Wetland Study

Exxaro
Belfast Implementation Project: Resettlement Site

GroundTruth

Water, Wetlands and Environmental Engineering

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[1] Project deliverables (including electronic copies) comprise *inter alia:* reports, maps, assessment and monitoring data, ESRI ArcView shapefiles, and photographs.

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List of Acronyms

Acronym	Explanation
BIP	Belfast Implementation Project
CEMP	Construction Environmental Management Plan
CR	Critically Endangered
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EDTEA	Department of Economic Development, Tourism and Environmental Affairs
EIS	Ecological Importance and Sensitivity
EN	Endangered
ETS	Ecosystem Threat Status
GIS	Geographic Information System
Gm	Mesic Highveld Grassland
Gm12	Eastern Highveld Grassland
GPS	Global Positioning System
Ha equiv	Hectare Equivalents
HGM	Hydrogeomorphic
MAP	Mean Annual Precipitation
NFEPA	National Freshwater Ecosystem Priority Areas
NP	Not protected
PES	Present Ecological State
PET	Potential Evapotranspiration
PGS	Present Geomorphic State
PHS	Present Hydrological State
PVS	Present Vegetation State
SANBI	South African National Biodiversity Institute
WCS	Wetland Consulting Services
WT	Wetland Type

1. INTRODUCTION

Local, regional and national regulatory bodies, such as the Departments of Water and Sanitation (DWS), have adopted legislation, policies and guidelines that regulate the use of freshwater ecosystems to protect and maintain these systems' benefits and services to society and the natural environment. In order to be regulated, these systems must first be identified, delineated and assessed.

The objective of the delineation procedure is to identify the boundary between the freshwater ecosystems and adjacent terrestrial areas. The process of freshwater ecosystem delineation identifies the extent of these ecosystems based on the following legal definitions[2]:

- *"Wetland means 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."*
- *"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."*

Hydrology is considered to be the primary biophysical driver of freshwater ecosystems, but due to its variability, it is not possible to efficiently and accurately delineate these systems based on water levels (Richardson and Vepraskas, 2001). The delineation of wetland/riparian habitat therefore, relies on indirect indicators, such as wetland/riparian vegetation, topography and soils.

Exxaro Coal Mpumalanga (Pty) Ltd. (hereafter referred to as Exxaro) is in the developmental phases of the Belfast Implementation Project (BIP). The BIP is located approximately 8 km to the south of Belfast town in the Mpumalanga province (**Figure 1-1**), with the proposed plant site located within Portions 6, 7, 9 and 10 of the Farm Blyvooruitzicht 383 JT (newly consolidated Portion 23 Blyvooruitzicht 383 JT). One of the consequences of the proposed mining development is the need to resettle a small community that currently resides within the mining site. The resettlement site that has been identified is Zoekop Farm 426 JS Portion 13, Leeuwbank Farm 427 JS Portion 13 and Paardeplaats Farm 425 JS Portion R (the study site) (**Figure 1-1**). However, before any formal planning and developments can be undertaken, a wetland study is required to identify, delineate and assess any wetland habitat that might potentially be affected by the proposed residential development. In order to inform the proposed development, and minimise impacts on wetland ecosystems, GroundTruth was requested to delineate and assess the wetlands within study site near Belfast, Mpumalanga. The details of the delineation and assessment of the identified wetlands are outlined in this report.

[2] As per the National Water Act (Act No. 36 of 1998)

Figure 1-1 Location of the study site in relation to Phase 1 mining site

2. STUDY SITE

The following section provides an overview of the study site, focusing on the regional context, climate, and wetland types.

2.1. Regional context

South Africa is a semi-arid country, and thus wetlands are important features within the landscape as they provide ecosystem services directly related to water quantity and quality. Approximately 300 000ha of wetlands or 2.4% of South Africa's surface area remain. It is estimated that over 50% of South Africa's wetlands have been lost (Kotze et al. 1995), and of the remaining systems, 48% are classified as critically endangered (Nel and Driver 2012). The loss of wetland habitat is considered to be of concern due to the value of wetlands in terms of contributions to water quantity and quality, supporting unique biological diversity and other ecosystem services (Kotze et al. 2007).

2.2. Climate

The study site falls within the B41A quaternary catchment, as defined by Midgley et al. (1994). The Mean Annual Precipitation (MAP) for B41A is 714.7mm and Potential Evapotranspiration (PET) is 1863.5mm (Schulze 2007), which suggests that the wetlands within the catchment would have a **Moderately High** sensitivity (Macfarlane et al. 2007) to hydrological impacts within the catchment.

2.3. Vegetation types

Under natural conditions the surrounding landscape and study site would have been characterised by particular vegetation types. The historical dominant vegetation type present would have been Eastern Highveld Grassland (Gm12) Group 12, which falls under the Mesic Highveld Grassland (Gm) Group 4 bioregion (Mucina and Rutherford 2006; Nel et al. 2011). The vegetation type has been classified as 'endangered', with less than 0.3% receiving formal protection. Of the remaining 56% only a small percentage is statutorily protected in reserves including Kwaggavoetpad, Van Riebeeck Park, Bronkhorstspruit and in private conservation areas including Doornkop and Mpophomeni. This vegetation type extends through the Mpumalanga and Gauteng provinces between Belfast and the eastern side of Johannesburg. The vegetation commonly occurs between 1520 – 1780m, but can commonly be found at lower altitudes. The greatest threats to this vegetation type can be attributed to cultivation, plantations, urbanisation and dam-building. Poor land management has resulted in continued degradation of significant portions of this land cover (Mucina and Rutherford 2006), which is evident within the study site as a result of dam-building and the encroachment of alien invasive plant species.

2.4. Wetland classification

To allow for the differentiation between wetland systems and the prioritisation of systems either for conservation or management purposes, the wetlands identified within the study site were classified in accordance with the South African National Biodiversity Institute's (SANBI) wetland classification system (**Table 2-1**) (Ollis et al. 2013). However, for the purpose of assessing the

Hydrogeomorphic (HGM) units, Kotze et al. (2007) was used to classify the wetland systems as HGM units (**Appendix 1**) rather than Level 4 of the SANBI system. The HGM unit types defined by Kotze et al. (2007) differ from Ollis et al. (2013), with the river classification being excluded and flat wetlands being grouped with the depression wetlands. The HGM units identified within the study site have been classified as a hillslope seep linked to a stream channel, an isolated hillslope seep and a depression wetland (**Table 2-1Error! Reference source not found.**).

Table 2-1 A description of the onsite wetlands based on the SANBI classification (Ollis et al. 2013) and Kotze et al. 2007.

System (Level 1)	Bioregion (Level 2)	Landscape Unit (Level 3)	HGM Unit (Level 4)	Description of HGM Units (Kotze et al. 2007)
Inland systems	Mesic Highveld Grassland (GM) Bioregion	Slope and Valley Floor landscape units	**Depressions (including Pans)**	
			Pan	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, and therefore this type is usually isolated from the stream channel network.
		Slope landscape units	**Hillslope seep**	
			Linked to a stream channel	Slopes on hillsides, which are characterised by the colluvial (transport by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined steam channel connecting the area directly to a steam channel
			Isolated	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 either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel

2.5. Threat status of the wetlands

The wetland types fall within the Mesic Highveld Grassland (GM) bioregion, as described in **Section 2.3**. Based on the wetlands and vegetation types, and the level of protection these systems receive, the ecosystem threat status can be assessed (Nel et al. 2011). **Table 2-2** depicts the HGM units found within the study site and the corresponding threat status.

Table 2-2 HGM units classified according to their threat status and level of protection (adapted from Nel et al. 2011)

Wetland Type (WT) / HGM Unit	Ecosystem Threat Status (ETS) per WT	Level of Protection (WT)	ETS per Wetland Vegetation Group
Depressions	Critically Endangered (CR)	Not Protected (NP)	CR
Seepage wetlands	Endangered (EN)	NP	CR

The wetlands within the study area have been classified as ‘critically endangered’ and ‘endangered’ ecosystem types. Critically endangered ecosystem types are ecosystems that have very little of their original extent left in a natural or near-natural state. Most of the ecosystem type has been moderately or severely modified from its natural condition and it is likely that most of the natural structure, functioning and species associated with the ecosystem may have been lost (Nel et al. 2011). Endangered ecosystems are those that are near critically endangered. Further degradation of these ecosystem types should be avoided and the remaining healthy examples should be conserved. The wetland habitat within the study area is relatively intact despite modifications to the systems. It is therefore important that no further degradation to the onsite systems occurs.

2.6. National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) is a tool developed to assist in the conservation and sustainable use of South Africa’s freshwater ecosystems, including rivers, wetlands and estuaries. Nel et al. (2011) classified the freshwater ecosystems according to their Present Ecological State ‘AB’, ‘C’, and ‘DEF’ or ‘Z’ (**Table 2-3**).

Table 2-3 Description of NFEPA wetland condition categories
(Nel et al. 2011)

PES equivalent	NFEPA condition	Description	% of total national wetland area*
Natural or Good	AB	Percentage natural land cover ≥ 75%	47
Moderately modified	C	Percentage natural land cover 25-75%	18
Heavily to critically modified	DEF	Riverine wetland associated with a D, E, F or Z ecological category river	2
	Z1	Wetland overlaps with a 1:50 000 ‘artificial’ inland water body from the Department of Land Affairs: Chief Directorate of Surveys and Mapping (2005-2007)	7
	Z2	Majority of the wetland unit is classified as ‘artificial’ in the wetland locality GIS layer	4
	Z3	Percentage natural land cover ≤ 25%	20

*this percentage excludes unmapped wetlands, including those that have been irreversibly lost

According to the available NFEPA wetlands and rivers coverage, some of the systems within the surrounding landscape have been classified as NFEPA wetlands or rivers (**Figure 2-1**) based on numerous criteria, including:

- Wetlands within the sub-quaternary catchment that have sightings or breeding areas for cranes;

- The river condition used by NFEPA is considered to be an 'AB' condition, and therefore is considered to be intact enough to contribute towards river ecosystem biodiversity targets.

