WETLAND ASSESSMENT

Portion 3 of the Farm Middel Pan 605, situated in the division of Vryburg, IN Registration Division, Province of the North-West, measuring 664,8825 (six hundred and sixty four comma eight eight two five) hectares, Title Deed No.: 76/1992

View of small wetland next to waterpoint outside the proposed footprint near the western boundary.
Photo: November 2015, R.F. Terblanche.

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1 INTRODUCTION

A wetland assessment is required for a proposed solar power plant development at Portion 3 of the Farm Middel Pan 605, situated in the division of Vryburg, IN Registration Division, Province of the North-West, measuring 664,8825 (six hundred and sixty four comma eight eight two five) hectares, Title Deed No.: 76/1992, 30 km west of Vryburg in the North West Province (elsewhere referred to as the site), and if wetlands are present an assessment of these wetlands will take place. Such an assessment would then focus on the hydro-geomorphic setting, an estimate of the properties of the wetlands, an assessment of the functional aspects of wetlands and an impact assessment to wetlands, should the development be approved.

1.1 Wetlands in South Africa

Wetlands are defined by the National Water Act (Act 36 of 1998) as:
“land which is transitional between terrestrial and aquatic ecosystems 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”.

According to *A practical field procedure for identification and delineation of wetlands and riparian areas* (DWAF 2005) wetlands must have one or more of the following attributes:

- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation
- The presence, at least occasionally, of water loving plants (hydrophytes)
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil

Wetlands, according to the definition of DWAF (2005) are at the interface of aquatic systems and the terrestrial environment. As such the characteristics of the surface water or near surface water in space and time at this interface between the terrestrial and aquatic environment are fundamental to understand the functioning of a particular wetland. At the higher elevations of South Africa surface water at wetlands are characterised by considerable contrasts between seasons and periodic precipitation events. Generally accepted definitions of wetlands which focus on the wetland attributes of soil and vegetation are therefore useful because of its consistency despite seasonal fluctuations.

The Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013) includes wetland ecosystems defined by the National Water Act (Act 36 of 1998) as well as those “wetland sytems” defined in the Ramsar Convention. The broader definition of wetlands, according to the Ramsar Convention is that wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water to the depth of which at low tide does not exceed six metres (cited by Ramsar Convention Secretariat 2011). This Ramsar definition of “wetlands” overlaps broadly with the definition of aquatic systems according to the South African system of classifying wetlands and other aquatic ecosystems. In South Africa an aquatic ecosystem is an ecosystem that is permanently or periodically inundated by flowing or standing water, or which has soils that are permanently or periodically saturated within 0.5 m of the soil surface (Ollis *et al*., 2013). Therefore an important consideration of the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013) is that a wetland (narrow definition according to water act and not Ramsar definition) is taken to be a unique type of aquatic system.

1.2 Importance of wetlands

The importance of wetlands for human well-being and the conservation of biodiversity are recognised world-wide. Ecosystem services which directly or indirectly benefit human well-being are of particular importance when wetlands are considered. Wetlands play a major role to enhance supporting services such as nutrient cycling and primary production, which in turn is the basis for other ecosystem services. Wetlands are very important to regulating services such as maintaining water flow and water quality by processing water and regulating water run-off, provisioning services such as providing freshwater, cultural services such as appreciating the landscape and biodiversity. Overall wetlands play a major role in the sustainability of land use from socio-economic and biodiversity conservation perspectives. The setting and function of wetlands at each site should therefore be evaluated to inform land use management.

Wetland vegetation is of significant importance for wetlands to play a role in valuable ecosystem services. Vegetation plays an important role in natural wetland ecosystems. It holds soil together and slows down the flow of water, reducing the risk of erosion and promoting sediment deposition. Plants are the source of organic material in wetland soils, and form the organic soil in peat wetlands. Vegetation also has an impact on the quality of surface and subsurface water as it (1) provides organic soil matter required by microbes in order to assimilate nutrients and toxicants (2) provides habitat for the microbes in the soil immediately surrounding the roots, and (3) contributes through direct uptake of nutrients and toxicants and incorporation of these into plant tissues (Sieben *et al.* 2009).

1.3 Aims and objectives of the survey

A survey consisting of three visits to investigate key elements of habitats on the site, relevant to the conservation of wetlands are conducted. The importance and significance of the site with special emphasis on the current status of biodiversity and ecological services of the wetland are evaluated. Literature investigations are integrated with field observations to identify potential ecological impacts that could occur as a result of the development and to make recommendations to reduce or minimise impacts, should the development be approved.

The objectives of the wetland habitat assessment are to provide:

- An indication of the existence of wetlands at the site and if so:
- An identification of major aspects of the hydro-geomorphic setting and terrain unit at which the wetland occur;
- An estimate of the size and roughness of the wetland
- An indication of the hydric soils at the site;
- An indication of erodability;
- An indication of the presence or absence of peat at the site;
- An outline of hydrological drivers that support the existence and character of the wetland;
- An assessment of the possible presence or absence of threatened or localised plant species, vertebrates and invertebrates of the region, at the site;
- A description of the functions provided by the wetland at the site;
- An interpretation of the priority of the wetland for local communities in the area;
- An interpretation of the priority of the wetland to biodiversity at the site;

2 STUDY AREA

The study area is at Portion 3 of the Farm Middel Pan 605, situated in the division of Vryburg, IN Registration Division, Province of the North-West, measuring 664,8825 (six hundred and sixty four comma eight eight two five) hectares, Title Deed No.: 76/1992, 30 km west of Vryburg in the North West Province.

