Upper Olifants River Catchment Wetland Inventory, Mpumalanga and Gauteng Provinces

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Environmental Business Unit

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Executive Summary

Introduction

The Environmental Business Unit of Exigent Engineering Consultants was appointed by Coaltech 2020 to collate all available literature on the wetlands in the Upper Olifants River Catchment (UORC) and compile a digital wetland map for the area with an associated database.

The UORC as defined by the Department of Water Affairs and Forestry includes the Olifants River and all its tributaries up to the Loskop Dam (referred to as "the site"). A portion of Gauteng, as well as Mpumalanga provinces are therefore included in the catchment.

This report defines wetlands according to the definition included in the National Water Act (Act No 36 of 1998). Artificial wetlands, not included in the DWAF definition, have also been included in the report in addition to the natural wetlands, as artificial wetlands can also contribute in performing several ecological functions.

The entire catchment is approximately 15 158 km^2 in extent and the total wetland area approximately 2 147 km^2. Wetlands therefore cover approximately 14% of the entire catchment area. These wetlands have been delineated according to the system used by Palmer et al *(2002) and attributes were added.*

Objectives of the study

The objective of the study is to compile a single comprehensive database with all available data on the wetlands of the UORC. This was accomplished by a thorough literature review of all available wetland literature for the catchment, as well as the combination of existing wetland layers into a comprehensive new wetland layer. The new wetland layer includes wetlands observed on aerial photographs.

Literature review

Literature currently available on wetlands in the UORC, as well as general information on wetlands, has been collected and included in this review. Tertiary institutions (such as universities and technicons), government departments, research Institutions (such as the CSIR, Council of Geoscience and the Water Research Commission), and mines were contacted to obtain any information available on the wetlands located within the UORC.

The following aspects are included in the literature review:

- *The association between wetland distribution and geology and soils;*
- *Wetland biodiversity, including the Red Data species and species of concern observed in wetlands in the UORC in the past;*
- *Wetland classification methods;*
- *Wetland services and functions;*
  - *Water balance;*
  - *Water purification;*
  - *Sediment trapping;*
  - *Harvesting of natural resources;*
  - *Tourism and recreation;*
  - *Livestock;*
  - *Crop farming;*
- *Wetland threats;*
  - *Water usage;*
  - *Mining and quarrying;*
  - *Agriculture;*
  - *Burning;*
  - *Dams and weirs;*
  - *Industries;*
  - *Harvesting of resources;*
  - *Infrastructure;*
- *Indicators of wetland health;*
- *Existing wetland inventories;*
- *Common wetland types identified in the UORC by Palmer* et al *2002; and*
- *The status of wetlands in the UORC based on the available literature.*

Methods

Three existing wetland databases were incorporated into one to obtain a baseline wetland map for the area. The wetland databases were:

- *The wetland layer of the catchment as included in Palmer* et al *(2002);*
- *The draft Mpumalanga C-Plan wetland layer (based on the National Landcover wetland layer); and*
- *The water bodies' shapefile layer of the 1:50 000 topographical maps.*

The databases were combined into a single layer and then split into a wetland database and dam layer. Verification of the wetland database and dam layer were done by comparing the layers to the 1:50 000 topographical maps and then the georeferenced aerial photographs of the site. Field verification of the wetlands was undertaken from July to October 2006, and the database was updated accordingly. The entire wetland database was reviewed against the aerial photographs after conducting the field verification site visits.

The attributes included in the wetland database were derived from the aerial photographs, as well as existing data and observations during the field verification site visits. Characteristics of the wetlands and surrounding areas that are visible on the aerial photographs were taken into account. Where wetlands were included in the field verification the attributes as observed on site were included.

The following fields were included in the wetland attribute table:

- *Type*
- *Threats*
- *Connectivity*
- *Status*
- *Red Data species*
- *Important species*
- *Functions*
- *Bird number*
- *Observed Red Data species*
- *Observed important species*
- *Dominant vegetation*

Results and Discussion

Wetlands and dams in the UORC were delineated based on the aerial photographs. Field verification of the wetlands took place from July 2006 to October 2006. Due to the large extent of the catchment and wetlands occurring on private properties, not all wetlands were surveyed during the field verification.

The most common wetland types in the catchment are seepage and non-floodplain riparian wetlands with approximately 34% of the total wetland area falling into each of these wetland types. The floodplain riparian wetlands comprise 28 % of the total wetland area. The riparian wetlands (floodplain riparian and non-floodplain riparian combined) are, therefore, the largest percentage contribution to wetlands in total. Although numerous pans occur in the catchment the pans only cover a small area of the total area. The non-perennial and perennial pans comprise 2.5 % and 1.5 % of the total wetland area of the catchment, respectively. Less than 0.2 % of the total wetland area has been classified as artificial wetlands.

Comparison to the National Landcover wetland layer

The final Landcover wetland layer, completed in June 2006, was compared to the completed UORC wetland database. The Landcover wetland layer compared very well to the UORC wetland database, since all of the Landcover wetlands were located in the areas already indicated as wetlands in the UORC wetland database.

The UORC wetland database has more extensive wetland areas, probably as a result of the differences in scale of the studies. The National Landcover wetland layer has a total wetland area of 16 303ha, whereas the UORC wetland database has a total wetland area of 214 731ha. The National Landcover wetland layer therefore only covers 1% of the total catchment area and 7.6% of the total wetland area indicated in the UORC wetland database.

It seems as if the Landcover layer includes the seasonal and permanent zones of some of the wetlands and not all the temporary zones. Areas of open water in the wetlands are also excluded from the Landcover layer. The pans are poorly represented, possibly because they contain areas of open water, and were identified as such.

Gap analysis

Although the wetlands in the UORC have been mapped extensively (mostly 1:50 000 scale), there is a lack of data on specific wetland attributes. The status of the wetlands in the UORC is not well known, with very few tools available to assess the wetland health on this scale. The species composition of only a few wetlands in the UORC is known with any detail resulting in only a generalised species list for wetlands in the catchment. Water quality data of very few wetlands in the UORC is available, with only a few studies conducted in the wetlands in the catchment.Although various species lists are available some flora and fauna species are only known to occur in wetlands in the area, with no reference as to which types of wetlands.

The wetland boundaries are based on aerial photo interpretation and only selected site verification. This study is only a baseline study and should be refined. The wetland types should also be further defined by more detailed wetland studies. This study is not intended to replace site specific wetland studies.

Database accuracy

The database accuracy was determined during the field verification of the site visits. A total of 632 wetlands of various sizes were verified. Approximately 17% of the wetlands indicated in the database did not exist. Eighty-seven percent of these non-existant wetlands were seepage wetlands.

In addition, a total of 133 wetlands observed in the field, but absent from the database, were delineated. The added wetlands only comprised 1.3% of the verified wetland area, an almost negligible difference. These wetlands were not observed on the aerial photographs, due to their small size.

After site verification, the total area of wetlands in the UORC has been lowered from 3 105 km^2 to 2 147 km^2, a difference of 31%. The total area of non-floodplain riparian wetlands and perennial pans changed little, but the total area of the artificial wetlands doubled in size, while the total seepage area halved. The floodplain riparian and non-perennial pans diminished in total area by 36% and 26%, respectively. The reason for these changes is in part due to faulty identification and delineation, but also in part due to the age of the aerial photographs. Although the aerial photographs are fairly recent (2004-2005) some wetlands has been destroyed in the meantime.

The attributes allocated based on the aerial photo interpretation was also verified on site where possible. Sixty percent of the verified wetlands had an inaccurate status indicated in the database. This was due to the fact that the status was based on what could be observed on the aerial photographs and a large number of impacts are not necessarily visible on the aerial photographs. The attributes in the database has an overall accuracy of 60% and the wetland layer an accuracy of 70%. The addition of wetlands to the database was responscible for only 1.3% of the change in the wetland layer, whereas the deletion of wetlands included in the database, but not present in the field was responsible for the remainder of the difference.

The way forward

- *The wetland layer, although baseline, is not intended as a static, once-off project and the data should be refined and updated on a regular basis.*
- *The layer should be handed over to a host organisation capable of refining and updating with site-specific information, e.g. SANBI.*

Conclusion

Limited literature is available on the wetlands in the UORC, but the literature available illustrates the importance of the wetlands within this catchmen, in terms of services and functions. In addition, the wetlands are under threat from various activities within the catchment. Although it is not feasible to prevent all activities impacting on the wetlands from taking place, the activities can be managed to obtain the most beneficial combination of economic development and wetland conservation.

A wetland database and a dam layer have been compiled for the catchment. The wetland layer is linked to a wetland database including various attributes such as wetland type, possible functions and status. The wetland database should, however, be viewed as a baseline study to guide decision making, and should not replace more detailed, site specific, wetland assessments.

The attributes in the database has an overall accuracy of 60% and the wetland layer an accuracy of 70%. This database should be updated regulatly by a host organisation, to continuously improve the accuarcy of the data.

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1. INTRODUCTION

The Environmental Business Unit of Exigent Engineering Consultants was appointed by Coaltech 2020 to collate all available literature on the wetlands in the Upper Olifants River Catchment (UORC) and to compile a wetland map for the area with an associated wetland database.

The UORC as defined by the Department of Water Affairs and Forestry (DWAF) includes the Olifants River and all its tributaries up to the Loskop Dam (Figure 1). In the report compiled by Palmer *et al* (2002) on wetlands in the UORC, the Olifants River and its tributaries up to the confluence of the Olifants River and the Klein Olifants River were included (Figure 3). In this report the UORC boundary encompasses the larger area as defined by DWAF (referred to as "the site"). The site incorporates the area as defined by Palmer *et al* (2002), but extends further to the north and east. A portion of Gauteng, as well as Mpumalanga is included in the catchment.

According to the National Water Act (No 36 of 1998) a wetland is defined as, "*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*." This definition includes all naturally occurring wetlands and pans, but excludes rivers, lakes and artificial wetlands, except for the transition zone from the river/lake and the terrestrial ecosystem.

The definition of wetlands as defined in the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) has a broader concept. Article 1.1 of the Ramsar Convention includes the following definition (Cowan 1995): "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas or marine water the depth of which at low tide does not exceed six metres*". Rivers, lakes and artificial wetlands, as well as tidal zones, are therefore included in this definition.

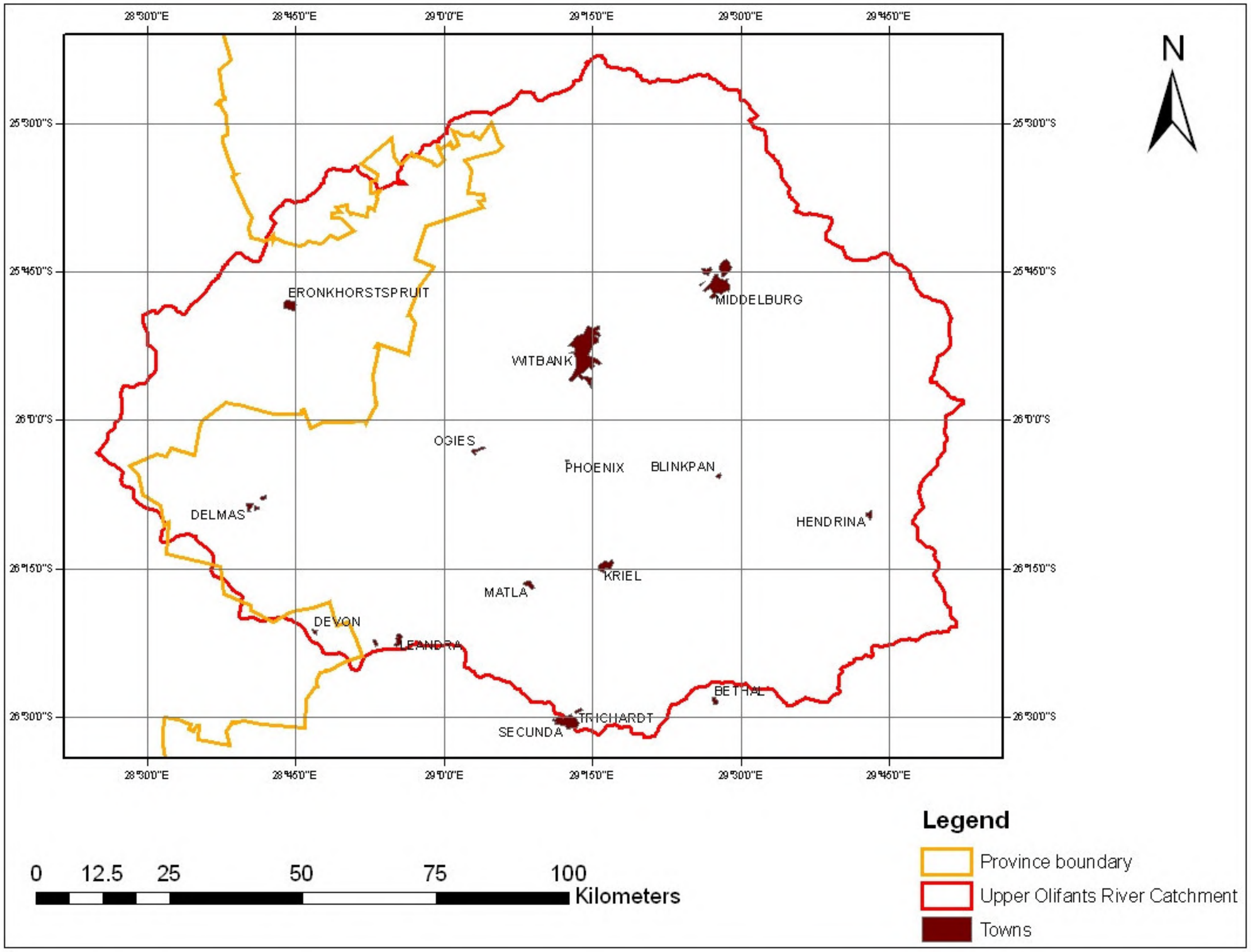

Figure 1. Extent of the UORC (referred to as the site)

This report defined wetlands according to the definition included in the National Water Act. We chose this definition, since it is the wetland definition applicable in South African legislation and most commonly used in South Africa. Artificial wetlands, not included in the DWAF definition, have also been included in this report in addition to the natural wetlands, since artificial wetlands can also perform a number of functions.

The project was divided into two phases. The first phase of the project included:

- Literature collection and review,
- Data capturing,
- Wetland mapping,
- Gap analysis, and
- Report compilation.

This first phase of the project commenced in July 2005 and continued until the end of June 2006.

The second phase of the project included:

- Site verification of wetlands throughout the catchment,
- Site verification of wetlands on mining properties,
- Camparison of the final Landcover wetland layer (completed June 2006) with the final UORC wetland database, and
- Collection and review of additional information from the mines.

The second phase of the project commenced in July 2006 and concluded in October 2006.

2. OBJECTIVES OF THE STUDY

The objectives of the study are to include all the available data on the wetlands of the UORC into one comprehensive database and to compile a literature review of all wetland literature available for the catchment. The literature review incorporates all the available information on the wetlands in the UORC, as well as some general wetland information. The literature review aims to provide a general overview of the wetland types occurring in the UORC and their possible functions and threats.

The aim of the wetland layer is to provide a baseline database of the wetlands in the area. The layer is only intended as a baseline to give an indication of what to expect and cannot replace site-specific wetland assessments. The layer should not be used to determine buffer zones around the wetlands, since not all wetland boundaries have not been delineated on site.

3. LITERATURE REVIEW

3.1 Introduction

Literature currently available on wetlands in the UORC, as well as general information on wetlands, has been collected and included in this review. Tertiary institutions (such as Universities and Technicons), Government Departments, Research Institutions (such as the CISR, the Council of Geoscience and the Water Research Commission), and mines were contacted to obtain any information available on the wetlands located within the UORC.

3.2 Geology and soils associated with wetland distribution

3.2.1 Geology

Various studies in the past have indicated that there is a relationship between wetland distribution, and the underlying geology and soils (Grundling & Marneweck 2001, Cirmo 2003, Merot *et al* 2003, Devito *et al* 1996). The geology of a site influences several of the topographical characteristics of the site, as well as erosion processes, groundwater and vegetation type. According to Palmer *et al* (2002) most of the wetlands in the UORC occur on sediments from the Vryheid Formation, with a few on the Waterberg Group, Dwyke Formation and the least on the Rooiberg Group, Bushveld Complex. Wetlands are also strongly associated with dolerite intrusions (Snyman 1998, Vegter 1995).

In addition to the correlation between wetland distribution and geology in the UORC a correlation between wetland type and geology has also been made by Palmer *et al* (2002). According to Palmer *et al* (2002) most (92%) of the seasonally inundated channelled valley bottom floodplains with footslope seepage wetlands were associated with drainage line wetlands draining the southern watershed. The watershed is dolerite dominant. The distribution of floodplain and valley bottom wetlands is influenced by the erosion and weathering properties of the underlying geology (mostly shales and sandstone in the Vryheid Formation). Seepage wetlands are closely linked to the permeability of the underlying geology, as well as faults and contacts between different geological units (Palmer *et al* 2002).

Bedrock type has been used as an indicator of the distribution of pans in the world, the bedrock type is, however not a very good indicator of the distribution of pans in South Africa. It has, however, been found that pans mostly occur on shales and unconsolidated surface sands. Pans occur mostly in areas without integrated drainage and with an average slope of less than one degree. Although they are mostly scattered across the landscape, without any obvious pattern, some occur linearly in the location of ancient rivers (Allan *et al* 1995).

3.2.2 Soil

The soil wetness and duration of wetness are an indicated by the colour of the soil. Grey soil is an indication of wetness for prolonged periods of time and mottles indicate a fluctuating water table. The permanent zone of a wetland is therefore characterised by grey soil, the seasonal zone has a high frequency of low chroma mottles and the temporary zone has less, high chroma, mottles. Soil in the terrestrial zone surrounding the wetland does not have mottles in the top 50 cm of the soil (DWAF 2003a, Lizamore *pers com* 2005).

Due to the physical attributes indicative of wetness in the soil, some soil forms can be classified as wetland soils. Soil forms indicative of the permanent zone of the wetland include Champagne, Katspruit, Willowbrooke and Rensburg. While the following soil forms indicate the seasonal and temporary zones of a wetland, Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee and various others soil forms displaying mottling in the top 50 cm (DWAF 2003a).

3.3 Wetland biodiversity

Wetlands play an important role in the maintenance of biodiversity. Several species from various taxa are dependant on wetlands for breeding and feeding purposes. Although the species diversity in an individual wetland may be low, the overall species diversity in the wetlands of the region may be very high. Several Red Data species occurring within the site, utilise wetland habitat, such as the Blue Crane and Nile Crocodile (Kotze *et al* 2005, Venter 2003).

This section on wetland species biodiversity focuses on the plants, invertebrates, fish, amphibians, reptiles, mammals and bird species that have been recorded in the area. Various reports contain species lists of the wetland species utilising the UORC. The species lists from the various reports have been entered into one database and are included in Addendum A to Addendum G.

3.3.1 Species of Concern

The World Conservation Organisation (IUCN) has three threatened categories, namely Critically Endangered, Endangered and Vulnerable. Species that have been evaluated according to the IUCN criteria and do not fall into one of the threatened categories can be classified as Least Concern, Near Threatened or Data Deficient. Species classified as Least Concern have been evaluated and do not qualify for the Critically Endangered, Endangered, Vulnerable or Near Threatened categories. Species that are widespread and abundant are normally included in this category. Species are classified as Near Threatened when they do not meet the criteria for the threatened categories, but are close to classifying as threatened or will likely classify as threatened in the near future. A species is classified as a Data Deficient species when there is a lack of appropriate data on the distribution and/or population status of the species. The species may be well studied, and the biology known, but data on the abundance and/or distribution are not available. The category indicates that more data is needed and that there is a possibility that the species may be classified into one of the threat categories in the future. Vulnerable species are facing a high risk of extinction in the wild, Endangered a very high risk and Critically Endangered an extremely high risk (IUCN 2002).

The catchment is located in the Mpumalanga and Gauteng provinces, and species protected in both these catchments have been included. Species referred to as protected in this section are species protected according to the Mpumalanga Nature Conservation Act (Act no 10 of 1998) and the Gauteng Nature Conservation Ordinance (Ordinance 12 of 1983). These species may not be killed, removed, moved or disturbed in any way without permission from the Mpumalanga Parks Board or the Gauteng Conservation Directorate.

The distribution ranges of some of the species were included in a separate shapefile. The distribution of the mammal and bird species was based on museum records. The quarter degree grids in which the species were recorded were noted and the possible occurrence of the species was based on these records. Where a species was observed in a number of quarter degree grids close together it was assumed that the species can also occur in the grids located between the recorded occurrences. It should also be taken into account that the museum records indicate historical location and that the habitat for the species may have been destroyed in the past. The species mentioned in each of the quarter degree grids are therefore only a possible indication of the species distribution. Inclusion of a species in a grid does not insure that the species occurs in the grid and exclusion does not ensure that it does not occur in the grid.

Table 1: Species of concern

Species name	Common name	Red Data	Potected	Wetland type	Habitat	Possible distribution
Birds						
Phoenicopterus ruber	Greater Flamingo	NT	Y	Non-perennial Pans, Perennial Pans	Large bodies of shallow water, inland and coastal; saline and brackish waters preferred. Occasionally forages along sandy coasts. Usually breeds colonially on mudflats in large pans.	
Alcedo semitorquata	Halfcollared Kingfisher	NT		Non-floodplain riparian	Fast-flowing perennial streams, rivers and estuaries, usually with dense marginal vegetation. Usually perches low down on the banks of streams, often on exposed roots. Requires riverbanks in which to excavate nest tunnels.	
Anthropoides paradiseus	Blue Crane	V	Y	Floodplain riparian, Non-floodplain riparian, Seepage Non-perennial Pans, Perennial Pans, Artificial wetlands	Midland and highland grassveld, edge of karoo, cultivated land and edges of vleis. Nests in both moist situations in vleis which have short grass cover and in dry sites far from water, usually exposed places such as on hillsides; forages in grassland, cultivated and fallow lands; roosts communally in the shallow water of pans and dams.	Entire catchment
Anthus chloris	Yellow-breasted Pipit	V		Seepage	Undulating grasslands	Eastern portion of the catchment
Botaurus stellaris	Eurasian Bittern	Cr En		Floodplain riparian, Non-floodplain riparian	Lowland swamps and densly vegetated swamps with tall vegetation	Gauteng Province
Bugeranus carunculatus	Wattled Crane	Cr En		Floodplain riparian, Non-floodplain riparian	Permanent wetlands, opportunistically seasonal	Rare over the entire catchment
Ciconia nigra	Black Stork	NT	Y	Floodplain riparian, Non-floodplain riparian, Artificial wetlands	Feeds in and around marshes, dams, rivers and estuaries; breeds in mountainous regions. Feeds mainly on fish and is therefore uncommon at seasonal pans lacking fish. It nests on cliffs.	
Circus ranivorus	African March-Harrier	V	Y	Floodplain riparian	Wetlands and surrounding grasslands. Most highveld wetlands > 100ha support a breeding pair. Nests in extensive reedbeds often high above water. Forage over reeds, lake margins, floodplains and occasionally even woodland. Almost entirely absent from areas below 300mm of rainfall.	Entire catchment
Falco naumanni	Lesser Kestrel	V	Y	Seepage	Forage preferentially in pristine grassland. They roost communally in tall trees, mainly *Eucalyptus*, in urban areas. Open grassland and intensively cultivated agricultural areas under maize, sorghum, peanuts, wheat, beans and other crops. Typical of semi-arid grasslands, avoiding wooded areas.	Entire catchment
Falco peregrinus	Peregrine Falcon	NT		Non-floodplain riparian	Cliffs, mountains, steep gorges, sometimes open grassland and rarely cities	

Species name	Common name	Red Data	Potected	Wetland type	Habitat	Possible distribution
Geronticus calvus	Southern Bald Ibis	V		Seepage	High grassland	The entire catchment, but more common towards the east
Glareola nordmanni	Blackwinged Pratincole	NT		Floodplain riparian, Pans	Open grassland	
Gyps coprotheres	Cape Vulture	V	Y	Seepage, Pans	Mostly mountainous country, or open country with inselbergs and escarpments; less commonly in savanna or desert. Forages over open grassland, woodland and agricultural areas; usually roosts on cliffs, but will also roost on trees and pylons. It occurs and breeds from sea level to 3100m.	In more mountainous country towards the east and north of the catchment
Mycteria ibis	Yellow-billed Stork	NT	Y	Floodplain riparian, Non-floodplain riparian, Non-perennial Pans, Perennial Pans, Artificial wetlands	Utilises diverse habitats, including dams, large marshes, swamps, estuaries, margins of lakes or rivers, seasonal wetlands where there are areas of vegetation free shallow water, and even small pools.	
Phoenicopterus minor	Lesser Flamingo	NT		Non-perennial Pans, Perennial Pans	Shallow pans, especially saline pans when they contain water. Larger brackish or saline inland and coastal waters. It breeds on mudflats far out in pans and lakes.	
Podica senegalensis	African Finfoot	V	Y	Non-floodplain riparian	Clear, perennial rivers and streams, lined with reeds, overhanging trees and shrubs (avoids both stagnant and fast-flowing waters). Roosts and breeds in dense overhanging vegetation.	Northern portion of the catchment
Polemaetus bellicosus	Martial Eagle	V	Y	Floodplain riparian, Non-floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans, Artificial wetlands	Tolerates a wide range of vegetation types, being found in open grassland, scrub, Karoo and woodland. Typically found in flat country and is rarer in mountains and it also avoids extreme deserts, and densely wooded and forested areas. Nests in large trees, but will also utilise electricity pylons, wind pumps and cliffs in treeless areas.	Rare in entire catchment
Rostratula benghalensis	Greater Painted-snipe	NT		Floodplain riparian, Non-floodplain riparian, Non-perennial Pans, Perennial Pans, Artificial wetlands	Marshes, swamps, edges of lakes, dams, ponds, streams	
Sagittarius serpentarius	Secretary Bird	NT	Y	Floodplain riparian, Non-floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans, Artificial wetlands	Semidesert, grassland, savanna, open woodland, farmland, mountain slopes. Absent from mountain fynbos, and avoids forest, dense woodland and very rocky, hilly or mountainous areas.	
Spizocorys fringillaris	Botha's Lark	En		Seepage	Upland moist grassland	Occurs throughout the entire catchment
Sterna caspia	Caspian Tern	NT		Floodplain riparian, Perennial Pans	Estuaries, marine shores, larger inland dams and pans	

Species name	Common name	Red Data	Potected	Wetland type	Habitat	Possible distribution
Turnix hottentottus	Hottentot Buttonquail	En		Seepage	Moist grassland	Eastern portion of the catchment
Tyto capensis	African Grass-Owl	V	Y	Non-floodplain riparian, Floodplain riparian, Seepage, Pans	Almost exclusively in rank grass, typically fairly high altitudes. Breeds in permanent and seasonal vleis, which it vacates while hunting or post-breeding. Will breed in any area of long grass and is not necessarily associated with wetlands. Foraging confined to tall grassland. May occur in sparse Acacia woodland where patches of dense grass cover are present.	Entire catchment
Mammals						
Aonyx capensis	Cape Clawless Otter		Y	Non-floodplain riparian, Floodplain riparian, Non-perennial Pans, Perennial Pans	They occur in rivers, lakes, swamps, dams, streams, estuaries and sea water. Fresh water is a requirement, as well as a food supply in the form of crabs, frogs, fish and other aquatic life. They also need some cover along the banks of the water.	Entire catchment
Atelerix frontalis	South African Hedgehog	NT	Y	Floodplain riparian, Non-floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans, Artificial wetlands	Occurs in a wide variety of habitats including suburban gardens, scrub bush in Botswana, the western Karoo in the Cape Province, and in grassland in Transvaal.	Entire catchment
Chrysospalax villosus	Rough-haired golden mole	Cr En	Y	Floodplain riparian, Non-floodplain riparian, Seepage	Grassland with a preference for dry ground at the fringes of marshes and vleis.	Rare in the north of the catchment
Crocidura mariquensis	Black or Swamp Musk Shrew	DD		Non-floodplain riparian, Floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	Along river banks, reedbeds and in swamp	Entire catchment
Dasymys incomtus	Water Rat	NT	Y	Non-floodplain riparian, Floodplain riparian	Water rats are associated with a wet habitat. They occur in reed beds and between semi-aquatic grasses in wetland areas and next to rivers and streams. Also in grassy and bracken areas close to water.	The northern portion of the catchment
Felis nigripes	Small spotted cat / Black-footed Cat		Y	Floodplain riparian	They are associated with arid areas, with annual rainfall between 100 and 500mm. They prefer open habitat with some cover in the form of tall grass, bush or the disused holes of some mammals.	Occurs over most of the catchment, but more concentrated in the west
Hyaena brunnea	Brown hyaena	NT	Y	Floodplain riparian	Occurs in South West Arid Zone and drier parts of the Southern Savannas, with annual rainfall lower than 650mm. They occur in semi-desert scrub, rocky maintainous areas with bush cover and in the Namib Desert. Cover to lie up during daytime is an essential requirement. Water is not a requirement.	Entire catchment

Species name	Common name	Red Data	Potected	Wetland type	Habitat	Possible distribution
Lutra maculicollis	Spotted-necked Otter	NT	Y	Non-floodplain riparian, Floodplain riparian, Non-perennial Pans, Perennial Pans	The species is aquatic and the habitat is limited to large rivers, lakes and swamps, with extensive areas of open water. They never wander far from the waters edge.	Entire catchment
Mellivora capensis	Honey badger	NT	Y	Floodplain riparian, Non-floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	Have a wide habitat tolerance, the only major association they are absent from is the dune desert.	Entire catchment
Mystromys albicaudata	White-tailed Rat	En	Y	Non-floodplain riparian, Seepage	Their distribution follows the savanna grassland zone and they also occur in the Karoo and the Cape Macchia Zone. Requires sandy soils.	Southen and western portions of the catchment
Orycteropus afer	Antbear / Aardvark		Y	Floodplain riparian, Non-floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	Has a wide habitat tolerance. They occur in the Southern Savanna and the South West Arid Zone in open woodland, scrub and grassland. They prefer sandy soil, but will utillise clay soils and hard ground. They tend to avoid rocky areas, as this makes digging difficult and prefers heavily utilised grassland with termites. They depend on the presence of formicid ants, including termites, as a food source.	Entire catchment
Ourebia ourebei	Oribi	En	Y	Floodplain riparian, Seepage	Oribi prefer open habitat such as open grassland, floodplains and grassed vleis. They do not occur where there is a dense cover of tall grass species, but prefer short grass with a few patches of tall grass in which to hide while resting. Grazing by cattle opens the vegetation and therefore renders a site suitable for Oribi. They are not found in the arid or forested areas.	Entire catchment
Proteles cristatus	Aardwolf		Y	Seepage	Occurs in a wide variety of habitats including open savanna. They are dependent on the availability of certain *Trinervitermes* species (termites) on which they depend for food. Occurs in areas with rainfall between 100 and 800mm/annum, but more often in areas with rainfall between 100 and 600mm/annum.	Entire catchment
Raphicerus campestris	Steenbok		Y	Floodplain riparian, Seepage	Open grassland, with areas of tall grass	Entire catchment
Rhabdomys pumilio	Striped mouse		Y	Floodplain riparian, Seepage	Associated with grassland in areas where there is good grass cover	Entire catchment
Suncus infinitesimus	Least Dwarf Shrew	DD		Floodplain riparian, Seepage	Termite mounds and forest	Entire catchment
Reptiles						
Acontias gracilicauda	Slender-tailed Legless Skink		Y	Non-floodplain riparian, Floodplain riparian, Seepage	Mesic thicket, grassland, sandy areas	Northern portion of the catchment

Species name	Common name	Red Data	Potected	Wetland type	Habitat	Possible distribution
Cordylus giganteus	Giant Girdled Lizard or Sungazer		Y	Seepage	Flat or gently sloping *Themeda* grassland or transitional zones	Entire catchment
Homoroselaps dorsalis	Striped Harlequin Snake		Y	Seepage	Prefers grassland	Very rare, distribution not well known
Pelomedusa subrufa	Cape Terrapin		Y	Non-floodplain riparian, Floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	Slow moving and still water, includes temporary pans	Entire catchment
Tetradactylus breyeri	Breyer's Longtailed Seps		Y	Seepage	Montane and highveld grassland	Northern portion of the catchment
Amphibians						
Pyxicephalus a. adspersus	Highveld Bullfrog/ Giant Bullfrog	NT	Y	Floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	They occur in a variety of vegetation types including the Grassland, Savanna, Nama Karoo and Thicket biomes. They breed in seasonal, grassy, shallow pans, but can also utilise non-permanent vleis, as well as shallow water next to waterholes and dams. These vleis and dams occur in flat open areas. They prefer sandy substrates, but sometimes inhabits clay soils.	In Gauteng province and the northern portion of the catchment
Invertebrates						
Gegenes hottentota	Hottentot Skipper		Y	Non-floodplain riparian, Floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	*Themeda triandra* host plant	North-western portion of the catchment
Metisela meninx	Marsh Sylph	V	Y	Non-floodplain riparian, Floodplain riparian, Perennial Pans	*Leersia hexandra* host plant	Entire catchment
Vegetation						
Aloe ecklonis	Aloe		Y	Non-perennial Pans, Perennial Pans, Seepage	Grassland	Eastern portion of the catchment
Boophone disticha	Poison Bulb		Y	Non-perennial Pans, Perennial Pans, Seepage	Grassland, often rocky areas	
Crinum bulbispermum	Orange River Lily		Y	Floodplain riparian, Non-floodplain riparian, Non-perennial Pans	Near river, streams and seasonal pans	
Cyrtanthus tuckii	Fire Lily		Y	Floodplain riparian, Non-floodplain riparian, Seepage	Grassland, wetlands	
Disa woodii	Orchid		Y	Floodplain riparian, Non-floodplain riparian	Wetlands	

Species name	Common name	Red Data	Potected	Wetland type	Habitat	Possible distribution
Eucomis autumnalis	Pineapple Flower		Y	Non-perennial Pans, Perennial Pans	Grassland, on wet areas and rocky hills	
Eulophia foliosa	Orchid		Y	Non-perennial Pans, Perennial Pans	Up to 2000m above sea level	
Eulophia welwitschii	Orchid		Y	Seepage	Rocky or wet grassland	
Gladiolus dalenii	Wild Gladiolus		Y	Non-floodplain riparian, Floodplain riparian, Seepage, Non-perennial Pans	Grassland, often in wetlands and rocky areas	
Gladiolus elliotii	Gladiolus		Y	Non-floodplain riparian, Seepage	Grassland	
Gladiolus papilio	Gladiolus		Y	Floodplain riparian, Non-floodplain riparian	Wetlands and near streams	
Habenaria filicornis	Orchid		Y	Seepage		
Haemanthus montanus			Y	Non-floodplain riparian, Floodplain riparian, Seepage, Non-perennial Pans, Perennial Pans	Grassland, seasonal wetlands	

Cr En – Critically Endangered

En – Endangered

V – Vulnerable

DD – Data Deficient

NT – Near Threatened

Y – Yes

3.3.2 <u>Birds</u>

Various bird species utilise the available habitat within the wetlands of the UORC. The various wetland types with their plant species diversity result in a variety of different habitats for the bird species to use (Barnes 2000). A large number of Red Data birds have been recorded utilising the wetlands in the catchment in the past. Due to the large distribution area of some of the bird species recorded, the populations in the catchment may make a significant contribution to the overall national number recorded for the species. The most important wetland type for bird distribution is probably the pans (Palmer *et al* 2002). Pans provide a great variety of habitat types including open saline water and fresh water, as well as different saturation zones (temporary, seasonal and permanent). Most water bird species are opportunistic and the diversity of species utilising artificial wetlands is also high (Palmer *et al* 2002, Barnes 2000, Barnes 1998).

