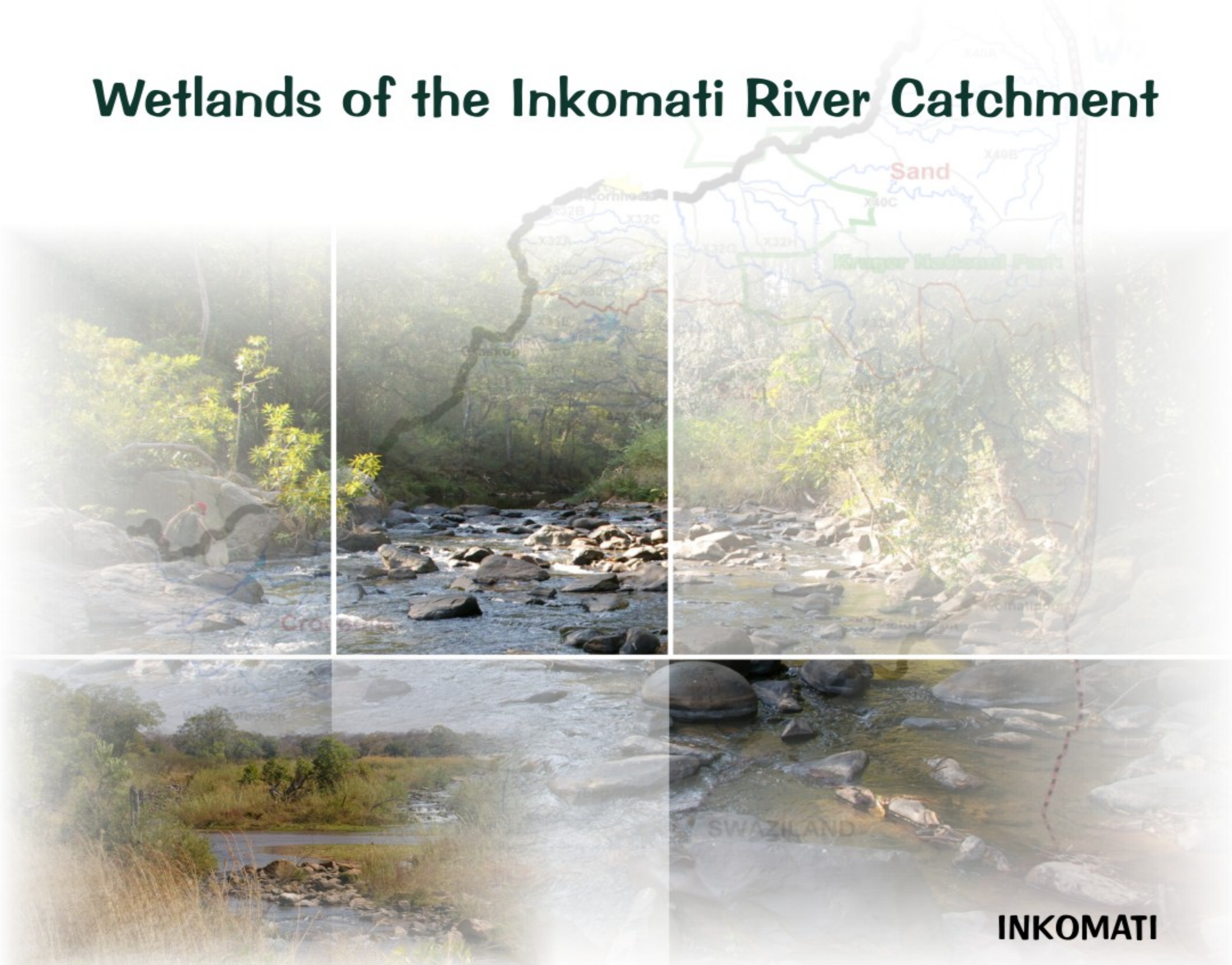
Comprehensive Reserve Determination Study for Selected Water Resources (Rivers, Groundwater and Wetlands) in the INKOMATI WATER MANAGEMENT AREA, MPUMALANGA

PROJECT NO: WP 9133

Wetlands of the Inkomati River Catchment



INKOMATI

MARCH 2010

REPORT NO.: 26/8/3/10/12/008

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DEPARTMENT OF WATER AFFAIRS AND FORESTRY

CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

COMPREHENSIVE RESERVE DETERMINATION STUDY FOR SELECTED WATER RESOURCES (RIVERS, GROUNDWATER AND WETLANDS) IN THE INKOMATI WATER MANAGEMENT AREA, MPUMALANGA.

SABIE AND CROCODILE SYSTEMS: WETLAND REPORT: FINAL

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COMPREHENSIVE RESERVE DETERMINATION STUDY FOR SELECTED WATER RESOURCES (RIVERS, GROUNDWATER AND WETLANDS) IN THE INKOMATI WATER MANAGEMENT AREA, MPUMALANGA

INKOMATI SYSTEM: WETLAND REPORT

March 2010

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Reports as part of this project:

Report no	Report title
26/8/3/10/12/001	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Inception report
26/8/3/10/12/002	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Desktop EcoClassification report
26/8/3/10/12/003	Newsletters
26/8/3/10/12/004	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Basic Human Needs Reserve report
26/8/3/10/12/005	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Groundwater report
26/8/3/10/12/006	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Resource Unit report
26/8/3/10/12/007	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Desktop Estimation report
26/8/3/10/12/008	**Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Wetland report**
26/8/3/10/12/009	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: EcoClassification report
26/8/3/10/12/010	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: EWR scenario report
26/8/3/10/12/011	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Operation scenarios and consequences report
26/8/3/10/12/012	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: EcoSpecs report
26/8/3/10/12/013	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Socio Economic Present State Evaluation Report
26/8/3/10/12/014	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Training audit and report
26/8/3/10/12/015	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Main report
26/8/3/10/12/016	Comprehensive Reserve Determination Study for selected water resources in the Inkomati WMA, Mpumalanga: Electronic information and data

Bold indicates this report

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Department of Water Affairs, South Africa. 2010. Comprehensive Reserve Determination Study for Selected Water Resources (Rivers, Groundwater and Wetlands) in the Inkomati Water Management Area, Mpumalanga. Wetland Report. Authored by Mark Rountree for Rivers for Africa edited by Louw, MD and Koekemoer, S. RDM Report no 26/8/3/10/12/008.

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Ms. Jackie Jay from the DWA: RDM Chief Directorate is thanked for the recommendations with regard to the wetland information requirements of the Department of Water Affairs (DWA). The assistance received from Mrs Nicolene Fourie (DWA: GIS Directorate) in obtaining relevant GIS layers is gratefully acknowledged.

The South African National Biodiversity Institute (SANBI) kindly allowed use of their draft National Wetland Probability Map for this study. Mr Allan Batchelor kindly provided insight and information regarding the wetlands of the Msukaligwa and Albert Luthuli Local Municipal Districts.

The river Desktop Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) models, developed by Dr Neels Kleynhans, were used as templates for the development of similar assessment tools for wetlands at the quaternary and sub-quaternary scale. Without the initial development of the river tools, modification to wetland-appropriate assessment tools would not have been easily possible. Dr Neels Kleynhans also very kindly assisted with sourcing old TPA wetland reports for the region.

The valuable reviewing and resultant comments and suggestions provided by Delana Louw and Shael Koekemoer for this report, and by Patsy Scherman, Delana Louw and Shael Koekemoer on similar wetland studies, have greatly improved this report, and their contributions are gratefully acknowledged.

EXECUTIVE SUMMARY

Background

The Chief Directorate Resource Directed Measures has identified the Crocodile East, Sabie and Sand River Catchment as one of the primary catchments that requires a high confidence level assessment of Ecological Water Requirements. As part of this study a need to conduct a scoping level assessment of the wetlands in these catchments and identify those wetlands which require more detailed studies was highlighted. Although not originally part of the project scope it was later decided to also include the Inkomati Catchment in this project scope. This study thus focussed on identifying and assessing wetlands in the Inkomati Water Management Area (WMA 5), incorporating the Inkomati, Crocodile (East), Sabie and Sand River catchments.

Purpose of the study

The purpose of this study was to identify the major wetland types within the catchment and conduct a primarily desktop assessment of wetlands within the Inkomati catchment. If any high priority wetlands (in terms of broad conservation importance, social importance and/or threats from proposed developments) were identified during the study, these were to be highlighted for further studies.

Methods

The most up-to-date version of the South African National Biodiversity Institute's (SANBI) Wetland Probability Map (SANBI, draft) (SANBI, draft) was used as a first-level assessment of wetland occurrence within the study area. These data are not field verified, and should thus be treated with caution. The SANBI maps do however provide an indication of relative wetland occurrence, size and density across the study area.

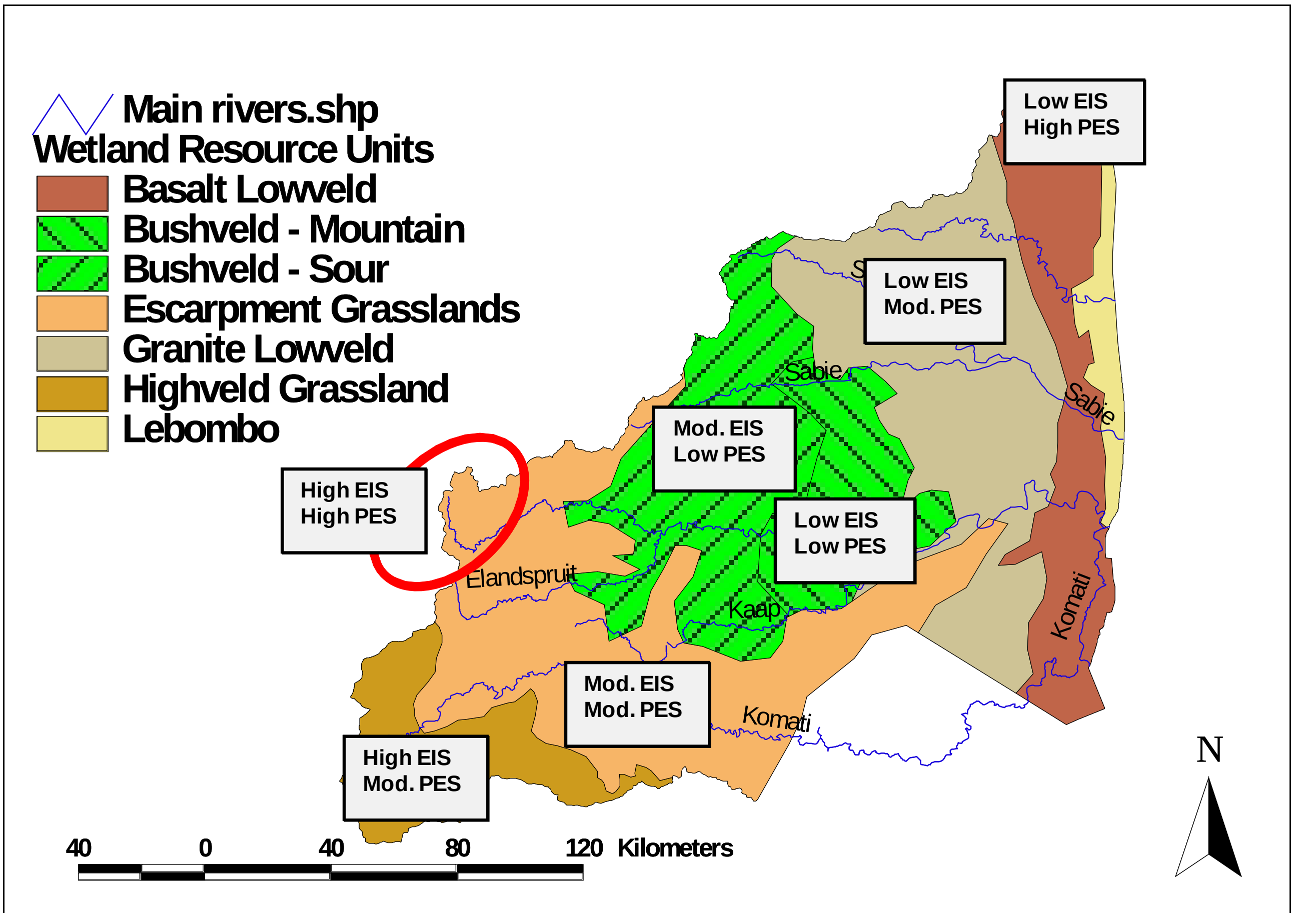
The wetland classification system developed by Rountree and Batchelor (in prep) was used to classify the wetlands in this study. This system is a modification of a hierarchical system for the classification of South African wetlands (developed by Ewart-Smith et al, 2003) and uses the underlying contemporary hydrological processes and formative geomorphological setting as the basis of classification of hydrogeomorphic (HGM) wetland types. The common HGM wetland types were identified and described across the study area. The HGM wetland typology is based on the underlying hydrological processes that create and maintain the wetlands. The likely sensitivities to particular types of activities (such as abstraction or increased runoff), and thus recommendations for future management, were then determined from this information, albeit at low confidence,

Since there are too many wetlands to evaluate in detail on an individual basis, a desktop level quaternary-scale catchment assessment of the wetlands across the entire study area was undertaken. A desktop scoring system for quaternary catchment scale wetland PES and EIS determination was developed and refined during this study. This tool was used to determine the average PES and EIS categories (at a low confidence) of wetlands within each quaternary catchment.

The wetlands in the study area were also grouped into Wetland Resource Units. These are broad groupings of similar types of wetlands that tend to be correlated with underlying dominant geology, EcoRegions and vegetation distribution. The identification of these Wetland Resource Units, and the identification and description of the common wetland types and sensitivities are provided to aid management of the wetlands within the study area.

Results

Results from the desktop Wetland PES and EIS assessments (at the quaternary catchment scale), and comparison with the available desktop river PES and EIS data are provided below. The PES and EIS scores reflect the expected AVERAGE scores of all wetlands within the quaternary catchment. PES is generally good to moderate whilst EIS scores range from Low to Moderate to High. PES is generally good to moderate whilst EIS scores range from Low to High. The wetlands in the extreme west (headwaters) have the highest EIS scores (See circled area in the figure below).



Estimated EIS and PES (average) for the wetlands within the quaternary catchments of the Inkomati WMA.

Quat	Desktop EIS	Desktop PES
X21A	**HIGH**	C
X21B	**HIGH**	C
X21C	**HIGH**	C
X21D	MODERATE	**B/C**
X21E	MODERATE	C
X21F	**HIGH**	**B/C**
X21G	MODERATE	C
X21H	MODERATE	C/D
X21J	MODERATE	D
X21K	MODERATE	D
X22A	MODERATE	C/D
X22B	LOW	C/D
X22C	MODERATE	D
X22D	MODERATE	C/D
X22E	MODERATE	C/D

Quat	Desktop EIS	Desktop PES
X22F	MODERATE	C
X22G	MODERATE	C/D
X22H	MODERATE	C
X22J	LOW	D
X22K	LOW	C
X23A	MODERATE	C
X23B	MODERATE	C
X23C	MODERATE	C/D
X23D	MODERATE	C
X23E	MODERATE	C/D
X23F	MODERATE	C
X23G	MODERATE	C
X23H	LOW	C
X24A	LOW	D
X24B	LOW	D
X24C	LOW	**B/C**
X24D	LOW	C
X24E	LOW	**B**
X24F	LOW	**B**
X24G	LOW	A
X31A	LOW	D
X31B	LOW	D
X31C	MODERATE	D
X31D	MODERATE	C
X31E	MODERATE	D
X31F	MODERATE	C
X31G	LOW	D
X31H	MODERATE	C/D
X31J	LOW	D
X31K	LOW	D
X31L	LOW	D
X31M	LOW	**A**
X32A	MODERATE	D
X32B	MODERATE	D
X32C	LOW	D
X32D	MODERATE	D
X32E	MODERATE	D
X32F	LOW	D
X32G	LOW	D
X32H	LOW	C
X32J	LOW	**A**
X33A	LOW	**A**
X33B	LOW	**A**
X33C	LOW	**A**
X33D	LOW	**A**
X40A	LOW	**A**
X40B	LOW	**A**
X40C	LOW	C
X40D	LOW	**A**

Wetland Resource Units (WRUs) and Hydrogeomorphic (HGM) types of Wetlands

Wetland density declines strongly from east to west across the WMA, mirroring the rainfall and elevation patterns. Vegetation Types and Level I and II EcoRegion boundaries were primarily used to delineate the Wetland Resource Units. Six main Wetland Resource Units were delineated, namely the

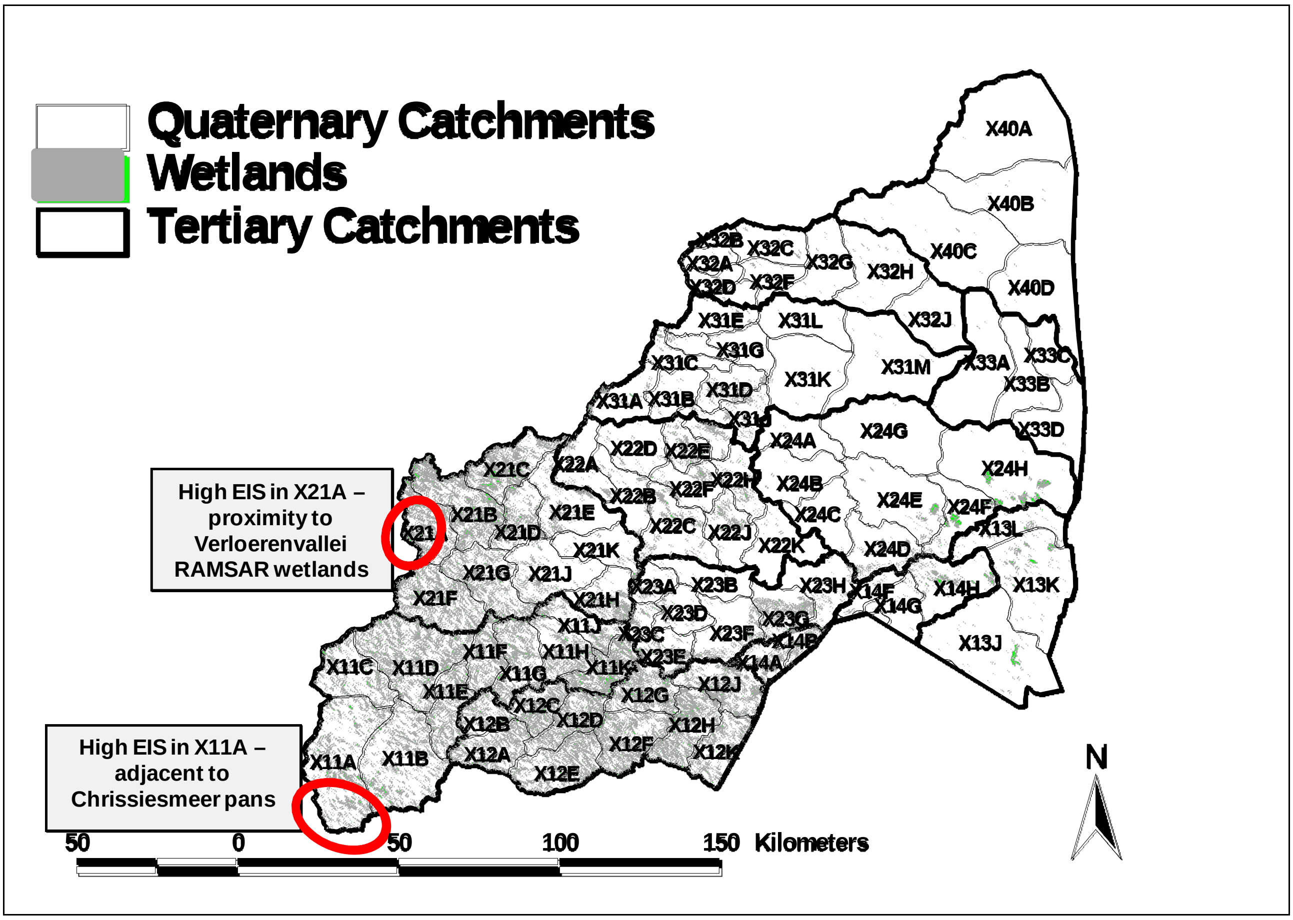
- WRU 1: **Highveld Grassland WRU** (high density of wetlands; high diversity; endangered vegetation)
- WRU 2: **Escarpment Grasslands WRU** (high density of wetlands; high diversity; vulnerable vegetation)
- WRU 3: **Bushveld WRU**, which can be subdivided into the Sour and Mountain Bushveld zones (moderate density of wetlands; moderate diversity)
- WRU 4: **Granite Lowveld WRU** (low density of wetlands; low diversity)
- WRU 5: **Basalt Lowveld WRU** (very low density of wetlands; low diversity)
- WRU 6: **Lebombo WRU** (no significant wetlands expected).

