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An evaluation of the wetlands on the Remainder of the Farm Boschhoek 3345, Newcastle, KwaZulu-Natal

April 2011

An evaluation of the wetlands on the Remainder of the Farm Boschhoek 3345, Newcastle, KwaZulu-Natal

by

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Commissioned by

LEAP Landscape Architect & Environmental Planner

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SUMMARY

General

A new development is planned for an area of about 202 ha on the Farm Boschhoek 3345 south of Newcastle. This report addresses the wetlands and potential ecological impact of the new development.

Wetland

The wetland areas are typical wetlands with wetland vegetation and wetland soil types. Two hydro-geomorpic types of wetland were identified, namely channelled valley bottom wetland as spruits and Hillslope seepage as wetlands. The Present Ecological Status (PES) score is B, indicating that the wetlands are in a good condition, largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place. The Ecological Importance and Sensitivity (EIS) score is C, indicating moderate importance and sensitivity. These are wetlands that are considered to be ecologically important and sensitive on a provincial or local scale.

Although most of the (terrestrial) area is suitable for development, the wetlands and spruits are protected by law and no development should take place within the 1:100 year flood line or within 32 m from the edge of the spruit or wetland. This is in line with the legal requirements for wetlands inside the urban edge. Although it is not realistic to exclude all activities from the buffer zone, it should still be considered as a sensitive feature of the landscape in which mitigation measures should be implemented.

DECLARATION OF INDEPENDENCE

I, George Johannes Bredenkamp, Id 4602105019086, declare that I:

- Am the owner of Eco-Agent CC, CK 95/37116/23
- Act as an independent specialist consultant in the field of ecology, vegetation science and botany
- Am assigned as specialist consultant by LEAP Landscape Architect & Environmental Planner for the proposed project “An evaluation of the wetlands on the Remainder of the Farm Boschhoek 3345, Newcastle, KwaZulu-Natal” described in this report
- I Do not have or will not have any financial interest in the undertaking of the activity other than remuneration for work performed
- Have or will not have any vested interest in the proposed activity proceeding
- Have no and will not engage in conflicting interests in the undertaking of the activity
- Undertake to disclose to the client and the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations 2006
- Will provide the client and competent authority with access to all information at my disposal, regarding this project, whether favourable or not.

GJ Bredenkamp

1. ASSIGNMENT

EcoAgent CC Ecology and Biodiversity Consultants was appointed by LEAP Landscape Architect & Environmental Planner to undertake an independent assessment of the wetlands of the site. In accordance with The Natural Scientific Professions Act (Act 27 of 2003) only a person registered with the Council may practice in a consulting capacity. Prof GJ Bredenkamp of EcoAgent CC undertook an independent assessment of the wetlands on the farm Boschhoek.3345, Newcastle, KwaZulu-Natal. A field survey was conducted on the 5th of March 2011.

This assignment is in accordance with the EIA Regulations (No. R. 385, Department of Environmental Affairs and Tourism, 21 April 2006) emanating from Part 5 of the National Environmental Management Act 1998 (Act No. 107 of 1998).

The terms of reference were as follows:

- Conclusively identify the presence or absence of wetland conditions as prescribed by the DWAF (2005) delineation guideline;
- Identify the outer edge of the wetland temporary zone, or edge of the riparian zone;
- Classify the wetland or riparian areas according to the system proposed in the national wetlands inventory if relevant,
- Indicate the relative functional importance of the wetland or riparian areas;
- Discuss wetland buffer zones;
- Indicate possible impacts on the wetland or riparian areas; and
- Recommend mitigation measures in order to limit the impact of the proposed development on the wetland or riparian areas.

Assumptions and Limitations

The GPS map 76CSx used for wetland and riparian delineations is accurate to within five meters. Therefore, the wetland and riparian delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries.

2. RATIONALE

It is widely recognised that it is of utmost importance to conserve natural resources in order to maintain ecological processes and life support systems for plants, animals and humans. To ensure that sustainable development takes place, it is therefore important that the environment is considered before relevant authorities approve any development. This led to legislation protecting the natural environment. The Environmental Conservation Act (Act 73 of 1989), the National Environmental Management Act, 1998 (NEMA) (Act 107 of 1998) and the National Environmental Management Biodiversity Act, 2004. (Act 10 0f 2004) ensure the protection of ecological processes, natural systems and natural beauty as well as the preservation of biotic diversity in the natural environment. It also ensures the protection of the environment against disturbance, deterioration, defacement or destruction as a result of man-made structures, installations, processes or products or human activities. A draft list of Threatened Ecosystems was published (Government Gazette 2009) as part of the National Environmental Management Biodiversity Act, 2004. (Act 10 0f 2004). These Threatened Ecosystems are described by SANBI & DEAT (2009).

All components of the ecosystems (physical environment, vegetation, animals) of a site are interrelated and interdependent. A holistic approach is therefore imperative to effectively include the development, utilisation and where necessary conservation of the given natural resources in an integrated development plan, which will address all the needs of the modern human population (Bredenkamp & Brown 2001).

Definitions and Legal Framework

In a South African legal context, the term watercourse is often used rather than the terms wetland, or river. The National Water Act (NWA) (1998) includes wetlands and rivers into the definition of the term watercourse in the following definition.

Watercourse means:

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows, and

- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

Riparian habitat is the accepted indicator used to delineate the extent of a river's footprint (DWAF, 2005). The National Water Act, 1998 (Act No. 36 of 1998), defines a riparian habitat as follows: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.".

In contrast, the National Water Act, 1998 (Act 36 of 1998) defines a wetland 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."

Authoritative legislation that lists impacts and activities on wetlands and riparian areas that requires authorisation includes (Armstrong, 2009):

- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983);
- Environment Conservation Act, 1989 (Act 73 of 1989);
- National Water Act, 1998 (Act 36 of 1998);
- National Forests Act, 1998 (Act 84 of 1998);
- National Environmental Management Act, 1998 (Act No. 107 of 1998);
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- GNR 1182 and 1183 of 5 September 1997, as amended (ECA);
- GNR 385, 386 and 387 of 21 April 2006 (NEMA);
- GNR 392, 393, 394 and 396 of 4 May 2007 (NEMA);
- GNR 398 of 24 March 2004 (NEMA); and
- GNR 544, 545 and 546 of 18 June 2010 (NEMA).