In this instance the wetlands occur within a sub-quaternary catchment containing records of crane species, an avifaunal study was conducted in early 2015 to confirm species. Continuous monitoring of such species will be implemented. The main river systems within the broader landscape, which are hydrologically isolated from the study site, include the Klein-Komati River (the eastern tributary) and the Witkloofspruit River (the western tributary). The Klein-Komati River and Witkloofspruit River have been identified as freshwater ecosystem priority areas as they are considered to be in an A/B condition (largely natural with few modifications) by NFEPA (Nel et al. 2011). This does, however, differ from the PES 1999 study (Kleynhans 2000), that classified both rivers as class C (moderately modified).

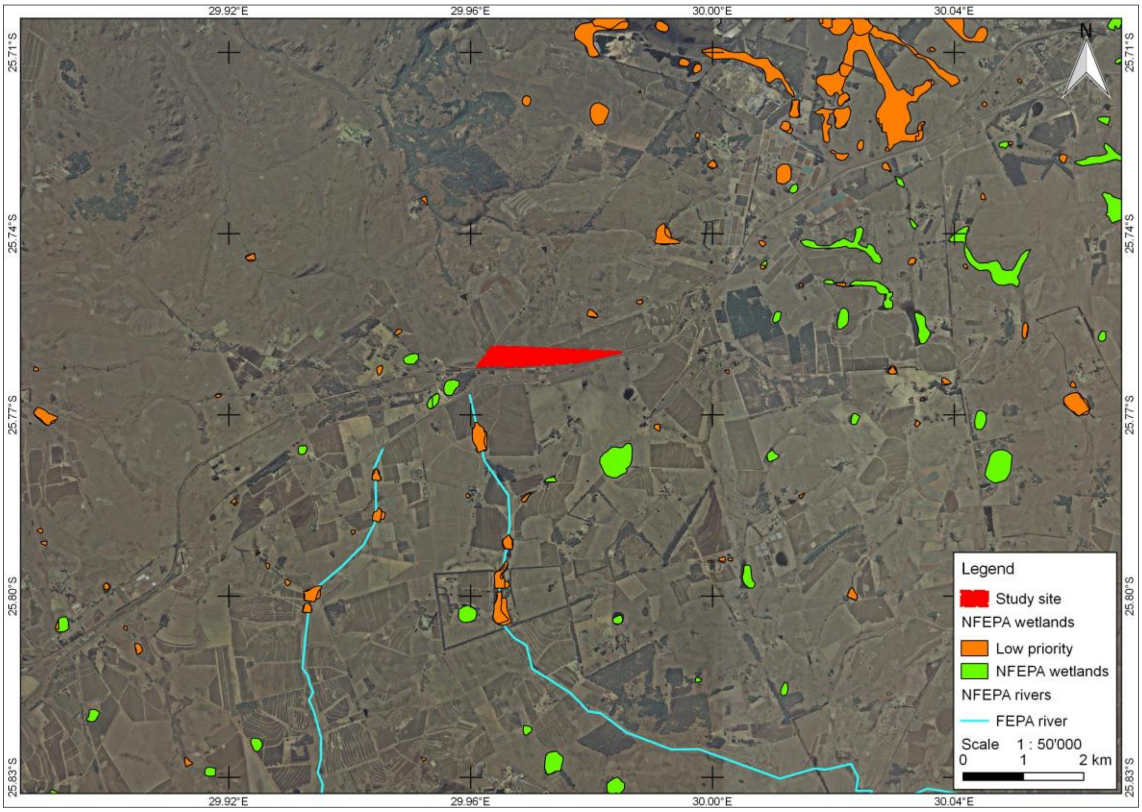


Figure 2-1 Overview of NFEPA systems within the greater study area

3. STUDY TEAM

Due to the nature of the study, the project team included personnel with experience in delineating and assessing wetland ecosystems (**Table 3-1**).

Table 3-1 Team members, roles, and experience levels

Practitioner	Roles in the Study	Experience Levels	Qualifications
Craig Cowden	• Delineation of wetlands; • Conducting the infield wetland assessments; and • Review of the project report.	16 years' experience, with input into various wetland studies, including: • Delineation and assessments; • Rehabilitation planning; and • Mitigation & offset requirements.	B.Sc. (Agric.) Pr.Sci.Nat – Ecology
Fiona Eggers	• Wetland assessments for the post-development scenario; • GIS mapping; and • Compilation of the project report.	5 years' experience with input into various wetland studies: • Delineation and assessments, • Rehabilitation planning; and • Mitigation & offset requirements.	M.Sc. (Botany) Pr.Sci.Nat. - Ecology
Matt Janks	• Wetland delineation; • Conducting the infield wetland assessment; • GIS mapping; and • Compilation of the project report.	1 years' experience, with input into various wetland studies, including: • Delineation; • Assessments; and • Monitoring and evaluation	M.Sc. (Botany)

4. METHODOLOGY

This section of the report provides an overview of the methodology adopted to assess those wetland ecosystems associated with the proposed development.

4.1. Site visit

A site visit was conducted on the 26th of November 2015 and the 10th March 2016 to verify the extent of wetland habitat within the study site and assess the current level of ecological integrity and ecosystem services provided by the wetland habitat.

4.2. Delineation of wetland ecosystems

The wetland habitat identified within the study site was delineated infield in accordance with the DWS guideline document (DWAF 2005). The derived boundaries were determined at appropriate intervals within the study area, and recorded using a mapping grade Global Positioning System (GPS)[3]. The subsequent information was used to inform the production of a Geographic Information System (GIS) spatial coverage of the boundaries of the wetland habitat. In accordance with the preferences of the regional DWS, the study also attempted to identify and/or describe the zones of wetness within the study site (**Figure 4-1**).

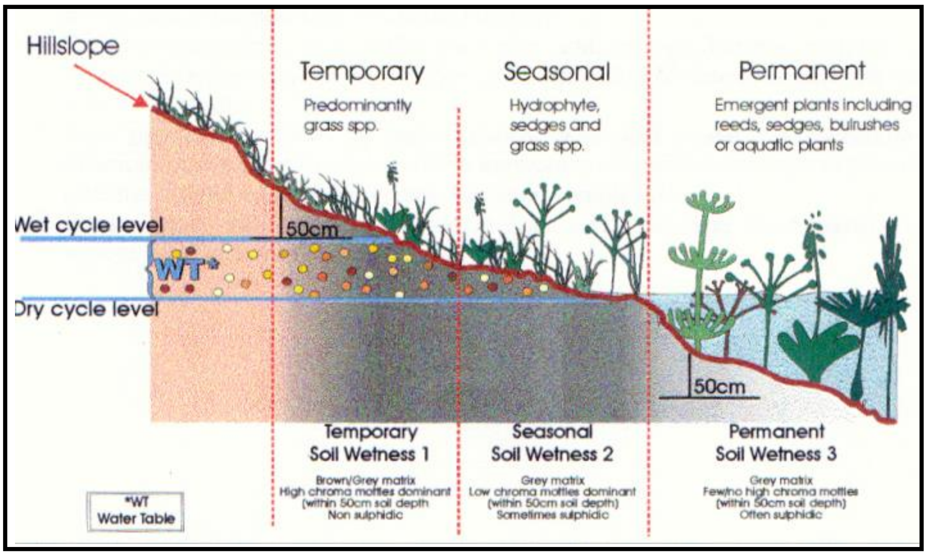


Figure 4-1 Wetness zones within wetland ecosystems
(DWAF 2005)

4.3. Assessment of wetland functioning and condition

The assessment of the HGM units was derived by evaluating the level of ecosystem functioning and ecological integrity/condition of the identified wetlands and are outlined in the following sections.

[3] Ashtech Mobile Mapper 10 handheld unit, a professional sub-meter accurate receiver

4.3.1. Assessment of wetland functioning

At the outset of the assessment, the wetland systems identified during the delineation study were classified as specific HGM units. To quantify the level of functioning of the wetland systems, and to highlight their relative importance in providing ecosystem benefits and services at a landscape level, a WET-EcoServices (Kotze et al. 2007) assessment was performed for the HGM units within the study site. The WET-EcoServices assessment technique focuses on assessing the extent to which a benefit is being supplied by each wetland system, based on both:

- The opportunity for the wetland to provide the benefits; and
- The effectiveness of the particular wetland in providing the benefit.

Ecosystem services, which include direct and indirect benefits to society and the surrounding landscape, were assessed by rating various characteristics of the wetland and its surrounding catchment, based on the following scale:

- Low (0);
- Moderately Low (1);
- Intermediate (2);
- Moderately High (3); and
- High (4)

The scores obtained from these ratings for the wetland HGM units were then incorporated into WET-EcoServices scores for each of the fifteen ecosystem services (**Table 4-1**):

Table 4-1 Ecosystem services supplied by wetlands
(Kotze et al. 2007, p14)

Ecosystem services supplied by wetlands	**Indirect benefits**	**Regulating and supporting benefits**		Flood attenuation	The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream
				Stream flow regulation	Sustaining stream flow during low flow periods
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation
				Carbon storage	The trapping of carbon by the wetland, principally as soil organic matter
	Direct benefits	**Biodiversity maintenance**			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity
		Provisioning benefits		Provision of water for human use	The provision of water extracted directly from the wetland for domestic, agricultural or other purposes
				Provision of harvestable resources	The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
				Provision of cultivated foods	The provision of areas in the wetland favourable for the cultivation of foods
		Cultural benefits		Cultural heritage	Places of special cultural significance in the wetland, e.g. for baptism 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

It should be noted that Wet-EcoServices assists in identifying the importance and sensitivity of specific wetlands, but is recognised as having limitations in terms of:

- Quantifying specific impacts linked to development or changes within the landscape; and
- Accounting for the size of the wetland and ecosystem services strongly associated with the size of the systems.