Within each of the six WRUs, the main HGM wetland types are relatively homogenous. For example, pans are primarily found within the Highveld Grassland WRU, whilst the highest densities of extensive seepage and wide, largely unchannelled valley bottom wetlands are located within the Escarpment Grassland areas. No wetlands of any significant size are expected within the Lebombo WRU. The steep slopes, very shallow soils and low rainfall within this WRU do not allow for conditions favouring the development of wetlands.

Priority Wetlands

Two areas of priority wetlands were identified in this study:

- The wetlands around Dullstroom (quaternary catchments X21A, X21B, X21C and X21F) all have High EIS scores and relatively high PES scores. These catchments are part of the Escarpment WRU and are located close to the RAMSAR Verloeren Vallei wetland complex.
- Wetlands of the Highveld WRU (X11A, X11B, X11C, X12A, X12B and X12E) generally have High EIS and Moderate PES scores. Of particular importance are the wetlands near the Chrissiesmeer Lake system – a dense grouping of pans in the headwaters of the Inkomati, Vaal and Usutu Rivers provides unique wetland habitats for birds and other fauna, and has a strong recreational and conservation value.



The distribution of wetlands across the WMA and the high priority wetland areas based on highest EIS scores

Two priority areas for wetlands are located within the X11A quaternary and within and around the X21A quaternary. X11A is adjacent to the Chrissiesmeer pan complex, and wetlands – especially pans – within the upper section of this catchment are likely to have strong ecological links with the adjacent pans despite no direct hydrological links. The upper section of X21A is immediately adjacent to the Verloerenvallei RAMSAR wetland site and is similarly expected to play an important role in ecological connectivity in the landscape due to the proximity to other important sites. The upper section of the X21 tertiary catchment has a generally high EIS due to the diversity, size and type of wetlands here.

Due to anticipated coal mining threats, a Comprehensive assessment of the high conservation priority Chrissiesmeer wetland complex should be undertaken to ensure that strategic, proactive management of these wetlands is enabled, and thus avoid the rather piecemeal approach to wetland management and impacts from coal mining as exists in the upper Olifants Catchment. Chrissiesmeer has been proposed as a RAMSAR site (a wetland of international importance). The hydrological characteristics of, and connectivity between, the pans should be thoroughly investigated in order than impacts of future developments can be more accurately predicted and mitigated if necessary. The risks associated with the future of the Dullstroom wetlands (X21A) are far lower than for Chrissiesmeer.

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ACRONYMS AND ABBREVIATIONS

CD: RDM	Chief Directorate: Resource Directed Measures
D:RQS	Directorate: Resource Quality Services
DEA	Department of environmental Affairs
DWA	Department of Water Affairs
DWAF	Department Water Affairs and Forestry
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
GIS	Geographic Information System
HGM	Hydro-Geomorphic Unit
MRU	Management Resource Units
NWA	National Water Act
PES	Present Ecological State
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
RU	Resource Unit
SANBI	South African National Biodiversity Institute
ToR	Terms of Reference
WETLAND IHI	Wetland Index of Habitat Integrity
WRU	Wetland Resource Unit

GLOSSARY

Aggradation	The filling or raising of land surface by deposition of sediment
Anaerobic	In the absence of oxygen.
Anthropogenic	Of, relating to, or resulting from the influence of human beings on nature.
Aquatic	Consisting of, relating to, or being in water.
Aquiclude	Sediment body, rock layer, or soil horizon that is incapable of transmitting significant quantities of water under normal hydraulic gradients.
Backswamp	Extensive, marshy, or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.
Base level	The lowest level to which a stream can erode its bed.
Bedload	Transported by being rolled or bounced along the bed of the stream.
Bedrock	The solid rock that underlies unconsolidated material, such as soil, sand, clay, or gravel.
Catchment	The area drained by a single stream.
Channel	The part of a river-bed containing its main current, naturally shaped by the force of water flowing within it.
Clastic sediment	The particles of minerogenic material (clay, silt, sand, cobbles and boulders) that are moved by running water.
Deposition	The laying down of material which has been transported by running water.
Depositional fan	A semi-circular alluvial depositional feature usually formed when a sediment laden, steep tributary or river flows out onto a very flat area.
Desiccation	The loss of moisture from material.
Discharge wetland	Wetlands where groundwater discharges into the wetland.
EcoRegions	Denotes areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources, and are designed to serve as a spatial framework for the research, assessment, management and monitoring of ecosystems and ecosystem components. Several levels or scales of EcoRegions can be delineated (e.g. Level I low resolution/detail; Level III high resolution and detail). In South Africa, EcoRegions form the basis of the River Health monitoring assessments with Level II delineations available for use.
EcoStatus	The overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component EcoStatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).
Endorheic	Refers to a watershed from which there is little or no outflow of water - either on the surface as rivers, or underground by flow or diffusion through rock or permeable material.
Ephemeral wetland	Wetland or portion thereof with markedly short-lived inundation.
Erosion	Physical and chemical processes that remove and transport soil and weathered rock.
Evapotranspiration	The loss of moisture from the terrain by direct evaporation plus transpiration from vegetation.
Exorheic	Referring to externally draining water bodies that have one or more points of outflow. Most lakes are exorheic, having some throughflow that prevents the accumulation of salts.
Flood frequency	The average number of times that a wetland is flooded in a given period.
Floodplain	The floor of a valley over which a river may spread in time of flood, depositing alluvium, often resulting in the formation of longitudinal or riparian wetlands within the floodplain.
Fluvial	Related to a river.
Geomorphology	The study of the origin and development of landforms of the earth.
Groundwater	Subsurface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric pressure.
Headwaters	The uppermost region of a catchment.
Hydric soil	Soil that is saturated or flooded long enough during the growing season to develop anoxic conditions, which favour the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).
Hydrogeomorphic (HGM)	Refers to particular wetland typing ("classification") methods based on the landscape (morphological) setting and hydrological characteristics of different wetland types.
HGM Unit	A single "reach", segment or unit of a particular type of HGM wetland type.
Hydroperiod	The hydrological signature describing the seasonal pattern of water level fluctuations in a wetland.
Interflow	Water moving downslope through the soil profile (i.e. below the surface, but not yet deep enough to be considered as true groundwater). This can be perched flows (where flows in the soil create locally perched water tables due to impervious layers in the soil or geology preventing seepage to deeper groundwater aquifers).
Landform	Any distinctive geomorphological feature on the earth's surface.
Mass-balance	The accounting of all inputs and outputs to a defined system.
Overland flow	Surface flow of water.
Palustrine wetlands	All non-tidal wetlands dominated by persistent emergent plants (e.g. reeds) emergent mosses or

	lichens, or shrubs or trees (see Cowardin *et al*., 1979).
Pan	Circular depressions that have no connection to the drainage system via surface flow.
Peat	Is a brownish-black organic soil that is formed in acidic, anaerobic wetland conditions. It is composed mainly of partially-decomposed, loosely compacted organic matter with more than 50% carbon. The 50% carbon content is mostly applicable for the sphagnum peat moss peat deposits in the Northern Hemisphere. The South African soil classification uses a > 10% carbon content as a guideline. Inorganic soil particles are blown or washed into peatlands and also form part of the peat.
Perched water table	The upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.
Perched wetland	A wetland where the wetland water table is higher than the local and regional water table. Such wetlands are maintained by the shallow impervious layers that create a site-specific high water table at or close to the surface.
Present Ecological State	The current ecological condition of the resource. This is assessed relative to the deviation from the Reference State.
Reference State	The natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development.
Rehabilitation	Restoring processes and characteristics that are sympathetic to and not conflicted with the natural dynamic.
Riparian	The physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas.
Runoff	The surface discharge of water from rainfall down a slope.
Seasonally wet soil	Soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season, but is predominantly dry during the dry season.
Terrestrial	Of or relating to or inhabiting the land as opposed to the sea or air.
Tributary	A stream that joins a larger one.
Wetland	in this report refers to the definition provided in the National Water Act; referring to “land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil” (National Water Act, Act 36 of 1998).
Wetland delineation	The determination and marking of the boundary of a wetland on a map. The DWAF (2005) guidelines should be employed to undertake this for field application.
Wetland Resource Unit	An area of a catchment which has wetlands with similar characteristics, processes and also broadly similar sensitivities to particular developments and impacts.

1 INTRODUCTION

1.1 BACKGROUND TO THE INKOMATI COMPREHENSIVE RESERVE STUDY

The National Water Act (NWA, Act No. 36 of 1998, Section 3) requires that the Reserve be determined for rivers, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. It is therefore imperative that the Reserve be determined and requirements met before other economic activities can be satisfied. As the Department of Water Affairs (DWA) is the custodian of the nation's water resources, it is their responsibility to ensure the adequate protection and effective management of these resources. The Chief Directorate: Resources Directed Measures (CD:RDM) of DWA is tasked with the responsibility of ensuring that Reserve assessments take place before licensing can proceed.

The CD:RDM identified the Inkomati Water Management Area (WMA) as requiring a comprehensive Reserve assessment in light of the initiation of the Compulsory Licensing Process in the WMA and the proposed Montrose and Mountain View Dams. This will assist the DWAF to make informed decisions regarding the authorisation of future water use and the magnitude of the impacts of the present and proposed developments.

Although the scope of this study was focussed on the riverine water resource, a desktop scoping assessment and prioritisation of wetlands for further Reserve studies within the catchment was also included. This was undertaken because the Department of Water Affairs is the custodian of all water resources, including wetlands. Whereas previously the lack of data and methods limited the extent to which wetlands could be included, recent advances in these areas meant that the DWA could now start to include wetland assessments in their studies and thereby support a more holistic and integrated approach to water resource management.

The Inkomati WMA is largely located within the Mpumulanga Province. It can be considered to consist of three largely independent catchments, the Komati, Crocodile (East) and Sabie–Sand River catchments. All these rivers drain the WMA and confluence to form the Inkomati River in Mozambique which flows into the Indian Ocean. The focus of the riverine component of this study is the Crocodile (East) and Sabie-Sand River catchments as the Inkomati river system had already been dealt with during a previous Reserve assessment study (Afridev, 2006). The wetlands for the Komati subsystem was addressed during 2002 (Godfrey, 2002) as part of the Comprehensive Reserve study. In light of the development of a new approach to wetland scoping studies for the Reserve and the availability of new data, it was decided to include the Komati catchment in the project scope for this task only. This will ensure that all the wetland information is at the same level and that consistent methods were applied.

Although the study was focussed on the riverine water resource, a desktop scoping assessment of the wetlands within the catchment was also included as part of the overall catchment study. This was undertaken because the Department of Water Affairs is the custodian of wetlands and is mandated to ensure the conservation, protection and sustainable utilisation of wetlands. Development and landuse activities that impact directly upon wetland systems require authorisation from the department in the same way as abstractions from rivers. Whilst wetlands are known to perform a variety of beneficial services for society (Mitsch and Gosselink, 1993), globally and in South Africa, wetlands are often heavily degraded due to intensive and sometimes inappropriate landuse practices. This is often exacerbated in more arid parts of the country where few wetlands are generally present and the availability of surface water, and wetter landscapes for cultivation, are in short supply.

1.2 INTRODUCTION TO WETLANDS

Whilst wetlands are known to perform a variety of beneficial services for society (Mitsch and Gosselink, 1993), globally and in South Africa, wetlands are often heavily degraded due to intensive and sometimes inappropriate landuse practices. Global assessments indicate that a large proportion of wetlands have been destroyed and the majority of remaining wetlands are degraded or under threat of degradation (Finlayson and Spiers, 1999). This is often exacerbated in more arid parts of the country where few wetlands are generally present and the availability of surface water, and wetter landscapes for cultivation, are in short supply.

The DWA is mandated through the National Water Act (Act 36 of 1998) to ensure the conservation, protection and sustainable utilisation of wetlands. For effective implementation of the National Water Act, but also for a wider range of activities such as conservation planning and management, it is important that the ecological condition, and importance and sensitivity of wetlands be determined and managed. In addition to the requirements of the National Water Act, South Africa is a contracting party to the Ramsar Convention on Wetlands and therefore has an obligation to promote the conservation and responsible use of wetlands. Despite this, more than half of the country's wetlands are estimated to have been destroyed or converted into areas of lower functional importance (Department of Environmental Affairs (DEA): http://soer.deat.gov.za/themes.aspx?m=149, accessed December 2009). The assessment and monitoring of wetland condition is therefore an important component in managing the use of wetlands (Ramsar Convention, 2002).

What is a Wetland?

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

Wetlands are essentially an expression of the presence of surface or near-surface water in the landscape. This water can either be static (e.g. pans) or slowly moving through the landscape. The source of the water can include surface flow, interflow (water flowing through the soil profile), groundwater (including deep and/or perched groundwater), direct rainfall, or any combination of these. Whatever the source, the water must be present for long enough to influence both the soil properties and the vegetation. In practice, the wetland boundary is defined as the position in the landscape where hydric indicators occur in the soil within 0.5 m of the surface (DWAF, 2005). Where these hydric indicators are deeper than 0.5 m, they generally do not support wetland adapted plants. Thus, the 0.5 m measurement traditionally forms the boundary between terrestrial and wetland adapted plant species (DWAF, 2008a).

1.3 PURPOSE OF THE WETLAND STUDY

The purpose of this study was to identify the location and types of wetlands within the Mokolo catchment, conduct a scoping level assessment of these wetlands and identify those wetlands which required more detailed Reserve Studies.

Following the development of new approaches for catchment wetland assessments developed in conjunction with other DWA:RDM studies, the scope of the study was expanded to include desktop assessments at the quaternary catchment level to estimate average PES and EIS categories for wetlands within these quaternary catchment areas.

The study was thus largely a desktop-level description and classification assessment which provides low confidence information on the wetlands within the study area that can be used for RDM and other DWA processes. A more detailed inventory of the wetlands within the study area; especially in the upper catchment (Wetland Resource Unit 1) would greatly improve the ability of the DWA and other departments associated with the management and regulation of use of wetlands to enact their respective mandates. At present the limited knowledge of the exact location and size of wetlands in the catchment remains a limitation to enactment and enforcement of protection and regulation policies.

1.4 STRUCTURE OF THE REPORT

The report consists of the main Wetland (this report) which is outlined below. Specialist appendices (Appendix B – C) are provided separately as a MS Word file in electronic format (Report 26/8/3/10/12/016) which will accompany the main report (Report 26/8/3/10/12/015) of this study. The tables provided in Appendix B and C are also available in Excel format as part of the electronic information.

This report combines various aspects that relate to the wetlands of the Inkomati catchment. The chapters are summarised as follows:

1.4.1 Chapter 1: Introduction

This chapter provides background and purpose of the study.

1.4.2 Chapter 2: Study area

This chapter provides an overview of the study area.

1.4.3 Chapter 3: Methods

This chapter outlines the methods followed for the wetland component. Methods are outlined for the identification of wetlands in the study area, the classification system applied, the approach for the delineation of Wetland Resource Units, and the desktop quaternary catchment PES and EIS assessment.

1.4.4 Chapter 4: Results: Desktop wetland PES and EIS

Results from the desktop PES and EIS assessments of the wetlands at quaternary catchment scale are provided.

1.4.5 Chapter 5: Results: Wetland Resource Units

The characteristics of the Wetland Resource Units that were identified are described. A Wetland Resource Unit is an area of a catchment that has wetlands with similar characteristics, processes and also broadly similar sensitivities to particular developments and impacts.

1.4.6 Chapter 6: Priority wetlands in the Inkomati Catchment

Priority wetland systems or regions are highlighted.

1.4.7 Chapter 7: Recommendations for wetland management

Recommendations for the management of wetlands are provided.

1.4.8 Chapter 8: Application of data

This chapter provides detail on how the data can aid in management strategies and decisions.

1.4.9 Chapter 9: References

1.4.10 Appendix A: Description of the HGM wetland types

This appendix provides a detailed description of the different Hydrogeomorphic (HGM) wetland types identified at level III of the wetland typing system employed in this study.

1.4.11 **Appendix B: Detailed PES tables per quaternary catchment** (provided electronically)

These tables provide the raw data and motivations for scores for the quaternary catchment wetland PES assessment.

1.4.12 **Appendix C: Detailed EIS tables per quaternary catchment** (provided electronically)

These tables provide the raw data and motivations for scores for the quaternary catchment wetland EIS assessment.

2 STUDY AREA

The Inkomati River and its primary tributaries rise in the western part of the Water Management Area and flow eastwards. Major rivers within the Inkomati WMA include the Komati, Crocodile (East) and Sabie Rivers (Figure 2-1). The Elands, Kaap, Wit, Nelspruit and Mbeyameti Rivers are large tributaries of the Crocodile River, whilst the smaller Sabie River Basin has the Sand and smaller Marite River as tributaries.

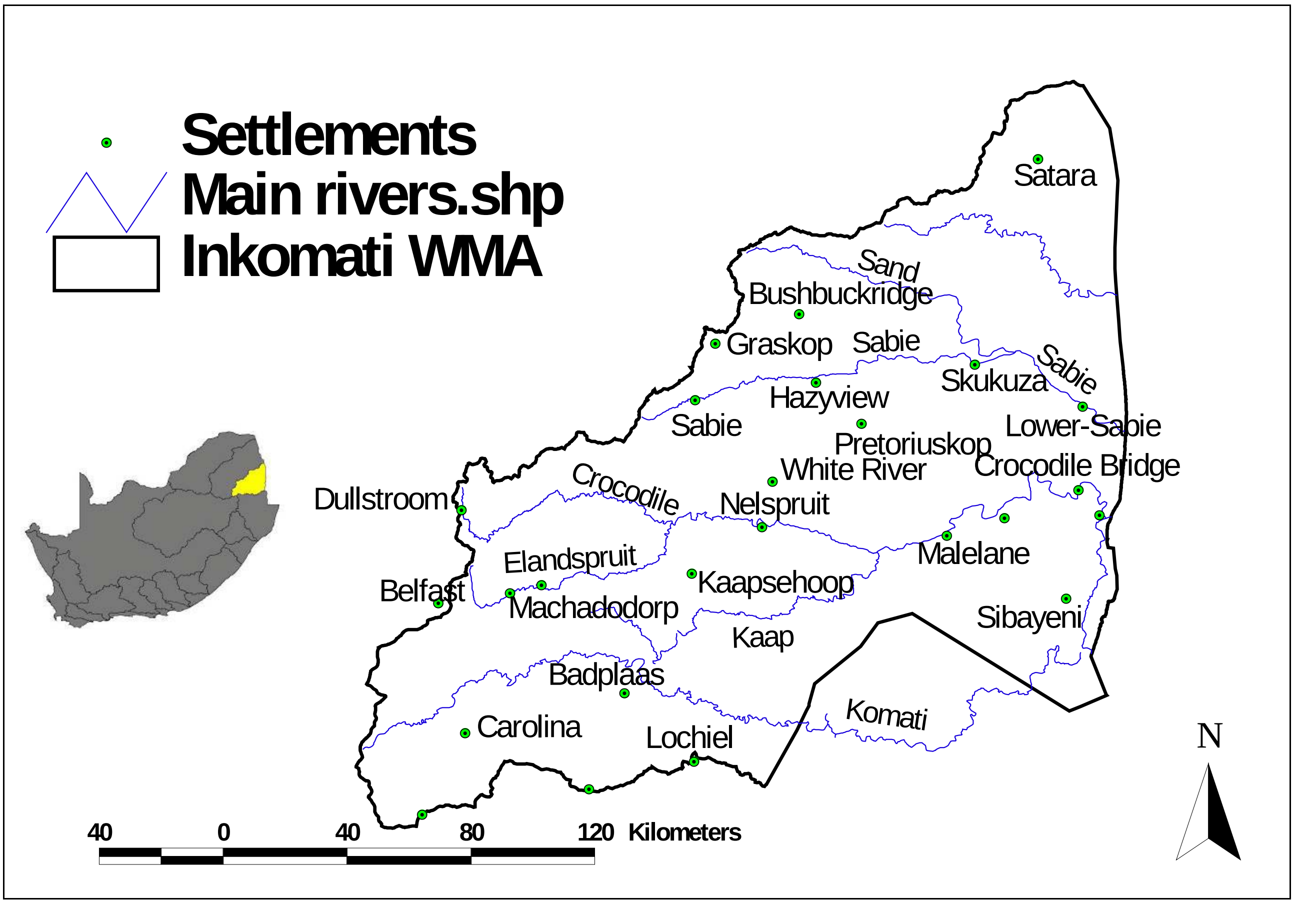

Figure 2-1 Main rivers and towns within the Inkomati Water Management Area.

Annual rainfall across the catchment is very high in the western and central western sections of the WMA and then declines to as little as 400mm in the rainshadows of the Lebombo mountains in the extreme north east of the catchment. There is thus a west-east aridity gradient across the WMA which to some extent mirrors the elevation gradient. The WMA is divided into the high elevation, high rainfall, flat eastern upper escarpment area; the mountainous (central west) and hilly (central) areas and the low rainfall undulating lowland areas to the east (Figure 2-2). The topography of the catchment indicates more undulating south-east and western areas of the catchment where conditions for wetland development could be expected to be more favourable. The centre and central west sections of the WMA are hilly (centre) to mountainous (central west). In general, very steep slopes do not promote the development of wetlands due to high, fast runoff and shallow soils.