3. STUDY AREA

3.1 Location

The site is approximately 202 ha in size and is located south of the suburb Fairleigh and east of Boundary Road in Newcastle (Figure 1)

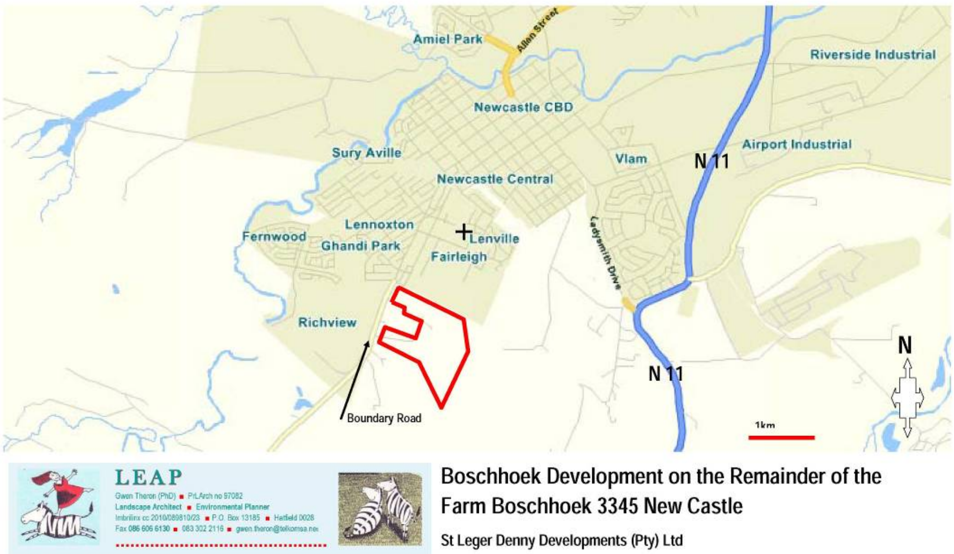


Figure 1: The locality of the site.

The following applies:

- The site does not fall within a conservancy.
- The site does not fall within a protected area.
- There are wetlands on the site.
- The site is topographically complex with ridges, valleys, plains and stream present.

3.2 Description of the Receiving Environment

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state.

The site falls within the Sub-Escarpment Grassland Bioregion of Mucina & Rutherford (2006) but is relatively complex topographically. It slopes and drains towards the town in the north, with two main dolerite ridges running approximately north-south across the site and two deeply incised streams running in the valleys between the ridges (Figure 2). There are also two wetlands draining down into the western stream. The temporary old, small man-made excavations or quarries at the south-western end of the study site are locally filled with water. Hygrophilous plant species that became established in these man-made ponds, which provide suitable habitat for many frog species, due to the absence of fish predation.

There was a clear division between the sandy, gravely slopes, with exposed rocks on the ridges and slopes, and the dark clay soils in the valley bottoms. There are at least four dwelling areas on the site (and more in the excised areas east of Boundary Road). There are signs of old croplands on the alluvial soils around the northern ends of the streams, but most of the site and surrounding habitats are natural grasslands that have been used for grazing livestock. There are also various other human impacts, such as small dams on the streams, vehicle tracks and foot paths, and a series of borrow pits in the elevated southwest corner. Woody vegetation is found mainly along the two ridges, mainly as scattered trees and bushes but forming dense clumps on the crest and western aspects of the ridges. Apart from a patch of alien wattle trees planted at the head of the more eastern stream, most of the areas have low alien infestation, except around the dwellings, including pine, syringe, eucalyptus, willow and mesquite trees.

Figure 2: Satellite image showing the location of the farm Boschhoek south of Newcastle, where residential development is proposed (purple polygon). The main features of ridges, streams and dwelling houses (H) are indicated.

3.3 Vegetation Types

The site is located directly south of Newcastle. The regional geology is dominated by Mudstone and shale of the Mid-Ecca Group of the Karoo Supergroup. The deep structureless soils of the plains are of the Avelon form while shallower soils on the ridges and rocky outcrops are of the Mispah or Glenrosa forms. The valley floors, especially the wetland soils are of the Katspruit or Rensburg forms.

The site is situated within the Natal Sour Sand Veld as described by Acocks (1988), but North-eastern Sandy Highveld is also prominent in the area. Low & Rebelo (1996) described the vegetation of the area as North Eastern Moist Grassland.

According to the most recent vegetation map of South Africa the vegetation on the study site is Low Escarpment Moist Grassland, though the site is close to the border of Northern KwaZulu-Natal Moist Grassland (Mucina & Rutherford, 2006). Within this vegetation type about 6% have been transformed by plantations or cultivated land and only 2% is statutorily conserved.

In general the area is covered by primary grassland, mainly dominated by *Hyparrhenia hirta,* but the rocky areas have an open shrubby component. Some areas were ploughed in the past and are now covered by *Hyparrhenia hirta.*

Wetlands, forming part of the drainage systems of two larger spruits, are prominent features of the landscape.

A surface water spatial layer reflected the presence of two perennial watercourses and two wetlands on the site (CDSM, 1996). The study site falls within Quartenary Catchment V31J. In this catchment, the ratios of Mean Annual Precipitation (MAP) to Potential Evapotranspiration (PET) is 0.441 (Table 1). This value indicates that wetlands lose more water through evapo-transpiration than they received through precipitation, unless they are associated with water input from river systems.

Table 1: Characteristics of Quaternary Catchment V31J relevant to the assessment of wetland health (Adapted from Schultze 1997)

Catchment	MAP (mm)	PET (mm)	Median Annual Simulated Runoff (mm)
V31J	832.6	1885.9	122.4

4. METHODS

The site was visited on 5 March 2011 by Prof GJ Bredenkamp accompanied by the EcoAgent team, including Dr IL Rautenbach (Mammologist), Dr A Kemp (ornithologist) and Mr JCP van Wyk (herpetologist).

The delineation method documented by the Department of Water affairs and Forestry in their document “A practical field procedure for identification and delineation of wetlands and riparian areas” (DWAF, 2005), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2009) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held GPSmap 76CSx was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary wetland boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey.

The vegetation descriptions were based on total floristic composition, following established vegetation survey techniques (Mueller-Dombois & Ellenberg 1974; Westhoff & Van der Maarel 1978). Data recorded included a list of the plant species present, including trees, shrubs, grasses and forbs, if present. Comprehensive species lists were therefore derived for each wetland plant community / ecosystem present on the site. These vegetation survey methods have been used as the basis of a national vegetation survey of South Africa (Mucina *et al*. 2000) and are considered to be an efficient method of describing vegetation and capturing species information. Notes were additionally made of any other features that might have an ecological influence.

5. RESULTS: VEGETATION AND FLORA

5.1 Wetland Delineation

Wetlands are identified based on the following characteristic attributes (DWAF, 2005):

- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

Several points were sampled during the course of the field investigation to determine compliance with the definition of wetland conditions. Details of vegetation and soil characteristics recorded are discussed below.

5.2 Vegetation Characteristics

EcoAgent described the vegetation and flora of the study site in a separate report (EcoAgent CC 2011).

Two different wetland plant communities / ecosystems were identified (Figure 3). They coincide with the hydro-geomorphic types.

1. Spruits
2. Wetland Drainage and Seepage Systems

Both these wetland communities were considered to have a high ecological sensitivity (Figure 4) (EcoAgent CC 2011).

