Ngonyama Link Road Development, Diepsloot Wetland Assessment

SEF Reference No:
505220

Prepared for:

Johannesburg Development Agency
The Bus Factory
No. 3 President Street
Newtown
Johannesburg
Tel. No.: 011 688 7851
Fax. No.: 011 688 7899
e-mail: nsibiya@jda.org.za

Prepared by:

Strategic Environmental Focus (Pty) Ltd
P.O. Box 74785
Lynnwood Ridge
0040
Tel. No.: (012) 349-1307
Fax. No.: (012) 349-1229
e-mail: sef@sefsa.co.za

S · E · F
STRATEGIC ENVIRONMENTAL FOCUS

July 2013

Compiled by	Authorised by
Willem Lubber *Cand. Sci. Nat.* Wetland Ecologist SACNASP Reg. No. 100064/08	**Byron Grant *Pr. Sci. Nat.*** Project Manager & Senior Natural Scientist SACNASP Reg. No. 400275/08 _______________ Date: 25/06/2013

Declaration of Independence

I, **Willem Lubbe,** in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Have and will not have 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 competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member;
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement; and
- Undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered.

________________________	July 2013
Willem Lubbe *Cand. Sci. Nat.*	**Date**
Wetland Specialist	
SACNASP Reg. No. 100064/08	

EXECUTIVE SUMMARY

Strategic Environmental Focus (Pty) Ltd. (SEF), as independent environmental practitioners and ecological specialists, was appointed by Johannesburg Development Agency to conduct wetland assessments for the proposed construction of a 2km Ngonyama Link Road and associated 60m long bridge over a river in Diepsloot in the City of Johannesburg Metropolitan Municipality, Gauteng Province. The terms of reference for the current study were as follows:

- Delineate and classify wetland and riparian areas within the study area;
- Determine the Present Ecological State as well as the Ecological Importance and Sensitivity of the identified wetlands within the study area; and
- Identify possible impacts and mitigation measures of proposed activities associated with wetlands within the study area.

The main wetland indicators used during the wetland delineation process included the terrain unit indicator, soil wetness indicator, and the presence or absence of hydric soils and hydrophytes. Two hydro-geomorphic types were delineated and classified into two different hydro-geomorphic units (HGM) within the proposed study area. These included a valley bottom wetland with a channel and a hillslope seepage wetland which is connected to a watercourse.

From a functional perspective, wetlands within the study area serve to improve habitat within and downstream of the study area through the provision of various ecosystem services such as streamflow regulation, flood attenuation, groundwater recharge, nitrogen removal, phosphate removal, toxicant removal, particle assimilation and provision of natural resources.

The Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank water resources in terms of provision of goods and service or valuable ecosystem functions which benefit people, biodiversity support and ecological value, and reliance of subsistence users (especially basic human needs uses). The low Ecological Importance and Sensitivity assigned to both HGM units can be attributed to the disturbed nature of the wetlands in the study area and the resultant low potential presence of species of conservation concern.

Based on the proposed activity and taking into consideration the present state of the wetlands and their associated functionality and biodiversity, several potential impacts and mitigation measures were identified. Current erosion processes within the valley-bottom wetland, particularly major headcut erosion incising upstream will threaten the proposed development within the next or following rainy seasons. It is therefore highly recommended that a limited number of rehabilitation initiatives be implemented in order to increase wetland functionality and reduce threats on the proposed development.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

With South Africa being a contracting party to the Ramsar Convention on Wetlands, the South African government has taken a keen interest in the conservation, sustainable utilisation and rehabilitation of wetlands in South Africa. This aspect is also reflected in various pieces of legislation controlling development in and around wetlands and other water resources, of which the most prominent may be the National Water Act, Act 36 of 1998. As South Africa is an arid country, with a mean annual rainfall of only 450mm in relation to the world average of 860mm (DWAF, 2003), water resources and the protection thereof becomes critical to ensure their sustainable utilisation. Wetlands perform various important functions related to water quality, flood attenuation, stream flow augmentation, erosion control, biodiversity, harvesting of natural resources, and others, highlighting their importance as an irreplaceable habitat type. Determining the location and extend of existing wetlands, as well as evaluating the full scope of their ecosystem services, form an essential part in striving towards sustainable development and protection of water resources.

1.1. Project Description

Strategic Environmental Focus (Pty) Ltd (SEF), as independent environmental practitioners and ecological specialists, was appointed by Johannesburg Development Agency to undertake wetland assessments of the areas that will be affected by the proposed construction of a 2km Ngonyama Link Road and associated 60m long bridge over a river in Diepsloot in the City of Johannesburg Metropolitan Municipality, Gauteng Province.

1.2. Terms of Reference

The terms of reference for the current study were as follows:

- Delineate and classify wetland and riparian areas within the study area;
- Determine the Present Ecological State as well as the Ecological Importance and Sensitivity of the identified wetlands within the study area; and
- Identify possible impacts and mitigation measures of proposed activities associated with wetlands within the study area.

1.3. Assumptions and Limitations

In order to obtain definitive data regarding the biodiversity, hydrology and functioning of particular wetlands, studies should ideally be conducted over a number of seasons and over a number of years. The current study relied on information gained during a two day field survey conducted during a single season, desktop information for the area, information obtained from provincial conservation authorities, as well as professional judgement and experience. Delineations of wetlands were therefore dependent on the extrapolation of data obtained during field surveys and from interpretation of orthophotos and other imagery. The potential for minor errors in delineating precise boundaries therefore exists as it would be impractical and expensive to verify each wetland boundary in totality. The confidence of the wetland delineation was poor as a result of the disturbed site conditions, particularly as a result of the large amount of infill and soil disturbances that has taken place in the study area. It should be noted that only a portion of HGM 1, in the vicinity of the proposed road was delineated and that this valley bottom wetland extends several kilometres north and south of the study area. Further, potential seepage wetlands to the south of the study area that would potentially support HGM 1 were not delineated.

1.4. Methodology

Field surveys were undertaken on the 1st and 5th of July 2013. The wetland delineation was based on the legislatively required methodology as described by DWAF (2005). In order to gauge the Present Ecological Status (PES) of wetlands within the study area, a Level 2 WET-Health assessment (Macfarlane *et al*., 2008) was applied in order to assign PES categories to wetlands. For a more comprehensive study approach and specific methodologies employed during the current study, see Appendix A.

2. BACKGROUND INFORMATION

2.1. Locality

The study area is located within the Diepsloot Township, in the City of Johannesburg Metropolitan Municipality, Gauteng Province (Figure 1). The coordinates for the two end points of the proposed road are 25°56'14.67S, 28°00'13.41"E and 25°56'29.55"S, 28°00'33.78"E. The study site falls within the 2528 CC quarter degree square.

2.2. Biophysical description

<u>Climate</u>

Johannesburg receives approximately 604mm of rain per year, with most rainfall occurring during summer. It receives the lowest rainfall (0mm) in July and the highest (113mm) in January. The monthly average midday temperatures range from 16.6℃ in June to 26.2℃ in January, while the region is c oldest in July when temperatures drop to 0.8℃ on average during the night (Mucina & Rutherford, 2006).

<u>Regional Vegetation</u>

The study site is situated within the Egoli Granite Grassland Biome of South Africa, (Rutherford & Westfall, 1994). High summer rainfall is characteristic of the Grassland Biome combined with dry winters with night frost and marked diurnal temperature variations. These conditions are unfavourable to tree growth. The Grassland Biome therefore comprises mainly of grasses and plants with perennial underground storage organs, for example bulbs and tubers. The majority of rare and threatened plant species in the summer rainfall regions of South Africa are restricted to high-rainfall grasslands, making this the vegetation type in most urgent need of conservation. It is not generally acknowledged that the majority of plant species in grasslands are non-grassy herbs (forbs), most of which are perennial plants with large underground storage structures. The highveld and montane grasslands of Mpumalanga are an important habitat for several threatened plant and animal taxa (Emery *et al*. 2002).

Frost, fire and grazing maintain the herbaceous grass and forb layer and prevent the establishment of thickets (Tainton, 1999). Fire is a natural disturbance caused by lightning, and regular burning is therefore essential for maintaining the structure and biodiversity of this biome. However, if prevented due to activities such as agriculture and mining, alien species eventually dominate the natural vegetation and place an additional burden on already scarce resources such as water.

