that it is the responsibility of the national government to ensure a more equitable distribution of land, to support the work of the Commission on Restitution of Land Rights and to implement a programme of land tenure and land administration reform (RSA 1997). It also recognises that any programme which reduces poverty, diversifies income, and allows people more control over their lives and their environment should reduce the risk of land degradation. The worst environmental health conditions and natural resource degradation occur around informal settlements, where people have few assets and minimal control over their surroundings. One of the challenges of land reform is to relieve land pressure without extending environmental degradation over a wider area.

The White paper on Spatial Planning and Land-use management recognises that land is an asset, a scarce and fragile natural resource. Its broad objective is to facilitate allocation of land to the uses that provide the greatest sustainable benefits and to promote the transition to a sustainable and integrated management of land resources. It states that conventional land-use planning has frequently failed to produce a substantial improvement in land management or to satisfy the priority objectives of land users. It also contains practical ways in which South Africa may move towards an improved approach for integrated planning for sustainable management of land resources (RSA 2001).

5.7.2 Policies, legislative tools and mechanisms

A long list of legislation guides the Department of Rural Development and Land Reform. These include:

- **The Restitution of Land Rights Act, 1994 (Act 22 of 1994)**, which provides for the restitution of land or the award of equitable redress to persons or communities dispossessed of land as a result of past racially discriminatory laws or practices (RSA 1994);

- **The Restitution of Land Rights Amendment Act, 2003 (Act 48 of 2003)**, which empowers the Minister of Rural Development and Land Reform to purchase, acquire in any other manner or expropriate land or rights in land for the purpose of restitution awards or for any related land reform purpose (RSA 2003b);

- **The Land Reform: Provision of Land and Assistance Act, 1993 (Act 126 of 1993)**, which aims to redress the imbalanced land allocation of the past by providing land and financial assistance to historically disadvantaged persons and communities (RSA 1993a);

- **The Distribution and Transfer of Certain State Land Act, 1993 (Act 119 of 1993)** provides for the distribution and transfer of State land to persons or descendants of persons who were removed from such land and had prior to 27 April 1994 submitted applications to the then Advisory Commission on Land Allocation and the said Commission had confirmed their possible entitlement to such land. It empowers the Minister of Rural Development and Land Reform to designate such land to be dealt with in terms of the Act and also appoint a Land Distribution Commissioner to investigate and make awards to such persons who are found to have legitimate claims to such land (RSA 1993b);

- **The Communal Property Associations Act, 1996 (Act 28 of 1996)**, which provides for the establishment of legal entities enabling communities to acquire, hold and manage land on an agreed basis in terms of a constitution (RSA 1996b) ;

- **The Communal Land Rights Act, 2004 (Act 11 of 2004)**, which provides for secure land tenure rights to persons and communities who occupy and use communal land as defined in that Act (RSA 2004c);

- **The Land-use Management Bill (2004)** which seeks to provide for a uniform, effective and efficient regulatory framework for land use and land-use management in the public interest; to establish directive principles and compulsory norms and standards for land-use management; to provide for land-use schemes; to establish Land Use Regulators in all spheres of government; to provide for a National Land Use Commission; and to repeal certain laws considered inappropriate for the desired land use and management dispensation (RSA 2004d).

The department has specific mechanisms for realising land development objectives. These are incorporated in integrated development plans for a specific area. They are also reflected in spatial development frameworks created to facilitate rural transformation.

5.7.3 Administration and implementation

The Department of Rural Development and Land Reform aims to effectively lead in the creation and maintenance of vibrant, equitable and sustainable rural communities through, inter alia, an effective and sustainable land dispensation which results in social and economic development for all South Africans. The main focus of the department and its core contribution to the transformation of society in South Africa is a rural development intervention that uses land and agricultural development as a solid foundation for food security and self-sufficiency. Its mandate is to provide enhanced land rights to all South Africans, with particular emphasis on black people, that would result in increased income levels and job opportunities, productive land use and well-planned human settlements. This is to be achieved through the design and implementation of a sustainable land and tenure reform programme (DRDLR 2009).

5.8 AGRICULTURAL SECTOR

5.8.1 Introduction

The Conservation of Agricultural Resources Act (CARA) (1983) is the core legislation. At present all national acts with relevance to agriculture are being re-written by the National Department of Agriculture (BFAP 2010). The Conservation of Agricultural Resources Act provides for control over the utilisation of natural agricultural resources in order to promote the production potential of the land, conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants. The Conservation of Agricultural Resources Act applies to all land except mountain catchment areas (see Section 5.3.3.2) and provides for the conservation of these resources by maintaining the land’s production potential, combating and preventing erosion, protecting vegetation and combating weeds and invaders. Regulation 7 of the Conservation of Agricultural Resources Act deals specifically with the utilisation and protection of vleis, marshes, water sponges and watercourses.

5.8.2 Policies, legislative tools and mechanisms

A number of related documents are also of relevance, including the following:

- **The National Land Care Programme (1997)**. This is a community-based and government-led initiative aimed at improving the ability of land users and communal farmers to manage their natural resources in a sustainable and self-reliant manner. This programme offers provincial support, technical assistance and education awareness programmes to community groups. The groups are expected to identify, implement and monitor management and conservation activities necessary to deal with land degradation problems while improving their livelihoods (Roux et al. 2006).

- **The Discussion Document on Agricultural Policy in South Africa (1998)**. This outlines broad principles that govern policy on the agricultural use of natural resources. It emphasises the government's responsibility in promoting the sustainable use of natural resources in agriculture and enhancing the ecological integrity of natural systems, while simultaneously minimising or avoiding risks that will lead to irreversible damage (Roux et al. 2006).

- **The Strategic Plan for South African Agriculture (2001)**. This reflects the government's commitment to the realisation of the sustainable use of agricultural natural resources. Sustainable resource management aims to improve the capacity of farmers to use resources in a sustainable way and to ensure the wise use and management of natural resources. The plan has a particular focus on preserving agricultural biodiversity and on promoting the sustainable use of soil and water through the enhancement of crop and livestock productivity and more sustainable farming systems (Roux et al. 2006).

- **The Draft Sustainable Utilisation of Agricultural Resources Bill (2003)**. This provides for the development of various incentive programmes and prescribes standards, control measures and law enforcement aimed at assisting farmers and natural agricultural resource users to promote conservation practices that improve the quality of the soil, water and agro-ecosystems in their utilisation process. When it has been approved, the Sustainable Utilisation of Agricultural Resources Bill will replace the Conservation of Agricultural Resources Act (Roux et al. 2006).

Additional legislative tools are control measures, schemes and trusts.

5.8.3 Administration and implementation

The Department of Agriculture, Forestry and Fisheries (DAFF), among other aims, must also enhance the sustainable development of natural agricultural resources and ecological systems and ensure efficient and effective governance and knowledge and information management (DAFF 2010). The Conservation of Agricultural Resources Act makes provision for the formation of conservation committees in any area determined by the Minister. These are tasked with promoting the conservation of the natural agricultural resources in a specific area and advising the department on any matter related to the act. Provision is also made for the establishment of regional conservation committees. Under the Draft Sustainable Utilisation of Agricultural Resources Bill (2003) land care committees may be established (RSA 2003c).

5.9 ARTS AND CULTURE SECTOR

5.9.1 Introduction

The National Heritage Resources Act (RSA 1999) aims to promote effective management of the national estate and to enable and encourage communities to nurture and conserve their legacy for the benefit of future generations. The key provisions and objectives are the management and conservation as well as governance of national heritage and cultural resources by means of an integrated and interactive system. The legislation also aims to empower civil society to nurture and conserve their heritage resources for the benefit of future generations. Another aim is to empower provinces to establish heritage authorities to protect and manage specific categories of heritage resources, and to provide for the protection and management of conservation-worthy areas by local authorities. Heritage resources include landscapes and natural features of cultural significance and geological sites of scientific or cultural importance.

The National Heritage Resources Act will typically choose areas for protection based on their cultural priorities. If these areas happen to overlap with, affect, or be affected by, FEPAs, then the respective management authorities will need to know of the other's responsibilities and cooperate accordingly.

5.9.2 Policies, legislative tools and mechanisms

Legislative tools and mechanisms under the National Heritage Resources Act (RSA 1999) include the national estate, national and provincial heritage areas, protected areas, heritage objects and heritage agreements.

- **National estate.** This (according to Section 3 of the National Heritage Resources Act) refers to those heritage resources in South Africa that are of cultural significance or other special value for the present population and future generations. The national estate may include landscapes and natural features of cultural significance (RSA 1999).