4.3.2. Ecological Importance and Sensitivity

In accordance with DWAF (1999), the ecological importance of a water resource provides an expression of its importance to the maintenance of ecological diversity and functioning at local and wider scales (DWAF 1999). As WET-EcoServices does not provide a consolidated score that can be used as a target, the current assessment scores were incorporated into the Ecological Importance and Sensitivity (EIS) assessment datasheets to provide an EIS score based on scores for ecological importance and sensitivity, hydro-functional importance, and direct human benefits (DWA 2013). **Table 4-2** provides an overview of the ratings used to interpret the derived EIS scores.

Table 4-2 Ecological Importance and Sensitivity Classes
(DWA 2013, p43)

Ecological Importance and Sensitivity Categories	**Range of EIS Score**	**EIS Class**
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	4	**A**
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quality and quantity of water in major rivers.	>3 and <4	**B**
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major river.	>2 and </=3	**C**
Low/Marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>1 and </=2	**D**
None: Wetlands that are rarely sensitive to changes in water quality/hydrological regime.	0	**E**

4.3.3. Assessment of wetland condition/integrity

To determine the level of ecological integrity, a WET-Health (MacFarlane et al. 2007) assessment was performed for the HGM units within the study site. The WET-Health assessment technique gives an indication of the deviation of the systems from the wetlands' natural reference condition for the following biophysical drivers:

- Hydrology - defined as the distribution and movement of water through a wetland and its soils;
- Geomorphology - defined as the distribution and retention patterns of sediment within the wetland; and
- Vegetation - defined as the vegetation structural and compositional state.

The impacts on the wetlands, determined by features of the wetlands and their catchments, for the current scenario, was scored based on the impact scores and then represented as Present State Categories as outlined in WET-Health (**Table 4-3**).

Table 4-3 Impact scores and present state categories for describing the present state of wetlands
(MacFarlane et al. 2007, p30)

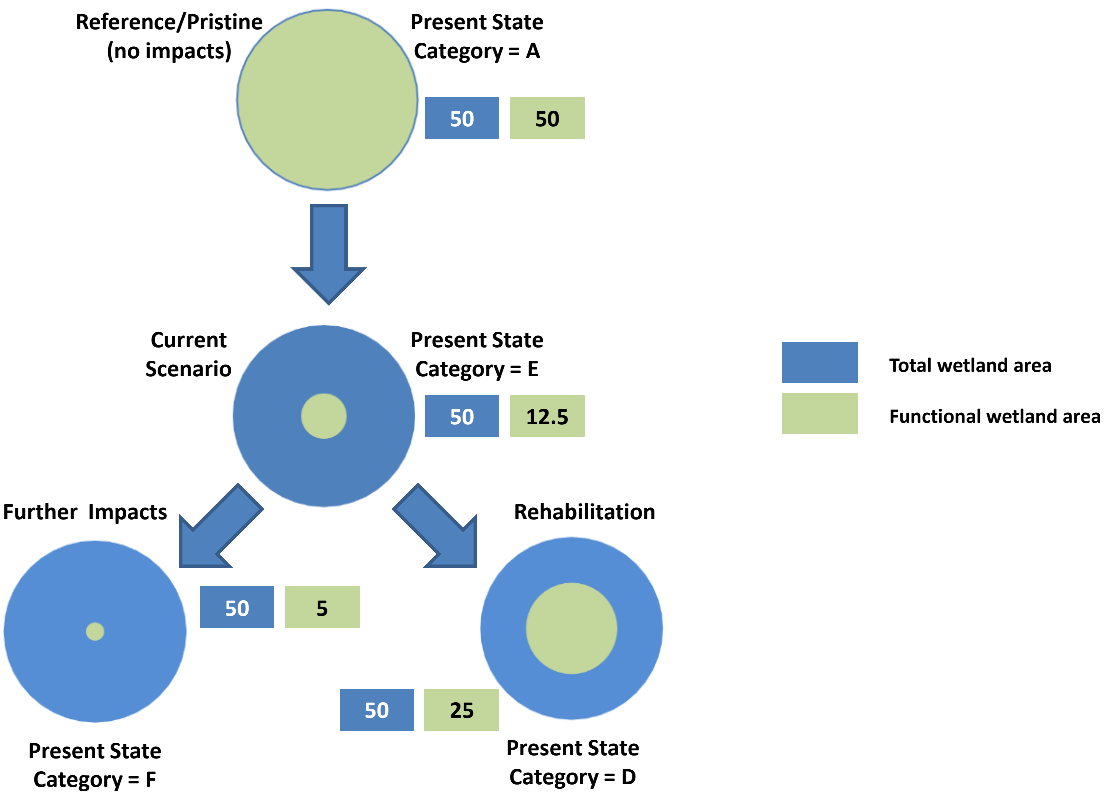
Impact Category	Description	Impact Score Range (0-10)	Present State Category
None	Unmodified, natural.	0-0.9	**A**
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	**B**
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	**C**
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	**D**
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	**E**
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	**F**

The scores for hydrology, geomorphology and vegetation were simplified into a composite impact score, using the predetermined ratio of 3:2:2 (MacFarlane et al. 2007), respectively for the three components. The composite impact score was used to derive a health score that then provided the basis for the calculation of hectare equivalents (also referred to as functional area), which can be described as the health of the wetland expressed as an area. Cowden and Kotze (2007) make use of a simple example to explain the concept of hectare equivalents conceptually illustrated in **Box 4-1**.

Box 4-1. Example of the use of hectare equivalents to represent changes in wetland health.

The assessment of wetland health is based on comparisons to a reference state *i.e.* where the wetland's health is unmodified and the functional area of wetland is equivalent to the full extent of the system. For example, if the health of a 50ha wetland is 100% (*Present State Category=A*) this equates to 50 hectare equivalents. In many instances the current scenario for a particular system reflects some form of historical degradation. If the abovementioned wetland was *seriously* degraded, the health would be reduced from the reference state to 25% (*reflecting a wetland health score of 2.5*); a drop in hectare equivalents from 50 to 12.5 (50ha x 0.25) hectare equivalents would be recorded. The following would therefore be expected if the wetland in the above scenario was subject to the following two future options:

a) Further degradation of the wetland linked to development, with the system's health being further reduced to 10% would result in a drop in hectare equivalents to 5 hectare equivalents; and
b) Rehabilitation of the wetland habitat, with the system's health being increased to 50% would result in a gain in hectare equivalents to 25 hectare equivalents.



NOTE:
The sizes of the circles are directly related to the extent of wetland habitat and functional wetland area in the landscape

4.4. Wetland buffer determination

To protect wetland habitat from impacts linked to adjacent land uses, during the construction and operational phases, appropriate buffer zones should be adopted. Wetland buffer zones[4] should therefore be determined for all wetlands in close proximity to a particular land use, thereby limiting the effects of the negative impacts. According to Macfarlane et al. (2015) buffer zones offer a wide range of functions to protect the water resource and associated biodiversity such as:

- Maintaining aquatic processes such as infiltration of surface water, promoting diffuse flow of water into the water course, stream bank stability and flood control;
- Reducing impacts from upstream and adjacent land uses through sediment control and the removal of pathogens, toxicants and nutrients;
- Providing habitat for aquatic, semi-aquatic and terrestrial species; and
- Providing societal benefits such as reducing flood risk, noise control, improved air quality and recreational prospects.

However, it should be emphasised that buffers zones have limitations and are not able to address certain impacts (Macfarlane et al. 2015) which include but are not limited to:

- Streamflow regulation;
- Mitigating point source impacts such as sewage discharges; and
- Prevention of groundwater contamination.

The newly developed Estuary, River and Wetland Buffer Guidelines (Macfarlane et al. 2015), which has been included in the recently released General Authorisation (GA) recommendations, have adopted a variable-width[5] buffer approach. The buffer tool derives two variable-width buffers for the construction and operational phases of the development, with the greater buffer distance being selected as the appropriate buffer distance. It should be noted that in order to account for the practical management of the buffer zone and to protect the watercourses from direct disturbances, a minimum buffer distance of 15m has been defined in the guideline document.

To determine the buffer distance to be adopted for the development site, a rapid infield assessment was undertaken for the identified wetland habitat and the adjacent landscape in accordance with the guideline. The infield assessment involved determining the slope[6], soil texture, vegetation[7] and micro-topography[8] characteristics of the buffer. This information was then captured into the Estuary, River and Wetland Buffer Guidelines model and the appropriate buffer distances derived.

[4] A zone of well vegetated land adjacent to a water resource designed to reduce sediment and pollutant transport via diffuse surface runoff to acceptable levels (Macfarlane et al. 2015).
[5] A variable-width buffer considers site specific attributes such as wetland type, adjacent land-use, and buffer zone characteristics such as vegetation, slope, biodiversity and desired function (Macfarlane et al. 2015).
[6] Areas of different slope characteristics are split into individual buffer segments, with a buffer distance derived per segment.
[7] Vegetation composition relating to the ability of the vegetation cover to control surface runoff through the buffer zone.
[8] Relating to the uniformity of the buffer surface in relation to the way water will be transported to the watercourse.