The Egoli Granite Grassland occurs in the Gauteng Province in the Johannesburg dome and extends toward Centurion in the North, Muldersdrift to the east and Tembisa to the west. The grassland is usually dominated by *Hyparrhenia hirta* with some woody species on rocky-out crops or rock sheets. Only about 3% of this unit is conserved in statutory reserves and private conservation and more than two thirds has already undergone transformations mostly by urbanisation, cultivation or by building of roads. This classifies the unit as Endangered (Mucina & Rutherford, 2006).

2.3. Associated Watercourses

The study area is located within the Upper Crocodile sub-area of the Crocodile (West) and Marico Water Management Area (WMA), within the quaternary catchment A21C which is classified as water stressed. Water courses in this catchment drain into the Jukskei River. The Jukskei River then drains into the Hartebeestpoort Dam and eventually into the Crocodile River.

2.4. National Freshwater Ecosystem Priority Areas Status

The National Freshwater Ecosystem Priority Areas project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and

- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development. The second aim comprises a national and sub-national component: The national component aims to align DWA and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems. The sub-national component aims to use three case study areas to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes at a sub-national level. The project further aims to maximise synergies and alignment with other national level initiatives such as the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation.

Based on current outputs of the NFEPA project, no FEPA wetlands were identified within the boundaries of the proposed road. However, one FEPA wetland was indicated to the south of the proposed road (Figure 2).