- **Heritage area.** This is a place of environmental or cultural interest that needs to be protected by a planning authority at the time of revision of a town or regional planning scheme if this is considered important. Where a provincial heritage resources authority feels that it is necessary to protect a place of environmental or cultural interest as a heritage area, it may request a planning authority to investigate its designation in accordance with its proposals. A local authority can also designate any area of land to be a heritage area on the basis of its environmental or cultural interest, but needs to consult the provincial heritage resources authority when doing so. A local authority is obliged to provide for the protection of a heritage area through the provision of its planning scheme or by-laws (RSA 1999).

- **Protected area.** This is an area of land surrounding a national heritage site that should be protected in order to ensure the protection and reasonable enjoyment of the site (RSA 1999).

- **Heritage agreements.** This refers to an agreement entered into by the South African National Heritage Resources Agency (SAHRA) or a provincial heritage resources authority to provide for the conservation, improvement or presentation of a clearly defined heritage resource (RSA 1999).

- **Heritage resources management.** Section 38 of the National Heritage Resources Act states that any person who intends to undertake developments as categorised under this section, must notify the responsible heritage resources authority and furnish it with details about the location, nature and extent of the proposed development. If the heritage resources authority believes that heritage resources will be affected by such development, it can notify the person who intends to undertake the development to submit an impact assessment report. Such a report must identify and map out all heritage resources in the area affected, assess the significance of such resources, assess the impact of the development on the heritage resources, propose alternatives if heritage resources will be adversely affected by the proposed development and plan for mitigation of any adverse effects during and after the completion of the proposed development (RSA 1999).

5.9.3 Administration and implementation

The Department of Arts and Culture is the responsible national authority. A three tier system exists in terms of heritage resource management: The national level functions are the responsibility of the South African Heritage Resources Agency (SAHRA). Provincial level functions are the responsibility of provincial heritage resource authorities. Local authorities are in charge of local level functions (RSA 1999).

SECTION 6: SCIENTIFIC PAPERS

This section summarises the published scientific papers funded or co-funded by this project, as well as those in review or in preparation for various peer-reviewed journals.

6.1 PROTECTED AREA EXPANSION

Publication: Biological Conservation. 142 (2009), 1605-1616.

Relevance to FEPA: This paper outlines published criteria to be used for identifying priority areas for freshwater ecosystems and provides a framework for optimising the achievement of these multiple criteria.

Title: Expanding protected areas beyond their terrestrial comfort zone: Identifying spatial options for river conservation

Authors: JL Nel, B Reyers, DJ Roux, RM Cowling

Abstract: There has been very little consideration of freshwater ecosystems in identifying and designing protected areas. Recent studies suggest that protected areas hold enormous potential to conserve freshwater biodiversity if augmented with appropriate planning and management strategies. Recognising this need, South Africa's relevant government authority commissioned a spatial assessment to inform their national protected area expansion strategy. This study presents the freshwater component of the spatial assessment, aimed at identifying focus areas for expanding the national protected area system for the benefit of river biodiversity. Conservation objectives to guide the assessment aimed to improve representation of river biodiversity pattern and processes in both new and existing protected areas. Data to address these objectives were collated in a Geographic Information System (GIS) and a biodiversity planning algorithm was used as a means of integrating the multiple objectives in a spatially efficient manner. Representation of biodiversity pattern was based on achieving biodiversity targets for 222 river types and 47 freshwater fish endemic to South Africa. Options were also identified for representing coarse-scale biodiversity processes associated with free-flowing rivers and catchment-estuarine linkages. River reaches that, with only minor expansion of existing protected area boundaries, could be fully incorporated into the national protected area system were also identified. Based on this study, generic recommendations are made on how to locate, design and manage protected areas for river biodiversity: use appropriate planning units, incorporate both biodiversity pattern and process, improve planning and management of individual protected areas, incorporate a mixture of protection strategies, and embed planning into an ongoing research and implementation process.

6.2 ENVIRONMENTAL FLOW AND FRESHWATER CONSERVATION PLANNING

Publication: Marine and freshwater research. 62 (2011), 290-299.

Relevance to FEPA: This paper provides some conceptual ideas for integrating approaches to biodiversity planning with tools used for water resource management, such as Department of Water Affairs' proposed Water Resources Classification System.

Title: Integration of environmental flow assessment and freshwater conservation planning: a new era in catchment management

Authors: JL Nel, EE Turak, S Linke, C Brown

Abstract: Integrated river basin management embraces sustainable development of water resources at a basin level and offers an ideal platform for addressing the goals of freshwater conservation and climate change adaptation. The fields of environmental flow assessment and systematic conservation planning have evolved separately in respective water and terrestrial realms, but are complementary to freshwater conservation and can be used to inform integrated river basin management. Aligning these two fields is mutually beneficial: conservation plans provide a systematic approach to devising conservation scenarios; environmental flow assessment offers approaches for incorporating the dynamics of the natural flow regime into freshwater conservation planning as well as methods for considering social and economic costs of conservation; and the scenario-planning approach of environmental flow assessment offers opportunities for examining consequences of different development scenarios and the likely impacts of climate change on achievement of freshwater conservation goals. Integration can already be accomplished by using freshwater conservation planning outputs to develop conservation scenarios for assessment against other development scenarios, and by assessing the extent to which each development scenario achieves biodiversity targets. New tools that maximise complementarity by achieving conservation and flow targets simultaneously should also be explored.

6.3 CALCULATING LANDFORMS AT A COUNTRY-WIDE SCALE

Publication: Landscape Planning (in review)

Relevance to FEPA: This paper outlines the approach used to determine land forms for South Africa and the many applications for this strategic national data layer, amongst which is its use in classifying wetlands at a desktop level.

Title: Calculating landforms at a country-wide scale

Authors: H van Deventer, JL Nel, A Maherry and N Mbona

Abstract: Landforms describe the topography of a land surface within the context in which it occurs, identifying a range of landform classes (e.g. valley floors, slopes and hill tops). The automation of country-wide landform data sets remain a challenge. Such data sets potentially assist in a variety of applications across different sectors, providing a broad classification of landscape settings within which policy formulation and national reporting can take place. Despite the availability of relatively high resolution digital elevation data for the world and even though computer processing and Geographical Information Systems (GIS) have enabled increased processing of large areas and automation of Digital Elevation Model (DEM) derivatives, there are still a number of challenges in the calculation of country-wide landform data sets. This article

presents the approach, method and steps taken to calculate a country-wide data set of landforms, using the Landform Tool as part of the Topography Tools for ArcGIS 9.3 suite. The Landform Tool primarily uses standard deviation from the average elevation, using both small and large neighbourhood distances. Here, we provide an approach for selecting neighbourhood distances across vast areas. The results were compared to 260 random points that were classified manually using Google Earth imagery and topographical maps, showing a 60% accuracy within 50 m of the right landform class. The Landform Tool by default tended to overestimate benches and valleys, and underestimate slopes. Although the Landform Tool provides an automated means of generating landforms, the use of a standard deviation from the average elevation indices was found to be inappropriate in a topographical diverse landscape, such as South Africa.

6.4 DERIVING SUB-QUATERNARY CATCHMENTS FOR SOUTH AFRICA

Publication: In preparation for submission to Water SA

Relevance to FEPA: This paper takes a critical examination of the utility of different Digital Elevation and River Network layers for mapping sub-quaternary catchments. Outcomes of this analysis were used to guide the approach used to delineate the sub-quaternary catchments that will be used as NFEPA's planning units. The new WRC project for identifying a nationally endorsed layer of quinary catchments will also build on this analysis.

Title: Testing the effectiveness of various DEMs in deriving sub-quaternary catchments in South Africa

Authors: D Hardwick, H van Deventer, LB Smith-Adao, G McFerren, JL Nel and A Maherry

Catchment delineation has improved with enhancements in GIS processing and delineation algorithms. Furthermore, global, satellite-derived Digital Elevation Models (DEMs) have become freely available and increasingly accessible. As these products are released with varying levels of accuracy and at different pixel resolutions, it is important to assess the impacts of using one DEM over another for catchment delineation. The aim of this paper is to recommend a scientifically defensible and repeatable approach for delineating sub-quaternary catchments for South Africa. We compared catchments delineated from different DEMs; compared the efficiency of stream carving techniques and determined appropriate thresholds for calculating level five to six sub-catchments. We found that the ASTER DEM created sub-quaternary catchments which mostly suited our evaluation criteria; that stream carving was recommended; that DEM edges produced the most variable results and that exterior basin threshold, study area size and quaternary catchment size influenced the production of five to six-level sub-quaternary catchments.

6.5 SYSTEMATIC BIODIVERSITY PLANNIGN FOR FRESHWATER ECOSYSTEMS

Publication: Freshwater Biology, 56 (2011), 6-20.

Relevance to FEPA: This paper makes a case for the use of systematic biodiversity planning approaches in identifying priority areas for high ecosystem protection, rather than the scoring approaches that are most commonly used in water resource management.