Twelve Tertiary catchments (X11-14; X21-24; X 31-33 and X40) and 100 Quaternary catchments are found within this WMA (excluding the catchments located inside Swaziland) (Figure 2-3).

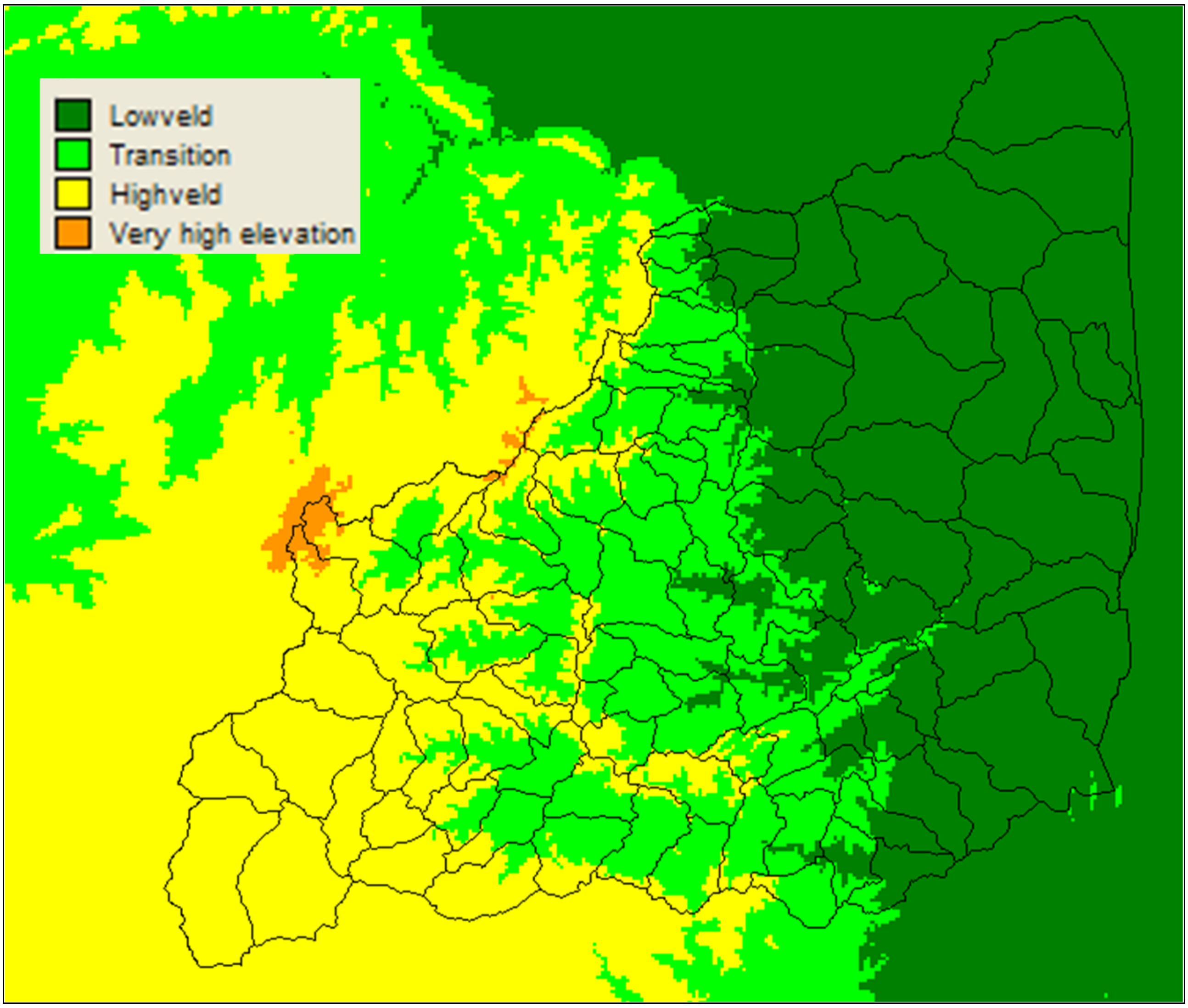

Figure 2-2 Topography of the catchment.

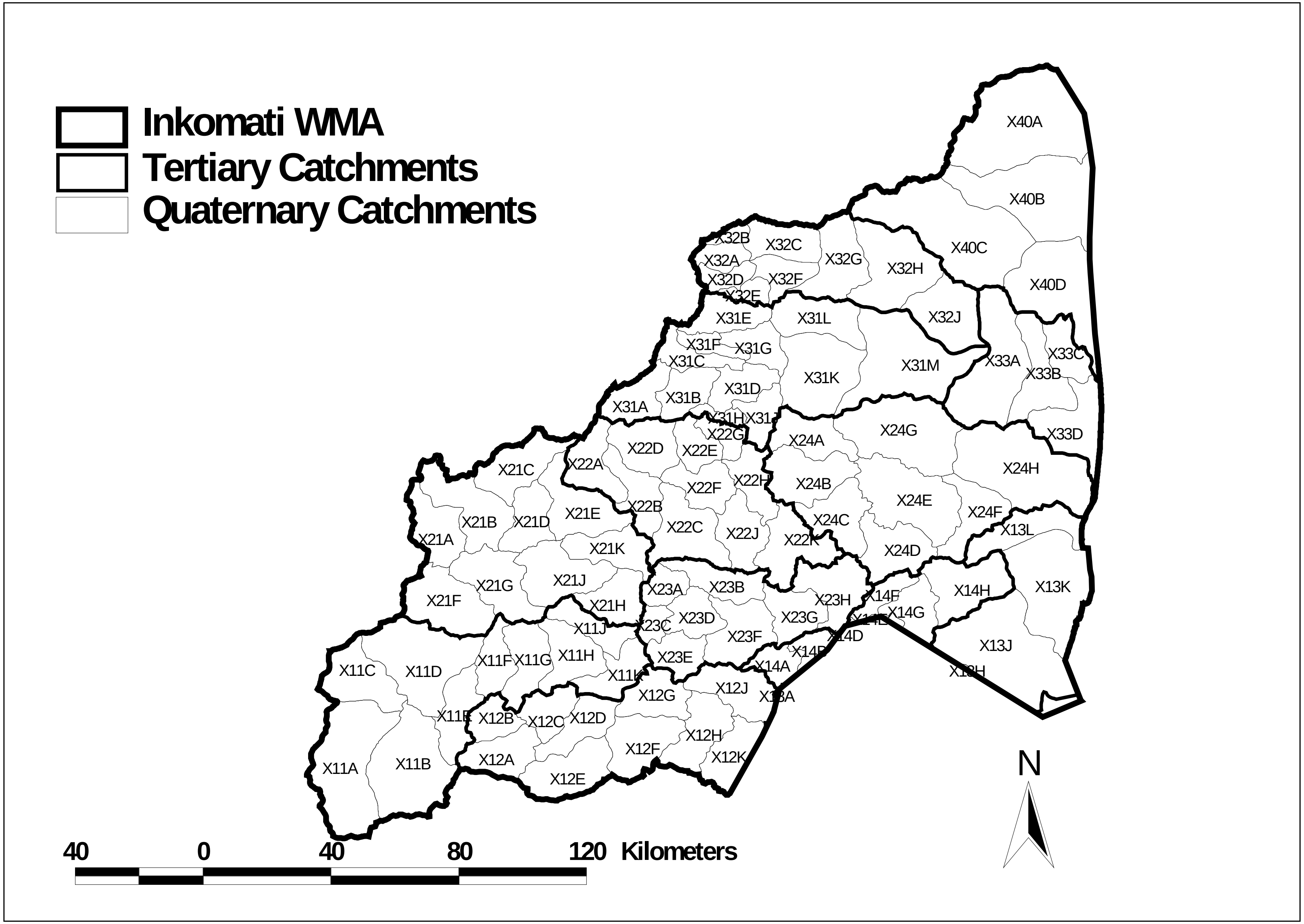

Figure 2-3 Quaternary catchments of the Inkomati River basin

2.1 ECOREGIONS

EcoRegional classification or typing allows the grouping of rivers according to similarities based on a top-down approach. The purpose of this approach is to simplify and contextualise assessments and statements on Ecological Water Requirements, allowing for extrapolation of information from data rich systems to similar systems within the same hierarchical typing which may be poor. It is assumed that, to some extent, the same potential exists for application to wetlands, and thus EcoRegions are used to guide the delineation of wetland resource units where appropriate.

Two levels of EcoRegion classification are available for South Africa. Level I delineates boundaries at a very broad scale using attributes such as physiography, climate, rainfall, geology and potential natural vegetation. Eighteen Level I EcoRegions were identified across South Africa (Kleynhans *et al*., 2005) and six of these are present within the Inkomati catchment (Figure 2-4):

- The Highveld and Eastern Bankenveld which characterise the upper sections of the WMA,
- The Northern Escarpment Mountains EcoRegion which separates these upper zones from the North Eastern Highlands; and
- The gently undulating Lowveld, the largest of the EcoRegions in this WMA, and the Lebombo Uplands, which are found in the low lying eastern sections of the WMA.

The Level II EcoRegion classification provides a higher resolution of expected biological units (Kleynhans *et al*., 2007). Thirteen Level II EcoRegion zones are present in the Inkomati WMA (Figure 2.5).

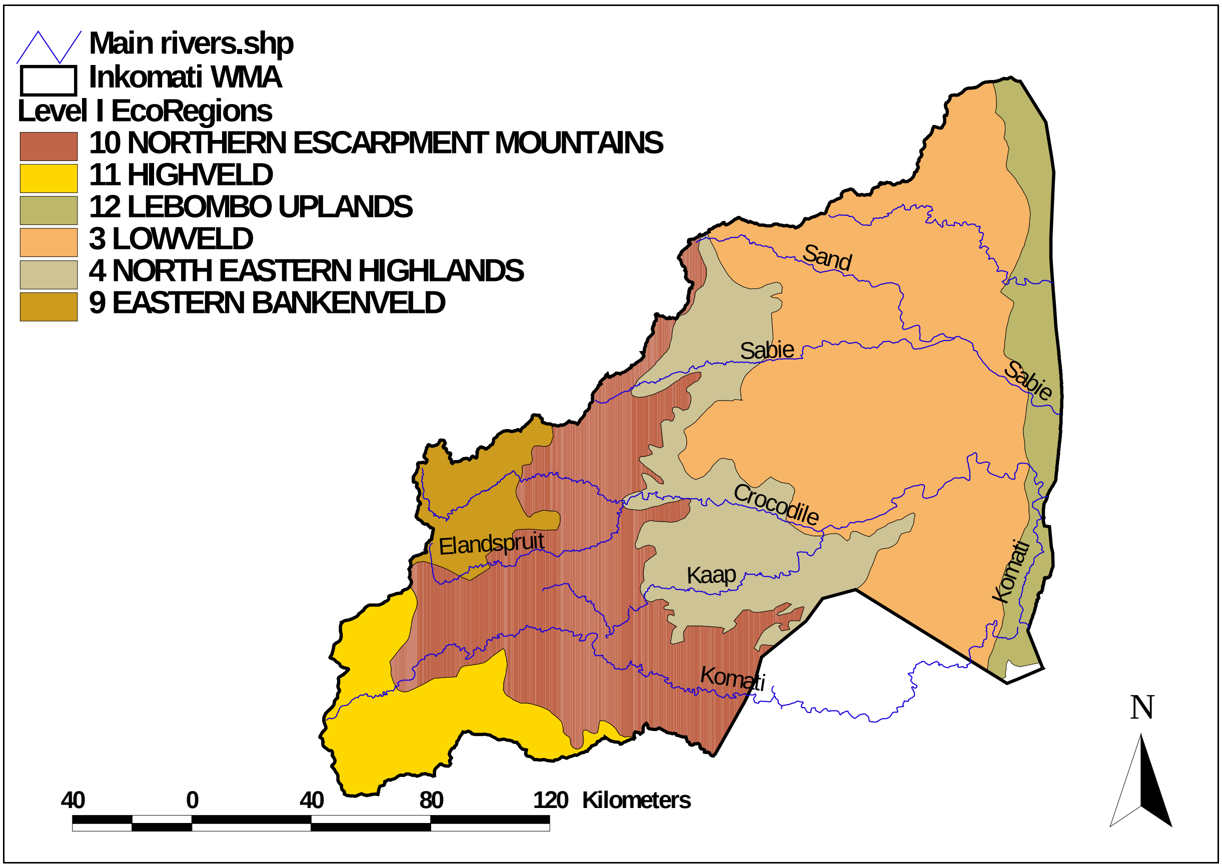

Figure 2-4 Level I EcoRegions of the Inkomati Catchment

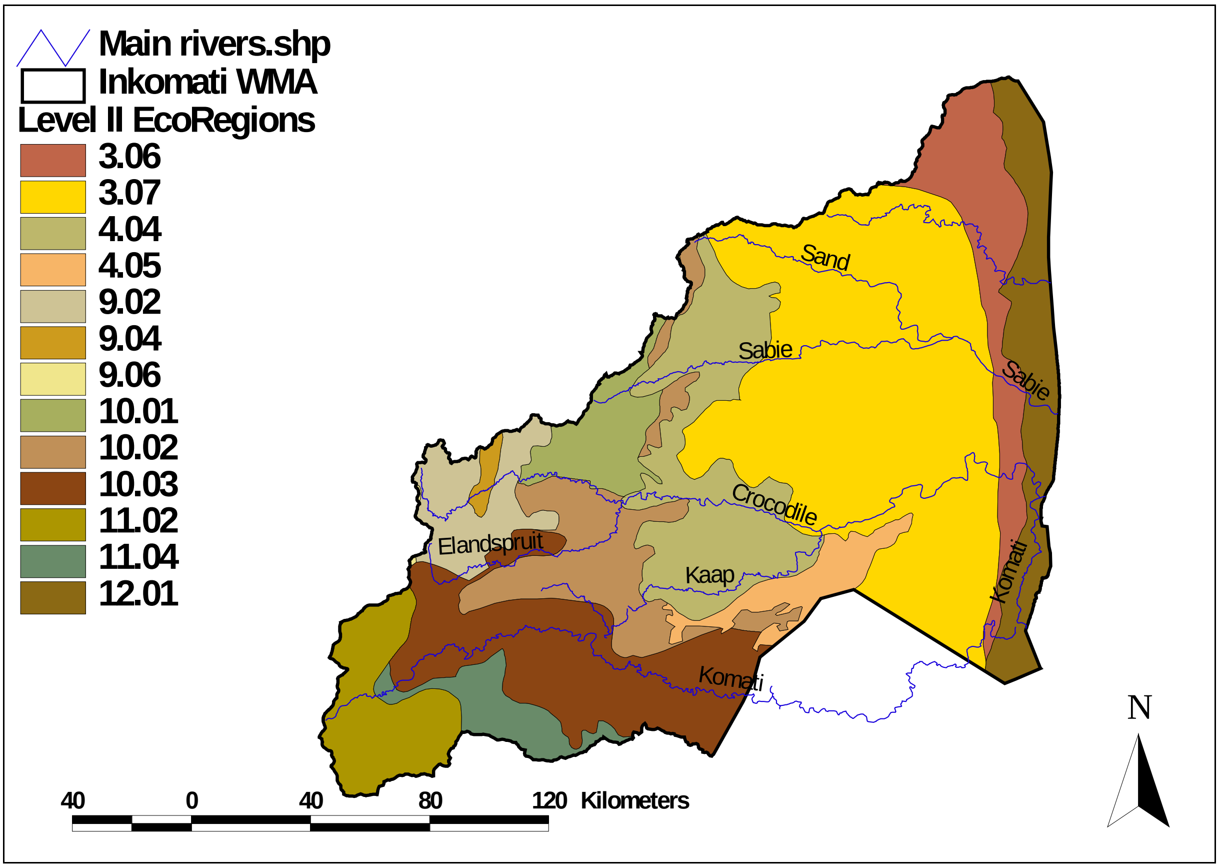

Figure 2-5 Level II EcoRegions of the Inkomati Catchment

2.2 GEOLOGY

Underlying geology is an important determinant of wetland type and densities found within a region, since the geology controls the landscape slopes, valleys and hills or mountains which occur; the distribution of groundwater (dependent on the porosity of the underlying rock) and indirectly controls infiltration though the soils which weather from the underlying rocks. The soils and landscape morphology can either promote or inhibit the occurrence of wetlands through high or low soil infiltration (and resultant interflow importance) capacities respectively.

Much of the Inkomati catchment is underlain by granites (Figure 2-6) which tend to produce shallow sandy soils underlain by clays. When the valley side and longitudinal gradients are sufficiently flat, this association of sandy upper and clay-rich lower soil horizons creates ideal conditions for infiltration into the upper sandy horizons and perched subsurface water flows (interflow) above the more impervious clay layers. Thus where granitic landscapes are not too steep and receive sufficiently high rainfall, perched subsurface flows develop and extensive hillslope seepage and valley bottom wetlands result. These same processes are repeated in other geologies where shallow infiltration is promoted (by sandy soils and low slopes) but deep infiltration is impeded (by underlying impervious layers) and the resultant subsurface interflow is forced to or close to the surface enabling the development of hydric soils and associated wetland conditions.

The upper (south western) section of the WMA is dominated by sedimentary rocks (arenite, a sandstone conglomerate that yields highly porous soils, and shales). Intrusions of harder rocks such as quartzite and dolerite also occur, with a band of dolomite and quartzite running north-south along the escarpment. Dolomites are usually associated with significant groundwater recharge and point source groundwater discharges (springs or eyes).

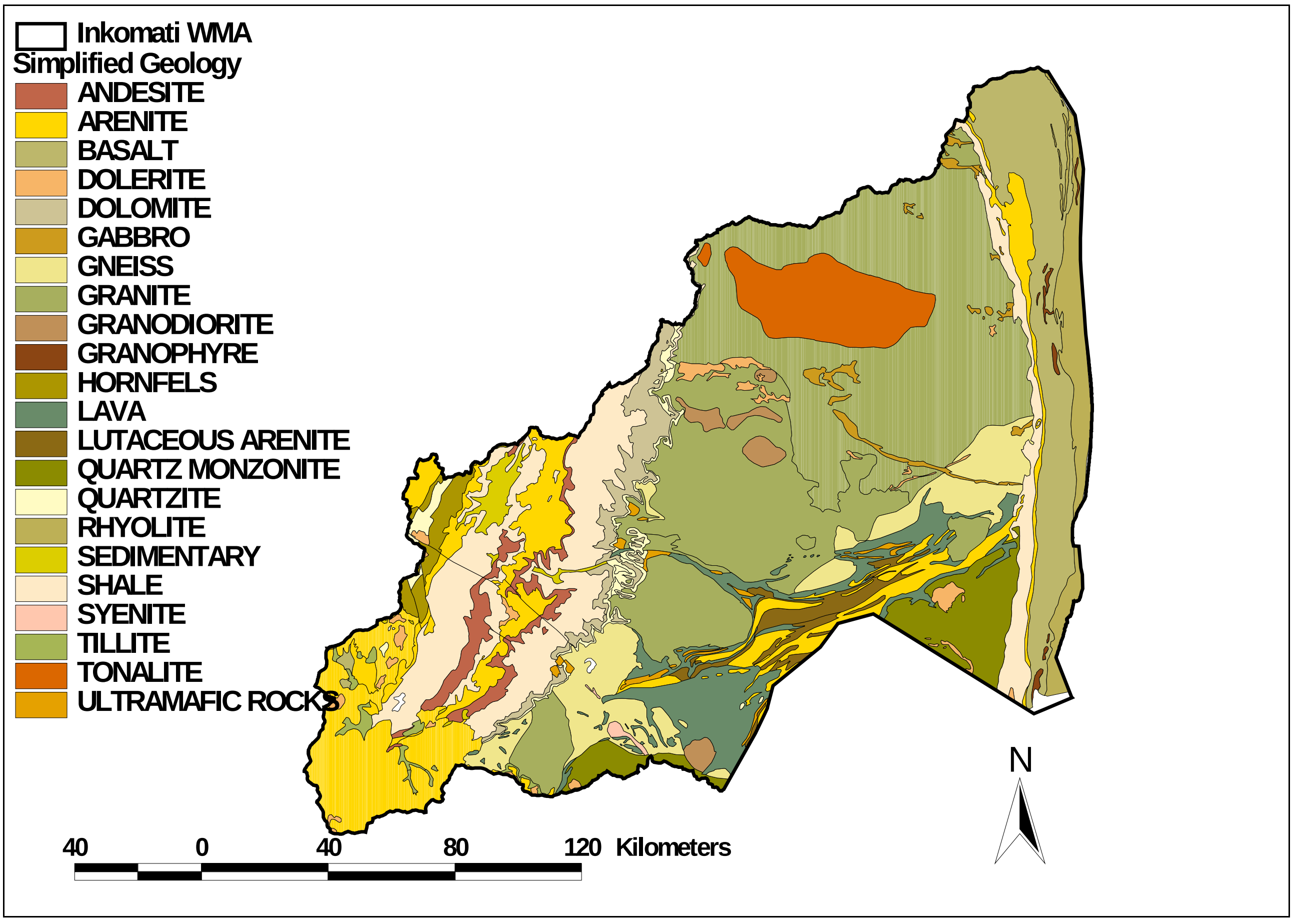

Figure 2-6 Simplified Geology of the Inkomati River catchment.