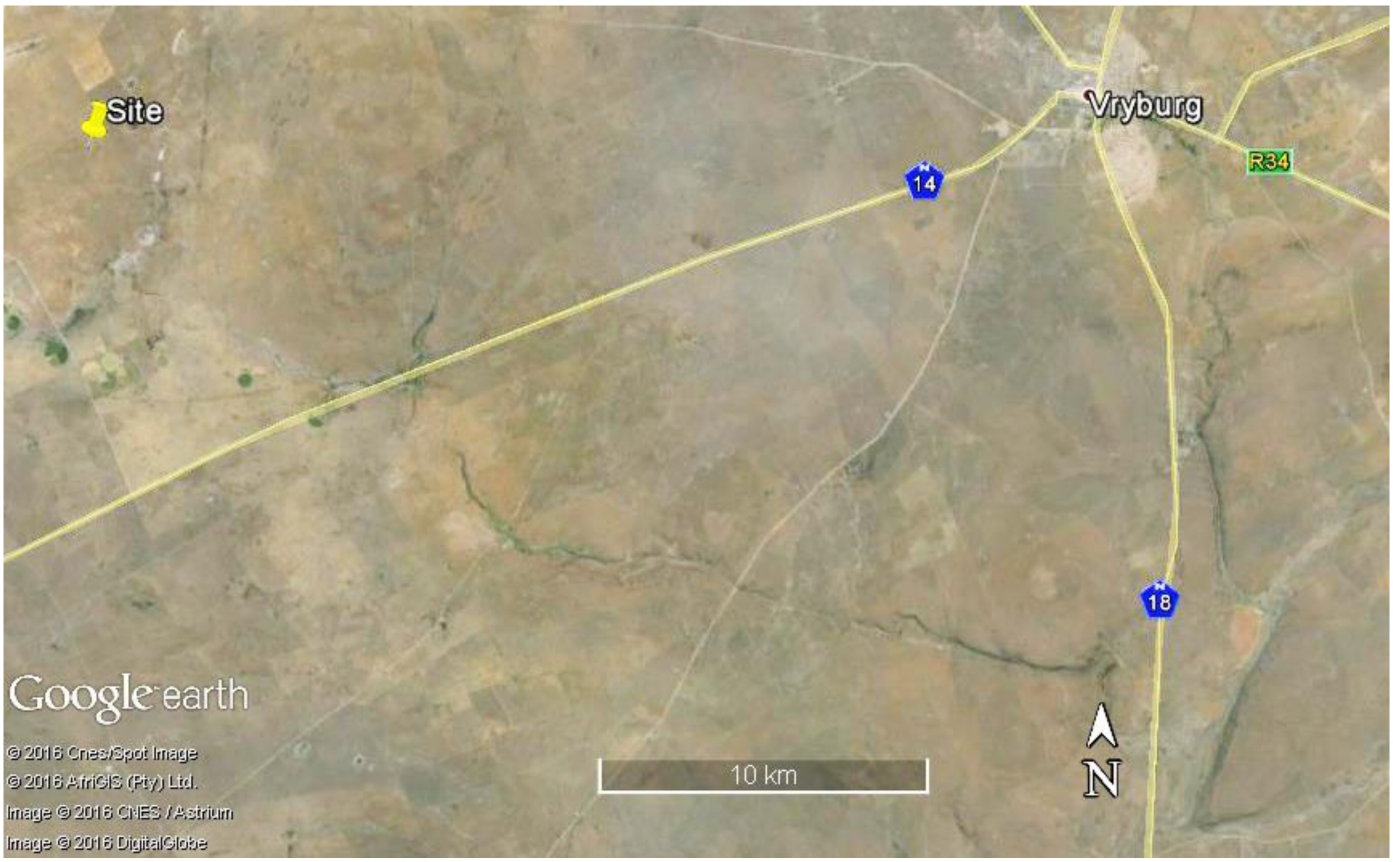

Figure 1 Location of the site in larger area.

Grid references and altitudes were taken at site with a GPS Garmin E-trex 20 ® instrument.
Map information were analysed and depicted on Google images with the aid of Google Earth Pro (US Dept. of State Geographer, MapLink/ Tele Atlas, Google).

The site is situated at the Savanna Biome which is represented by the Mafikeng Bushveld vegetation type (Mucina & Rutherford 2006). A brief overview of SVk 1, the Mafikeng Bushveld vegetation type in which the site is located, follows:

SVk 1 Mafikeng Bushveld

Distribution: In South Africa the Mafikeng Bushveld is found in the North West Province to the west of Mafikeng and south of the Botswana border westwards to around Vergeleë, south-wards to Piet Plessis and Setlagole at an altitude that ranges from 1100 – 1400 m (Mucina & Rutherford, 2006).

Vegetation and landscape features comprise well developed tree and shrub layers, dense stands of *Terminalia sericea, Acacia luederitzii* and *Acacia erioloba* in certain areas. Shrubs include *Acacia karroo, Acacia hebeclada* and *Acacia mellifera, Dichrostachys cinerea, Grewia flava, Grewia retinervis, Searsia tenuinervis* and *Ziziphus mucronata*. Grass layer is also well-developed.

Geology & Soils: Aeolian Kalahari sand of the Tertiary to Recent age on flat sandy plains, soils deep (>1.2 m). Clovelly and Hutton soil forms. Land types Ah, Ai and Ae.

Climate is summer rainfall with very dry winters. Mean annual precipitation (MAP) from about 350 mm in the west to about 520 mm in the east. Frost frequent in winter (Mucina & Rutherford, 2006).

Important taxa noted for the Mafikeng Bushveld are: Tall Tree: *Acacia erioloba*. Small Trees: *Acacia karroo, Acacia mellifera* subsp. *detinens, Terminalia sericea, Ziziphus mucronata*. Tall Shrubs: *Dichrostachys cinerea, Grewia flava, Searsia tenuinervis, Diospyros austro-africana*, *Ehretia rigida* subsp. *rigida, Rhigozum obovatum, Tarchonanthus camphoratus*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada, Grewia retinervis, Aptosimum procumbens, Felicia muricata, Gnidia polycephala, Helichrysum zeyheri, Hoffmannseggia burchellii, Lantana rugosa, Talinum arnotii. Geoxylic Suffrutex: Elephantorrhiza elephantina.* Succulent Shrub: *Lycium cinereum.* Woody Climber: *Asparagus africanus*. Graminoids: *Anthephora pubescens, Cymbopogon pospischilii, Digitaria eriantha* subsp. *eriantha, Eragrostis lehmanniana, Eragrostis pallens, Schmidtia pappophoroides, Stipagrostis uniplumis, Aristida congesta, Arisitida meridionalis, Arisitida mollissima* subsp. *argentea, Aristida stipitata* subsp. *stipitata, Brachiaria nigropedata,* *Brachiaria serrata, Cynodon dactylon, Digitaria argyrograpta, Eragrostis superba, Eragrostis trichophora, Melinis repens, Tragus racemosus, Urochloa panicoides.* Herbs: *Barleria macrostegia, Erlangea misera, Harpagophytum procumbens* subsp. *procumbens, Hermannia tomentosa, Hermbstaedtia odorata, Indigofera daleioides, Limeum fenestratum, Nidorella resedifolia, Oxygonum dregeanum* subsp. *canescens* var. *canescens*, *Senna italica* subsp. *arachoides.* Geophytic Herb: *Ledebouria marginata*.