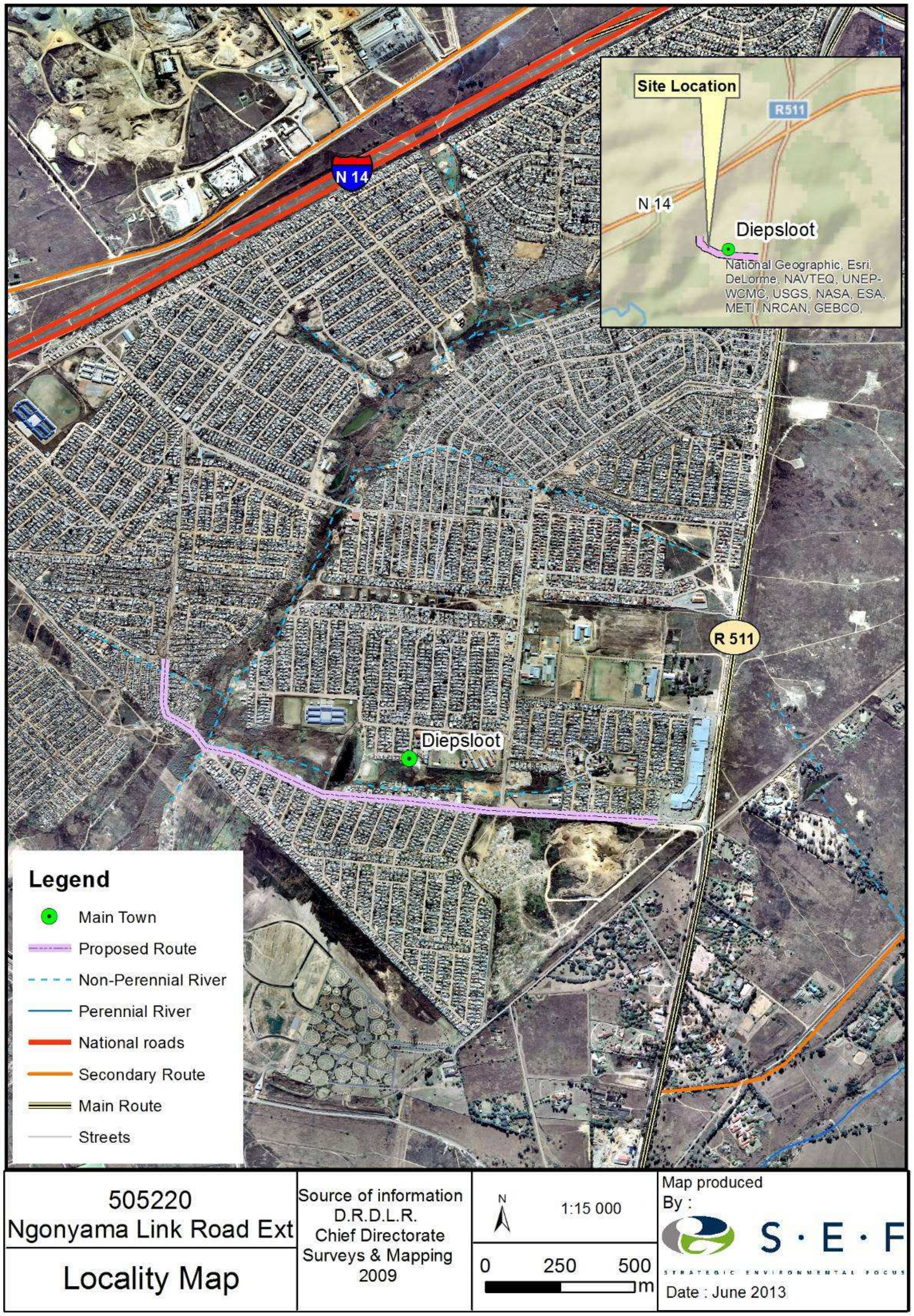


Figure 1: Locality map of the study area

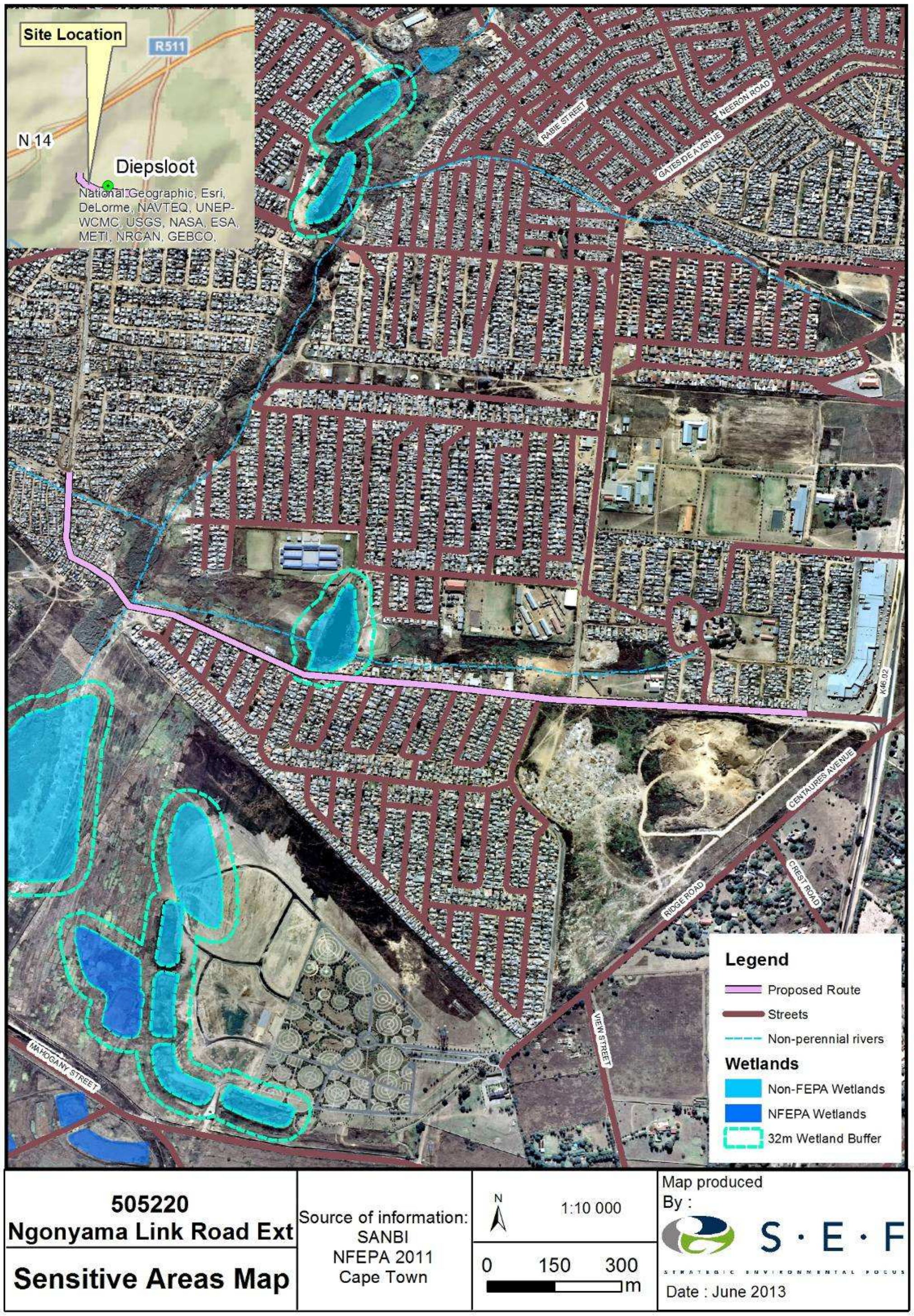


Figure 2: NFEPA map

3. RESULTS

3.1. Wetland soils

According to DWAF (2005), the permanent zone of a wetland will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991). The seasonal and temporary zones of the wetlands will have one or more of the following soil forms present (signs of wetness incorporated at the form level): Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu. Alternatively, the seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level): Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee (DWAF, 2005). Soil profiles within the study area were heavily disturbed as a result of several current and historic anthropogenic activities. The only identifiable soil forms within wetland habitat were Katspruit and Dundee *cf*. soil forms, although several areas did indicate remnant gleyed and soft plinthic horizons which could potentially be indicative of Westleigh, Longlands, Avalon and Kroonstad soil forms, which was further supported by the presence of a plinthic cantena just south of the study area. Terrestrial areas within the wetland's catchment consisted of Clovelly and Witbank soil forms.

Several redoximorphic features were also present within soil profiles of the study area, including mottles and rhizospheres. Redoximorphic features are the result of the reduction, translocation and oxidation (precipitation) of iron and manganese oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic. Redoximorphic features typically occur in three types (Collins, 2005):

- **A reduced matrix** - i.e. an *in situ* low chroma (soil colour), resulting from the absence of Fe^{3+} ions which are characterised by "grey" colours of the soil matrix (Photograph 1).
- **Redox depletions** - the "grey" (low chroma) bodies within the soil where Fe-Mn oxides have been stripped out, or where both Fe-Mn oxides and clay have been stripped. Iron depletions and clay depletions can occur.
- **Redox concentrations** - Accumulation of iron and manganese oxides (also called mottles). These can occur as:
    - Concretions - harder, regular shaped bodies;
    - Mottles - soft bodies of varying size, mostly within the matrix, with variable shape appearing as blotches or spots of high chroma colours; and,
    - Pore linings – zones of accumulation that may be either coatings on a pore surface, or impregnations of the matrix adjacent to the pore. They

are recognised as high chroma colours that follow the route of plant roots, and are also referred to as oxidised rhizospheres.

According to the DWAF (2005), soil wetness indicators (i.e. identification of redoximorphic features) are the most important indicator of wetland occurrence due to the fact that soil wetness indicators (redoximorphic features) remain in wetland soils, even if they are degraded or desiccated. It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric (a wetland soil), or non-hydric (non-wetland soil) (Collins, 2005). However, soils within wetland habitat did not always display redoximorphic reactions as a result of severe soil disturbances and especially infilling that took place throughout the wetlands.

3.2. Wetland Vegetation

According to DWAF (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands. Vegetation also forms a central part of the wetland definition in the National Water Act, Act 36 of 1998. Using vegetation as a primary wetland indicator however, requires undisturbed conditions (DWAF, 2005) which were not the situation within the study area. A cautionary approach must be taken as vegetation alone cannot be used to delineate a wetland, as several species, while common in wetlands, can occur extensively outside of wetlands. When examining plants within a wetland, a distinction between hydrophilic (vegetation adapted to life in saturated conditions) and upland species must be kept in mind. There is typically a well-defined 'wetness' gradient that occurs from the centre of a wetland to its edge that is characterised by a change in species composition between hydrophilic plants that dominate within the wetland to upland species that dominate on the edges of, and outside of the wetland (DWAF, 2003). This wetness gradient was disturbed as a result of historic anthropogenic activities such as infilling. Further, vegetative indicators which usually determine the three wetness zones (temporary, seasonal and permanent), characterising wetlands, were cryptic as a result of the disturbances. As expected, permanent wetland areas contained *Phragmites australis, Typha capensis* and *Persicaria* sp. with a mixture of facultative and terrestrial species (mostly graminoids and weeds) dominating the seasonal and temporary wetland areas.

3.3. Delineated Wetland Areas

According to the National Water Act (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*." Hydrophytes and hydric soils are used as the two main wetland indicators. The presence of these two indicators is symptomatic of an area that has sufficient saturation to classify the area as a wetland. The soil form indicator examines soil forms, as defined by the Soil Classification Working Group. Typically soil forms associated with prolonged and frequent saturation by water, where present, is a sign of wetland occurrence (DWAF, 2005). Terrain unit refers to the land unit in which the wetland is found. Wetlands can occur across all terrain units from the crest to valley bottom. Many wetlands occur within valley bottoms, but wetlands are not exclusively found within depressions. Terrain unit is a useful indicator in assessing the hydro-geomorphic form of the wetland.

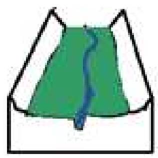
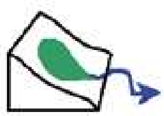
In practice, all indicators should be used in any wetland assessment / delineation exercise, the presence of redoximorphic features being most important, with the other indicators being confirmatory. An understanding of the hydrological processes active within the area is also considered important when undertaking a wetland assessment. Indicators should be 'combined' to determine whether an area is a wetland and to delineate the boundary of a wetland. According to the DWAF delineation guidelines, the more wetland indicators that are present the higher the confidence of the delineation. In assessing whether an area is a wetland, the boundary of a wetland or a non- wetland area should be considered to be the point where indicators are no longer present. As a result of the highly disturbed condition within the study area, the confidence of the delineation was low, with a likelihood that wetland habitat were much more extensive historically.

Two HGM types were delineated and classified into two different hydro-geomorphic (HGM) units within the proposed study area. These included a valley bottom wetland with a channel and a hillslope seepage wetland which is connected to a watercourse. The HGM units are presented graphically in Figure 3. HGM units encompass three key elements (Kotze *et al*, 2005):

(1) 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);
(2) Water source. There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
(3) Hydrodynamics, which refers to how water moves through the wetland.

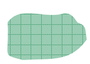
Table 1 describes the characteristics that form the basis for the classification of the HGM units in the study area.

Table 1: Wetland hydro-geomorphic types typically supporting inland wetlands in South Africa (adapted from Kotze et al, 2005)

Hydro-geomorphic types	Description	Source of water maintaining the wetland[1]	
		Surface	Sub-surface
Valley bottom with a channel 	Valley bottom areas with a well defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterised by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/ ***
Hillslope seepage connected to a watercourse 	Slopes on hillsides, which are characterised 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 stream channel.	*	***

[1] Precipitation is an important water source and evapotranspiration an important output in all of the above settings

Water source: * Contribution usually small
*** Contribution usually large
*/ *** Contribution may be small or important depending on the local circumstances