3.3.3 <u>Mammals and Reptiles</u>

Although the wetlands are characterised by a low diversity of reptile and mammal fauna, the wetlands provide important ecological corridors for the species to receive genetic diversity from other populations (Palmer *et al* 2002).

Three of the mammal species observed in wetlands of the UORC are Red Data species. One of these species is Critically Endangered (Rough-haired Golden Mole (C*hrysospalax villosus*)) and White-tailed Rat (*Mystromys albicaudatus*) and Oribi (*Ourebia ourebei*) are Endangered. The Rough-haired Golden Mole occurs in grassland and has a preference for dry ground next to marshes and damp vleis (Skinner & Smithers 1990). The White-tailed Rat is closely associated with the savanna/grassland zone and is not specifically associated with wetlands (Skinner & Smithers 1990). Oribi prefer open habitat such as open grassland, floodplains and grassed vleis. They do not occur where there is a dense cover of tall grass species, but prefer short grass with a few patches of tall grass in which to hide while resting. Grazing by cattle opens the vegetation and therefore renders a site suitable for Oribi. They are not found in arid or forested areas (Skinner & Smithers 1990).

One of the reptile species, the Striped Harlequin Snake (*Homoroselaps dorsalis*) is included in the Gauteng Department of Agriculture, Conservation and Environment (GDACE) species list of species of concern. The species prefers grassland as its habitat and is therefore not wetland dependant (Branch 1998). The wetlands may, however serve as refugia for the species, especially the drier/temporary wetlands. A number of additional reptile species are protected under the Nature Conservation Ordinances and are included as species of concern.

3.3.4 Amphibians

A wide variety of frog species utilise wetlands in the UORC. Of the 23 frog species that have been observed in the UORC and the five species from adjacent areas, 26 are wetland dependant. *Pyxicephalus adspersus* (Giant Bullfrog), a Near Threatened species is the only species of concern observed in the UORC (Bryan Maritz *pers com* 2005). The Giant Bullfrog occurs in a variety of vegetation types including the Grassland, Savanna, Nama Karoo and Thicket biomes. They breed in seasonal, grassy, shallow pans, but can also utilise non-permanent vleis, as well as shallow water next to waterholes and dams. These vleis and dams occur in flat open areas. They prefer sandy substrates, but sometimes utilises clay soils (Minter *et al* 2004).

3.3.5 Invertebrates

Existing data studied by Palmer *et al* (2002) indicated that the aquatic invertebrates found in the UORC consist mostly of common, widespread taxa. The abundance and productivity of these taxa are important to maintain higher trophic levels, most notably birds. The local variation in the species composition is also high, probably due to local variation in habitat. Although most insect species have good dispersal abilities, their ability to disperse into disturbed areas is dependant on the availability of natural refugia. Most of the crustacea and snail species are adapted to temporary dry conditions, whereas some other species depend on areas that are permanently wet. Dams and weirs therefore favour species dependant on permanent wet conditions and lowers the diversity, and species numbers adapted to temporary dry conditions. It is therefore necessary to maintain a mosaic of temporary, seasonal and permanently wet systems in order to support the wide variety of aquatic invertebrates potentially utilising the wetlands in the catchment (Palmer *et al* 2002, CSIR 2001).

3.3.6 Fish

The UORC has a low diversity of fish species (Palmer *et al* 2002). Historically the catchment had 11 indigenous fish species, but this has lowered to eight at present. In addition three exotic and three translocated indigenous species occur in the catchment. The presence of large impoundments is probably the most important factor limiting the distribution of the fish species, limiting the movement of the species and lowering the potential habitat for several indigenous fish species (Heath and Claassen 1999, Palmer *et al* 2002).

3.3.7 Vegetation

According to Palmer *et al* (2002) the wetlands in the UORC has a high plant species diversity. In their study they recorded 354 indigenous and 59 exotic plant species. There seems to be considerable local and regional diversity in the plant species composition, and richness between and within the different wetland types in the catchment. The variability can be attributed to a variety of factors including hydrological characteristics and water quality, but more detailed studies should be conducted in order to reach any conclusion on the impact of various wetland characteristics on the wetland vegetation (Palmer *et al* 2002).

Hillslope seepage wetlands in the catchment are the most impacted systems in the UORC, due to agricultural practices such as cultivation of crops and pastures. The species diversity in this wetland type is therefore probably not an accurate indication of the natural situation (Palmer *et al* 2002).

Pans are poorly studied systems with little information available on the changes on plant species diversity in relation to the changes in the water dynamics of the wetlands (Palmer *et al* 2002).

Red Data plant species have been recorded in the wetlands of the UORC. It is possible that some additional Red Data species that have not been recorded in any of the publications can utilise the wetlands in the catchment (Palmer *et al* 2002). None of the plant species recorded in the literature are included in one of the IUCN threat categories. One of the species, *Calamagrostis epigeios* var. *capensis* is a Near Threatened species and is therefore a species of concern. A number of protected species have also been listed.

3.4 Wetland classification

Wetlands can be classified according to different classification methods, based on the hydrological functioning, fauna and / or flora composition or diversity, soil, or a combination of these features. The classification method used mostly depends on the reason for classification. Botanists would mostly use vegetation composition to classify wetlands, whereas an ornithologist will mostly use bird habitat features as a defining criterion. Ecologists are, however, more interested in the interaction of different biotic and abiotic features within a system and will therefore use the complete system functioning as part of the classification (Ward & Lambie 1999, Allan *et al* 1995, Cowardin *no date*, Kiai & Mailu *no date, http://dept.my.gov/wqinfo/wetlands/classification.asp*). In addition, there are also various classification methods using remote sensing, depending on the percentage open water, type of vegetation cover and density of the vegetation cover (Dely *et al* 1999, Shanmugam *et al in press*).

One of the most popular methods for the classification of wetlands is the fundamental hydrological functioning of the wetland. The wetlands are therefore classified into different hydro-geomorphic units. The hydro-geomorphic units differ from one project to another and from one specialist to another (Ward & Lambie 1999, Kotze *et al* 2005). The most popular wetland classification method used in South Africa is the classification of hydro-geomorphic units.

The classification used by Kotze *et al* (2005) in WET-EcoServices is a classification using hydro-geomorphic units. This is a useful classification method for assessment of the functions and services of wetlands, since specific functions and services can be associated with each unit type, depending on site specific conditions. The level 1 assessment of Wet-EcoServices is a desktop study focussed on the hydro-geomorphic type of the wetland. The hydro-geomorphic types specified in Wet-EcoServices include floodplain, valley bottom with channel, valley bottom without channel, hillslope seepage feeding a water course, hillslope seepage not feeding a water course and depressions (pans).

Palmer *et al* (2002) classified the wetlands into hydro-geomorphic units during the previous wetland inventory. Six broad hydro-geomorphic units were identified. The six units are Non-floodplain riparian, floodplain riparian, hillslope seepage, pans, other non-riparian and artificial wetlands.

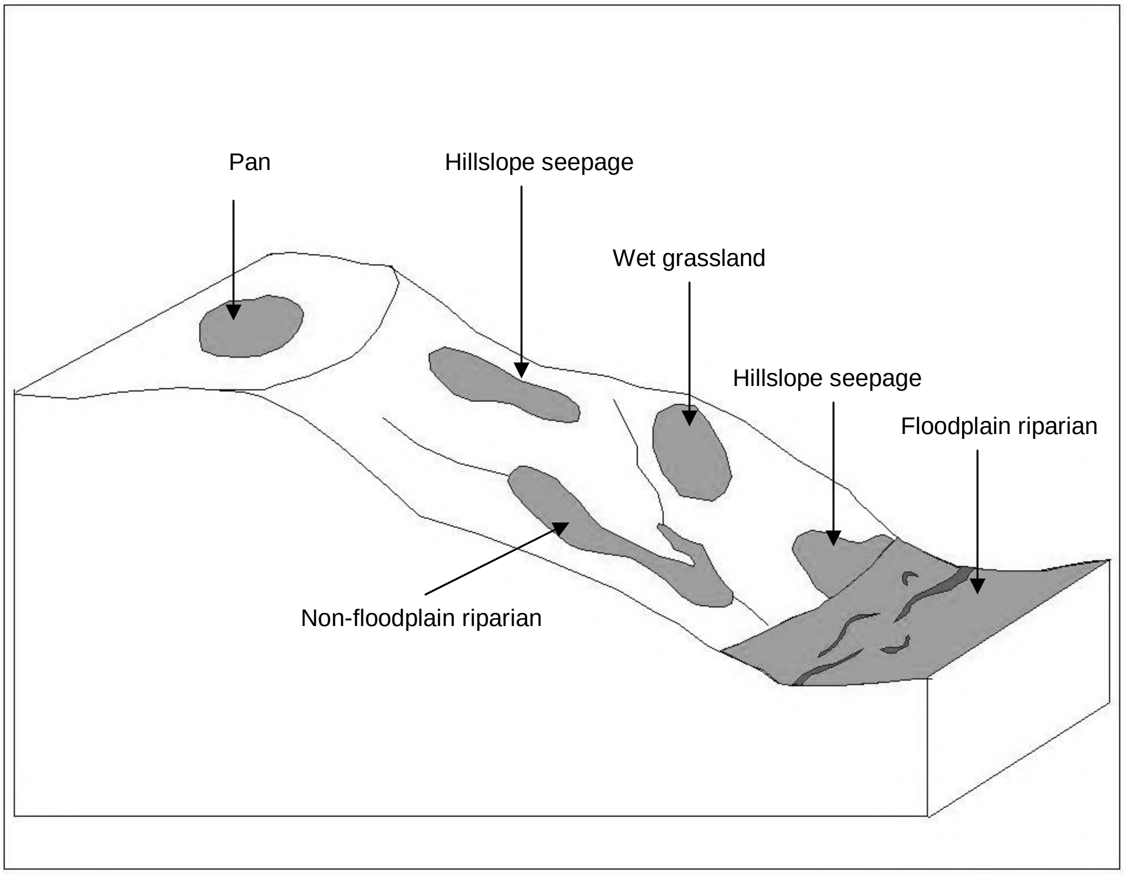

Figure 2. Scematic illustration of wetland types

Included in the table below are the hydro-geomorphic wetland classifications used by Palmer *et al* (2002) and the corresponding classification by Kotze *et al* (2005).

Table 2. Differences and similarities between the hydro-geomorphic units used by Palmer *et al* and Kotze *et al*.

Palmer *et al*	**Kotze *et al***
Non-floodplain riparian	Valley bottom with channel Valley bottom without channel
Floodplain riparian	Floodplain Valley bottom with channel Valley bottom without channel
Hillslope seepage	Hillslope seepage feeding a water course, Hillslope seepage not feeding a water course
Pans	Depressions
Other non-riparian	
Artificial	

As indicated in the above table, the hydro-geomorphic classifications as defined by Palmer *et al* (2002) and Kotze *et al* (2005) have definite similarities and differences. The most significant difference between the two classification systems are the inclusion of artificial wetlands by Palmer *et al* (2002).

A draft wetland classification system for South Africa was completed in 2006, after the wetland layer for this project was compiled. This classification is a hierarchical classification system based on the hydrological characteristics to determine the ecolocical character and functions of the wetlands. The definition used in this classification system is a definition as modified from definition in the RAMSAR convention and therefore includes seashores, rivers and dams. Wetlands can be classified into three levels. The first level is the System level, the second the Subsystem level and the third level the Functional Unit. The Systems level is the most general level and incorporates only three types, marine, estuarine and inland wetlands. Each level incoporates more detail until the wetlands are distinguised based on the habitat units in each wetland (Ewart-Smith *et al* 2006). This system can therefore be used to classify wetlands on a number of levels. This wetland classification system will be completed in 2007 and the will be applied to the National Landcover wetland layer. This classification system can also be applied to the database once it is in the custody of Working for Wetlands.

Included below is a description of the various wetland types as defined by Palmer *et al* (2002).

3.4.1 <u>Riparian wetlands</u>

All riparian wetlands are recognised as boundaries between terrestrial and riverine ecosystems. Riparian wetlands are linear systems, due to their location next to drainage lines. These wetlands are connected through the river system to other riparian wetlands upstream and downstream of the wetland. The riparian wetlands are therefore intrinsically interconnected (Kotze *et al* 2005, Palmer *et al* 2002*,* Ward & Lambie 1999, Rogers 1995).

3.4.1.1 Non-floodplain riparian

Non-floodplain riparian wetlands are associated with drainage lines, but without a floodplain. They lack the characteristic floodplain features such as oxbows (Kotze *et al* 2005, Rogers 1995).

3.4.1.2 Floodplain riparian

Floodplain riparian wetlands occur in lower-lying areas with or without a drainage channel. These wetlands have features such as oxbows, typically associated with floodplains and are inundated by overspill during a flooding event. This type of wetland consists of a permanently wet riverine zone, a seasonally or temporary inundated grassland zone and/or standing water in typical floodplain features such as oxbows, and back swamps. The oxbows and back swamps are only connected to the river system during a flooding event (Kotze *et al* 2005, Palmer *et al,* Ward & Lambie 1999, Rogers 1995).

3.4.2 Seepage

Seepage wetlands occur where groundwater emerges, generally at faults or joints in the underlaying geology, or at the junction of a permeable layer on an impermeable layer. The soil is normally saturated and can contain peat. It is very difficult to quantify the nutrient removal function of the seepage wetlands. The groundwater flow should be measured, as well as the diversity of nutrients in the groundwater, as a starting point to quantify the nutrient removal. In addition, there is a lack of information on the evaporative losses from seeps. The seeps may also receive contaminated runoff during a rainfall event. The portions of nutrients originating from the different sources are difficult to determine (Palmer *et al* 2002, Deocampo 1997).

Springs and seeps can be seasonal, permanent, diffuse or point source. These wetlands can basically be divided into two groups based on the geohydrology, namely confined and unconfined. The groundwater of unconfined wetlands occurs mostly close to the surface and the hydrolic conduit is unconfined. In confined wetlands the groundwater is normally deep underground and is forced to the surface by some pressure, e.g. heat. The hydrolic conduits are confined by the presence of relatively impermeable layers. Most of the seeps are unconfined and seasonal, whereas springs are confined and seasonal or permanent. The aerial extent of seeps is regulated by the landform setting and the volume of discharged water (Palmer *et al* 2002, Deocampo 1997).

Seeps contain both vertical and horizontal flow, while vertical flow is more significant for confined springs. In an unconfined seep the soil is saturated and horizontal surface flow is taking place (Palmer *et al* 2002).

3.4.3 <u>Pans</u>

Pans are sometimes difficult to define (Allan *et al* 1995, Morant 1983). Endorheic pans are typically circular to oval shallow depressions without an outflow. Pans are seldom more than three meters deep, although systems up to 20m deep have been defined as pans. Some systems in Mpumalanga that are large, deep and permanently wet can be defined either as pans or as lakes. In addition, pans have been viewed as a lake type in the past (Allan *et al* 1995).

The classification of pans in South Africa has various problems and is mostly based on the function of the classification system. A classification system proposed by Noble and Hemens in 1978 classified pans on the physical characteristics of the pans, as well as the fauna and flora species composition. The pans were classified as, salt, temporary, grass, sedge, reed and semi-permanent pans. Other classification systems also focussed on the duration of inundation (Allan *et al* 1995, Geldenhuys 1982). Pans in the UORC cannot be sub-divided into different wetland types, since too little information of pans in the catchment is currently available to attempt this.

Pans are normally distributed in the dry part of the country, but a number of pans also occur in the wetter portions of the country, including the UORC. Pans are also distributed across various vegetation biomes, including grassland, the vegetation biome present in the UORC. The distribution of pans across the world is generally affected by four abiotic factors. These factors are bedrock, drainage, slope and climate. Climatic conditions normally associated with the formation of pans are low mean annual rainfall (lower than 500mm) and high mean annual evaporation loss (higher than 1 000mm). A good example of an exception to this rule is the pans in the UORC, an area with annual rainfall of approximately 700mm (Allan *et al* 1995).

The formation of pans is complex and can be influenced by climate, geology, surfaces, disturbance by animals, lack of integrated drainage systems and wind. The collection of water in the pans contributes to the enlargement of the pans. When pans dry out in the dry season the area is bare of vegetation. The loss of sediment takes place through the action of wind. The pans therefore, become deeper and larger and the round shape of the pans is caused by the swirling action of winds. Animals trample the edges of the pans thereby loosening the soil and carrying mud away from the pan (Allan *et al* 1995, Goudie & Thomas 1985).

3.4.4 Other non-riparian wetlands

Other non-riparian wetlands include wet grassland. Wet grassland is a temporary wetland mostly occurring in areas where water tends to accumulate, but not in large quantities. This may be caused by the topology or geology present at a site. Some wet grasslands occur due to human disturbance, such as adjacent to roads where water accumulates, or where there is excessive runoff from urban areas (Bredenkamp *pers com* 2004, Lizamore *pers com* 2005).

3.4.5 Artificial Wetlands

Artificial wetlands are any type of wetland constructed by man. The main type of wetland included in this group is dams and weirs (Palmer *et al* 2002, Lizamore *pers com* 2005). These wetlands are not included in the definition of a wetland as supplied by DWAF (DWAF 2003a), it is however included under the RAMSAR wetland definition.

3.5 Wetland services and functions

Wetlands can perform a number of services and functions, depending on the specific characteristics of the wetland, such as wetland type, micro-topography, vegetation and flow characteristics (Kotze *et al* 2005). Some of the functions that can be performed by the wetlands are briefly discussed below. Some of the functions are also included under the wetland threats, since the functions are, or can be, detrimental to the health of the wetland.

Table 3. Functions discussed in the report

Function	Aspects discussed
Water balance	Streamflow regulation & flood attenuation
	Groundwater recharge
Water purification	Nitrogen removal
	Phosphate removal
	Toxicant removal
	Water quality
	Storage and evaporation of mine water
Sediment trapping	
Harvesting of natural resources	
Tourism and recreation	Fishing
	Birding
Livestock	Water for livestock
	Grazing for livestock
	Livestock diseases
Crop farming	

3.5.1 Water balance

3.5.1.1 Stream flow regulation and flood attenuation

Wetlands have a surface flow augmentation function in a catchment. Wetlands contribute to higher runoff, due to the higher soil saturation in the wetland. The most important contributing factor is the baseflow present at the wetland site. The higher the baseflow present (higher soil saturation) the sooner runoff will occur during a rainfall event. The release of baseflow therefore also contributes to streamflow regulation. The amount of vegetation in the wetland may also slow the flow of water in the wetland and thus the runoff intensity, thereby attenuating flooding conditions. In the UORC, this is however a rare occurrence, as evapotranspiration is higher in the wetland area than in the surrounding natural veld, due to the greater amount of water available in a wetland (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000, Wolski & Savenije *in press*, Ferrati & Canziani 2005).

3.5.1.2 Groundwater recharge

Various wetland types, including floodplain and riparian wetlands may contribute to groundwater recharge. Pans may also contribute to groundwater recharge. This outward seepage from the pans may help to regulate the build-up of dissolved solids in the system. Seeps are responsible for groundwater discharge and almost never contribute to groundwater recharge (Palmer *et al* 2002, Allan *et al* 1995, Kotze 2000, Kotze *et al* 2000).

3.5.2 <u>Water purification</u>

3.5.2.1 Nitrogen removal

It is difficult to determine the amount of nitrogen removal by a wetland without measuring the input and output nitrogen. The transformation processes, such as denitrification, requires specific conditions in order to proceed. The reaction rate of this process is a function of the reactant concentration and the applicable bacteria. These processes are therefore more likely to take place in wetlands and wetland areas with more organic material (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000).

The three transformation processes of nitrogen are plant uptake, nitrification and denitrification (Palmer *et al* 2002). The specific processes and rate of the process depends on the specific characteristics of the wetland. It should be taken into account that all three of the processes may take place in the same wetland (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000, Brady & Weil 1999).

3.5.2.2 Phosphate removal

Phosphates enter a wetland from various sources, both natural and anthropogenic. Phosphate removal is not a microbial process, but a physiochemical process. As with nitrogen removal the amount of phosphate removed cannot be determined without measuring the input and output phosphate. Unlike nitrogen removal, however, the removal of phosphates is not dependant on the presence of bacteria. The removal of phosphates takes place via precipitation, absorption onto clay particles or uptake by plants. These phosphates can therefore be released into the environment by a change in the micro-environment or by the natural die-back of plants (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000).

Pans may contribute to groundwater recharge. This outward seepage from the pans may help to regulate the build-up of dissolved solids in the system. When the deposited material is not transported out of the system they redissolve after a rainfall event and contribute to the saline nature of the pans. Phosphates in the pans convert from absorbed to soluble and back on a regular basis. Plants should be harvested for the removal of phosphate (Palmer *et al* 2002, Allan *et al* 1995).

3.5.2.3 Toxicant removal

The reduction or transformation of sulphate in wetlands is an important process in the wetland biochemistry. This process requires the presence of sulphate reducing bacteria. The bacteria occur in sediment and micro zones in plant litter. The process requires an environment with low oxidation potential (-120mV) and the presence of organic matter. Once the sulphate has been reduced other processes are required to immobilise or remove the sulphur compounds from the system (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000, Brady & Weil 1999).

The removal of metals takes place through precipitation, absorption and plant uptake. The metals can enter the wetland system in particulate form or in a dissolved state. Metals associated with mine water often precipitates out. The precipitation of metals are influenced by the pH and redox potential present at a particular moment. The oxidation potential varies between and within wetlands. This is greatly influenced by the wetland species present, since plants have the ability to aerate soils. Although the precipitation of metals is an important process in wetlands the metal uptake by plants also plays an important role. The dominant species in wetlands in the UORC receiving mine drainage are *Typha capensis* and *Phragmites* species. These species are metal accumulators, thereby allowing the plants to grow in areas with high pollution. The level of metal accumulation by plants is very low (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000, Brady & Weil 1999).

More important in the removal of metals is the role played by algae. Algae are manganese accumulators and can accumulate other metals as well. The metal uptake ability of algae is controlled by the specific bioaccumulation and physical-chemical factors present. Although algae can accumulate vast amounts of metals in relation to mass, the distribution of algae in wetlands is limited and therefore the total metal uptake by algae in the wetland. The most important role of plants in the removal of metals from the system are therefore not in the accumulation of metals, but in changing the environment to that more suitable for the removal of toxicants (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000).

Acid mine drainage has entered the Kromdraaispruit wetland (located approximately 20 km north-west of Witbank) for 20 years, a wetland with distinct morphological zones. The Kromdraaispruit wetland is located in the Kromdraaispruit, a tributary of the Zaalklapspruit, flowing into the Wilge River. Vegetation in the wetland removes high percentages of influent metals. The accumulation of iron and manganese takes place in the roots and aerial parts (stems and leaves) of the wetland vegetation (Limpitlaw 1995). It was determined that the biochemical water quality of acid mine drainage passing through a wetland improves with distance moved through the wetland. It was also determined that the concentration of sulphate-reducing bacteria increases with distance away from the pollution source (Limpitlaw 1996). The immobilisation of metals was best in the areas of optimal organic adsorption of metals (Limpitlaw 1995, 1996).

Permanently wet seeps can function to reduce nitrate, sulphate, iron and manganese. Where there are both nitrates and sulphates in the groundwater competition occurs for the available carbon and reduction is therefore a slower process. Similar processes occur in the seasonal seeps, but the leaching of immobilised substances can occur before soil saturation, thereby affecting changes to the redox potential and pH of the site. Organic materials in the wetland are lost when the water levels drop (Palmer *et al* 2002).

3.5.2.4 Water quality

Floodplain wetlands are connected systems with the water in different zones (compartments). These zones include the permanent, seasonal and temporary wet zones. It is therefore possible that salts previously deposited during a drying out cycle will be dissolved and leached from the soil during rewetting. This can contribute to a mineral exchange between floodwater and sediment. Flooding changes the redox potential in the wetland that will in turn increase the solubility of metals such as manganese and iron, and triggers the release of phosphates. The opposite applies when the wetland dries out. The concentration of nutrients in this wetland type is normally low, due to the dilution effect of water passing through the wetland. The wet and dry cycles in a wetland, therefore contribute to the water quality leaving the system. Water leaving the system during a drying out cycle will have less dissolved salts and will therefore be of a better quality (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000).

3.5.2.5 Storage and evaporation of mine water

Wetlands can be used for the storage and evaporation of water, thereby contributing to potential storage facilities at mine sites. The use of natural wetlands in stead of man made dams is highly detrimental to the wetland (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000, Limpitlaw 1995, 1996).

3.5.3 Sediment trapping

Wetlands play an important role in the sediment balance of streams and rivers. Wetlands generally slow the water flow in a channel, thereby allowing the precipitation of sediments to take place. However, should the flow velocity increase, the sediment load in the water will increase as well (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000, Kitheka 2003, Zierholtz 2001).

The soil losses in the portion of the UORC investigated by Palmer *et al* (2002) are moderate to high, at an average of 44 - 47 tons/km^2/year. The extent to which wetlands contribute to sediment trapping in the catchment has not yet been determined. The presence of this function in wetlands depends on the type of wetland (Palmer *et al* 2002, Midgley *et al* 1994).

The flow velocity in the channel of a floodplain wetland is high, with a high suspended load. When the water overtops the river bank the flow velocity lowers and deposition of the load occurs. The sedimentation in the floodplain reduces the phosphate loads in the short term. Drying out of the floodplain wetlands is similar to endorheic pans (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000).

3.5.4 Harvesting natural resources

Wetlands throughout the world are used for the harvesting of resources, including the harvesting of food, building materials and peat. In many instances various communities depend on wetlands for their survival, either as a source of food or building material or, alternatively, as a source of income. The income gained from the wetlands can be direct or indirect, through the sale of wetland products or from the income from tourists visiting the wetlands (Mmpolewa *in press*, Scott *pers. com.* 2004, Wateryear 2003).

Harvesting of wetland resources plays an important role in the lives of various individuals and communities in South Africa. An access database was developed in order to assist wetland scientists constructing and rehabilitating wetlands with the choice of species to use in revegetation. The database is called New Green and contains 38 species that can be harvested in a wetland and what the various species are used for. Species used for food, building material and medicinal purposes are included (Abbot Grobicki *no date*). The database is available from the Water Research Commission.

The amounts of plants, animals and other materials harvested from the wetlands in the catchment are unknown, since no research has been conducted in the UORC in this regard. During interviews conducted by Turpie and van Zyl (Palmer *et al* 2002) it was concluded that a variety of resources in the wetlands are utilised by farmers and their workers. A list of 50 plant species previously recorded in the wetlands of the UORC has medicinal and/or food value. The extent to which these plants are used in the catchment are however unknown (Palmer *et al* 2002).

Labourers on farms most often utilise the wetland resources on private farms. There are, however instances where farmers have problems with trespassers and squatters. In these instances it is possible that the outsiders will utilise the wetland resources. Resources most frequently utilised by labourers are mammals, with the grass and medicinal plants utilised less frequently. Dogs and traps are used to hunt the small mammals, which serve as an additional source of food. The harvested grass is used for thatching or for the feeding of livestock. Although less commonly, clay, reeds, fish, birds and crabs are also utilised on some farms. These figures can, however be understated especially when it takes place without his permission (Palmer *et al* 2002).

In the UORC the harvesting of wetland resources is unlikely to make a significant contribution to household material, even though it may save costs of food, medicines and building materials. Very few households are likely to depend on the presence of these resources for survival, as it is mostly labourers who have access to the wetlands and they already have an income (Palmer *et al* 2002).

The farm owners do not normally harvest any plants from the wetlands, but some farmers do collect sand for building purposes, and in some instances are even used for the commercial supply of building sand (Palmer *et al* 2002). The above activities in wetlands require a permit from the National Department of Agriculture in terms of the Conservation of Agricultural Resources Act (Act 43 of 1983) (CARA) (Landcare South Africa) as well as the Mineral and Petroleum Resources Development Act (MPRDA).

3.5.5 Tourism and recreation

3.5.5.1 Fishing

Fishing activities form an integral part of not only recreational activities, but also as part of the livelihoods of various communities across the world. The quality of wetlands not only has an impact on the fish resources in the vicinity of the wetlands, but may influence fish resources far downstream. Wetlands influence the quality of water downstream and may have an impact on the possible breeding habitat of fish resources. Therefore not only important for recreational fishing, but also for sustainable utilisation by local communities and, indirectly, larger commercial practices (Veitch & Sawynok 2005, Great Barrier Reef Marine Park 2006).

The most important fishing activity in the UORC is recreational fishing, attracting tourists from many regions, especially fly fishermen. A large number of fishing clubs occur within the UORC and every town in the catchment contains a shop selling fishing gear. Angling, therefore contributes towards the economy of the area. A value can be attached to the fishing activities associated with wetlands by estimating the total expenditure of anglers on fishing gear, licences and other costs related to fishing, such as travel costs and accommodation (Palmer *et al* 2002). An estimate of this total is given in Palmer *et al* (2002) as R16,5 million per year in the smaller UORC. It was determined that 70% of fishing takes place in dams, 20% in rivers and 10% in pans (Palmer *et al* 2002).

3.5.5.2 Birding

The importance of wetlands for waterfowl habitat was identified and the conservation of wetlands forms part of the Ramsar Convention (Convention on Wetlands of International Importance especially as Waterfowl Habitat). Various Red Data bird species and bird species of concern, including the Blue Crane, Wattled Crane, Flamingoes (Greater and Lesser) and Grass Owl, are also dependant on wetlands for breeding and/or feeding activities (Cowan 1995, South Africa Tourism 2006).

Birding in the UORC takes place at various locations where different habitat types occur. According to Palmer *et al* (2002) 40% of birding takes place at dry land sites, 20% at rivers, 20% at dams, 15% at pans and 5% at other wetlands. Birders spend approximately R1 855 440 per year on birding in the area, including birding equipment and the expenditure of a birding trip (Palmer *et al* 2002). This total has probably increased significantly since the study was conducted.

The south-western portion of the UORC, between Bethal, Hendrina, Ermelo and Caroline is located within an Important Bird Area (IBA) (Barnes 1998). Threatened bird species occuring in this IBA includes the Bald Ibis, Lesser Kestrel, Wattled Crane, Blue Crane, Botha's Lark, Martial Eagle, Crowned Crane, Stanley's Bustard, Whitebellied Korhaan and Grass Owl (Barnes 1998). The primary grasslands and the wetland areas are important bird habitat areas in the IBA (Barnes 1998). No other IBAs are located on the site.

3.5.6 Livestock

3.5.6.1 Water for livestock

Wetlands can act as water sources for livestock on farms. Farmers usually use boreholes to provide water for their animals in different camps, but the presence of permanent wetlands in a camp makes the construction of a watering point in the camp unnecessary. The farmer can, therefore save money for each camp where a watering point does not need to be constructed (Palmer *et al* 2002, Kotze 2000, Kotze *et al* 2000).

3.5.6.2 Grazing for livestock

According to a literature review conducted in New Zealand on the effects of livestock grazing on wetlands, the impact of grazing on a wetland is site specific. Direct effects of grazing include trampling, the removal of biomass, nutrient inputs, bacterial contamination and the dispersal of seeds. The effect of the grazing on the biomass depends on the specific characteristics of the wetland, including the palatability of the plant species and how each of the species reacts to grazing. The ratio of increaser to decreaser species has a huge impact on the biomass in the wetland with and without grazing, as well as, the eventual species composition and dominant species in the wetland. It is, therefore necessary to have site specific research in order to determine the impact on a specific wetland (Reeves & Champion 2004). In a study conducted in the arid portions of the western United States it was determined that grazing by livestock was responsible for 80% of all damage sustained to riparian ecosystems (Hengle *no date*). It is, therefore important to assess the impact of grazing on wetland ecosystems in a certain area before allowing grazing to occur.

Wetlands provide good grazing for livestock during the winter months in the UORC and are, therefore valuable for the provision of grazing during the end of the winter when the rest of the grazing areas do not have good grazing left. The wetlands do not have any particulate benefits for the rest of the year, since good quality grazing occurs over the entire grazing area. The most commonly grazed wetland types are the seepage wetlands. Some farmers within the UORC also seed the wetlands to encourage better grazing grasses to grow. Although seepage wetlands produce roughly twice the amount of grazing as normal veld, the seepage wetlands can normally not be utilised through summer as they are generally too wet for the livestock to move through it and can pose a threat of disease (Palmer *et al* 2002). The over-grazing of wetlands is an illegal activity in terms of the CARA.

3.5.6.3 Livestock Diseases

Various livestock diseases are associated with wetlands, mainly nematodes and arboviruses. Livestock grazing in the wetlands are susceptible to the diseases associated with wetlands and can also spread the diseases between wetlands (Reeves & Champion 2004, Wilson 2003). The livestock in the catchment are regularly vaccinated against these diseases and several farmers remove their livestock from wetland areas during the summer months to reduce the risk of these diseases (Palmer *et al* 2002). Diseases associated with wetlands include (Palmer *et al* 2002):

- Nematodes, most importantly Wireworm;
- Flukes;
- Lumpy Skin Disease;
- Three Day Stiff Sickness;
- Blue Tongue; and
- Horse Sickness.

3.5.7 <u>Crop farming</u>

The production of crops in wetlands is prohibited by the CARA. Section 7 of the act prohibits cultivation in a wetland area or within 10 m horizontally of the flood area of a watercourse. Any cultivation practices taking place in a wetland, which did not take place prior to the promulgation of the act, is therefore an illegal activity (Landcare South Africa).