Note: Though many of the above plant species occurs at the site, not all of them necessarily occur at the site.

Mafikeng Vaalbosveld is listed as threatened, Vulnerable, according to the National List of Threatened Ecosystems (2011).

3 METHODS

A desktop study comprised not only an initial phase, but also it was used throughout the study to accommodate and integrate all the data that became available during the field observations.

Surveys of a number of study areas in the vicinity of Vryburg, including the site, were conducted from 10 – 16 November 2015, December 2015 and 23 - 31 January 2016 to note key elements of habitats on the site, relevant to the conservation of fauna and flora. Notes and experience from earlier surveys at the larger study area of the Taung-Vryburg area by R.F. Terblanche that had taken place in July 2011, November 2011, January 2012, February 2012, August 2013, December 2013, January 2014 and November 2014 were also taken into account where applicable.

Classification of any inland wetland systems that could be present at the site is according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013). One of the major advantages of the Classification System for South Africa (Ollis *et al*., 2013) is that the functional aspects of wetlands are the focal point of the classification. Wetlands are very dynamic systems and their functionality weighs high against the often rapid changes in their appearance (Terblanche *In prep*). In this document the main guideline for the delineation and identification of wetlands where present is the practical field procedure for identification and delineation of wetlands by DWAF (2005).

The following sections highlight the materials and methods applicable to different aspects that were observed.

3.1 Classification of wetlands (SANBI: Ollis *et al*., 2013)

3.1.1 System, regional setting and landscape unit (Levels 1, 2 and 3)

Three broad types of Inlands Systems are dealt with in the Classification System namely rivers, open waterbodies and wetlands. These Inland Systems are then classified according to a six-tiered structure.

At the systems level (Level 1) of wetland classification, a distinction is made between Marine, Estuarine and Inland ecosystems using the level of connectivity to the open ocean as discriminator of the biophysical character of each (Ollis *et al*., 2013). Inland wetland systems are aquatic ecosystems with no existing connection to the ocean (i.e. characterised by the complete absence of marine exchange and/ or tidal influence (Ollis *et al*., 2013). In this case if any wetland is present it obviously qualifies as an Inland wetland system.

At Level 2 the regional setting is a spatial framework that is preferred by the investigator to allow for gaining an understanding of the broad ecological context within which an aquatic system occurs (Ollis *et al*., 2013). A regional setting can be identified according to the DWA ecoregion classification of Kleynhans *et al.* (2005).

A distinction is made between four landscape units at Level 3 of the Classification System for Inland Systems on the basis of the landscape setting (i.e. topographical position) (Ollis *et al*., 2013). Four landscape units are recognized: slope, valley floor, plain and bench.

3.1.2 Hydrogeomorphic units (Level 4)

Seven primary hydrogeomorphic (HGM) units are recognised for Inland Systems at Level 4A of the Classification System for Wetlands and other Aquatic Ecosystems in South Africa, on the basis of hydrology and geomorphology (Ollis *et al*., 2013). These are a River, Channeled valley-bottom wetland, Unchannelled valley-bottom wetland, Floodplain wetland, Depression, Seep and Wetland flat.

3.1.3 Hydrological regime (Level 5)

While the hydrogeomorphic unit (HGM) is influenced by the source of water and how it moves into, through and out of an Inland System, the hydrological regime (as catergorised by the Classification System) describes the behaviour fo the water within the system and, for wetlands, in the underlying soil (Ollis *et al.,* 2013). Together with the hydrogeomorphology the hydrological regime are used to describe the wetland as a functional unit (Ollis *et al.*, 2013). In the case of Inland wetlands which are classified as rivers, perenniality is an important characteristic to describe the hydrological regime. For Inland Systems other than rivers, five categories relating to the frequency and duration of inundation have been provided: Permanently inundated, Seasonally inundated, Intermittently inundated, Never inundated/ rarely inundated and unknown (Ollis *et al*., 2013). Period of saturation within the upper 0.5 m of the soil is a very important discriminator that also links to the wetland delineation system of DWAF (2005). The following categories for saturation of wetland soils are recognised: Permanently saturated, Seasonally saturated, Intermittently saturated and unknown. These categories of period of saturation correspond to the permanent, seasonal and temporary zones of wetlands respectively.

3.1.4 Wetland descriptors (Level 6)

At Level 6 several "descriptors" are included for the structural/ chemical/ biological characterisation of Inland Systems (Ollis *et al.,* 2013). These descriptors are non-hierarchical to one another and can be applied in any order depending on the purpose of a study and the availability of information. Descriptors include natural vs. artificial, salinity, substratum type, pH, geology and vegetation cover (Ollis *et al*., 2013). Various definitions are given for the descriptors which are likely to increase the consistency and use of the system.

3.2 Delineation of wetland

Together with terrain unit, indirect indicators of prolonged saturation by water: wetland plants (hydrophytes) and wetland (hydromorphic) soils are identified and used to delineate the wetland (DWAF 2005). Three zones, which may not all three be present in all wetlands, namely the permanent zone of wetness, the seasonal zone and the temporary zone are identified. The temporary zone is the outer zone and is saturated for only a short period of the year that is sufficient, under normal circumstances, for the formation of hydromorphic soils and the growth of wetland vegetation (DWAF 2005). Hydromorphic soils must display signs of wetness within 50cm of the soil to qualify as wetland soil that can support hydrophytic vegetation. Grid references and altitudes are taken on site with a GPS Garmin E-trex 20 ® instrument. Map information are analysed and depicted on Google images with the aid of Google Earth Pro (US Dept. of State Geographer, MapLink/ Tele Atlas, Google, 2015).

A few important pointers should be kept in mind when assessing wetlands in South Africa especially for cryptic wetlands and especially for wetlands in their dry conditions. These pointers are then regarded as of particular importance to wetlands in areas with less rainfall in South Africa. No one indicator provides adequate information about wetland presence, type, hydroperiod, biodiversity, function and principle ecological and hydrological drivers to be useful on its own – particularly with regard to actual or suspected cryptic and/or temporary wetlands (Day *et al*., 2010). A suite of indicators is required, to build up even a conceptual understanding of wetland ecosystem structure and function (Day *et al.,* 2010). The absence of an indicator does not necessarily equate to the absence of a wetland (Day et al., 2010). DWAF (2005) notes the presence of numerous mottles as indicative of seasonal saturation, while temporary or permanent saturation would both be associated with less abundant mottles. Cryptic wetlands do not usually exhibit mottling, though, often because the soils have naturally low levels of iron, so the absence of mottles does not necessarily indicate the absence of a wetland (Day *et al.*, 2010).