Additionally, man-made quarries or borrow pits in the south-western corner of the site accumulated water, with resulting hygrophilous plant species and frog habitats. This is only briefly mentioned, as this is highly disturbed area.

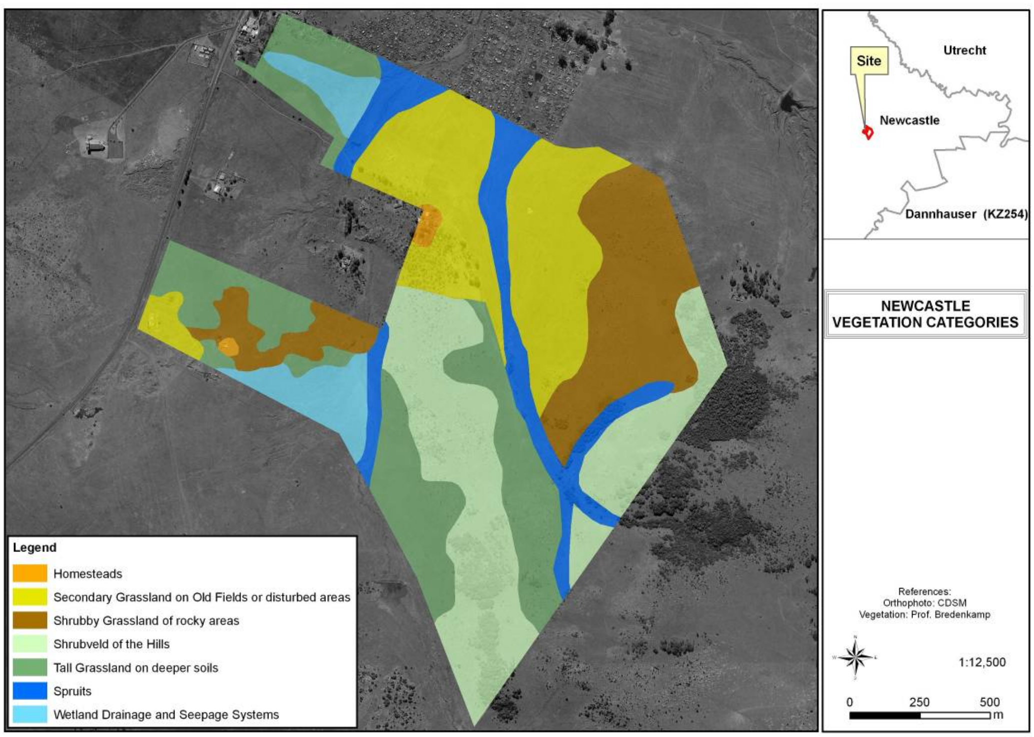


Figure 3: Vegetation map of the site (from EcoAgent 2011)

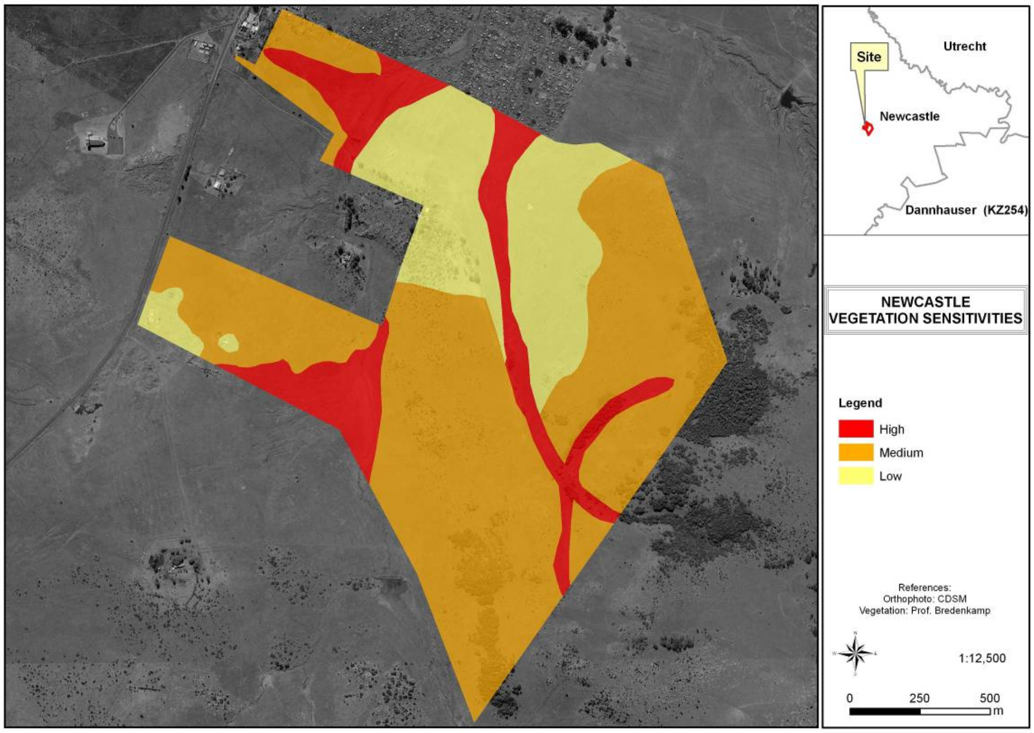


Figure 4: Sensitivity map of the site (from EcoAgent 2011)

5.2 Description of the Wetland Plant Communities

1. Spruits (Channelled valley bottom wetlands)

The two deeply incised streams run along the floor of the two valleys between the ridges and elevated edges of the site (Figures 5 & 6). At certain localities small dams occur in the streams (Figure 7). In their lower reaches, the streams spill out into temporary wetlands. The streams are fed by runoff from the surrounding valleys, including seepage from the southern edge of the site and from the valley sides. At the time of the survey both the major streams were strongly flowing, as a result of good rains during the season. The grassy vegetation on the banks was relatively tall with grassland species. Dense stands of *Typha capensis* (Figure 7) occur mainly in the dams, and with scattered sedges most prominent along the edge of the water. Very few, if any, woody species occur on the spruit banks, except for a few single plants locally. However, a few alien woody species (*Acacia* mearnsii) occur in the higher reaches of the spruits. A definite riparian zone is not recognised, though the grassland vegetation is lusher on the spruit banks (Figure 5). A patch of alien wattle trees occur at the head of the more eastern stream. This is a source of infection and should be removed as soon as possible.