Title: Freshwater conservation planning: The case for systematic approaches

Authors: S Linke, E Turak and J Nel

Summary:

1. We review recent advances in systematic conservation planning in fresh waters. Most modern systematic planning approaches are based on the CARE principles: comprehensiveness, adequacy, representativeness and efficiency. Efficiency is usually provided by a complementarity-based strategy, aiming to select new conservation areas in the light of previously protected features. These strategies have to be modified to account for the connected nature of rivers.

2. Choice of surrogates for conservation features depends on the scale of the assessment, as well as the available expertise and resources. Ideally, real information about taxa or processes – extrapolated by models – ensures that target features are protected. Where this is not feasible, it is critical that the choice of environmental surrogates is informed by target biota or processes.

3. Setting adequacy targets – the most challenging aspect in planning – needs to be evaluated in a freshwater-specific context, as species–area relationships and the distribution of diversity differ in dendritic networks. Adequately designed conservation plans also need to consider upstream land use and catchment disturbances. Recent studies have largely addressed longitudinal connectivity either by setting rules to protect adjacent sub catchments (or even the entire catchment upstream), or by considering the magnitude of disturbance upstream of selected planning units. Very few studies have addressed lateral and vertical connectivity in a systematic way.

4. To implement freshwater conservation plans, we recommend adopting a recently proposed hierarchical protection strategy, from ‘freshwater focal areas’ that contain the actual features to be protected to mixed-use ‘catchment management zones’. Stakeholder involvement is crucial, especially in the large multi-use areas upstream and in the surrounding catchment.

5. We conclude that conservation planning using CARE principles is the only efficient way forward. This special issue shows significant efforts are under way to adapt freshwater-specific adequacy, connectivity and implementation issues in conservation planning. However, a more holistic research investment is required to link freshwater, terrestrial and marine ecosystems.

6.6 PROMOTING UPTAKE AND USE OF CONSERVATION SCIENCE IN SOUTH AFRICA

Publication: WaterSA (in review).

Title: Promoting uptake and use of conservation science in South Africa.

Authors: N Funke and S Nienaber

Relevance to FEPA: The paper sets the scene by describing the complicated and challenging nature of the policy and decision making context in South Africa in general terms, and relating this to the water, environmental and planning sectors. It identifies key challenges related to this environment, and makes some context-specific recommendations with regards to promoting uptake of the NFEPA products.

Abstract: This paper aims to analyse how to encourage science uptake and use in a South African context. While science uptake into implementation is a very case and context specific process, the authors propose that a general framework for analysis of the policy-making context in South Africa needs to be considered when analysing how to promote the use of science in specific cases. In this paper, the National Fresh Water Ecosystem Priorities Areas (NFEPA) Project is used as an example to illustrate how to apply this framework and how science projects in South Africa can be better positioned for impact and use. The paper starts by introducing the framework for conceptualising the complex set of dynamic processes and actors that can be involved in science uptake in South Africa i.e. the policy-making context. From this theoretical platform the authors analyse to what extent the NFEPA project will be able to support more effective implementation of existing environmental and water legislation. This is done by exploring the challenges that hinder the uptake of science in government departments and then offering recommendations on how to address these with a view to improving the uptake and use of science products in general.

6.7 ABSORPTIVE CAPACITY

Publication: Environmental Management (2011) 47:917–925

Relevance to FEPA: This paper explores the literature relating to absorptive capacity in a commercial context and distils lessons that can help institutionalise the FEPA products in South Africa.

Title: Absorptive capacity as a guiding concept for effective public sector management and conservation of freshwater ecosystems

Authors: K Murray, D Roux, J Nel, A Driver, W Freimund

Abstract: The ability of an organisation to recognise the value of new external information, acquire it, assimilate it, transform, and exploit it, namely its absorptive capacity (AC), has been much researched in the context of commercial organisations and even applied to national innovation. This paper considers four key AC-related concepts and their relevance to public sector organisations with mandates to manage and conserve freshwater ecosystems for the common good. The concepts are the importance of in-house prior related knowledge, the importance of informal knowledge transfer, the need for motivation and intensity of effort, and the importance of gatekeepers. These concepts are used to synthesise guidance for a way forward in respect of such freshwater management and conservation, using the imminent release of a specific scientific conservation planning and management tool in South Africa as a case study. The tool comprises a comprehensive series of maps that depict national freshwater ecosystem priority areas for

South Africa. Insights for implementing agencies relate to maintaining an internal science, rather than research, capacity; making unpublished and especially tacit knowledge available through informal knowledge transfer; not underestimating the importance of intensity of effort required to create AC, driven by focussed motivation; and the potential use of a gatekeeper at national level (external to the implementing organisations), possibly playing a more general 'bridging' role, and multiple internal (organisational) gatekeepers playing the more limited role of 'knowledge translators'. The role of AC as a unifying framework is also proposed.

6.8 REFLECTIVE COASSESSMENT FOR PROMOTING COOPERATION

Publication: Ecology & Society (in press)

Relevance to FEPA: The identification and effective management of FEPAs require cooperation across disciplinary, organisational and sectoral boundaries. This paper proposes a scorecard-based approach to social learning to promote cooperation between agencies with shared mandates for freshwater management and conservation.

Title: From scorecard to social learning: A reflective co-assessment approach for promoting multiagency cooperation in natural resource management

Authors: DJ Roux, K Murray, JL Nel, L Hill, H Roux and A Driver

Abstract: The responsibility for managing and conserving freshwater ecosystems is typically shared by multiple organisations with sometimes conflicting policy mandates. However, scorecard-based approaches for measuring management effectiveness in natural resource management are usually confined to single organisations. This paper describes a social learning approach which acknowledges cooperation as an essential precondition for effective management and that encourages reflective co-assessment of cooperative relationships. The approach was pilot tested with eight participating organisations in one Water Management Area in South Africa. It specifically aimed to allow for a multi-agency reflective assessment of issues determining cooperative behaviour, allow context-specific adaptations, and be embedded in adaptive management. It involved development of a spreadsheet-based scorecard-type tool that can be used to facilitate a multi-agency workshop. This workshop serves to bring parties face-to-face and helps them co-discover their interdependence, shortcomings and strengths. The spreadsheet structures reflection on their respective roles and effectiveness while the reflective co-assessment motivates participants to address shortcomings. Overall, insights that emerged included: Cooperation should be an explicit component of each organisation's operational strategy; facilitation of appropriate cooperative behaviour could be very effectively achieved by external 'bridging organisations'; the reflective assessment process must be followed by purposefully adaptive interventions; the ability of the scorecard to be contextually adaptive was important; and institutional readiness requires investigation as the approach does fall somewhat uncomfortably with much current practice.

6.9 HISTORY OF FRESHWATER CONSERVATION PLANNING IN SOUTH AFRICA

Publication: Water SA (in preparation)

Relevance to FEPA: A systematic planning approach for freshwater conservation has developed rapidly since the early 2000s. South Africa has played a leading role in establishing this new branch of conventional conservation planning with its terrestrial bias. This paper explores the relation between systematic freshwater conservation planning and earlier approaches and suggests how the new scientific advances can serve society at large through effective implementation.

Title: Trends in freshwater conservation planning: A South African perspective

Authors: DJ Roux and JL Nel

Abstract: South Africa's chronology of freshwater conservation planning mimics trends in the rest of the world, evolving from ad hoc approaches where freshwater features were incidentally conserved as a result of terrestrial conservation action, to attempts to be more strategic in the allocation of limited conservation resources. The first strategic attempts were based largely on identifying lists of sites that freshwater scientists knew were of conservation importance. This approach was further advanced by developing scoring systems for comparing the relative importance of different sites. Scoring approaches used expert opinion and available data to rate sites according to a suite of attributes for diversity, naturalness, representativeness, rarity, species richness and special features. Problems exist with using scoring approaches to prioritise conservation action. Choosing high scoring sites over low scoring ones without explicitly considering how the sites complement or duplicate each other in their biodiversity content has a tendency to undermine representation even if representativeness is a criterion that is scored and heavily weighted. Systematic conservation planning addresses these problems through setting explicit biodiversity targets for representing biodiversity, and achieving these targets in an efficient manner by employing the concept of complementarity. Complementarity of a site is calculated as the contribution it makes to biodiversity targets not yet achieved in the existing set of conservation areas. This value is a relative measure that needs to be recalculated each time a new site is added to the conservation area network. In this paper we present the technical advances associated with freshwater conservation planning of the 2000s in South Africa. Integral to the latest approach is a strong focus on the implementation of conservation plans. We highlight a number of case studies to demonstrate how designing for representation of biodiversity and designing for implementation are complementary activities.

SECTION 7: DATA LIMITATIONS AND FUTURE RESEARCH NEEDS

This section acknowledges the data limitations that affect the confidence we have in the data. From these, we identify research needs that will help advance the field of freshwater biodiversity planning as well as contribute to improving future refinements of FEPA maps.