3.3 Vegetation at and near wetland

Though vegetation is a key component of the wetland definition in the Water Act, using vegetation as a primary indicator requires undisturbed conditions and expert knowledge (DWAF 2005). Modern wetland classification systems in South Africa therefore place more emphasis on the soil wetness indicators. It remains however, that plant assemblages undergo distinct changes in species composition from the centre of a wetland to the edge, and into adjacent terrestrial areas (DWAF 2005). This change in species composition of vegetation provides valuable clues for determining the wetland boundary and wetness zones (DWAF 2005).

Apart from botanical aspects which are integrated into the description of a wetland it is imperative to note the existence or not of threatened plant species or other plant species of conservation concern, such as near-threatened, data deficient or declining species in a wetland. Floristic composition is therefore also considered during the wetland assessment. Voucher specimens of plant species are only taken where the taxonomy is in doubt or where the plant specimens are of significant relevance for invertebrate conservation. Field guides such as those by Germishuizen (2003), Manning (2003), Manning (2009), Van Oudtshoorn (2012), Van Wyk (2000), Van Wyk & Malan (1998) and Van Wyk & Van Wyk (2013) were used to confirm the taxonomy of the species. Works on specific plant groups (often genera) such as those by Goldblatt (1986), Goldblatt & Manning (1998), Jacobsen (1983), McMurtry, Grobler, Grobler & Burns (2008), Smit (2008), Van

Jaarsveld (2006) and Van Wyk & Smith (2014) were also consulted to confirm the identification of species. An important source of identifications of plant species for the wetland survey is Van Ginkel, Glen, Gordon-Gray, Cilliers, Muasya & Van Deventer (2011). In this case no plant specimens were needed to be collected as voucher specimens or to be send to a herbarium for identification. For the most recent treatise of scientific plant names and broad distributions, Germishuizen, Meyer & Steenkamp (2006) or Raimondo *et al*. (2009) or updated lists on SANBI websites are followed to compile the lists of species.

3.4 Fauna at and near wetland

Species composition of fauna is not used in wetland characterization and assessments. However, it is important to note species that favour wetlands and especially whether threatened animal species are present at a wetland or not.

Mammals are noted as sight records by day. For the identification of species and observation of diagnostic characteristics Smithers (1986), Skinner & Chimimba (2005), Cillié, Oberprieler and Joubert (2004) and Apps (2000) are consulted. Sites are walked with the aim to cover as many habitats as possible. Signs of the presence of mammal species, such as calls of animals, animal tracks (spoor), burrows, runways, nests and faeces are recorded. Walker (1996), Stuart & Stuart (2000) and Liebenberg (1990) are consulted for additional information and for the identification of spoor and signs. Trapping is only done if necessary. Habitat characteristics are also surveyed to note potential occurrences of mammals. Many mammals can be identified from field sightings but, with a few exceptions bats, rodents and shrews can only be reliably identified in the hand, and even then some species needs examination of skulls, or even chromosomes (Apps, 2000).

Birds are noted as sight records, mainly with the aid of binoculars (10x30). Nearby bird calls of which the observer was sure of the identity were also recorded. For practical skills of noting diagnostic characteristics, the identification of species and observation techniques Ryan (2001) is followed. For information on identification, biogeography and ecology Barnes (2000), Hockey, Dean & Ryan, P.G. (2005), Cillié, Oberprieler & Joubert (2004), Tarboton & Erasmus (1998) and Chittenden (2007) are consulted. Ringing of birds falls beyond the scope of this survey. Sites are walked, covering as many habitats as possible. Signs of the presence of bird species such as spoor and nests are additionally been recorded. Habitat characteristics are surveyed to note potential occurrences of birds.

Reptiles are noted as sight records in the field. Binoculars (10x30) can also be used for identifying reptiles of which some are wary. For practical skills of noting diagnostic characteristics, the identification of species and observation techniques, Branch (1998), Marais (2004), Alexander & Marais (2007) and Cillié, Oberprieler and Joubert (2004) are followed. Sites are walked, covering as many habitats as possible. Smaller reptiles are sometimes collected for identification, but this practice was not necessary in the case of this study. Habitat characteristics are surveyed to note potential occurrences of reptiles.

Frogs and toads are noted as sight records in the field or by their calls. For practical skills of noting diagnostic characteristics, the identification of species and observation techniques Carruthers (2001), Du Preez (1996), Conradie, Du Preez, Smith & Weldon (2006) and the recent complete guide by Du Preez & Carruthers (2009) are consulted. CD's with frog calls by Carruthers (2001) and Du Preez & Carruthers (2009) are used to identify species by their calls when applicable. Sites are walked, covering as many habitats as possible. Smaller frogs are often collected by pitfall traps put out for epigeal invertebrates (on the soil), but this practice falls beyond the scope of this survey. Habitat characteristics are also surveyed to note potential occurrences of amphibians.

Invertebrates of which enough information is available to be integrated into an assessment, such as butterflies, are recorded as sight records, photographic records or voucher specimens. Voucher specimens are mostly taken of those species of which the taxa warrant collecting due to taxonomic difficulties or in the cases where species can look similar in the veldt. Many butterflies use only one species or a limited number of plant species as host plants for their larvae. Myrmecophilous (ant-loving) butterflies such as the *Aloeides*, *Chrysoritis*, *Erikssonia, Lepidochrysops* and *Orachrysops* species (Lepidoptera: Lycaenidae), which live in association with a specific ant species, require a unique ecosystem for their survival (Deutschländer & Bredenkamp, 1999; Terblanche, Morgenthal & Cilliers, 2003; Edge, Cilliers & Terblanche, 2008; Gardiner & Terblanche, 2010). Known food plants of butterflies are therefore also recorded. Other invertebrate groups such as fruit chafer beetles and mygalomorph spiders are also investigated where relevant.