The following plant species were recorded from this plant community:

Trees and Shrubs

Acacia mearnsii

Diospyros lycioides

Searsia pyroides

Grasses and Sedges

Aristida junciformis

Cymbopogon excavatus

Cynodon dactylon

Cyperus spp (several)

Eragrostis bicolor

Eragrostis curvula

Eragrostis plana

Hyparrhenia dregeana

Imperata cylindrica

Juncus sp

Kyllinga alata

Leersia hexandra

Mariscus congestus

Miscanthus capensis

Paspalum dilatatum

Schoenoplectus corymbosus

Setaria nigrirostris

Setaria sphacelata

Themeda triandra

Typha capensis

Forbs

Berkheya onopordifolia

Berkheya radula

Haplocarpha scaposa

Ranunculus multifidus

Senecio inornatus

Verbena bonariensis

1. Spruits			
Status	Channelled valley bottom wetland		
Soil	Clay	**Rockiness**	0-2%
Conservation priority:	High	**Sensitivity:**	High
Agricultural potential:	Low	**Need for rehabilitation**	Low
Dominant spp.	*Eragrostis plana, Typha capensis*,		

Vegetation structure		
Layer	**Height (m)**	**Cover (%)**
Trees	-	-
Shrubs	1-3	<1
Grass and sedge	0.4-2	70
Forbs	0.3	3

Discussion

The species richness is medium along the spruit. All water courses have high conservation value and are therefore considered to be sensitive. Plant species recorded reflected the hydrological zonation of the wetlands associated with the study site.

Figure 5: Upper reaches of the eastern spruit – the channel very narrow and grassland growing to the spruit edge

Figure 6: The western spruit with rocks and with grassland growing to the spruit edge

Figure 7: A small dam in the spruit, with *Typha capensis* prominent.

2. Wetland Drainage and Seepage Systems (**Hillslope seepages)**

Two large wetlands occur within the site, both draining into the western spruit. A large and important wetland originates from springs and drainage of rainfall water on the southern boundary of the site (Figure 8). This wetland drains north-eastwards towards the western spruit. This wetland is densely covered with hygrophilous grass and sedges, the most prominent being *Eragrostis plana, Hemarthria altissima* and *Leersia hexandra.* A further wetland originates on the north-western boundary (Figure 9) and drains south-eastwards towards the spruit. An area between the localities where the two spruits exit the site is also quite wet, but is included in the spruit systems.

The soil is mostly of the Katspruit or Rensburg soil forms, with a wet G-horizon.
The following plant species were recorded from this plant community:

Trees and Shrubs

No woody species are present

Grasses and Sedges

Aristida junciformis
Cymbopogon excavatus
Cyperus esculentus
Cyperus spp (several)
Eragrostis bicolor
Eragrostis plana
Fimbristylis complanata
Fuirena pubescens
Helictotrichon turgidulum
Hemarthria altissima
Imperata cylindrica
Kyllinga alata
Leersia hexandra
Mariscus congestus
Paspalum dilatatum
Pycreus macranthus
Setaria nigrirostris
Setaria sphacelata

Forbs

Berkheya onopordifolia
Berkheya radula
Centella asiatica
Drosera natalensis
Gladiolus crassifolius
Haplocarpha scaposa
Lobelia flaccida
Monopsis decipiens

Oenothera rosea
Pachycarpus sp
Ranunculus multifidus
Rhynchosia sp
Senecio inornatus
Striga elegans
Verbena bonariensis

2. Wetland Drainage and Seepage Systems			
Status	Hillslope seepages		
Soil	Black clay	**Rockiness**	0%
Conservation priority:	High	**Sensitivity:**	High
Agricultural potential:	Low	**Need for rehabilitation**	Medium
Dominant spp.	*Eragrostis plana*, *Hemarthria altissima, Leersia hexandra*		

Vegetation structure		
Layer	**Height (m)**	**Cover (%)**
Trees	-	-
Shrubs	-	-
Grass and sedge	0.4-1	80
Forbs	0.2	3

Discussion

The species richness is medium in this wetland. All wetlands have high conservation value and are therefore considered to be sensitive. Plant species recorded reflected the hydrological zonation of the wetlands associated with the study site.

Figure 8: The southern seepage wetland draining towards the spruit

Figure 9: A wetland area near the northern border of the study site.

3. Man-made quarries / Borrow pits

A disturbed, excavated area is present in the south-western corner of the site. Here is also a borrow pit, currently filled with water, housing several hygrophilous plant species. In the excavated area, some of the ditches are also filled with water, with hygrophilous species growing in the water (Figure 10).

The following plant species were recorded from this plant community:

Trees and Shrubs

Acacia karroo
Diospyros lycioides
Lippia javanica
Opuntia ficus-indica
Searsia pentheri
Searsia pyroides

Grasses

Aristida bipartita
Aristida congesta
Brachiaria eruciformis
Cymbopogon excavatus
Cynodon dactylon
Eragrostis chloromelas
Eragrostis curvula
Eragrostis gummiflua
Eragrostis micrantha
Eragrostis plana
Hyparrhenia hirta
Melinis repens
Microchloa caffra
Paspalum dilatatum
Paspalum urvillei
Sporobolus africanus

Forbs

Anthospermum hispidulum
Aponogeton sp
Bidens bipinnata
Cyperus spp
Helichrysum nudifolium
Hermannia depressa
Juncus sp
Kyllinga erecta
Monsonia angustifolia
Persicaria serrulata
Schkuhria pinnata
Schoenoplectus corymbosus
Sida alba
Solanum panduriforme
Tagetes minuta
Verbena bonariensis
Vernonia oligocephala

3. Man-made quarries / Borrow pits			
Status	Secondary grassland highly disturbed / transformed		
Soil	sandy-loam	**Rockiness % cover**	2
Conservation priority:	Low	**Sensitivity:**	Low
Agricultural potential:	Low	**Need for rehabilitation**	Low
Dominant spp.	*Hyparrhenia hirta, Aristida congesta, Cynodon dactylon*		

Vegetation structure		
Layer	**Height (m)**	**Cover (%)**
Trees	4	<1
Shrubs	0.5-3	<1
Grass	1.3	40
Forbs	0.4	5

Discussion

The area of this plant community represents disturbed and transformed vegetation, medium in species richness and with no red data species present.

Though this could be considered as wetland, this area is highly disturbed borrow pit / excavations, and should be rehabilitated or developed. Although this area can be rehabilitated and the water features utilised for recreational area, it is not worth-while to protect it as wetland area.

Figure 10: One of the man-made quarries on the study site, which creates habitat for hygrophilous plants and water-dependent fauna.

5.3 Wetland Soils

The wetland soils recorded on the site were either dark and clayey with evident vertic properties, with a grey G horizon (Rensburg form) or orthic with a grey G horizon (Katspruit form). Mottling and oxidised rhizospheres were recorded throughout the wetland, indicating saturated soil conditions. Decolouration of the soil occurs when iron and manganese become soluble under anaerobic conditions and are removed from the soil profile by gradual leaching. Once most of the iron has been dissolved out of the soil as a result of prolonged saturated conditions, the soil matrix becomes gleyed. Mottling occurs when a fluctuating water table allows for the precipitation of iron and manganese from solution during periods of aerobic conditions. The same environment leads to the formation of oxidised rhizospheres, a visible red sheath around roots of plants in wetland areas (Fey, 2005; DWAF, 2005).