Biodiversity planning is a pragmatic science that relies on making assumptions based on best available science. The notion is to advance implementation and promote improved management and conservation of ecosystems in a 'learn by doing' manner. Where there are gaps in available science, 'bold' assumptions can be made using scientific expertise. Indeed, the NFEPA project used over 1000 person years of collective expertise to reach consensus on major assumptions that were made during the planning process. This is necessary to develop scientific products that are immediately useful for decision makers. However, to improve future products, science should be strategically directed towards addressing data limitations, with research investments aimed at filling these gaps in our knowledge. This section covers some of the key data limitations to identifying FEPAs and recommends some immediate research priorities towards addressing these limitations.

Sub-quaternary catchments: A standardised quaternary catchment GIS layer with a unique quaternary catchment naming convention (Midgley et al. 1994) has been endorsed by the Department of Water Affairs since 1994. This has resulted in the collation of considerable data within these units to assist in water resources assessment and planning. However, quaternary catchments are relatively large units within many of which the landscape, climate and stream network are highly heterogeneous. It is therefore inaccurate to interpolate quaternary catchment data to smaller regions or streams within the quaternary. This is problematic for studies that require finer levels of resolution, such as freshwater biodiversity planning and climate change modelling. NFEPA sub-quaternary catchments represent a pre-cursor to developing river network quinary catchments. Precursors to 'altitudinal' quinary catchments have also been developed for climate change modelling (WRC K5/1843). However, both these GIS layers need to undergo rigorous refinement processes so that they can be endorsed by the Department of Water Affairs and used as national GIS layers for collation of compatible data across the country. A constraint with the existing NFEPA sub-quaternary GIS layer is that it does not accommodate dams or land use changes within the sub-quaternary catchment – these drive changes in river condition and thus the river condition within the sub-quaternary catchment may be variable. For example, a dam in the foothills of a sub-quaternary catchment may have the effect of changing the condition of a natural mountain stream to modified in the lower reaches within the sub-quaternary. This may be problematic for water resource planning in some instances. Connecting reliable daily hydrological data (field observations and modelled) to each sub-quaternary catchment is also crucial for integrating FEPAs into processes that examine social, ecological and economic trade-offs, such as the water resources classification system (Dollar et al. 2010).

River network: The NFEPA project made use of the 1:500 000 river network as it is the one which is used by the Department of Water Affairs for water resource planning and decision-making processes. A finer network river network layer for biodiversity planning and land-use planning is preferable, as this would pin-point smaller stream networks and habitats within the sub-quaternary catchments that need to be managed and conserved. A 1:50 000 river network GIS layer exists but this has no hydrological orders and no river-tree network. Preparing this as an option to use instead of the 1:500 000 river GIS layer may be useful to future refinements of the FEPA maps.

River ecosystem types: The river ecosystem types used in the NFEPA project were based on the combination of existing data. These river ecosystem types could be improved by either: (1) focussing on improving the underpinning GIS layers used to derive ecosystem types; or (2) exploring new scientific approaches that have been developed for ecosystem classification. The first approach would aim to refine and test spatial predictions for ecoregions (Kleynhans et al. 2005), flow variability (DLA:CDSM 2005-7) and geomorphic zonation (Rowntree and Wadeson 1999). For example, ecoregion boundaries (especially Level 2 ecoregions) could be refined using a more recent vegetation map of South Africa, Lesotho and Swaziland (Mucina and Rutherford 2006); flow variability could be defined through developing hydrological indices for sub-quaternary catchments similar to those for quaternary catchments (Hannart and Hughes 2003); and geomorphic zones could be consolidated (at the moment there are GIS slivers in the layer) and verified. The second approach to improving the river ecosystem types GIS layer involves exploring new technologies such as those of generalised dissimilarity modelling (GDM) which can be used to classify ecosystems across large regions using biological data to partition biophysical GIS data layers (Ferrier et al. 2002). This approach has recently been applied to classify river ecosystem types in New Zealand (Snelder et al. 2007). It has the advantage of explicitly combining biophysical data layers (e.g. climate, vegetation, soils, water chemistry) with species distribution patterns and compositional turnover, which is appealing for use in freshwater biodiversity planning.

River condition: The Department of Water Affairs has developed several pragmatic approaches to estimating river condition across large regions in South Africa, the most common are the Present Ecological Status category (Kleynhans 2000; **Table 3.3**) and Ecostatus determination (Kleynhans et al. 2005). These approaches bring together groups of regional river health experts to evaluate drivers of change that affect river condition, using data where it exists. Expert scores are then combined to produce an overall assessment of the condition of the river, based on the extent it has changed from its natural state. This information was used and updated where necessary, to estimate condition of quaternary mainstem rivers. For the tributaries of the 1:500 000 that are nested within quaternary catchments, NFEPA used existing data where possible, and filled the data gaps using estimates modelled from land cover (Section 3.4.4). While all these data provide the best available science on river condition, the ideal still remains to test these through stratified River Health Programme sampling. Expert-derived data also cannot be used for monitoring purposes because they are not quantitative measures and changes may therefore be based on a change in the understanding or knowledge of experts. It is crucial for monitoring to use quantitative and objective techniques for assessing river condition. Further collation of river condition data is required – there were many problems with access to existing River Health Data (see Section 3.4.4). This should be a number one priority to get right for future assessments. The potential of using dynamic modelling of land use combined with flow models should also be investigated (Stein et al. 2002).

Free-flowing rivers: Identification of free-flowing rivers relied on the use of a dams GIS layer for 2007. There are gaps in this data, and new dams have been built since 2007. In addition, differences in spatial accuracy between the river network GIS layer and the dams GIS layer led to several inaccurate predictions of free-flowing rivers. River condition was used as a surrogate of flow modification – rivers that have been subject to moderate to heavy use are unlikely to have natural flow regimes. As discussed above, the predictions of river condition are estimated, and thus use of river condition here brings further inaccuracies. A further problem is that a GIS layer for the location of weirs, and therefore identification of free-flowing rivers did not include weirs. Weirs represent further barriers and in some instances can be as damaging as instream dams to movement of biota and sediment. All these problems resulted in several inaccuracies in the identification of free-flowing rivers, which were minimised by rigorous review in the regional review workshops. The final list of free-flowing rivers is a consensus list based on much discussion with river experts across the country. Future improvements of this GIS layer include: developing and maintain reliable GIS data layers and databases for dams and weirs across the country; and examining different categories of free-flowing rivers.

Wetland locality mapping: Wetlands were mapped using a combination of remotely sensed data and existing mapped localities (Section 3.4.6). There are still numerous gaps in these data, particularly in the areas that relied solely on remote sensing. The minimum mapping unit for a wetland using remote sensing is 0.02 ha, and smaller wetlands (such as seeps), or thin longitudinal wetlands (such as valley bottoms) smaller than this tend not to get detected. Remote sensing also detects wetlands better in some landscape than others – for example, wetlands in forested areas or areas invaded by alien trees are not easily detected. Improved remote sensing techniques for wetlands exist since 2000 and these should be explored. Finer resolution seems not to be as important a factor for detection compared to sourcing seasonal images from the same area (Mark Thomson, *pers. comm.*). More importantly, there should be a concerted effort to roll out the mapping of wetlands at a provincial level (the effort should be nationally coordinated). SANBI's wetland inventory programme is ideally positioned to be a national coordinator, but this will require long term commitment of funds for both national coordination, and provincial roll out.

Wetland ecosystem types: NFEPA wetland ecosystem types use the national wetland classification system (SANBI 2010) to perform a desktop classification of wetlands. This desktop classification is a good step towards classifying wetlands across the country, but still needs to be considerably refined. Wetland vegetation groups, derived by expert grouping of the vegetation types of South Africa, Lesotho and Swaziland (Mucina and Rutherford 2006), should be refined using more scientific methods, e.g. grouping of wetlands according to plant community analyses. Landform types, used to classify the hydrogeomorphic unit of a wetland, was assessed in the field and found to be only 50-60% accurate – future improvements should strive for better accuracy in this regard. The utility of the national wetland classification system (SANBI 2010) needs to be tested in the field, as this is a recently defined framework. In addition, exploring novel methods for wetland ecosystem classification need to be explored – such as the use of generalised dissimilarity modelling, which combines biophysical data layers (e.g. climate, vegetation, soils, water chemistry) with species distribution patterns and compositional turnover.

Wetland condition: The GIS layer of wetland condition provides an estimate of the likely condition of a wetland given the surrounding land cover and river condition. The accuracy of the model has not been tested. Research exploring the effectiveness of indices for estimating wetland condition at a landscape level should be explored to advance wetland research beyond the site-by-site assessment approach.

Wetland clusters: A scientifically defensible distance for migration between wetlands should be tested using a variety of taxa (e.g. insects, wetland-dependent birds, frogs) and other ecological processes (e.g. wetland plant pollination processes). The uniform distance of 1 km used in delineating wetland clusters for NFEPA may also need to be different, depending on the region and its associated biota, and ecological and biophysical processes.