Wetland

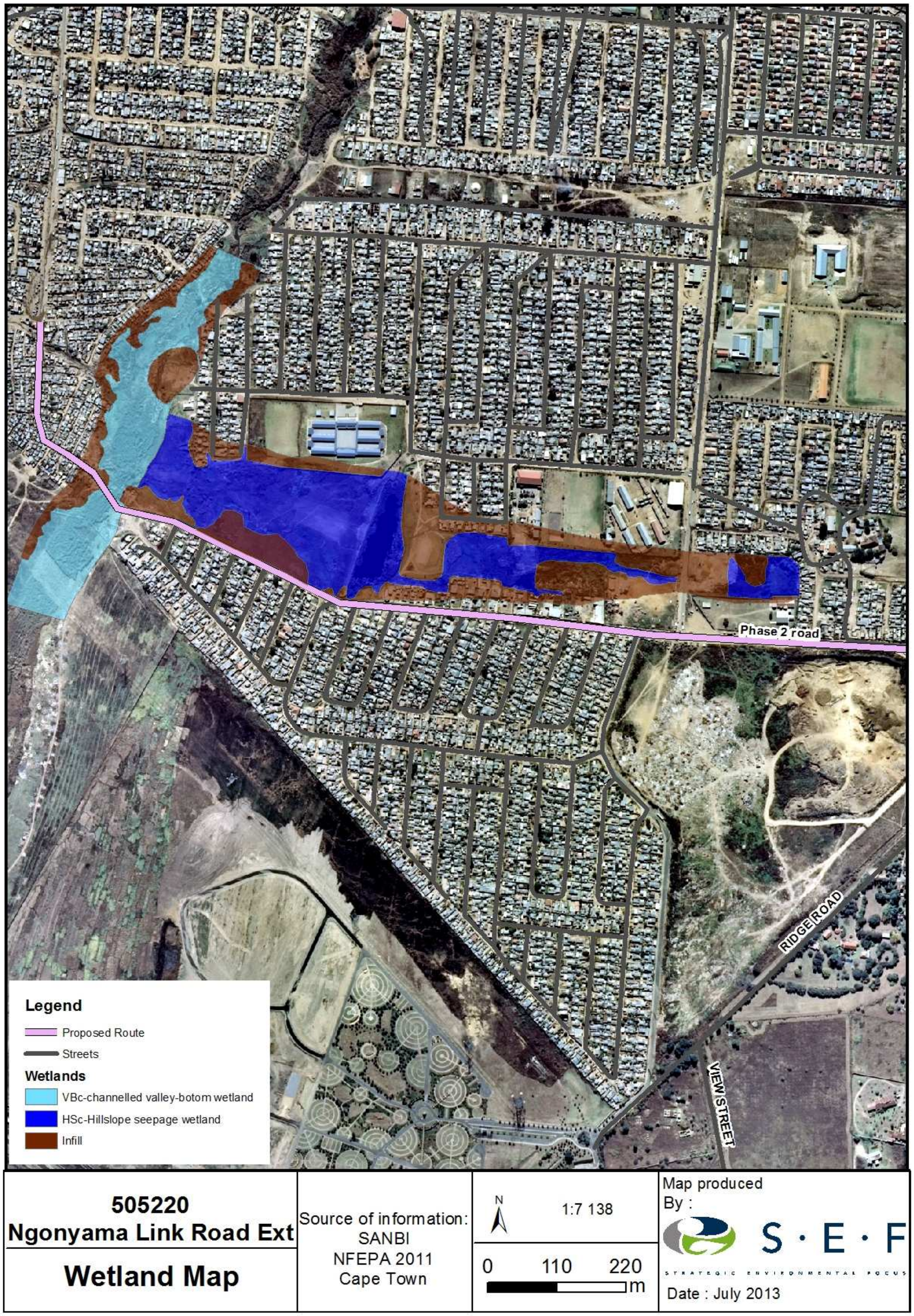


Figure 3: Map indicating all wetlands which occur within the study area

4. FUNCTIONAL ASSESSMENT

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increase biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes (Table 2).

Table 2: Potential wetland services and functions in study area

Function	Aspect
Water balance	Streamflow regulation
	Flood attenuation
	Groundwater recharge
Water purification	Nitrogen removal
	Phosphate removal
	Toxicant removal
	Water quality
Sediment trapping	Particle assimilation
Harvesting of natural resources	Reeds, Hunting, etc.
Livestock usage	Water for livestock
	Grazing for livestock
Crop farming	Irrigation

Hydro-geomorphic units are inherently associated with hydrological characteristics related to their form, structure and particularly their position in the landscape. This, together with the biotic and abiotic character (or biophysical environment) of wetlands in the study area, means that these wetlands are able to contribute better to some ecosystem services than to others (Kotze *et al.* 2005) (Table 3).

Each wetland's ability to contribute to ecosystem services within the study area is further dependant on the particular wetland's Present Ecological State (PES) in relation to a benchmark or reference condition. Present Ecological State scores were assigned for various wetlands within the study area using WET-Health Level 2 assessment. Through the use of a scoring system, the perceived departure of elements of each particular system from the "natural-state" was determined. The following elements were considered in the assessment:

- Hydrologic: Flow modification (has the flow, rates, volume of run-off or the periodicity changed);
- Geomorphic (Canalisation, impounding, topographic alteration and modification of key drivers); and

- Biota (Changes in species composition and richness, Invasive plant encroachment, over utilisation of biota and land-use modification).

Table 3: Preliminary rating of the hydrological benefits likely to be provided by a wetland given its particular hydro-geomorphic type (Kotze et al., 2005)

WETLAND HYDRO-GEOMORPHIC TYPE	HYDROLOGICAL BENEFITS POTENTIALLY PROVIDED BY THE WETLAND							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phosphates	Nitrates	Toxicants[2]
1. Valley bottom - channelled	+	0	0	++	+	+	+	+
2. Valley bottom - unchannelled	+	0	0	++	0	0	++	+
3. Hillslope seepage connected to a watercourse	+	0	+	++	0	0	++	++

[2]Toxicants are taken to include heavy metals and biocides

Rating: 0 Benefit unlikely to be provided to any significant extent

+ Benefit likely to be present at least to some degree

++ Benefit very likely to be present (and often supplied to a high level)

4.1. Present Ecological State for HGM 1

Wet-health results obtained for HGM 1, i.e. the Valley Bottom Wetland, are displayed in Table 4.

Table 4: Wet-health scores for HGM 1

Wetland size	Hydrology	Geomorphology	Vegetation	PES category
	6.3	6.2	6.4	E (6.3)

Scores obtained for the hydrology module indicated that water inputs (derived from its catchment) and water retention and distribution patterns within the hydrogeomorphic unit itself have been severely altered. The majority of wetland catchments have been converted to informal and formal housing which altered the surface roughness and run-off characteristics. Seepage wetlands to the south, supporting HGM 1, have been historically utilised for waste treatment (cake drying beds) by the adjacent Waste Water Treatment Works and subsequently been used for cultivation, thereby dramatically altering the hydrology, geomorphology and vegetation's species composition. Impeding features within wetlands included farm dams, infilling and roads.

Collectively, major wetland loss has occurred within the study area as a result of urban sprawl and especially infilling which has effected large portions of the valley bottom wetland. This has in turn resulted in a high run-off regime which initiated major erosion processes, including headcut erosion which is rapidly incising upstream. PES and associated wetland functionality within the study area were therefore low as a result of these anthropogenic impacts, with the majority of wetland scoring a PES category of E, representing a seriously modified system.

4.2. Present Ecological State for HGM 2

Wet-health results obtained for HGM 2, i.e. the Hillslope Seepage Wetland, are displayed in Table 5.

Table 5: Wet-health scores for HGM 2

Wetland size	Hydrology	Geomorphology	Vegetation	PES category
	6.9	6.7	7.1	E (6.9)

HGM 2 was delineated as a hillslope seepage wetland that supports HGM 1. It has been classified as seriously modified, with the loss of natural habitats and basic ecosystem functions being extensive. Changes to the hydrological and geomorphologic processes which took place were as a result of especially infilling, roads and footpaths crossing the wetland (formal and informal), the removal of sediment from the wetland through several excavations, channel incision and major changes to the catchment hydrology as a result of urban sprawl through formal and informal housing developments. The informal road infrastructure abruptly ends on the wetland periphery with no stormwater management measures in place, further increasing peak run-off deliveries to the wetland. Vegetation composition within the seepage wetland was representative of transformed habitat with several exotics and pioneer species dominant. In addition to littering and dumping, the outflow of raw sewage into the watercourse was a major concern.

5. ECOLOGICAL IMPORTANCE AND SENSITIVITY

All wetlands, rivers, their flood zones and their riparian areas are protected by law and no development is allowed to negatively impact on rivers and river vegetation. The vegetation in and around rivers and drainage lines play an important role in water catchments, assimilation of phosphates, nitrates and toxins as well as flood attenuation. Quality, quantity and sustainability of water resources are fully dependent on good land management practices within the catchment.

The Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank water resources in terms of:

- Provision of goods and service or valuable ecosystem functions which benefit people;
- Biodiversity support and ecological value; and
- Reliance of subsistence users (especially basic human needs uses).