3.6 Wetland threats

Wetland threats dicussed below are:

- Water usage
- Mining and quarrying
- Agriculture
  - Cultivation
  - Livestock
- Burning
- Dams and weirs
- Industries
- Harvesting of resources
- Infrastructure

- Fauna and flora
    - Flora
    - Forestry
    - Fauna

3.6.1 Water Usage

Large amounts of water are required in the UORC for various activities, most importantly for power generation (181 million m^3/a). Other uses also requiring significant amounts of water are urban use (62 million m^3/a), irrigation (44 million m^3/a), and mining and industrial use (20 million m^3/a) (Figure 2). Another important consideration in the water budget are the transfers out of the catchment (96 million m^3/a). The main storage dams in the UORC are the Bronkhorstspruit, Witbank, Doringpoort, Middelburg and Loskop dams. In addition the extraction of large amounts of groundwater also takes place in the catchment. The total water yield in the catchment from various sources, including surface water, groundwater and transfers into the catchment totals 409 million m^3/a. It is expected that the total requirements of the catchment will exceed this with 56 million m^3/a in the base scenario for water use in 2025 and with 87 million m^3/a in the high scenario in 2025 (DWAF 2003b). The other catchments in the Olifants River Catchment are already showing a large deficit in the water budget. The Olifants River Catchment is therefore a water stressed area. The water shortage can be mitigated to some extent by the potential for development in the water supply services (DWAF 2003b).

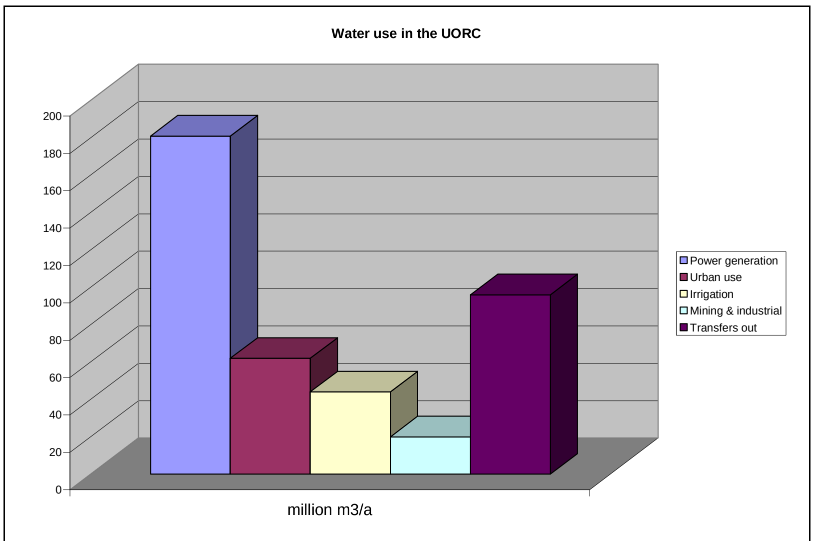

Figure 3. Water use in the UORC (DWAF 2003b)

3.6.2 Mining and Quarrying

There is a strong correlation between coal and wetlands, since the precursor of coal is peat. For this reacon several of the large wetlands in the catchment occur above shallow coal deposits. The mining of these coal deposits by open cast mining methods therefore results in the destruction of the overlaying wetlands. Coal mining in the Mpumalanga province is very important to the economy and a large amount of the coal (62% of coal that is not exported) is used for the generation of electricity. Wetlands are often impacted by surface coal mining, since the wetlands are located in low-laying areas and are therefore a shorter distance above the coal than the adjacent areas. These surface mining activities lead to the total destruction of the wetlands (Palmer *et al* 2002, Marneweck 2003, De Lange *et al* 2003, Marneweck 2004a, Wetland Consulting Services 2005).

Underground mining can also have a significant impact on the wetlands, especially if the mines are located close to the surface. Mining activities influence both the water quantity and quality. The reduction of groundwater due to mining activities is not an uncommon feature and this lowering of the groundwater table may cause some wetlands to dry up. Acid mine drainage is another common feature once the mining activities have ceased. If the polluted mine water decants from the mine, and thereby enters the surface drainage system it will add pollution to the already stressed environment. The long term environmental impact of these mining activities is not yet known (Palmer *et al* 2002).

The impacts from underground mines on the wetlands are less drastic than from open cast mines and can be further limited by best practice mining activities, such as the proper management of mine water.

Artificial wetlands are formed by the subsidence of mines, thereby creating depressions, but the fauna and flora associated with these wetlands can differ from the species in a natural system. This subsidence may also cause alterations in the topography of existing wetlands, altering the hydrological processes and the location of the different wetness zones within the wetland (Palmer *et al* 2002).

Although all of the wetland types, including artificial wetlands, can be threatened by mining activities some wetland types are more threatened than others. The wetlands at greatest risk from the mining activities include (Palmer *et al* 2002, Marneweck 2003, De Lange *et al* 2003, Marneweck 2004a, Wetland Consulting Services 2005);

1. drainage lines with riparian zones,
2. midslope seepage wetlands,
3. non-permanently wet pans,
4. seasonally inundated valley bottom floodplain without footslope seepage, and
5. seasonally inundated valley bottom floodplains with footslope seepage wetlands.

One of the most polluted river systems in the region is the Olifants River System (Myburgh 1999; CSIR 2001).

ECOSUN cc (2006) has been conducting a Biological Monitoring Project in the Catchments of the Witbank Dam and Middelburg Dam since May 1999. The monitoring conducted during 2006 coincided with the mine-water releases. The ecological components that were assessed during the survey included:

- *In situ* water quality
- Invertebrate Habitat Assessment System (IHAS, version 2)
- Intermediate Habitat Integrity Assessment (IHIA)
- Aquatic Macroinvertebrate Assessment (SASS5)
- Sediment Contaminant Analysis

The Total Dissolved Salt (TDS) varied across the entire catchment. The TDS at three sampling points exceeded the target water quality guideline limits for the management units. These sampling points were located at:

- The Olifants River at Wolvekrans Colliery, immediately upstream of the Witbank Dam;
- Woestalleenspruit, approximately 1km upstream of the of the confluence of the Klein Olifants River; and
- Klein Olifants River, approximately 1km before Bosmanspruit confluence (ECOSUN 2006).

The IHAS conducted during the current investigation indicated significant increases in the Instream Habitat Availability were observed at: (ECOSUN 2006)

- The Rietspruit, approximately 1km upstream of the Rietspruit Dam;
- Koningspruit before the confluence with the Olifants River;
- Naauwpoortspruit at Control Point B1H019;

- Dwars-in-die-wegspruit at the low water bridge before the confluence with Trichardtspruit;
- Olifants River at Control Point B1H018;
- Upper reaches of the Olifants River;
- Tributary of the Klein Olifants River at the bridge on the road between Hendrina and Middelburg;
- Klein Olifants River at Control Point B1H012; and
- Arendsfonteinspruit 2km upstream of the Middelburg Dam.

While the instream habitat significantly decreased at:

- Trichardspruit downstream of the Syferfontein Coliery; and
- Tributary upstream of the Klein Olifants River, upstream of the Hendrina Power Station and the Boschmanskop Dam (ECOSUN 2006).

Comparison to the previous year's results (2005) showed few significant changes in the habitat integrity. The IHAS showed that the modifications to habitat integrity are mostly large to critical in the catchment (Classes D to F). In some areas basic ecosystem functions have been destroyed (ECOSUN 2006).

The Ecological State Classes obtained from the SASS results indicated both significant spatial and temporal variation in the catchment. The significant variation can be attributed to the complexity of the variety of impacts in the catchment, including: effluent, channel modification, exotic vegetation, competition from exotic fish species and veld fires (ECOSUN 2006).

The Sediment Contaminant Analysis showed significant decreases in analytes in the sediments, due to the high flows experienced before the 2006 analysis in the catchment. The Olifants River upstream of the Koringspruit confluence had the highest concentration of analytes in the Witbank Dam catchment and a tributary of the Klein Olifants River, as well as a section of the Klein Olifants River which had the highest analyte concentration in Middelburg Dam (ECOSUN 2006).

The study only reflects the biotic integrity of the study area at the time of the survey. The possible impact of the biotic integrity on the rivers and streams were not analysed and will form part of a later phase of the study (ECOSUN 2006).

3.6.3 <u>Agriculture</u>

3.6.3.1 Cultivation

One of the greatest threats to wetlands is commercial dryland farming. The cultivated areas are normally abutting or adjacent to wetlands in the catchment. Many of the midslope seeps have been drained and are currently under cultivation for the production of maize, as well as, potatoes, beans, lucerne and soybeans. Pesticides and herbicides used during cultivation can have a large negative impact on the local fauna and flora, and therefore, the wetlands. Some of the wetlands are harvested for winter fodder and others are cultivated for grazing grasses (Palmer *et al* 2002). The impacts on the wetlands are, therefore both direct and indirect.

Changes in the runoff patterns, infiltration rate of rain and increased soil erosion are caused by mismanagement practices and contribute to the degradation of rivers and wetlands. The additional sediment from the exposed cultivated fields also contribute to increased sediment load in the rivers. The increased sediment leads to changes in the riverbed and therefore, a loss in habitat for some freshwater species. The extraction of water for cultivation purposes results in a decrease in stream flow and changes in the water temperature and chemical properties. Structures associated with irrigation activities, including channels, pumps and weirs, also has an impact on the rivers and wetlands (Myburgh 1999).

3.6.3.2 Livestock

Livestock are often moved to grassland containing wetlands, especially during winter, for additional fodder. Overgrazing and trampling by the cattle can have a large negative impact on the wetland (Palmer *et al* 2002, Reeves & Champion 2004).

3.6.4 Burning

Wetlands are burnt on a regular basis, normally annually. The burning can be intentional, to improve the grazing potential for livestock or unintentional, through accidental fires (Palmer *et al* 2002). Although wetlands in the Highveld, like the grasslands, are adapted to burning the frequency and timing of the burn is important. Burning leads to a loss of organic compounds and can alter the soil properties. In addition the burning practices may lead to a significant loss in wildlife, including bird nests (Palmer *et al* 2002). It is therefore important to ensure that burning practices are managed according to environmental principles.

3.6.5 Dams and weirs

A large number of dams and weirs have been constructed in the various streams and rivers in the UORC. These dams are mainly used for agricultural purposes such as stock watering and irrigation. These structures can cause the inundation of wetlands upstream of the dam wall. In addition, the dam outlets are not always sufficient during flood periods and may break, leading to erosion. The cumulative impact of the dams on the hydrology of the catchment is large, especially during low-flow periods (Palmer *et al* 2002).

The most important impacts of dams and weirs on the natural hydrological system are (Myburgh 1999):

- Changes in the water temperature;
- Changes in the chemical properties of the river;
- Changes in the habitat complexity;
- Changes in the composition and functioning of the biotic populations;
- Changes in flooding frequency;
- Changes in the extent of flooding;
- Changes in the movement of sediment and organic material;
- Changes in nutrient cycling; and
- Restricting the movement of various aquatic fauna species, both up-stream and down-stream of the dam.

3.6.6 Industries

Industries can have a large impact on wetlands. The impacts differ between industries, but some impacts are common to all, e.g. polluted water. In addition, bad practices during the construction or operational phase can have far reaching impacts on wetlands in the vicinity or downstream of the industries. It is therefore imperative that sustainable development takes place and that industries adhere to strict control measures to limit the impacts of the development on the environment (Adebayo *no date*, Dugan 2005).

3.6.7 Harvesting of wetland resources

Wetlands are a source of various useful products, including fish, medicinal plants, plants used for crafts and building sand. The removal of these products is seldom controlled and this has led to the degradation of some of the wetland systems. Wetlands are an important source of building sand and the mining of these wetlands for sand has been extensive in the past. It has often happened that the sand is removed and the wetland is not rehabilitated afterwards. This degradation of the natural habitat favours the establishment of pioneer, and alien and invasive species (Palmer *et al* 2002, Kotze *et al* 2005).

3.6.8 Infrastructure

The network of roads and railways, with associated infrastructure such as bridges and culverts, in the catchment is well developed. The structures have a significant impact on the surface drainage patterns. Wetlands downstream of the roads and railways are drying up, and new wetlands are forming upstream of the structures. A common feature of road and railway crossings are that they restrict water flow, thereby causing backflooding upstream and concentrated flow downstream of the bridges. The result of this is erosion downstream of the bridges, often with extensive erosion gullies, and associated channel incision. This reduces the amount and frequency of overtopping occurring during a flood event. Several wetlands that are historically seasonally wet have therefore dried out to temporary wetness. The structures also interfere with the normal migration patterns of a number of animals, including frogs (Palmer *et al* 2002, Lizamore *pers com* 2004).

3.6.9 Alien Fauna and Flora

3.6.9.1 Flora

Any plant that occurs in an area where it is not indigenous is referred to as an alien (exotic, foreign, introduced, non-native, non-indigenous) plant. If these plants are able to maintain populations without human help they can be referred to as naturalised plants. If such naturalised plants are also able to spread over considerable distances into new, undisturbed, natural areas and replace the indigenous vegetation, they are regarded as alien invasive plants, or invaders (Klein 2002).

Alien invasive plants are similar to pioneer plants in that they rapidly colonise disturbed areas, but differ from pioneer plants in having the additional ability to encroach upon undisturbed, pristine areas. They usually grow vigorously and disperse rapidly, and instead of being outcompeted by better-adapted plants, the invasive plants actively displace the indigenous vegetation and often transform the plant community. Several factors enable alien plants to become invaders, the most important of which is the absence of their natural enemies. Other characteristics that could enhance the invasiveness of an alien plant are strong vegetative growth, prolific seed production, long-lived seeds, a high seed germination rate, effective seed dispersal mechanisms, rapid maturation to a seed-producing stage and the ability to reproduce vegetatively (the ability of stems, leaves or roots to produce new plants) (Klein 2002)

Alien plant invasions can cause:

- A decline in biological diversity,
- Local extinction of indigenous species,
- Decrease in productivity of agriculture and rangeland,
- Increased agricultural input costs,
- Reduced streamflow in rivers,
- Choking of watercourses,
- A decline in animal species, and
- Respiration by submerged weeds can cause oxygen deficiencies in water.

Disturbances such as construction activities and overgrazing favour the establishment of alien and invasive species. The most common invasive plants in the riparian zones include *Acacia mearnsi* (Wattle) and *Sesbania* sp (Palmer *et al* 2002, Marneweck 2003, De Lange *et al* 2003, Marneweck 2004a, Wetland Consulting Services 2005).

Alien invasive plants have a huge impact on the natural environment and the Working for Water group was started to clear invasive vegetation.. A study was conducted by Versfeld *et al* in 1998 to assess the current distribution of invasive species. Results of the study indicated that alien vegetation use between 0 % and 5 % of the available water in the catchment. It is however, necessary to update the database again, since the database was only intended as a baseline study.

Invasion of the riparian habitats is taking place in all of the provinces, with approximately 1.4% of the general landscape invaded by alien species. Invasive plants therefore, cover a greater extent than commercial plantations (Versfeld *et al* 1998).

The control of invasive plant species is addressed under CARA, Regulations 15 and 16. Invasive species are classified under three categories according to their invasiveness, uses and threat to the environment. Category 1 invaders are species that will no longer be allowed to occur on any property in South Africa, because their harmful properties outweigh their useful qualities. The plants may not be planted or propagated in any way and existing individuals should be removed. These species may not be transported or allowed to disperse (Landcare South Africa).

Category 2 plants are species proven to have a potential for becoming invasive, but with commercial value. Provision is made in CARA in Regulation 15 and 16 for the species to occur in certain demarcated areas, but the species have to be removed from all areas outside the demarcated areas. An area for the growing of category 2 plants can only be demarcated by the Executive Officer. Since the growing of category 2 plants qualifies as a water use, a water use licence has to be obtained from DWAF for an area of 1ha and larger. It is also important to ensure that all reasonable steps have been taken to stop the spread of the species to other areas, through seed or vegetative growth. Category 2 plants may never occur within 30m of the 1:50 year floodline of any wetlands or watercourses (Landcare South Africa).

Category 3 plant invaders are plants that are proven to have the potential of becoming invasive. These plants are however, popular garden plants (ornamentals or shade trees) and it will take a long time to replace these species. Category 3 plants are not allowed to occur anywhere, unless the plants were already in existence when the regulations came into effect. The conditions for the plants to remain is that all reasonable measures are taken to prevent the spread of the species and that none of the plants occur within 30m of the 1:50 year flood zone of any wetlands or water courses. No propagative material of these plants may be planted, imported or transported in any way. It is however, legal to trade the wood of these plants, as well as other products that do not have the potential to grow (Landcare South Africa).

Table 4. List of invasive species observed in the wetlands of the UORC.

Species name	Common name	Category
Acacia dealbata	Silver Wattle	2
Acacia mearnsii	Black Wattle	2
Azolla filiculoides	Azolla, Red Water Fern	1
Cirsium vulgare	Scotch Thistle	1
Populus species	Poplar	2
Salix babylonica	Weeping Willow	2
Sesbania punicea	Red Sesbania	1
Solanum eleagnifolium	Silver-leaf Bitter Apple	1
Solanum sisymbriifolium	Wild Tomato / Dense-thorned Bitter Apple	1
Xanthium spinosum	Spiny Cocklebur	1
Xanthium strumarium	Large Cocklebur	1

3.6.9.2 Forestry

Forestry is restricted to only a few areas in the catchment and the most common trees in these forestry plantations are Poplars (*Populus* sp) and Eucalyptus (*Eucalyptus* sp). These exotic species utilise more water than the indigenous vegetation, and the presence of these plantations in close proximity to the wetlands lowers the water level in the wetlands and can cause drying out of previously permanent zones. The plantations change the habitat of a variety of wetland species and may threaten rare populations (Palmer *et al* 2002, Van Wyk *pers com* 2000).

3.6.9.3 Fauna

A number of alien fish and invertebrate species occur in the wetlands of the UORC. These species can have a large impact on the indigenous fauna due to competition and pressure from natural enemies. Trout fishing is a mayor recreational activity in the area and trout are introduced to trout dams on a continuous basis. The trout often have a negative impact on the native fish populations, due to competition for resources. The introduction of trout into rivers where they are absent at present is prohibited (Heath and Claassen 1999, Palmer *et al* 2002).

3.7 Indicators of wetland health

3.7.1 National River Health Programme

Although rivers are not included as wetlands the health of the river system can reflect the health of the wetlands in the area. Healthy wetlands, especially healthy riparian wetlands, have a positive impact on the river health and degraded wetlands often have a negative impact on the river health.

The National River Health Programme is a programme that assesses the health of a river system. The health of the river systems are published in reports and are available to the public (CSIR 2001, http://www.csir.co.za/rhp/index.html). An assessment of the Crocodile, Sabie-Sand and Olifants River Systems has been conducted as part of this programme.

The UORC is divided into ecoregions, representing distinct units within the catchment. The ecoregions of the Olifants River catchment relevant to this project are 2.08, 2.09, 7.02, 7.03, 7.04 and 7.05 (Figure 4). Ecoregions 7.02, 7.03 and 7.04 are located in the grasslands of the escarpment plateau, with some rolling rocky areas interspersed. The Wilge, Bronkhorstspruit, Klein Olifants and Olifants Rivers originate in these ecoregions. Ecoregions 2.08 and 2.09 are located on the Highveld Plateau and descend the Drakensberg Escarpment. The confluences of the Olifants and the Klein Olifants Rivers, as well as the confluence between the Olifants River and the Wilge River are included in these ecoregions (CSIR 2001).

Tools used to assess the health of the rivers are:

- o South African Scoring System (SASS) 5;

- The Fish Assemblage Integrity Index (FAII);
- The Riparian Vegetation Index (RVI); and
- The Index of Habitat Integrity (IHI).

SASS 5 uses the specific habitat requirements of invertebrates, including snails, crabs, worms, insect larvae, mussels and beetles, to assess the overall condition of a river system. Most invertebrate species are short-lived, the changes in river condition are therefore, displayed accurately by the species composition. The SASS 5 results are expressed as an index score and as an average score per taxon (CSIR 2001).

The FAII is an index using fish as an indicator of river health. Fish are long-lived and are therefore, indicators of long-term changes in the river health. The index categorise fish populations according to their intolerance to changes in habitat and pollution. The results are expressed as a ratio of the observed conditions to the expected conditions without human impact. The system is currently being utilised, but is also being refined to ensure greater accuracy (CSIR 2001).

The RVI focuses on the health of the riparian zones of rivers. Various impacts including the collection of firewood, changes in the flow regime and grazing or cultivation practices in the riparian zone, can change the characteristics of the zone. A number of criteria are used to assess the riparian vegetation including vegetation removal, cultivation, construction, inundation, erosion, sedimentation and alien vegetation. The health of the riparian zone is then expressed as a percentage of change from the natural conditions (CSIR 2001).

The greater the diversity of available habitat in and around streams, the greater the species diversity that can be expected in a river system. Different habitat types that can be expected include pools, rapids, sandbanks, stones in the riverbed and riparian vegetation. The IHI is an index that assesses the available habitat in a river or stream, and the impacts of human activities such as water abstraction, flow regulation, and bed and channel modification. The index includes the status of both the riparian and in-stream habitats (CSIR 2001).

Table 5. According to the National River Health Programme (2001) the river health in the UORC can be defined as follows:

	Ecoregions 7.02, 7.04	**Ecoregions 2.08 and 2.09**
Riparian Habitats	Fair to Unacceptable	Good
General Condition	Poor to Fair	Bronkhorstspruit: Good to Fair

		Wilge: Good Klein Olifants: Fair
Biological Communities	Fair to Unacceptable	No info
In-stream conditions	No info	Good to Fair

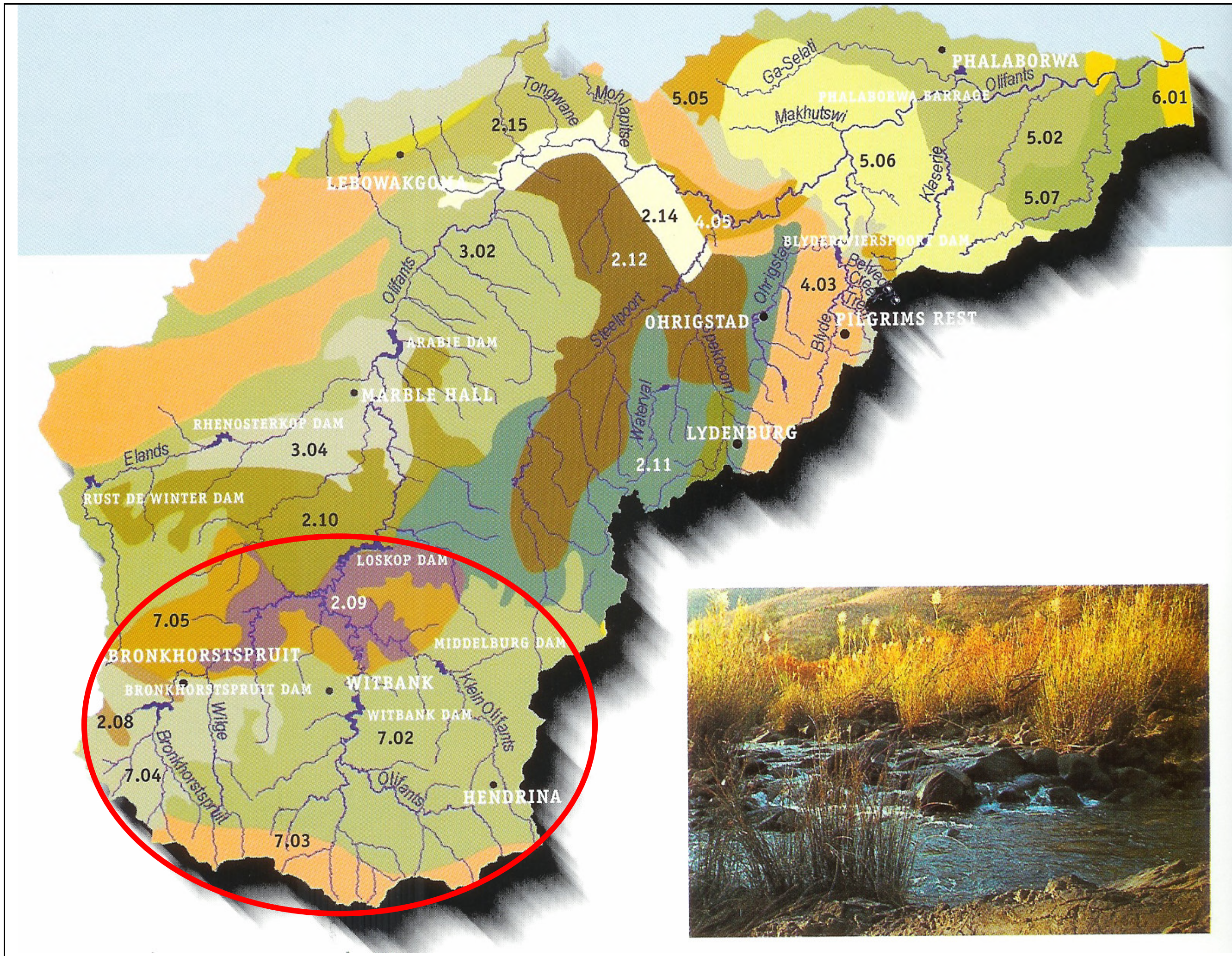

Figure 4. The ecoregions of the Olifants River Catchment as taken from the State of the Rivers Report (CSIR 2001)

3.7.2 Fish Surveys

Heath and Claassen (1999) conducted a study on the feasibility of using fish as indicators of pollution. Impacts on the systems are often reflected by the aquatic organisms present in the system. Fish tend to accumulate pollution in their tissues. The accumulation of pollution in the fish tissues do however vary between fish species and the different tissue types within a fish. There are also various advantages and disadvantages to using fish as pollution indicators (Heath and Claassen 1999).

Advantages of using fish (Heath and Claassen 1999):

- Fish are long-lived and mobile, they can therefore, indicate long-term habitat changes;
- Fish communities consist of various fish species;
- Fish represent various trophic levels;
- Fish are eaten by humans and should be assessed for contamination;
- Fish are easy to identify to species level;
- Life history and distribution data of most fish species is known; and
- Water quality standards of species are known.

Disadvantages of fish as pollution indicators (Heath and Claassen 1999):

- Fish are mobile and can move to sections of the river away from the pollution;
- They do not always reflect the pollution in the area they were captured; and
- Fish can regulate some elements, and the levels in their body do not reflect the pollution in the river.

The Olifants River has been included in the study conducted by Heath and Claassen (1999) and samples of the river water and fish tissue were analysed for metals and pesticides. It was found that the water has high mean conductivity values (>100mS/m). The high conductivity values are probably a result of mining, agricultural runoff and rural settlement. The nutrient values were also high and is mostly likely a result of fertilisers used during agricultural activities. The mean sulphate concentration was very high, most likely as a result of the mining activities taking place in the catchment. Cobalt was detected (30ųg/l), as well as low copper levels. Cadmium and chromium concentrations were below the level that could be detected (Heath and Claassen 1999).

Sixteen fish species (four of which were exotic) were analysed for the presence of metals and pesticides by Heath and Claassen (1999). Representative specimens in each of the species were analysed. There is a dietary difference between species in different rivers, and this may also influence comparisons between rivers. A marked difference exists between accumulation of different metals in different tissues such as the liver, gills, ovaries and testes. The different tissues were, therefore, analysed for each of the metals. The mean metal value per tissue was converted to ɥg/l as a common unit. The result of the study was that fish can be used as indicators of pollution and that the bio-accumulation of metals and pesticides is taking place in the Olifants River. The bio-accumulation of pesticides such as DDT may be from past usage of the pesticide within the catchment (Heath and Claassen 1999).

3.8 Wetland inventories

3.8.1 National Landcover database

The wetland layer in the National Landcover was updated. The scale of the wetland cover is approximately 1:250 000. The expected date of release to the public is not yet known, however it is expected that the data will be released very soon, since the wetland layer was completed in July 2006.

3.8.2 Endorheic pans (Allan *et al* 1995)

A synthesis of all literature on the pans in the Transvaal and Free State was compiled by Allan *et al* (1995). The report included the definition, distribution, density and the size of pans. The distribution map is on a very small scale (approximately 1:9 000 000), and is therefore, difficult to identify the locations of pans in the UORC. The classification of pans and the difficulties experienced in classifying pans are discussed, as well as, the possible origin and maintenance of the pans. The report includes a section on the abiotic and biotic characteristics of pans, as well as, a section on threats to the pans (Allan *et al* 1995).

3.8.3 Mpumalanga Parks Board

A wetland inventory is being compiled by the Mpumalanga Parks Board of all the wetlands in the Mpumalanga province (Figure 6 is a locality map of the UORC in relation to Mpumalanga and Gauteng). Floodplain wetlands, seepage wetlands and pans are distinguished in this layer. A large area of the UORC is included in the inventory. In addition a wetland layer for Gauteng is being compiled by the Gauteng Department of Agriculture, Conservation and Environment. The project is still progressing and it is not known when the wetland layer will be made available to the public. Different types of wetlands will be included in the layer. Unfortunately it is unlikely that the wetland layer will be available for use in this project.

3.8.4 Wetland inventory (Palmer et al 2002)

A wetland inventory was conducted by Palmer *et al* (2002) of UORC including the area up to the confluence of the Olifants and Klein Olifants Rivers (Figure 4). The Wilge River catchment, included in the UORC boundaries by DWAF, was not included in the study.

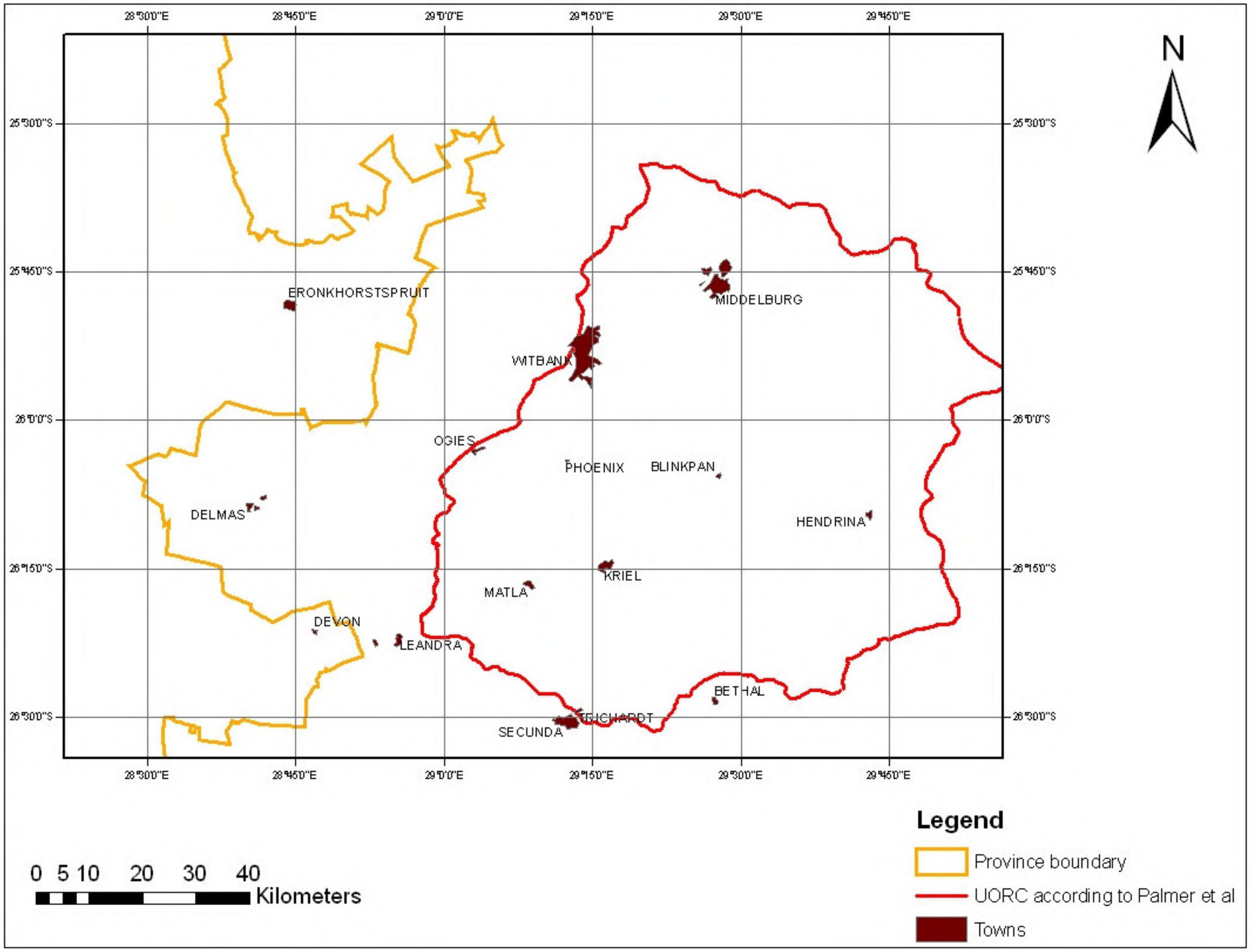

Figure 5. Extent of the UORC according to Palmer *et al*

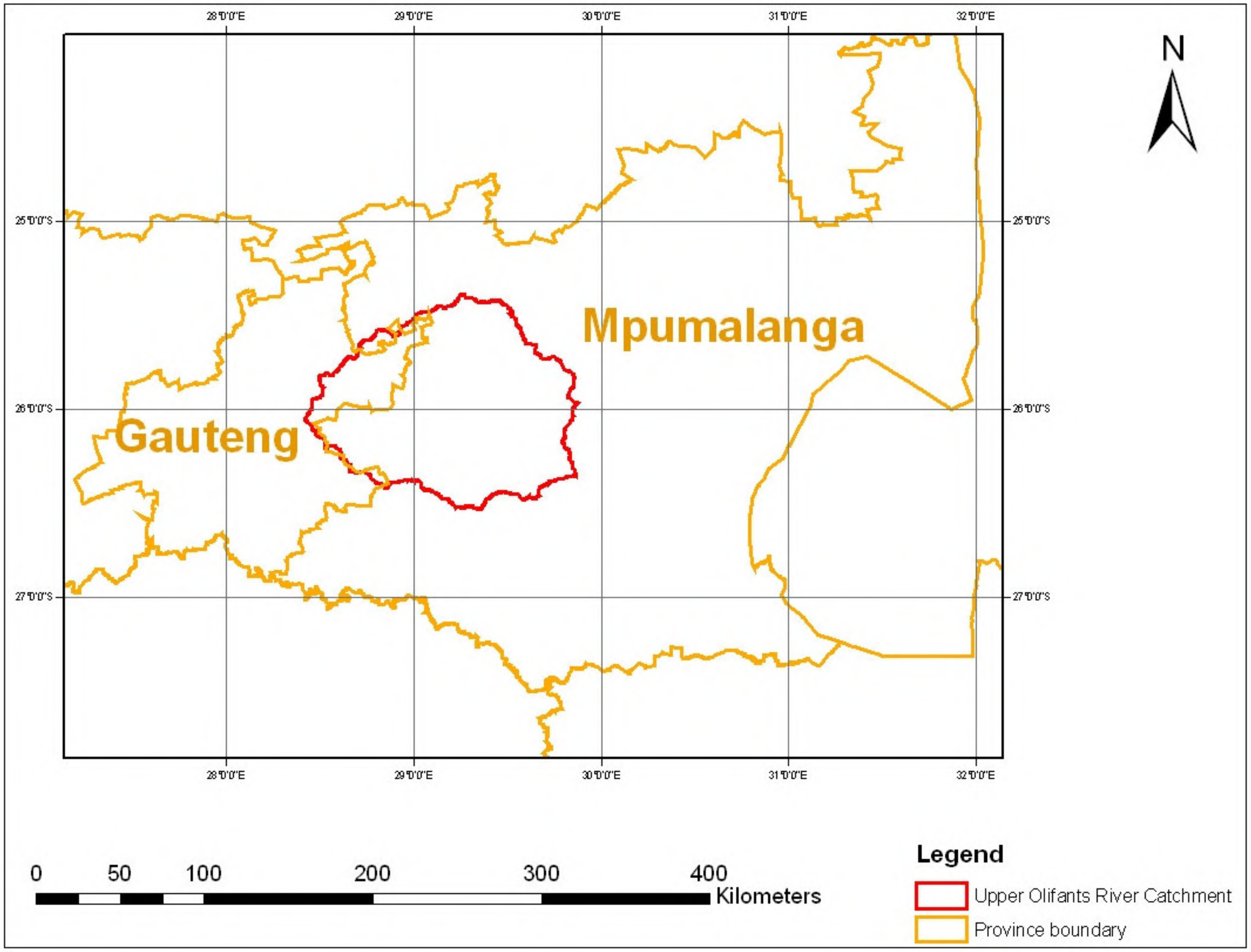

Figure 6. UORC in relation to Mpumalanga and Gauteng

3.9 Common wetland types in UORC

According to Palmer *et al* (2002) the most extensive wetland type in the catchment are the riparian wetlands. Since riparian wetlands are associated with rivers and streams, the total length of the rivers in the catchment is the most important contributing factor towards making the riparian wetlands the most extensive wetland type (22%).