2.3 VEGETATION

At a broad scale, the WMA is composed of grasslands in the higher-lying, high rainfall western half of the WMA and Savanna in the drier, lower-lying eastern half, with small pockets of forest occurring along the escarpment zone (Figure 2-7). These broad distinctions have been sub-divided into several vegetation types (Figure 2-8) by Mucina and Rutherford (2006). The Eastern Highveld Grasslands in the western margin of the WMA, and the Legogote Sour Bushveld and Northern Escarpment Dolomite Grasslands of the middle (escarpment) zones have an “Endangered” conservation status (Figure 2-9), and it can be assumed that any wetlands located within these vegetation type units have been similarly impacted by the landuse activities which have resulted in the very poor conservation status of the vegetation types.

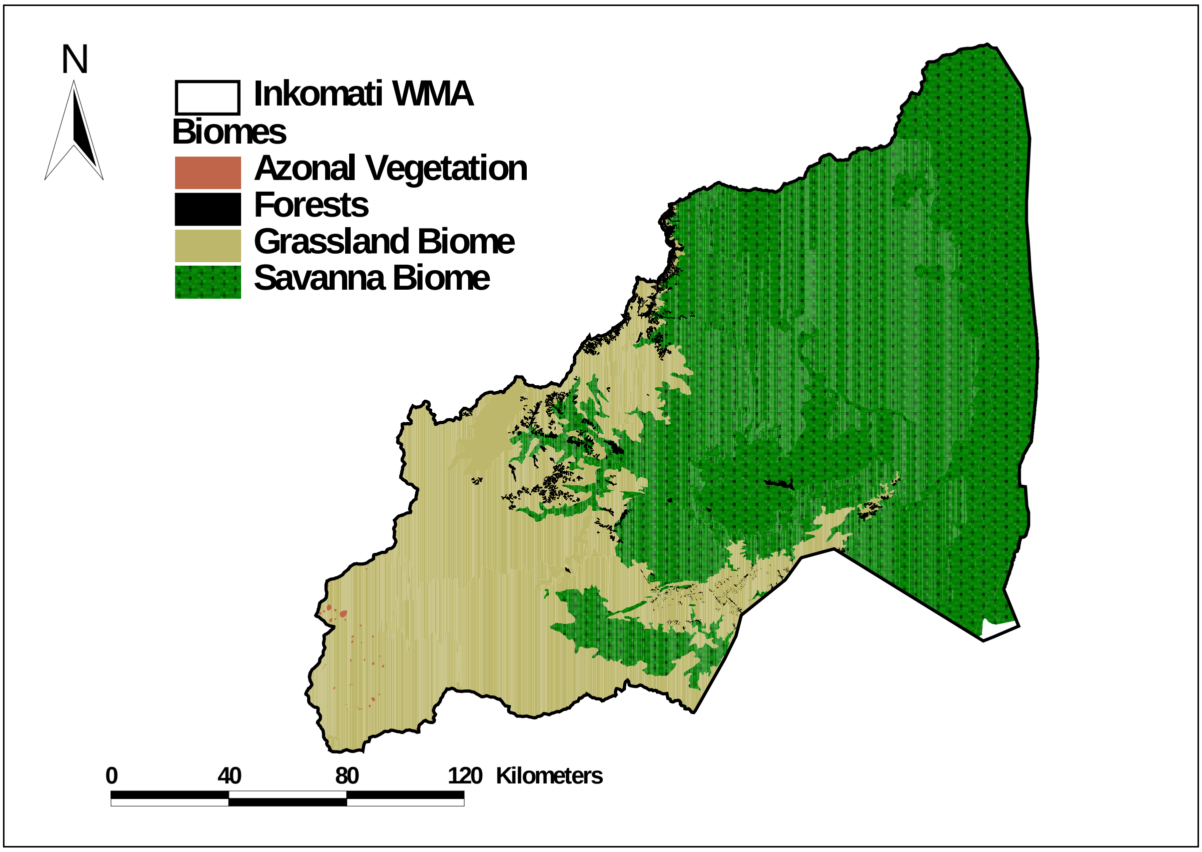

Figure 2-7 Biomes of the Inkomati Water Management Area (after Mucina and Rutherford, 2006)

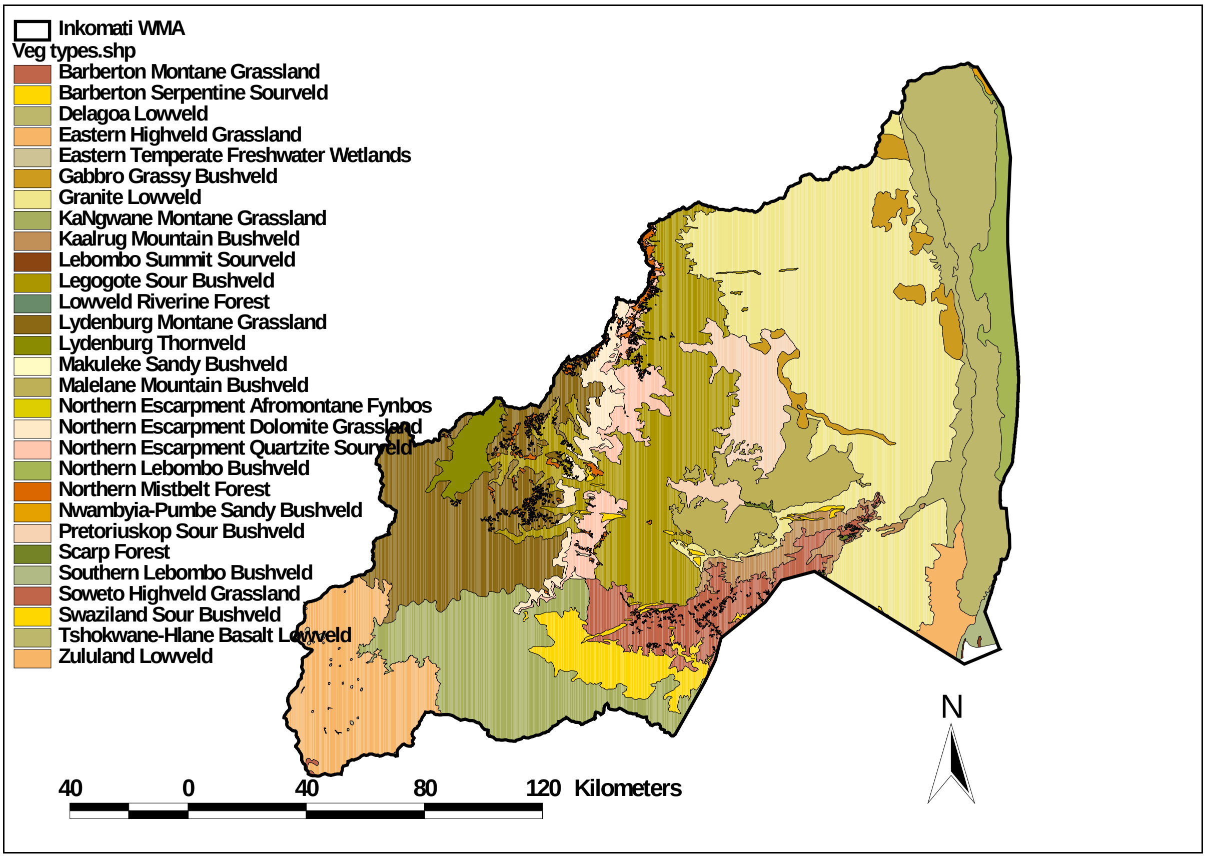

Figure 2-8 Vegetation types across the Inkomati catchment (after Mucina and Rutherford, 2006)

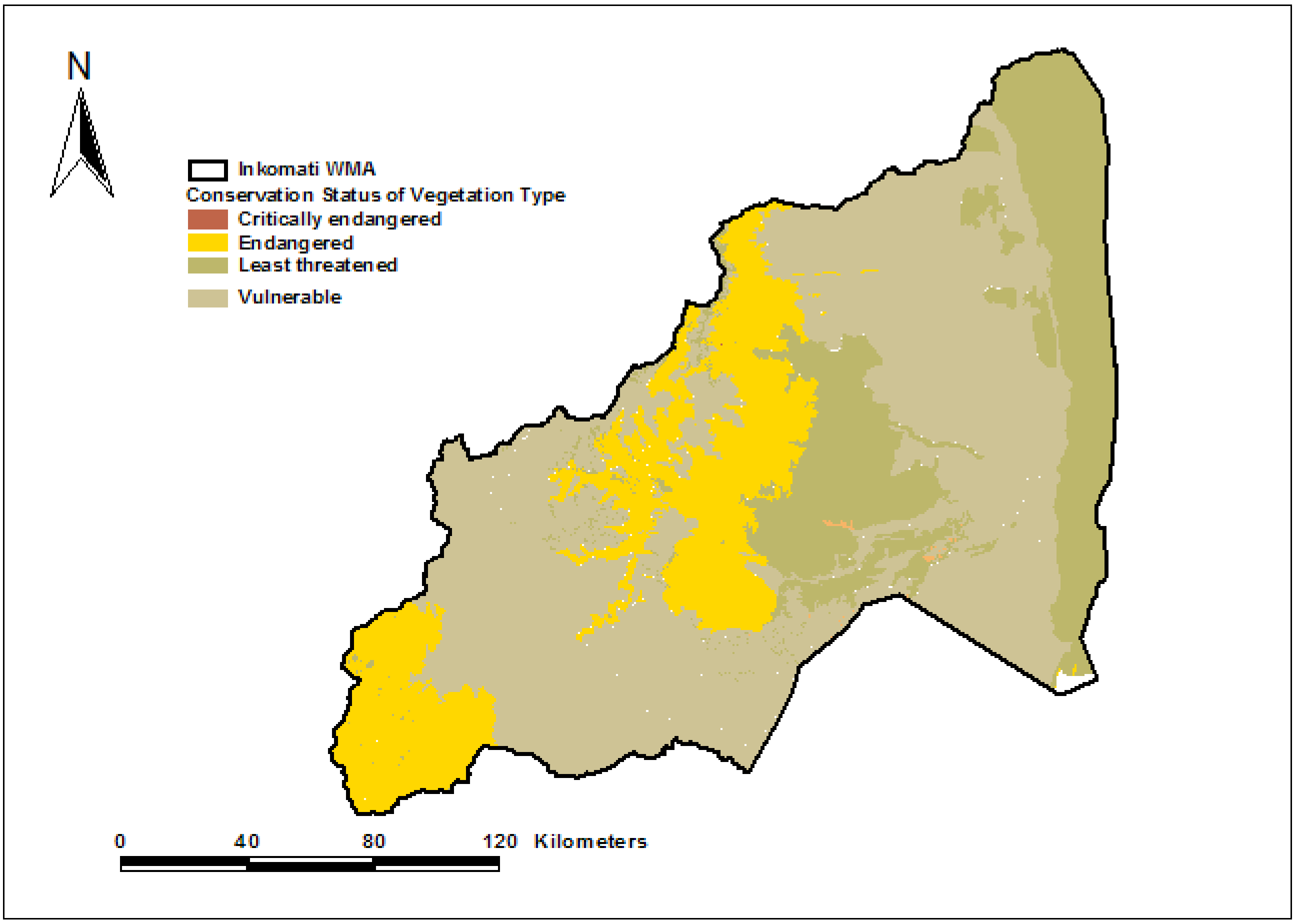

Figure 2-9 Conservation Status of Vegetation Types within the WMA (after Mucina and Rutherford, 2006)

3 METHODS

3.1 IDENTIFICATION AND DESCRIPTION OF WETLANDS IN THE CATCHMENT

The most up-to-date version of the South African National Biodiversity Institute's (SANBI) Wetland Probability Map (SANBI, draft), was used as a first-level assessment of wetland occurrence within the study area. These data are not ground-truthed, and should thus be treated with caution. Although the wetland scoping study for this catchment precluded a catchment-wide wetland identification, classification and mapping exercise, the available SANBI map does provide a good indication of relative wetland occurrence, size and density across the study area. This information was also improved by using the wetland distributions, types and sizes obtained from 1:50 000 topographical maps, Google Earth and a rapid field verification trip.

The wetland probability map (SANBI, draft) provided the locations of many possible wetlands, and these could be verified in the field. Additional remote verification using Google Earth imagery allowed the main wetland types to be identified across the catchment.

3.1.1 Rapid field assessment for Desktop verification

A rapid ground-truthing trip was undertaken during January and February 2010 to verify the presence and identify the types of wetlands indicated in the catchments by the available data. This field verification entailed criss-crossing the catchment and making notes of the type, location and condition of wetlands within the sub-catchments as well as rapidly assessing the types and severity of impacts that are imposed by the surrounding landuse practices.

The findings of the field verification were used to refine the understanding generated from the desktop component of the study, and to inform the description of wetland types; impacts and general condition; the quaternary PES and EIS assessments and the delineation of the Wetland Resource Units.

3.1.2 Description of HGM Wetland Types

Landform (geomorphological setting or landscape position) and wetland hydrology (the way water flows into, through and out of a wetland system) (Table 3.1) are commonly-acknowledged as the fundamental determinants of the existence of wetlands (Brinson, 1993; Semeniuk and Semeniuk, 1995; Finlayson *et al*., 2002; Jones, 2002; Kotze *et al*., 2005, Ellery *et al*., 2005). Since not all wetlands behave the same way, it is necessary to type or classify them in order for them to be effectively managed. Wetland classification systems based on geomorphic and hydrologic aspects are regarded as more robust and consistent than those based on other criteria (Finlayson *et al*., 2002) because they describe the fundamental reason for the existence of a wetland in a landscape and some insight in to their underlying drivers. These characteristics – hydrology and geomorphology - are the foundation for hydrogeomorphic (HGM) classification systems for wetlands (e.g. Brinson, 1993; Semeniuk and Semeniuk, 1995).

The generic international HGM classification systems for wetlands cited above have previously undergone some adaptations for application in South African Palustrine wetlands (Marneweck and Batchelor, 2002; Jones and Day, 2003; Kotze *et al*., 2005; Ewart-Smith *et al*., 2006). For a review of these adaptations refer to DWA (2007). The HGM classification system employed in this study (Table 3.1) is considered to be robust and simple enough to allow for application by DWA and DEA technicians and regional staff. Correct identification of the wetland type is expected to carry a number of consequences for management decisions (for instance, such as how, and at what level, WULAs are to be handled), and thus the classification system must be reliable.

This system was also adopted because it allows for effective classification at the desktop level where data and budget are limited, as in this study. On the basis of desktop information and interpretation thereof, it is possible to distinguish a number of different wetland types according to the landscape position in which they are found, and on the assumed flow patterns or hydrological characteristics that typify those HGM wetland types. A detailed description of each HGM wetland type is provided in Appendix A.

Table 3.1 A wetland typing system for inland wetlands of South Africa (Rountree and Batchelor, in prep.)

Landscape setting		Flow pattern within wetland	HGM Wetland Type
Valley Bottoms	Confined	Channeled	River
		Standing water	Lake
	Unconfined	Diffuse	Unchanneled Valley Bottom
		Channeled (parallel to valley)	Channeled Valley Bottom
		Channeled (meandering across valley; Sinuosity Index > 1.5)	Meandering Floodplain
Slopes		Diffuse => diffuse	Seepage (isolated)
		Diffuse => surface/channel	Seepage (connected to channel)
Crests		Diffuse flow => standing water	Seepage (connected to pan)
		Standing water	Pan
Flats		Standing water	Wetland flat

3.2 DESKTOP QUATERNARY CATCHMENT SCALE ASSESSMENTS

Since there are too many wetlands to evaluate on an individual basis, a desktop level assessment of the average PES and EIS of the wetlands in the Mokolo Catchment was undertaken for each quaternary catchment. A desktop scoring system for quaternary catchment scale PES and EIS determination was developed during this and a parallel (DWA, 2009) study for this purpose.

3.2.1 Desktop PES assessment of the wetlands at quaternary catchment scale

Low confidence desktop assessments of the Wetland PES and EIS were conducted for each of the quaternary catchments of the study area, using approaches based on similar desktop assessments of quaternary scale for rivers and tributaries (Kleynhans, 2000). These were done to provide an overview of the present ecological state of wetlands across the study area.

The impact criteria from the Wetland Index of Habitat Integrity (Wetland IHI) PES assessment tool (DWAF, 2007) were divided into those that needed to be considered at the catchment scale and those that needed to be assessed at the individual wetland unit (i.e. within-wetland) scale (Table 3.2). Each was rated on a scale of 0 (no impact evident) to 5 (the maximum possible extent or intensity of impact possible) for each quaternary catchment. An average weighted score for each quaternary catchment was then calculated and PES categories (Table 3.3) assigned using the approach of Kleynhans (2000). These results yield an average PES category for all wetlands within the relevant quaternary catchment.

Table 3.2 Criteria (potential impacts) assessed for the desktop wetland PES assessment

Criteria assessed at the quaternary catchment scale
Afforestation/Invasive plants
Dams, irrigation, other flow reduction activities
Extent of Urbanisation/catchment hardening
Mining/urban/cropping - water quality factors
Criteria assessed within the wetlands:
Invasive plants
Landuse activities (mining-cropping-grazing)
Altered hydrology (drains/dams)
Erosion of wetlands

Table 3.3 Generic ecological categories for EcoStatus components (after Kleynhans, 1996 and Kleynhans, 1999)

PES 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. 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 has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is 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 cases the basic ecosystem functions have been destroyed and the changes irreversible.

3.2.2 Desktop EIS assessment of the wetlands at quaternary catchment scale

An adaptation of the river quaternary desktop EIS assessment tool (Kleynhans, 2000) was adapted for use in determining the EIS of wetlands at the quaternary catchment scale. Criteria that could be assessed using available desktop information were identified (Table 3.4). These were rated from low (score of 1) to very high (score of 4). An average weighted score for each quaternary catchment was then calculated and EIS categories (Table 3.5) assigned.

Assessment of site-specific criteria and/or those that require field-data such as direct human benefits (e.g. grazing, subsistence agriculture, etc.) and the potential hydrological functional importance of wetlands (such as flood attenuation or flow regulation) were precluded from the desktop assessment because these could not be reliably assessed at the quaternary catchment scale.

Table 3.4 The list of criteria used to derive the quaternary scale EIS scores for wetlands. Each criterion was rated from 1 (none) to 4 (very high)

Ecological Importance and Sensitivity criteria
Diversity of wetland types
Density of wetlands
Unique wetlands – size; type etc.
Species Richness
Importance of conservation and natural areas
Migration route/corridor - links to other systems
Rare/endangered/unique populations

Ecological Importance and Sensitivity criteria
Sensitivity to water quality changes
Sensitivity to upstream flow changes
Dependence on Groundwater

Table 3.5 Generic Ecological Importance and Sensitivity categories for EIS components

EIS Category	Description
Very High	Wetlands that are considered ecologically important and sensitive on a **national or even international** level. The biodiversity of these systems is usually very sensitive to water and habitat modifications. They are likely to also play a major role in moderating the quantity and quality of water of major rivers.
High	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They are likely to also play a role in moderating the quantity and quality of water of major rivers.
Moderate	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They are likely to also play a small role in moderating the quantity and quality of water of major rivers.
Low	Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They are not likely to play a significant role in moderating the quantity and quality of water of major rivers.

3.3 IDENTIFICATION OF WETLAND RESOURCE UNITS

A modification of a hierarchical system for the classification of South African wetlands (Ewart-Smith *et al.*, 2006, with updates by SANBI, 2009) was used to group the numerous individual HGM wetlands identified in the catchment. This modified classification system (DWAF, 2007; Rountree and Batchelor, in prep.) can be easily applied at the desktop level and relies on the underlying smaller scale HGM classification described above.

Three levels of the classification system are appropriate for large-scale studies. At the smallest scale, individual wetlands can be classified according to their hydrogeomorphic characteristics (Table 3.6). These individual wetland units can be nested within a larger (Level II) scale of classification of wetland resource units (Table 3.6), and these in turn can be nested within the very large scale Level I classification of wetlands (all wetlands in this study fall under the Level I: Inland System unit).