Water resources which have high values for one or more of these criteria may thus be prioritised and managed with greater care due to their ecological importance (for instance, due to biodiversity support for endangered species), hydrological functional importance (where water resources provide critical functions upon which people may be dependent, such as water quality improvement) or their role in providing direct human benefits (Rountree, 2010).

Degradation of wetlands through impacts in catchments or in wetlands themselves is resulting in the reduction and loss of their functional effectiveness and ability to deliver ecosystem services or benefits to humans and the environment (Kotze *et al.,* 2008). The set relationships allow the provision of ecosystem services to be inferred from the determination of wetland health (PES) and presented as healthy wetland hectare equivalents. EIS scores results for each of the two HGM units are listed in Table 13.

Table 6: Ecological Importance and Sensitivity scores for wetland complexes

Wetland Complex	Parameter	Rating (0 -4)	Confidence (1 – 5)
HGM 1 (Channelled valley bottom wetland)	Ecological Importance & Sensitivity	**Low** (1.00)	3.14
	Hydrological / Functional Importance	**Low** (1.32)	2.00
	Direct Human Benefits	**Low** (1.03)	2.00
HGM 2 (Hillslope seepage wetland)	Ecological Importance & Sensitivity	**Low** (1.00)	3.2
	Hydrological / Functional Importance	**Low** (1.00)	2.00
	Direct Human Benefits	**Low** (1.33)	2.00

The low Ecological Importance and Sensitivity assigned to both HGM units can be attributed to the disturbed nature of the wetlands in the study area and the resultant low potential presence of species of conservation concern. The transformed and fragmented nature of the wetlands accompanied by the high density housing within the catchment resulted in the wetlands being utilised less as faunal corridors. Direct human benefits were associated with cattle and goat grazing and the cultivation of crops in a few small plots.

6. IMPACT ASSESSMENT AND MITIGATION

Any developmental activities in a natural system will have an impact on the surrounding environment, usually in a negative way. The purpose of this phase of the study was to identify and assess the significance of the impacts caused by the proposed development activities and to provide a description of the mitigation required so as to limit the perceived impacts on the natural environment.

6.1. Impact Assessment Methodology

The environmental impacts are assessed with mitigation measures (WMM) and without mitigation measures (WOMM) and the results presented in impact tables which summarise the assessment. Mitigation and management actions are also recommended with the aim of enhancing positive impacts and minimising negative impacts.

In order to assess these impacts, the proposed development has been divided into two project phases, namely the operation and decommissioning phase. The criteria against which these activities were assessed are discussed below.

Nature of the Impact

This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

Extent of the Impact

A description of whether the impact will be local, limited to the study area and its immediate surroundings, regional, or on a national scale.

Duration of the Impact

This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

Intensity

This indicates the degree to which the impact would change the conditions or quality of the environment. This was qualified as low, medium or high.

Probability of Occurrence

This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

Degree of Confidence

This describes the degree of confidence for the predicted impact based on the available information and level of knowledge and expertise. It has been divided into low, medium or high.

Table 7: Possible impacts arising during construction phase

Possible impact	Source of impact
Destruction of wetland habitat	Reshaping and construction activities of road within wetland habitat
Surface water pollution including sedimentation	Flooding of construction area; construction vehicles; construction camp within wetland habitat or wetland cathcments

Table 8: Possible impacts arising during operation phase

Possible impact	Source of impact
Increased erosion	Increased surface runoff

4.2.1 Construction Phase

4.2.1.a Destruction of wetland habitat through road construction and borrow pit activities

Extent	Duration	Intensity	Probability of occurrence	Significance		Confidence
				WOMM	WMM	
Local	Permanent	Medium	Probable	Medium	Low	High

Description of Impact

Footprint of new road could infringe or destroy wetland habitat and associated biota through removal of hydrophytic vegetation and or hydric soils.

Specific Mitigation Measures

- The design of drainage systems must ensure there is no contamination, eutrophication or increased erosion of the wetland areas. Drainage systems should be maintained regularly in order to minimise the runoff of harmful chemical substances into the wetland areas.

- The construction of surface stormwater drainage systems during the construction phase must be done in a manner that would protect the quality and quantity of the downstream system. The use of swales, which could then be grassed for the operational phase, is recommended as the swales can form part of a stormwater attenuation plan for the road upgrade.

- Stormwater outflows should not enter directly into a wetland. The velocity of water that may reach wetlands should be slowed before it is intercepted by virgin soils using a siltation and erosion control structure such as swales.

- Re-vegetation of disturbed areas must be undertaken with site indigenous species and in accordance with the instructions issued by the ECO. Areas where soil compaction or ruts developed should be rehabilitated. The following species could be utilised in each of the different wetland zones for rehabilitation:

    - Temporary zone: *Aristida junciformis; Conyza ulmifolia; Eriocaulon dregei; Fingerhuthia sesleriiformis; Gunnera perpensa; Helichrysum mundii; Imperata cylindrica; Miscanthus capensis; Miscanthus junceus; Paspalum scrobiculatum; Pennisetum macrourum; Pennisetum sphacelatum; Ranunculus meyeri; Ranunculus multifidus* and *Setaria sphacelata.*

    - Seasonal zone: *Andropogon appendiculatus; Arundinella nepalensis; Carex acutiformis; Carex cognata; Cladium mariscus; Cyperus digitatus; Cyperus latifolius; Cyperus longus; Eriocaulon dregei; Fimbristylis complanata; Fimbristylis dichotoma; Fingerhuthia sesleriiformis; Gunnera perpensa; Helichrysum mundii; Isolepis costata; Juncus dregeanus; Juncus exsertus; Juncus oxycarpus; Juncus punctorius; Kniphofia linearifolia; Limosella longiflora; Ludwigia palustris; Paspalum scrobiculatum; Pennisetum macrourum; Phragmites mauritianus; Pycreus mundii; Pycreus nitidus; Ranunculus meyeri; Ranunculus multifidus; Sacciolepis chevalieri; Schoenoplectus decipiens; Scleria welwitschii; Setaria sphacelata; Xyris capensis and Xyris congensis.*

- Permanent zone: *Arundinella nepalensis; Carex acutiformis; Carex cognata; Cladium mariscus; Cyperus digitatus; Cyperus latifolius; Fimbristylis dichotoma; Gunnera perpensa; Isolepis costata; Juncus dregeanus; Juncus exsertus; Juncus oxycarpus; Juncus punctorius; Kniphofia linearifolia; Limosella longiflora; Ludwigia palustris; Phragmites australis; Pycreus mundii; Pycreus nitidus; Ranunculus meyeri; Ranunculus multifidus; Sacciolepis chevalieri; Schoenoplectus decipiens and Scleria welwitschii.*

- The establishment and use of borrow pit areas, if required, are not permitted within wetland areas or within 30m of a wetland. The borrow pit areas should also not impact on the hydrology of wetland areas through increased run-off or desiccation of geo-hydrological pathways feeding the wetlands. Effective rehabilitation of the borrow pit areas must be implemented as soon as they are finished.

- After completion of the construction phase, a wetland monitoring program must be initiated that ensure that all wetland protection infrastructure and storm-water systems are properly installed and that all affected wetland areas are adequately rehabilitated.

- Avoid construction activities in wetlands at all cost through proper demarcation and appropriate environmental awareness training. The Contractor has a responsibility to inform all staff of the need to be vigilant against any practice that will have a harmful effect on wetlands. This information shall form part of the Environmental Education Programme to be effected by the Contractor, including the following:

    - No construction shall take place in areas of high sensitivity such as wetlands i.e. "NO-GO Areas". All no-go areas must be demarcated with red tape under guidance of the ECO.

    - Any proclaimed weed or alien species that germinates during the contract period shall be cleared by hand before flowering.

    - Infilling, excavation, drainage and hardened surfaces (including buildings and asphalt) should not occur in any of the wetland zones (i.e. permanent, seasonal or temporary), or within 30m of a wetland.

    - Should construction be contained to non-wetland areas, caution must be taken to ensure building materials are not dumped or stored within a delineated wetland buffer zone of 30m.

- Imported fill material should be monitored during and after construction for the presence of any alien species. Any such species should be removed immediately.

- Emergency plans must be in place in case of spillages into wetland systems.

- All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised, and be surrounded by bunds. It should also only be stored for the minimum amount of time necessary.