The seasonally inundated channelled valley bottom floodplains with footslope seepage wetlands are the wetland types with the largest individual wetlands (Palmer *et al* 2002). Although wetlands in this type are few, they account for 18% of the wetland area indicated in Palmer *et al* (2002).

Numerous pans occur in the study area, but account for only a small percentage of the total wetland area (5%). The non-permanent pans are more numerous than the permanent pans, but account for a smaller total area (less than 4%). The permanent pans in the UORC are larger than the non-permanent pans (Palmer *et al* 2002).

Artificial wetlands (dams and weirs) are the most common wetlands in the study area, accounting for almost 50% of the wetlands recorded in Palmer *et al* (2002). Some of the dams and weirs are small and the total area therefore, account for 11% of the total wetland area.

3.10 Status of wetlands within the UORC

Various wetland assessments were conducted on the wetlands in the UORC for developments, mining expansions etc. The results from some of these assessments are included below to give a general indication of the status of the wetlands in the UORC. A map (Figure 7) is included to indicate the location of the wetlands discussed in relation to the catchment.

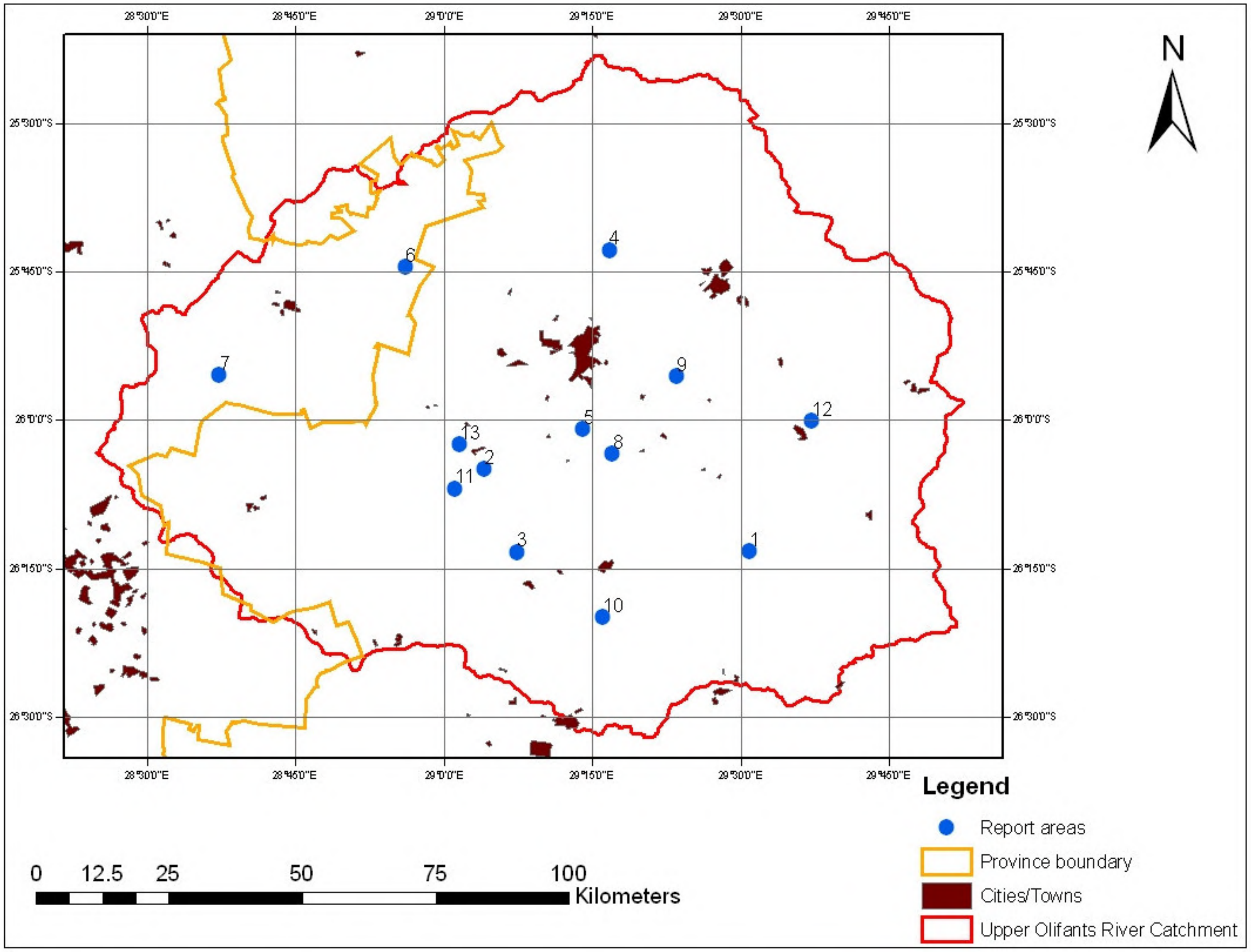

Figure 7. Distribution of assessed wetlands

In a wetland assessment conducted as part of a proposed new extension of the Elders Strip and Underground Mine (1), the status of the wetlands on the property was investigated (Marneweck 2003). The investigated area is located to the north of Bethal. The current status of the wetlands differs from the historical status of the wetlands due to impacts of agriculture, as well as, the road and railway infrastructure. The wetlands in the area are not in a pristine condition, but can be considered to be in a relatively natural state. There are however, sections of the wetlands that have been disturbed, with some erosion taking place on some portions, and signs of overgrazing, and poor water quality due to discharges in portions of the wetland. Another disturbance is the farm dams located in the drainage channel. Cultivation practices have mostly taken place outside the floodplains, pans and riparian areas, but seepage areas have been lost due to cultivation. Agricultural practices in the area had an indirect impact on all of the pans, through cultivation, damming, water abstraction, or other activities (Marneweck 2003).

The assessments on the aquatic ecosystems at the Elders Strip and Underground Mine (1), focussing on SASS and fish also concluded that the wetland system was moderately modified to largely natural (Palmer and Engelbrecht 2003). The species from the assessment are included in the species lists (Addendums to this report).

Several of the wetlands in the Goedehoop Colliery (2) area have been impacted on by various activities, mainly damming. Agricultural practices also have an impact on the wetlands by reducing water into the wetland systems. Water is extracted from the dams to irrigate crops and water livestock, thereby reducing the flow in the streams. Several alien species also occur in the wetlands, indicating disturbed conditions (De Lange *et al* 2003).

In a study conducted on Goedgevonden to the south of Ogies (2) seven wetland types were identified (Marneweck 2004a, Wetland Consulting Services 2005):

- Valley bottom wetlands with channels;
- Valley bottom wetlands without channels;
- Hillslope seepage connected to watercourses;
- Isolated hillslope seepage;
- Hillslope seepage connected to pans;
- Pans; and
- Mined wetlands.

Most of the wetlands in the area have been moderately to critically modified (Marneweck 2004a, Wetland Consulting Services 2005).

During an assessment of the Rietspuit at the Kriel Colliery (3) Chutter and Engelbrecht (1997) concluded that the invertebrate and fish habitat diversity in the Rietspruit varies from poor to intermediate. No further indication of wetland status is given.

Pans in the Kriel area (3) investigated by Loxton, Venn and Associates (1998) are mostly of average to moderate health, with one of the pans in good health.

The ecological integrity index of the Olifants River between Witbank and the Loskop dam (4) was determined during an honours thesis (Munday and Wepener 2004). The SASS scores indicated a fair to excellent condition. The average score per taxon (ASPT) indicated good condition and the habitat quality was fair (Munday and Wepener 2004).

The wetlands at the Kleinkopje Colliery close to Witbank (5), although not in pristine condition, are in a fairly good condition (de Frey and Robbeson 1999). This conclusion was based on the vegetation present at the site. Niehaus *et al* (1999) however, was concerned about the status of the wetland and the water quality, based on the aquatic vertebrates and macro invertebrates present at the site. He suggested that biomonitoring should take place to identify the impacts at the wetland. It was also suggested that a toxicity test be conducted. No further work was conducted on this system.

In an ecological study conducted on Portions 32 and 72 of the Farm Klipfontein 498 JR (6) various wetlands were identified and the species composition of the wetlands noted. A very small peatland was also identified at one of the hillslope seeps. The wetlands were in a good condition overall, with the only impacts on the wetlands occurring due to the construction of two dams and a road crossing the wetland. Some grazing is also taking place in the wetlands (Exigent Engineering Consultants 2006).

During an assessment of two dams at Oxbow Country Estates (7) it was determined that the wetland on this property has been disturbed by various activities in the past and is in need of rehabilitation. A rehabilitation plan was compiled for a portion of the wetland recently disturbed (Exigent Engineering Consultants 2005).

In a wetland study at Douglas Colliery (8) by Marneweck (2004b) it was determined that wetlands in this area were modified by agriculture and mining related impacts and can therefore not be regarded as pristine. Most of the wetlands are largely modified and the mining activities may cause some of the wetlands to degrade to a critically modified status.

The wetlands at the Middelburg Mine (9) were assessed as part of an ecological assessment conducted in the mine area. Two Vulnerable Red Data species were observed in the wetlands during the site visits. These species are the Grass Owl (*Tyto capensis*) and the Marsh Sylph (*Metisella meninx*). Various protected species also occurred in the wetlands. The riverine system in this area suffered a major loss in ecosystem functions, but the wetlands in general are still in a moderate condition (Natural Scientific Services, 2006).

A wetland assessment was conducted on the Steenkoolspruit in the Kriel South area (10). During this assessment it was found that the species diversity in the wetland is high. It was therefore suggested that a more detailed wetland assessment be conducted to compare the species diversity in the wetland to the species diversity present in similar wetland systems in the area. The wetland was found to be slightly modified (Marneweck 2001).

In a follow-up study in the Kriel South area (10) the species diversity in the wetlands at Steenkoolspruit, Blesbokspruit and Viskuile wetlands were investigated. The highest species diversity was found at the Steenkoolspruit and the lowest species diversity at the Blesbokspruit. The floodplain wetlands at Viskuile and Steenkoolspruit were found to be only slightly modified, while the floodplain of the Blesbokspruit is heavily degraded. The hillslope seepages at the Viskuile were also heavily impacted upon by cultivation and draining of the wetlands, whereas the hillslope seepages at the Steenkoolspruit and Blesbokspruit, although slightly degraded, were in a better condition (Marneweck and Bell, 2002).

In a wetland assessment conducted by Marneweck and Batchelor (2004) on the proposed new strip mine area at Khutala Colliery (11) it was determined that most of the wetlands in the area are moderately modified. Some of the functions and habitat features of the wetlands are lost. Since these wetlands are located in an area proposed for future strip mine operations the wetlands will be lost if mining authorisation is granted (Marneweck and Batchelor, 2004).

Optimum Colliery (12) commissioned an endorheic pan assessment in the mine area. During the assessment various pans were assessed and the status of the pans varied from severely degraded to a fairly good condition. The pans also have various conservation priorities, since some of the pans have very unique features (Strategic Environmental Focus, 2004).

A wetland assessment was conducted at the Klipspruit Colliery (13) by Marneweck in 2002. It was determined that the wetlands on site are impacted on by various anthropogenic influences, including agriculture, mining activities in the past and the present mining activities. The wetlands were found to be moderately modified (Marneweck, 2002).

An ecological assessment was conducted after the wetland assessment at Klipspruit Colliery (13) in 2003. The wetlands are indicated on the vegetation map of the mine area and the different wetland communities were identified. The wetlands are mostly moderately modified (de Frey, 2003).

The status of wetlands assessed in the UORC therefore ranges from poor to excellent, however, it seems as if the majority of wetlands assessed are in a good condition. Only a very small percentage of the wetlands in the UORC were assessed and the status of the assessed wetlands may not be a true reflection of the general status of the wetlands in the catchment. The main impacts on the wetlands have been identified as Agriculture and associated activities, e.g. pesticides.

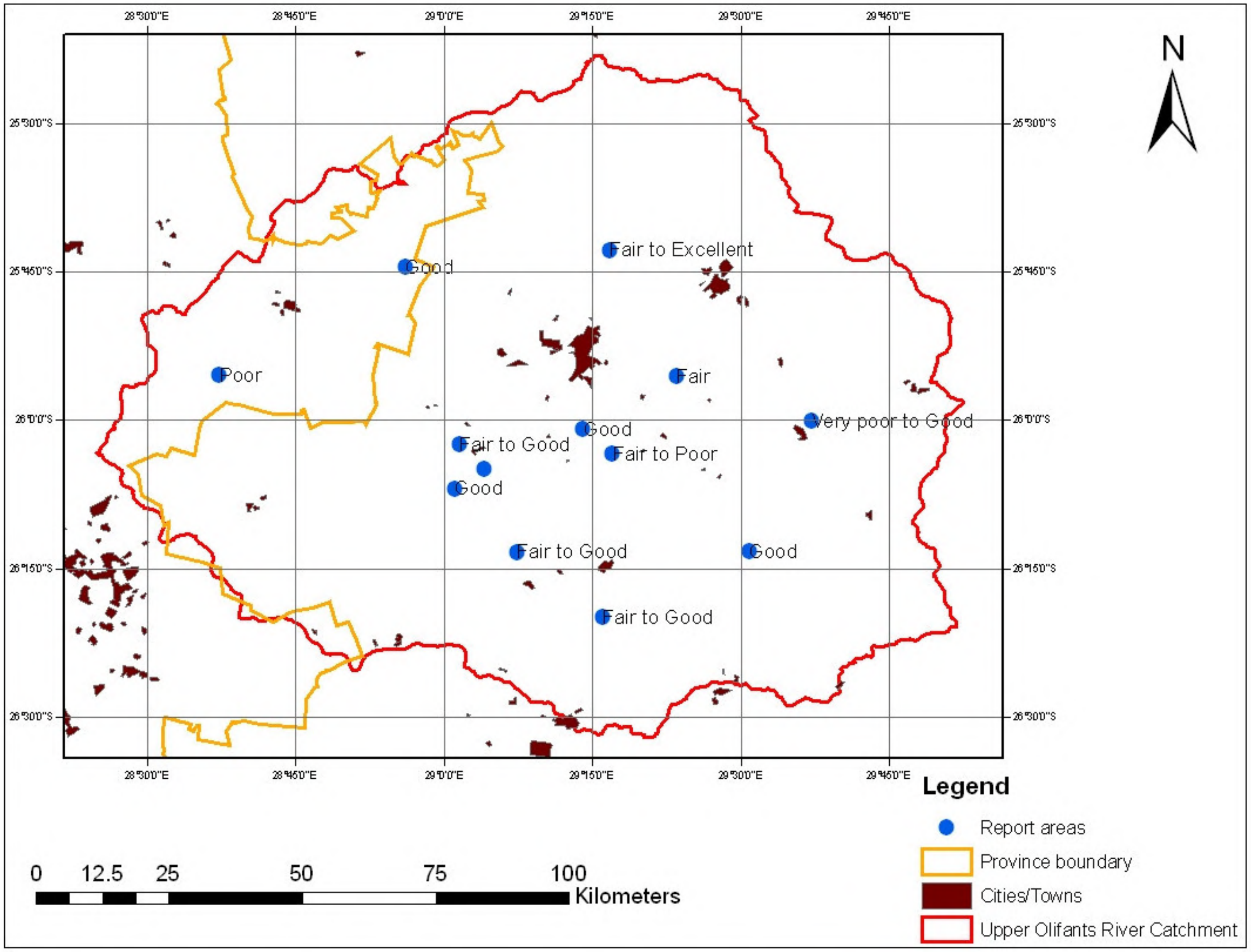

Figure 8. Status of assessed wetlands

4. METHODS

4.1 Aerial photographs

Georeferenced aerial photographs could only be obtained for a small portion of the catchment. Digital1:50 000 aerial photographs (not georeferenced), were obtained from the Chief Directorate: Surveys and Mapping at the Department of Land Affairs, Mowbray, Cape Town for the whole catchment. The aerial photographs were georeferenced with ArcView 9.1, using the 1:50 000 topographical map shapefile layers as a reference. The spatial reference of the aerial photographs is geographic, with the ellipsoid as WGS84. The aerial photographs were taken during a 2003/2004 survey of the area.

We investigated Google Earth for potential to use in this survey, but found the quality of the images too poor to be of use for this project.

During phase 2 of the project, aerial photographs abtained from some of the mines were used to verify the presence of wetlands indicated in the UORC wetland database. These aerial photographs only cover a small portion (approximately 10%) of the catchment.

4.2 Compilation of the wetland and dam layers

Three existing wetland databases were incorporated into one to obtain a baseline wetland database for the area. The wetland databases were:

- The wetland database of the catchment as included in Palmer *et al* (2002) (Figure 9);
- The draft Mpumalanga C-Plan wetland database (Figure 10); and
- The water bodies' shapefile layer of the 1:50 000 topographical maps (Figure 11).

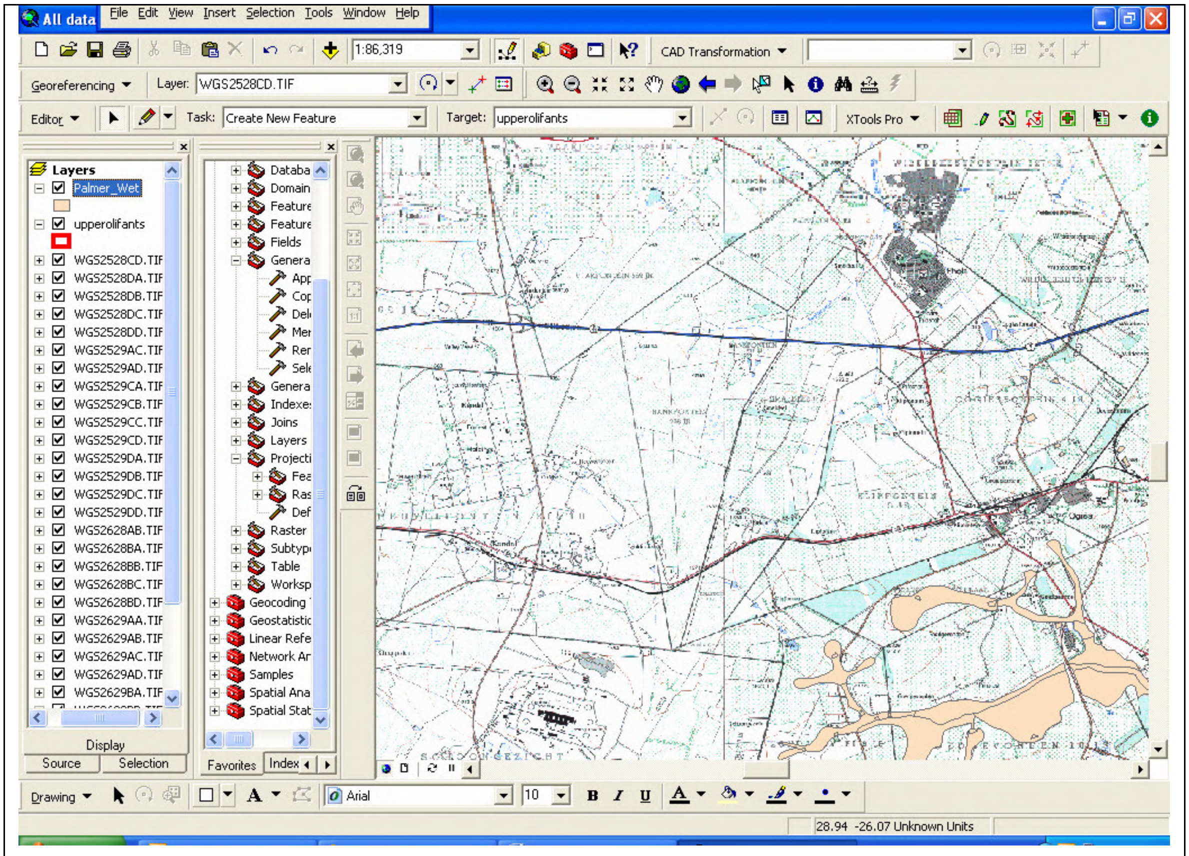

Figure 9. Portion of the wetland layer included in Palmer *et al* (2002)

Mpumalanga C-plan has two wetland databases (Figure 10). One wetland database incorporates all the perennial pans and non-perennial pans and the other database include all the other wetlands, including riparian and seepage wetlands. These layers were based on the draft National Landcover wetland layer (2005 version).

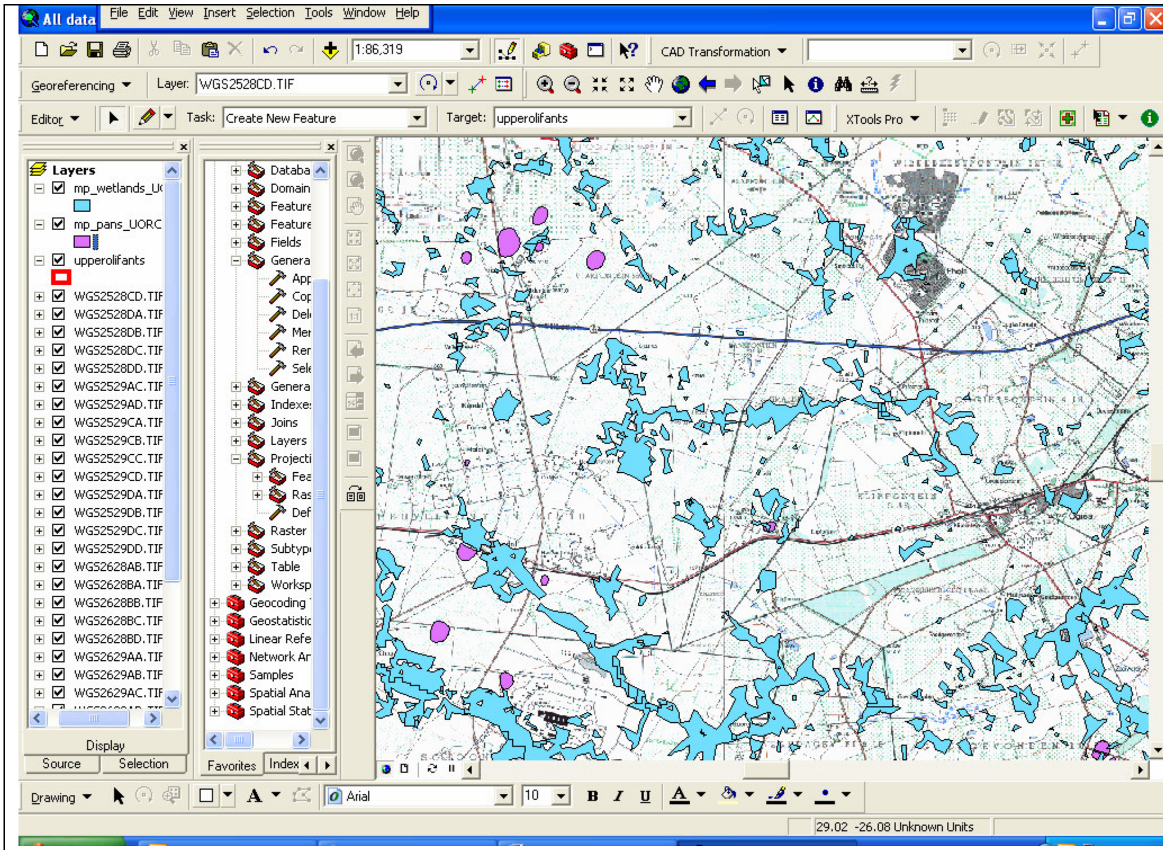

Figure 10. Portion of the Mpumalanga C-Plan wetland layer

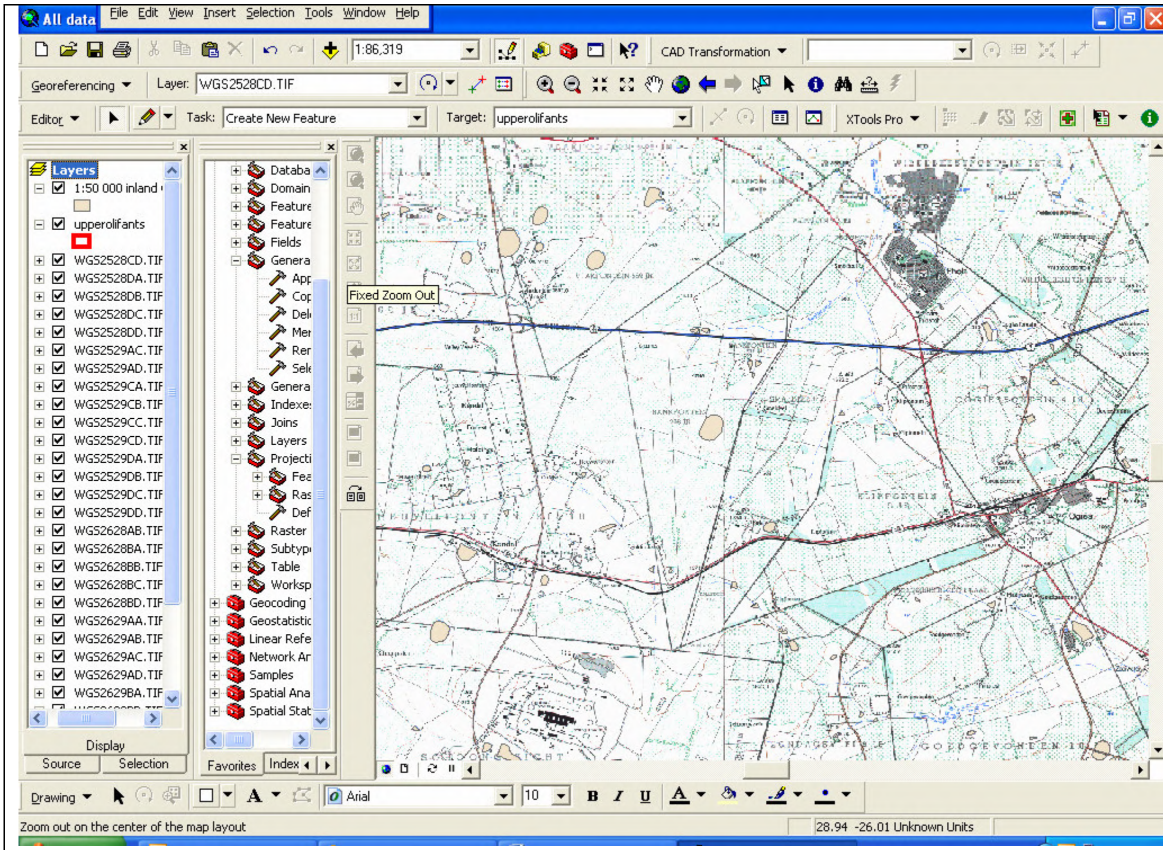

Figure 11. Portion of the water bodies' shapefile layer of the 1:50 000 topographical maps

The databases were combined into a single database (Figure 12) and then split into a wetland database and a dam layer (Figure 13).

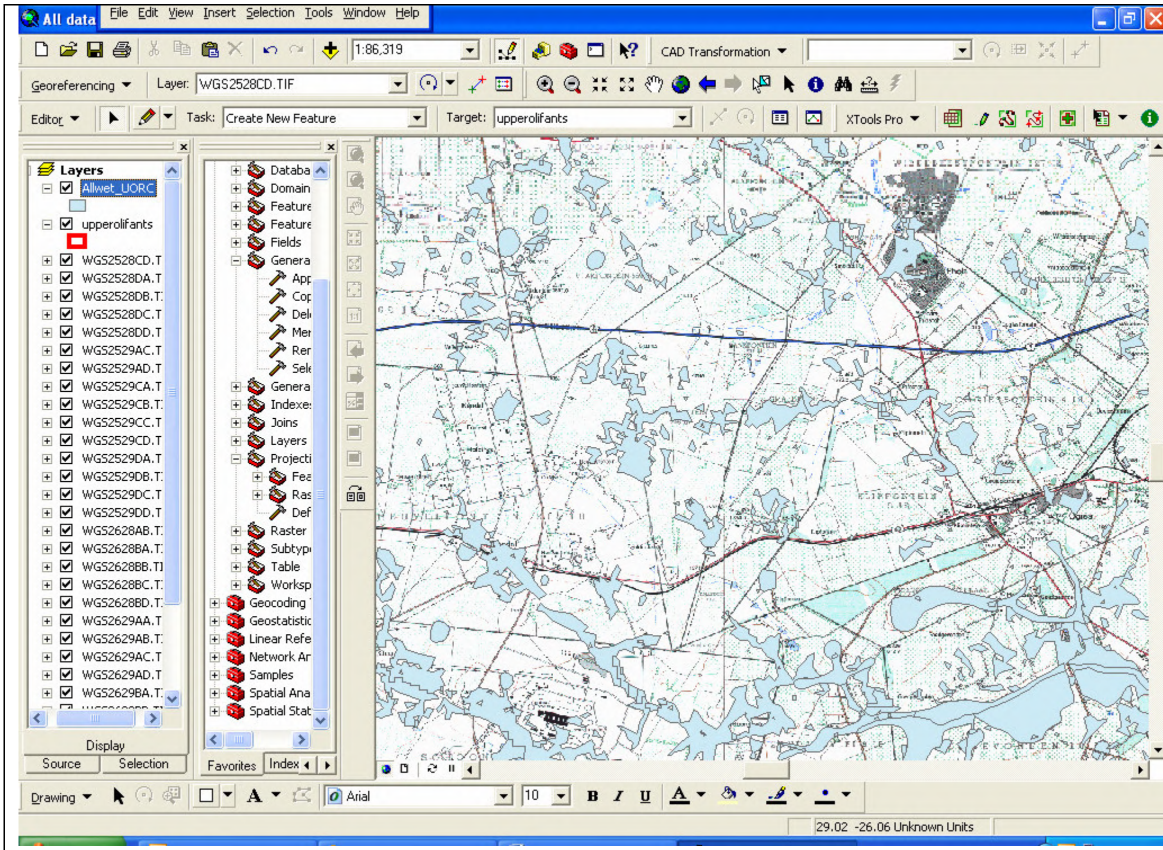

Figure 12. Portion of the combined wetland layer

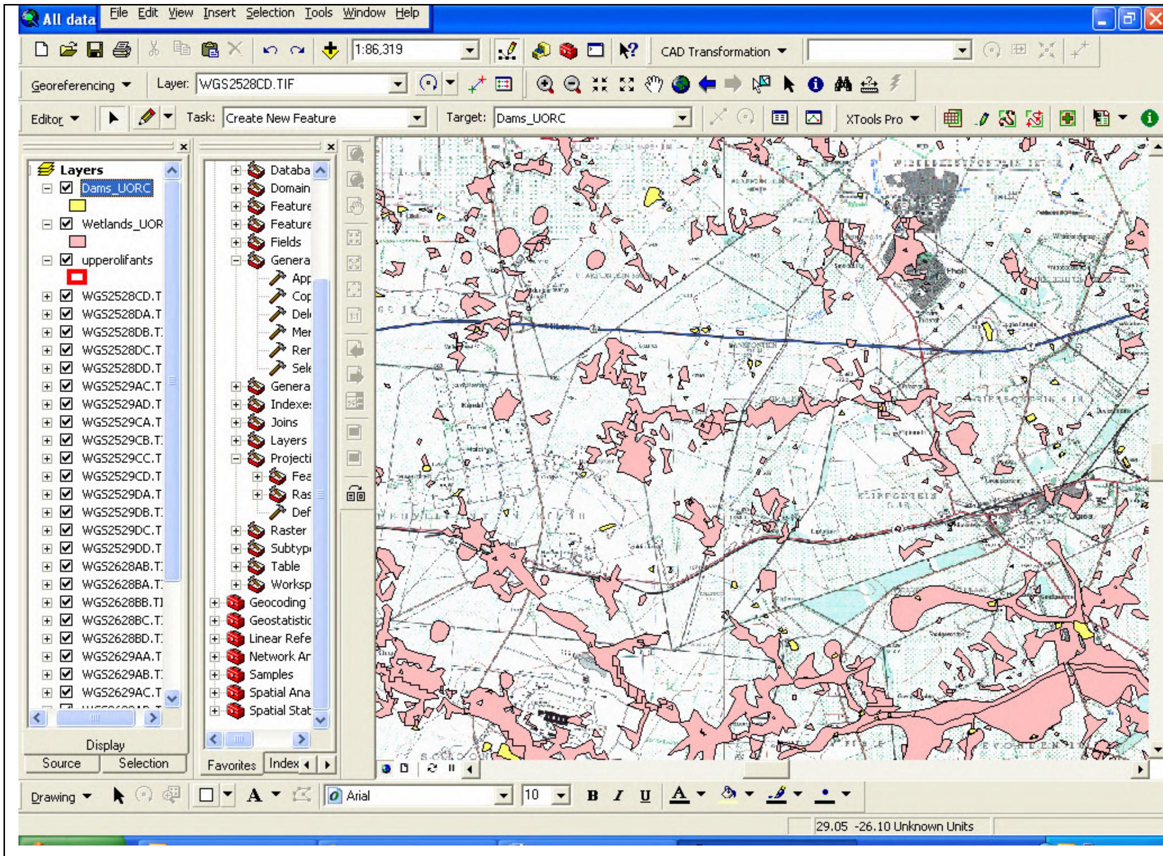

Figure 13. Portion of the separated wetland and dam layers

The wetland database and dam layer were verified by comparing the layers to the 1:50 000 topographical maps (Figure 14) and then the georeferenced aerial photographs of the site (Figure 15). A large percentage of the wetlands on the combined database were found to be wrong, with a number of even the larger wetlands not indicated and various wetlands indicated in built-up areas.