5. ASSUMPTIONS AND LIMITATIONS

Studies relating to natural ecosystems and understanding historical conditions rely on various assumptions, with the following assumptions being made during the assessment of these particular systems:

- The reference benchmark vegetation of the wetlands onsite is considered to be Eastern Highveld Grassland (Gm12) (Mucina and Rutherford 2006).
- The bioregion is considered to be Mesic Highveld Grassland (Gm) Group 4 (Nel et al. 2011), which has been classified as being ‘endangered’.
- The HGM units were assessed in their entirety, even if they extended beyond the boundary of the study site.
- The hectare equivalents calculations relating to functional wetland area in the study site accounts for the entire extent of the HGM units in the landscape (*i.e*. including wetland areas that extend beyond the study site).

The following limitations apply to the studies undertaken for this report:

- Due to time constraints, soil descriptions are based on moist conditions, rather than the dry conditions stipulated in the DWS guidelines (DWAF 2005). Generally, the recorded Munsell colour values would increase as the soil dried and this is taken into consideration during the infield studies.
- The wetland/riparian assessment techniques are considered to be the most appropriate at the time of the compilation of the report, however, in some instances, systems that have been highly modified/transformed, may have shortfalls. These techniques, however, have been compiled based on international best practice to apply to South African conditions, undergoing a peer-review process during their development. These assessment techniques should therefore, be seen as the most appropriate tools for wetland/riparian assessments at this time.
- The assessment of the wetland systems’ ecological integrity includes catchment conditions and it should be noted that changes in the HGM units’ catchments may have an adverse effect on the systems’ integrity.
- WET-EcoServices assists in identifying the importance and sensitivity of specific wetlands, but is recognised as having limitations in terms of quantifying specific impacts linked to development or changes within the landscape; and accounting for the size of the wetlands and ecosystem services strongly associated with the size of the systems.

6. STUDY RESULTS

The results of the delineation and assessment of the wetland habitat within the study site are outlined in the following sections.

6.1. Characteristics of the freshwater ecosystems

The study site is characterised by the presence of two hillslope seeps linked to a stream channel (HGM Unit 1 and 4), an isolated hillslope seep (HGM Unit 2), and a depression wetland (HGM Unit 3) (**Figure 6-1** and **Map GTW613-290416-01**). The full extent of the wetland ecosystems is approximately 10.5 ha within the study site, however, some of the HGM units extend beyond the study site boundary. The seepage wetlands are fed predominantly by sub-surface water inputs and the depression/pan is fed predominantly by surface water inputs.

HGM Unit 1 covers an area of approximately 2.69 ha and flows in a northerly direction. The system has been impacted upon by a dam at the head of the HGM unit and the encroachment of alien invasive tree species into the system and its catchment. It is characterised by large temporary and seasonal wetness zones with the absence of a permanent wetness zone. HGM Unit 2 flows in a north-easterly direction and covers an area of approximately 4.37 ha. The system has been impacted upon by two dam walls, infilling associated with the railway line and two berms at the head of the HGM unit and the encroachment of alien invasive tree species within the system's catchment. It is characterised by a large temporary wetness zone and a small seasonal wetness zone with the absence of a permanent wetness zone. A link exists between HGM Unit 2 and HGM Unit 1, with surface flows onto shallow soils serving to hydrologically link the two HGM units. While this area was not identified as wetland habitat, it should be excluded from the area available for development. HGM Unit 3 covers an area of approximately 0.05 ha and it has been impacted upon by an area of excavation within the HGM unit and the presence of alien invasive tree species within its catchment. It is characterised by a temporary wetness zone and lacks both a seasonal and permanent wetness zone. HGM Unit 4 covers an area of approximately 7.68 ha, however only 3.26 ha fall within the study site boundary. This system has been impacted upon by earthen berms which are located upstream of the dirt road and serve to divert the water from the road into the wetland. The lower reaches of the system are characterised by cultivated lands. This system is dominated by temporary zones of wetness, with a limited seasonal zone of wetness within the lower reaches of the system.

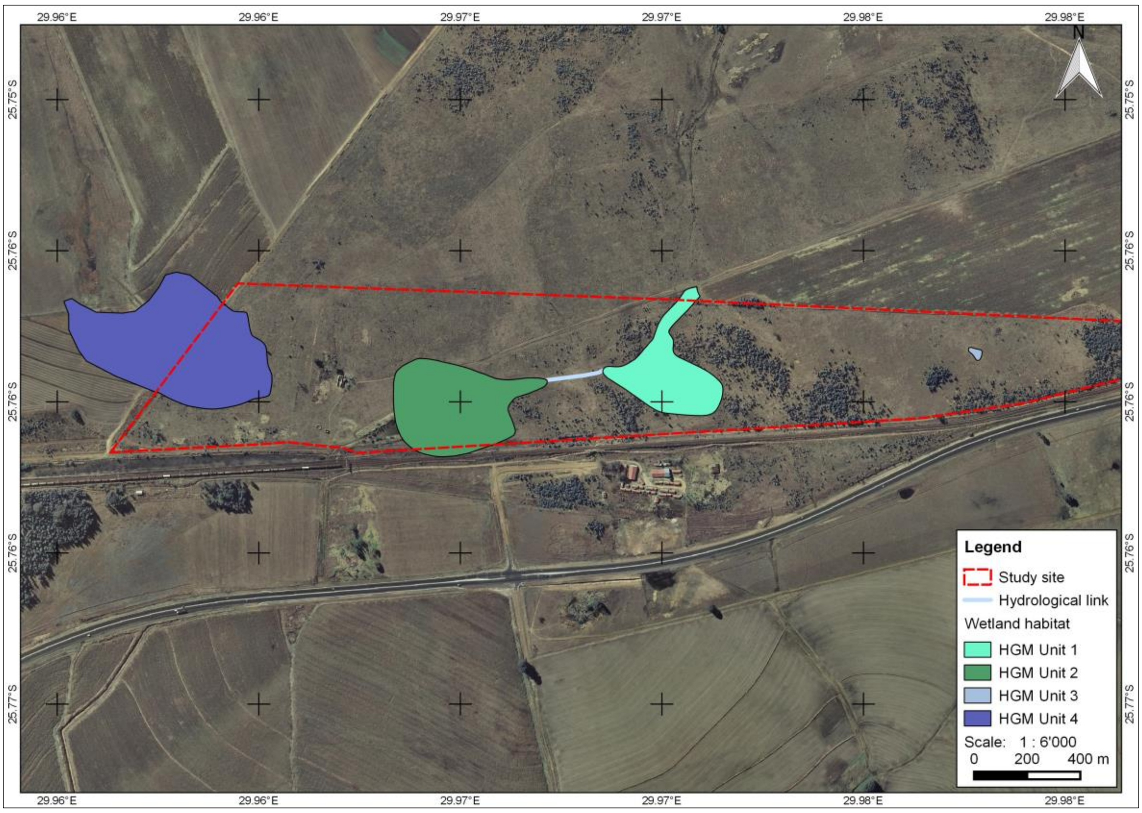


Figure 6-1 Overview of the wetland systems within the study site

6.2. Wetland ecosystem functioning assessment

The general features of the HGM units were assessed in terms of the ecosystem functioning at a landscape level. The score for each ecosystem service represents the likely extent to which that benefit is being supplied by the specific wetland and was interpreted based on the following rating outlined by Kotze et al. (2007):

- <0.5 Low;
- 0.5-1.2 Moderately low;
- 1.3-2.0 Intermediate;
- 2.1-2.8 Moderately high; and
- >2.8 High.

Generally, the HGM units were seen to be supplying regulatory ecosystem services at an ***Intermediate*** to ***Moderately high*** level for the current scenario (**Table 6-1** and **Appendix 3**). In some instances, the wetlands' effectiveness at providing a particular ecosystem service differs markedly from the opportunity that exists to supply that ecosystem service. For example, the effectiveness of the wetlands in trapping phosphates and removing nitrates was considered to be **High**. However, due to an absence of phosphate and nitrate sources within the catchments of the wetlands, the opportunity for the wetlands to trap phosphates and remove nitrates is **Low**.
Overall the wetlands were considered to be important in terms of flood attenuation, enhancing water quality within the landscape and erosion control. Biodiversity has also been recorded as **Intermediate**. The system's provision of direct benefits and services, such as harvestable natural resources and use for education, was seen as limited due to their location within privately-owned property.

Assessments for the post-development scenario have not been undertaken for WET-EcoServices (Kotze et al. 2007), as it is anticipated that the functioning of the systems will remain largely unchanged in the post-development landscape. It is assumed that the design of the houses have made provisions for potable water from taps and/or through an easily available source and therefore, there would be no reliance on the dams within the systems. It is recommended that rehabilitation of the systems is undertaken including the removal of the dams, except for the large dam within HGM Unit 2. Additionally, it is assumed that any cultivation of any land would take place beyond the 15m mitigated buffer zone. Although rehabilitation is advocated, it is anticipated that the changes to the ecosystem functioning will be limited and undertaking the assessment would be an academic exercise.