- Erosion control of all banks must take place so as to reduce erosion and sedimentation into river channels or wetland areas.

- Silt traps and culverts should be regularly maintained and cleared so as to ensure effective drainage.

- Littering and contamination of water sources during construction must be mitigated by effective construction camp management

- All construction materials including fuels and oil should be stored in a demarcated area that is contained within a bunded impermeable surface to avoid spread of any contamination (outside of wetlands or wetland buffer zones)

- Cement and plaster should only be mixed within mixing trays. Washing and cleaning of equipment should also be done within a bermed area, in order to trap any cement or plaster and avoid excessive soil erosion. These sites must be rehabilitated prior to commencing the operational phase.

4.2.1.b Surface water pollution

Extent	**Duration**	**Intensity**	**Probability of occurrence**	**Significance**		**Confidence**
				WOMM	WMM	
Local	Short	Low	Probable	Low	Low	High

<u>Description of Impact</u>

Hydrocarbons-based fuels or lubricants spilled from construction vehicles, construction materials that are not properly stockpiled, and litter deposited by construction workers may be washed into wetlands and surface water bodies. Stripping of topsoil will result in increased runoff of sediment from the site into watercourses associated with the study area. Should appropriate toilet facilities not be provided for construction workers at the construction crew camps, the potential exists for surface water resources and surrounds to be contaminated by raw sewage. While it is acknowledged that the impacts associated with the proposed activities will be negligible, every effort should still be taken so as to limit additional contributions.

Mitigation Measure

- Make use of existing roads and tracks where feasible, rather than creating new routes through vegetated areas;
- Vegetation and soil must be retained in position for as long as possible, and removed immediately ahead of construction / earthworks in that area (DWAF, 2005);
- Runoff from roads must be managed to avoid erosion and pollution problems. Where excessive loose sediment is created, attenuation swales and / or soils screens should be installed;
- Construction vehicles are to be maintained in good working order, to reduce the probability of leakage of fuels and lubricants;
- A walled concrete platform, dedicated store with adequate flooring or bermed area should be used to accommodate chemicals such as fuel, oil, paint, herbicide and insecticides, as appropriate, in well-ventilated areas;
- Storage of potentially hazardous materials should be above any 100-year flood line, or as agreed with the ECO. These materials include fuel, oil, cement, bitumen etc.;
- Sufficient care must be taken when handling these materials to prevent pollution;
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils;
- Oil residue shall be treated with oil absorbent such as Drizit or similar and this material removed to an approved waste site;
- Concrete, if used, is to be mixed on mixing trays only, not on exposed soil;
- Concrete and tar shall be mixed only in areas which have been specially demarcated for this purpose;
- All concrete and tar that is spilled outside these areas shall be promptly removed by the Contractor and taken to an approved dumpsite;
- After all the concrete / tar mixing is complete all waste concrete / tar shall be removed from the batching area and disposed of at an approved dumpsite;

- Storm water shall not be allowed to flow through the batching area. Cement sediment shall be removed from time to time and disposed of in a manner as instructed by the Consulting Engineer;
- All construction materials liable to spillage are to be stored in appropriate structures with impermeable flooring;
- Portable septic toilets are to be provided and maintained for construction crews. Maintenance must include their removal without sewage spillage;
- Portable septic toilets are to be located outside of the 1:100 year floodline;
- Under no circumstances may ablutions occur outside of the provided facilities;
- At all times care should be taken not to contaminate surface water resources;
- No uncontrolled discharges from the construction crew camps to any surface water resources shall be permitted. Any discharge points need to be approved by the relevant authority;
- In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water Affairs (DWA) must be informed immediately;
- Where construction in close proximity to sewer lines is unavoidable then excavations must be done by hand while at all times ensuring that the soil beneath the sewer lines is not destabilised;
- Store all litter carefully so it cannot be washed or blown into any of the water courses within the study area;
- Provide bins for construction workers and staff at appropriate locations, particularly where food is consumed;
- The construction site should be cleaned daily and litter removed;
- Conduct ongoing staff awareness programs so as to reinforce the need to avoid littering; and

▪ Backfill must be compacted to form a stabilised and durable blanket; and

▪ The current load above the sewer lines must at no time be exceeded.

4.2.2 Operational Phase

Increased erosion

Extent	Duration	Intensity	Probability of occurrence	Significance		Confidence
				WOMM	WMM	
Local	Permanent	Medium	Possible	Medium	Low	Medium

Description of Impact

Due to road widening and therefore increase in impermeable surfaces, there is an associated increase in flow velocities and erosion potential within affected wetland habitats. Runoff from the road surface may enter into the associated watercourse and wetlands, resulting in higher catchment runoff, wetland scouring and increased flooding of downstream areas. Increased runoff could potentially also affect existing erosion processes within catchments to such an extent that the newly constructed road itself is threatened in the medium to long term. Additionally, the incorrect choice of culvert structure may concentrate the water flow, and result in downstream erosion. Velocity breaking structures such as baffles should be placed on the downstream side of all culverts and piping. Other erosion interventions such as gabion mattresses and attenuation facilities should also be constructed where erosion potential have been identified. In anticipation of increased run-off regimes, wetland rehabilitation within a few localities are proposed to mitigate potential negative effects from the proposed development.

Mitigation Measure

- An ecologically-sensitive stormwater management plan should be developed that does not allow concentrated stormwater to enter into a wetland or watercourse directly, but instead makes use of flow diffusers and retention areas (such as artificial wetland areas, swales, baffles and gabion structures). It is highly recommended that the current “infill” areas (Figure 3) be utilised for stormwater attenuation and diffuse release infrastructure. The stormwater plan must include adequate attenuation facilities to ensure that peak flows do not cause negative impacts on wetlands. More specifically as a guideline:
    - Post development flows for frequent, average every afternoon type storm event 6 mm over 2 hours, will not exceed pre development flows.
    - Post development velocities associated with the 1:5 year return event storm will be within 25% of predevelopment velocities.
    - Stormwater release structures must be designed to release diffusely, mimicking seepage wetlands outside of the watercourse.

- Current erosion processes within HGM1, particularly major headcut erosion incising upstream will threaten the proposed development within the next or following rainy season. It is therefore highly recommended that rehabilitation initiatives as illustrated in Figure 4 be implemented in order to increase wetland functionality and reduce threats on the proposed investment. A concrete weir should be placed across the whole width of the valley bottom wetland in order to halt the headcut erosion processes. Further, in support of the concrete weir, a number of smaller gabion structures should be constructed as well as the partial re-establishment of the failed dam wall downstream, rewetting large sections of desiccated wetland habitat. This would not only help to halt the current erosion process but also increase the functionality of the wetland complex, thereby better coping with a likely increase in future stormwater and protecting investment. A detailed rehabilitation plan and stormwater management plan should be designed in conjunction with a wetland specialist.