Species data: NFEPA supplemented river and wetland ecosystem types with species data for threatened fish species, threatened wetland-dependent bird species and threatened wetland-dependent frog species. The inclusion of river and wetland macro-invertebrate species is a gap in FEPA identification. Future research should focus on collating databases of macro-invertebrates (at the species, not family, level) for use in future assessments. In addition, there is a need to update the existing taxonomy of fish species with new information (Section 3.4.13), as this severely affects the assessment of a species conservation status. The taxonomic uncertainty was addressed in NFEPA by recognising distinct lineages within fish species as discrete entities for conservation, and assessing their conservation status separately from other lineages within that species (Section 3.4.13). This makes reporting on number of threatened species somewhat confusing.

Groundwater: Consideration of groundwater in the identification of FEPAs was included only in terms of identifying areas of high groundwater recharge (Section 3.4.15). Future refinement of FEPAs should seek to include groundwater more broadly.

Mountain catchment and water supply areas: High water yield and high groundwater recharge areas identified by NFEPA should be verified in the field. Research is also required on the use of mountain catchments in protecting water supply areas, which includes quantifying the benefits derived, the costs of protection, and the affected parties for each of these. Further work is also required to re-instate the Mountain Catchment Areas Act, which is a key recommendation stemming from the NFEPA project (Section 8.3).

Incorporating FEPAs into environmental flow assessment: Integrating freshwater biodiversity planning principles into environmental flow assessment is a key area of new research in the management and conservation of freshwater ecosystems. Several potential avenues to explore in this regard have been identified by Nel et al. (2011), including the use of priority areas to inform scenario development, using biodiversity targets as a quantitative assessment of ecological impacts of different developing scenarios, and designing efficient catchment configurations of use through the use of adapted environmental flow assessment and biodiversity planning software tools. A water resource classification system has been developed in South Africa using concepts from environmental flow assessment. This system feeds into the water resource classification process and represents a key implementation mechanism for managing and conserving FEPAs in terms of the National Water Act.

Exploring mechanisms for implementing site specific FEPAs: This would include investigating how biodiversity stewardship and financial incentives can best be used, alongside investments from the extended Public Works Programme (e.g. Working for Water, Working for Wetlands), to leverage shared management of FEPAs amongst private land owners. This brings in a host of research ranging from implementation and governance issues, (e.g. payment for ecosystem service schemes; use of pilots with Water User Associations or Fire Protection Agencies to create shared management structures), to ecological investigations (e.g. quantifying the flow of benefits of ecosystem service benefits; setting widths of riparian and wetland buffer areas).

Monitoring of NFEPA uptake and feeding results into future assessments and management: There is a need to establish an evidence-base for how FEPAs influence decisions and shape environmental outcomes. A suite of indicators should be developed and implemented to monitor the effectiveness of FEPA uptake, from its early stages into policy, to action on the ground. Suitable feedback to improving future updates, or similar initiatives should also be established.

SECTION 8: CONCLUSIONS AND RECOMMENDATIONS

This provides key findings, from which key messages and recommendations are derived.

8.1 KEY FINDINGS

8.1.1 Tributaries are in a better condition than main rivers

- Using 1:500 000 rivers, only 35% of mainstem length is in good condition (A or B ecological category), compared to 57% of the tributary length.
- Tributaries offer refuge for many freshwater biota and hold good conservation potential. They sustain working rivers by providing natural flow and sediment pulses.
- Mainstems may still need to be managed in a state that supports connectivity between tributaries, particularly if they have been selected as an Upstream Management Area on the NFEPA maps.

8.1.2 Freshwater and estuarine ecosystems are highly threatened

- The National Biodiversity Assessment 2011 (Driver et al. 2005) found that respectively, 82%, 65% and 57% of estuarine, wetland and river ecosystem types are threatened (critically endangered, endangered or vulnerable).
- Threatened ecosystem distribution patterns coincide with areas of intense land-use pressure, with these pressures accumulating from source to sea.
- Estuarine, wetland and river ecosystems are more threatened than their marine and terrestrial counterparts (47% and 51% of marine and terrestrial ecosystem types are threatened respectively).
- A worsening trend in river condition (from River Health data) indicates that threat levels are unlikely to improve without concerted effort to manage these ecosystems more effectively (Strydom et al. 2006).

8.1.3 Freshwater Ecosystem Priority Areas comprise only 22% of the 1:500 000 river length

- FEPAs maps show strategic spatial priorities for conserving freshwater ecosystems and supporting sustainable use of water resources.
- FEPAs need to be managed in a good condition to conserve and manage freshwater ecosystems, and protect water resources for human use. This does not mean that FEPAs need to be fenced off from human use, but rather that they should be supported by good planning, decision making and management so that human use does not impact on ecosystem condition.

8.1.4 There are only 62 large free-flowing rivers, representing only 4% of our river length

- Only 25 of these are larger than 100 km.
- Twenty free-flowing rivers have been chosen as flagships to represent free-flowing rivers across the country. These should receive top priority for retaining their dam-free status.
- Large rivers such as these and other FEPAs form ideal ecological corridors for ecosystem-based adaptation to climate change, and their explicit identification is proving useful to projects focusing on terrestrial and freshwater biodiversity planning and climate change adaptation.

8.1.5 Only 18% of our water supply areas are formally protected

- The Mountain Catchment Areas Act provides an enabling multiple-use protection tool, e.g. provides for tax incentives and the clearing of water using invasive alien plants on private land.
- Formal protection in terms of the Mountain Catchment Areas Act currently makes up only 3% of this statistic. Additionally, these are often considered ‘paper parks’ with no implementation of environmental and hydrological protection principles.
- The Mountain Catchment Areas Act needs to be revived to secure our water future.
- Stream-flow reduction activities should be avoided in water supply areas, e.g. no new plantations in these areas.

8.1.6 By protecting only 15% of our river length we protect all our fish on the brink of extinction

- Fish sanctuaries have been selected to conserve our threatened freshwater fish species. Many of these coincide with FEPAs.
- Fish sanctuaries also perform the function of conserving all the widespread and common species.
- Fish sanctuaries do not need to be in an A or B ecological condition, but each (or groups of them) require management plans to manage issues that impact on the persistence of the fish species it supports.
- Control of invasive alien fish species is a critical issue. Although some of the worst invasive alien fish are also economically valuable (for aquaculture and recreational angling), with careful planning it is possible to support their associated economies and conserve indigenous fish species.
- Maps showing permitting zones for invasive alien fish that have been drafted for the Biodiversity Act should be used in conjunction with NFEPA maps to plan control operations and assessing license applications to stock invasive alien fishes. This is already being piloted by CapeNature in the Western Cape.

8.2 KEY MESSAGES

8.2.1 Freshwater Ecosystem Priority Areas are a valuable national asset

Managing FEPAs in a good condition is not just about conserving freshwater plants and animals – it should also be regarded as a comprehensive approach to sustainable and equitable development of water resources. Keeping strategically-chosen freshwater ecosystems in a good condition serves a dual purpose of meeting government objectives for both sustainable water resource development (National Water Act) and freshwater biodiversity conservation (National Environmental Management: Biodiversity Act).The current and recommended ecological category for all river FEPAs is A or B. Wetland FEPAs that are currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.

8.2.2 Freshwater inputs are critical to estuarine and marine environments

Fresh water flowing to estuaries and the sea provide important inputs such as nutrients, sediments and carbon, which in turn maintain important ecological processes that keep our marine resources healthy. Healthy marine and coastal ecosystems sustain commercial and recreational fish stocks, and provide a source of food to poor coastal communities that depend directly on marine resources for food. A certain amount of water is also required to scour the mouth of most estuaries – without this scouring effect, sediments build up at the mouth and the risk of back-flooding during storms increases. Artificial breaching of an estuary mouth to minimise this risk is expensive and damages estuarine ecosystems. This is why water running out to sea should not be considered wasted.

8.2.3 Free-flowing rivers are an important part of our natural heritage

A free-flowing river is a long stretch of river that has not been dammed. It flows undisturbed from its source to the confluence with another large river or to the sea. Today there are very few large rivers that remain dam-free, or ‘free-flowing’ in South Africa and globally. Free-flowing rivers are rare features in our landscape and an important part of our natural heritage. They offer considerable social, economic and conservation value, supporting the livelihoods of people in the catchment. Poor rural populations with close livelihood links to the river are likely to be impacted most and benefit least from dams. The flagship free-flowing rivers identified by NFEPA should receive top priority for maintaining their dam-free status.