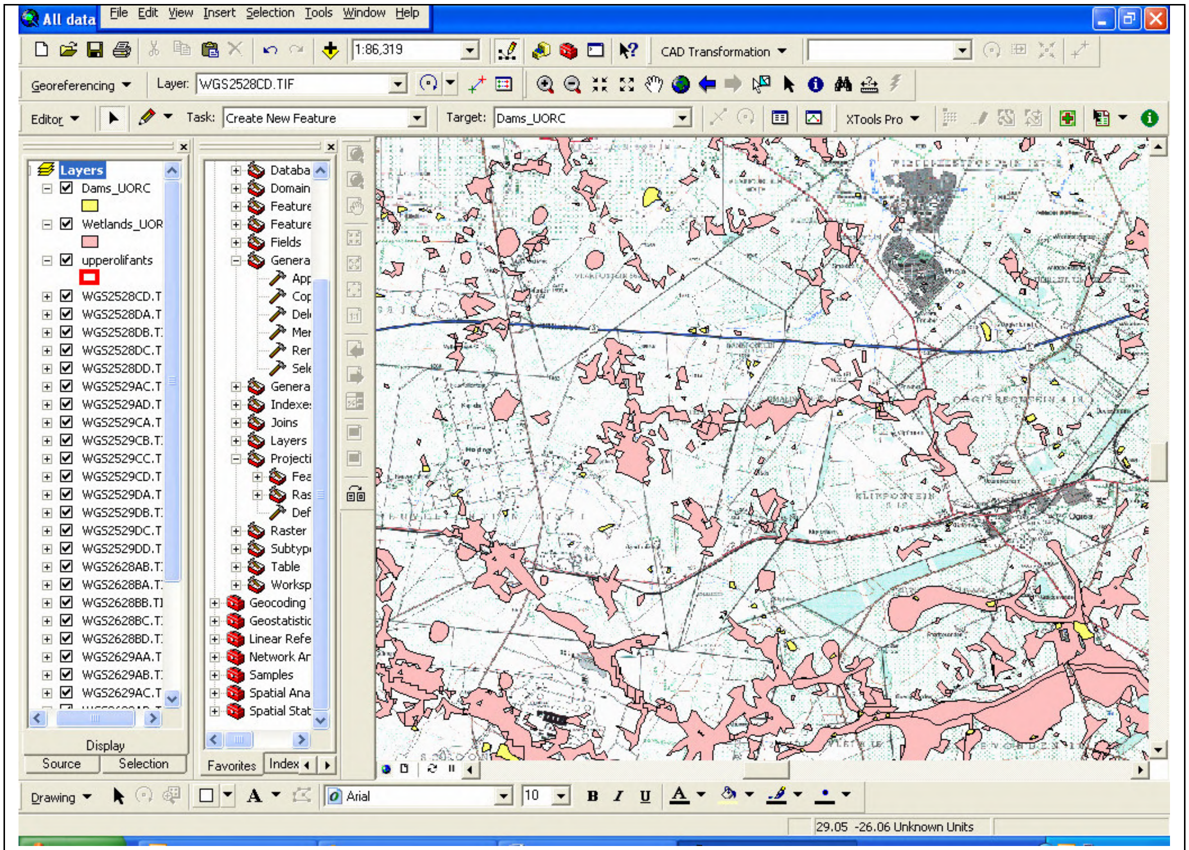

Figure 14. Portion of the wetland layer verified on the 1:50 000 topographical maps

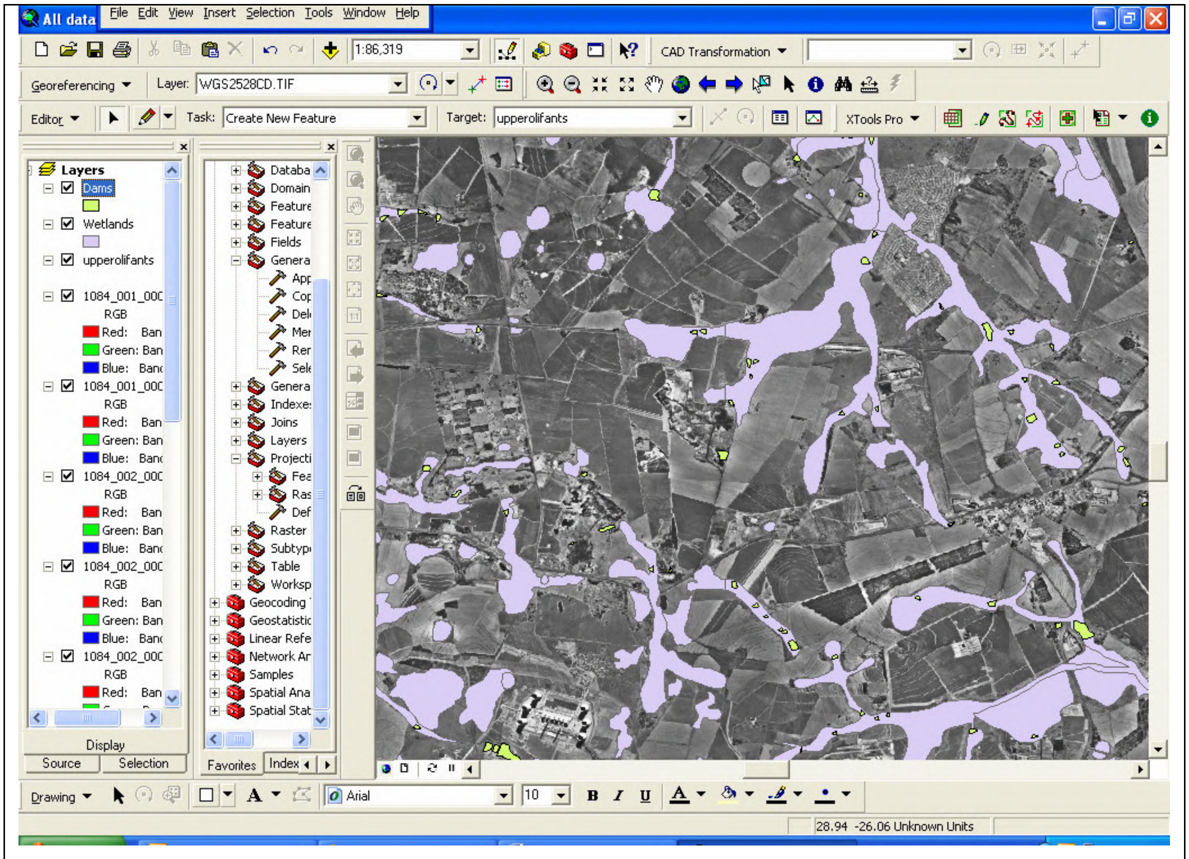

Figure 15. Portion of the wetland layer verified on the aerial photograps

The attributes included in the wetland database were derived from the aerial photographs, available data and the observations during the field verification site visits.

Only characteristics of the wetlands and surrounding areas that are visible on the aerial photographs could be taken into account for the following attributes:

- Type
- Threats
- Connectivity
- Status

Attributes based on available literature include:

- Red Data species
- Important species
- Functions
- Bird number
- Observed Red Data species

- Observed important species

Attributes observed in the field:

- Dominant vegetation as an indication of status of the wetland

Wetlands should be seen as a system and not as separate entities. For this reason wetland sections were combined. For example, some portions of a floodplain riparian wetland may change to non-floodplain riparian or seepage (up-stream or downstream of the floodplain), but since it is part of the same system it has been included as part of the floodplain riparian wetland.

4.3 Field verification of the wetlands

Field verification of the wetlands took place as part of the second phase of the project. The field verification was divided into two portions:

- o Field verification of wetlands throughout the catchment, and
- o Field verification of wetlands on the mining properties.

For the first part of the field verification the wetlands adjacent to public roads were verified. The location of the wetlands were marked using a Garmin GPS 60 and, where possible, a photograph was taken of the site. The observed status, connectivity and threats to the wetland were noted, as well as, the dominant vegetation in the wetland. Since there are more public roads in the southern portion of the catchment, and most of the mines are located in this area, verification of the wetlands was focussed in the southern portion of the catchment.

For the second part of the verification phase the wetlands on the mine properties were verified. The various environmental and safety officers at the mines were contacted for appointments to visit the mines and to serve as guides to the wetlands. The same data was collected for the wetlands at the mines as at the previous field verification site visit wetlands adjacent to the public roads.

The UORC wetland database was corrected using the information obtained from the field verification site visits.

Since the field verification site visits enabled us to get a clearer picture of which areas are wetlands and which not, the wetland database was reviewed again on the aerial photographs and corrections made.

5. RESULTS AND DISCUSSION

5.1 Wetland maps

Wetlands and dams in the UORC were delineated based on the aerial photographs. Field verification of the wetlands was completed as part of the second phase of the project. The final wetland database is indicated in Figure 16 and the dam layer in Figure 17.

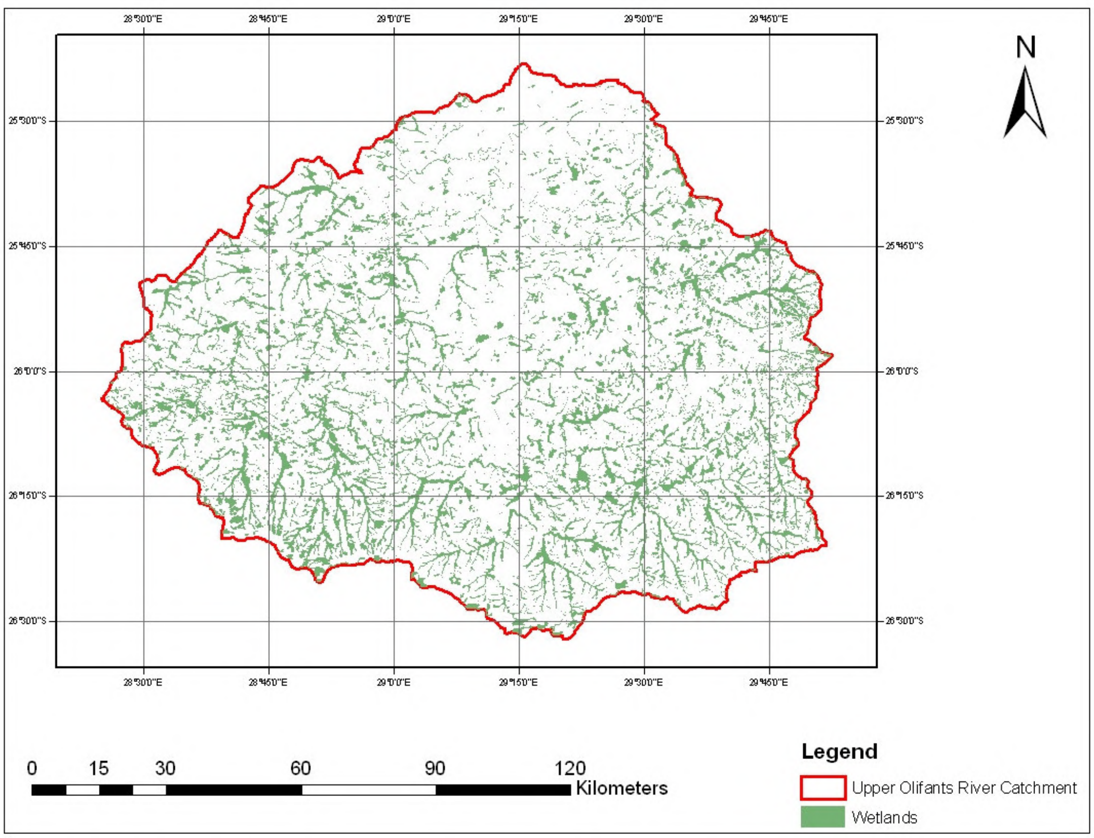

Figure 16. Final wetland database of the UORC

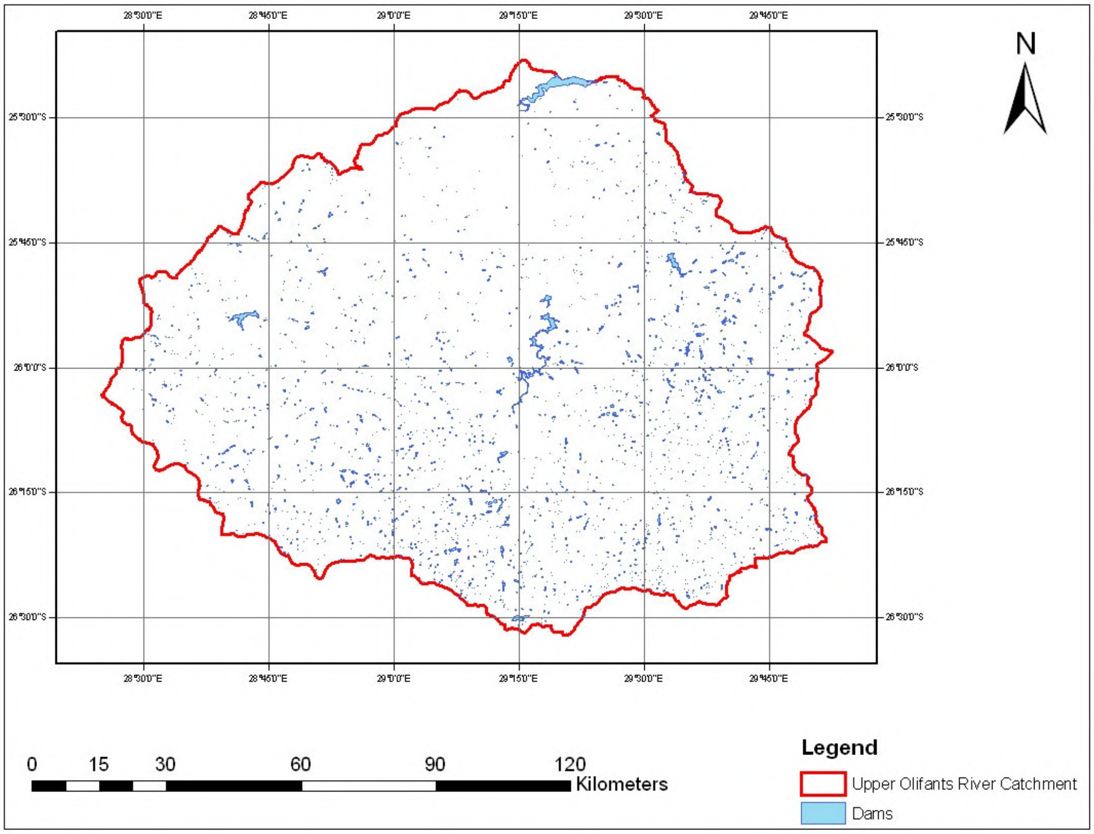

Figure 17. Final dams layer of the UORC

Figure 18. Portion of the final wetlands and dams on aerial photographs

5.2 Wetland database

Included in the wetland attribute table are the following fields. The fields included in the attribute table are those wetland features most commonly used in a decision making process. These fields are discussed in the sections below.

5.3 Type

Six wetland **types** have been included in the wetland layer. The wetlands were not further divided, due to the difficulties associated with classifying wetlands on an aerial photograph. The six types are perennial pans, non-perennial pans, seepage, floodplain riparian, non-floodplain riparian and artificial wetlands. Wetlands were only included under the artificial wetlands if the wetlands were obviously artificial. A number of artificial wetlands may therefore be included under the other wetland types, but has not been indicated as such, because they are not clearly identified on the aerial photographs. The wetland types were based on the wetland classification used by Palmer *et al* (2002).

5.4 Threats

The **threats** included are the threats visible on the aerial photographs. The threats include disturbance such as agriculture, infrastructure, developments and damming. The most significant impacts are agriculture and infrastructure, with approximately 94% and 85% of the wetland area impacted by these activities, respectively. Approximately 53% of the wetlands are visibly impacted by damming, 37% by alien vegetation and by development, 20% by mining and less than 0.5% by industy and trampling. Wetlands may be impacted by activities such as mine water decanting and industrial pollution for great distances downstream of the activity. These impacts are mostly not visible on the aerial photographs and are therefore not included. Impacts on ground water quality and quantity is also not visible and could not be included. The impact of these activities may be far reaching and the impacts from mining and industy are probably more extensive than indicated in the database.

5.5 Status

The five categories indicating the **status** of the wetland are on a gradient from 1 to 5, with 1 indicating a wetland that is destroyed and 5 a wetland in pristine condition. This is the most inaccurate of the attributes included in the table. The status of the wetlands is based on the aerial photographs and only a small portion of field verification. The status therefore could not be determined with much accuracy.

Upon a request from DWAF the status of the wetland was converted to the Present Ecological State (PES) Categories for Reserve Determinations. These categories are included in the table below:

ECOLOGICAL CATEGORY	DESCRIPTION
A	Unmodified, natural.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. 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 modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible

In order to convert the scoring the following table was used:

Status	PES Category
1	E
2	D
3	C
4	B
5	A

Both categories are indicated in the wetland database.

5.6 Connectivity

Five categories were included to indicate the **connectivity** of the wetland to other wetlands.

- o Excellent – The wetland is located within the stream channel, or directly adjacent to the stream channel, and the wetland is directly connected to other wetlands.

- Good – The wetland is in close proximity to other wetlands and the movement of organisms and water from the one to the other readily takes place.
- Fair – The wetland is some distance away from other wetlands, but the movement of organisms and water can still take place via exitsing migration routes, e.g. green belts, etc.
- Poor – The wetland is located away from other wetlands and the movement of organisms or water only takes place occasionally.
- Very poor – The wetland is isolated from other wetlands.

The connectivity of the wetlands is not a function of wetland health. Numerous wetlands, mostly pans, have poor connectivity but are in a good condition. The connectivity of the wetland only gives an indication on the level of fauna and flora interchange between the wetland and other wetlands, as well as the extent of the impact that a negative activity will have on the wetland system. Spillage in a riparian wetland, with excellent connectivity, will have a far reaching impact, whereas spillage in a pan, with poor connectivity, will have a more localised impact.

5.7 Red Data and important species

Red Data species observed in the wetlands are included in the table, as well as other **important species** associated with the wetland types. The important species include protected species included in the Mpumalanga Nature Conservation Act, as well as the Transvaal Nature Conservation Ordinace, as well as Near Threatened and Data Deficient species. The species in this table are not site specific, but the species that may utilise the wetland type. It is therefore, important to conduct site specific studies before this list can be refined. Please note that the status of the wetland has a significant impact on the species that may utilise the site, but this has not been taken into account due to the uncertainty of the accuracy of the status attribute field.

5.8 Functions

The **functions** likely performed by each of the wetland types are included in the table. These are only the possible functions of the wetlands and it will differ from wetland to wetland. A more detailed study is necessary to determine the exact functions of each wetland type. The possible functions performed by the wetlands were based on both WET-EcoServices (Kotze *et al* 2005) and the functions mentioned by Palmer *et al* (2002).

5.9 Bird count data from Mpumalanga Parks Board

Bird count data was received from the Mpumalanga Parks Board and the data was entered into three attribute fields in the wetlands database. The three fields are:

- **Bird number** – The number of bird species observed in the wetland are noted. This includes both Red Data and common bird species.
- **Observed Red Data Bird species** – The bird species observed in the wetland, and included in one of the three Red Data threat catogories, are listed in this attribute field.
- **Observed important Bird species** – Bird species of concern observed in the wetland, including Near Threatened and Data Deficient species, are listed under this attribute.

5.10 Dominant vegetation

Only the distinctive vegetation groups were included in the **dominant vegetation** attribute in the wetland database. This attribute was based on the field verification site visit data and various wetlands lack data in this attribute. The following are referred to in this attribute field:

- Grass – Members from the family Poaceae, but excluding *Phragmites australis* and *Phragmites mauritianus*, ranging in height between 20cm to 1.5m.
- Sedge – Members from the family Cyperaceae, ranging in hieght from 10cm to 1.2m.
- Juncus – Members from the family Juncaceae, normally between 30cm and 1m in height.
- Typha – *Typha capensis* from the family Typhaceae. This species is normally between 50cm and 1.5m in height, although individuals up to 3m can be observed.
- Reeds – *Phragmites australis, Phragmites mauritianus* or *Arundo donax* from the Poaceae family. These species are normally between 1.5m and 3m in height.
- Invasive trees – Trees listed in one of the three invasive Categories according to CARA. These species include *Populus* species, *Eucalyptus* species, *Acacia mearnsii* and *Pinus* species.
- Invasives – Including the invasive trees as defined above, and/or herbaceaous invasives, such as *Cirsium vulgare*.
- Weeds – Weeds are species not included in one of the three invasive categories in CARA, but include alien species and a few indigenous species that are a nuisance in disturbed areas.

The general description of the dominant vegetation gives an indication of the vegetation structure in the wetland. The vegetation in the wetland often occurs in diverse communities within the wetland. The vegetation structure within the wetland may therefore vary over distance.

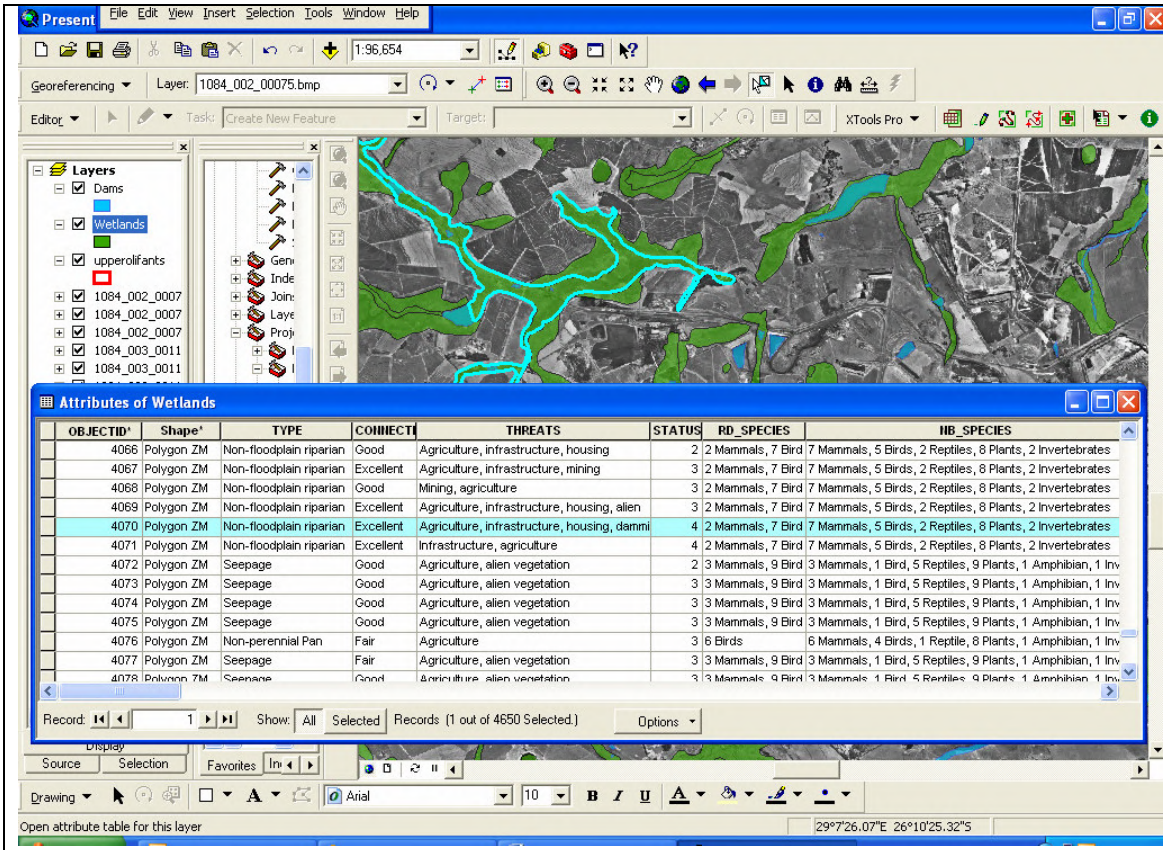

Figure 19. Attributes in the wetland database

5.11 Wetland types

The entire catchment is approximately 15 158 km^2 in extent and the total wetland area is approximately 2 147 km^2. Wetlands cover approximately 14% of the entire catchment area.

5.11.1 **Non-floodplain riparian**

Non-floodplain riparian wetlands are associated with drainage lines, but they lack the characteristic floodplain features such as oxbows (Kotze *et al* 2005, Rogers 1995). This, wetland type, along with the seepage wetlands, is the largest wetland type with 34% of the wetlands in the catchment being non-floodplain riparian wetlands.

5.11.2 **Floodplain riparian**

Floodplain riparian wetlands occur in lower-lying areas of the UORC with or without a drainage channel. These wetlands have features, such as oxbows, typically associated with floodplains and are inundated by overspill during a flooding event (Kotze *et al* 2005, Rogers 1995). Floodplain riparian wetlands are fairly common in the catchment, with 28% of the wetlands classified as floodplain riparian wetlands.

5.11.3 **Seepage**

Seepage wetlands occur where groundwater emerges, and occurs on hillcrests, slopes and adjacent to water courses and pans. Seepage wetlands also include springs (Palmer *et al* 2002). This wetland type, along with non-floodplain riparian wetlands, is the most common wetland type in the UORC, with 34% of the total wetland area in the catchment falling into this category.

5.11.4 **Pans**

Pans are typically circular to oval shallow depressions without an outflow and seldom more than three meters deep, although deeper systems have been defined as pans. It is also often difficult to distinguish between pans and lakes. Since no lakes have been classified, all of the wetlands complying with the requirements have been included as either non-perennial or perennial pans (Allan *et al* 1995). Since most of the pans had already been identified in the three existing wetland layers a large portion of the pans have already been delineated. Pans in general are fairly small with the perennial pans being larger than the non-perennial pans, but the non-perennial pans are more numerous. Only 1.5% of the total wetland area is perennial pans, while 2.5% of the wetland area is non-perennial pans.

5.11.5 Artificial Wetlands

Artificial wetlands are any type of wetland constructed by man and mostly include dams and weirs. In this case the dams are included in a separate layer and the artificial wetlands only include those wetlands that are obviously anthropogenic, excluding dams. Some of the wetlands may however be a result of a dam or weir, upstream or downstream of the wetland. Less than 0.2 % of the wetlands in the catchement are indicated as artificial wetlands, although it is suspected that a much larger percentage of the wetlands may be artificial.

5.12 Dams

Although dams are not included in the DWAF definition of a wetland, a layer of the dams has been included, since dams can perform some wetland functions. Dams are, however, a threat to most wetlands and riverine systems by changing the hydrological patterns, sediment load and temperature of the wetlands and rivers although they provide habitat to various wetland species including frogs, birds and invertebrates. Although the dams in the UORC are numerous (3 701 in total) they have a total extent of approximately 120 km^2, and therefore only cover about 5.6 % of the total catchment area.

6. DATABASE CONSTRAINTS

The greatest problem was the lack of georeferenced aerial photographs for the area. Google Earth was investigated to determine if it would provide value to the project, but the quality of the images was too poor for the purpose of this project. The 1:50 000 aerial photographs, as obtained from the Chief Directorate: Surveys and Mapping at the Department of Land Affairs, Mowbray, Cape Town, was the only complete set of aerial photographs available for the site. The georeferencing of these aerial photographs was based on the 1:50 000 topographical map and accuracy is therefore dependant on the accuracy of the topographical layers. In addition, all aerial photographs are skewed towards the edges due to the concave structure of the camera lens. We attempted to correct this feature during the georeferencing process, but the effect could not be removed completely. The wetlands located to the edges of the aerial photographs may therefore be slightly removed from their exact position.

Where areas under cultivation were obviously located on a seepage area the wetland was indicated and the status of the wetland was given as E or F (destroyed). Some additional seepage areas covered by cultivation may occur, but have not been identified. This is because wetlands under cultivation are not easily distinguished. Patchiness in a cultivated area can be caused by a number of influences, including differences in soil and patchy distribution of fertiliser, in addition to the presence of seepage wetlands. Other highly disturbed wetlands may also not be identifiable on the aerial photographs as wetlands and these wetlands will be absent from the wetland layer. In addition, small wetlands are not visible on the 1:50 000 aerial photographs and are therefore not included.

Tonal variations between the aerial photographs complicated the mapping of the wetlands on the aerial photographs. The changes from one strip of aerial photograps to another may be due to the time of day the photographs were taken and the light quality. Even without cloud cover the light quality may differ from day to day.

7. COMPARISON TO THE NATIONAL LANDCOVER WETLAND LAYER

The final Landcover wetland layer, completed in June 2006, was compared to the completed UORC wetland database. The Landcover wetland layer compared very well to the UORC wetland database, since all of the Landcover wetlands were already identified in the UORC database (Figure 20).

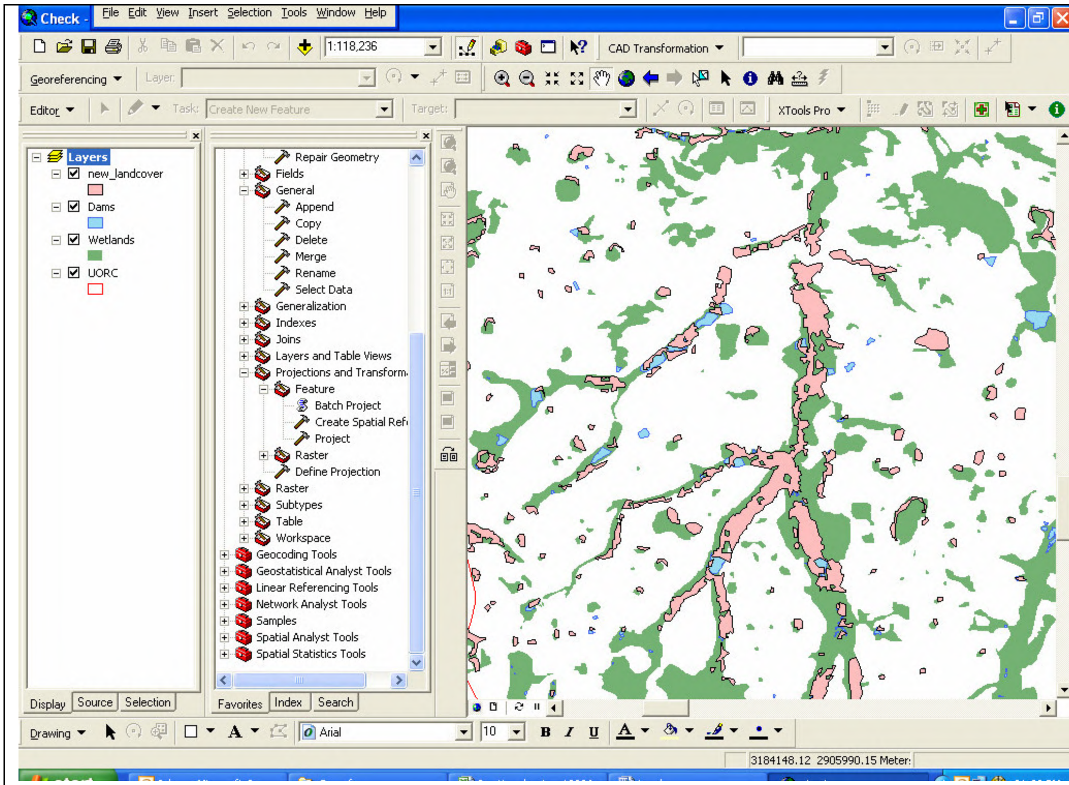

Figure 20. Comparison between the Landcover and UORC wetland layers

The UORC wetland database has more extensive wetland areas, probably as a result of the differences in the scale of the study areas. Changes due to satellite and aerial photography differences are also better accommodated in a smaller scale study area than a large scale study area. The National Landcover wetland layer has a total wetland area of 16 303ha, whereas the UORC wetland database has a total wetland area of 214 731ha. The National Landcover wetland layer therefore only covers 1% of the total UORC area and 7.6% of the total wetland area indicated in the UORC wetland database.