Table 6-1 Summary of current ecosystem services scores for the HGM units[9]

Ecosystem services	HGM Unit 1	HGM Unit 2	HGM Unit 3	HGM Unit 4
Flood attenuation	**1.8**	**1.9**	**1.9**	**1,7**
Score for effectiveness:	*2.0*	*2.3*	*2.8*	*1,8*
Score of opportunity:	*1.5*	*1.4*	*1.0*	*1,2*
Stream flow regulation	**1.8**	**1.2**	**0.0**	**1,6**
Sediment trapping	**1.4**	**1.3**	**1.4**	**1,6**
Score for effectiveness:	*1.5*	*1.2*	*1.4*	*1,6*
Score of opportunity:	*1.3*	*1.3*	*1.3*	*2,3*
Phosphate trapping	**1.7**	**1.6**	**1.7**	**1,0**
Score for effectiveness:	*3.4*	*3.3*	*3.4*	*1,8*
Score of opportunity:	*0.0*	*0.0*	*0.0*	*0,6*
Nitrate removal	**1.6**	**1.6**	**1.3**	**0,0**
Score for effectiveness:	*3.2*	*3.2*	*2.6*	*0,0*
Score of opportunity:	*0.0*	*0.0*	*0.0*	*0,0*
Toxicant removal	**1.6**	**1.6**	**1.4**	**0,0**
Score for effectiveness:	*2.9*	*2.8*	*2.9*	*0,3*
Score of opportunity:	*0.3*	*0.3*	*0.0*	*1,7*
Erosion control	**2.7**	**2.8**	**3.0**	**1,8**
Score for effectiveness:	*3.3*	*3.3*	*3.3*	*1,2*
Score of opportunity:	*2.2*	*2.3*	*2.8*	*1,6*
Carbon storage	**1.7**	**1.7**	**1.7**	**1,6**
Biodiversity maintenance	**1.9**	**2.0**	**2.2**	**1,6**
Score for noteworthiness:	*1.5*	*1.5*	*1.5*	*2,3*
Score for integrity:	*2.3*	*2.5*	*2.9*	*1,0*
Water supply	**0.6**	**0.4**	**0.4**	**1,8**
Source of harvestable goods	**0.0**	**0.0**	**0.0**	**0,6**
Source of cultivated goods	**0.0**	**0.0**	**0.0**	**0,0**
Socio-cultural significance	**0.0**	**0.0**	**0.0**	**0,0**
Tourism and recreation	**0.1**	**0.1**	**0.1**	**0,0**
Education and research	**0.3**	**0.3**	**0.3**	**0,0**

[9] Please note that Table 6-1 forms a summary table developed for reporting purposes. Full data can be made available if required.

6.3. Ecological Importance and Sensitivity

According to the DWA (2013) Manual for Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0), the wetland systems associated with the proposed development would be a **D** class for all three HGM Units (**Table 6-2**). The ecological importance and sensitivity (EIS) category for all three HGM units is derived from the ecological importance and sensitivity score, i.e. the highest of three scores is used to determine the overall EIS category of the wetland. The ecological importance and sensitivity score in the case of HGM Units 2 and 3 is strongly linked to the sensitivity of the wetland to changes in water quality and changes in floods.

Table 6-2 Ecological Importance and Sensitivity Score for the wetland systems[10]

Ecological Importance and Sensitivity				
	HGM Unit			
	1	**2**	**3**	**4**
Ecological Importance and Sensitivity	1.9	2.0	2.0	2.0
Hydro-functional Importance	1.8	1.7	1.6	1.6
Direct Human Benefits	0.2	0.1	0.1	0.2
Overall Importance and Sensitivity Score	1.9	2.0	2.0	2.0
Overall Importance and Sensitivity Category	**D**	**D**	**D**	**D**

Ecological Importance and Sensitivity Categories	**Range of EIS Score**	**EIS Class**
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	4	**A**
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quality and quantity of water in major rivers.	>3 and <4	**B**
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major river.	>2 and </=3	**C**
Low/Marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>1 and </=2	**D**
None: Wetlands that are rarely sensitive to changes in water quality/hydrological regime.	0	**E**

[10] Please note that Table 6-2 forms a summary table developed for reporting purposes. Full data can be made available if required.

6.4. Wetland ecological integrity assessment

The ecological integrity or Present Ecological State (PES) of the HGM units associated with the proposed development was assessed for the hydrology, geomorphology and vegetation components (
Table 6-3). The results of the assessments are outlined in the following sections.

Table 6-3 Summary of the overall ecological integrity of the wetlands for the current scenario[11]

		Hydrology	Geomorphology	Vegetation	Overall Score
HGM Unit 1	Impact Score	3.5	2.5	5.0	3.7
	PES Category	**C**	**C**	**D**	**C**
HGM Unit 2	Impact Score	1.5	2.7	3.6	2.4
	PES Category	**B**	**C**	**C**	**C**
HGM Unit 3	Impact Score	1.0	1.0	2.4	1.4
	PES Category	**B**	**B**	**C**	**B**
HGM Unit 4	Impact Score	3.5	3.5	7.3	4.6
	PES Category	**C**	**C**	**E**	**D**

Description	**Impact score**	**Present state category**
Unmodified, natural.	0 – 0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 – 1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4 – 5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9	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.	8 – 10	F

6.4.1. Assessment of impacts on hydrology

The impact scores recorded for the hydrological component of the three wetlands ranged from **1.0** to **3.5**, translating into a Present Hydrological State (PHS) category of **B** to **C**. The change in ecosystem processes therefore ranges from largely natural to moderately modified, with the modifications to the wetlands' PHS being linked primarily to the following factors:

- Impeding features resulting in flooding of portions of the systems;
- Infilling directly within the wetland habitat;
- Alien invasive vegetation within the wetland habitat, increasing the direct uptake of water; and
- Altered water flows into the wetlands linked to catchment changes.

[11] Please note that Table 6-3 forms a summary table developed for reporting purposes. Full data can be made available if required.

6.4.2. Assessment of impacts on geomorphology

The impact scores recorded for the geomorphic component of the three wetlands ranged from **1.0** to **3.5**, which indicates a Present Geomorphic State (PGS) category of **B** to **C**. The modifications to the wetlands' PGS are linked primarily to the following factors:

- Altered water flows into the wetland linked to catchment changes; and
- Infilling directly within the wetland habitat.

6.4.3. Assessment of impacts on vegetation

The impact scores recorded for the vegetation component of the three wetlands ranged from **2.4** to **7.3**, translating into a Present Vegetation State (PVS) category of **C** to **E**. The change in ecosystem processes and loss of natural habitat ranges from moderately to seriously modified, with modifications to the wetlands' PVS being linked primarily to the following factors:

- Encroachment of alien invasive and pioneer vegetation into portions of the wetland habitat;
- Impeding features resulting in flooding of portions of the systems;
- Infilling directly within the wetland habitat; and
- Excavation of portions of wetland habitat.

6.5. Buffer results

Generally, buffers are adopted to protect wetland habitat from physical disturbance and to protect the water resource from pollution from the adjacent landscape. The wetland habitat within the study site has been moderately modified, with the alteration of the systems' integrity associated with historical disturbances, and as such the buffer distances are largely associated with the buffer functions that contribute towards protecting the water resource rather than biodiversity.

The buffers derived for the onsite wetland habitat using The Estuary, River and Wetland Buffer Guidelines model (Macfarlane et al. 2015) were based on the characteristics of the wetlands, the impacts associated with the proposed development and the characteristics of the derived buffer zones. The derived buffer zones are presented in **Table 6-4** (**Appendix 5, Map 613-290416-02**). The buffer considers scenarios with or without impact mitigation. The potential unmitigated impacts on the wetlands associated with the proposed development include:

- Increased surface runoff associated with hardened surfaces;
- The introduction of pollutants associated with the development; and
- The introduction of pollutants associated with sewage infrastructure.

The mitigation measures required in order to adopt the mitigation buffer distance are described in greater detail in **Section 7**, and include:

- Installation of the sediment trapping measures;
- Stormwater management infrastructure; and
- Management of the buffer zone as a 'natural filter' of waste water and pollution.

Table 6-4 Recommended wetland buffer distances to be adopted for the proposed development

HGM Unit	Buffer Segment	Phase	Buffer Distance (m)		
			No Mitigation	Mitigation	Final*
1	1	Construction Operational	20 15	15 15	15
2	1	Construction Operational	21 15	15 15	15
3	1	Construction Operational	24 15	15 15	15
4	1	Construction Operational	21 15	15 15	15

***The final buffer distance is subject to the adoption of the proposed mitigation measures as outlined in Section 7**

6.6. Wetland ecological integrity for the post-development scenarios

Based on the afore-mentioned recommended buffer zones, the proposed development for the relocation site has adopted the mitigated buffer zone of 15 m into the design of the development layout (**Figure 6-2**). The adoption of this buffer distance requires the adoption of the recommended mitigation measures (refer to **Section 7**) to ensure the proposed development does not negatively impact the wetland habitat onsite.

It is therefore anticipated that the scores for the ecological integrity under the post-development scenario will remain unchanged. However; the vegetation component is anticipated to improve slightly with the removal of the alien invasive vegetation, which is a prerequisite of the landowner in any case. The levels of the alien invasive vegetation should be managed to ensure that the levels of infestation do not exceed 5% of the system, i.e. maintenance levels. The maintenance of the alien vegetation will ensure the integrity of the systems is marginally improved.

It should be noted that the post-development scenario does not account for any impacts associated with livestock management. It is assumed that the community to be relocated to the proposed site are dependent on livestock and therefore, would utilise the surrounding open space for grazing and possibly even the cultivation of various crops. The introduction of livestock to the areas could result in the degradation of the systems particularly if the livestock are not managed appropriately e.g. grazing of the wetland habitat during the summer months leading to the trampling of the wetland and over-grazing of the vegetation negatively affecting the integrity of the systems. Should livestock be brought into the area, ideally stocking rates and grazing regimes should be implemented.