The Level II: Wetland Resource Units (Table 3.6) were identified and delineated using the following information:

- Level I (Kleynhans *et al*., 2005; Figure 2-4) and Level II (Kleynhans *et al*., 2007; Figure 2-5) EcoRegion information.
- Regional geological series (Figure 2-6).
- Vegetation distribution data (Mucina and Rutherford, 2006, Figure 2-8).
- 1:50 000 topographical maps.
- Information on relative wetland density (Figure 4-1), size, type and condition (as derived from Google Earth imagery and results of the rapid field verification trip).

Table 3.6 The nested hierarchical classification system

Level I: System	Level II: Wetland Resource Units		Level III: Wetland HGM Types
INLAND	Geomorphic Province/EcoRegion (as defined by the Driver *et al.*, 2004)	Dominant Geology (from 1:250 000 maps)	River
			Lake
			Meandering Floodplain
			Channeled Valley Bottom
			Unchanneled Valley Bottom
			Hillslope seepages (connected)
			Hillslope seepages (isolated)
			Pan
			Flat

The common HGM wetland types, general PES and EIS information (derived from the component quaternary PES and EIS assessments within the Wetland Resource Units) and risks posed by current landuse activities on the wetlands within the Resource Unit were identified and described.

3.4 IDENTIFICATION OF PRIORITY WETLANDS

Based on the information obtained in this study, wetlands or regions which are regarded as important (high PES and/or high EIS) and which are deemed to be at risk from current or expected future developments in the catchment were identified. Any systems thus identified were then considered in terms of prioritisation for future Reserve Determination or other similar assessment studies to provide strategic information for their management, protection and regulation of use.

In this study, Priority wetlands were identified based on high importance. The priority wetlands identified were highlighted through a consultative approach with D:RDM but this is by no means a result of a detailed inventory or widespread prioritisation process. The available budget precluded a widespread prioritisation study of wetlands for the WMA. Should a full prioritisation assessment of wetlands in this WMA be desired, or other priority wetlands come to light, it suggested that the recent approach adopted in the Upper Vaal Comprehensive Reserve Determination study be considered for adaption in this WMA whereby wetlands are prioritised relative to each other according to weighted scores relating to c size, functional importance, threat potential, ecological importance and other criteria.

4 RESULTS: QUATERNARY CATCHMENT WETLAND PES AND EIS

The purpose of the quaternary scale PES and EIS assessments is to provide some low confidence information on wetland condition and importance across the WMA. There are thousands of individual wetlands within the WMA (Figure 5-1), and the Department of Water Affairs may be called upon to evaluate any one of these as part of standard Water User Licence Applications. It is not feasible to conduct individual PES and EIS assessments on all wetlands within the WMA, so a quaternary-scale desktop assessment was developed to provide low confidence assessments of the expected average PES and EIS of all wetlands within the quaternary catchment.

Since the quaternary catchments are nested within the Wetland Resource Units, the characteristics of the latter can be used to inform the expected PES and EIS characteristics; specifically with regard to the likely sensitivities of the specific wetland types within each WRU to the different landuse impacts observed within the quaternary catchment.

4.1 PES AND EIS ATTRIBUTES OF THE WETLANDS OF THE INKOMATI WMA

A large proportion of the Inkomati WMA has been modified or transformed from its natural condition. The dominant land use is agriculture (pasture, dryland or irrigated cultivation) and forestry production, but there are also mining, urban and industrial activities. However, in the east and northern sections of the WMA there are large conservation areas, including the internationally renowned Kruger National Park.

Landuse transformations invariably degrade the surrounding and downstream wetlands through a combination of:

- Increased fires and grazing pressures.
- Channelization, erosion and drainage of wetlands.
- Effluent and stormwater disposal, and
- Direct water abstraction and afforestation which has indirectly reduced water supply.

The degradation of wetlands reduces biodiversity, ecosystem services (such as flood attenuation and water quality amelioration) and results in loss of harvestable resources. In the more arid, former homeland areas of the Inkomati WMA, poor communities are buffered from poverty by the goods and services derived from wetlands. The degradation of wetlands and associated reduced goods and service provision there from necessitates a dependence on other more expensive materials or sources of food. However, the increasing density and extent of these peri-urban areas is also impacting negatively on wetlands (the few that are present in this semi-arid part of the country).

The average wetland PES and EIS per quaternary catchment within the WMA has been determined (at desktop level) and these results are summarised in Table 4.1. The general PES and EIS trends per WRU are presented below based on the estimations per quaternary catchment located within the WRUs (Figure 4-1). High scoring PES scores (B and B/C) are in bold typeface and highlighted in dark grey. Specific detail per quaternary catchment is provided in Appendix B and C for the PES and EIS attributes respectively.

Table 4.1 Average EIS and PES per quaternary catchment

Quat	Desktop EIS	Desktop PES
X21A	**HIGH**	C
X21B	**HIGH**	C
X21C	**HIGH**	C
X21D	MODERATE	**B/C**
X21E	MODERATE	C
X21F	**HIGH**	**B/C**
X21G	MODERATE	C
X21H	MODERATE	C/D
X21J	MODERATE	D
X21K	MODERATE	D
X22A	MODERATE	C/D
X22B	LOW	C/D
X22C	MODERATE	D
X22D	MODERATE	C/D
X22E	MODERATE	C/D
X22F	MODERATE	C
X22G	MODERATE	C/D
X22H	MODERATE	C
X22J	LOW	D
X22K	LOW	C
X23A	MODERATE	C
X23B	MODERATE	C
X23C	MODERATE	C/D
X23D	MODERATE	C
X23E	MODERATE	C/D
X23F	MODERATE	C
X23G	MODERATE	C
X23H	LOW	C
X24A	LOW	D
X24B	LOW	D
X24C	LOW	**B/C**
X24D	LOW	C
X24E	LOW	**B**
X24F	LOW	**B**
X24G	LOW	A
X31A	LOW	D
X31B	LOW	D
X31C	MODERATE	D
X31D	MODERATE	C
X31E	MODERATE	D
X31F	MODERATE	C
X31G	LOW	D
X31H	MODERATE	C/D
X31J	LOW	D
X31K	LOW	D
X31L	LOW	D
X31M	LOW	**A**
X32A	MODERATE	D
X32B	MODERATE	D
X32C	LOW	D
X32D	MODERATE	D
X32E	MODERATE	D
X32F	LOW	D
X32G	LOW	D
X32H	LOW	C
X32J	LOW	**A**
X33A	LOW	**A**
X33B	LOW	**A**

Quat	Desktop EIS	Desktop PES
X33C	LOW	A
X33D	LOW	A
X40A	LOW	A
X40B	LOW	A
X40C	LOW	C
X40D	LOW	A

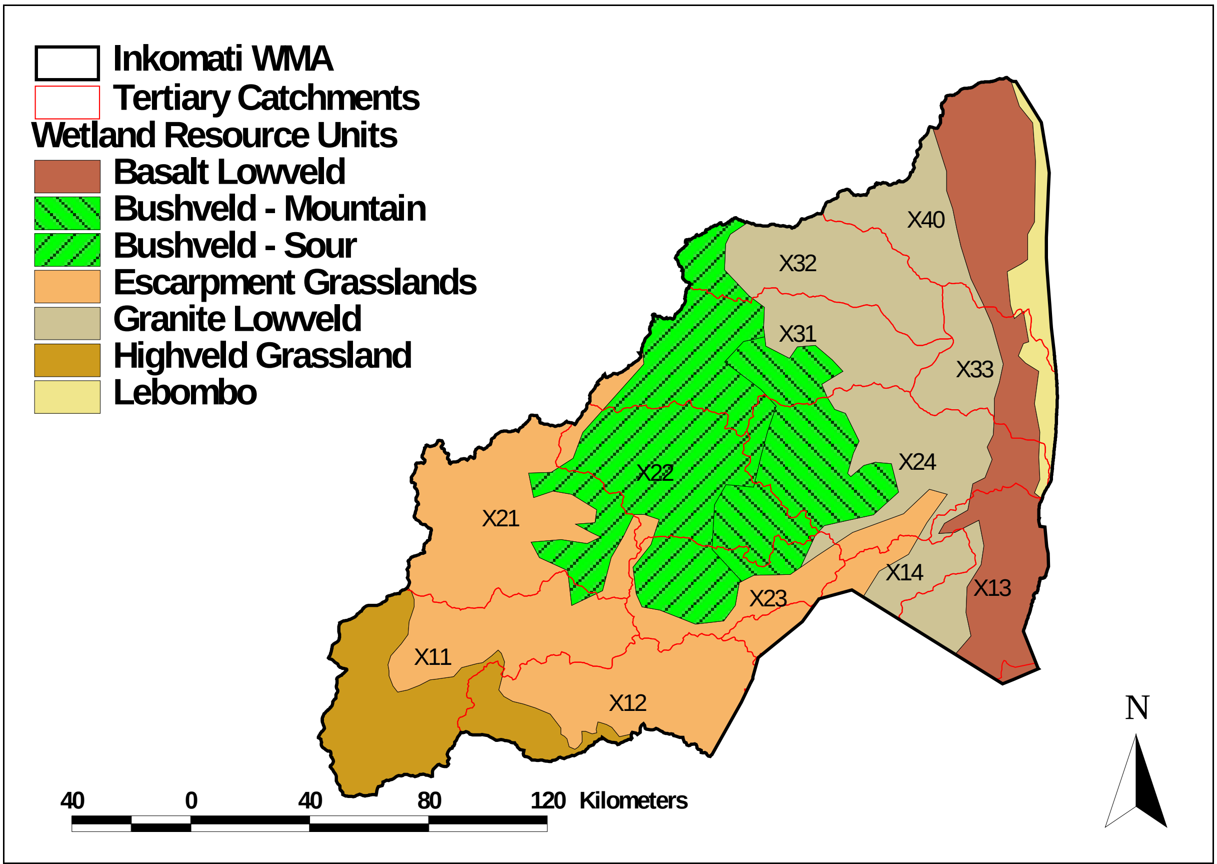

Figure 4-1 The distribution of quaternary catchments in relation to the Wetland Resource Units

4.2 LANDUSE, PES AND EIS OF THE HIGHVELD GRASSLAND WRU

The quaternary catchments located within the Highveld Grassland WRU (Figure 4-1) tend to have ***High EIS*** scores (Table 4.1). This is because

- Wetland density and diversity are very high here.
- There are a number very large pans, a relatively rare wetland type in this WMA.
- The vegetation type characterising this WMU is regarded as "Endangered" and it can be assumed that the wetland-dependent species within this vegetation type are similarly threatened.

In addition, some of these catchments are in close proximity to the important wetland area of Chrissiesmeer and the extended distribution of wetlands; particularly pans, is important for the wider ecological functioning of the area.

Impacts within this WRU are primarily associated with the widespread agricultural areas (water quality impacts; trampling/grazing, erosion of wetlands; and encroachment into and channelization of wetlands), but they also include water quality impacts from mining (Figure 4-2); limited impacts from invasive alien plants and the effects of dams drowning some wetlands and reducing water availability downstream. ***The average PES of the wetlands of the WRU is Moderate*** - in the quaternaries of this WRU estimates range from ***a C to C/D Ecological Category***.

Figure 4-2 Pans (left) are important and sensitive wetland types within the Highveld WRU. Impacts from agriculture and mines (right) have reduced the PES of the wetlands to predominantly a C condition

4.3 LANDUSE, PES AND EIS OF THE ESCARPMENT GRASSLAND WRU

Most quaternary catchments located within the Escarpment Grassland WRU (Figure 4-1) have ***Moderate EIS*** scores (Table 4.1). This is because:

- Although wetland density is high, diversity of types tends to be moderate, and
- The vegetation types characterising this WMU are regarded as "Vulnerable", but not Endangered, and it can be assumed that the wetland-dependent species within this vegetation type are therefore similarly not critically threatened.

The ***X21A, X21B, X21C and X21F quaternary catchments are notable exceptions; all having High EIS scores.*** In these catchments diversity of wetland types is higher (there are a number of large pans, a relatively rare wetland type in this WMA) and density of wetlands is extremely high. In addition, catchment X21A is adjacent to the RAMSAR-listed Verloeren Vallei wetland (see text box in Section 6). The biodiversity-support functions of this wetland of international importance are enhanced by the surrounding wetlands in that avifauna has more feeding and breeding sites in the region.

Impacts within this WRU are primarily associated with trout farming (dams drowning some wetlands and reducing water availability downstream, water quality impacts and canalisation) and agricultural areas (runoff; trampling/grazing and erosion of wetlands; and encroachment into and channelization of wetlands), but also include impacts from extensive afforestation, invasive alien vegetation and mining. ***The average PES of the wetlands of the WRU is relatively High*** - in the quaternaries of this WMU estimates range from ***a B/C to C Ecological Category***.

4.4 LANDUSE, PES AND EIS OF THE BUSHVELD WRU

Quaternary catchments within the ***Sour Bushveld WRU*** (Figure 4-1) have ***Moderate EIS*** scores (Table 4.1), whilst those in the ***Mountain Bushveld WRU*** tend to have ***Low EIS*** scores. Although wetland density and diversity is low in both these WRU subunits, density is slightly higher in the Sour Bushveld area, and the vegetation type found here is regarded as Endangered whilst those vegetation types in the Mountain Bushveld unit are listed as "Least Threatended" (Mucina and Rutherford, 2006). This accounts for the slight differences in average EIS scores.

Impacts within this WRU are primarily associated with the extensive afforestation of the catchments. This has reduced interflow in the landscape, reducing water availability for wetlands. In many areas the forestry has encroached into the wetlands, and although buffers are sometimes laid out, the edge effects of forestry and roads disturb the wetlands and result in degradation. In some areas adequate buffers have been put in place and the buffer and wetlands are well-managed.

Irrigation farming, peri-urban areas of the former homelands and invasive alien vegetation have also caused some wetland degradation within this WRU. ***The average PES of the wetlands*** in the quaternaries of this WMU is relatively low, estimated to range from ***a C to D Ecological Category***.

4.5 LANDUSE, PES AND EIS OF THE GRANITE LOWVELD WRU

Quaternary catchments within the ***Granite Lowveld WRU*** (Figure 4-1) have ***Low EIS*** scores (Table 4.1). Wetland density and diversity is very low – there are thus few wetlands and the few that do occur are not rare types or occur in high diversity relative to one another. The vegetation types which comprise this WRU are listed as "Vulnerable" but not endangered (Mucina and Rutherford, 2006). Large areas of this section of the catchment are protected within significant conservation areas.

Impacts within this WRU are primarily associated with the afforestation, agriculture and peri-urban areas. Forestry and the extensive agricultural areas have reduced the area of wetlands and the water available to them. Both landuse activities have encroached in places on the wetlands; whilst per-urban areas have caused erosion (though increased runoff, grazing pressures and confinement of the drainage lines associated with infrastructure development). ***A wide range of average PES conditions for the wetlands*** in the quaternaries of this WMU is exists - estimates ranging from ***D to A Ecological Categories*** for various catchments. This extreme range of PES averages for the quaternary catchments is indicative of the diverse conditions of the WRU – in some areas, entire catchments are impacted by the urbanisation of former homeland areas, whilst the lower catchments of this WRU are located within the Kruger National Park and associated private conservation areas. Within this latter zone very little change from Reference conditions have occurred; albeit that very few wetlands are found here.

4.6 LANDUSE, PES AND EIS OF THE BASALT LOWVELD WRU

Quaternary catchments within the ***Granite Lowveld WRU*** (Figure 4-1) have ***Low EIS*** scores (Table 4.1). Wetland density and diversity is very low – there are thus few wetlands and the few that do occur are not rare types or occur in high diversity relative to one another. The vegetation types which comprise this WRU are listed as "Least Threatened" (Mucina and Rutherford, 2006). Most of this section of the catchment is protected within conservation areas.

Because most of the quaternaries associated with this WRU are located within the Kruger National Park, and no significant impacts at a regional (catchment) scale are thus likely to have occurred within the WRU, it is not surprising that the ***average PES conditions for the wetlands*** in the quaternaries of this WMU ***are very high – in A and B Ecological Categories***. Notable exceptions are the quaternaries of the lower WMA – X13J, X13K and X13L – which have been heavily impacted by urban and peri-urban areas of the former homelands, as well as by extensive irrigation farming.

4.7 LANDUSE, PES AND EIS OF THE WITHIN LEBOMBO WRU

No wetlands of regional significance are expected to be found here. Diversity would be very low, and density/occurrence extremely low.

4.8 SUMMARY OF THE PES AND EIS ATTRIBUTES ACROSS THE WRUs

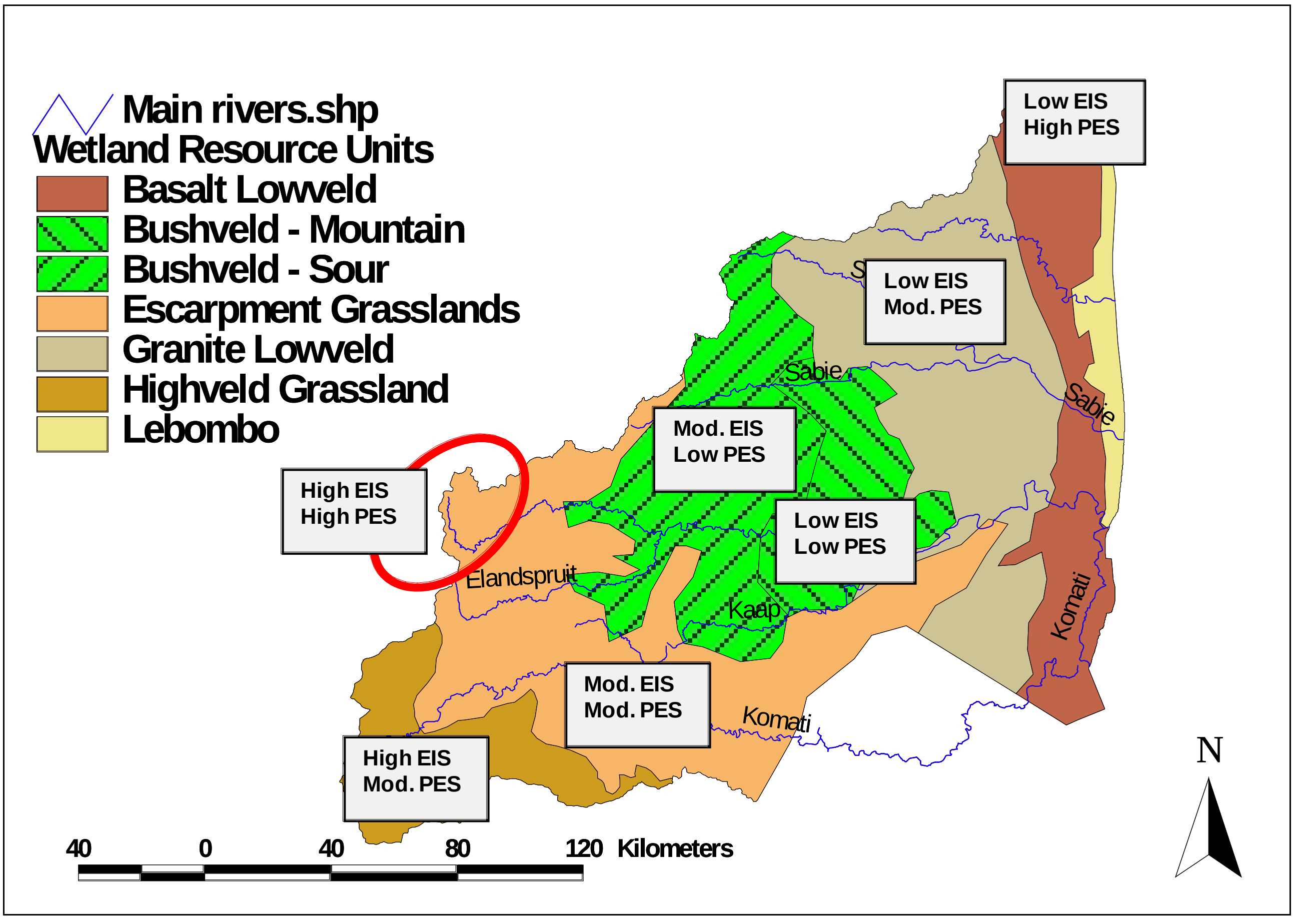

Figure 4-3 Summary of the PES and EIS attributes across the catchment. Density and diversity of wetlands declines from west to east across the catchment

5 RESULTS: WETLAND RESOURCE UNITS

5.1 GENERAL DESCRIPTION OF WETLANDS IN THE INKOMATI CATCHMENT

The SANBI wetland probability map indicated that the majority of wetlands in the Inkomati catchment are concentrated in the upper (western and south-western) sections of the catchment (Figure 5-1), and this was verified in the field and by examination of 1:50 00 maps and of high resolution Google Earth imagery of the catchment. This area of the WMA is a high rainfall, gently sloping landscape and such conditions favour the development of wetlands. Wetland development is favoured in flatter landscapes since the flatter landscapes tend to promote increased infiltration and storage of water in the landscape and inhibit rapid drainage and high flow velocities. However, although the wetland density in this section of the WMA is high, where the local slopes are steep few wetlands are encountered (Figure 5-2). Large valley bottom and seepage wetlands occur in the gently undulating valleys and slopes within these Highveld and Bankenveld EcoRegions (Figure 5-4), but riverine drainage lines (with no or small associated wetlands) develop where the local valleys are steeper and narrower.