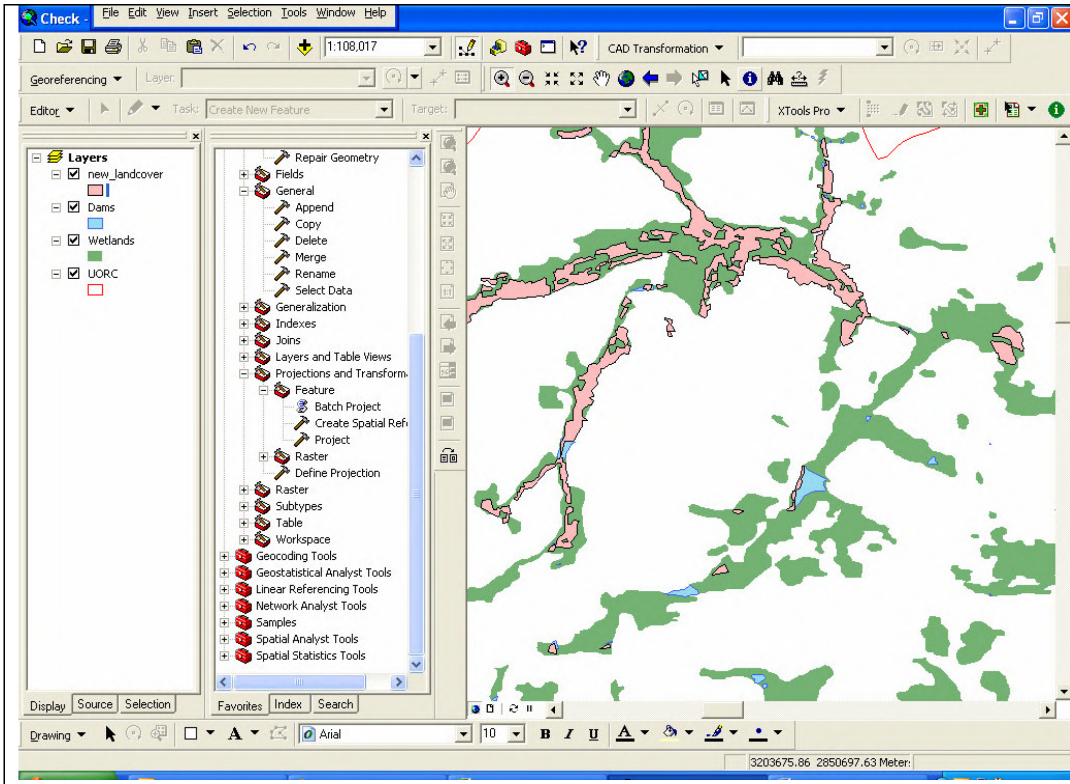

Figure 21. The wetland in the UORC wetland database are more extensive

It appears as if the Landcover layer includes the seasonal and permanent zones of some of the wetlands and not all the temporary zones, however a more in depth study, including site visits, would be necessary to prove this. Areas of open water in the wetlands are also excluded. The pans are poorly represented, possibly because they contain areas of open water, and were identified as dams. This would explain the partial representation of some pans (Figure 22).

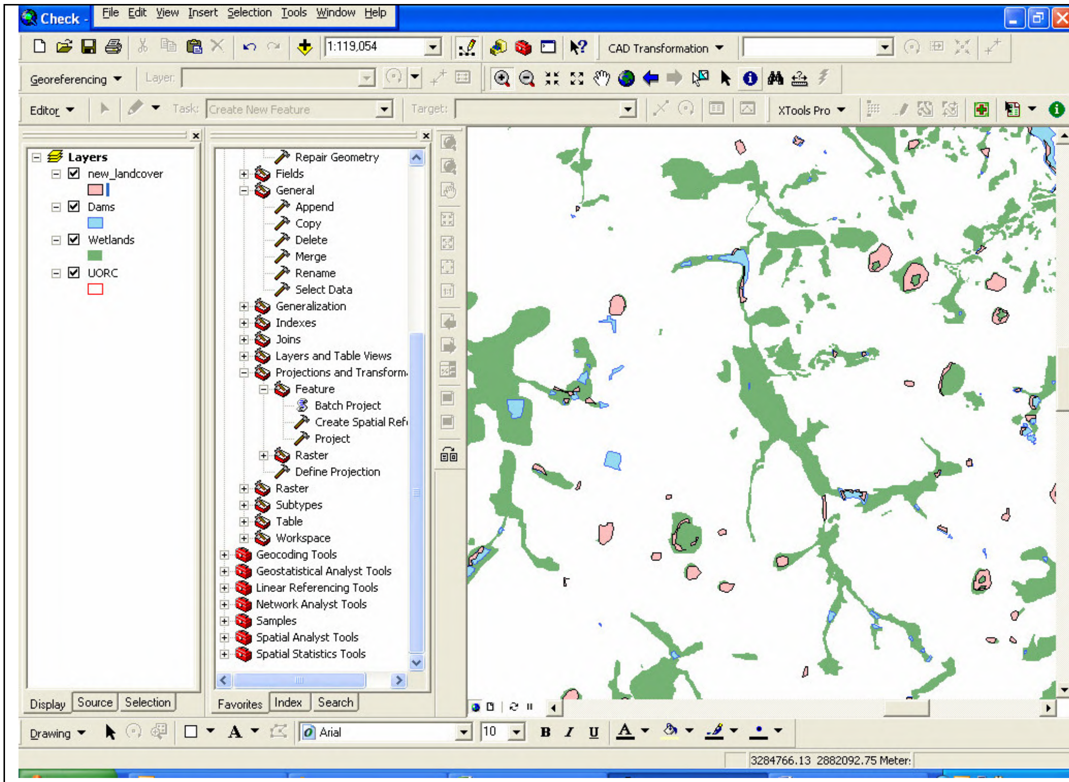

Figure 22. Incomplete pans in the Landcover wetland layer

8. GAP ANALYSIS

8.1 Available literature

- Although the wetlands in the UORC have been mapped extensively (mostly 1:50 000 scale), there is a lack of data on specific wetland attributes.
- The status of the wetlands in the UORC is not well documented and some of the data is old.
- Limited data is available on the classification of wetlands in the UORC.
- The species composition of only a few wetlands in the UORC is known with any detail resulting in only a generalised species list for wetlands.
- Water quality of only a few wetlands in the UORC is known.
- Some species are only known to occur in wetlands in the area, with no reference as to which types of wetlands.
- Tools for the determination of wetland health are focussed on riparian wetlands with no tools available to determine the health of seepage wetlands.

8.2 Mapping

- Small wetlands (of less than half a hectare) cannot be identified on the 1:50 000 aerial photographs and these wetlands are therefore excluded from the wetland layer.
- The 1:50 000 aerial photographs are slightly skewed to the edges and there may be some inaccuracy on the exact location of some of the wetlands.
- The aerial photographs were mostly taken in the winter months, thereby affecting the visibility of the wetlands on the aerial photographs.
- Terrain shadow, cloud shadow and smoke from industries affect the accuracy of the wetland delineation, since these shadows can be interpreted as wetlands or can obscure wetlands.
- The aerial photographs are two to three years old and changes may have taken place, including the expansion of developments over wetland areas. These developments may include residential, mining, cultivation and industrial developments.
- The attributes included in the wetland database was based on the aerial photographs and the available literature, with only limited field verification possible.
- The field verification of some of the wetlands will not replace site specific assessments.
- The status of the wetlands are the most inaccurate of the attributes, since this attribute was only based on the aerial photographs and a small amount of field verification, and a number of threats not visible on an aerial photograph may impact on the wetland.
- The Red Data species and important species attributes are not site specific, but based on the wetland type. The status of the wetland was not taken into account.
- Threats included in the wetland database are only those threats visible on the aerial photographs. Additional threats, not visible on the aerial photographs, may be present.

8.3 Database accuracy

The database accuracy was determined during the field verification exercise. A total of 632 wetlands of various sizes were verified, a number of which (107) were deleted, since the wetlands could not be observed during the site visit. It was therefore determined during the site visit that approximately 17% of the wetlands verified do not exist. Eighty-seven percent of these wetlands indentified, were seepage wetlands. Therefore, it can be concluded that seepage wetlands are most difficult to delineate accurately based on aerial photographs. Seepage wetlands are very similar to the surrounding grassland areas in vegetation structure and the two can easily be confused when delineating from aerial photographs.

In addition, a total of 133 wetlands (21% if the verified wetlands) observed in the field, but absent from the database, were delineated. The wetlands were small (1 350ha in total) in comparison to the total area (105 843ha) of the verified wetlands. The added wetlands therefore only comprised 1.3% of the verified wetlands, an almost negligible difference. This inaccuracy is probably due to the scale of the aerial photographs. All of the wetlands observed in the field, but not included in the database, were significantly less than $100m^2$.

The total area of wetlands in the UORC has been lowered from 3 $105km^2$ to 2 $147km^2$, a difference of 31%. The total area of non-floodplain riparian wetlands and perennial pans changed little, but the total area of artificial wetlands doubled in size, while the total seepage area halved. The floodplain riparian and non-perennial pans diminished in total area by 36% and 26%, respectively.

Most of the changes in the total wetland area in each wetland type are not due to changes in the delineated wetland areas, it is a matter of reassigning the wetland type. During the field verification visits it was determined that 28% of the verified wetlands were listed under the incorrect wetland type. It is important to note that an even larger percentage of the delineated wetlands may be artificial wetlands, and that this has not been picked up during the field verification site visits. A large number of seepage wetlands were erroneously indicated due to tonal and structural similarities between temporary wetland plants and terrestrial plants during the winter months. These similarities were noted during the field verification site visits and the entire wetland database amended accordingly, including areas not field verified. This amendment was based on the aerial photographs. It is therefore expected that the accuracy of the wetland layer has been improved to 70% accuracy.

The attributes in the attribute table was also verified where possible. The most inaccurate attribute was the *status* of the wetlands. Sixty percent of the verified wetlands had an inaccurate status indicated in the database. The status was mostly increased, but in some cases the status of the wetlands were also decreased. This attribute is very difficult to determine from an aerial photograph.

The *connectivity* attribute of 39% of the wetlands were changed, either lower or higher, and the *threat* attribute has been added to for 35% of the wetlands. Various threats were observed in the field, which are not visible on the aerial photographs.

The attributes in the database has an overall accuracy of 60% and the wetland layer an accuracy of 70%.

8.4 The way forward

- This layer, although baseline, is not intended as a static, once-off project and the data should be refined and corrected on a regular basis.
- The layer should be handed over to a host organisation capable of refining and updating the wetland layer, e.g. SANBI.

9. CONCLUSION

Limited literature is available on the wetlands in the UORC, but the literature available illustrates the importance of the wetlands in terms of services and functions of the wetlands in general and specifically in the UORC. In addition, the wetlands are under threat from various activities within the catchment. Although it is not feasible to prevent all activities impacting on the wetlands from taking place, the activities can be managed to obtain the most beneficial combination of economic development and wetland conservation.

A wetland database and a dam layer have been compiled for the catchment, based on the existing wetland databases and 1:50 000 aerial photographs. The wetland layer is linked to a wetland database including various attributes such as wetland type, possible functions and status. The wetland database and dam layer should, however, be viewed as a baseline study to guide decision making, and should not replace more detailed, site specific, wetland assessments.

Field verification site visits were conducted in the catchment area to assess the location and attributes of the wetlands indicated in the wetland database. The attributes in the database has an overall accuracy of 60% and the wetland layer an accuracy of 70%.

10. REFERENCES

Abbott Grobicki (Pty) Ltd. No date. *New Green. A database of developing green crops*. Water Research Commission.

Adebayo, A.A. No date. *Sustainable construction in Africa. Agenda 21 for sustainable construction in developing countries.* African position paper: Prof A. Adebayo.

Allan, D.G., Seaman, M.T. & Kaltja, B. 1995. *The endorheic pans of South Africa*. In: Cowan, G.I. 1995. Wetlands of South Africa. Department of Environmental Affairs and Tourism. Pretoria.

Barnes, K.N. 1998. *The important bird areas of southern Africa*. BirdLife South Africa, Johannesburg.

Barnes, K.N. 2000. *The ESKOM Red Data Book of Birds of South Africa, Lesotho and Swaziland.* BirdLife South Africa, Johannesburg.

Brady, N.C. & Weil, R.R. 1999. *The nature and properties of soils*. Prentice Hall Inc. New Jersey.

Branch, B. 1998. *Field guide to snakes and other reptiles of southern Africa.* Struik Publishers, Cape Town.

Bromilow, C. 2001. *Problem plants of South Africa*. Briza Publications, Pretoria.

Chutter, F.M. and Engelbrecht, J.S. 1997. *A Report on the invertebrate/fish survey of that part of the Rietspruit to be diverted in the development of the Kriel Block 6 Open Cast Coal Pits undertaken in the 22nd August 1997.* Afridev Consultants.

Cirmo, C.P. *Adirondack and Catskill wetland comparisons based on geology, surficial stratigraphy and hydrology*. Presentation, 2003 Seattle annual meeting (Nov 2-5) Geological Society of America. Abstracts with Programs 35(6): 206.

Coetzee, J.P. 1993. *Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area*. M.Sc. dissertation. Faculty of Science. University of Pretoria. Pretoria.

Cowan, G.I., *South Africa and the Ramsar convention*. In: Cowan, G.I. (ed) 1995. Wetlands of South Africa. Department of Environmental Affairs and Tourism, Pretoria.

Cowardin, L.M., Carter, V. Golet, F.C. & LaRoe, E.T. No date. *Classifiaction of wetlands and deepwater habitats of the United States*. US Department of the Interior. Washington.

CSIR. 2001. *State of the Rivers Report. Crocodile, Sabie-Sand & Olifants River Systems*. WRC Report No. TT 147/01.

De Frey, W.H. & Robbeson, R.A.J. 1999. *A baseline study on the Landau-Tewwfontein Spruit wetlands at Kleinkopje Coelliery, SACE*. Eco-Info.

De Lange, B.J., Bate, M.D. & Bate, J.M. 2003. *Identification and delineation of permanent, seasonal and temporary wetlands occurring on the Goedehoop Colliery mine property.* Geovicon cc. 264/2003.

Dely, J.L., Kotze, D.C., Quinn, N.W. & Mander, J.J. *A pilot project to compile an inventory and classification of wetlands in the Natal Drakensberg Park*. Research Report Series. South African Wetlands Conservation Programme. Department of Environmental Affairs and Tourism, Pretoria.

Deocampo. 1997. *Modern sedimentation and geochemistry of freshwater springs: Ngorongoro Crater, Tanzania*. Unpubl M.Sc Thesis, State University of New Jersey, New Brunswick.

Devito, K.J., Hill, A.R. & Roulet, N. 1996. *Groundwater-surface water interactions in headwater forested wetlands if the Canadian Shield*. Journal of Hydrology 181: 127-147.

Dugan, P. 2005. *Philip's guide to wetlands. An illustrated guide to the ecology and conservation of the world's wetlands*. Philip's devision of Octopus Publishing Group, London.

DWAF. 2003a. *A practical field procedure for identification and delineation of wetlands and riparian areas*.

DWAF. 2003b. *Olifants Water Management area. Overview of Water Resources Availability and Utilisation*. Report No. P WMA 04/000/00/0203.

ECOSUN cc. 2006. Biological monitoring: Witbank Dam and Middelburg Dam Catchment Managed Release Scheme. 2006 Monitoring Cycle. E450/06/A.

Ewart-Smith, J.L., Ollis, D.J., Day, J.A. & Malan, H.L. 2006. *National wetland inventory: Development of a wetland classifecation system for South Africa.* Water Research Commission. WRC Report No. KV 174/06.

Exigent Engineering Consultants. 2005. *Assessment of two dams on portion 10 of the Farm Boschkop 543 JR*. Report to the National Department of Agriculture.

Exigent Engineering Consultants. 2006. *Ecological assessment on Portion 32 and 72 of the Farm Klipfontein 498 JR*. Internal report.

Ferrati, R. & Conziana, G.A. 2005. *An analysis of water level dynamics in Esteros del Ibera wetland.* Ecological Modelling 186: 17-27

Geldenhuys, J.N. 1982. *Classification of pans in the western Orange Free State according to vegetation structure, with reference to avifaunal communities*. South African Journal of Wildlife Reseatch 12: 55-62.

Golding, J. 2002. *Southern African plant Red Data lists*. Southern African Botanical Diversity Network Report No. 14.

Goudie, A.S. & Thomas, D.S.G. 1985. *Pans in southern Africa with particular reference to South Africa and Zimbabwe.* Zeitschrift fur Geomorphologie NF29:1-19.

Great Barrier Reef Marine Park 2006: http://www.gbrmpa.gov.au/corp_site/key_issues/water_quality/documents/wetlands_report/wetlands_part_01.pdf

Grundling, P. and Marneweck, G.C. 2001. *Defining and classification of peat wetland eco-regions in South Africa*. WCS report: 28/99, Agricultural Research Council, Pretoria.

Heath, R.G.M. & Claassen, M. 1999. *An overview of the pesticide and metal levels present in populations of the larger indigenous fish species of selected South African rivers*. WRC report no 428/1/99.

Hengle, D. No date. *Livestock herbivory effects on the forage quality of riparian vegetation*. Department of renewable resources. University of Wyoming.

Hilton-Taylor, C. 1996. *Red Data list of southern African Plants.* Strelitzia 4. National Botanical Institute. Pretoria.

IUCN 2002. *IUCN Red List categories*. Prepared by the IUCN Species Survival Commission, Gland, Switzerland.

Kiai, S.P.M. & Mailu, G.M. No date. *Wetland classification for agricultural development in eastern and southern Africa*. Food and Agriculture Organisation (FAO) corporate document repository. Kenya country paper.

Kitheka, J.U., Ongwenyi, G.S., Mavuti, K.M. 2003. *Fluxes and exchanges of suspended sediment in tidal inlets draining a degraded mangrove forest in Kenya*. Estuarine, Coastal and Shelf Science 56: 655-667.

Klein, H. (compiler) 2002. *Weeds, alien plants and invasive plants*. PPRI Leaflet Series: Weeds Biocontrol, No 1.1. ARC-Plant Protection Research Institute, Pretoria. pp. 1-4.)

Kotze, D.C. 2000. *Wetlands and water quality enhancement*. Mondi Wetlands Project.

Kotze, D.C., Breewn, C.M. & Klug, J.R. 2000. *Wetland-Use. A wetland management decision support system for South African freshwater palustrine wetlands*.

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. & Collins, N.B. 2005. *WET-EcoServices. A technique for rapidly assessing ecosystem services supplied by wetlands*.

Landcare South Africa. Brochure. *CARA Legislation Made Easy. The Conservation of Agricultural Resources Act, 1983 (Act No 43 of 1983) (CARA)*.

Limpitlaw, D. 1995. *The assimilative capacity of the Kromdraaispruit wetland*. M.Sc dissertation. Faculty of Engineering, University of the Witwatersrand.

Limpitlaw, D. 1996. *Sediments as indicators of wetland efficacy in ameliorating acid mine drainage*. The Journal of the South Africa Institute of Mining and Metallurgy Vol 96 no 7, p 309 – 316.

Low, A.B. and A.G. Rebelo (eds). 1996. *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria. Republic of South Africa.

Loxton, Venn and Associates. 1998. *Conservation and functional status assessment of four pans in the Kriel area*.

Marneweck, G.C. 2001. *An ecological assessment of the riparian zone and wetland habitats of the Kriel South area*. Wetland Consulting Services. Reference 40/2000.

Marneweck, G.C. 2002. *Wetland baseline and impact assessment: Klipspruit*. Wetland Consulting Services. Reference 73/2002.

Marneweck, G.C. 2003. *Wetland baseline and Impact Assessment: Elders strip and underground mine*. Wetland Consulting Services. Reference 88/2002.

Marneweck, G.C. 2004a. *Preliminary wetland delineation on the farms Goedgevonden, Zaaiwater and Klenzuikerboschplaat near Ogies in Mpumalanga*. Wetland Consulting Services. Reference 110/2004.

Marneweck, G.C. 2004b. *Wetland specialist assessment for Douglas EMP amendment*. Wetland Consulting Services. Reference 123/2004.

Marneweck, G.C. and Bell, S.M. 2002. *A floristic comparison of the Steenkoolspruit, Blesbokspruit and Viskuile wetlands, Mpumalanga*. Wetland Consulting Services. Reference 65/2001.

Marneweck, G.C. and Batchelor, A.L. 2004. *Wetland specialist study for Khutala Colliery: Delineation, conservation status and recommendations for developing a rehabilitation strategy*. Wetland Consulting Services. Reference 112/2004.

McLeroth, B.B. 2003a. *Soil survey, pre-mining land capability, wetland classification, land use, natural vegetation/plant life, animal life, sites of archaeological and cultural interest and sensitive landscapes of Goedehoop 46IS (portion of portions 3 and 8) pillar extraction area and surrounds Goedehoop Colliery, Middelburg District*. Red Earth cc. REMS26.

McLeroth, BB. 2003b. *Soil survey, pre-mining land capability, wetland classification, land use, natural vegetation/plant life, animal life, sites of archaeological and cultural interest and sensitive landscapes as well as soil utilisation (stripping) guide, and rehabilitation topsoil budget of portions of Bultfontein 187 IS Bord and Pillar area Goedehoop Colliery, Middelburg District*. Red Earth cc. REMS28.

Merot, P., Squividant, H., Aurousseau, P., Hefting, H., Burt, T., Maitre, V., Kruk, M., Butturini, A., Thenail, C. & Viaud, V. 2003. *Testing a climato-topographic index for predicting wetland distribution along an European climate gradient*. Ecological Modelling 163: 51-71.

Midgeley, B.J., Pitman, W.V. & Middleton, B.J. 1994. *Surface water resources of South Africa 1990. Volume 1*. Drainage regions A, B. WRC Report no. 298/1.1/94.

Minter, L.R., Burger, M., Harrison, J.A., Braack, H.H., Bishop, P.J. & Kloepfer, D., eds. 2004. *Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland.* SI/MAB Series #9. Smithsonian Institution, Washington, DC.

Mmopelawa, G. *In press*. *Economic and financial anaysis of harvesting and utilisation of river reed in the Okavango Delta, Botswana*. Journal of Environmental Management.

Morant, P.D. 1983. *Wetland classification: towards an approach for southern Africa*. Journal of Limnological Society of southern Africa. 9:76-84.

Munday and Wepener. 2004. *Assessment of the ecological integrity status of a reach along the Olifants River, Mpumalanga and a comparison of invertebrate species found during high flow versus low flow periods*. Honours thesis. Department of Zoology. University of Johannesburg.

Myburgh, W.J. 1999. *Oewerplantegroei vam die Olifantsriviersisteem – 'n ekologiese perspektief*. WNK Verslag no. 663/1/99.

Natural Scientific Services. 2006. *Biodiversity Assessment for Middelburg Mine on the Farms Hartbeestfontein 339 JS, Goedehoop 315 JS, Sterkwater 317 JS and Driefontein 338 JS, Mpumalanga*. Compiled for Jones & Wagener.

Niehaus, B.H., Kotze, P.J. & Bekker, F. 1999. *Assessment of the aquatic vertebrate, macro invertebrate and the habitat of the Landau- and Tweefontein spruit wetlands*.

Palmer, R.W., Turpie, J., Marneweck, G.C. & Batchelor, A.L. 2002. *Ecological and economic evaluation of wetlands in the Upper Olifants River catchment, South Africa*. WRC Report no. 1162/1/02.

Palmer, R. & Engelbrecht, J. 2003. *Feasibility study: Elders strip mine and underground. Aquatic ecosystems: Baseline assessment*. Afridev Consultants.

Reeves, P.N. & Champion, P.D. 2004. *Effects of Livestock Grazing on Wetlands: Literature Review*. Environment Waikato Regional Council, Hamilton East, New Zealand.

River Health Programme. 2001. *State of the Rivers Report. Crocodile, Sabie-Sand & Olifants River Systems.* WRC Report no. TT 147/01.

Rogers, K.H. 1995. *Riparian wetlands*. In: Cowan, G.I. 1995. Wetlands of South Africa. Department of Environmental Affairs and Tourism. Pretoria.

Roux, D.J. 2001. *Development of procedures for the implementation of the National River Health Programme in the province of Mpumalanga*. WRC Report no. 850/1/01.

Shanmugam, P., Ahn, Y. & Sanjeevi, S. *In press. A comparison of classification of wetland characteristics by linear spectral mixture modelling and traditional hard classifiers on multispectral remotely sensed imagery in southern India*. Ecological Modelling.

Skinner, J.D. and R.H.N. Smithers. 1990. *The Mammals of the Southern African Sub region* (New Edition). University of Pretoria. Pretoria, Republic of South Africa.

Snyman, C.P. 1998. *Coal*. In: Wilson M.G. & Anhauser C.R. (eds.): The mineral resources of South Africa handbook, Council of Geoscience, 16: 136-206.

Smit, C.M., Bredenkamp, G.J., van Rooyen, N., van Wyk, A.E., & Combrink, J.M. 1997. *Vegetation of the Witbank Nature Reserve and its importance for conservation of threatened Rocky Highveld Grassland*. Koedoe 40(2): 85-104. Pretoria. ISSN 0075-6458.

South Africa Tourism 2006: http://www.southafrica.info/plan_trip/holiday/wildlife/birding.htm

Strategic Environmental Focus. 2004. *Endorheic pan ecological assessment: Pullenshope, Mpumalanga*. Prepared for Optimum Colliery – Ingwe coal.

Vegter, J.R. 1995. *An explanation of a set of national groundwater maps*. Department of Water Affairs and Forestry, Pretoria.

Veitch, V. & Sawynok, B. 2005. *Freshwater wetlands and fish. Importance of freshwater wetlands to marine fisheries resources in the Great Barrier Reef*. Sunfish Queensland Inc.

Venter, C.E. 2003. *The vegetation ecology of Mfabeni peat swamp, St Lucia, KwaZulu-Natal*. Magister Scientia thesis. University of Pretoria.

Versveld, D.B., Le Maitre, D.C., Chapman, R.A. 1998. *Alien invading plants and water resources in South Africa: A preliminary assessment*. WRC Report no. TT99/98.

Ward, J.C. & Lambie, J.S. 1999. *Monitoring changes in wetland extent: An environmental performance indicator for wetlands*. Licoln Environmental, Lincoln University, Canterbury, New Zealand.

Wateryear 2003: http://www.wateryear2003.org/en/ev.php-url_ID=2081&URL_DO=DO_TOPIC&URL_section=201.html

Wetland Consulting Services. 2005. *Wetland delineation and Environmental Impact Assessment: Goedgevonden expansion project on the farms Goedgevonden, Zaaiwater and Klenzuikerboschplaat near Ogies in Mpumalanga*. Reference 154/2005.

Wilson, R.T. 2003. *Animal health and disease control in the Usangu wetland of south western Tanzania*. Tropical Animal Health and Production 35(1):47-67.

Wolski, P. & Savenije, H.H.G. *In press. Dynamics of floodplain-island groundwater flow in the Okavango Delta, Botswana*. Journal of Hydrology.

Zierholtz, C., Prosser, I.P., Fogarty, P.J. & Rustomji, P. 2001. *In-stream wetlands and their significance for channel filling and the catchment sediment budget, Jugoing Creek, New South Wales*. Geomorthology 38: 221-235.

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Xtrata Coal

Addendum A – Plan species list

				Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
Family name	**Species name**	**Red Data**	**Exotic**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dadms & Weirs	Other	Unspecified
Fabaceae	*Acacia dealbata*		Y									*													
Fabaceae	*Acacia erioloba*											*													
Fabaceae	*Acacia karroo*						*					*													
Fabaceae	*Acacia mearnsii*		Y				*														*				
Euphorbiaceae	*Acalypha angustata*											*									*				
Euphorbiaceae	*Acalypha caperonioides*											*									*				
Euphorbiaceae	*Acalypha punctata*																				*				
Asteraceae	*Acanthospermum australe*		Y																		*				*
Amaranthaceae	*Achyranthes aspera var aspera*											*													
Lamiaceae	*Acrotome hispida*																				*				
Rosaceae	*Agrimonia bracteata*											*													
Poaceae	*Agrostis continuata*																				*				
Poaceae	*Agrostis eriantha*						*					*								*	*				*
Poaceae	*Agrostis eriantha var. eriantha*						*					*									*				*
Poaceae	*Agrostis lachnantha*											*													
Poaceae	*Agrostis lachnantha var. lachnantha*						*					*								*	*			*	

Lamiaceae	*Ajuga ophrydis*											*													
Hyacinthaceae	*Albuca species*												*	*								*			
Poaceae	*Alloteropsis semialata*											*									*				
Poaceae	*Alloteropsis semialata ssp semialata*																								*
Asphodelaceae	*Aloe ecklonis*																				*				
Amaranthaceae	*Amaranthus hybridus*		Y																		*				*
Amaranthaceae	*Amaranthus viridis*		Y									*													
Primulaceae	*Anagallis huttonii*																				*				
Poaceae	*Andropogon appendiculatus*											*													
Poaceae	*Andropogon eucomus*						*				*	*	*								*	*			
Poaceae	*Andropogon huillensis*						*				*								*		*				*
Poaceae	*Andropogon schirensis*																				*	*			
Rubiaceae	*Anthospermum hispidulum*											*									*				
Rubiaceae	*Anthospermum rigidum*																				*				
Rubiaceae	*Anthospermum rigidum ssp rigidum*											*													*
Aponogetonaceae	*Aponogeton junceus*																		*						
Asteraceae	*Arctotis arctotoides*											*													*
Papaveraceae	*Argemone ochroleuca ssp ochroleuca*																								*
Papaveraceae	*Argemone subfusiformis*						*					*													
Fabaceae	*Argyrolobium tuberosum*											*													
Poaceae	*Aristida bipartita*											*													
Poaceae	*Aristida congesta*																				*				
Poaceae	*Aristida congesta subsp.barbicollis*											*									*				
Poaceae	*Aristida congesta subsp.congesta*											*									*				

Poaceae	*Aristida diffusa*																				*				
Poaceae	*Aristida diffusa subsp.burkei*																				*				
Poaceae	*Aristida junciformis*												*						*		*	*			
Poaceae	*Aristida junciformis subsp.junciformis*						*					*								*	*				*
Poaceae	*Aristida species*											*													
Poaceae	*Aristida transvaalensis*											*									*				
Poaceae	*Artemisia afra*											*													
Poaceae	*Arundinella nepalensis*						*					*									*				*
Apocynaceae	*Asclepias eminens*											*													
Apocynaceae	*Asclepias gibba var.gibba*						*					*								*					
Apocynaceae	*Asclepias multicaulis*											*													
Apocynaceae	*Asclepias stellifera*											*													
Asparagaceae	*Asparagus larcinus*						*																		
Asparagaceae	*Asparagus virgatus*											*													
Asteraceae	*Aster harveyanus*																				*				
Asteraceae	*Aster squamatus*		Y									*									*			*	*
Pteridophyta, Azollaceae	*Azolla filiculoides*		Y																		*				*
Lamiaceae	*Becium abovatum*											*									*				
Asteraceae	*Berkheya bipinnatifida subsp bipinnatifida*																								*
Asteraceae	*Berkheya carlinopsis*											*													
Asteraceae	*Berkheya insignis*																				*				
Asteraceae	*Berkheya onopordifolia*												*						*			*			
Asteraceae	*Berkheya pinnatifida*											*													
Asteraceae	*Berkheya radula*						*					*								*					*
Asteraceae	*Berkheya seminivea*																				*				
Asteraceae	*Berkheya setifera*																				*				

Asteraceae	*Berkheya speciosa*																				*				
Asteraceae	*Berkheya zeyheri*												*						*			*			
Apiaceae	*Berula erecta*											*													
Asteraceae	*Bidens bipinnata*		Y																		*				*
Asteraceae	*Bidens biternata*		Y																		*				
Asteraceae	*Bidens pilosa*		Y				*					*	*								*	*			
Asteraceae	*Blumea dregeanoides*											*													
Amaryllidaceae	*Boophone disticha*																		*		*				
Poaceae	*Bothriochloa bladhii*						*																		
Poaceae	*Bothriochloa insculpta*												*						*						
Poaceae	*Brachiaria brizantha*											*													
Poaceae	*Brachiaria eruciformis*											*													
Poaceae	*Brachiaria serrata*											*													
Poaceae	*Bromus catharticus*		Y				*					*													*
Cyperaceae	*Bulbostylis burchellii*																				*				*
Cyperaceae	*Bulbostylis humilis*																				*				
Poaceae	*Calamogrostis epigeios var.capensis*	NT																			*				
Asteraceae	*Callilepis leptophylla*																				*				
Dicotyledons	*Cardylogyne globosa*											*								*					
Cyperaceae	*Carex austro-africana*											*													
Cyperaceae	*Carex cf.austro-africana*											*													
Cyperaceae	*Carex glomerabilis*											*								*					
Celtidaceae	*Celtis africana*											*													
Apiaceae	*Centella asiatica*						*				*	*	*						*	*	*	*			*
Apiaceae	*Centella species*											*													
Dipsacaceae	*Cephalaria zeyheriana*						*					*	*												
Haloragaceae	*Cf.Laurembergia repens*											*													
Haloragaceae	*Cf.Laurembergia repens subsp.brachypoda*																			*					

Acanthaceae	*Chaetacanthus costatus*											*													
Acanthaceae	*Chaetacanthus setiger*											*													
Fabaceae	*Chamaecrista biensis*																				*				
Fabaceae	*Chamaecrista capensis*																							*	
Fabaceae	*Chamaecrista comosa*											*													
Fabaceae	*Chamaecrista mimosoides*																				*				
Chenopodiaceae	*Chenopodium album*		Y									*									*			*	
Chenopodiaceae	*Chenopodium ambrosioides*		Y									*													
Chenopodiaceae	*Chenopodium glaucum*		Y									*									*				
Chenopodiaceae	*Chenopodium schraderianum*		Y																		*			*	*
Gentianaceae	*Chironia palustris*						*					*													
Gentianaceae	*Chironia purpurascens*						*						*	*						*	*	*			
Poaceae	*Chloris gayana*																				*			*	
Poaceae	*Chloris pycnothrix*																				*				
Anthericaceae	*Chlorophytum cooperi*												*						*			*			*
Anthericaceae	*Chlorophytum fasciculatum*																				*				
Apiaceae	*Ciclospermum leptophyllum*		Y									*								*	*				*
Asteraceae	*Cineraria lyratiformis*											*									*				
Asteraceae	*Cirsium vulgare*		Y				*					*	*	*						*	*	*		*	*
Capparaceae	*Cleome monophylla*						*																		*
Capparaceae	*Cleome rubella*																				*				
Euphorbiaceae	*Clutia natalensis*											*													
Euphorbiaceae	*Clutia species*																								*
Cyperaceae	*Coleochloa setifera*											*													*
Commelinaceae	*Commelina africana*										*	*								*	*				

Commelinaceae	*Commelina africana var africana*																								*
Commelinaceae	*Commelina africana var krebsiana*											*													
Commelinaceae	*Commelina africana var lancispatha*											*													
Commelinaceae	*Commelina erecta*											*													
Commelinaceae	*Commelina species*																								*
Commelinaceae	*Commelina subulata*																				*				
Apiaceae	*Conium chaerophylloides*						*					*													
Convolvulaceae	*Convolvulus sagittatus*											*									*				
Asteraceae	*Conyza albida*		Y				*					*									*			*	
Asteraceae	*Conyza bonariensis*		Y									*													*
Asteraceae	*Conyza chilensis*		Y																		*				*
Asteraceae	*Conyza podocephala*											*									*				
Asteraceae	*Conyza scabrida*						*																		
Apocynaceae	*Cordylogyne globosa*																								*
Asteraceae	*Cosmos bipinnatus*		Y									*									*			*	*
Asteraceae	*Cotula anthemoides*											*													
Asteraceae	*Cotula microglossa*											*													
Acanthaceae	*Crabbea acaulis*											*									*				
Acanthaceae	*Crabbea hirsuta*											*													
Acanthaceae	*Crabbea nana*																								*
Crassulaceae	*Crassula capitella*												*						*						
Crassulaceae	*Crassula lanceolata*																		*						
Crassulaceae	*Crassula vaillantii*		Y																		*				
Asteraceae	*Crepis hypochaeridea*																				*				*
Amaryllidaceae	*Crinum bulbispermum*											*													*
Fabaceae	*Crotalaria lotoides*													*											
Poaceae	*Ctenium concinnum*																				*				
Cucurbitaceae	*Cucumis myriocarpus*																				*				
Cucurbitaceae	*Cucumis zeyheri*											*	*						*						