8.2.4 Healthy tributaries and wetlands support the sustainability of hard-working rivers

With effective planning, freshwater ecosystems in a catchment can be designed to support multiple levels of use, with natural rivers and wetlands that are minimally-used supporting the sustainability of heavily-used rivers, wetlands and estuaries that often form the economic hub of the catchment. Healthy tributaries can improve water quality by ‘flushing’ pollutants when they join their mainstem rivers, and they also replenish water supply in the mainstem. Wetlands filter pollutants and sediments from the surrounding landscape thus preventing them from entering the river. They also regulate flow of water from the surrounding landscape which helps to reduce the effects of flood (by slowing down run-off) and droughts (by reducing evaporation).

8.2.5 Healthy buffers of natural vegetation mitigate the impact of land-based activities

Freshwater ecosystems are generally the lowest point in the landscape, making them the ‘receivers’ of wastes, sediment and pollutants in runoff. This combined with the strong connectivity of freshwater ecosystems means that they are highly susceptible to upstream, downstream and upland impacts. Managing land-based impacts in the whole catchment is therefore essential. While it is seldom feasible for entire catchments to be ‘locked away’ from human use, catchments can be designed to incorporate varying levels of use and impacts on freshwater ecosystems. Buffers of vegetation surrounding all freshwater ecosystems, even heavily used ones, go a long way to reducing the effects of deleterious land-use practices. The effective width of the management buffer should be determined on a site-specific basis. The NFEPA implementation manual provides some recommendations for delineating management buffers.

8.2.6 Groundwater sustains river flows particularly in dry seasons

Groundwater abstracted from river beds, close to streams, and from shallow alluvial aquifers has a very direct influence on river flow, and should be not be viewed as an additional water resource. Such groundwater plays an important role in sustaining wetlands and river flows (‘base flows’) and supporting refuge pools in the dry season. Apart from the human benefits of maintaining river flows in the dry season, refuge pools in seasonal rivers support water-dependent animals that would otherwise not survive when the rivers dry up. Healthy riparian areas, which filter pollutants that drain from the land, are also often maintained by groundwater. It is only when groundwater has very weak links to surface water (such as in deep, confined aquifers) that it may be possible to abstract it without significantly impacting on river flow; however, long-term impacts are not well understood.

8.2.7 Mountain catchment areas play a critical role in securing our water supplies

High water yield areas and high groundwater areas generally occur in mountain catchment areas. These are the ‘water factories’ of the catchment and generate a large proportion of the water for human and ecological use. Maintaining these areas is a healthy state will allow for the use of clean water downstream that can also maintain ecosystem functioning and biodiversity.

8.2.8 Healthy freshwater ecosystems support resilience and adaptation to climate change

Healthy natural ecosystems can increase resilience to the impacts of climate change, by allowing ecosystems and species to adapt as naturally as possible to the changes and by buffering human settlements and activities from the impacts of extreme weather events. Freshwater ecosystems are likely to be particularly hard hit by rising temperatures and shifting rainfall patterns, and yet healthy, intact freshwater ecosystems are vital for maintaining resilience to climate change and mitigating its impact on human well-being. In the western part of South Africa, which is likely to become dryer, intact rivers and wetlands will help to maintain a consistent supply of water; in the eastern part of the country, which is likely to become wetter, intact rivers and wetlands will be important for reducing flood risk and mitigating the impact of flash floods.

8.3 KEY RECOMMENDATIONS

This section draws together and highlights some of the key recommendations that have emerged from NFEPA. Recommendations that pertain to the use of FEPA maps in various different policy mechanisms are cross-referenced to the relevant sections of the NFEPA implementation manual where most of them have been discussed in more detail.

- **Employ aquatic ecologists in provinces, Catchment Management Agencies and municipalities** to promote sustainable water development decisions. A concerted effort is required to improve management of freshwater ecosystems if we are to halt and reverse the deterioration of freshwater ecosystems and ensure sustainable use of water resources. A good understanding of aquatic ecosystem functioning is needed. As discussed in the NFEPA implementation manual, provincial conservation authorities play an especially pivotal role in implementing and monitoring freshwater ecosystem priorities, as they have the major line function responsibility for ecosystem management and conservation. Provincial conservation authorities ideally require at least six to eight aquatic scientists and technicians, with expertise in limnology, hydrology, fish biology, aquatic invertebrate biology, aquatic plant biology and other aspects of aquatic ecology, in order to play an effective role in managing and conserving freshwater ecosystems. At the time of writing, most provincial conservation authorities had only one aquatic scientist. It is also essential to employ aquatic scientists in Catchment Management Agencies, and preferably in municipalities.
- Set up mechanisms to **support uptake of FEPA maps, especially by provincial conservation authorities and Catchment Management Agencies**. SANBI’s freshwater programme has an important role to play in coordinating, catalysing and facilitating the use of FEPA maps, and in convening relevant stakeholders to share knowledge and lessons. However, this programme has limited resources.

- **Use FEPA maps in assessing EIA applications** and making land-use decisions, as discussed in Sections 5.4 and 5.6 of the NFEPA implementation manual.
- **Use FEPA maps in water resource development processes**, including classification of water resources, ecological reserve determinations, resource quality objectives, water use authorisations, and development of Catchment Management Strategies, as discussed in Section 5.1 of the NFEPA implementation manual.
- **Applications for mining and prospecting** in FEPAs and associated sub-quaternary catchments should be subject to rigorous environmental and water assessment and authorisation processes, as mining has a widespread and major negative impact on freshwater ecosystems. See Section 5.7.2 of the NFEPA implementation manual as well as those aspects of the ecosystem management guidelines in Chapter 6 of the NFEPA implementation manual that relate to mining and prospecting.
- Pilot **formal mechanisms for the management and protection of FEPAs**, including the use of biodiversity stewardship programmes and fiscal incentives. See Section 5.3.3 of the NFEPA implementation manual.
- **Revive the Mountain Catchment Areas Act**, which has the potential to play a much larger role in protecting our water supply areas. See Section 5.7.1 of the NFEPA implementation manual.
- **Review general authorisations** of the National Water Act in relation to their impact on FEPAs. See Section 5.7.1 of the NFEPA implementation manual.
- Strengthen and expand the scope of the **River Health Programme** to include wetlands and actively target FEPAs as new monitoring sites. See Section 5.9.1 of the NFEPA implementation manual.
- **Strengthen collaboration of DWA and DEA** around managing and conserving freshwater ecosystems. The single Minister for the two departments provides an ideal opportunity for formalising co-operation around freshwater ecosystem management, and NFEPA provides tools on which to focus such combined efforts. The NFEPA stakeholder engagement process went some way towards developing and strengthening the necessary relationships between stakeholders in the water and biodiversity sectors. The recently established **Inter-Departmental Liaison Committee for Freshwater Ecosystems** provides an opportunity for the various key role-players in freshwater ecosystem management and conservation to establish shared objectives and to collaborate actively, and to tease out respective roles and responsibilities in more detail. See Chapter 4 of the NFEPA implementation manual.

SECTION 9: REFERENCES

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APPENDIX A: NFEPA meetings, workshops and presentations Held, attended and presented at between 2008 and 2011

Meeting or workshop	Date	Place	Participants
NFEPA Inception Workshop	26 August 2008	SANBI, Pretoria	Stakeholders from freshwater biodiversity sector and stakeholders with a mandate to conserve, protect and manage inland water resources
National governance: DWAF and the identification of NFEPA	22 September 2008	DWAF, Pretoria	Dirk Roux, Chris Swiegers
National governance: Meeting to discuss Strategic Framework Agreement between DEAT an DWAF	30 September 2008	Pretoria	Barbara Schreiner, Dirk Roux, Nikki Funke
Meeting to explore alignment of DWAF and DEAT policy mechanisms	9 October 2008	Kirstenbosch	Mandy Driver, Jeanne Nel, Cate Brown, Dana Grobler, Jenny Day, Mao Amis, John Dini
1st NFEPA WRC reference group meeting	17 November 2008	WRC offices, Pretoria	Reference group members, project team members
Sub-national governance: Meeting with Mpumalanga Tourism and Parks Agency (MTPA)	28 January 2009	MTPA, Lydenburg	Nikki Funke, Ernita van Wyk, Liesl Hill, Kevin Murray
CAPE capacity building workshop for using the water resource classification system	5-6 February 2009	Cape Town	Western Cape water resource managers, Mandy Driver, Jeanne Nel (presentation by Mandy)
Meeting to align DWAF technical tools (including PES-EIS update) with NFEPA	16 February 2009	SANBI, Pretoria	Barbara Weston, Neels Kleynhans, Dana Grobler, Jeanne Nel, Mandy Driver
NFEPA Symposium at National Biodiversity Planning Forum	4 March 2010	Warmbaths	Biodiversity Planners, technical project team