3.5 Present Ecological Status

Ecological status of wetlands are based on models such as the modified Habitat Integrity approach developed by Kleynhans (1996, 1999). Present ecological status PES methodology is then largely based on criteria for assessing the habitat integrity of floodplain wetlands and notes for allocating a score to attributes and rating the confidence level associated with each score (DWAF 1999). Such criteria are selected on the assumption that anthropogenic modification can generally be regarded as the primary causes of degradation of the ecological integrity of a wetland (see DWAF 1999). This is done by using Table W4-1 given by DWAF (1999):

- Score each attribute according to the guidelines provided in the footnote.
- Calculate a mean score for Table W4-1 using the individual scores for all attributes.
- Provide a confidence rating for each score according to the guidelines provided in the footnote to indicate the areas of uncertainty in the determination.

Table W4-2 provides guidelines for the determination of the Present Ecological Status Class (PESC), based on the mean score determined for Table W4-1. If any of the attributes scores < 2 (i.e., it is considered to be seriously or critically modified) this score and not the mean should be taken into consideration. This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the Present Ecological Status Category (PESC). In any case, the mean on which the assessment of the PESC is based should be regarded as a guideline and should also be tested against the opinion of local experts (DWAF 1999).

Biological integrity is not directly estimated through this approach though in some systems or parts of systems, information on biological integrity is available. In such cases, the information on biological integrity can be used as a check of the PES Category determination. The mean is used to relate the ecological state of the wetland to a particular PES Category (Table W4-2) (DWAF 1999).

3.6 Ecological Importance and Sensitivity

The assessment of the ecological importance and sensitivity is according to DWAF (1999) which in turn is adapted from Kleynhans (1996) and Kleynhans (1999). "Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system’s ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and Sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC) DWAF (1999).

In the method outlined here, a series of determinants for EIS according to Table W5-1 of DWAF (1999) are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. The method is used as a guideline for the professional judgement of individuals familiar with an area and its wetlands. The assessors must substantiate and document their judgement as far as possible for future reference and revision (DWAF 1999).

3.7 Limitations

Wetlands are very dynamic systems and owing to time constraints a glimpse of conditions at wetlands are taken. However, the hydrogeomorphological setting, soil wetness characteristics and established vegetation constitute some longer term features of a wetland. For each site visited, it should then be emphasized that surveys can by no means result in an exhaustive list of wetland plants and animals present on the site, because of the time constraint. Surveys of a number of study areas in the vicinity of Vryburg, including the site, were conducted from 10 – 16 November 2015, December 2015 and 23 - 31 January 2016 which cover a good range of times of the year to to note key elements of habitats on the site, relevant to the conservation of wetland fauna and flora. Notes and experience from earlier surveys at the larger study area of the Taung-Vryburg area by R.F. Terblanche that had taken place in July 2011, November 2011, January 2012, February 2012, August 2013, December 2013, January 2014 and November 2014 were also taken into account where applicable. Weather conditions during the surveys were favourable for recording fauna and flora. The focus of the survey remains a habitat survey that concentrates on the hydrogeomorphological, hydrological and additional descriptors to classify and assess the wetland.

4 RESULTS AND DISCUSSION

4.1 Absence of wetlands at the proposed footprint

Careful search at the proposed footprint led to the conclusion that presence of wetlands at the proposed footprint is highly unlikely.

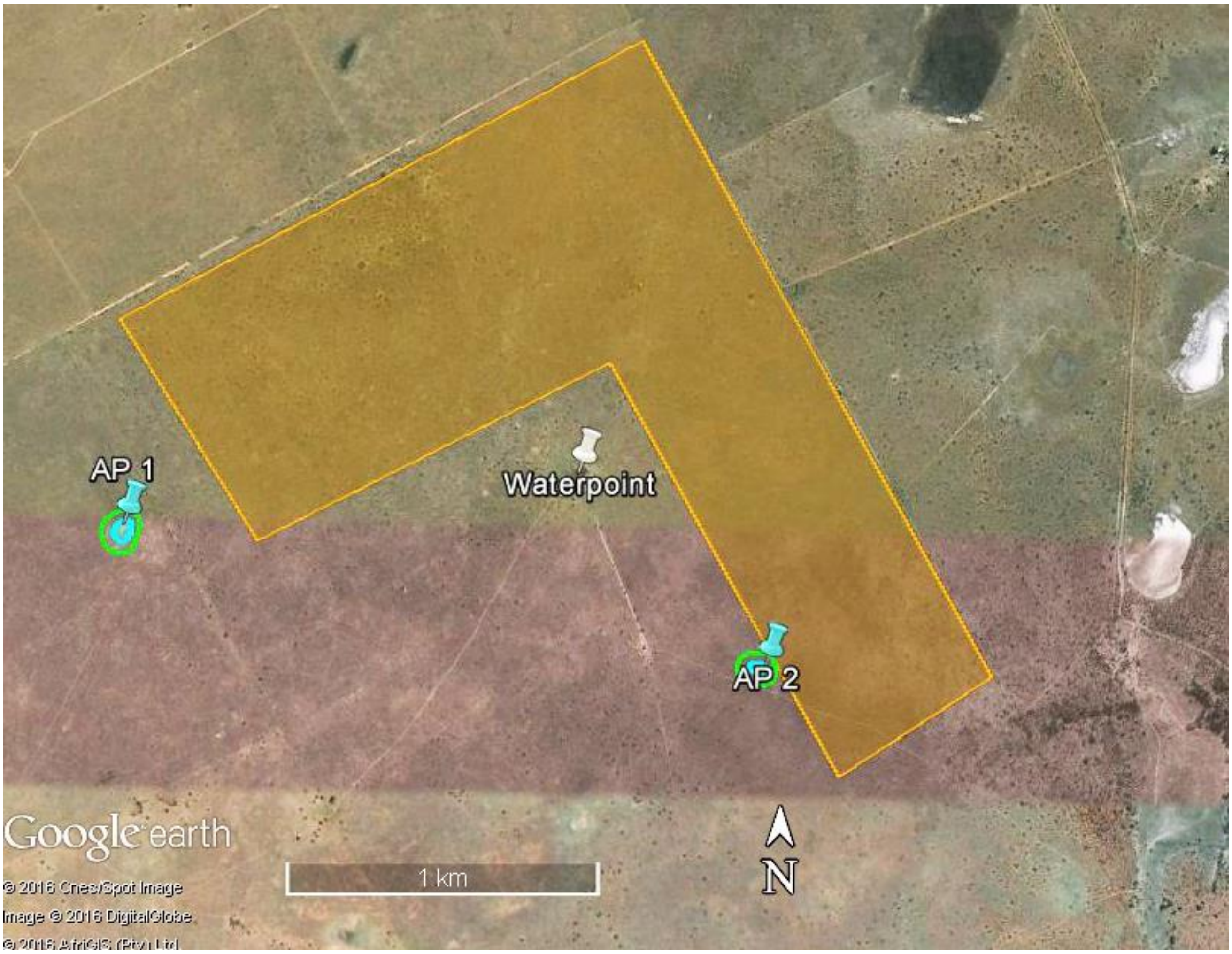

Figure 2 Indications of the small wetland depressions (pans) **AP 1** and **AP 2** of which the outer edges are outlined. Indication of outer edge of buffer zone of 30 m is depicted in green around the wetlands. There are some water points at this area of which one is depicted on this map and another being next to AP 1.