Commelinaceae	*Cyanotis speciosa*											*													*
Orobanchaceae	*Cycnium tubulosum*											*													
Poaceae	*Cymbopogon excavatus*																				*				*
Poaceae	*Cymbopogon nardus*						*					*									*				
Poaceae	*Cymbopogon pospischilii*											*									*				
Poaceae	*Cynodon dactylon*				*		*				*	*	*						*	*	*	*		*	*
Poaceae	*Cynodon hirsutus*											*									*			*	
Poaceae	*Cynodon incompletus*											*													
Poaceae	*Cynodon transvaalensis*																				*				
Boraginaceae	*Cynoglossum lanceolatum*											*													
Cyperaceae	*Cyperus denudatus*											*									*				*
Exotic plant species	*Cyperus difformis*																				*				*
Cyperaceae	*Cyperus distans*											*													
Cyperaceae	*Cyperus effusus*						*																		
Cyperaceae	*Cyperus esculentus*				*		*					*	*						*		*	*		*	*
Cyperaceae	*Cyperus esculentus var esculentus*																								*
Cyperaceae	*Cyperus fastigiatus*						*					*													*
Cyperaceae	*Cyperus laevigatus*																				*				
Cyperaceae	*Cyperus latifolius*						*					*													
Cyperaceae	*Cyperus longus*						*					*									*				
Cyperaceae	*Cyperus longus var.longus*											*													
Cyperaceae	*Cyperus longus var.tenuiflorus*											*													
Cyperaceae	*Cyperus maculatus*											*													
Cyperaceae	*Cyperus marginatus*											*	*	*					*		*	*			*
Cyperaceae	*Cyperus obtusiflorus*											*													
Cyperaceae	*Cyperus obtusiflorus var obtusiflorus*																								*

Cyperaceae	*Cyperus rigidifolius*																				*				
Cyperaceae	*Cyperus rupestris*						*					*	*						*			*			
Cyperaceae	*Cyperus sexangularis*						*					*													
Cyperaceae	*Cyperus species*																				*				
Cyperaceae	*Cyperus sphaerospermus*																			*	*				
Amaryllidaceae	*Cyrtanthus tuckii*											*													
Poaceae	*Dactyloctenium aegyptium*																			*					
Solanaceae	*Datura stramonium*						*					*	*						*		*	*		*	*
Asteraceae	*Denekia capensis*											*								*	*				
Apiaceae	*Deverra species*											*													
Poaceae	*Diandrochloa namaquensis*																							*	
Caryophyllaceae	*Dianthus mooiensis*						*																		
Caryophyllaceae	*Dianthus mooiensis ssp mooiensis var mooiensis*																								*
Acanthaceae	*Dicliptera clinopodia*											*													
Acanthaceae	*Dicliptera minor*						*																		
Asteraceae	*Dicoma anomala*												*	*							*	*			*
Poaceae	*Digitaria eriantha*											*	*						*		*	*		*	*
Poaceae	*Digitaria ternata*						*																		
Poaceae	*Digitaria tricholaenoides*																				*				
Poaceae	*Diheteropogon amplectens*											*	*						*		*	*			
Asteraceae	*Dimorphotheca jucunda*																				*				
Asteraceae	*Dimorphotheca spectabilis*																								*
Ebenaceae	*Diospyros lycioides*						*																		
Ebenaceae	*Diospyros lycioides ssp lycioides*																								*
Ebenaceae	*Diospyros lycioides ssp sericea*											*													

Hyacinthaceae	*Dipcadi ciliare*											*													
Hyacinthaceae	*Dipcadi species*																								*
Orchidaceae	*Disa woodii*											*													*
Melastomatacea e	*Dissotis canescens*																				*				
Poaceae	*Echinochloa crus-galli*											*													
Poaceae	*Echinochloa crus-pavonis*																				*			*	
Poaceae	*Echinochloa jubata*						*					*									*			*	
Cyperaceae	*Eleocharis dregeana*						*					*								*	*				
Poaceae	*Eleusine coracana subsp.africana*											*									*			*	
Poaceae	*Elionurus muticus*											*								*	*				*
Onagraceae	*Epilobium hirsutum*		Y									*													
Poaceae	*Eragrostis capensis*						*					*								*	*				*
Poaceae	*Eragrostis chloromelas*						*					*	*	*					*		*	*			*
Poaceae	*Eragrostis curvula*						*					*							*	*	*			*	*
Poaceae	*Eragrostis gummiflua*						*					*	*							*	*	*			*
Poaceae	*Eragrostis heteromera*						*					*													
Poaceae	*Eragrostis inamoena*																				*				
Poaceae	*Eragrostis lappula*											*									*				
Poaceae	*Eragrostis micrantha*											*													
Poaceae	*Eragrostis nindensis*																				*				
Poaceae	*Eragrostis plana*						*				*	*								*	*				*
Poaceae	*Eragrostis planiculmis*											*									*				
Poaceae	*Eragrostis racemosa*						*					*	*						*	*	*	*			*
Poaceae	*Eragrostis rotifer*																				*				
Poaceae	*Eragrostis species*																				*				
Poaceae	*Eragrostis superba*						*						*	*					*			*			
Poaceae	*Eragrostis tef*		Y																*						
Poaceae	*Eragrostis trichophora*																		*						
Ericaceae	*Erica*													*					*						

	drakensbergensis																								
Ericaceae	*Erica species*																				*				
Fabaceae	*Eriosema cordatum*																				*				*
Fabaceae	*Eriosema salignum*											*													
Eriocaulaceae	*Eriospermum cooperi*										*														
Geraniaceae	*Erodium species*																				*				
Fabaceae	*Erythrina zeyheri*											*									*	*			
Ebenaceae	*Euclea crispa ssp crispa*											*													
Hyacinthaceae	*Eucomis autumnalis*																				*				
Orchidaceae	*Eulophia foliosa*																				*				
Orchidaceae	*Eulophia welwitschii*																			*					
Euphorbiaceae	*Euphorbia clavarioides*											*													
Euphorbiaceae	*Euphorbia striata*											*	*						*			*			
Euphorbiaceae	*Euphorbia striata var.striata*											*								*	*				
Convolvulaceae	*Falkia oblonga*											*									*			*	
Asteraceae	*Felicia muricata*												*								*	*			
Cyperaceae	*Fimbristylis complanata*						*					*								*	*				
Cyperaceae	*Fimbristylis obtusifolia*						*					*	*						*						
Poaceae	*Fingerhuthia sessleriiformis*											*													
Cyperaceae	*Fuirena coerulescens*											*								*					
Cyperaceae	*Fuirena hirsuta*												*									*			
Cyperaceae	*Fuirena pubescens*						*					*								*	*				
Cyperaceae	*Fuirena stricta*																				*				
Rubiaceae	*Galium capense*						*					*													
Rubiaceae	*Galium capense ssp garipense*											*													
Asteraceae	*Gamochaeta coarctata*		Y									*								*					
Asteraceae	*Gamochaeta subfalcata*		Y																						*

Asteraceae	*Gazania krebsiana*											*									*				
Asteraceae	*Geigeria burkei*											*													
Asteraceae	*Geigeria burkei ssp burkei var burkei*																								*
Asteraceae	*Gerbera piloselloides*											*									*				
Asteraceae	*Gerbera viridifolia*											*									*				
Iridaceae	*Gladiolus dalenii*																		*						
Iridaceae	*Gladiolus elliotii*						*																		
Iridaceae	*Gladiolus papilio*											*													*
Iridaceae	*Gladiolus species*																								*
Thymelaeaceae	*Gnidia capitata*											*									*				
Apocynaceae	*Gomphocarpus fruticosus*											*	*	*					*		*	*			
Apocynaceae	*Gomphocarpus fruticosus subsp fruticosus*						*					*	*							*	*			*	
Apocynaceae	*Gomphocarpus physocarpus*											*													
Apocynaceae	*Gomphocarpus tomentosus*												*	*											
Apocynaceae	*Gomphocarpus tomentosus subsp tomentosus*											*	*												
Buddlejaceae	*Gomphostigma virgatum*						*					*													
Amaranthaceae	*Gomphrena celosioides*		Y				*					*							*		*				*
Celastraceae	*Gymnosporia heterophylla*											*													
Orchidaceae	*Habenaria filicornis*																			*					
Amaryllidaceae	*Haemanthus montanus*											*								*					
Asteraceae	*Haplocarpha lyrata*						*					*								*					*
Dicotyledons	*Haplocarpha scaposa*											*								*	*				
Poaceae	*Harpochloa falx*						*					*	*	*					*		*				*
Orobanchaceae	*Harveya randii*						*					*													
Asteraceae	*Helichrysum*						*				*	*								*	*				*

	aureonitens																								
Asteraceae	*Helichrysum aureum*												*						*						
Asteraceae	*Helichrysum caespititium*																				*				
Asteraceae	*Helichrysum callicomum*																				*				
Asteraceae	*Helichrysum coriaceum*											*									*				
Asteraceae	*Helichrysum inornatum*												*						*			*			
Asteraceae	*Helichrysum krausii*						*						*												
Asteraceae	*Helichrysum mundtii*											*													
Asteraceae	*Helichrysum nudifolium*						*					*									*				*
Asteraceae	*Helichrysum odoratissimum*												*						*						
Asteraceae	*Helichrysum oreophilum*																				*				
Asteraceae	*Helichrysum pilosellum*											*	*						*			*			
Asteraceae	*Helichrysum rugulosum*						*					*									*				*
Asteraceae	*Helichrysum species*																				*				*
Poaceae	*Helictotrichon caespititium*											*													
Poaceae	*Helictotrichon turgidulum*											*								*	*				*
Boraginaceae	*Heliotropium species*																				*				
Poaceae	*Hemarthria altissima*				*		*					*	*						*		*				*
Lamiaceae	*Hemizygia species*											*													
Sterculiaceae	*Hermannia cordata*																								*
Sterculiaceae	*Hermannia depressa*											*	*						*		*	*			
Sterculiaceae	*Hermannia transvaalensis*											*	*						*		*	*			
Poaceae	*Heteropogon contortus*						*					*	*	*					*		*	*			*
Malvaceae	*Hibiscus aethiopicus*																				*				

Malvaceae	*Hibiscus microcarpus*											*	*								*	*			
Malvaceae	*Hibiscus pusillus*																				*				
Malvaceae	*Hibiscus trionum*											*									*			*	
Poaceae	*Hyparrhenia dregeana*																				*				
Poaceae	*Hyparrhenia filipendula*																				*			*	
Poaceae	*Hyparrhenia hirta*						*					*	*						*	*	*	*			*
Poaceae	*Hyparrhenia rufa*																				*				
Poaceae	*Hyparrhenia tamba*											*													
Dicotyledons	*Hypericum aethiopicum*																				*				
Hypericaceae	*Hypericum lalandii*																				*				*
Asteraceae	*Hypochaeris brasiliensis*		Y																						*
Asteraceae	*Hypochaeris radicata*		Y				*					*	*						*	*	*	*			*
Hypoxidaceae	*Hypoxis acuminata*						*					*								*	*				
Hypoxidaceae	*Hypoxis filiformis*											*								*					
Hypoxidaceae	*Hypoxis hemerocallidea*											*	*	*						*	*	*			
Hypoxidaceae	*Hypoxis iridifolia*						*						*						*			*			
Hypoxidaceae	*Hypoxis rigidula*						*					*	*						*			*			*
Poaceae	*Imperata cylindrica*						*					*	*						*	*	*	*			*
Fabaceae	*Indigofera daleoides*																				*				
Fabaceae	*Indigofera dimidiata*											*								*					
Fabaceae	*Indigofera evansiana*						*					*													
Fabaceae	*Indigofera filipes*																				*				
Fabaceae	*Indigofera frondosa*											*													
Fabaceae	*Indigofera species*																								*
Convolvulaceae	*Ipomoea bathycolpos*											*									*				
Convolvulaceae	*Ipomoea crassipes*											*													
Convolvulaceae	*Ipomoea oblongata*												*								*				
Poaceae	*Ischaemum fasciculatum*						*					*								*					*

Cyperaceae	*Isolepis cernua*						*					*									*				
Cyperaceae	*Isolepis costata*											*									*				
Cyperaceae	*Isolepis costata var.costata*																			*					
Cyperaceae	*Isolepis fluitans*																				*				
Cyperaceae	*Isolepis setacea*											*								*					
Scrophulariaceae	*Jamesbrittenia montana*											*													
Juncaceae	*Juncus dregeanus*						*					*								*	*				
Juncaceae	*Juncus effusus*						*					*	*						*	*	*			*	*
Juncaceae	*Juncus exsertus*																				*				
Juncaceae	*Juncus exsertus ssp exsertus*																								*
Juncaceae	*Juncus krausii*												*												
Juncaceae	*Juncus lomatophyllus*											*								*	*				
Juncaceae	*Juncus oxycarpus*						*					*								*	*				*
Juncaceae	*Juncus punctorius*											*								*					
Juncaceae	*Juncus rigidus*																				*				
Juncaceae	*Juncus species*																				*				
Acanthaceae	*Justicia anagalloides*																				*				*
Rubiaceae	*Kohautia amatymbica*											*									*				
Cyperaceae	*Kyllinga alba*						*					*													*
Cyperaceae	*Kyllinga erecta*						*					*									*				
Cyperaceae	*Kyllinga erecta var erecta*																				*				
Cyperaceae	*Kyllinga pulchella*																				*				
Asteraceae	*Lactuca inermis*										*	*									*				
Hyacinthaceae	*Lagarosiphon major*											*								*					
Hyacinthaceae	*Lagarosiphon muscoides*																				*				
Hyacinthaceae	*Ledebouria cooperi*											*									*				
Hyacinthaceae	*Ledebouria marginata*																				*				
Hyacinthaceae	*Ledebouria obtusifolia*												*												
Hyacinthaceae	*Ledebouria ovatifolia*											*	*							*					

Hyacinthaceae	*Ledebouria revoluta*																								*
Hyacinthaceae	*Ledebouria species*											*													
Poaceae	*Leersia hexandra*						*					*								*	*			*	*
Juncaginaceae	*Lemna minor*																				*				
Juncaginaceae	*Lemna species*																				*				
Lamiaceae	*Leonotis ocymifolia*																								*
Brassicaceae	*Lepidium bonariense*		Y									*													
Brassicaceae	*Lepidium virginicum*		Y									*													
Poaceae	*Leptochloa fusca*																				*				
Fabaceae	*Lessertia stricta*											*													
Scrophulariaceae	*Limosella longiflora*																				*				
Scrophulariaceae	*Limosella species*																				*				
Verbenaceae	*Lippia javanica*																				*				
Verbenaceae	*Lippia rehmannii*											*													
Lobeliaceae	*Lobelia erinus*											*									*				
Lobeliaceae	*Lobelia erinus*																								*
Lobeliaceae	*Lobelia flaccida*											*													
Lobeliaceae	*Lobelia flaccida subsp.flaccida*																			*					
Fabaceae	*Lotononis laxa*																				*				
Asteraceae	*Macledium zeyheri*																				*				
Cyperaceae	*Mariscus congestus*						*					*									*				
Cyperaceae	*Mariscus keniensis*																				*				
Marsileaceae	*Marsilea species*																				*				
Fabaceae	*Medicago sativa*		Y																		*			*	*
Orobanchaceae	*Melasma scabrum*																								*
Poaceae	*Melinis nerviglumis*																				*				
Poaceae	*Melinis repens*						*														*				
Poaceae	*Melinis repens ssp repens*																								*
Fabaceae	*Melolobium wilmsii*																				*				
Lamiaceae	*Mentha aquatica*						*					*													
Lamiaceae	*Mentha longifolia ssp*											*													

	polyadena																								
Poaceae	*Microchloa caffra*											*									*				
Scrophulariaceae	*Mimulus gracilis*											*								*					
Poaceae	*Miscanthus junceus*				*		*					*	*						*			*			*
	Monandrus squarrosus																				*				
Poaceae	*Monocymbium ceresiiforme*																				*				
Lobeliaceae	*Monopsis decipiens*						*				*	*								*	*				
Geraniaceae	*Monsonia angustifolia*											*									*				
Iridaceae	*Moraea elliotii*						*					*													
Iridaceae	*Moraea pallida*						*					*									*				
Iridaceae	*Moraea stricta*																				*				
Moraceae	*Morus alba*		Y									*													
Brassicaceae	*Nasturtium officinale*											*													*
Scrophulariaceae	*Nemesia fruticans*											*									*				*
Asteraceae	*Nidorella anamola*						*				*		*	*											
Menyanthaceae	*Nymphoides thunbergiana*																				*				
Poaceae	*Odontelytrum abyssinicum*																				*				
Onagraceae	*Oenothera glazioviana*		Y									*													
Onagraceae	*Oenothera indecora*		Y									*									*				
Onagraceae	*Oenothera parodiana subsp. parodiana*		Y									*								*					
Onagraceae	*Oenothera rosea*		Y				*					*								*	*			*	*
Onagraceae	*Oenothera tetraptera*		Y									*								*	*			*	*
Rubiaceae	*Oldenlandia herbacea*																				*				
Rubiaceae	*Oldenlandia herbacea var herbacea*																								*
Hyacinthaceae	*Ornithogalum flexuousum*						*																		
Poaceae	*Oropetium capense*																				*				
Oxalidaceae	*Oxalis corniculata*		Y																		*				

Oxalidaceae	*Oxalis depressa*						*					*	*												
Oxalidaceae	*Oxalis obliquifolia*						*					*								*	*				
Oxalidaceae	*Oxalis species*																								*
Poaceae	*Panicum coloratum*						*					*							*						
Poaceae	*Panicum coloratum var coloratum*																								*
Poaceae	*Panicum dregeanum*						*					*													
Poaceae	*Panicum maximum*																		*						
Poaceae	*Panicum natalense*																				*				*
Poaceae	*Panicum repens*																				*				
Poaceae	*Panicum repentellum*																				*				
Poaceae	*Panicum schinzii*						*														*			*	
Poaceae	*Panicum species*																				*				
Poaceae	*Panicum subalbidum*																							*	
Poaceae	*Paspalum dilatatum*		Y		*		*				*	*	*						*		*	*		*	*
Poaceae	*Paspalum distichum*						*					*							*		*			*	
Poaceae	*Paspalum notatum*		Y																		*				*
Poaceae	*Paspalum scrobiculatum*											*									*				*
Poaceae	*Paspalum urvillei*		Y		*		*					*	*						*	*	*				*
Poaceae	*Pelaea claomelanos var calomelanos*																								
Geraniaceae	*Pelargonium luridum*						*					*	*	*					*	*	*	*			*
Geraniaceae	*Pelargonium minimum*																				*				
Poaceae	*Pennisetum clandestinum*		Y																		*			*	*
Poaceae	*Pennisetum setaceum*		Y		*																				
Poaceae	*Pennisetum sphacelatum*											*									*				*
Poaceae	*Pennisetum thunbergii*											*	*									*			
Rubiaceae	*Pentanisia angustifolia*						*					*									*				
Poaceae	*Perotis patens*																				*				

Polygonaceae	*Persicaria attenuata*											*													
Polygonaceae	*Persicaria attenuata ssp africana*											*													
Polygonaceae	*Persicaria decipiens*						*					*									*				
Polygonaceae	*Persicaria hystricula*																				*				
Polygonaceae	*Persicaria lapathifolia*		Y		*		*				*	*	*						*	*	*	*		*	*
Polygonaceae	*Persicaria salicifolium*						*					*								*	*			*	
Apiaceae	*Peucedanum magalismontanum*																				*				
Poaceae	*Phragmites australis*				*		*					*	*								*			*	*
Apiaceae	*Pimpinella transvaalensis*											*													
Pittosporaceae	*Plantago lanceolata*						*					*		*						*	*	*		*	*
Pittosporaceae	*Plantago longissima*											*													
Pittosporaceae	*Plantago major*													*					*						*
Pittosporaceae	*Plantago virginica*		Y				*					*								*				*	
Poaceae	*Poa annua*		Y																*						
Poaceae	*Pogonarthria squarrosa*																				*				
Caryophyllaceae	*Pollichia campestris*												*								*				
Polygalaceae	*Polygala hottentotta*											*	*												*
Polygonaceae	*Polygonum species*																				*				
Salicaceae	*Populus species*		Y									*													
Portulacaceae	*Portulaca oleracea*		Y										*						*		*	*		*	*
Portulacaceae	*Portulaca quadrifida*																		*						
Potamogetonaceae	*Potamogeton pectinatus*																				*			*	
Potamogetonaceae	*Potamogeton schweinfurthii*						*																		*
Potamogetonaceae	*Potamogeton thunbergii*											*									*				
Molluginaceae	*Psammotropha myriantha*																								*
Asteraceae	*Pseudognaphalium luteo-album*											*								*	*			*	*

Asteraceae	*Pseudognaphalium undulatum*																				*			*	
Dennsteadtiaceae	*Pteridium aquilinum*											*													*
Poaceae	*Puccinellia species*																				*				
Cyperaceae	*Pycreus cooperi*																				*				
Cyperaceae	*Pycreus macranthus*											*								*	*				
Cyperaceae	*Pycreus nitidus*																								*
Cyperaceae	*Pycreus rehmannianus*																				*				
Rubiaceae	*Pygmaeothamnus pygmaeum*																				*				
Rubiaceae	*Pygmaeothamnus zeyheri*																				*				
Ranunculaceae	*Ranunculus meyeri*											*									*				
Ranunculaceae	*Ranunculus multifidus*						*					*								*	*				
Anacardiaceae	*Rhus dentata*						*																		*
Anacardiaceae	*Rhus gerrardii*						*					*													
Anacardiaceae	*Rhus lancea*											*													
Anacardiaceae	*Rhus leptodictya*																								*
Anacardiaceae	*Rhus pyroides*																		*						
Anacardiaceae	*Rhus pyroides var pyroides*											*													
Anacardiaceae	*Rhus rigida*						*																		*
Fabaceae	*Rhynchosia caribaea*						*																		*
Fabaceae	*Rhynchosia minima*																				*				
Fabaceae	*Rhynchosia monophylla*												*						*			*			
Exotic plant species	*Richardia brasiliensis*																				*				*
Exotic plant species	*Richardia humistrata*																				*				*
Apocynaceae	*Riocreuxia picta*						*																		*
Brassicaceae	*Rorippa nudiuscula*											*								*					
Rosaceae	*Rubus fruticosus*											*													

Polygonaceae	*Rumex acetosella subsp.angiocarpus*											*								*					
Polygonaceae	*Rumex crispus*		Y				*					*	*						*	*	*			*	*
Polygonaceae	*Rumex lanceolatus*						*					*								*					
Rutaceae	*Salix babylonica*		Y				*					*									*			*	*
Rutaceae	*Salix mucronata*						*																		
Chenopodiaceae	*Salsola kali*																				*			*	
Lamiaceae	*Salvia repens*												*						*			*			
Dipsacaceae	*Scabiosa columbaria*											*									*				*
Asteraceae	*Schistostephium crataegifolium*																				*				
Poaceae	*Schizachyrium jeffreysii*																				*				
Poaceae	*Schizachyrium sanguineum*						*						*						*						
Asteraceae	*Schkuhria pinnata*		Y									*									*			*	*
Cyperaceae	*Schoenoplectus brachyceras*																			*	*				
Cyperaceae	*Schoenoplectus corymbosus*						*					*									*				*
Cyperaceae	*Schoenoplectus decipiens*						*					*								*	*				
Cyperaceae	*Schoenoplectus muriculatus*											*								*					
Cyperaceae	*Schoenoplectus paludicola*																				*				
Cyperaceae	*Schoenoplectus tabernaemontani*		Y																		*				
Cyperaceae	*Schoenoplectus triqueter*		Y																		*				
Cyperaceae	*Scirpoides burkei*											*								*	*				*
Cyperaceae	*Scirpoides dioecus*																				*				
Cyperaceae	*Scirpus species*																				*				
Cyperaceae	*Scleria woodii*																			*					
Gentianaceae	*Sebaea grandis*											*									*				
Gentianaceae	*Sebeae leiostyla*																			*					

Convolvulaceae	*Seddera capensis*																				*				
Selaginellaceae	*Selaginella species*																								*
Scrophulariaceae	*Selago densiflora*						*					*									*				
Asteraceae	*Senecio achilleifolius*																								*
Asteraceae	*Senecio apiifolius*																				*			*	
Asteraceae	*Senecio burchellii*																				*				
Asteraceae	*Senecio coronatus*																				*				
Asteraceae	*Senecio erubescens*											*													
Asteraceae	*Senecio erubescens var.crepidifolius*																			*					
Asteraceae	*Senecio harveianus*																				*				
Asteraceae	*Senecio inaequidens*											*								*	*			*	
Asteraceae	*Senecio inornatus*						*					*									*			*	*
Asteraceae	*Senecio othonniflorus*																				*				
Asteraceae	*Senecio polyodon var.polyodon*											*								*					
Asteraceae	*Senecio serratuloides*																								*
Asteraceae	*Senecio species*																								*
Asteraceae	*Senecio venosus*											*													*
Fabaceae	*Sesbania punicea*		Y				*					*	*												
Poaceae	*Setaria incrassata*											*									*				
Poaceae	*Setaria nigrirostris*						*					*								*	*				*
Poaceae	*Setaria pumila*											*	*								*			*	
Poaceae	*Setaria sphacelata*											*									*	*			
Poaceae	*Setaria sphacelata var.sericea*						*					*	*							*	*				
Poaceae	*Setaria sphacelata var.sphacelata*				*		*					*	*						*		*	*			*
Poaceae	*Setaria verticillata*																				*				
Malvaceae	*Sida rhombifolia*											*													
Caryophyllaceae	*Silene bellidiodes*											*													
Asteraceae	*Silybum marianum*		Y																		*			*	*
Brassicaceae	*Sisymbrium thellungii*																				*				
Apiaceae	*Sium repandum*						*					*													

Solanaceae	*Solanum eleagnifolium*		Y																		*				
Solanaceae	*Solanum lichtensteinii*												*						*		*	*			
Solanaceae	*Solanum nigrum*		Y																		*				
Solanaceae	*Solanum panduriforme*												*								*	*			
Solanaceae	*Solanum sisymbriifolium*		Y																		*				*
Asteraceae	*Sonchus asper*		Y									*									*				
Asteraceae	*Sonchus species*																								*
Asteraceae	*Sonchus wilmsii*											*													
Caryophyllaceae	*Spergularia media*		Y																		*				
Poaceae	*Sporobolus africanus*						*				*	*	*						*			*			
Poaceae	*Sporobolus albicans*																				*				
Poaceae	*Sporobolus pyramidalis*																				*				
Lamiaceae	*Stachys hyssopoides*											*													
Lamiaceae	*Stachys natalensis*																				*				
Poaceae	*Stiburus alopecuroides*											*									*				*
Asteraceae	*Stoebe vulgaris*						*					*	*	*					*	*	*	*			*
Orobanchaceae	*Striga asiatica*																				*				
Asteraceae	*Tagetes minuta*		Y				*					*								*	*			*	*
Fabaceae	*Tephrosia capensis*											*									*				
Fabaceae	*Tephrosia longipes*											*													
Fabaceae	*Tephrosia lupinifolia*																				*				
Fabaceae	*Tephrosia multijuga*																				*				
Fabaceae	*Tephrosia polystachya*												*									*			
Fabaceae	*Tephrosia purpurea*																				*				
Poaceae	*Themeda triandra*						*				*	*	*	*					*	*	*	*			*
Asphodelaceae	*Trachyandra asperata*											*													
Asphodelaceae	*Trachyandra asperata var asperata*											*													

Asphodelaceae	*Trachyandra asperata var.nataglencoensis*																			*					
Asphodelaceae	*Trachyandra saltii*											*									*				
Poaceae	*Trachypogon spicatus*																				*				*
Asteraceae	*Tragopogon dubius*		Y									*													*
Poaceae	*Trichoneura grandiglumis*											*									*				
Fabaceae	*Trifolium africanum*																				*				
Fabaceae	*Trifolium pratense*		Y									*													*
Fabaceae	*Trifolium repens*		Y									*													*
Asteraceae	*Tripteris aghillana*											*													
Poaceae	*Triraphis andropogonoides*																				*				
Poaceae	*Tristachya leucothrix*												*								*				
Alismataceae	*Tulbaghia acutiloba*											*													
Typhaceae	*Typha capensis*				*		*					*	*						*	*	*	*		*	*
Poaceae	*Urelytrum agropyroides*											*									*				*
Poaceae	*Urochloa mosambicensis*																		*						
Poaceae	*Urochloa panicoides*											*									*				
Asteraceae	*Ursinia nana*												*						*			*			
Lentibulariaceae	*Utricularia gibba*																			*					
Lentibulariaceae	*Utricularia stellaris*																				*				
Rubiaceae	*Vangueria cyanescens*											*													
Verbenaceae	*Verbena bonariensis*						*				*	*	*	*					*	*	*	*		*	*
Verbenaceae	*Verbena brasiliensis*											*									*			*	*
Asteraceae	*Vernonia anogallis-aquatica*											*								*					
Asteraceae	*Vernonia galpinii*																				*				
Asteraceae	*Vernonia oligocephala*											*								*	*				*
Asteraceae	*Vernonia poskeana*																				*				
Asteraceae	*Vernonia poskeana*																								*

	ssp botswanica																								
Fabaceae	*Vigna vexillata*																				*				
Fabaceae	*Vigna vexillata var angustifolia*											*													
Campanulaceae	*Wahlenbergia buseriana*																							*	
Campanulaceae	*Wahlenbergia denticulata*																				*				
Campanulaceae	*Wahlenbergia undulata*						*					*									*			*	*
Asteraceae	*Xanthium spinosum*		Y																		*			*	*
Asteraceae	*Xanthium strumarium*		Y																		*			*	*
Xyridaceae	*Xyris capensis*											*													*
Apocynaceae	*Xysmalobium undulatum*																				*				
Araceae	*Zantedeschia albomaculata*												*						*						
Rhamnaceae	*Ziziphus mucronata ssp mucronata*											*													
Rhamnaceae	*Ziziphus zeyheriana*											*									*				
Fabaceae	*Zornia capensis*																				*				

Addendum B – Mammal species list

				Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
Group	**Species name**	**Common name**	**Red Data**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dams & Weirs	Other	Unspecified
Carnivora	*Aonyx capensis*	Cape Clawless Otter		X	X							X						X	X				X	X	
Insectivora	*Atelerix frontalis*	South African Hedgehog	NT																						X
Carnivora	*Atilax paludinosus*	Water Mongoose		X	X	X		X	X	X	X	X						X	X	X	X		X	X	
Carnivora	*Canis mesomelas*	Black-backed jackal																							X
Carnivora	*Caracal caracal*	Caracal																							X
Insectivora	*Chrysospalax villosus*	Rough-haired golden mole	CrEn																						X
Insectivora	*Crocidura mariquensis*	Black or Swamp Musk Shrew	DD	X	X	X		X	X	X	X	X	X	X	X	X		X		?	X		X		
Rodentia	*Cryptomys hottentotus*	Common mole-rat		X									X	X	X	X					X				

Carnivora	*Cynictis penicillata*	Yellow mongoose					X					X	X	X	X	X					X				X
Rodentia	*Dasymys incomtus*	Water Rat	NT	X	X	X		X	X														X		
Carnivora	*Felis nigripes*	Small spotted cat / Blach-footed Cat																							X
Carnivora	*Felis silvestris*	African Wild Cat																							X
Carnivora	*Galerella sanguinea*	Slender mongoose																							X
Carnivora	*Hyaena brunnea*	Brown hyaena	NT																						X
Rodentia	*Hystrix africaeaustralis*	Cape Porcupine																							X
Lagomorpha	*Lepus saxatilis*	Scrub hare																							X
Carnivora	*Lutra maculicollis*	Spotted-necked Otter	NT	X	X							X									X		X		
Rodentia	*Mastomys coucha*	Multimammate mouse																							X
Carnivora	*Mellivora capensis*	Honey badger	NT																						X
Rodentia	*Mystromys albicaudata*	White-tailed Rat	En																						X
Tubulidentata	*Orycteropus afer*	Antbear / Aardvark																							X
Rodentia	*Otomys irroratus*	Vlei Rat		X	X	X		X	X	X								X					X		
Rodentia	*Otomys angoniensis*	Angoni vlei rat										X													
Artiodactyla	*Ourebia ourebei*	Oribi	En																						X
Carnivora	*Proteles cristatus*	Aardwolf																							X
Artiodactyla	*Raphicerus campestris*	Steenbok																							X
Rodentia	*Rhabdomys pumilio*	Striped mouse																							X

Insectivora	*Suncus infinitesimus*	Least Dwarf Shrew	DD																						X
Artiodactyla	*Sylvicapra grimmia*	Common duiker																							X
Rodentia	*Tatera brantsii*	Highveld gerbil																							X
Rodentia	*Thryonomys swinderianus*	Greater Cane Rat		X	X			X	X																
Carnivora	*Vulpes chama*	Cape fox																							X

Addendum C – Bird species list

					Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
New species name (Group)	**Old species name**	**New common name**	**Old common name**	**Red Data**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dams & Weirs	Other	Unspecified
** Phoenicopterus ruber*			Greater Flamingo	V																		X		X	X	
**Alcedo semitorquata*			Halfcollared Kingfisher	NT				X																		
**Phoenicopterus minor*			Lesser Flamingo	V																		X				
**Rostratula benghalensis*		Greater Painted-snipe	Painted Snipe	NT									X													
Accipiter melanoleucus			Black Sparrowhawk																							X
Acridotheres tristis		Common Myna	Indian Mynah																							X
Acrocephalus arundinaceus		Great Reed-Warbler	Great Reed Warbler					X					X									X		X	X	
Acrocephalus baeticatus		African Reed-Warbler	African Marsh Warbler					X					X									X		X	X	
Acrocephalus gracilirostris		Lesser Swamp-Warbler	Cape Reed Warbler										X									X		X	X	
Acrocephalus palustris		Marsh Warbler	European Marsh Warbler					X					X									X				
Acrocephalus schoenobaeus		Sedge Warbler	European Sedge Warbler					X					X									X				