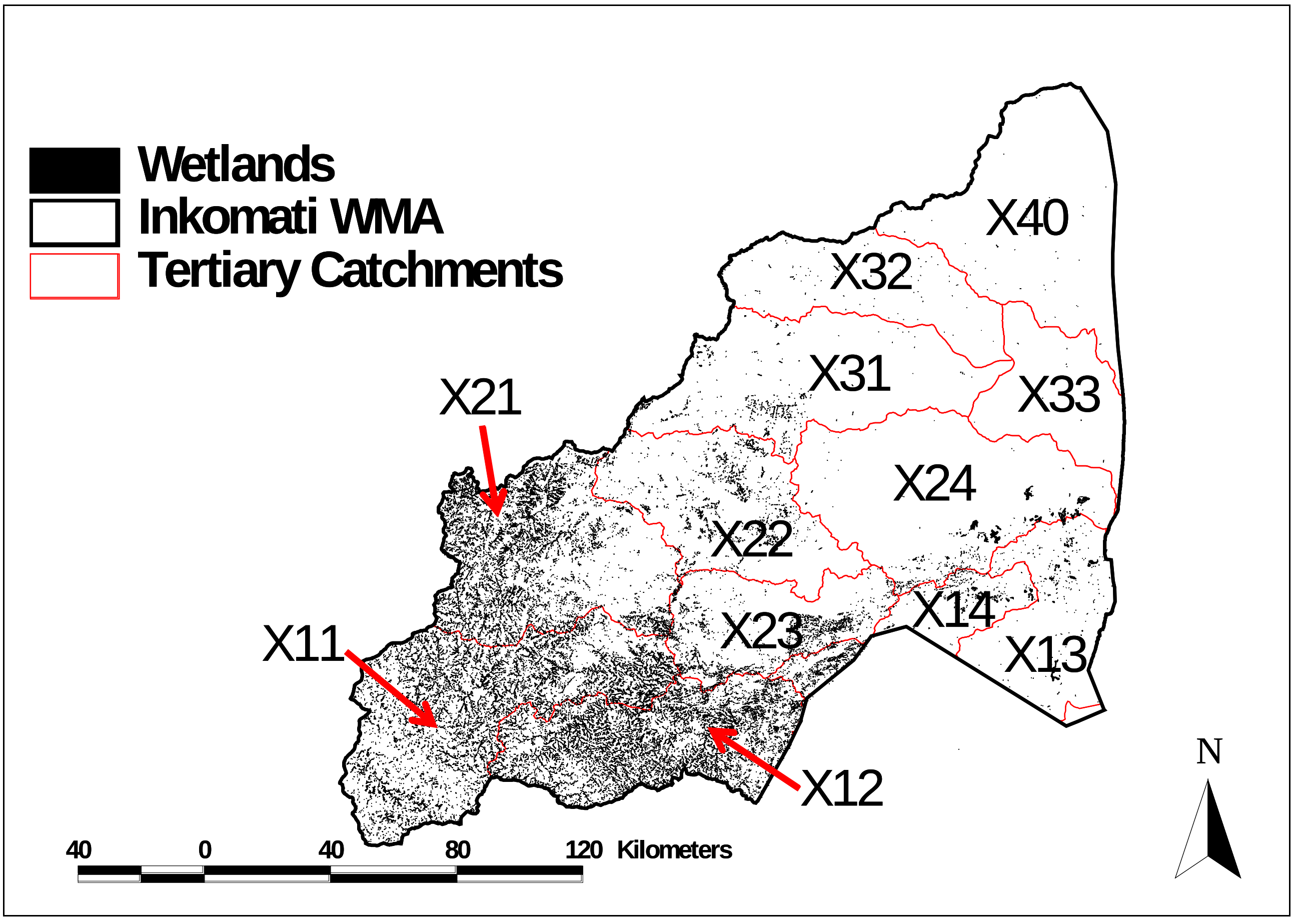

Figure 5-1 Distribution (as identified in the SANBI wetland probability map) of wetlands across the Inkomati catchment.

Wetland density is also relatively high in the central (Figure 5-2) areas of the WMA, which corresponds to the Escarpment EcoRegion (Figure 2-4). Wetland density then declines sharply along a north-east gradient. This is expected since the WMA becomes progressively more arid, and evaporation demand progressively higher, along this gradient.

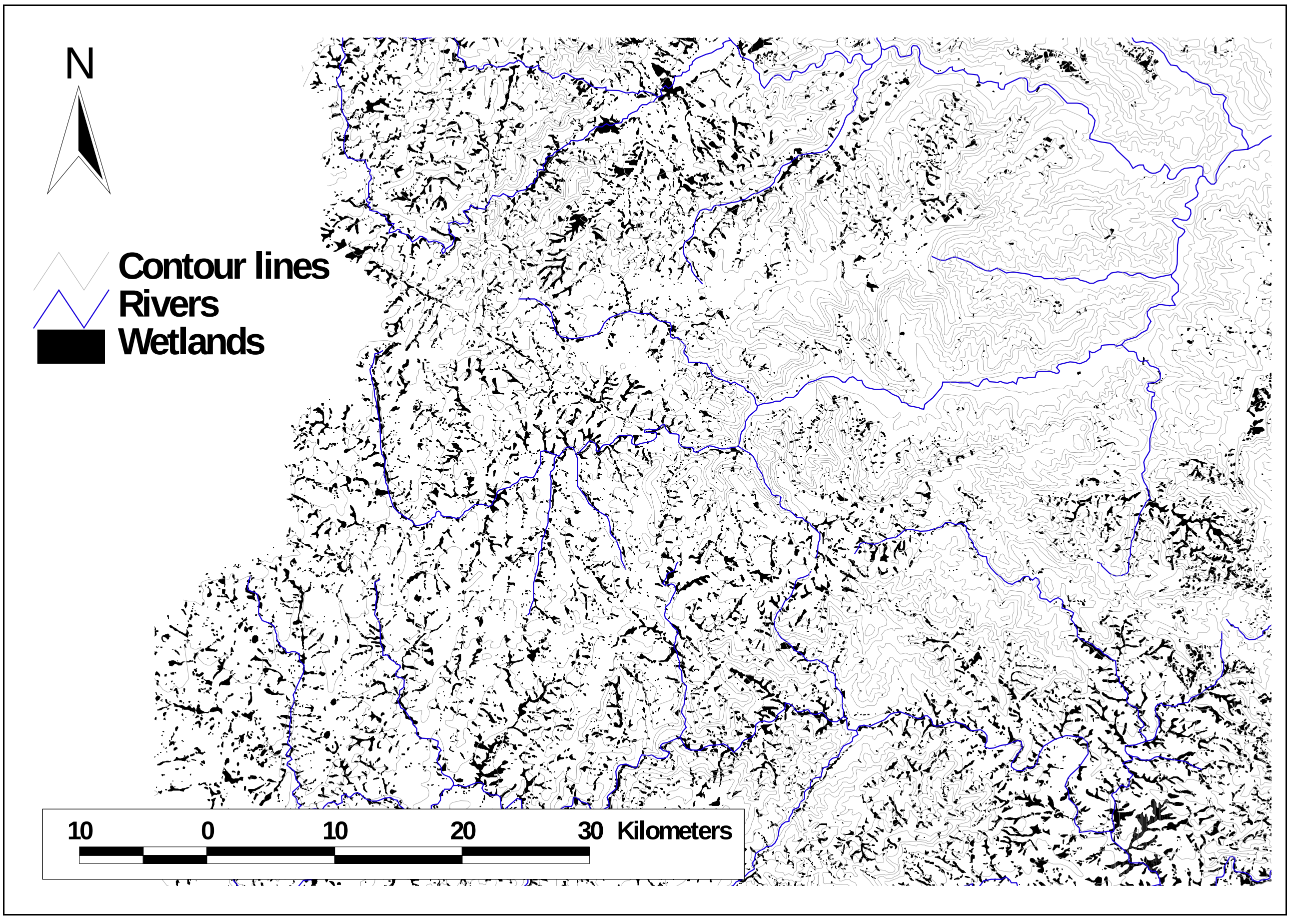

Figure 5-2 The relationship between slope and wetland density in the upper catchment. Where slopes are very steep (contour lines are close together) the density of wetlands is very low, and where slopes are flat (contour lines are widely spaced) wetlands are larger and more common

The SANBI wetland probability map (Figure 5-1) does however underestimate the occurrence of wetlands in the WMA. Wide unchannelled and weakly channelled wetlands occur within the basalts (Figure 2-6) corresponding to the Level II EcoRegion number 3.06 (Figure 2-5), but these have not been indicated on the SANBI map. Similarly, in the level II Ecoregion number 3.07 (Figure 2-5), there are extensive seepage wetlands which are particularly prominent in the granitic zones (Figure 2-5) which have also not been identified by the current SANBI wetland probability map. These are often associated with *Terminalea sericea* trees, a tree which, although widely distributed, is particularly common on mid-slope seepage wetlands in the Lowveld (http://home.intekom.com/ecotravel/plant-kingdom/trees/terminalia-sericea-silver-clusterleaf.htm, accessed January 2010).

Where detailed wetland mapping has been undertaken for small properties (e.g. Fluvius Environmental, 2008; Imperata, 2007) or municipalities (Wetland Consulting, 2009) these indicate far a higher occurrence and density of wetlands than is identified by the SANBI wetland probability map. However, although the SANBI wetland probability is underestimating wetland number, size and density, the map is still highly useful at the desktop level for these purposes since a standardised dataset of wetland density now exists for the entire WMA. This enables relative comparisons to be drawn across the catchment.

There is thus a variety of wetland types as well as differing densities of wetlands across the WMA. The aim of delineation Wetland Resource Units is to simplify the complexity of different wetland types and the variety of underlying driving processes to enable easier assessment of the wetlands and for more effective and appropriate management decisions to be reached.

The relevance of understanding the underlying driving conditions maintaining different wetland types may become apparent when, for example, evaluating the impacts of proposed developments or Water User Licence Applications (WULAs). Wetlands that are maintained by interflow[1] can be expected to have a relatively small catchment, but would be highly sensitive to developments within that immediate topographically-defined catchment area. Wetlands maintained by regional groundwater however could be expected to be less sensitive to individual developments in the immediate vicinity of the wetland, but to be more sensitive to cumulative impacts of regional development. Abstraction through boreholes several kilometres from an interflow-dominated wetland may not be expected to have a significant impact (since this is maintained by the immediate catchment), but if the wetland was groundwater-dependent, then abstraction, even if far from the wetland, may affect the regional groundwater aquifer and thus the "downstream" wetland; albeit that the impact point and groundwater-maintained wetland may not be connected by surface hydrological processes, nor located immediately adjacent to one another.

5.2 WETLAND RESOURCE UNITS OF THE INKOMATI CATCHMENT

Wetland type and density was found to be poorly correlated with either the Level I (Figure 5-3) or Level II (Figure 5-4) EcoRegions. Whilst a better correlation is apparent between underlying geology and wetland densities (Figure 5-5), the best relationship that emerged was between vegetation types and wetland density (Figure 5-6). A combination of vegetation types, Geology and EcoRegions were thus used to guide the delineation of the Wetland Resource Units to create meaningful WRU boundaries.

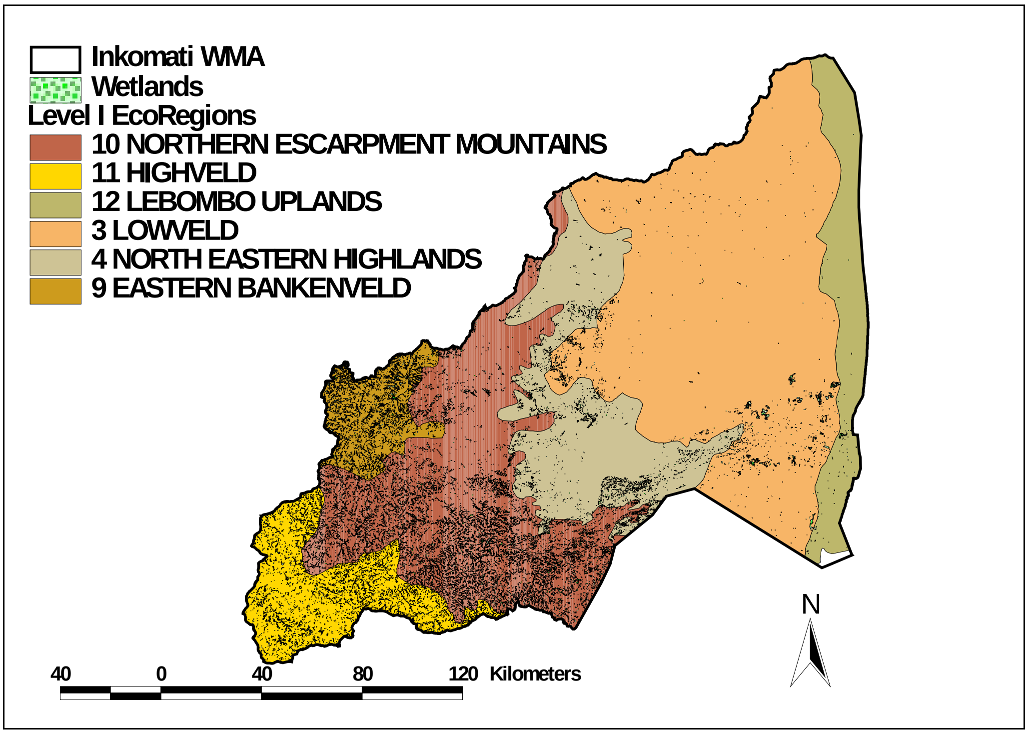

Figure 5-3 Relationship between wetland density and Level I EcoRegions

[1] For the purposes of this wetland report, a distinction is drawn between the relatively deep geological ***groundwater*** (water flowing in the rocks of the primary and secondary aquifers) versus very shallow ***interflow*** (which is water moving through the soil profile in a downslope direction).