Orange area and outline: Proposed footprint
Blue areas and outlines: Wetlands of which the edge are within 500 m from the closest edge of the proposed footprint.
Green lines: Indication of outer edge of 30 m buffer zone.

Grid references and altitudes were taken at site with a GPS Garmin E-trex 20 ® instrument. Map information was analysed and depicted on Google images with the aid of Google Earth Pro (US Dept. of State Geographer, MapLink/ Tele Atlas, Google).

4.2 Assessment and classification of two wetlands outside the proposed footprint but within 500 m from the edge of the proposed footprint

There are two small temporary wetlands within 500 m of the edge of the proposed footprint, one near the western boundary of the proposed footprint labelled **AP 1** and one near the southeastern extension of the proposed footprint labelled **AP 2** (Figure 2).

4.2.1 Small temporary wetland depression AP 1 near the western boundary of the proposed footprint

A small temporary wetland **AP 1** of approximately 0.32 ha is found outside and west of the proposed footprint but within 500 m of the edge of the proposed footprint. Wetland is at a small shallow basin that occurs at a plain, the latter with very gentle slopes. No conspicuous inlet or outlet could be found. This depression is probably endorheic, so that water that flows in during rainfall events probably leaves mostly through evaporation and infiltration. Surface water is probably only present following substantial rainfall in a semi-arid zone given that the mean annual rainfall in the area is 500 mm or below.

Rocks surface at the bottom of the shallow basin with brown-greyish soils in most places very shallow. Vegetation cover is visibly poor at the bottom of the small marginal pan owing possibly to salinity but likely also to grazing. Herbs include *Vahlia capensis* and a sparse cover of the hydrophyte *Persicaria* species at a few places at the bottom of the depression. Grass species include *Cynodon dactylon* and *Eragrostis porosa*. In general the grass cover appears to be sparse and poor at centre of the small pan.

The present ecological status (PES) of the wetland system is CATEGORY B which means the system is largely natural with few modifications, but with some loss of natural habitats (Table 4.2 and Table 4.3). The ecological importance and sensitivity (EIS) of the wetland system is low to marginal because the wetland is small and ecologically somewhat disturbed. Furthermore the wetland is not of distinct known ecological importance (Table 4.4 and Table 4.5). Presence or particular association of any threatened wetland plant or animal species at the wetland has not been found and is unlikely.

Photo 1 View towards the north of the small pan depression AP 1 that occurs near the western boundary of the proposed footprint.
Photo: November 2015, R.F. Terblanche.

Photo 2 Individuals of a *Persicaria* species, a hydrophyte, are found sparsely at the bottom of the depresssion AP 1. Photo: November 2015, R.F. Terblanche.

Table 4.1 Classification and outline of characteristics of wetland **AP 1** at the site according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013).

CHARACTERISTIC TYPE WETLAND DISCRIMINATORS AND DESCRIPTORS	**DESCRIPTION**
System (level 1)	Inland wetland
Regional setting (level 2)	Southern Kalahari Ecoregion (Kleynhans *et al.* 2005)
Landscape unit (level 3)	Plain
Hydrogeomorphic unit (level 4)	Depression (Pan)
Hydrological regime (Level 5)	Wetland is at a small shallow basin that occurs at a plain, the latter with very gentle slopes. No conspicuous inlet or outlet could be found. This depression is probably endorheic, so that water that flows in during rainfall events probably leaves mostly through evaporation and infiltration. Surface water is probably only present following substantial rainfall in a semi-arid zone given that the mean annual rainfall in the area is 500 mm or below.
Additional descriptors (Levels 5,6)	Rocks surface at the bottom of the shallow basin with brown-greyish soils in most places very shallow. Vegetation cover is visibly poor at the bottom of the small marginal pan owing possibly to salinity but likely also to grazing. Herbs include *Vahlia capensis* and a sparse cover of the hydrophyte *Persicaria* species at a few places at the bottom of the depression. Grass species include *Cynodon dactylon* and *Eragrostis porosa*. In general the grass cover appears to be sparse and poor at centre of the small pan.

Table 4.2 Scoresheet with criteria for assessing habitat integrity of wetland depression **AP 1** according to DWAF (1999) such as adapted from Kleynhans (1996).

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	4	4
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	4	4
Water Quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	3	3
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	3	3
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	3	4
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or change wetland habitat directly or through changes in inundation patterns.	3	4
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	3	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	3	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	4	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	4	4
Overutilisation of biota	Overgrazing, over-fishing etc.	3	4
TOTAL **MEAN**		**37** **x=3.4**	**42** **x=3.8**

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 4.3 Interpretation of scores for determining present ecological status **(PES)** of the small depression **AP 1** according to DWAF (1999) such as adapted from Kleynhans (1999). Present ecological status of the wetland is Category B (indicated in blue font).

Interpretation of Mean* of Scores for all Attributes: Rating of Present Ecological Status Category (PES Category)
WITHIN GENERALLY ACCEPTABLE RANGE
CATEGORY A >4; Unmodified, or approximates natural condition.
CATEGORY B **>3 and <=4; Largely natural with few modifications, but with some loss of natural habitats.**
CATEGORY C >2 and <=3; moderately modified, but with some loss of natural habitats.
CATEGORY D =2; largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E >0 and <2; seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F 0; 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.

Table 4.4 Score sheet for for determining ecological importance and sensitivity for floodplains for **AP 1** (DWAF 1999, adapted from Kleynhans 1996, 1999).