Actitis hypoleucos			Common Sandpiper					X																X	X	
Actophilornis africanus			African Jacana																					X	X	
Alcedo cristata			Malachite Kingfisher					X					X											X	X	
Alopochen aegyptiaca	*Alopochen aegyptiacu s*		Egyptian Goose					X					X									X		X	X	
Amadina erythrocephala		Red-headed Finch	Redheaded Finch																							X
Amaurornis flavirostis			Black Crake										X									X		X	X	
Anas capensis			Cape Teal										X									X		X	X	
Anas erythrorhyncha			Redbilled Teal										X									X		X	X	
Anas hottentota			Hottentot Teal										X									X		X	X	
Anas smithii		Cape Shoveler	Cape Shoveller										X									X		X	X	
Anas sparsa			African Black Duck																					X	X	
Anas undulata		Yellow-billed Duck	Yellowbilled Duck					X					X									X		X	X	
Anhinga rufa		African Darter	Darter										X									X		X	X	
Anthropoides paradiseus			Blue Crane	V																						X
Anthus chloris	*Hemimacr onyx chloris*	Yellow-breasted Pipit	Yellowbreasted Pipit	V																						X
Anthus cinnamomeus		African Pipit	Grasveld (Richard's) Pipit																							X
Anthus similis		Long-billed Pipit	Longbilled Pipit																							X
Apus affinis			Little Swift																							X
Apus caffer		White-rumped Swift	Whiterumped Swift					X					X									X		X	X	
Apus horus			Horus Swift																							X
Ardea cinerea			Grey Heron										X									X		X	X	
Ardea goliath			Goliath Heron																					X	X	

Ardea melanocephala			Blackheaded Heron										X									X		X	X	
Ardea purpurea			Purple Heron										X					X				X		X	X	
Ardeola ralloides			Squacco Heron																					X	X	
Asio capensis			Marsh Owl					X					X					X				X		X	X	
Balearica regulorum		Grey Crowned Crane	Crowned Crane																							
Batis molitor			Chinspot Batis																							X
Bostrychia hagedash			Hadeda Ibis					X					X									X		X	X	
Botaurus stellaris		Eurasian Bittern	Bittern	CrEn																						X
Bradypterus baboecala		Little Rush-Warbler	African Sedge Warbler					X					X									X		X	X	
Bubo africanus		Spotted Eagle-Owl	Spotted Eagle Owl																							X
Bubulcus ibis			Cattle Egret					X					X									X		X	X	
Bugeranus carunculatus	*Grus carunculatus*		Wattled Crane	CrEn																						X
Burhinus capensis		Spotted Thick-knee	Spotted Dikkop										X													
Buteo rufofuscus			Jackal Buzzard																							X
Buteo vulpinus	*Buteo buteo*		Steppe Buzzard																							X
Butorides striata	*Butorides striatus*		Greenbacked Heron																							
Calandrella cinerea			Redcapped Lark																							X
Calendulauda sabota	*Mirafra sabota*		Sabota Lark					X														X		X	X	
Calidris ferruginea			Curlew Sandpiper																					X	X	
Calidris minuta			Little Stint																			X		X	X	
Casmerodius albus			Great White Heron										X											X	X	
Cercomela familiaris			Familiar Chat																							X

Ceryle rudis			Pied Kingfisher					X					X									X		X	X	
Chalcomitra amethystina	*Nectarinia amethystin a*	Amethyst Sunbird	Black Sunbird																							X
Charadrius hiaticula		Common Ringed Plover	Ringed Plover																							
Charadrius pecuarius			Kittlitz's Plover																			X		X	X	
Charadrius tricollaris		Three-banded Plover	Threebanded Plover										X									X		X	X	
Chersomanes albofasciata		Spike-heeled Lark	Spikeheeled Lark																							X
Chlidonias hybrida			Whiskered Tern																			X		X	X	
Chlidonias leucopterus		White-winged Tern	Whitewinged Tern																					X	X	
Chrysococcyx caprius		Diderick Cuckoo	Diederick Cuckoo																							X
Ciconia abdimii			Abdim's Stork																							
Ciconia Ciconia			White Stork																			X		X	X	
Ciconia nigra			Black Stork	NT																						
Circus ranivorus		African March-Harrier	African Marsh Harrier	V									X													
Cisticola aridulus	*Cisticola aridula*		Desert Cisticola																			X		X	X	
Cisticola ayresii		Wing-snapping Cisticola	Ayres' Cisticola					X														X		X	X	
Cisticola fulvicapilla			Neddicky										X									X		X	X	
Cisticola juncidis		Zitting Cisticola	Fantailed Cisticola					X					X					X				X		X	X	
Cisticola lais			Wailing Cisticola					X					X													
Cisticola textrix			Cloud Cisticola																							X
Cisticola tinniens			Levaillant's Cisticola					X					X					X				X		X	X	
Colius striatus			Speckled Mousebird																							X

Columba guinea	*Columbus arquatrix*	Speckled Pigeon	Rock Pigeon										X									X		X	X	
Columba livia		Rock Dove	Feral Pigeon																							X
Coracias garrulus			European Roller																							X
Corvus albus			Pied Crow																							X
Corvus capensis		Cape Crow	Black Crow																							X
Cossypha caffra		Cape Robin-Chat	Cape Robin																							X
Coturnix coturnix			Common Quail																							X
Crithagra atrogularis	*Serinus atrogularis*		Blackthroated Canary																			X		X	X	
Crithagra gularis	*Serinus gularis*	Streaky-headed Seedeater	Streakyheaded Canary																							X
Crithagra mozambicus	*Serinus mozambicus*	Yellow-fronted Canary	Yelloweyed Canary																							X
Cuculus clamosus			Black Cuckoo																							X
Cuculus solitarius			Redchested Cuckoo																							X
Delichon urbicum	*Delichon urbica*	Common House-Martin	House Martin																							X
Dendrocygna bicolor			Fulvous Duck																			X		X	X	
Dendrocygna viduata		White-faced Duck	Whitefaced Duck																					X	X	
Dicrurus adsimilis			Forktailed Drongo																							X
Egretta alba		Great Egret	Great White Egret																							X
Egretta ardesiaca		Black Heron	Black Egret																					X	X	
Egretta garzetta			Little Egret					X					X											X	X	
Egretta intermedia		Yellow-billed Egret	Yellowbilled Egret					X					X									X		X	X	
Elanus caeruleus			Blackshouldered Kite					X					X									X		X	X	
Eremopterix leucotis		Chestnut-backed Sparrowlark	Chestnutbacked Finchlark																							X

Eremopterix verticalis		Grey-backed Sparrowlark	Greybacked Finchlark																							X
Estrilda astrild			Common Waxbill					X					X									X		X	X	
Euplectes afer		Yellow-crowned Bishop	Golden Bishop					X					X													
Euplectes albonotatus		White-winged Widowbird	Whitewinged Widow																							X
Euplectes axillaris		Fan-tailed Widowbird	Redshouldered Widow																							X
Euplectes orix		Southern Red Bishop	Red Bishop					X					X									X		X	X	
Euplectes progne		Long-tailed Widowbird	Longtailed Widow					X					X					X				X		X	X	
Falco amurensis		Amur Falcon	Redfooted Kestrel																							X
Falco naumanni			Lesser Kestrel	V																						X
Falco peregrinus			Peregrine Falcon	NT																						X
Falco rupicoloides			Greater Kestrel																							X
Falco rupicolus	*Falco tinnunculus*		Rock Kestrel																							X
Fulica cristata		Red-knobbed Coot	Redknobbed Coot					X					X									X		X	X	
Gallinago nigripennis		African Snipe	Ethiopian Snipe					X					X					X				X		X	X	
Gallinula chloropus		Common Moorhen	Moorhen										X									X		X	X	
Geronticus calvus		Southern Bald Ibis	Bald Ibis	V																						
Glareola nordmanni			Blackwinged Pratincole	NT									X									X				
Gyps coprotheres			Cape Vulture	V																						X
Haliaeetus vocifer		African Fish-Eagle	African Fish Eagle																					X	X	
Himantopus himantopus			Blackwinged Stilt										X									X		X	X	
Hirundo albigularis		White-throated Swallow	Whitethroated Swallow					X					X									X		X	X	

Hirundo cucullata			Greater Striped Swallow					X					X					X				X		X	X	
Hirundo dimidiata			Pearl Breasted Swallow					X																		
Hirundo fuligula			Rock Martin										X									X		X	X	
Hirundo rustica		Barn Swallow	European Swallow					X					X					X				X		X	X	
Hirundo spilodera		South African Cliff-Swallow	South African Cliff Swallow																							X
Ispidina picta		African Pygmy-Kingfisher	Pygmy Kingfisher					X																		
Ixobrychus minutus			Little Bittern										X									X		X	X	
Jynx ruficollis		Red-throated Wryneck	Redthroated Wryneck																							X
Laniarius ferrugineus			Southern Boubou																							X
Lanius collaris		Common Fiscal	Fiscal Shrike					X					X					X				X		X	X	
Lanius collurio		Red-backed Shrike	Redbacked Shrike										X									X		X	X	
Lanius minor			Lesser Grey Shrike																							X
Larus cirrocephalus			Greyheaded Gull										X									X		X	X	
Macronyx capensis		Cape Longclaw	Orangethroated Longclaw					X					X					X				X		X	X	
Megaceryle maximus	*Megaceryle maxima*		Giant Kingfisher					X					X									X		X	X	
Mirafra africana		Rufous-naped Lark	Rufousnaped Lark																							X
Mirafra apiata		Cape Clapper Lark	Clapper Lark																							X
Motacilla capensis			Cape Wagtail					X					X					X				X		X	X	
Motacilla flava			Yellow Wagtail																			X		X	X	
Mycteria ibis		Yellow-billed Stork	Yellowbilled Stork	NT																				X	X	
Myrmecocichla formicivora			Anteating Chat					X					X									X		X	X	

Netta erythrophthalma			Southern Pochard										X									X		X	X	
Numida meleagris			Helmeted Guineafowl					X					X					X				X		X	X	
Nycticorax nycticorax		Black-crowned Night-Heron	Blackcrowned Night Heron										X									X		X	X	
Oena capensis			Namaqua Dove					X					X					X								
Oenanthe monticola		Mountain Wheatear	Mountain Chat																							X
Oenanthe pileata			Capped Wheatear																							X
Ortygospiza atricollis		African Quailfinch	Quail Finch										X									X		X	X	
Oxyura maccoa			Maccoa Duck																							
Pandion halieatus			Osprey																					X	X	
Passer diffusus		Southern Grey-headed Sparrow	Greyheaded Sparrow																							X
Passer domesticus			House Sparrow										X													X
Passer melanurus			Cape Sparrow										X									X		X	X	
Phalacrocorax africanus			Reed Cormorant					X					X									X		X	X	
Phalacrocorax lucidus	*Phalacrocorax carbo*	White-breasted Cormorant	Whitebreasted Cormorant										X									X		X	X	
Philomachus pugnax			Ruff																			X		X	X	X
Phoeniculus purpureus		Green Wood-Hoopoe	Redbilled Woodhoopoe										X									X		X	X	
Platalea alba			African Spoonbill										X									X		X	X	
Plectropterus gambensis			Spurwinged Goose					X					X									X		X	X	X
Plegadis falcinellus			Glossy Ibis																			X		X	X	
Ploceus capensis			Cape Weaver																							X
Ploceus velatus		Southern Masked-Weaver	Masked Weaver					X					X									X		X	X	

Podica senegalensis			African Finfoot	V																						
Podiceps cristatus			Great Crested Grebe																					X	X	
Podiceps nigricollis			Blacknecked Grebe																							
Pogoniulus chrysoconus		Yellow-fronted Tinkerbird	Yellowfooted Tinker Barbet																							X
Polemaetus bellicosus			Martial Eagle	V																						X
Porphyrio madagascariensis	*Porphyrio porphyrio*	African Purple Swamphen	Purple Gallinule										X					X				X		X	X	
Prinia flavicans		Black-chested Prinia	Blackchested Prinia																							X
Pternistis swainsonii	*Francolinus swainsonii*	Swainson's Spurfowl	Swainson's Francolin										X									X		X	X	
Pycnonotus tricolor	*Pycnonotus barbatus*	Dark-capped Bulbul	Blackeyed Bulbul										X									X		X	X	
Quelea quelea			Redbilled Quelea																							X
Rallus caerulescens			African Rail										X									X		X	X	
Recurvirostra avosetta		Pied Avocet	Avocet										X									X		X	X	
Riparia cincta			Banded Martin										X									X		X	X	
Riparia paludicola			Brown Throated Martin					X					X									X		X	X	
Sagittarius serpentarius			Secretary Bird	NT																						X
Sarkidiornis melanotos		Comb Duck	Knobbilled Duck																					X	X	
Sarothrura rufa			Redchested Flufftail																							
Saxicola torquatus		African Stonechat	Stonechat					X					X					X				X		X	X	
Scopus umbretta			Hamerkop					X					X									X		X	X	
Sigelus silens			Fiscal Flycatcher										X									X		X	X	
Spermestes cucullatus			Bronze Mannikin																							X

Spizocorys conirostris			Pinkbilled Lark																							X
Spizocorys fringillaris			Botha's Lark	En																						X
Sporaeginthus subflavus			Orangebreasted Waxbill					X					X									X		X	X	
Spreo bicolor			Pied Starling										X									X		X	X	
Stenostira scita			Fairy Flycatcher																							X
Sterna caspia	*Hydroprogne caspia*		Caspian Tern	NT									X											X	X	
Streptopelia capicola		Cape Turtle-Dove	Cape Turtle Dove										X									X		X	X	
Streptopelia semitorquata			Redeyed Dove					X					X									X		X	X	
Streptopelia senegalensis			Laughing Dove					X					X									X		X	X	
Struthio camelus		Common Ostrich	Ostrich																							X
Tachybaptus ruficollis		Little Grebe	Dabchick										X									X		X	X	
Tadorna cana			South African Shelduck																							
Tadorna cana			South African Shelduck																							X
Tchagra senegalus		Black-crowned Tchagra	Blackcrowned Tchagra																			X		X	X	
Telophorus zeylonus			Bokmakierie										X									X		X	X	
Thalassornis leuconotus		White-backed Duck	Whitebacked Duck																							
Threskiornis aethiopicus		African Sacred Ibis	Sacred Ibis										X									X		X	X	
Trachyphonus vaillantii			Crested Barbet																							X
Tricholaema leucomelas		Acacia Pied Barbet	Pied Barbet																							X
Tringa glareola			Wood Sandpiper										X									X		X	X	
Tringa nebularia		Common Greenshank	Greenshank																					X	X	
Tringa stagnatilis			Marsh Sandpiper																					X	X	

Turdus olivaceus			Olive Thrush																							X
Turnix hottentottus		Hottentot Buttonquail	Black-rumped Buttonquail	En																						X
Tyto alba			Barn Owl																							X
Tyto capensis		African Grass-Owl	Grass Owl	V				X					X					X				X				
Upupa africana	*Upupa epops*	African Hoopoe	Hoopoe																							X
Uraeginthus angolensis			Blue Waxbill										X									X		X	X	
Urocolius indicus	*Colius indicus*		Redfaced Mousebird										X									X		X	X	
Vanellus armatus		Blacksmith Lapwing	Blacksmith Plover					X					X									X		X	X	
Vanellus coronatus		Crowned Lapwing	Crowned Plover										X									X		X	X	
Vanellus senegallus		African Wattled Lapwing	Wattled Plover										X					X				X		X	X	
Vidua macroura			Pintailed Whydah					X					X					X				X		X	X	
Vidua paradisaea		Long-tailed Paradise-Whydah	Paradise Whydah																							X

Addendum D – Reptile species list

			Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
Family	**Species name**	**Common name**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dams & Weirs	Other	Unspecified
Scincidae	*Acontias g. gracilicauda*	Slender-tailed Legless Skink	X	X			X	X		X											X			
Varanidae	*Varanus niloticus*	Water Monitor	X	X			X	X														X		
Atractaspididae	*Aparallactus capensis*	Cape centipede eater																						X
Viperidae	*Bitis arietans*	Puff adder																						X
Cordylidae	*Cordylus giganteus*	Giant girdled lizard or sungazer																						X
Elapidae	*Hemachatus haemachatus*	Rinkhals	X	X			X	X	X	X						X	X	X	X		X	X		
Elapidae	*Homoroselaps dorsalis*	Striped harlequin snake																						X
Colubridae	*Lamprophis aurora*	Aurora House Snake	X	X			X	X															X	
Colubridae	*Lamprophis fuscus*	Yellowbellied house snake																						X
Colubridae	*Lycodonomorphus rufulus*	Brown Water Snake	X	X	X		X	X		X							X					X	X	

Elapidae	*Naja haje*	Egyptian cobra								X	X								
Elapidae	*Naja nivea*	Cape cobra																	X
Pelomedusidae	*Pelomedusa subrufa*	Cape Terrapin	X	X		X	X	X	X			X	X	x			X	X	
Pelomedusidae	*Pelomedusa subrufa*	Cape terrapin								X					X				
Colubridae	*Philothamnus hoplogaster*	Green Water Snake	X	X	X	X	X		X								X	X	
Colubridae	*Psammophylax r. rhombeatus*	Spotted Skaapsteker	X	X		X	X	X	X		X	X	X	X		X	X	X	
Gerrhosauridae	*Tetradactylus breyeri*	Breyer's longtailed seps																	X
Colubridae	*Crotaphopeltis hotamboeia*	Herald or Red-lipped snake																	X

Addendum E – Amphibians species list

				Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
Group	**Species name**	**Common name**	**Red Data**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dams & Weirs	Other	Unspecified
Pipidae	*Xenopus l. laevis*	Common Clawed Frog		X	X			X	X	X	X							X			X		X	X	
Bufonidae	*Bufo gutturalis*	Gutteral Toad					X	X	X	X	X						X	X	X	X			X	X	
	Bufo maculatus	Flat-backed Toad						X	X	X	X														
	Bufo rangeri	Raucous Toad						X	X	X	X												X	X	
	Schismaderma carens	Red Toad						X	X	X	X												X	X	
	Schismaderma carens	Red-backed Toad																							X
Ranidae	*Pyxicephalus a. adspersus*	Highveld Bullfrog/ Giant bullfrog	NT					X	X	X	X							X	X	X	X		X	X	
	Tomopterna cryptotis	Tremolo Sand Frog						X	X	X	X						X	X	X	X			X	X	
	Afrana angolensis	Common River Frog		X	X			X	X														X	X	
	Afrana fuscigula	Cape River Frog		X	X			X	X															X	
	Strongylopus f. fasciatus	Striped Stream Frog						X	X	X	X		X	X	X	X		X			X		X	X	
	Ptychadena porosissima	Striped Grass Frog										X	X	X	X	X		X			X				
	Phrynobatrachus	Common/ Snoring						X	X	X	X							X	X	X			X	X	

	natalensis	Puddle Frog																							
	Cacosternum boettgeri	Common Caco				X	X	X	X	X	X		X	X	X	X		X	X	X			X	X	
	Kassina senegalensis	Bubbling Kassina					X	X	X	X	X						X	X	X	X			X	X	
	Kassina (Semnodactylus) wealii	Rattling Kassina/ frog						X	X	X	X							X	X	X			X	X	
	Strongylopus fasciatus	Striped Stream Frog																							X

Addendum F – Fish species list

		Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
Species name	**Common name**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dams & Weirs	Other	Unspecified
Anguilla mossambica		?																			?	?	
Barbus anoplus	Chubby head barb	X				X	X				X										x		
Barbus neefi		X				X	X				X										x		
Barbus paludinosus	Straightfin barb	X				X	X				X										x		X
Barbus polylepis	Smallscale Yellowfish	X				X															x		X
Babus trimaculatus		X				X															X		X
Clarias gariepinus	Sharptooth catfish	X				X															X		
Pseudocrenilabrus philander	Southern mouthbrooder	X				X	X				X										X		X
Tilapia sparrmanii	Banded tilapia	X				X	X				X					X					X		X
Ctenopharyngodon idella																					X		
**Cyrpinus carpio*	carp	X				X										X					X		
**Gambusia affinis*	mosquito fish					X															X		
Micropterus salmoides		X				X										X					X		
Onchorhynchus mykiss																					X		

Austroglansis sclateri						X															X		
Barbus aeneus		X				X															X		
Labeo capensis		X				X															X		
Labeo umbratus		X				X															X		
Barbus pallidus	Goldie barb																						X
Amphilius uranoscopus																							X
Chiloglanis pretoriae																							X
Barbus argenteus																							X
Barbus marequensis																					X		
Brycinus imberi																					X		
Labeo cylindris																							X
Marcusenius macrolepidotus																					X		
Schilbe intermedius																					X		
Oreochromis mossambicus																					X		
Labeobarbus polylepis																							X
Micropterus dolomieu																							X

Addendum G – Invertebrate species list

				Non-floodplain riparian				Floodplain riparian					Hillslope seepage					Pans				Other	Artificial		
Phylum	**Group**	**Species name**	**Common name**	Drainage line with riparian zones	Channels riparian	Non-channelled riparian	Unspecified	Channeld valley bottom with footslope seepage	Valley bottom without footslope seepage	Non-channelled valley bottom	Temporary and seasonal channelled valley bottom	Unspecified	Footslope seepage	Midslope seepage	Valleyhead seepage	Crest seepage	Unspecified	Permanent	Non-permanent	Seepage wetlands associated with pans	Unspecified	Wet grassland	Dams & Weirs	Other	Unspecified
PORIFERA			**Sponges**																						
CNIDARIA	**Coelenterata**				?	?		X	X	X	X		?	?	?			X	X	X			X	X	
		Hydra sp																							
		Turbellaria		?	?	?		X	X	X	X		?	?	?	?		X	X	X			X	X	
PLATYHELMINTHES			**Flatworms**																						
NEMATODA			**Roundworms**	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	
		Actinolaimus hutchinsoni																							
		Haemonchus contortus																							
ANNELIDA			**Segmented Worms**					?			?							?	?				?		
	Oligochaeta		**Earthworms**	X	X	X		X	X	X	X		X	X	X	X		X	X	X			X	X	
		Tubificidae																							
		Branchiura sowerbyi																							
	Hirudinea		**Leeches**					?	?	?								X	X	X			X	X	
ECTOPROCTA/ BRYOZOA			**Moss anamalcules**		?	?		X	X	X	X		?	?	?	?		X	X	X			X	X	

		Plumatella sp																							
		Lophopodella capensis																							
ARTHROPODA	**Anostraca**		**Fairy shrimps**																X					?	
		Streptocephalus cafer																							
		Streptocephalus indistinctus																							
	Conchostraca		**Clam shrimps**																X					?	
		Cyzicus australis																							
	CRUSTACEA																								
	Ostracoda		**Seed shrimps**	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	
		Actocypris abtusa																							
		Chrissia levetzoti																							
		Cypria capensis																							
		Cypronotus congener																							
		Cyprodopsis mastigophora																							
		Heterocypris gunningi																							
		Limnocythere aethiopica																							
		Plesiocypridopsis chrissiensis																							
		Plesiocypridopsis inaequivalva																							
		Pseudocypris expansa																							
		Pseudocypris spinosa																							
		Sclecypris tuberculata																							
		Stenocypris pectinata																							

		Tanycypris obtusa																							
	Arachnida	*Hydrozetes* sp.																							
		Limnesia africana																							
		Neumania dura																							
		Piona coccinea																							
	Copepoda				?	?	?	?							X	X	X			X	X				
		Cyclops varicans																							
		Diaptomus spectabilis																							
		Eucyclops prasinus																							
		Euclops serralatus																							
		Levenula sp																							
		Lovenula excellens																							
		Lovenula falcifera																							
		Macrocyclops albidus																							
		Mesocyclops leuckarti																							
		Metadiaptomus tranvaalensis																							
		Thermodiaptomus mixtus																							
	Potamonidae		**Crabs**																						
		Simocephalus vetulus																							
		Simocephalus vetuloides																							
				X	X	X		X	X	X	X		?	?	?	?		X	X	X			X	X	
		Potamonautes sidneyi	Natal River Crab																						
		Potamonautes unispinus	Single spined river crab																						

	Atyidae		**Freshwater shrimps**		X			?	?	?	?														
	Caridina nilotica																								
	INSECTA																								
	Collembola		**Springtails**	X	X	X		X	X	X	X		X	X	X	X		X	X	X		X	X	X	
	Plecoptera		**Stoneflies**					?			?														
	Neuroptera	**Sisyridae**	**Sponge flies**					?			?														
		Sisyra producta																							
	Cladocera	**Chyodoridae**	**Waterfleas**		?	?	?	?						X	X	X			X	X					
		Alona sp.																							
		Alona guttata																							
		Alona intermedia																							
		Chydorus carolinae																							
		Chydorus gibsoni																							X
		Chydorus sphaericus																							
		Graptoleberis testudinaria																							
		Leydigia trispinosa																							
		Macrothricidae																							
		Macrothrix laticornis																							
		Moinidae																							
		Moina dubia																							
		Ostracoda																							
	Daphniidae																								
		Ceriodaphnia quadrangular																							
		Ceriodaphnia rigaudi																							
		Daphnia sp.																							
		Daphnia																							

		gibba																							
		Daphnia pulex																							
		Simocephalus capensis																							
		Simicephalus corniger																							
	Ephemero ptera		**Mayflies**																						
		Leptophlebii dae	**Prongills**					?			?														
		Choroterpes nigrescens																							
		Euthraulus sp.																							
		Euthraulus elegans																							
		Polymitarcyi dae	**Pale burrowers**					?			?							X	?				X		
		Povilla?adust a																							
		Caenidae	**Squaregills**	X	X	X		X	X	X	X		?	?	?	?		X	X	X			X	X	
		Tricorythidae	**Stout crawlers**					?			?														
		Dicercomyzon costale																							
		Tricorythus spp.																							
		Tricorythus discolor																							
		Prosopistom atidae	**Water specs**					?			?														
		Prosopistoma sp.																							
		Oligoneuriid ae	**Brushlegged mayflies**																						
		Elassoneuria sp																							
		Heptageniida e	**Flathead mayflies**																						
		Afronurus sp.																							
		Compsoneuri a njalensis																							
		Baetidae	**Small minnow**		X															X					

			mayflies																						
		Baetis harrisoni																							
		Centroptiloides bifasciata																							
		Cheleocloeon)Afroptilum) excisum																							
		Cloeon spp.																							
		Cloeon virgillae																							
		Demoulinia crassi (Centroptilum pulchrum)																							
		Potamocloeon macafetiorum																							
		Pseudocloeon gluacum (Baetis glaucus)																							
		Pseudopannata maculosa																							
	Odonata	**Zygoptera**	**Damselflies**																						
		Chlorestidae (Synlestidae)						X	?	?	X														
		Chlorolestes fasciata																							
		Chlorestes tessellata																							
		Lestidae		?	?	?		X	?	?	X		?	?	?			?	?	?			X	?	
		Lestes palida																							
		Lestes plagiata																							
		Lestes virgata																							
		Protoneuridae	**Threadtail damselflies**	?	?	?		X	X	X	X		?	?	?	?		?	?	?			?	?	
		Elattoneura glauca																							
		Platycnemididae						?			?														
		Coenagrionidae	**Pond damselflies**	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X		X	X	
		Ceriagrion glabrum																							
		Enallagma glaucum																							

		Ischnura senegalensis																							
		Pseuddgrion sp.																							
		Pseudagrion assegaii																							
		Pseudagrion kersteni																							
		Pseudagrion newtoni																							
		Pseudagrion salisburyense																							
		Pseudagrion vaalense																							
		Calopterygidae/ Agriidae	**Broadwinged damselflies**	?	?	?		?	?	?	?														
		Chlorocyphidae						?	?	?	?														
		Platycypha caligata																							
		Anispotera	**Dragonflies**																						
		Aeshnidae		?	X	?		X	X	X	X		?	?	?	?		X	X	X			X	X	
		Aeshna sp																							
		Anax imperator																							
		Anax sp																							
		Hemianax ephippiger																							
		Corduliidae	**Green-eyed skimmers**		X			?			?							X	?	X			X	X	
		Gomphidae	**Clubtails**					X			X							X	?	X			X	X	
		Ceratogomphus pictus																							
		Paragomphus cognatus																							
		Libelluliidae	**Skimmers**	?	X	?		X	X	X	X		?	?	?	?		X	X	X			X	X	
		Diplacodes lefebvrii																							
		Nesciothems farinosa																							
		Ortherum machadoi																							

		Orthetrum abbotti																							
		Orthetrum chrysostigma																							
		Orhtetrum icteromelas																							
		Orthetrum julia falsum																							
		Orhtetrum trinacria																							
		Palpopleura lucia																							
		Pantala flavescens																							
		Sympetrum fonscolombei																							
		Trithemis arteriosa																							
		Trithemis dorsalis																							
		Trithemis stictica																							
	Hemiptera		**Bugs**																						
	Heteroptera	**Notonectidae**	**Backswimmers**		X															X				X	
		Anisops sp.																							
		Anisops aglaia																							
		Nychia sp.																							
		Pleidae	**Pigmy back swimmers**	?	X															X				X	
		Plea pullula																							
		Naucoridae	**Creeping water bugs**	?																X					
		Nepidae	**Water scorpions**	?																X				X	
		Ranatra sp.																							
		Belostomatidae	**Giant water bugs**	?																				X	
		Sphaerodema sp.																							
		Corixidae	**Water boatmen**	X	X															X				X	

		Micronecta sp.																							
		Micronecta piccanin																							
		Micrinecta scutellaris																							
		Gerridae	**Water striders**		X																			X	
		Gerris sp.																							
		Hydrometridae	**Water measurers**	?																					
		Veliidae	**Broad-shouldered water striders**	?	X																				
		Rhagovelia sp.																							
	Trichoptera		**Caddisflies**																						
		Ecnomidae																							
		Ecnomus sp.																							
		Ecnopmus oppidanus																							
		Hydropsychidae	**Net-spinning caddisflies**																						
		Aethaloptera maxima																							
		Cheumatopsyche afra																							
		Cheumatopsyche thomasseti																							
		Cheumatopsyche near zuluensis																							
		Macrostemum sp.																							
		Macrostemum capense																							
		Hydroptilidae		?																					
		Hydroptyla sp.																							
		Hydroptila capensis																							

		Oxyethira velocipes																							
		Orthotrichia																							
		Leptoceridae	**Long-horned caddisflies**																						
		Athripsodes sp.																							
		Athripsodes harrisoni																							
		Leptocerus sp.																							
		Philopotamidae	**Finger-net caddisflies**																						
		Chimarra sp.																							
		Psychomyiidae	**Tube-net caddisflies**																						
	Lepidoptera		**Moths**																						
		Spialia paula																							
		Metisela meninx																						X	
		Gegenes hottentota																						X	
		Nymphulidae / Pyralidae		?																					
	Coleoptera		**Beetles**																						
		Dytiscidae	**Diving beetles**																					X	
		Laccophilus sp.																							
		Elmidae/Dryopidae	**Riffle beetles**																						
		Stenelmis thusa																							
		Gyrinidae	**Whirligig beetles**																	X					
		Aulonogyrus sp																							
		Haliplidae	**Crawling Water beetles**	X																					
		Noteridae	**Burrowing Water beetles**	X																					
		Helodidae	**Marsh beetles**	X																					

		Hydraenidae	**Minute Moss beetles**	X																					
		Hydrophilidae	**Water scavenger beetles**	X																X					
		Berosus sp.																							
		Psephenidae	**Water pennies**																						
	Diptera		**Flies**																						
		Tipulidae	**Crane flies**	?																					
		Dixidae	**Dixin midges**	?																					
		Dixa sp																							
		Chaoboridae	**Phantom midge**																				X		
		Chaoborus sp.																							
		Culicidae	**Mosquitoes**	X	X															X				X	
		Culicinae																							
		Anopheles sp.																							
		Ceratopogonidae	**Biting midges**	X																					
		Bezzia sp																							
		Culicoides magna																							
		Dsyhelea sp.																							
		Chironomidae	**Midges**	X	X															X				X	
		Tanypodinae																							
		Pentaneura sp																							
		Pentaneura dusoleili																							
		Orthocladiinae																							
		Corynoneura scotti																							
		Corynoneura sp.																							
		Cricotopus harrisoni																							

		Cricotopus obscurus																							
		Cricotopus sp.																							
		Limnophyes spinosa																							
		Metriocnemus																							
		Nanocladius scotti																							
		Smittia conigera																							
		Thienemanniella lineola																							
		Trichocladius capensis																							
		Chironominae																							
		Chironomus linearis																							
		Chironomus peringueyi																							
		Chironomus pulcher																							
		Chironomus sp																							
		Cricotopus sp.																							
		Cryptochironomus sp.																							
		Endochironomus disparilis																							
		Microtendipes																							
		Pentaneura sp																							
		Pentapedilum anale																							
		Rheotanytarsus sp.																							
		Tanytarsini																							
		Tanytarsus pallidus																							
		Xenochironomus ugandae																							
		Simuliidae	**Blackflies**		X																				

		Simulium adersi																							
		Simulium ?bequaerti																							
		Simulium damnosum																							
		Simulium dentulosum																							
		Simulium hargreavesi																							
		Simulium impukane																							
		Simulium mcmahoni																							
		Simulium nigritarse																							
		Simulium ruficorne																							
		Tabanidae	**Horse Flies**	?	X																				
		Tabanus sp.																							
		Athericidae/ Rhagionidae		?																					
		Empididae	**Dance Flies**	?																					
		Ephydridae	**Shore Flies**	?																					
		Muscidae		X																					
	Caenogast ropoda	**Thiaridae/ Melanidae**																							
	Hydrachne llidae		**Water mites**	X	X	X		X	X	X	X		X	X	X	X		X	X	X		X	X	X	
MOLLUSCA		*Melanoides sp.*																							
	Bassomat ophota	**Lymnaeidae**		?																					
		Lymnaea columella																							
		Lymnaea natalensis																							
		Lymnaea truncatula																							
		Ancylidae																							
		Burnupia sp.																							
		Ferrissia sp.																							

		Planorbidae		?	X																				
		Biomphalaria pfeifferi																							
		Bulinis reticulatus																							
		Bulinis tropicus																							
		Belinus depressus																							
		Bulinus forskalii																							
		Bulinus sp																							
		Ceratophallus natalensis																							
		Gyraulus connollyi																							
		Gyraulus costulatus																							
	Pulmonata	**Physidae**	**Pouch snails**	?																X					
		Physa acuta																							
	Eulamelleb ranchia	**Unionidae**																							
		Unio caffer																							
		Unio framesi																							
		Corbiculidae																							
		Corbicula sp																							X
		Corbicula astartina																							X
	Veneroida	**Sphaeriidae**		?																					X
		Pisidium spp.																							X
		Sphaerium capense																							X