5.4 Classification of the wetland into hydro-geomorpic types

Differential weathering of geological formations may create steep slopes with shallow soils. In this instance, water is expected to flow in well defined channels at a high velocity. These conditions are conducive to the deposition of alluvial soils and the formation of channelled valley bottom wetlands and rivers.

Where gentle slopes allow sediments to be accumulated and vegetation attenuates water flow velocity, waterlogging may occur. This in turn, leads to the formation of anaerobic conditions in the soil and un-channelled wetlands and floodplains are often the result. The reasoning follows that wetlands (particularly valley bottom wetlands) are most likely to occur at the lowest point of gravity in the landscape.

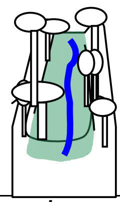
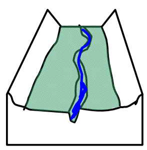
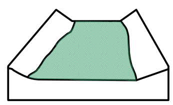
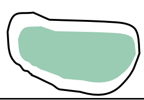
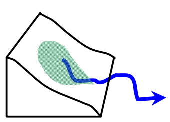
The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (Ewart-Smith *et al.* 2006). The current wetland study follows the same approach by classifying wetlands in terms of a functional unit in line with a level three category recognised in the classification system proposed in Ewart-Smith *et al*. (2006). HGM units take into consideration factors that determine the nature of water movement into, through and out of the wetland system. HGM units encompass three key elements (Kotze *et al*, 2005):

- Geomorphic setting - This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
- Water source - There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
- Hydrodynamics - This refers to how water moves through the wetland.

Two HGM wetland areas were recorded on the study site, although differences in, particularly degradation, are evident between the eastern and western streams. Despite these differences on a fine scale, the streams are classified as a channelled valley bottom wetland (see Table 2).

The wetlands are classified as Hillslope seepage (see Table 2).

Table 2: Classification of wetland and riparian (adapted from Brinson, 1993; Kotze, 1999, Marneweck & Batchelor, 2002 and DWAF, 2005). The **bold/italic** section**s** refer to the classification of the wetland on the study site

Hydro-geomorphic types	Description
Riparian habitat 	Riparian areas commonly reflect the high energy conditions associated with water flowing in a channel. Wetlands generally display more diffuse flows and are low energy environments. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth is high and the vegetation under the trees is usually lush.
Valley bottom with a channel 	***Valley bottom areas with a well defined stream channel lack characteristic floodplain features. The may be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.***
Valley bottom without a channel 	Valley bottom areas with no clearly defined stream channel are usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channels entering the wetland and also from adjacent slopes.
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.
Hillslope seepage 	***Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse.***

5.5 Buffer Zones

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a wetland or riparian area. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. A hard impervious surface such as parking areas, roads and roofs adjacent to the wetland or riparian area will block normal water flow to the wetland, while increasing storm water flow during a rainfall event. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is therefore often characteristic of transformed catchments.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining land-uses; (iii) providing habitat for various aspects of biodiversity.

A brief description of each of the functions and associated services is outlined in Table 3:

Table 3: Generic functions of buffer zones relevant to the study site (adapted from Macfarlane *et al.*, 2010)

Primary Role	Buffer Functions
Maintaining basic aquatic processes, services and values.	• Groundwater recharge: Seasonal flooding into wetland areas allows infiltration to the water table and replenishment of groundwater. This groundwater will often discharge during the dry season providing the base flow for streams, rivers, and wetlands. • Flood attenuation: Wetland vegetation increases the roughness of stream margins, slowing down flood-flows. This may therefore reduce flood damage in downstream areas. Vegetated buffers have therefore been promoted as providing cost-effective alternatives to highly engineered structures to reduce erosion and control flooding, particularly in urban settings.
Reducing impacts from upstream activities and adjoining land-uses	• Storm water attenuation: Flooding into the buffer zone increases the area and reduces the velocity of storm flow. Roots, braches and leaves of plants provide direct resistance to water flowing through the buffer, decreasing its velocity and thereby reducing its erosion potential. More water is exchanged in this area with soil moisture and groundwater, rather than simply transferring out of the area via overland flow. • Sediment removal: Surface roughness provided by vegetation, or litter, reduces the velocity of overland flow, enhancing settling of particles. Buffer zones can therefore act as effective sediment traps, removing sediment from runoff water from adjoining lands thus reducing the sediment load of surface waters. • Removal of toxics: Buffer zones can remove toxic pollutants, such hydrocarbons that would otherwise affect the quality of water resources and thus their suitability for aquatic biota and for human use. • Nutrient removal: Wetland vegetation and vegetation in terrestrial buffer zones may significantly reduce the amount of nutrients (N & P), entering a water body reducing the potential for excessive outbreaks of microalgae that can have an adverse effect on both freshwater and estuarine environments. • Removal of pathogens: By slowing water contaminated with faecal material,

	buffer zones encourage deposition of pathogens, which soon die when exposed to the elements.

Despite limitations, buffer zones are well suited to perform functions such as sediment trapping, erosion control and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land-uses / activities planned adjacent to water resources. These must however be considered in conjunction with other mitigation measures.

Local government policies require that protective wetland buffer zones be calculated from the outer edge of the temporary zone of a wetland and river buffer zones be calculated from the outer edge of the riparian zone (KZN DAEA, 2002; CoCT, 2008; GDACE, 2009). Although research is underway to provide further guidance on appropriate defensible buffer zones, there is no current standard other than the generic recommendation of 32 m for rivers, and 30 m for wetlands inside the urban edge. Outside the urban edge the standard is 100m. The wetland area associated with the study area, together with the standard required buffer zone is reflected in Figure 7.

Due to the grassland nature of the buffer zone surrounding the streams and wetland areas, an integrated approach to the management of this area is proposed which balances its conservation with its value to the development. For example, low impact recreational spaces consisting of un-compacted playgrounds, hiking trails, picnic sites, bird hides or other forms of low intensity utilization could ideally be connected to the proposed development.

5.6 Wetland Condition (WET-Health)

Wetland Condition is defined as a measure of the deviation of wetland structure and function from its natural reference condition (Macfarlane *et al.*, 2007). In the current assessment the hydrological, geo-morphological and vegetation integrity was assessed for the wetland units associated with the study site, to provide a Present Ecological Status (PES) score (Macfarlane *et al.*, 2007).

In terms of wetland functionality and status, and particularly its deviation from an original pristine condition, the spruit areas are discussed separately from the wetland areas. Health categories used by WET-Health are indicated in Table 4.