Determinant	**Score**	**Confidence**
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	0	3
2. Populations of Unique Species	0	3
3. Species/taxon Richness	2	3
4. Diversity of Habitat Types or Features	2	3
5. Migration route/breeding and feeding site for wetland species	0	3
6. Sensitivity to Changes in the Natural Hydrological Regime	2	3
7. Sensitivity to Water Quality Changes	2	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	2	3
MODIFYING DETERMINANTS		
9. Protected Status	0	4
10. Ecological Integrity	2	4
TOTAL	**12**	**32**
MEAN	**1.2**	**3.2**

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 4.5 Ecological importance and sensitivity categories for **AP 1**. Interpretation of median scores for biotic and habitat determinants (DWAF 1999, adapted from Kleynhans 1996, 1999).

Ecological Importance and Sensitivity Category (EIS)	**Range of Median**	**Recommended Ecological Management Class**
Very high Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains 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.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate **Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.**	**>1 and <=2**	**C**
Low/marginal Floodplains which are not ecologically important and sensitive at any scale. The biodiversity of these floodplains 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.	>0 and <=1	D

4.2.2 Wetland depression AP 2 near the southeastern extension of the proposed

A small temporary wetland **AP 2** of approximately 0.18 ha is found outside and west of the proposed footprint but within 500 m of the edge of the proposed footprint. Wetland is at a small shallow basin that occurs at a plain, the latter with very gentle slopes. No conspicuous inlet or outlet could be found. This depression is probably endorheic, so that water that flows in during rainfall events probably leaves mostly through evaporation and infiltration. Surface water is probably only present following substantial rainfall in a semi-arid zone given that the mean annual rainfall in the area is 500 mm or below.

Rocks surface at the bottom of the shallow basin with brown-greyish soils in most places very shallow. Vegetation cover is visibly poor at the bottom of the small marginal pan owing possibly to salinity but likely also to grazing. Herbs include a sparse cover of the hydrophyte *Persicaria* species at a few places at the bottom of the depression. Grass species include *Cynodon dactylon* and *Eragrostis porosa*. In general the grass cover appears to be sparse and poor at centre of the small pan.

The present ecological status (PES) of the wetland system is CATEGORY B which means the system is largely natural with few modifications, but with some loss of natural habitats (Table 4.6 and Table 4.7). The ecological importance and sensitivity (EIS) of the wetland system is low to marginal because the wetland is small and ecologically somewhat disturbed. Furthermore the wetland is not of distinct known ecological importance (Table 4.9 and Table 4.10). Presence or particular association of any threatened wetland plant or animal species at the wetland has not been found and is unlikely.

Photo 3 View of small temporary wetland depression AP 2 outside the proposed footprint at the plain of the site.
Photo: January 2016, R.F. Terblanche.

Photo 4 Rocks surface at the bottom of the shallow depression of wetland AP 2. Vegetation cover at this part of the depression is poor and dependent on sporadic higher rainfall events.
Photo: January 2016, R.F. Terblanche.

Table 4.6 Classification and outline of characteristics of wetland **AP 2** at the site according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013).

CHARACTERISTIC TYPE WETLAND DISCRIMINATORS AND DESCRIPTORS	**DESCRIPTION**
System (level 1)	Inland wetland
Regional setting (level 2)	Southern Kalahari Ecoregion (Kleynhans *et al.* 2005)
Landscape unit (level 3)	Plain
Hydrogeomorphic unit (level 4)	Depression (Pan)
Hydrological regime (Level 5)	Wetland is at a small shallow basin that occurs at a plain, the latter with very gentle slopes. No conspicuous inlet or outlet could be found. This depression is probably endorheic, so that water that flows in during rainfall events probably leaves mostly through evaporation and infiltration. Surface water is probably only present following substantial rainfall in a semi-arid zone given that the mean annual rainfall in the area is 500 mm or below.
Additional descriptors (Levels 5,6)	Rocks surface at the bottom of the shallow basin with brown-greyish soils in most places very shallow. Vegetation cover is visibly poor at the bottom of the small marginal pan owing possibly to salinity but likely also to grazing. Herbs include a sparse cover of the hydrophyte *Persicaria* species at a few places at the bottom of the depression. Grass species include *Cynodon dactylon* and *Eragrostis porosa*. In general the grass cover appears to be sparse and poor at centre of the small pan.

Table 4.7 Scoresheet with criteria for assessing habitat integrity of wetland depression **AP 2** according to DWAF (1999) such as adapted from Kleynhans (1996).

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	4	4
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	4	4
Water Quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	4	3
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	3	3
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	4	4
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or change wetland habitat directly or through changes in inundation patterns.	4	4
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	4	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	3	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	4	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	4	4
Overutilisation of biota	Overgrazing, over-fishing etc.	3	4
TOTAL **MEAN**		**41** **x=3.7**	**42** **x=3.8**

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 4.8 Interpretation of scores for determining present ecological status **(PES)** of the wetland depression **AP 2** according to DWAF (1999) such as adapted from Kleynhans (1999). Present ecological status of the wetland is Category B (indicated in blue font).

Interpretation of Mean* of Scores for all Attributes: Rating of Present Ecological Status Category (PES Category)
WITHIN GENERALLY ACCEPTABLE RANGE
CATEGORY A >4; Unmodified, or approximates natural condition.
CATEGORY B **>3 and <=4; Largely natural with few modifications, but with some loss of natural habitats.**
CATEGORY C >2 and <=3; moderately modified, but with some loss of natural habitats.
CATEGORY D =2; largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E >0 and <2; seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F 0; 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.

Table 4.9 Score sheet for for determining ecological importance and sensitivity for floodplains for **AP 2** (DWAF 1999, adapted from Kleynhans 1996, 1999).

Determinant	**Score**	**Confidence**
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	0	3
2. Populations of Unique Species	0	3
3. Species/taxon Richness	2	3
4. Diversity of Habitat Types or Features	2	3
5. Migration route/breeding and feeding site for wetland species	0	3
6. Sensitivity to Changes in the Natural Hydrological Regime	2	3
7. Sensitivity to Water Quality Changes	2	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	2	3
MODIFYING DETERMINANTS		
9. Protected Status	0	4
10. Ecological Integrity	3	4
TOTAL	**13**	**32**
MEAN	**1.3**	**3.2**

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 4.10 Ecological importance and sensitivity categories for **AP 2**. Interpretation of median scores for biotic and habitat determinants (DWAF 1999, adapted from Kleynhans 1996, 1999).