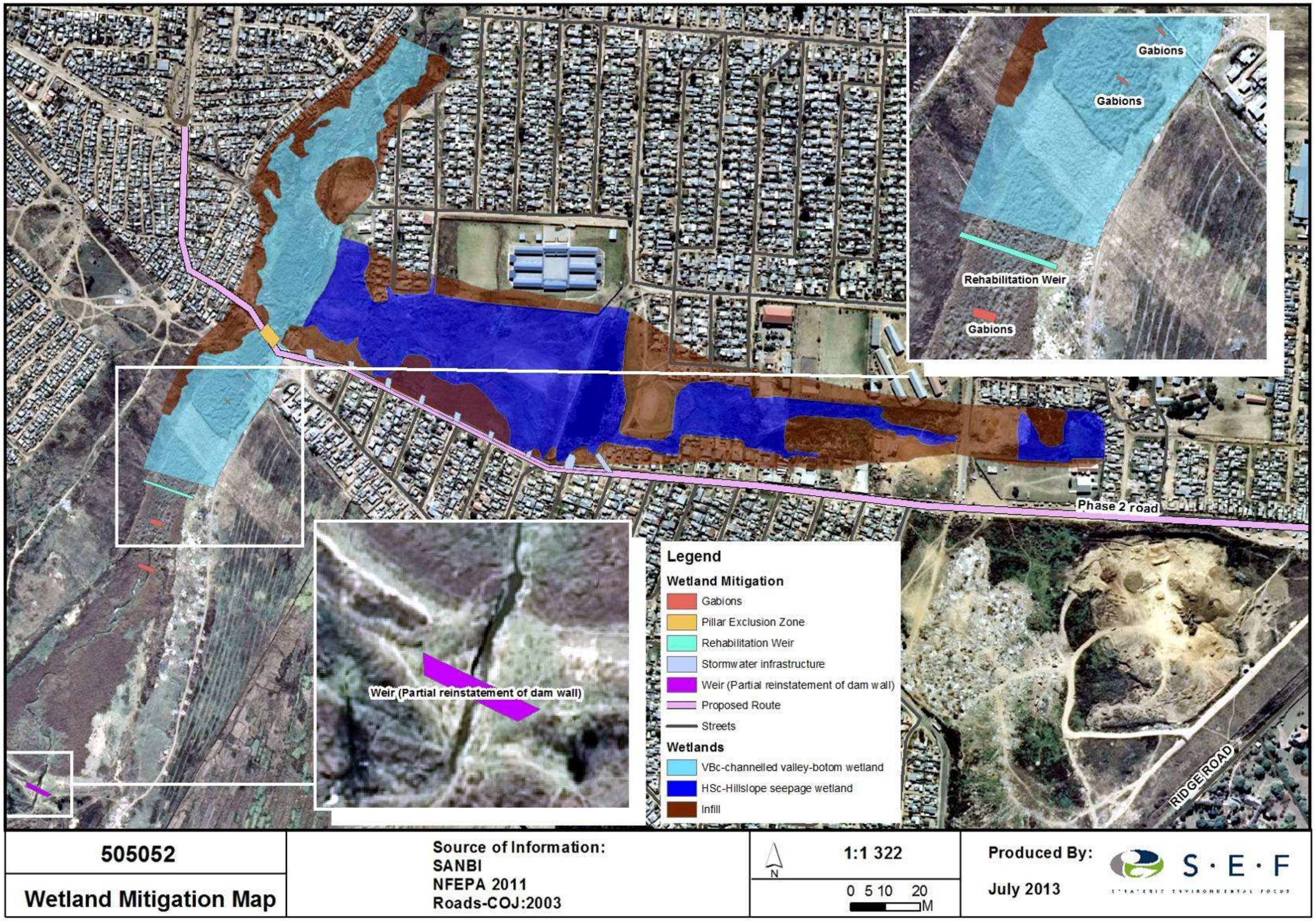


Figure 4: Map indicating positions of proposed wetland mitigation infrastructure

- The proposed placement of the free span bridge are well located at a narrow point in the valley (partly the result of historic infilling) which would facilitate the placement of supporting pillars outside of the macro stream channel. Figure 4 indicates the area, "pillar exclusion zone" that should not be utilised for pillar placement in order to avoid impacts on the surface hydrology of the stream. The proposed use of a free span bridge supported by pillars will ensure hydrological connectivity across wetland area, thus minimising any impact on hydrology. However, it is recommended that floodlines be determined for the water course to ascertain the accuracy of the above statement. If the results of a modelling exercise should indicate that flow concentration will occur during regular return flood events, the bridge design should be modified to prevent flow concentration.
- A wetland monitoring program should be initiated at the start of the construction phase. The monitoring program should be designed in situ with the wetland rehabilitation plan by a wetland specialist. The Environmental Control Officer should be briefed by a wetland specialist on specific monitoring issues. Appropriate mitigation needs to be implemented after consultation with relevant specialist if any problems are detected;

5. CONCLUSION

Two hydro-geomorphic types were delineated and classified into two different hydro-geomorphic units within the proposed study area. These included a valley bottom wetland with a channel and a hillslope seepage wetland which is connected to a watercourse. From a functional perspective, wetlands within the study area serve to improve habitat within and downstream of the study area through the provision of various ecosystem services. However, the low Ecological Importance and Sensitivity assigned to both HGM units that can be attributed to the disturbed nature of the wetlands, reduced their functionality.

Based on the proposed activity and taking into consideration the present state of the wetlands and their associated functionality and biodiversity, several potential impacts and mitigation measures were identified. Current erosion processes within HGM1, particularly major headcut erosion incising upstream will threaten the proposed development within the next or following rainy seasons. It is therefore highly recommended that a limited number of rehabilitation initiatives be implemented in order to increase wetland functionality and reduce threats on the proposed investment.

6. GLOSSARY

Alien species Plant taxa in a given area, whose presence there, is due to the intentional or accidental introduction as a result of human activity.

Biodiversity Biodiversity is the variability among living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biome A major biotic unit consisting of plant and animal communities having similarities in form and environmental conditions, but not including the abiotic portion of the environment.

Buffer zone A collar of land that filters edge effects.

Conservation The management of the biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations. The wise use of natural resources to prevent loss of ecosystems function and integrity.

Critically Endangered A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

Ecosystem Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space.

Ecological Corridors Corridors are roadways of natural habitat providing connectivity of various patches of native habitats along or through which faunal species may travel without any obstructions where other solutions are not feasible.

Edge effect Inappropriate influences from surrounding activities, which physically degrade habitat, endanger resident biota and reduce the functional size of remnant fragments including, for example, the effects of invasive plant and animal species, physical damage and soil compaction caused through trampling and harvesting, abiotic habitat alterations and pollution.

Endangered A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

Exotic species Plant taxa in a given area, whose presence there, is due to the

	intentional or accidental introduction as a result of human activity
Fauna	The animal life of a region.
Flora	The plant life of a region.
Forb	A herbaceous plant other than grasses.
Habitat	Type of environment in which plants and animals live.
Indigenous	Any species of plant, shrub or tree that occurs naturally in South Africa.
Invasive species	Naturalised alien plants that have the ability to reproduce, often in large numbers. Aggressive invaders can spread and invade large areas.
Outlier	An observation that is numerically distant from the rest of the data
Primary vegetation	Vegetation state before any disturbances such as cultivation, overgrazing or soil removal
Threatened	Species that have naturally small populations, and species which have been reduced to small (often unsustainable) population by man's activities.
Red data	A list of species, fauna and flora that require environmental protection. Based on the IUCN definitions.
Species diversity	A measure of the number and relative abundance of species.
Species richness	The number of species in an area or habitat.
Vulnerable	A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

7. REFERENCES

Boto, K G, and Patrick, W H, 1979. Role of wetlands in removal of suspended sediments. In: GREESON P E, CLARK J R, and CLARK J L, (eds.) *Wetland functions and values: the state of our understanding.* American Water Resources Association, Minneapolis, Minnesota.

Collins, N.B. (2005). Wetlands: The basics and some more. *Free State Department of Tourism, Environment and Economic Affairs*.

Cronk, J K, and Siobhan Fennessy, M, 2001. *Wetland Plants: Biology and Ecology*. Lewis Publishers.

Department of Water Affairs and Forestry (2003) National Water Resource Strategy (Final draft). *Department of Water affairs and Forestry*. Pretoria. South Africa.

Department of Water Affairs and Forestry. (2005) A practical field procedure for identification and delineation of wetlands and riparian areas*. Department of Water affairs and Forestry.* Pretoria. South Africa.

Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N., (2011). Implementation Manuel for Freshwater Ecosystem Priority Areas. Water Research Commission. Pretoria. South Africa.

Dynesius, M. and Nilsson, C., (1994). Fragmentation and flow regulation of river systems in the northern third of the world. *Science* 266, 753– 762.

Ewel C, (1997). Water quality improvement by wetlands In: DAILY G. (Ed.) *Nature's Services: Societal Dependence on Natural Ecosystems*, Island Press: Washington DC.

Gren I, (1995). 'The value of investing in wetlands for nitrogen abatement', *European Review of Agricultural Economics* 22: 157-172.

Hemond, H F, and Benoit, J, 1988. Cumulative impacts on water quality functions of wetlands. *Enviornmental Management* 12: 639-653.

Keddy, P A, 2002. Wetland Ecology: Principles and Conservation*.* Cambridge University Press

Kotze, D.C., Marneweck G.C., Bachelor, A.L., Lyndley, D.S. & Collins, N.B. (2005). Wet-EcoServices. South African National Botanical Institute. Pretoria. South Africa.

McCarntey, M P, (2000). The influence of a headwater wetland on downstream river flows in sub-Saharan Africa. In: Land-Water Linkages in Rural Watersheds Electronic Workshop*. 18 September – 27 Ocober.* Food and Agriculture Organization of the United Nations, Rome, Italy.