Table 4: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al.*, 2007)

DESCRIPTION	PES SCORE
Unmodified, natural.	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	***B***
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	**D**
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	**E**
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	F

Spruit systems

The Spruit systems are regarded to have a PES score of B, which is largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place. Modifications of ecosystem processes are mainly:

- Presence of alien trees (*Acacia mearnsii*) in the upper reaches
- Old agricultural fields close to the spruits
- Old residences close to the spruit
- Previous and current grazing by cattle

Wetland systems

The Wetland systems are regarded to have a PES score of B, but in the case of the southern wetland, very close to a PES score of A. These systems are largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place. Modifications of ecosystem processes are mainly:

- Previous and current grazing by cattle
- Slight erosion at the origin of the spring feeding into the wetland

The PES scores indicate that both the spruit systems and the wetland systems are largely natural and in good health.

5.7 Ecological Importance and Sensitivity (EIS)

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity;
- Ecological functions; and
- Basic human needs.

Table 5: Environmental Importance and Sensitivity rating scale used for calculation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	**Rating**	**Recommended Ecological Management Class**
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating	>2 and <=3	B

the quantity and quality of water of major rivers		
<u>Moderate</u> ***Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers***	***>1 and <=2***	***C***
<u>Low/Marginal</u> Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1	D

The Ecological Importance and Sensitivity of both the Spruit Systems and Wetland Systems are regarded as being in Moderate (Class C)(Table 5). They are Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The assessment of the biodiversity (flora, mammals, avifauna, herpetofauna) for this site by EcoAgent CC (2011) suggested that the wetlands are the most sensitive habitats on the site, both for vegetation and fauna.

The streams function as important dispersal corridors for fauna and flora. Protection of the wetlands will allow for connectivity. This protection could be in the form of a green area to service the needs of both ecosystem functioning and recreation for the residents. It must ensure that the drainage habitats are maintained as a natural corridor for those species largely confined to these habitats.

This would be important especially considering the possibility of the occurrence of the “Critically Endangered” rough-haired golden mole. It will also accommodate the possible presence of the “Near Threatened” African marsh rat, as well as the confirmed presence of sensitive vlei rats.

At places in the larger western stream has been dammed and throughout it contains fish, which include *Tilapia sparrmanii* (banded bream) and *Micropterus salmoides* (largemouth bass).

Many reptile and amphibian species are dependent on water sources and their surrounding areas for breeding and foraging. The only red data listed frog species that might occur on the site is the Spotted Shovel-nosed Frog (*Hemisus guttatus*). If it occurs on the study site and the water sources and their surrounding areas are protected it can also be safely protected.

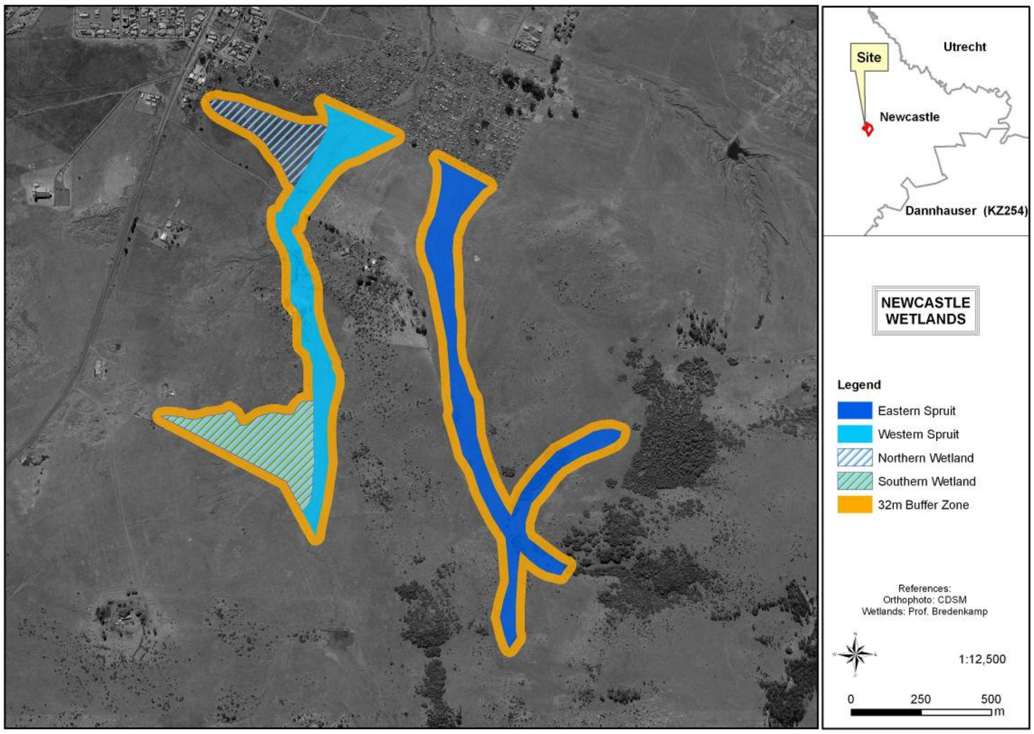


Figure 11: Wetland delineation and buffer zones

6. IMPACT ASSESSMENT

6.1 Methods

The following generic criteria drawn from published literature and general South African practise will be used to describe magnitude and significance of impacts in an objective, systematic manner.

These criteria are:

- Extent or scale of the impact (what size of the area will be affected?)
- Duration (how long will the impact last?)
- Intensity (the intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself.
- Probability (how likely is it that the impact will occur?)
- Significance (how severe will the impact be?)
- Mitigatory potential and mitigation measures

Impacts should be identified for the construction and operational phases of the proposed development. Proposed mitigation measures should be practical and feasible such that they can be realistically implemented by the applicant.

The impacts are given in table form. Conventions and definitions used in these tables are described below:

Extent of impact

Site:	Effect confined to the development area
Local:	Effect limited to within 3-5km of the development area
Regional:	Effect extends beyond the borders of the development area to influence the area as a whole.

Duration of impact

Short:	Effect last for a period up to five years
Medium:	Effect continues for a period of between five and ten years

Long: Effect continues for a period in excess of 10 years

Permanent: Effect lasts permanently

Intensity

Low: Will have no or little effect on the vegetation and fauna

Medium: Will have some effect but parts of vegetation will remain in tact

High: Will destroy the vegetation or habitat for fauna completely

Probability of occurrence

Low: Less than 33% chance of occurrence

Medium: Between 33 and 66% chance of occurrence

High: Greater than 66% chance of occurrence

Significance

Low: Where the impact will have a relatively small effect on the environment which does not need to be accommodated

Medium: Where the impact can have an influence on the environment that might require modification of the project

High: Where the impact definitely has an impact on the environment and needs mitigation

Status

Positive: Impact will be beneficial to the environment

Negative: Impact will not be beneficial to the environment

Neutral: No positive or negative impact

Confidence

Low: It is uncertain whether the impact will occur

Medium: It is likely that the impact will occur

High: It is relatively certain that the impact will occur

6.2 Results

Impact Table

In the following impact table ait ia assumed that there will be development in the wetlands. Therefore the Probability is High, with a resulting High Intensity and Significance.