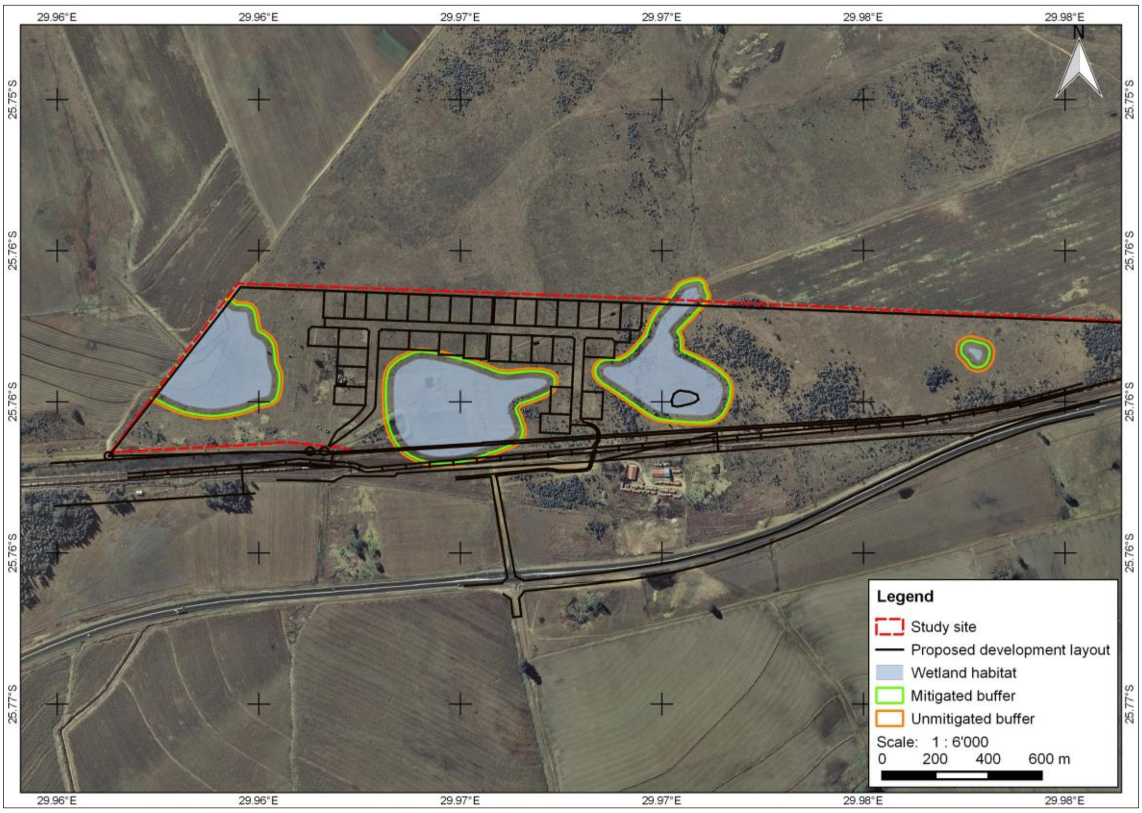


Figure 6-2 Overview of the proposed development footprint and the mitigated and unmitigated buffer zones

Although the integrity scores for the wetlands within the post-development landscape remain unchanged, with the only possible improvement in terms of vegetation; the assessments and the buffer tool do not account for any groundwater impacts e.g. use and/or contamination thereof, and do not account for point-source pollution e.g. leaking sewerage. Although, suitable measures should be implemented within the proposed development layout to minimise any risks to the wetlands associated with such activities and/or system failures.

6.6.1. Wetland ecological integrity for the post-development scenario with rehabilitation

Although it is anticipated that the proposed development would not negatively impact the wetland habitat, should the recommended mitigation measures be adopted; the rehabilitation of the systems to improve their integrity should be considered. The rehabilitation of the systems would entail the removal of some of the dams within the systems (HGM Unit 1 and 2), removal of earthen berms (HGM Unit 2), reshaping of the systems where applicable, and decommissioning of dirt tracks through the systems (HGM Unit 2). The rehabilitation of the systems, particularly the ones with the dams in them (HGM Unit 1 and 2) would contribute to conserving the systems from trampling as there would be no open water to attract livestock. It would, however, be recommended that the largest of the dams within the upper reaches of HGM Unit 2 be retained, as this could serve as a water source for the livestock. Additionally, access to the water body would be via the upper portion of the dam, which extends beyond the wetland. It is anticipated that the proposed rehabilitation activities would improve the overall integrity of the systems. **Table 6-5** provides an overview of the anticipated post-rehabilitation integrity scores.

Table 6-5 Summary of the overall ecological integrity of the wetlands for the post-rehabilitation scenario[12]

		Hydrology	Geomorphology	Vegetation	Overall Score
HGM Unit 1	Impact Score	3.0	2.0	3.6	2.9
	PES Category	**C**	**C**	**C**	**C**
HGM Unit 2	Impact Score	1.0	2.1	3.1	1.9
	PES Category	**B**	**C**	**C**	**B**
HGM Unit 3	Impact Score	1.0	1.0	2.1	1.3
	PES Category	**B**	**B**	**C**	B
HGM Unit 4	Impact Score	3.5	3.5	6.7	4.4
	PES Category	**C**	**C**	**E**	**D**

6.6.2. Overall ecosystem integrity for the current and post-development with rehabilitation scenarios

For ease of interpretation the scores for hydrology, geomorphology and vegetation are able to be simplified into a composite impact score for the HGM units by weighting the scores obtained as outlined in Macfarlane et al. (2007) (**Table** 6-6 and **Table 6-7**). These scores were then used to derive hectare equivalents, which can be used as the 'currency' for assessing the loss and/or gains in wetland integrity (Cowden and Kotze 2009).

Table 6-6 Overall area weighted ecological integrity for all of the HGM units within the study site for the current scenario

	Hydrology	Geomorphology	Vegetation
Area weighted impact scores	2.9	3.1	5.8
PES Categories	**C**	**C**	**D**
Overall Impact Score	**3.8**		
Overall PES Category	**C**		
Hectares of Wetland	**14.7**		
Hectare Equivalents	**5.3**		

[12] Please note that Table 6-3 forms a summary table developed for reporting purposes. Full data can be made available if required.

Table 6-7 Overall area weighted ecological integrity for all of the HGM units within the study site for the post-development with rehabilitation scenario

	Hydrology	Geomorphology	Vegetation
Area weighted impact scores	2.7	2.8	5.1
PES Categories	**C**	**C**	**D**
Overall Impact Score	**3.45**		
Overall PES Category	**C**		
Hectares of Wetland	**14.7**		
Hectare Equivalents	**5.4**		

The gain in hectare equivalents associated with the proposed rehabilitation activities does not reflect a large gain in integrity, namely only a gain of 0.1 hectare equivalents. The marginal gain in hectare equivalents is largely associated with the fact that the rehabilitation activities are limited. Nevertheless, it is recommended that the proposed rehabilitation activities be undertaken to ensure the integrity of the systems is retained and/or improved within the post-development landscape, particularly if livestock are introduced to the site.

7. RECOMMENDATIONS

Considering the loss of freshwater ecosystems within South Africa, it is generally recommended that the planning and implementation of any development should adopt a 'no-nett-loss' approach. This would include the following options for the proposed development:

- Maintaining the current levels of ecosystem integrity and service delivery of the systems within the landscape; and/or
- Mitigating impacts of the proposed development on the systems by rehabilitating the habitat within the study area and introducing mitigation measures during the construction process.

In terms of mitigating the impacts of the proposed development, the following mitigation activities should be considered.

7.1. Buffer zones

To protect the freshwater ecosystems from impacts linked to the construction phase and the operational phase appropriate buffer zones should be adopted. The derived buffer zones presented in **Section 6.5** indicate that without the implementation of mitigation measures, the required buffer distances are between 20m and 24m. If the recommended mitigation measures are implemented onsite, the required buffer distance is 15m. The mitigation measures[13] that should be implemented during both the construction and implementation phases in order to adopt the buffer associated with impact mitigation are described below.

7.1.1. Mitigation during the construction phase

The following mitigation activities should be incorporated into the Construction Environmental Management Plan (CEMP) to assist in reducing the impacts of the proposed development on the wetland habitat during the construction phase:

- To manage and avoid potential impacts associated with the development, any areas of concern should be highlighted from the outset of the development. To ensure that the construction team is aware of any sensitive freshwater ecosystems, these systems should be demarcated and avoided from the outset of the project. Through demarcating the construction zone and the area in which majority of the activities may occur, this may assist in minimising the area of soil disturbance and the potential for mobilisation of sediments from bare areas could be stabilised through the implementation of:
  - Earth dikes and diversions to direct all storm flows from disturbed areas into silt traps;
  - Soil stabilisation practises, such as sediment blankets and mulching, introduced onsite;
- Vegetation should remain intact where possible during the construction phase to limit high surface flows and mobilisation of sediment. Should site clearing be required, clearing of the vegetation should be undertaken immediately before earthworks are to commence to reduce the length of time which bare soil is exposed. This should involve a rough 'site fingerprinting' and/or 'construction phasing', which involves clearing only those areas essential to undertake construction.

[13] A number of the described mitigation activities are aligned with mitigation measures described by Macfarlane et al. (2015).

- Controlling onsite stormwater management and runoff is essential to ensure that sedimentation of the nearby freshwater ecosystems does not occur. Such stormwater management considerations include:
    - Areas characterised by bare and disturbed soils should be carefully drained to ensure that sediment mobilisation is limited where possible. This may be achieved through temporary mulching, revegetation where possible and sediment traps/filters.
    - Limited access through the site will require that temporary access roads are constructed. The potential environmental impact of these unpaved roads can prove to be an issue if not properly managed. To reduce surface runoff and mobilisation of sediment, these roads should remain vegetated where possible and occur along contour banks; preferably avoiding steep slopes. Where possible, water crossings should be avoided.
    - Permanent roads constructed onsite should be built above the natural ground surface to ensure efficient drainage. Water falling on the road should be directed off the hardened surface as quickly as possible to minimise the risks of water flowing along the road and directly into the water course. Since surface runoff often picks up sediments and other pollutants, the runoff should be redirected into drains with sediment traps and vegetated filters, removing all the unnecessary sediments.
    - In regions within the site that are expected to receive high rainfall and/or surface flows, detention basins should be implemented. These are designed specifically to manage and reduce peak flows, attenuating storm flows and slowly releasing the storm water over several hours.
- During soil excavation, where the soil is still relatively intact, the soils should be excavated one layer at a time and stored in separate stockpiles. Through this process the soil can be returned in their natural order when the area is backfilled.
- Should the buffer zone be characterised by cultivated lands and/or dense alien invasive vegetation, the buffer zone should be rehabilitated prior to construction to comprise of a **dense** community of natural vegetation, preferably grass species.
- No mixed concrete should be directly deposited on the ground without a mixing tray and any concrete spilled out of the demarcated area should be removed immediately to avoid impacting on the freshwater ecosystems.
- No concrete mixing machinery can be washed onsite. The concrete wash water contains high levels of chromium, which has the potential to contaminate ground and surface water.