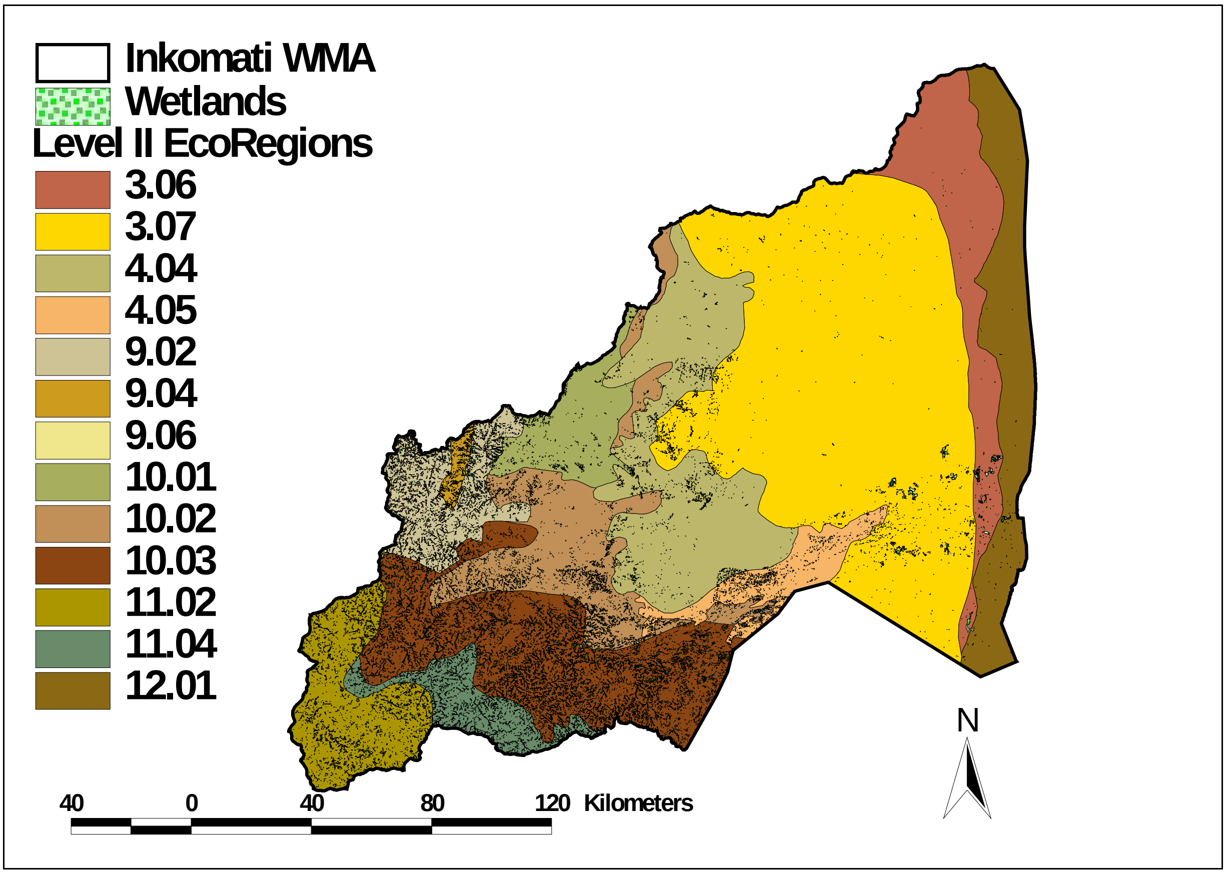

Figure 5-4 Relationship between wetland density and Level II EcoRegions

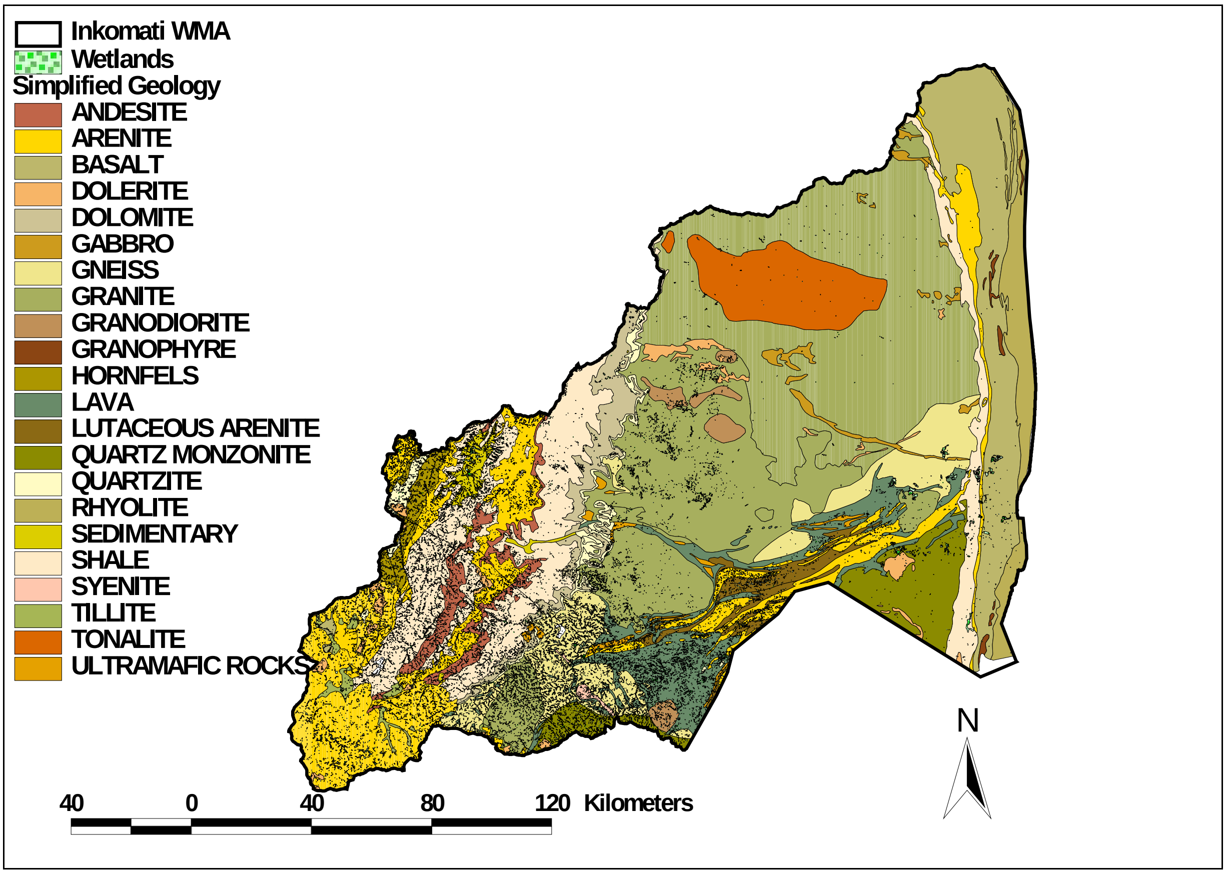

Figure 5-5 Relationship between wetland density and underlying geology

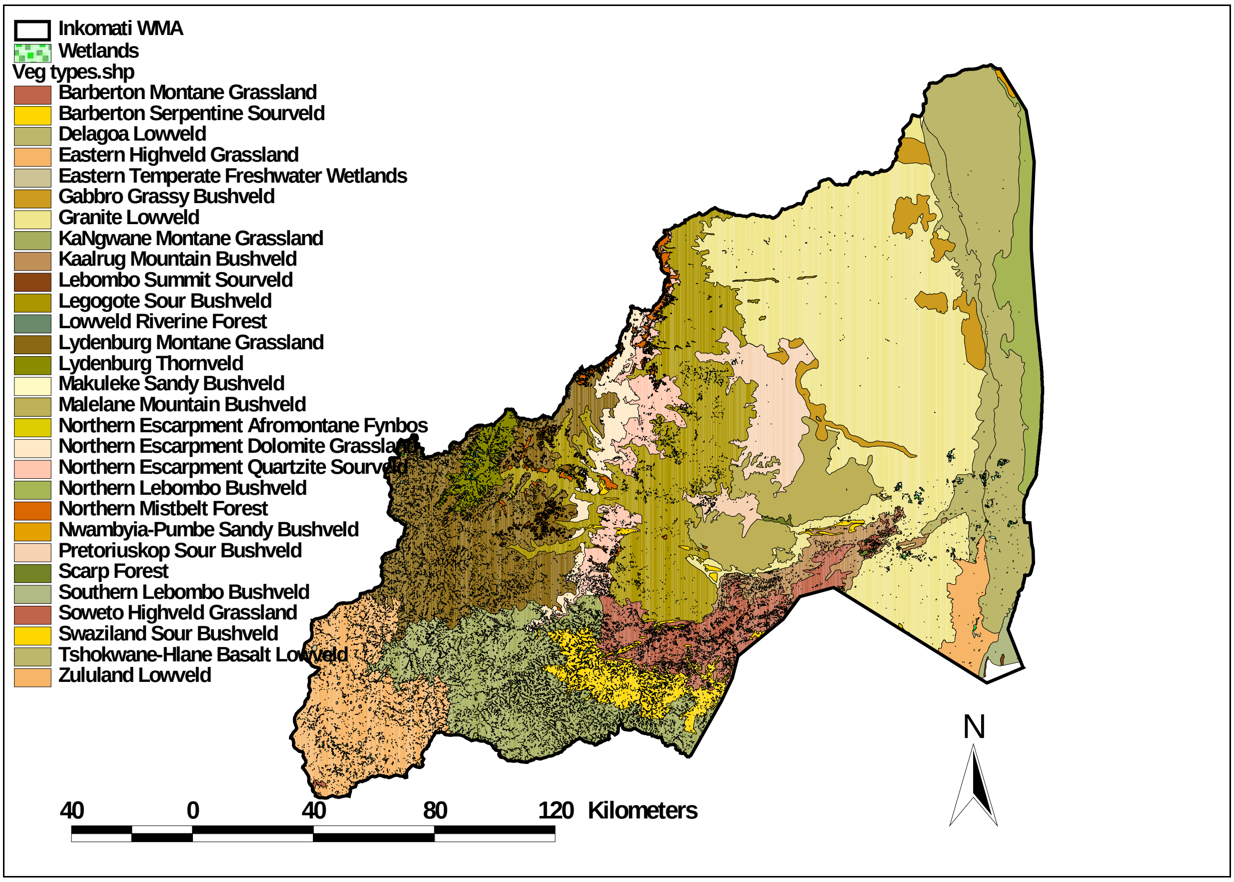

Figure 5-6 Relationship between vegetation types and wetland densities

In this catchment the Vegetation Types and Level I and II EcoRegion boundaries were primarily used to delineate the Wetland Resource Units. Six main Wetland Resource Units (Figure 5-7) were delineated, namely the:

- WRU 1: Highveld Grassland WRU.
- WRU 2: Escarpment Grasslands WRU.
- WRU 3: Bushveld WRU, which can be subdivided into the Sour and Mountain Bushveld zones.
- WRU 4: Granite Lowveld WRU.
- WRU 5: Basalt Lowveld WRU; and
- WRU 6: Lebombo WRU.

Within each of the six WRUs, the main HGM wetland types are relatively homogenous (Table 5.1). For example, pans are primarily found within WRU 1 (Highveld Grassland WRU), whilst the highest densities of extensive seepage and wide, largely unchannelled valley bottom wetlands are located within the Escarpment Grassland areas of WRU 2 (Figure 5-7). No wetlands of any significant size are expected within the Lebombo WRU. The steep slopes, very shallow soils and low rainfall within this WRU do not allow for conditions favouring the development of wetlands.

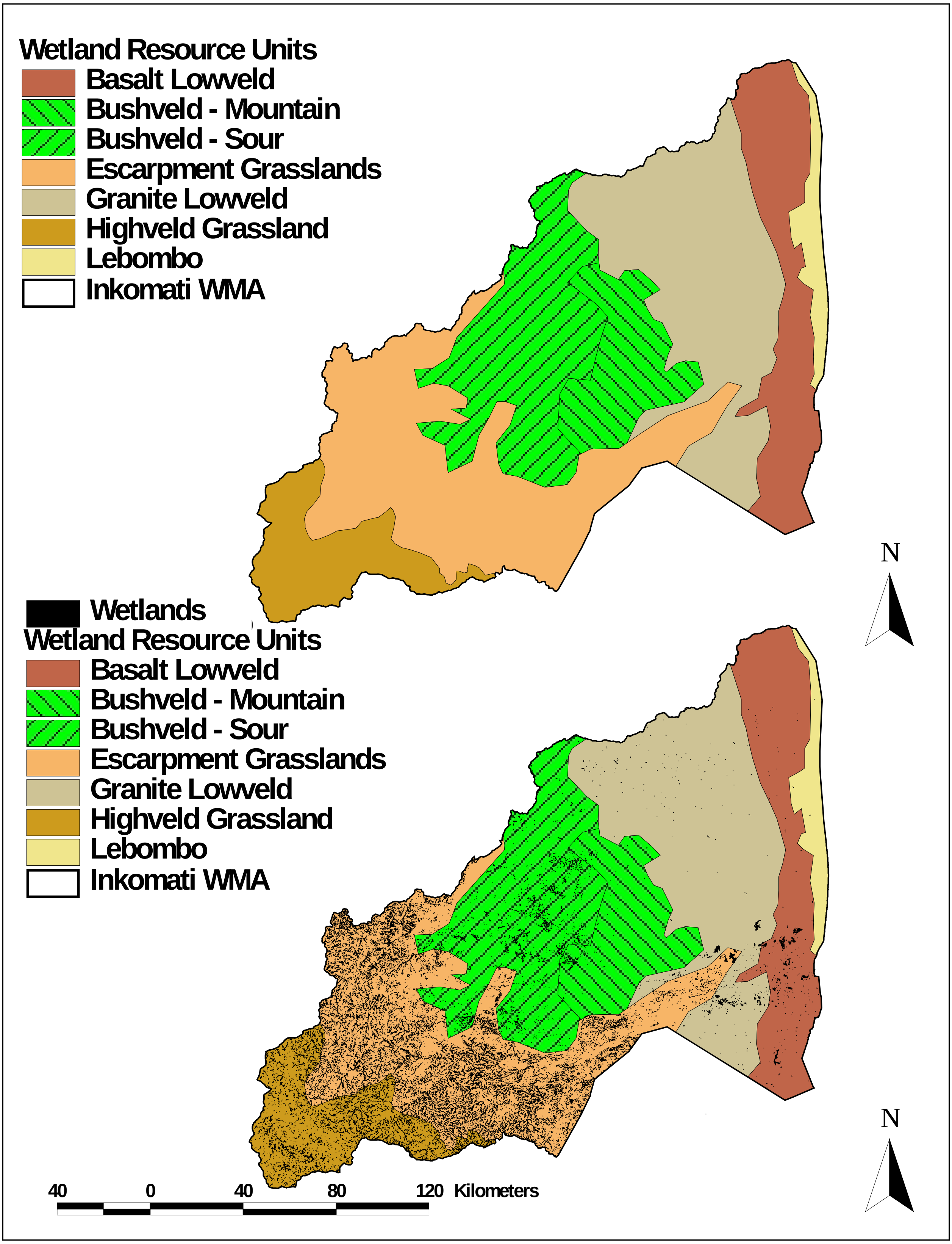

Figure 5-7 The Wetland Resource Units within the Inkomati WMA (top) and distribution of wetlands within the WRUs (bottom)

Table 5.1 Common HGM wetland types associated with the different Wetland Resource Units

Level II: *Wetland Resource Units*	Level III: *Dominant Wetland Types within the WRU*
Highveld Grasslands - Very high density of wetlands. - Wetlands large. - Portions of catchments X11 and X12.	River Channeled Valley Bottom (common) Unchanneled Valley Bottom (common) Hillslope seepages - connected (common) Hillslope seepages - isolated (common) Pans (moderately common)
Escarpment Grasslands - Very high density of wetlands. - Wetlands very large. - Portions of catchments X11, X12, X21, X23 and X14.	River Channeled Valley Bottom (common) Unchanneled Valley Bottom (common) Hillslope seepages - connected (common) Hillslope seepages - isolated (common) Pans (uncommon)
Bushveld (Sour and Mountain) - Moderate (Mountain Bushveld) to low (Sour Bushveld) density of wetlands. - Wetlands moderate to small. - X22 and portions of catchments X21, X31, X23 and X24.	River Channeled Valley Bottom (uncommon) Unchanneled Valley Bottom (uncommon) Hillslope seepages - connected (common) Hillslope seepages - isolated (common)
Granite Lowveld - Moderate to low density of wetlands. - Wetlands small or cryptic. - Portions of catchments X31, X32, X40, X33, X24, X14 and X13.	River Channeled Valley Bottom (uncommon) Unchanneled Valley Bottom (very uncommon) Hillslope seepages - connected (common) Hillslope seepages - isolated (common)
Basalt Lowveld - Low density of wetlands. - Wetlands confined to valley bottom positions. - Portions of catchments X40, X33, X24 and X13.	River Channeled Valley Bottom (uncommon) Unchanneled Valley Bottom (uncommon)
Lebombo - No wetlands of any regional importance are expected in this WRU due to steep slopes, shallow soils, low rainfall and high evaporation demands. - Portions of catchments X40, X33 and X24.	River

5.2.1 Highveld Grassland Wetland Resource Unit (WRU 1)

This WRU is characterised by a high density (Figure 5-7) and diversity (Table 5.1) of wetland types. Extensive seepage wetlands, unchannelled and channelled valley bottom wetlands and occasional pans are located within this WRU. These wetlands have formed in the gentle valleys and associated slopes of this upper catchment area. The seeps are dominated by sedges and grasses and valley bottoms by reeds (*Phragmites*), sedges and grasses. The morphology of the valley bottoms, under Reference conditions, would have often been unchannelled or weakly channelled (Figure 5-8).

Some loss of wetland areas in the valley bottoms and seeps has been caused due to:

1) Encroachment of agricultural (cropping) and forestry activities into the wetlands.
2) Drainage and desiccation of some sections of wetlands through agricultural activities or as a result of drains or dongas associated with road crossings.
3) Farm dams located within the valley bottom wetlands drowning out vegetation; and
4) Invasive
5) vegetation (Poplars, Eucalyptus and Willow trees) shading out the indigenous reeds and grassland wetland vegetation.

The vegetation type (Eastern Highveld Grassland) is regarded as Endangered (Figure 2-9) because only 0.3% of this vegetation type is protected in conservation areas.

Whilst wetlands do not "make" water, these extensive low energy systems are dominated and maintained by slow interflow across the catchment. The slow nature of the drainage prolongs the base flows of the downstream streams and rivers and ameliorates drought periods. Maintaining the slow interflow within the catchments, and within the wetlands specifically, should be promoted and drainage or other desiccation of the wetlands should be inhibited.

Figure 5-8 An unchannelled Valley Bottom wetland in the WRU 1

5.2.2 Escarpment Grassland Wetland Resource Unit (WRU 2)

This WRU has the highest density of wetlands within the WMA (Figure 5-7). Very large seepage and both unchannelled and channelled valley bottom wetlands are present within the WRU. These wetlands have formed in the gentle valleys and associated slopes of this upper catchment area. Pans are very uncommon (only found in the eastern sections of this WRU) and are generally small.

In most respects the wetlands are similar to those found in the Highveld Grassland WRU (Table 5.1), but the seepage and valley bottom wetlands are found in higher densities and are generally of larger size in the Escarpment Grassland than in the Highveld Grassland WRU. Pans are notably more common in the Highveld Grassland WRU. The vegetation types which characterise the Escarpment Grassland WRU are considered to be Vulnerable (Figure 2-9), whilst those vegetation types characterising the Highveld Grassland WRU have higher conservation priority and are ranked as Endangered (Mucina and Rutherford, 2006).

5.2.3 Bushveld Wetland Resource Unit (WRU 3)

The Bushveld Wetland Resource Unit is characterised by a moderate to low density of wetlands, and the WRU can be subdivided into two subunits; the South Bushveld and Mountain Bushveld. Wetland occurrence is slightly higher in the Sour Bushveld and lower in the Mountain Bushveld subunits of this WRU, but types (Table 5.1) are expected to be the same. Seepage wetlands are expected to be the most common wetland type here, but these are often wooded - *Terminalea sericea* are usually associated with the seeplines in the bushveld and Lowveld (http://home.intekom.com/ecotravel/plant-kingdom/trees/terminalia-sericea-silver-clusterleaf.htm, accessed January 2010) – and therefore somewhat cryptic in nature. The mapping approach adopted by SANBI for the South African Wetland Probability Map does not easily identify wetlands in wooded or savanna areas of the country due to the modelling approach employed. The estimates of wetland size and number in this and the Lowveld (Savanna) WRU's is thus likely to be underestimated by the SANBI Wetland Probability Map.

However, because of the lower rainfall, higher evaporation rates and the steeper topography, conditions within this hilly and mountainous zone are not favourable for the development of large or numerous wetlands. The density of wetlands in this WRU is thus much lower than in comparison to the Highveld and Escarpment Grassland WRUs (Figure 5-7).

5.2.4 Granite Lowveld Wetland Resource Unit (WRU 4)

Very low densities of wetlands are found in this area of the WMA. Despite the presence of granites which promotes interflow and wetland development, the low rainfall and high evaporation rates preclude extensive wetland development. As with the Bushveld WRU, some seeps along the hillslopes can be expected where local conditions force interflow close to the surface. *Terminalea sericea* may again be expected to be found associated with such features.

Along the Sabie River, seasonal and temporary pans are occasionally located within the depositional fans associated with tributary confluences. These have not been identified on the SANBI wetland probability maps as they are usually small and partially covered by an overstorey of riparian trees, but would provide locally important habitats for amphibians, possibly fish and also birds.

5.2.5 Basalt Lowveld Wetland Resource Unit (WRU 5)

The drainage lines that originate on the basalts in the eastern section of the Inkomati WMA are typically low gradient, low energy unchannelled or weakly channelled valley bottom wetlands. Most can be expected to be seasonal in nature due to the strongly seasonal summer rainfall patterns and the very dry winters and lack of significant groundwater inputs which might otherwise maintain permanent wetland conditions.

The basalts do not promote infiltration or interflow in the landscape, so it is unlikely that extensive seepage wetlands would be found – especially given the low rainfall and high evaporation rates of this section of the WMA. Wetland density and diversity is thus low within this WRU, although local importance of these wetlands within the general semi-arid landscape would be high in terms of forage, firebreak functions and general biodiversity support. These wetlands have also been shown to be critically important for the breeding success of rare antelope species within the Kruger National Park (Kröger and Rogers, 2005).

5.2.6 Lebombo Wetland Resource Unit (WRU 6)

No wetlands of any significant size or regional importance are expected within the Lebombo WRU. The steep slopes, shallow soils, high evaporation rates and low rainfall within this WRU do not favour the development of wetlands.

6 PRIORITY WETLANDS IN THE INKOMATI CATCHMENT

Two areas of priority wetlands were identified in this study based on extremely high EIS scores (Table 4.1) derived from the desktop assessment:

- The wetlands around Dullstroom (quaternary catchments X21A, X21B, X21C and X21F) all have High EIS scores and relatively high PES scores. These catchments are part of the Escarpment WRU (Figure 4-3) and are located close to the RAMSAR Verloeren Vallei wetland complex. Quaternary catchment X21A has an EIS bordering on Very High (Table 4.1).
- Wetlands of the Highveld WRU (X11A, X11B, X11C, X12A, X12B and X12E) generally have High EIS and Moderate PES scores (Figure 4-3). Of particular importance are the wetlands near the Chrissiesmeer Lake system – a dense grouping of pans in the headwaters of the Inkomati, Vaal and Usutu Rivers provides unique wetland habitats for birds and other fauna, and has a strong recreational and conservation value. This quaternary catchment (X11A) has an EIS bordering on Very High (Table 4.1).

VERLOEREN VALLEI

Verloren Valei Nature Reserve was designated as South Africa's 17th Wetland of International Important, effective 16 October 2001. This Ramsar site is situated on a watershed between the Olifants and Crocodile drainage systems. The upper catchment drainage systems on the Reserve are the streamsources of tributaries to the Steelpoort River, which is part of the Olifants system. The east flowing streams are part of the Lunsklip River, a tributary of the Crocodile River. It is a provincial protected area (5,891 hectares, 25°17'S 030°09'E) comprising more than 30 wetlands that are primarily permanent freshwater marshes with emergent vegetation. These wetlands contribute in ensuring a sustained flows to downstream regions, even during dry periods.

Biodiversity support functions are also high - at least 50 butterfly species occur in the reserve, with Warren's Blue (*Orachrysops warreni*) being restricted to the reserve. The reserve also provides habitat for fish (5 species), amphibians (9 species), reptiles (36 species) and 160 bird species (12 of which are endemic).

http://www.ewisa.co.za/misc/Wetlands/defaultwetVerloren.htm

Early reviews of the state of wetland ecosystems in South Africa have highlighted these same areas for priority planning and research (Noble and Hemens, 1978).

It has recently been reported that prospecting rights for coal are again being applied for (http://www.fin24.com/articles/default/display_article.aspx?ArticleId=1518-25_2577498, accessed 29th March 2010) in the area of pans surrounding Chrissiesmeer. ***A Comprehensive assessment of the high conservation priority Chrissiesmeer wetland complex should be undertaken to ensure that strategic, proactive management of these wetlands is enabled***, and thus avoid the rather piecemeal approach to wetland management and impacts from coal mining as exists in the upper Olifants Catchment. Chrissiesmeer is unique in southern Africa in terms of the size and concentration of pans and associated wetlands, and has been proposed as a RAMSAR site (a wetland of international importance). The hydrological characteristics of, and connectivity between, the pans should be thoroughly investigated in order than impacts of future developments can be more accurately predicted and mitigated if necessary. Some small mines already exist in the area, and given the global demand for coal and requirement for job creation and foreign exchange earnings through coal exports provided by mines, it is likely that future expanded mining will need to be evaluated in this region.