Meeting or workshop	Date	Place	Participants
NFEPA WRC Steering Committee meeting	10 March 2010	WRC, Pretoria	Liesl Hill, Jeanne Nel, Mandy Driver and WRC Steering Committee
Biodiversity Planning Forum: NFEPA update presentation	12 March 2009	Pumula Beach, KZN	Biodiversity planning forum members (approximately 30 people attended the NFEPA session)
SAIAB NFEPA launch and progress reporting	19 March 2009	SAIAB, Grahamstown	Scientists and anglers from SAIAB and Rhodes University (approximately 30 people)
Fish sanctuaries delineation workshop: Cape and Arid interior regions	16 to 20 March 2009	SAIAB, Grahamstown	Ashton Maherry, Ernsta Swartz, Jeanne Nel, Jim Cambray, Johan Engelbrecht Roger Bills, Sherwin Mack, Willem Coetzee
Landforms Accuracy Assessment Technical Workshop	30-31 March 2010	CSIR, Pretoria	Heidi van Deventer, Ashton Maherry, Devlyn Hardwick, Jeanne Nel, Lindie Smith-Adao, Chantel Petersen
NFEPA Map Products Meeting	13 April 2010	SANBI, Kirstenbosch	Jeanne Nel, Mandy Driver, Stephen Holness
NFEPA wetland task team	24 April 2009	Kirstenbosch, Cape Town	Ashton Maherry, Jeanne Nel, Justine Ewart-Smith, Mao Amis, Namhla Mbone Nancy Job, Pete Illgner
Presentation of NFEPA to the Biodiversity Stewardship Working Group	4 May 2010	SANBI, Kirstenbosch	Mandy Driver, Jeanne Nel, Tracey Cummings, Provincial Biodiversity Stewardship managers
NFEPA Project Planning meeting	5 to 6 May 2009	SANBI, Pretoria	Ashton Maherry, Chantel Petersen, Devlyn Hardwick, Dirk Roux, Heidi Van Deventer, Jeanne Nel, Kevin Murray, Liesl Hill, Lindie Smith-Adao, Mandy Driver, Namhla Mbona, Nikki Funke, Nokuthula Wistebaar, Smiso Bhengu John Dini; Tammy Smith, Tshifhiwa Tshusa, Nhlanganiso Biyela

Meeting or workshop	Date	Place	Participants
Fish Sanctuaries Delineation workshop: KZN, Limpopo and Mpumalanga regions	13 May 2009	SANBI, Pretoria	Ashton Maherry, Ernst Swartz, Mick Angliss Mike Coke, Neels Kleynhans, Stan Rogers, Francois Roux
NFEPA Expert workshop: Western & Eastern Cape regions	27 to 28 May 2009	SANBI, Cape Town	See Appendix B
NFEPA Expert workshop: KZN	2 to 3 June 2009	Institute for Natural Resources, Pietermaritzburg	See Appendix B
Wetland typing task team meeting	19 June 2009		Ashton Maherry Donovan Kotze Heidi van Deventer Jeanne Nel Justine Ewart-Smith Namhla Mbone Nancy Job Pete Illgner
NFEPA Expert workshop: Arid regions	24-25 June 2009	University of the Free State, Bloemfontein	See Appendix B
NFEPA Expert workshop: Lowveld region	22-23 July 2009	Lowveld Botanical Gardens, Nelspruit	See Appendix B
NFEPA Expert workshop: Highveld region	28-29 July 2009	SANBI, Pretoria	See Appendix B
Workshop for developing the NFEPA conceptual and GIS planning protocol (1 day workshop that will be back-to-back with a 2-day National Biodiversity Assessment 2011 planning workshop)	August 2009		Jeanne Nel Heidi van Deventer Chantel Petersen Lindie Smith-Adao Ashton Maherry Namhla Mbona
National Wetlands Indaba	October 2009	Club Mykonos, Saldanha	Heidi van Deventer Ashton Maherry Jeanne Nel Namhla Mbona
3rd Annual Grasslands Partners Forum	10-12 November 2009	SANBI	Jeanne Nel and Mandy Driver (presentation by Jeanne)
Meeting with the South African Risk and Vulnerability Atlas (SARVA)	1 December 2009		Wilma Strydom Jeanne Nel Mandy Driver Rebecca Massemurule Dirk Roux Liesl Hill
DWA, SANBI, DEA meeting re NFEPA and listing of threatened river ecosystems	2 December 2009	DWA Pretoria	Wilma Lutsch Barbara Weston (acting for Harrison Pienaar) Sidimo Manamela Jeanne Nel Mandy Driver

Meeting or workshop	Date	Place	Participants
			John Dini
Crocodile Marico WMA Implementation meeting	3 February 2010	Villa Paradiso, Hartbeespoort Dam	Dirk Roux, Hermien Roux, Liesl Hill, Linda Downsborough, Nikki Funke, Jeanne Nel, Piet Muller, Ray Schaller
Inkomati CMA Implementation Meeting	5 February 2010	Lowveld Botanical Gardens, Nelspruit	Brian Jackson, Harry Biggs, Anton Linstrom, Mervyn Lotter, Tolmay Hopkins, Jeanne Nel, Dirk Roux, Nikki Funke, Liesl Hill, Ursula Franke
NFEPA Symposium at National Biodiversity Planning Forum	4 March 2010	Bela Bela	Biodiversity Planners, technical project team
NFEPA 2nd Steering Committee Meeting	10 March 2010	WRC Offices, Pretoria	Steering Committee members, project team members
Landforms Accuracy Assessment Technical Workshop	30-31 March 2010	CSIR, Pretoria	Heidi van Deventer, Ashton Maherry, Devlyn Hardwick, Jeanne Nel, Lindie Smith-Adao, Chantel Petersen
NFEPA Map Products Workshop (to explore how to summarise the spatial analyses visually)	13 April 2010	SANBI, Kirstenbosch	Jeanne Nel, Mandy Driver, Stephen Holness, Kerry Sink
Breede/Overberg CMA Implementation meeting	29 April 2010	SANBI, Kirstenbosch	Phakamain Buthelezi, Jannie van Staden, Dean Impson, Wilna Kloppers, Jeanne Nel, Mandy Driver, Dirk Roux, Kevin Murray
National governance: DWA-SANParks Liaison Committee (discussion on expanding the committee to DWA Liaison Committee on Freshwater Ecosystems)	6 May 2010	SANParks Head Office, Pretoria	Committee Members, Mandy Driver

Meeting or workshop	Date	Place	Participants
C.A.P.E. Ecological Reserve Implementation Component and CMA Component: Meeting to discuss lessons learnt and way forward. Substantial discussion on ensuring uptake of NFEPA products and mechanisms for implementation of freshwater ecosystem priorities.	17 May 2010	CapeNature, Jonkershoek	Convened by Pierre de Villiers and Dana Grobler (Mandy Driver attended)
National governance: Meeting with Barbara Western re alignment between NFEPA and DWA processes, including PES/EIS update and preliminary reserve determination	25 May 2010	SANBI, Kirstenbosch	Barbara Weston, Jeanne Nel, Mandy Driver
NFEPA Presentation to Western Cape Wetlands Forum quarterly meeting	2 June 2010	SANBI, Kirstenbosch	Jeanne Nel, Western Cape Wetland Forum members
Breede/Overberg CMA Follow-up Implementation meeting with CMS team including CMS consultants (Pegasys), to explore integration of NFEPA outputs in BOCMA CMS	3 June 2010	SANBI, Kirstenbosch	Jeanne Nel, Mandy Driver, Guy Pegram, Marcia Gouws
DWA PES/EIS updates: discussion on how NFEPA products could be used	28 June 2010	WRC, Pretoria	Barbara Weston, National DWA RDM staff, Neels Kleynhans, consultants that will do the PES/EIS updates, WRC management team
Southern Waters, SANBI, CSIR meeting to incorporate NFEPA into water resource assessment for BOCMA catchment management strategy (Southern Waters = sub-consultants on BOCMA CMS)	26 July 2010	Southern Waters, Cape Town	Jeanne Nel, Mandy Driver, Cate Brown, Alison Joubert
NFEPA National Expert Review Workshop	27 and 28 July 2010	SANBI, Pretoria	See Appendix B
CapeNature meeting on integrating NFEPA and Biodiversity Sector Plans into institutional activities and policy	30 July 2010	CapeNature, Jonkershoek	Jeanne Nel
Southern Waters, SANBI, CSIR meeting to refine NFEPA incorporation into water resource assessment	11 August 2010	Southern Waters, Cape Town	Jeanne Nel, Mandy Driver, Alison Joubert