7.1.2. Mitigation during the operational phase

The following mitigation activities should be incorporated into the Construction Environmental Management Plan (CEMP) to assist in reducing the impacts of the proposed development on the freshwater ecosystems during the operational phase:

- To limit the impacts of storm water runoff on the downstream freshwater ecosystems, the discharge of storm water runoff into the buffer zone should be managed by means of a storm water management plan, including *inter alia*:
    - A means of attenuating flows originating from the site, so as to ensure the post-development scenario is ‘flood neutral’;
    - Multiple discharge points that are reasonably spread out across the development;

- Accompanying each discharge point should be suitable baffle structures (*e.g*. gabion mattresses) that will dissipate the energy of storm flow and encourage infiltration thus reducing the likelihood of erosion;
- Bare areas should be minimised and revegetated where possible. In those instances where revegetation may not be an option, silt fences, mulch and other runoff controls should be implemented;
- The runoff entering the natural environment should not exceed 1.5m/sec as this is considered to reduce the pollutant removal performance of buffer areas (Valparaiso City 2004); and
- It is also recommended that these outflow points incorporate a best management practice approach to trap excess suspended solids and/or waste originating from the proposed development before entering the natural environment. These will need to be regularly serviced and maintained to ensure adequate functioning and efficacy. This may include the installation of oil/grit separators and sand filters to manage the potential risks of pollution and uncontrolled soil mobilisation.

* To limit the impact of increased nutrient inputs and toxic contaminants to the downstream freshwater ecosystems, the following mitigation measures should be implemented:
    - Rehabilitation of the buffer zone, with the removal of alien invasive vegetation, to ensure an undisturbed vegetation community;
    - The establishment of indigenous vegetation cover within the buffer zone to filter run-off before it enters the freshwater habitat (Valparaiso City 2004);
    - Management of the buffer zone to ensure that there is no encroachment that would reduce efficacy of the buffer zone. The buffer zone should be characterised by a high density of natural vegetation that is taller than 15 cm. Management of the buffer should include overgrazing, trampling by livestock, alien invasive encroachment and undesirable burning regimes (Macfarlane et al. 2015); and
    - Onsite sanitation systems are to be accompanied by detailed contingency plans to ensure that the risks of pollution have been properly managed. Since the development is within close proximity to freshwater ecosystems, the management of these systems is vital to ensure that pollution of the natural habitat is avoided. Different sanitation systems each present their strengths and weaknesses, as such the contingency plans should be designed specifically to deal with the potential issues associated with the system implemented.

8. CONCLUSION

The identified wetlands are in a largely natural to moderately modified condition and have the potential to supply a level of ecosystem services to the surrounding environment. To ensure a 'no-nett-loss' in ecosystem services and integrity of the identified systems within the post-development landscape, a suitable buffer zone and its associated mitigation activities was adopted in the layout planning. The adoption of the mitigation measures however, does not account for any potential impacts associated with the introduction of livestock within the area. In order to mitigate the potential impacts associated with livestock, it is recommended that the identified wetland systems are rehabilitated. The rehabilitation of the systems would reduce the risk of livestock concentrating within portions of the systems, thereby threatening the systems' integrity and supply of ecosystem services.

9. REFERENCES

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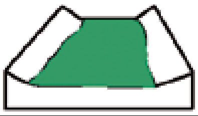
10. APPENDICES

Appendix 1:

Hydrogeomorphic (HGM) types (as per Kotze et al. 2007, p 27)

Hydrogeomorphic types	Description	Source of water maintaining the wetland[1]	
		Surface	Sub-surface
Floodplain 	Valley-bottom areas with a well defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley-bottom, channelled 	Valley-bottom areas with a well defined stream channel but lacking characteristic floodplain features. 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, unchannelled 	Valley-bottom areas with no clearly defined stream channel, usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.	***	*/ ***
Hillslope seepage linked to a stream 	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 stream channel.	*	***
Isolated Hillslope seepage 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel	*	***
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, and therefore this type is usually isolated from the stream channel network	*/ ***	*/ ***

Appendix 2:

Sample plot descriptions and photographs collected during the field component of the study using a data collection sheet adapted from Job (2009).

Project/Site: Resettlement Site Wetland Study
Sample Plot No.: 1
Date: 26 November 2015
Lat: 29.9734776
Long: -25.7614379

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? Yes ~~No~~
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR

Position in the landscape:
☐ crest ☐ footslope
☐ scarp ☐ valley bottom
☒ midslope
Local relief:
☒ flat
☐ concave
☐ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Poaceae sp	Terrestrial	80%

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? ~~Yes~~ No

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 10cm	7.5yr 2.5/1	N/A	N/A
10 - 40cm	7.5yr 3/2	N/A	N/A
40 – 55cm	10yr 5/6	N/A	N/A

Zone of Wetness:
☐ Permanent Wetness Zone
☐ Seasonal Wetness Zone
☐ Temporary Wetness Zone
☒ Non-Wetland or Dryland

Features present within 50cm of the soil surface:
☐ Organic soil ☐ High organic content in surface layer
☐ Grey/gleyed matrix ☐ Mottle / concretions
☐ Organic streaking ☐ Sulfidic odour
☐ Other

Munsell colour one of the following? ~~Yes~~ No
Gley 1:
☐
Gley 2:
☐
Hue 5YR:
☐value 5 or more/chroma 2 or less OR
☐value 6 or more/chroma 4 or less
Hue 7.5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less.
Hue l0YR:
☐value 4 or more/chroma 2 or less OR
☐ value 5 or more/chroma 3 or less OR
☐ value 6 or more/chroma 4 or less
Hue 2.5Y:
☐value 5 or more/chroma 2 or less OR
☐value 6 or more/chroma 4 or less
Hue 5Y:
☐value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)
☐ Inundated
Depth of Surface Water: N/A
☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
☐ Saturated within 50 cm of surface
Depth to Saturated Soil: N/A
☐ Sediment Deposits
☐ Aquatic invertebrates
☐ Salt Crust
☐ Oxidized Root Channels
☐ Water-Stained Leaves
☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	~~Yes~~	No
Vegetation indicators present?	~~Yes~~	No
Soil wetness indicators present?	~~Yes~~	No
Hydrology indicators present?	~~Yes~~	No
Is this sampling plot within wetland?	~~Yes~~	No

Overview of the Soil Profile and Location	
	

Project/Site: Resettlement Site Wetland Study
Sample Plot No.: 2
Date: 26 November 2015
Lat: 29.9734776
Long: -25.7611052

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? Yes ~~No~~
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR

Position in the landscape:
- ☐ crest
- ☐ footslope
- ☐ scarp
- ☐ valley bottom
- ☒ midslope

Local relief:
- ☐ flat
- ☒ concave
- ☐ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Paspallum dilatatum	Facultative positive	60%
Juncus oxycarpus	Obligate	10%
Fuirena cf pubescens	Obligate	10%

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? Yes ~~No~~

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 10cm	10yr 3/2	N/A	N/A
10 - 40cm	10yr 4/1	7.5yr 4/6	N/A
40 – 55cm	10yr 5/2	10yr 5/8	N/A

Zone of Wetness:
- ☐ Permanent Wetness Zone
- ☐ Seasonal Wetness Zone
- ☒ Temporary Wetness Zone
- ☐ Non-Wetland or Dryland

Features present within 50cm of the soil surface:
- ☐ Organic soil
- ☐ High organic content in surface layer
- ☒ Grey/gleyed matrix
- ☒ Mottle / concretions
- ☐ Organic streaking
- ☐ Sulfidic odour
- ☐ Other

Munsell colour one of the following? Yes ~~No~~
Gley 1:
☐
Gley 2:
☐
Hue 5YR:
☐value 5 or more/chroma 2 or less OR
☐value 6 or more/chroma 4 or less
Hue 7.5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less.
Hue l0YR:
☒value 4 or more/chroma 2 or less OR
☐ value 5 or more/chroma 3 or less OR
☐ value 6 or more/chroma 4 or less
Hue 2.5Y:
☐value 5 or more/chroma 2 or less OR
☐value 6 or more/chroma 4 or less
Hue 5Y:
☐value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)
☐ Inundated
Depth of Surface Water: N/A
☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
☐ Saturated within 50 cm of surface
Depth to Saturated Soil: N/A
☐ Sediment Deposits
☐ Aquatic invertebrates
☐ Salt Crust
☐ Oxidized Root Channels
☐ Water-Stained Leaves
☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	~~Yes~~	No
Vegetation indicators present?	Yes	~~No~~
Soil wetness indicators present?	Yes	~~No~~
Hydrology indicators present?	~~Yes~~	No
Is this sampling plot within wetland?	Yes	~~No~~

Sample Plot Photographs

Overview of the Soil Profile and Location	
	

Project/Site: Resettlement Site Wetland Study
Sample Plot No.: 3
Date: 26 November 2015
Lat: 29.9727847
Long: -25.7607580

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? Yes ~~No~~
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR

Position in the landscape:
- ☐ crest
- ☐ scarp
- ☐ midslope
- ☒ footslope
- ☐ valley bottom

Local relief:
- ☐ flat
- ☒ concave
- ☐ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Juncus effuses	Obligate	80%