McCartney, M P, Neal, C, and Neal, M, (1998). Use of deuterium to understand runoff generation in a headwater catchment containing a dambo. *Hydrol. Earth Syst. Sci. 5: 65-76*

Mucina, L. & Rutherford, M.C. (2006): The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia 19. South African National Biodiversity Institute*, Pretoria.

Muscutt, A. D., Harris G L, Bailey S W, and Davies D B, (1993). Buffer zones to improve water quality: a review of their potential use in UK agriculture. *Agriculture, Ecosystems and Environment* 45: 59-77.

Nel, J., Maree, G., Roux, D., Moolman, J., Kleynhans, N., Silberbauer, M. & Driver, A. (2004). South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 2: River Component. CSIR Report Number ENV-S-I-2004-063. Council for Scientific and Industrial Research, Stellenbosch

Ogden, R. and Thoms, M.C., (2002). The importance of inundation to floodplain soil fertility in a large semi-arid river. *Internationale Vereinigung fur Theoretishce und Angewandte Limnologie* 28, 744– 749.

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.

Postel, S. and Carpenter, S. (1997). Freshwater ecosystem services In: Daily G (Ed.) *Nature's Services: Societal Dependence on Natural Ecosystems*, Island Press: Washington DC.

Rogers F E, Rogers K H and Buzer J S. (1985). Wetlands for wastewater treatment: with special reference to municipal wastewaters. WITS University Press, Johannesburg.

Rutherford, M. C. & Westfall, R. H. (1994): *Biomes of Southern Africa: an objective categorisation*, Pretoria: National Botanical Institute.

Soil Classification Working Group (1991). Soil classification. A taxonomic system for South Africa, Mem. agric. nat. Resour. S. Afr. No. 15. Dept. Agric. Dev., Pretoria.

SoilKraft. (2006). Roads projects in Blaauwbosch, Johnstown, Madadeni and Osizweni. Geotechnical report for the contruction of three roads and two bridges.

Thompson N, Marneweck G, Bell S, Kotze D, Muller J, Cox D, and Clark R. (2002). A methodology proposed for a South African national wetland inventory. Division of Water, Environment and Forest Technology, CSIR, Pretoria

VanOorschot, M., Hayes, M., Strien, I.V., (1998). The influence of soil desiccation on plant production, nutrient uptake and plant nutrient availability in two French floodplain grasslands. Regulated Rivers: Research and Management 14, 313–327

WRP, (1993). Wetland groundwater processes. WRP Technical Note HY-EV-2.2.

APPENDIX A

Wetland delineation methodology

The report incorporated a desktop study, as well as field surveys, with site visits conducted during July 2013. Additional data sources that were incorporated into the investigation for further reliability included:

- Google Earth images;
- 1:50 000 cadastral maps; and
- Ortho-rectified aerial photographs.

Identified wetland areas were marked digitally using GIS (changes in vegetation composition within wetlands as compared to surrounding non-wetland vegetation show up as a different hue on the orthophotos, thus allowing the identification of wetland areas). These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field surveys.

The wetland delineation methodology used was the same as the one set out by the Department of Water affairs and Forestry (DWAF, 2005) document "*A Practical field procedure for the identification and delineation of wetlands and riparian areas"*.

The Department of Water affairs and Forestry (DWAF) wetland delineation guide makes use of indirect indicators of prolonged saturation by water, namely wetland plants (hydrophytes) and (hydromorphic) soils. The presence of these two indicators is indicative of an area that has sufficient saturation to classify the area as a wetland. Hydrophytes were recorded during the site visit and hydromorphic soils in the top 0.5 m of the profile were identified by taking cored soil samples with a bucket soil auger and Dutch clay auger (photographs of the soils were taken). Each auger point was marked with a handheld Global Positioning System (GPS) device. All cored samples were analysed for signs of wetness that indicate wetland associated conditions. Areas denuded of primary vegetation often corresponded to areas that have been tilled, making vegetation and soil profiles poor wetland indicators.

The methodology "*Wet-EcoServices"* (Kotze *et al,* 2005) was adapted and used to assess the different benefit values of the wetland units. An adapted level two assessment, including a desktop study and a field assessment were performed to determine the wetland functional benefits between the different hydro-geomorphological types within the study area. Other documents and guidelines used are referenced accordingly. During the field survey, all possible wetlands and drainage lines identified from maps and aerial photos were visited on foot. Where feasible, cross sections were taken to determine the state and boundaries of the wetlands.

Following the field survey, the data was submitted to a GIS program for compilation of the map sets. Subsequently the field survey and desktop survey data were combined within a single project report.

In order to gauge the Present Ecological State of various wetlands within the study area, a level 1 and level 2 Wet-Health assessments were applied in order to assign PES categories to certain wetlands. Wet-Health (Macfarlane *et al., 2*009) is a tool which guides the rapid assessment of a wetland's environmental condition based on a site visit. This involves scoring a number of attributes connected to the geomorphology, hydrology and vegetation, and devising an overall score which gives a rating of environmental condition.

Wet-Health is useful when making decisions regarding wetland rehabilitation, as it identifies whether the wetland is beyond repair, whether rehabilitation would be beneficial, or whether intervention is unnecessary, as the wetland's functionality is still intact. Through this method, the cause of any wetland degradation is also identified, and this facilitates effective remediation of wetland damage. There is wide scope for the application of Wet-Health as it can also be used in assessing the Present Ecological State of wetlands and thereby assist in determining the Ecological Reserve as laid out under the National Water Act. Wet-Health offers two levels of assessment, one more rapid than the other.

For the assessments, an impact and indicator system is used. The wetland is first categorized into the different hydrogeomorphic (HGM) units and their associated catchments, and these are then assessed individually in terms of their hydrological, geomorphologic and vegetation health by examining the extent, intensity and magnitude of impacts, of activities such as grazing or draining. The extent of the impact is measured by estimating the proportion the wetland that is affected. The intensity of the impact is determined by looking at the amount of alteration that occurs in the wetland due to various activities. The magnitude is then calculated as the combination of the intensity and the extent of the impact and is translated into an impact score. This is rated on a scale of 1 to 10, which can be translated into six health classes (A to F – compatible with the Ecostatus categories used by DWAF, Table 9). Threats to the wetland and its overall vulnerability can also be assessed and expressed as a likely Trajectory of Change.

Table9: Interpretation of scores for determining present ecological status (Kleynhans 1999)

Rating of Present Ecological State Category (PES Category)
CATEGORY A Score: 0-0.9; Unmodified, or approximates natural condition.
CATEGORY B Score: 1-1.9; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C Score: 2 – 3.9; Moderately modified, but with some loss of natural habitats.
CATEGORY D Score: 4 – 5.9; Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E Score: 6 -7.9; Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F Score: 8 - 10; Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean

Determination of Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table 10. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 11.

Table10: Example of scoring sheet for Ecological Importance and sensitivity

ECOLOGICAL IMPORTANCE AND SENSITIVITY:			
Ecological Importance	Score (0-4)	*Confidence (1-5)*	**Motivation**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rareity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			

	Direct Human Benefits		Score (0-4)	*Confidence (1-5)*
Subsistence benefits	***Water for human use***	*The provision of water extracted directly from the wetland for domestic, agriculture or other purposes*		
	Harvestable resources	*The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.*		
	Cultivated foods	*Areas in the wetland used for the cultivation of foods*		
Cultural benefits	***Cultural heritage***	*Places of special cultural significance in the wetland, e.g., for baptisms or gathering of culturally significant plants*		
	Tourism and recreation	*Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife*		

	Education and research		*Sites of value in the wetland for education or research*		
			TOTAL OVERALL SCORE AND CONFIDENCE:		

Table11: Category of score for the Ecological Importance and Sensitivity

Rating	Explanation
Very low (0-1)	Rarely sensitive to changes in water quality/hydrological regime.
Low (1-2)	One or a few elements sensitive to changes in water quality/hydrological regime.
Moderate (2-3)	Some elements sensitive to changes in water quality/hydrological regime.
High (3-3.5)	Many elements sensitive to changes in water quality/ hydrological regime.
Very high (+3.5)	Very many elements sensitive to changes in water quality/ hydrological regime.