Impact on Vegetation	**Extent**	**Duration**	**Intensity**	**Probability**	**Significance**	**Status**	**Conf**
Wetland Ecosystems	Regio nal	Permanent	High	High	High	Neg	High
Impact on Plant species							
Indigenous species	Site	Permanent	Medium	High	Low	Neg	High
Alien woody plant species	Site	Permanent	Low	High	High	Pos	High

6.3 Discussion

Wetland Ecosystems

Planning the new residential development, as an extension to existing suburbs, is laudable and accepted as an inevitable consequence of a burgeoning population.

The spruits and wetlands are protected ecosystems. Therefore, to avoid the negative impacts of any development on the wetland ecosystems no development of permanent structures with a high impact should be allowed within the 1:100 year flood line, or 32 m from the edge of the wetland / spruit. However, it is recommended that this buffer be even larger wherever possible. A special, additional impact assessment will be needed at the localities where the spruits have to be crossed. Properly designed bridges allowing absolute free flow of water must be used to cross the spruits. In this case special mitigation measures will be needed.

Fluctuating water levels will be artificially amplified by the development and may result in undue erosion and damage to wetlands. In addition, water contamination of wetlands and streams ex stormwater flowing from hard surfaces will result in severe damage to the ecosystems within the riparian zones on the site and further downstream. As such it will deleteriously affect connectivity, species richness and diversity, food chains and breeding success / cycles.

Predicting the effect of chemical and sediment contamination on the wetland and stream systems is largely speculative, and will require a more comprehensive overview. However, it is anticipated that contaminants and sediments deposited on hard surfaces will wash into the streams, unless the proposed mitigation measures are accepted.

A reduction in water flow / cessation of flow or of flush floods on site will inevitably result in damage to the wetlands in the riparian zones. This in turn will cause a quantitative and qualitative reduction in the life-support systems (habitats) of animals. It is predicted that damage to the wetland systems may have a cumulative effect on faunal diversity and richness, unless the proposed mitigation measures are heeded.

Given a significant damage to wetlands caused by a decreased water flow or the scouring effect of flush floods, a decrease of fauna population densities can be expected as concomitant to decreasing life-support systems. If decreased natural availability of water is prolonged or water is contaminated, the possibility of local species loss must be entertained, and following that more unacceptable effects such as a cumulative loss of inter-reliant species.

Increased runoff from residential development (roofs, sealed roads) and wastewater will require proper control so that flushing and/or contamination of wetlands and streams does not damage ecosystems within the riparian zones on site and further downstream. Protection and improvement of the riparian vegetation will help to counter these impacts. Protection of wooded patches will enhance the diversity of birds likely to remain within the development, besides providing important transit areas for woodland species between adjacent patches.

The quantity and quality of water emanating from the development will impinge on all downstream communities, besides affecting water quality within the on site watercourses. Maintenance of the drainage systems on the site as well managed green areas, and careful planning of surplus (storm) and wastewater disposal will be imperative.

Drainage systems are by nature a series of interconnected linear habitats. The movements of any plant or animal species confined to these habitats are therefore restricted largely to linear patterns. Hence any damage leading to breaks in these systems imposes dispersal barriers to riparian and wetland species, leading to a reduction in species diversity and abundance. A number of species based in wetland or woodland habitats also visit adjacent habitats for some of their requirements (food, nest material), and so preservation of as much natural habitat as possible within the development should form a basis for initial planning. Connectivity varies from fair to good and real opportunities for migration exist to the south and east of the study site. Informal settlements to the north of the study site influence the water quality and thus migration of water-dependent herpetofauna down steam

Most of the threatened species of birds identified as possible visitors to the site prefer grassland habitats, and these will be inevitably be reduced given the nature of residential development. However, those species that prefer wetlands (African Grass-Owl, Grey Crowned Crane and African Marsh-Harrier) could have their habitats protected and even enhanced if the lower reaches of the streams and their associated riparian and 100-year flood zones are developed as a green reserve area within the development.

Due to the grassland nature of the buffer zone surrounding the streams and wetland areas, an integrated approach to the management of this area is proposed which balances its conservation with its value to the development. For example, low impact recreational spaces consisting of un-compacted playgrounds, hiking trails, picnic sites, bird hides or other forms of low intensity utilization could ideally be connected to the proposed development. No high impact permanent structures should be allowed.

6.4 Mitigation measures

- The wetland systems are no-go areas that should be kept natural, without any paths for pedestrians or vehicles

- Construct proper bridges over streams.
- Avoid erosion at all times.
- Rehabilitate and stabilise the stream banks immediately after construction.
- Use only indigenous grasses and other species for the rehabilitation.
- Avoid all pollution at all times.
- The contractors must ensure that no fauna species are disturbed, trapped, hunted or killed during the construction phase. Conservation-orientated clauses should be built into contracts for construction personnel, complete with penalty clauses for non-compliance.
- Out of concern for the possible releases of noxious substances on water quality of the extensive wetland / water system on the site and further downstream, it is suggested that the contracted hydrologist adopt a wide research approach to address all the ecological issues raised in this report.
- The hydrologist should, if possible, also attend to the fact that where the streams later flow through the town physical impediments and contamination will act as ecological bottlenecks. The new development will magnify such effects and will require amelioration of downstream conditions. This proposal resorts under the precondition that the effect of the development must be interpreted in a wider context.

The following principles should be applied:

- Ecological principles must hold sway in determining how best to manage the wetland area, including downstream wetland areas. Ecological principles include:
    - Maintaining the zonation of wetland areas by avoiding canalization and increased water velocity.
    - Making use of soft engineering rather than hard engineering by using natural landscape features and vegetation to direct water flow rather than concrete canals, for example by planting suitable appropriate plant species in the stream channel as well as areas disturbed by the construction activities including removal of soil dumps
- Engineering interventions must enhance rather than further deteriorate the ecological functions of the wetland and must:
    - Promote groundwater recharge by avoiding impermeable structures, or where this is not possible by incorporating bio-swales into which runoff from hardened surfaces is directed;

- Allow for lateral movement of water;
- Focus on storm water management in terms of flow attenuation and reduced velocity; Artificial wetlands/dams can be constructed for runoff water to help create a habitat for water-dependent herpetofauna.
- Avoid stagnant water pools;

- Must be based on calculated volumes from the before and after development scenario, taking cognizance of the area of land required to maintain wetland conditions, while managing storm water impacts.