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? Yes ~~No~~

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 10cm	10yr 4/2	N/A	N/A
10 - 50cm	10yr 5/2	10yr 5/8	N/A

Zone of Wetness:
- ☐ Permanent Wetness Zone
- ☒ Seasonal Wetness Zone
- ☐ Temporary Wetness Zone
- ☐ Non-Wetland or Dryland

Features present within 50cm of the soil surface:
- ☐ Organic soil
- ☒ Grey/gleyed matrix
- ☐ Organic streaking
- ☐ Other
- ☐ High organic content in surface layer
- ☒ Mottle / concretions
- ☐ Sulfidic odour

Munsell colour one of the following? Yes ~~No~~

Gley 1:
☐
Gley 2:
☐
Hue 5YR:
☐value 5 or more/chroma 2 or less OR
☐value 6 or more/chroma 4 or less
Hue 7.5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less.
Hue l0YR:
☐value 4 or more/chroma 2 or less OR
☒ value 5 or more/chroma 3 or less OR
☐ value 6 or more/chroma 4 or less
Hue 2.5Y:
☐value 5 or more/chroma 2 or less OR
☐value 6 or more/chroma 4 or less
Hue 5Y:
☐value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)

☐ Inundated
Depth of Surface Water: N/A
☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
☐ Saturated within 50 cm of surface
Depth to Saturated Soil: N/A
☐ Sediment Deposits
☐ Aquatic invertebrates
☐ Salt Crust
☐ Oxidized Root Channels
☐ Water-Stained Leaves
☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	Yes	~~No~~
Vegetation indicators present?	Yes	~~No~~
Soil wetness indicators present?	Yes	~~No~~
Hydrology indicators present?	~~Yes~~	No
Is this sampling plot within wetland?	Yes	~~No~~

Sample Plot Photographs

Overview of the Soil Profile and Location	
	

Appendix 3

WET-EcoServices current scenario graphs

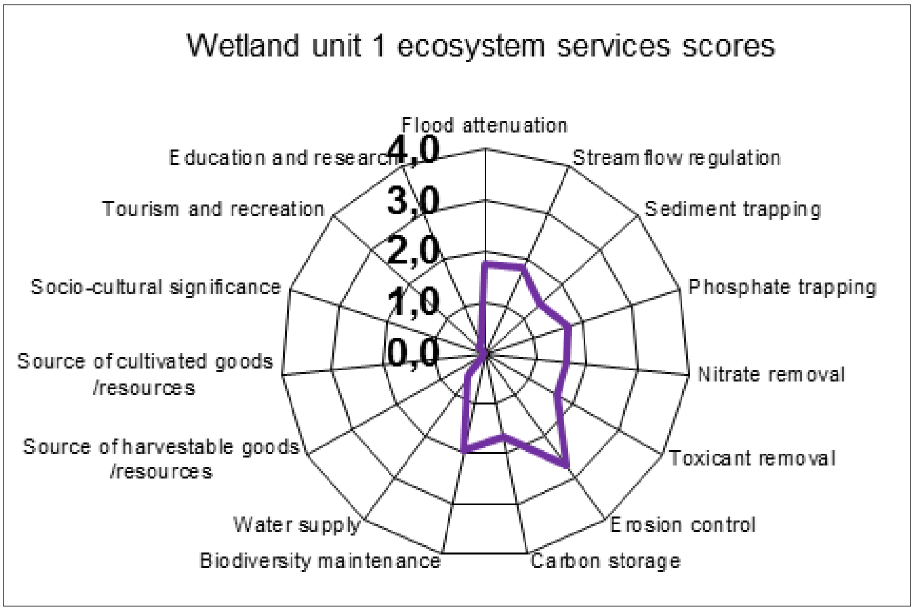


Figure 10-1 Wet-EcoServices graph for HGM Unit 1 for the current scenario

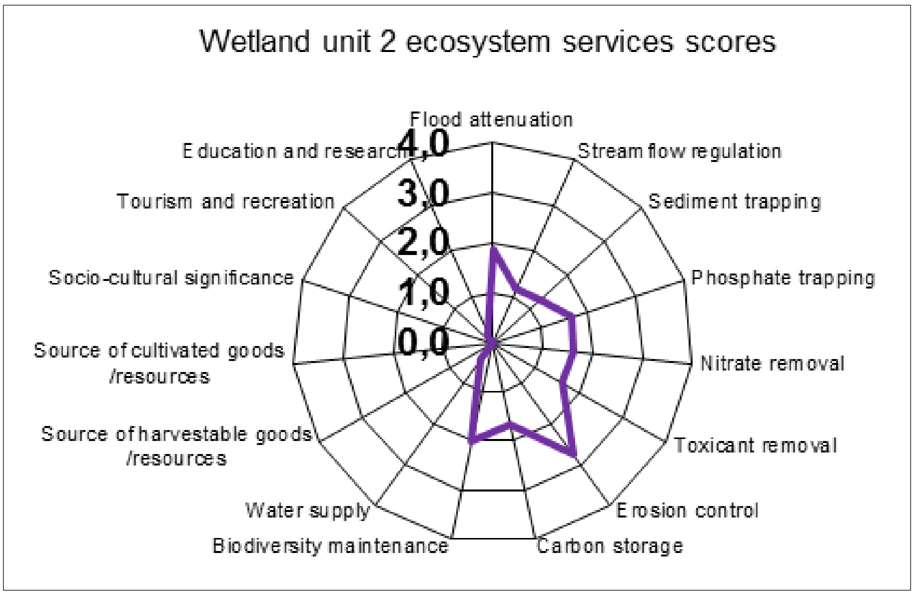


Figure 10-2 Wet-EcoServices graph for HGM Unit 2 for the current scenario

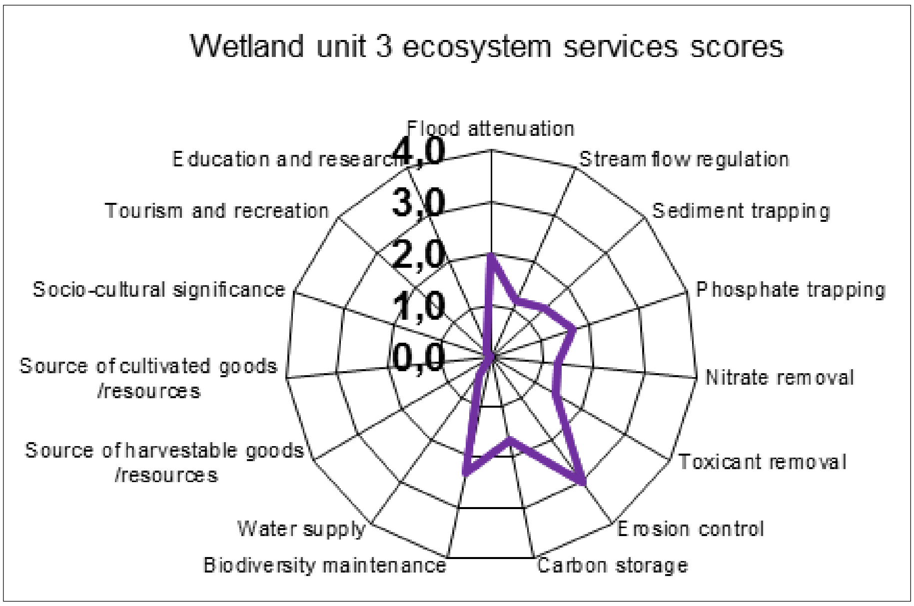


Figure 10-3 Wet-EcoServices graph for HGM Unit 3 for the current scenario

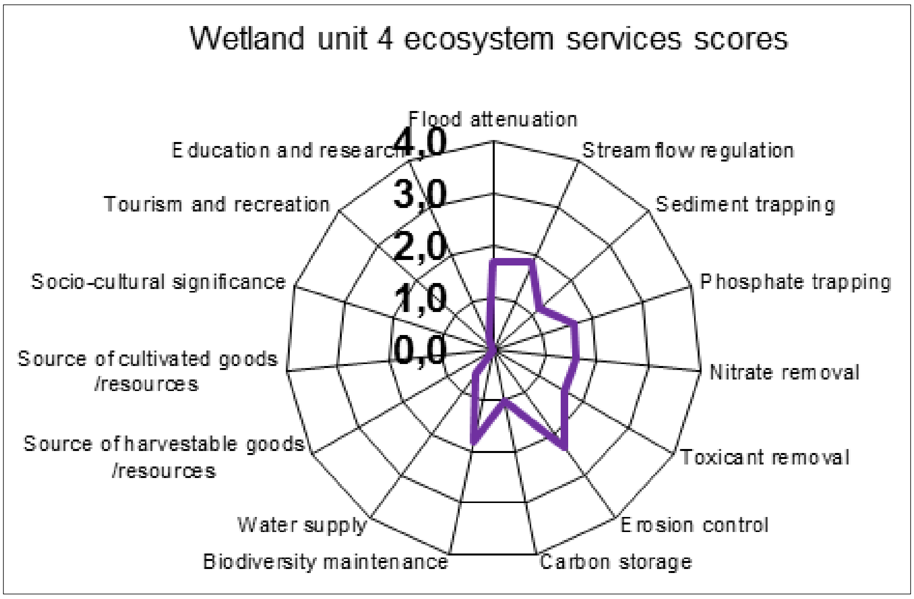


Figure 10-4 Wet-EcoServices graph for HGM Unit 4 for the current scenario

Appendix 4:

Maps

The following maps show the extent of wetland ecosystems and the associated buffer requirements within the study area

Appendix 5:

Buffer zone tool for the determination of aquatic buffers and additional setback requirements for wetland ecosystems

(This appendix has been taken directly from the buffer tool spreadsheet to determine the buffer requirements associated with the proposed development).