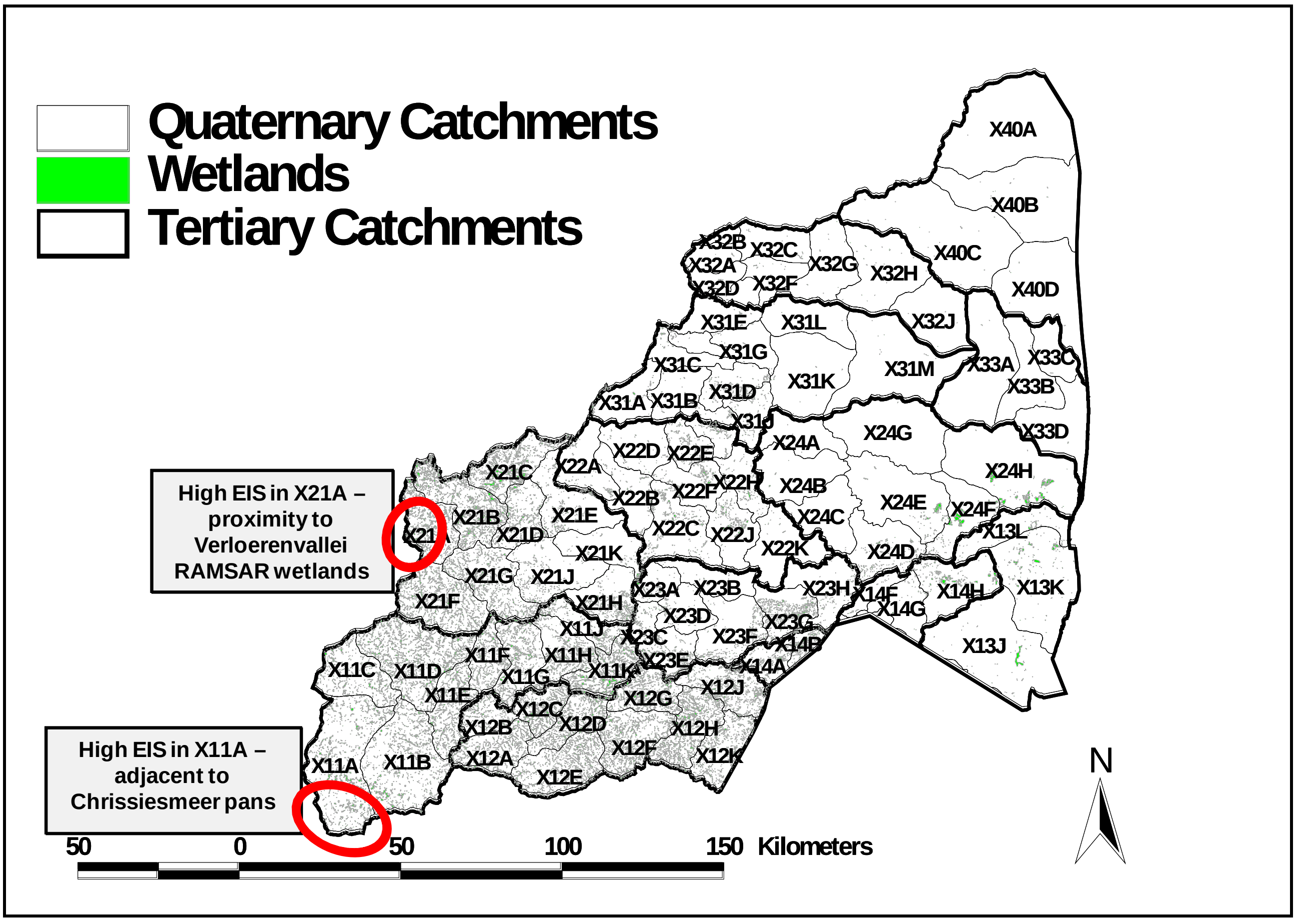

Figure 6-1 High Priority wetlands are located in the headwater sub-catchments of the X21 and X11 tertiary catchments, most notably in the X21A and X11A quaternary catchments

Thus whilst the wetlands around Dullstroom/Verloeren Vallei have both High EIS and High PES scores, the Highveld WRU wetlands are likely to be under greater threat and thus should be prioritised despite their generally lower PES scores.

Previous reviews of wetlands in this area of the country have also highlighted the temporary pans along the Sabie River; cited as providing important refuge for the *Serranochromis meridianus* fish (Noble and Hemens, 1978). Since these pans are maintained by large flood events that are beyond reasonable management intervention, it is not recommended that these areas are prioritised for research or studies to aid management of wetland resources in this WMA.

7 RECOMMENDATIONS FOR WETLAND MANAGEMENT

It is essential to recognise that rising temperatures and reducing rainfall patterns associated with contemporary climate change (global warming) will negatively impact upon marginal and transitional wetland systems, decreasing their extent and modifying their species diversity (Ellery *et al*, in press). The wetlands of the Mokolo catchment are likely to be particularly sensitive to the expected reduced rainfall and higher temperatures (with associated increased evapotranspiration losses) because these wetlands are located in a low rainfall region with already very high evaporation rates.

Although many of the wetlands in the Mokolo catchment remain in a good to moderate condition, more than 50% of South Africa's wetlands are estimated to have already been destroyed (DEA: State of the Environment, http://soer.deat.gov.za/themes.aspx?m=149). South Africa is a contracting party to the Ramsar Convention on Wetlands and therefore has an obligation to promote the conservation and responsible use of wetlands (Ramsar Convention, 2002). The assessment and monitoring of wetland condition is an important component in managing the use of wetlands in terms of meeting international obligations, but also as related to the regulation of use of water resources, as well as impacts on associated biodiversity, as required by DWA and DEA.

The National Water Act requires the DWA to ensure the conservation, protection and sustainable utilisation of wetlands. A key aspect of regulating the use and enabling sustainable utilisation and protection of wetlands is through Section 21 Water User Licence Applications (WULAs). The following impacts upon wetlands requires an authorisation from DWA through the approval of a relevant WULA:

- (Section 21a): Taking water directly from the wetland or from groundwater.
- (Section 21c): Impeding or diverting the flow of water in a wetland or upstream watercourse.
- (Section 21d): Afforestation in the catchment.
- (Section 21f): Discharging waste or water containing waste into a wetland through a pipe, canal, sewer, sea outfall or other conduit.
- (Section 21i): Altering the bed, banks, course or characteristics of a wetland; and
- (Section 21k): Using water for recreational purposes.

Additional legislation regulates the use of wetlands. The DEA's National Environmental Management Act (NEMA, Government Gazette of 21 April 2006, no. 386 & 387) lists the following impacting activities as requiring authorisation from DEA:

- Mining of peat (not relevant for this catchment),
- Any purpose within the 1:10 year floodline, or within 32 m of the bank; including canals; channels; bridges; dams and weirs (excludes existing residential use); and
- The dredging, excavation, infilling, removal or moving of soil, sand or rock exceeding 5 cubic metres from a river, tidal lagoon, tidal river, lake, in-stream dam, floodplain or wetland.

The first step in the protection of wetlands and the regulation of their use is to determine if wetlands exist at proposed development sites, and if so, what the potential is that the proposed activity will impact upon the wetland/s and how it will do so. For this reason, wetlands should be identified and mapped according to the DWA (DWAF, 2005 and DWAF, 2008a) guidelines on wetland delineation. If a wetland is located at the site, and the development footprint is within 500 m of the wetland, or the nature of the impact is such that a Water User Licence is required, then the developer should be advised to proceed with the WULA application in conjunction with the standard EIA study (e.g. Figure 7-1).

In general, due to the critical loss of wetlands across the country, the DWA has proposed, in a draft position paper on wetland management that future losses of wetlands are to be discouraged. Using the DWA guidelines, the edges of wetlands should be identified and these should not be encroached upon by future developments. In addition, suitable buffer zones should also be provided for to limit the impacts of developments upon nearby wetlands.

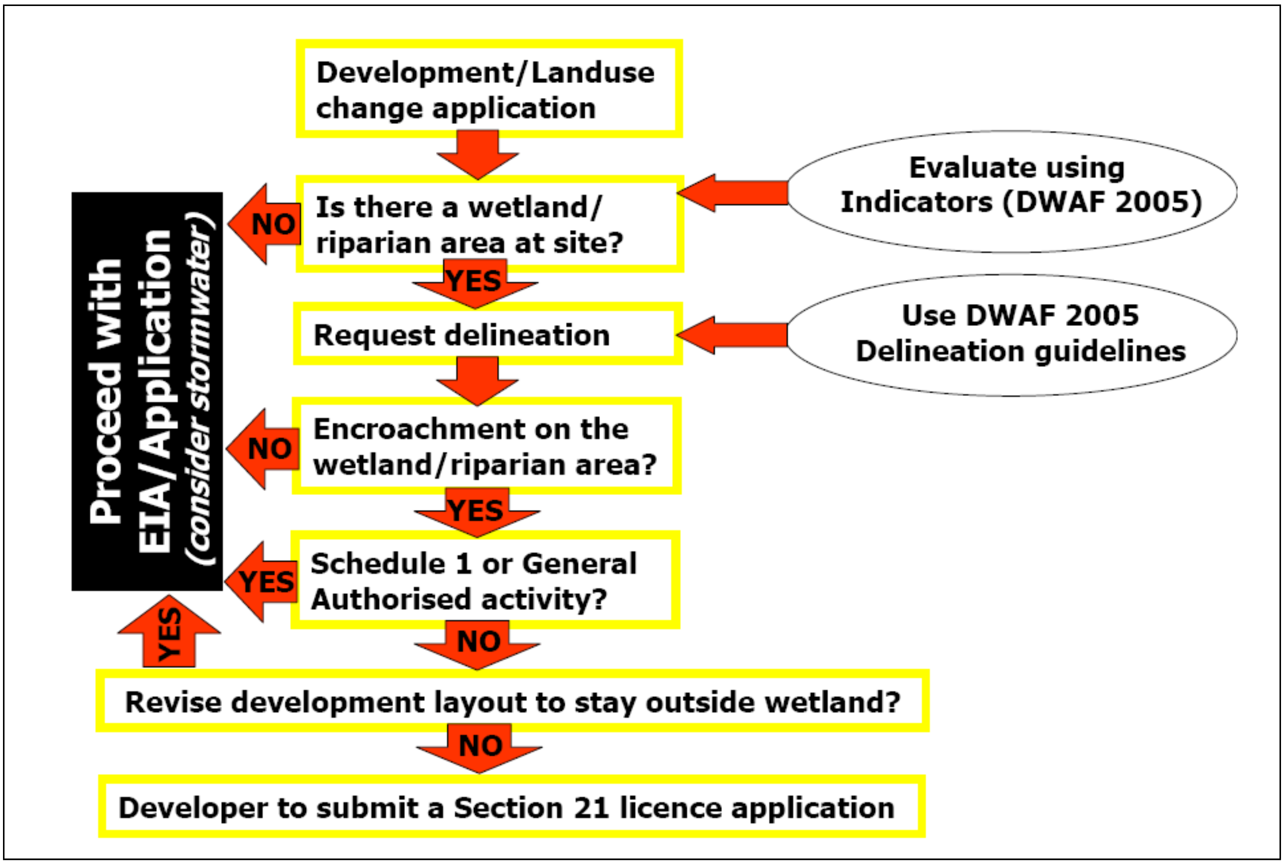

Figure 7-1 Generalised procedures for aligning EIA and DWA Water User Licence Applications in the case of residential developments

7.1 ROAD CROSSINGS

Road crossings through wetlands can cause erosion and drainage of wetlands. Where diffuse flows are concentrated into one or two culverts, an incised channel develops downstream of the road (left, Figure 7-2) and this lowers the local water table, drying out the wetland and enhancing further erosion by the continued concentration of flows. If the headcuts from the erosion pass under the road crossing, the eroding channel can propagate upstream (right, Figure 7-2) and further reduce wetland condition and integrity. Simple drop inlet structures as part of the bridge or road crossing design can prevent upstream erosion, whilst flow dissipaters; numerous culverts and sensitive sitting of road crossings can reduce downstream erosion.

Figure 7-2 Incised channel (left) and eroding channel upstream (right) caused by crossings

Wetlands which are eroded - where flows are concentrated into channels and floodplains desiccate - have reduced functioning and cannot attenuate floods or ameliorate water quality problems as well as intact wetlands.

To minimise the impacts of road crossings, the following recommendations are provided:

- No road crossings through unchannelled valley bottom wetlands; since these are specifically sensitive to flow concentrations and erosion.
- Wherever possible, road crossings could coincide with the local keypoints across the wetland.
- Drop inlets should be built as part of the bridge design where culverts are proposed on small wetlands and streams;
- Numerous culverts and flow dissipators should be constructed where feasible and necessary to prevent risk of erosion on downstream wetlands.

7.2 FORESTRY

Adequate buffers (Figure 7-3) between forestry areas, roads and/or infrastructure must be maintained, since this can allow the wetlands within them to persist with fair ecological integrity.

To minimise the impacts of afforestation, the following recommendations are provided:

- Delineate the temporary wet hydrological zone of wetlands (following the DWAF, 2005 guidelines) and move all afforestation and agricultural activity at least 20 meters from this edge.
- This buffer zone should be managed for indigenous vegetation to reduce edge effects and allow for some water table recovery.
- Roads cannot be included as part of the buffer since these enhance the disturbance/edge effects.
- Invasive exotic vegetation must be controlled within the wetland and buffer zones.

Figure 7-3 Buffers around wetlands within afforested areas in Mpumalanga. Effective buffers allow much of the wetland functionality to persist

7.3 AGRICULTURE

Agriculture impacts directly on wetlands through encroachment of fields into wetlands, canalisation/drainage of wetlands to increase useable land and through grazing and trampling effects of livestock. Runoff from fields can also create secondary water quality impacts on the receiving wetlands.

To mitigate these impacts:

- Appropriate buffers should be placed around wetlands, and the buffer vegetation managed correctly. Buffers of natural vegetation should also be left in place along the major rivers of the WMA.
- SusFarms, Farming for the Future and other lower input approaches to farming can create win-win situations for the farmer and water resources, since the former reduces costs through reduced inputs, and the receiving waters have lower doses of nutrients to process.

7.4 MINING

Coal mining is likely to expand within the WMA; specifically in the Highveld WRU. Each mining should be evaluated on its individual merits, but it is highly recommended that a strategic approach to wetland management be adopted if the footprint of mining is to expand within the catchment. This would enable trade-off and reasonable, effective mitigation options to be identified upfront and avoid the current piecemeal approach being applied in the now critically modified Upper Olifants River catchment.

It has recently been reported that prospecting rights for coal are again being applied for (http://www.fin24.com/articles/default/display_article.aspx?ArticleId=1518-25_2577498, accessed 29th March 2010) in the area of pans surrounding Chrissiesmeer, and it is highly recommended that a Comprehensive assessment of the high conservation priority Chrissiesmeer wetland complex be undertaken to ensure that strategic, proactive management of these wetlands is enabled.

In general, some of the objectives which could be considered for mining might be:

- No net loss of wetlands, or no net loss of the functions of wetlands (incorporating aspects of off-site mitigation, wetland engineering and recognition of the ecosystem goods and services that need to be replaced or reinstated if wetlands are impacted).
- Maintenance or restoration of as much of the pre-mining hydrological (diffuse surface, channelled and soil interflow) flows as possible.
- Where river diversions are required, the same HGM wetland must be created – i.e. diffuse lows across unchannelled valley bottoms should not be replaced with a canal.
- Clean water should be diverted and reinstated in the landscape in a similar way so that similar landscape hydrological processes can be achieved.

7.5 GENERAL MANAGEMENT AND REHABILITATION ACTIONS

7.5.1 Recommendations

- Eradicate all exotic invader vegetation species and, where feasible, rehabilitate important palustrine wetlands.
- Comply with the recommended grazing carrying capacity for that area, to prevent over-grazing in wetlands.
- Establish a fire management plan to benefit the integrity of wetlands.

8 APPLICATION OF THE DATA

There are thousands of wetlands in South Africa, and it would be difficult, if not impossible, to manage each wetland individually as many are small (i.e. beyond a reasonable mapping scale), some are cryptic (i.e. not be easily identified) and others have been extensively modified, thus making their identification and delineation difficult. Even if all the wetlands within a region could be identified and mapped, their sheer number would preclude a site-specific approach to wetland management.

Grouping individual wetlands by similar characteristics into larger units - Wetland Resource Units – provides working at a scale that identifies fewer assemblages of wetlands rather than the many individual wetland systems. Through the use of WRUs, DWA and other natural resource managers can more easily manage wetlands on the basis of similar characteristics, driving processes, and sensitivities to developments and other impacts. Provided they are correctly classified and fairly well understood, the classification and delineation of Wetland Resource Units and description of dominant wetland types within these can be used for reporting, assessment and monitoring purposes, as well as to provide some insight and understanding of wetland processes and predictions of likely impacts when WULAs are being evaluated. WRUs can thus facilitate the implementation of the National Water Act by allowing for the management, conservation, protection and sustainable utilisation of wetlands, at a scale appropriate to available knowledge and resources. For instance, the information about wetland processes and sensitivities for a WRU can be used in low confidence (desktop) Reserve studies, which may be sufficient for many Water User Licence Applications (WULAs).

Whilst the WRU classification and descriptions provide some insight into the underlying processes of the different types of wetlands across the study area, the quaternary scale PES and EIS for wetlands provides a first step for managing wetlands (The WRUs could be further divided according to quaternary catchment areas if appropriate). Although these data were derived from largely desktop information and are therefore very low confidence, the data could aid in low confidence Wetland Reserve studies associated with the WULAs of small-scale, low impact developments. When assessing the risk of activities on wetlands it is critical to identify underlying processes at the Wetland Resource Unit scale. Desktop PES and EIS assessments provided for wetlands at the quaternary catchment scale could be used in conjunction with WRU characteristics to evaluate the potential risks of WULAs. Very low risk WULAs may be able to be evaluated at the desktop level; low to moderate risk WULAs may require at least a brief field-based assessment of the site; whilst moderate to high risk WULAs may necessitate a full wetland Reserve determination study to be initiated.

The PES and EIS of a catchment can additionally be used to inform how wetlands within that area should be managed. For example, high EIS scores in areas where the wetland PES scores are low or moderate would suggest that interventions (such as Working for Wetlands) could be considered to stabilise and/or improve the condition of the wetland. In such areas, developments that result in a net decline in wetland extent or condition would not enable the DWA to achieve the aims of the National Water Act. Thus developments which result in an overall decline in wetland condition should be discouraged from areas where the REC is to maintain or improve the PES.

The use of WRUs does not, however, obviate the need for detailed Reserve studies for large, unique or highly-sensitive individual wetlands, particularly where potential developments are likely to have a significant impact upon their water supply. In such situations, DWA and other managers could evaluate the anticipated impacts of the development against the general characteristics and sensitivities of wetlands within the relevant WRU to assess whether or not the impact is likely to be significant, and thus require a detailed Reserve assessment. Where site-specific information for wetland does exist, some extrapolation of that information is possible. For the purposes of extrapolation, it should be noted that the extrapolation of information should only be made between wetlands of the same or very similar HGM wetland types. Additionally, there is a greater potential for effective extrapolation of wetland information between catchments but within the same WRU type, than within the same catchment area but across WRU boundaries.

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APPENDIX A: DESCRIPTION OF HGM WETLAND TYPES

A1 DESCRIPTION OF HGM WETLAND TYPES

The following describe the level III HGM wetland types recognised by the classification system applied in this study.

A1.1 RIVERS

Linear fluvial, eroded landforms that carry channelised flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorges) or within an incised macro-channel. The "river" includes both the active channel (the portion which carries the water) as well as the riparian zone. For the purposes of this wetland report, no further focus has been placed upon the rivers of the study area.

A1.2 MEANDERING FLOODPLAIN

Linear fluvial, net depositional valley bottom surfaces that have a meandering channel which develop upstream of a local (e.g. resistant dyke) base level, or close to the mouth of the river (upstream of the ultimate base level, the sea). The meandering channel flows within an unconfined depositional valley, and ox-bows or cut-off meanders - evidence of meandering – are usually visible at the 1:10 000 scale (i.e. observable from 1:10 000 orthomaps). The floodplain surface usually slopes away from the channel margins due to preferential sediment deposition along the channel edges and areas closest to the channel. This can result in the formation of backwater swamps at the edges of the floodplain margins.

A1.3 CHANNELED VALLEY BOTTOMS

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

A1.4 UNCHANNELED VALLEY BOTTOMS

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

A1.5 LAKES

These are depressions in the valley bottoms that may be temporarily, seasonally or permanently inundated. Unlike pans, they are not deflationary erosional features, but instead they have, or would have had, an outlet at the downstream end of the valley (a low point); which has been variously blocked or otherwise restricted by dune deposits (e.g. Kosi Bay), terminal moraines (e.g. Lake District; United Kingdom.) or landslides (Lake Fundudzi) or other depositional features across the valley bottom. Within this study area, sand dunes had blocked previously eroded river valleys and when sea levels rose, these interdune depressions have become drowned as the regional water table rose (Allanson *et al*., 1990). The shape of lakes is therefore determined by the surrounding slopes/higher ground rather than deflational processes creating the typical circular or oval pan shape.

A1.6 SEEPAGE WETLANDS (ISOLATED OR CONNECTED)

Hillslope seepage wetlands are the most common type of wetland (in extent and number), but also probably the most overlooked. Hillslope seepage wetlands are located on the mid- and footslopes of hillsides, and are connected to valley bottom wetlands or riparian zones. Hillslope seepage wetlands occur where springs are decanting into the soil profile near the surface, causing hydric conditions to develop; or where throughflow in the soil profile is forced up to/near the surface due to impervious layers (such as Plinthite or other impervious layers; or where large outcrops of impervious rock force subsurface water to the surface). Seepage wetlands can also occur connected to (fringing, or surrounding) pan wetlands.

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

A1.7 PANS

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

A1.8 FLATS

Wetland flats could be expected to occur in specific geologies that have a significant groundwater component (i.e. very pervious rock) where the permanently or seasonally high water table intersects with low-lying portions of the landscape. These troughs in the topography become permanently or seasonally saturated due to the proximity of the water table and wetland conditions are able to develop at these points. Such conditions exist in areas like the Cape Flats; in low-lying sections of the northern KwaZulu-Natal coastal belt and in some low-lying areas of Dolomitic regions.

APPENDIX B: DETAILED QUATERNARY CATCHMENT WETLAND PES SCORING

(Provided electronically)

APPENDIX C: DETAILED QUATERNARY CATCHMENT WETLAND EIS SCORING

(Provided electronically)