Meeting or workshop	Date	Place	Participants
for BOCMA catchment management strategy			
Meeting with SANBI's Biodiversity GIS website (BGIS) project manager re preparation for serving NFEPA maps on BGIS	16 August 2010	SANBI, Kirstenbosch	Jeanne Nel, Mandy Driver, Ashton Maherry, Sediqa Khatieb
NFEPA atlas Writing Retreat	17-19 August 2010	CSIR, Pretoria	Jeanne Nel, Mandy Driver, Dirk Roux, Wilma Strydom, Ashton Maherry
CSIR Conference showcasing NFEPA to government departments and other stakeholders	3 September 2010	CSIR, Pretoria	Jeanne Nel
York Conference, York, UK – using systematic conservation planning to inform freshwater ecosystem protection in South Africa	6 September	UK	Jeanne Nel, Dirk Roux
SANBI's Biodiversity Information Management Forum	20-23 September 2010	SANBI, Pretoria	Mandy Driver
SANBI Freshwater Programme Strategy Development session – seeking potential institutional home for NFEPA products	12 October 2010	SANBI, Pretoria	Mandy Driver, Jeanne Nel, Dirk Roux
NFEPA presentation at DEA's Working Group 1 (part of DEA's decision making structures, involves all provincial env. affairs depts. and conservation authorities)	13 October 2010	Johannesburg, Emperor's Palace	Mandy Driver
Breede-Overberg Reference Group meeting – developing a conservation management sub-strategy for the catchment management strategy	14 October 2010	Arabella Estate, Kleinmond	Jeanne Nel
National Wetlands Indaba 2010: NFEPA products: progress and way forward	27 October 2010	Kimberley	Jeanne Nel, Heidi van Deventer, Namhla Mbona
NFEPA progress and potential mechanisms for uptake by WWF	29 October 2010	WWF, Stellenbosch	Jeanne Nel
BOCMA catchment management strategy Reference Group Meeting	4 November 2010	Caledon	Mandy Driver
NFEPA Presentation at DEA MinTech (DG of DEA and all provincial HODs, also reps from other national departments including DWA)	5 November 2010	Johannesburg	Mandy Driver
NFEPA: Implementation meeting: Crocodile (west) Marico WMA	10 November 2010	Hartbeespoort Dam: Kurperoord	Jeanne Nel, Mandy Driver, Dirk Roux, Kevin Murray, Linda Downsborough, Liesl

Meeting or workshop	Date	Place	Participants
			Hill, Shanna Nienaber + see spreadsheet
NFEPA Ecosystem Management Guidelines workshop	15 November 2010	SANBI, Kirstenbosch	Kate Snaddon, Barbara Weston, Charl de Villiers, Doug MacFarlane, Jeanne Nel, Jeff Manuel, Kerry Maree, Liz Day, Mandy Driver, Mervyn Lotter, Nancy Job, Jeanne Gouws, Susie Brownlie, Wilna Kloppers, Sam Ralston, Donovan Kotze, Namhla Mbona and Dean Ollis
NFEPA: Implementation meeting: Inkomati WMA	16 November 2010	Nelspruit, Lowveld Botanical Gardens	Jeanne Nel, Mandy Driver, Dirk Roux, Kevin Murray, Linda Downsborough, Nikki Funke, Liesl Hill, Shanna Nienaber

APPENDIX B: Attendees at expert review workshops

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EASTERN CAPE / WESTERN CAPE, 27 & 28 May 2009

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LOWVELD EXPERT WORKSHOP, 22 & 23 July 2009

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HIGHVELD & LIMPOPO, 28 & 29 July 2009

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APPENDIX C:
Template for an aquatic Conservation Management Strategy

Prepared for the Breede-Overberg Catchment Management Agency

INTRODUCTION

The Water Resource Protection Strategy (Chapter 4) of the Breede-Overberg catchment management strategy identifies three strategic areas for achieving water resource protection in the Breede-Overberg: Environmental Flow Requirements, Water Quality Requirements, and Aquatic Ecosystem Protection. This section focuses on the third strategic area, providing a Conservation Management Strategy for aquatic ecosystem protection.

Aquatic ecosystem protection is not just about protecting freshwater plants and animals but should rather be regarded as a comprehensive approach to sustainable and equitable development of the catchment's scarce water resources. Keeping some aquatic ecosystems in a good condition serves a dual purpose of promoting the sustainable use of water resources in the catchment, while conserving its associated biodiversity. A healthy ecosystem supports functional communities of plants and animals that are able to remove nutrients and toxic substances from water, keeping it cleaner for drinking, irrigation and recreation. Healthy rivers, wetlands and groundwater systems also maintain water supply and buffer the effects of storms, reducing the loss of life and property in the event of floods. Healthy riparian zones help trap sediments, stabilise river banks and break down pollutants draining from the surrounding land. Estuaries provide nursery areas for marine and estuarine animals, and supply fresh water and nutrients to the sea, which drive marine food webs and maintain important fisheries. A certain amount of water is also required to scour the mouth of most estuaries – without this scouring effect, sediments build up at the mouth and the risk of back-flooding during storms increases. Aquatic ecosystem protection is therefore an essential component to meeting government objectives for both sustainable water resources development (National Water Act) and freshwater biodiversity conservation (National Environmental Management: Biodiversity Act, hereafter referred to as the Biodiversity Act).

STRATEGIC OBJECTIVES

Strategic Objective 1: Incorporate Freshwater Ecosystem Priority Areas (FEPAs) into planning and decision making processes that impact on aquatic ecosystems

- Take Freshwater Ecosystem Priority Areas (FEPAs) into consideration in catchment visioning, water resource classification, reserve determination, setting and monitoring of resource quality objectives, and water-use license applications
- Take Critical Biodiversity Areas and Ecological Support Areas into consideration in decisions regarding water resource development
- Establish a process whereby BOCMA can comment on development applications in collaboration with CapeNature and DEA&DP
- Promote a catchment approach to development in municipal integrated Development plans (IDPs) and Spatial Development Frameworks (SDFs)
- Facilitate coordination of planning processes amongst implementing agencies that manage or impact on aquatic ecosystem protection

Strategic Objective 2: Develop and implement estuary management plans

- Support the development and implementation of estuary management plans under the Integrated Coastal Management Act
- Assist in the establishment of estuary management forums required to implement these plans

- Clarify roles and responsibilities of the different implementing agencies in estuary management, particularly between the CMA, Department of Water Affairs, CapeNature and local municipalities
- Include estuary management forum representatives in CMA planning and decision making processes
- Promote the policy of no new development in the estuarine functional zone (defined largely according to the 5 m contour line)

Strategic Objective 3: Develop and implement management plans for priority wetlands
- Identify which wetlands need most urgent attention using wetland Freshwater Ecosystem Priority Areas (FEPAs) as a starting point
- Delineate extent of these wetlands and the management buffers that will be required for their protection
- Form a collaboration with relevant implementing agencies to support the development and implementation of management plans for these wetlands
- Engage with the relevant land owners to ensure that they comply with the protection of these priority wetlands (e.g. through working with Department of Agriculture LandCare and the Biodiversity Stewardship Programmes)

Strategic Objective 4: Develop and implement management plans for priority rivers
- Prioritise the development of management plans for Freshwater Ecosystem Priority Areas (FEPAs)
- Identify the smaller streams and habitats within the river Freshwater Ecosystem Priority Area (FEPA) that require protection and delineate management buffers that will be required for their protection
- Form a collaboration with relevant implementing agencies to support the development and implementation of management plans for these river habitats
- Engage with water user associations to support the protection of these priority river habitats
- Engage with the relevant land owners to ensure that they comply with the protection of these priority river habitats (e.g. through working with Department of Agriculture LandCare and the Biodiversity Stewardship Programmes)

Strategic Objective 5: Management of riparian and alien vegetation
- Identify priority areas for re-establishment of the riparian zone
- Assist existing extension services (e.g. dept of agric and BWI extension officers) to prevent further ploughing in riparian zones
- The principle of no ploughing in riparian zones should be adopted and the rehabilitation/re-establishment of riparian zones should be supported
- Identify priority areas for clearing of invasive alien vegetation
- Assist in the development of contractual mechanisms for clearing on private land that include stringent mechanisms to ensure follow-up treatment
- Coordinate clearing of alien plants in priority sites on private land with Working for Water, SANParks and CapeNature
- Help capacitate local landowners and contractors in clearing of invasive plants

Strategic Objective 6: Management of threatened fish sanctuaries
- Develop fish management plans for threatened fish species, using the NFEPA threatened fish sanctuaries as a starting point and aligning with CapeNature development plans
- Avoid stocking of invasive alien fish, whether for aquaculture or recreational fishing, in FEPAs (e.g. by partnering with CapeNature's permitting processes for alien invasive fish species on private land)
- Produce a clear policy statement for the CMA on freshwater and estuarine aquaculture, aligned to CapeNature's policies on utilisation of indigenous, utilisation of alien invasive fish, and the use of rotenone in the eradication of alien invasive fish

Strategic Objective 7: Monitoring the state of freshwater ecosystems
- Clarify roles and responsibilities of monitoring agencies, including the CMA, Department of Water Affairs and local municipalities
- Align CMA monitoring activities with all enforcement partners, working towards having a monitoring node immediately downstream of every FEPA