Erosion Control

Erosion control measures should form part of the planning as well as the construction and implementation phases of the development. A rehabilitation plan should be put into place that will address any erosion (including alien vegetation encroachment or pollution) of the watercourse resulting from the proposed activities. Appropriate flow diversion and erosion control structures (i.e. earth embankments) must be put in place where soil may be exposed to high levels of erosion due to steep slopes, soil structure etc. All cleared areas should be top-soiled and vegetated as soon as possible to reduce the exposure of the soil to water and wind action.

Water quality enhancement

Prevention of pollution from crew camps, or input of hydrocarbons from construction vehicles is a first-line defence against watercourse pollution during the construction phase of the development. Following completion of the construction activities, trapping of oils and pollutants from parking areas and roads can be achieved by vegetated buffers and swales that direct polluted water into appropriate settling areas before release into the system.

Storm water management remains of importance to avoid undesirable pollution of the streams.

Alien Plant Control

The wetland habitats recorded on the study site are in a good condition and they are functional components within the ecological landscape. Vegetation clearing associated with the proposed activities are likely to result in the encroachment of alien invasive plant species. Re-vegetating of cleared areas with suitable indigenous species as soon as possible after the disturbance, together with an alien species monitoring and eradication program should prevent encroachment of these problem plants.

7. GENERAL DISCUSSION AND CONCLUSION: WETLAND STUDY

An assessment of both the streams and wetlands identified within the study site show that the wetland's current functionality, ecological status and sensitivity results in scores that can be summarised as reflecting largely natural streams and wetlands in the Moderate Ecological Importance and Sensitivity.

To comply with the laws and regulations protecting wetlands, it is suggested that the streams and wetland be considered as no-go areas, applying the 32 m buffer zone and with low impact recreational spaces consisting of un-compacted playgrounds, hiking trails, picnic sites, bird hides or other forms of low intensity utilization that could ideally be connected to the proposed development.

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- MGSSA Grassland Society of Southern Africa
  - 1986 Elected as Sub-editor for the Journal
  - 1986-1989 Serve on the Editorial Board of the Journal

- - 1990 Organising Committee: International Conference: Meeting Rangeland challenges in Southern Africa
- 1993 Elected as professional member

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Academic career:

• Students:

- Completed post graduate students: M.Sc. 53; Ph.D. 14.

- Presently enrolled post-graduate students: M.Sc. 4; Ph.D. 2.

• Author of:

- 175 scientific papers in refereed journals

- >150 papers at national and international congresses

- >250 scientific (unpublished) reports on environment and natural resources

- 17 popular scientific papers.

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• Editorial Committee of

- South African Journal of Botany,
- Journal Grassland Society of Southern Africa,
- Bulletin of the South African Institute of Ecologists.
- Journal of Applied Vegetation Science.(Sweden)
- Phytocoenologia (Germany)
-

• FRD evaluation category: C2 (=leader in South Africa in the field of Vegetation Science/Plant Ecology)

Membership:

• International Association of Vegetation Science.

• British Ecological Society

• International Society for Ecology (Intecol)

• Association for the Taxonomic study of the Flora of Tropical Africa (AETFAT).

• South African Association of Botanists (SAAB)

1988-1993 Elected to the **Council** of SAAB.

1989-1990 Elected as **Chairman** of the Northern Transvaal Branch

1990 Elected to the Executive Council as **Vice-President**

1990- Sub-editor Editorial Board of the Journal

1991-1992 Elected as **President** (2-year period)

1993 **Vice-President** and Outgoing President

• Wildlife Management Society of Southern Africa

• Suid-Afrikaanse Akademie vir Wetenskap en Kuns
(=South African Academy for Science and Art).

• Wildlife Society of Southern Africa

1975 - 1988: Member

1975 - 1983: Committee member, Pietersburg Centre

1981 - 1982: **Chairman**, Pietersburg Centre

• Dendrological Society of Southern Africa

1984 - present: Member

1984 - 1988: Committee member, Western Transvaal Branch

1986 - 1988: **Chairman**, Western Transvaal Branch

1987 - 1989: Member, Central Committee (National level)

1990 - 2000: Examination Committee

• Succulent Society of South Africa

1987 - 2000

• Botanical Society of South Africa

2000 – present: Member

2001- 2008: Chairman, Pretoria Branch

2002 – 2006: Chairman, Northern Region Conservation Committee

2002- 2007: Member of Council

Special committees:

• Member of 10 special committees re ecology, botany, rangeland science in South Africa.

• Member of the International Code for Syntaxonomical Nomenclature 1993-present.

Merit awards and research grants:

1968 Post graduate merit bursary, CSIR, Pretoria.

1977-1979 Research Grant, Committee re Research Development, Dept. of Co-operation and Development, Pretoria.

1984-1989 Research Grant, Foundation for Research Development, CSIR, Pretoria.

1986-1987 Research Grant, Dept. of Agriculture and Water Supply, Potchefstroom.

1990-1997 Research Grant, Dept. of Environmental Affairs & Tourism, Pretoria.

1991-present Research Grant, National Research Foundation , Pretoria.

1991-1993 Research Grant, Water Research Commission.

1999-2003 Research Grant, Water Research Commission.

2006 South African Association of Botanists Silver Medal for outstanding contributions to South African Botany

Abroad:

1986 Travel Grant, Potchefstroom University for Christian Higher Education, Potchefstroom

Visits to Israel, Italy, Germany, United Kingdom, Portugal.

1987 Travel Grant, Potchefstroom University for Christian Higher Education, Potchefstroom.

Visits to Germany, Switzerland, Austria, The Netherlands, United Kingdom.

1990 Travel Grant, FRD.

Visit to Japan, Taiwan, Hong-Kong.

1991 Travel Grant, FRD.

Visits to Italy, Germany. Switzerland, Austria, France, The Netherlands, United Kingdom.

1993 Travel Grant, University of Pretoria.

Visits to the USA, Costa Rica, Czech Republic, Austria.

1994 Travel Grant FRD.

Visits to Switzerland, The Netherlands, Germany, Czech Republic.

1995 Travel Grant FRD, University of Pretoria

Visits to the USA

1996 Travel Grant, University of Pretoria

Visit to the UK.

1997 Travel Grant University of Pretoria, Visit Czech Republic, Bulgaria

1998 Travel Grant, University of Pretoria, Visit Czech Republic, Italy, Sweden

1999 Travel Grant, University of Pretoria, Visit Hungary, Spain, USA

2000 Travel Grant, University of Pretoria, Visit Poland, Italy, Greece.

2001 Travel Grant, NRF, Visit Brazil

2006 German Grant Invited lecture in Rinteln, Germany

Consultant

Founder and owner of Ecotrust Environmental Services CC and Eco-Agent CC

Since 1988 **>250** reports as consultant on environmental matters, including:

- Game Farm and Nature Reserve planning,
- Environmental Impact Assessments,
- Environmental Management Programme Reports,
- Vegetation Surveys,
- Wildlife Management,
- Veld Condition and Grazing Capacity Assessments,
- Red data analysis (plants and animals).

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