Ecological Importance and Sensitivity Category (EIS)	**Range of Median**	**Recommended Ecological Management Class**
Very high Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains 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.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate **Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.**	**>1 and <=2**	**C**
Low/marginal Floodplains which are not ecologically important and sensitive at any scale. The biodiversity of these floodplains 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.	>0 and <=1	D

5 ANTICIPATED RISKS AND MITIGATIONS TO THE WETLANDS OUTSIDE THE PROPOSED FOOTPRINT BUT WITHIN 500 M FROM THE EDGE OF THE PROPOSED FOOTPRINT

5.1 Anticipated risks, impacts and mitigation measures of proposed development on the wetland, the latter to be excluded from the proposed footprint

There are two small temporary wetlands within 500 m of the edge of the proposed footprint, one near the western boundary of the proposed footprint labelled **AP 1** (approximately 0.32 ha) and one near the southeastern extension of the proposed footprint labelled **AP 2** (approximately 0.18 ha) (Figure 2). Both are similar in that they are small, rocks surface at the bottom and individuals a sparse cover of hydrophyte *Persicaria* species is found at the bottom of the small shallow basins. There is a waterpoint next to AP 1 which leads to more grazing pressure compared to AP 2. No development or any clearance of vegetation is planned at the wetlands or at the buffer zone of these wetlands and therefore no direct impact is foreseen. Indirect impacts or risks of the development to the two small temporary wetlands are considered in the section below.

5.1. Surface flow

Two wetlands outside the proposed footprint are situated as small shallow basins of a plain of which the slope is very gentle (flat). Upper soils at the slopes of the plain are also conspicuously sandy which means the infiltration of the soil is high and the water run-off most likely relatively low. Site is also located in a relatively low rainfall area. The amount of runoff and the percentage of runoff as a proportion of rainfalll tend to increase with rainfall such that while runoff in the northwest of South Africa is less than 5 mm per annum, there is a fairly systematic increase of runoff towards southwards and eastwards in South Africa (Ellery *et al.,* 2009). Because the site falls in the northwestern parts of the country with a rainfall of 500 mm or less, and the above factors of soil and very gentle slopes the water runoff is relatively very low.

It is anticipated the solar panels could lead to an increase of water runoff during rainfall events and when the solar panels are washed (once a year). This increase in water from the solar panels could however be counteracted by possibly more vegetation at the buffer zone owing to the decrease/ absence in grazing activities. It should also be noted that there is no distinct inlets at the depressions at the site therefore the water runoff is a sheet flow into the depression rather than a channeled inflow. Diffusion rather than chanelling of water flow towards the excluded wetland depression disperses any water run-off or impact on erosion. Furthermore, the slope at the site is very low, the buffer zone at the site may have more vegetation owing to the planned decrease in intensity of grazing, revegetation in shaded areas of proposed solar panels is likely to be rapid, so that the buffer zone for a the wetlands on a very gentle slope could be highly effective in minimizing changes in water flow into the wetland. In addition the upper soils at the proposed footprint are visibly sandy with high infiltration that will further limit surface water runoff.

Wetlands are small pan depressions which mean that the surface flow at these wetlands when inundated would be diffuse.

Maintaining water quality of the wetlands outside the proposed footprint is essential. Risks of fuel spillages and any sewage or domestic waste that could eventually reach the wetland are low because of mitigation measures to prevent these during the construction phase of the solar power plant. Any such spillages should be avoided and if accidently taken place be remediated in an immediate time frame.

Mitigation measures:

- A buffer zone of 30 m from the outer edge of the small pan depressions AP 1 and AP 2, applies.
- Significant decrease in grazing activities to enhance the functioning of the buffer zone around the wetlands.
- Monitoring of any possible sedimentation effects or any significant increases in water runoff owing to the proposed development, if any, should take place. If any such impacts occur necessary steps should be introduced to counteract any significant changes in waterflow and erosion.
- Quick revegetation at soil surface at the solar panel areas should take place.
- Sediment capture and stormwater runoff systems should be planned carefully so that the risk of excessive water runoff towards the wetlands is low.

5.2 Soil erosion

Soil erosion problems occur when the rate of erosion is increased above natural levels (Ashman & Puri 2002). The erosion risk at any site can be determined by considering erosivity and erodability. Erosivity is related to the number of intense storms during a year and erodability depends on the the texture and organic matter content of a soil coupled with site characteristics such as slope and whether the soil is exposed or has vegetative cover (Ashman & Puri 2002). Therefore rainfall intensity, soil characters related to erodibility, slope angle and length and vegetation cover are all primary factors that could lead to the increase of erosion. Flowing water contains energy which is linked to Mannings equation (also Gauckler-Manning Coefficient (Gauckler 1867, Chanson 2004, Russel 2009) of the velocity of water flow: $v = \frac{R^{2/3} x s^{1/2}}{n}$ where v is the cross-sectional average velocity, R is the hydraulic radius of the channel, s is the slope of the channel and n is the Manning coefficient (unitless) of roughness. Note Manning's equation is an empirical formula and should be applied as such with care. In practice the relation of Manning's equation means that the flatter the slope, the wider and flatter the area over which the water flows and in addition increased roughness of the area over which the water flows in a wetland, the slower and more diffuse the flow of water will be. Erosion itself is among other factors dependent on the velocity and discharge of water (amount of water), as well as the erodibality of the substrate.

Rainfall is sporadic and low at the site with typical thunderstorm events of the summer rainfall interior of South Africa could lead to a rush of increase of runoff towards the wetlands if substantial rain falls, which in fact is one of the reasons why the wetlands exists in a dry area. The slope at the site is low and the roughness of the area could still be high at the soil surface level, especially at the buffer zone where grazing activities would decrease. It should be noted that at the plain and proposed footprint at the site upper soils are conspicuously sandy which means that infiltration is relatively high and the runoff effects are further limited.

<u>Mitigation measures:</u>

- A buffer zone of 30 m from the outer edge of the small wetlands located outside the proposed footprint applies.
- Significant decrease in grazing activities to enhance the functioning of the buffer zones around the wetlands.
- Monitoring of any possible sedimentation effects or any significant increases in water runoff owing to the proposed development, if any, should take place. If any such impacts occur necessary steps should be introduced to counteract any significant changes in waterflow and erosion.
- Quick revegetation at soil surface at the solar panel areas should take place.
- Sediment capture and stormwater runoff systems should be planned carefully so that the risk of excessive water runoff towards the wetland patch remains low.

5.3 Interflow ("Subsurface stormwater flow)

Small wetlands are very shallow and on a plain in the landscape of an area of which the average annual rainfall is 500 mm or less. There is no distinct indication that interflow plays an important role in the maintenance of the wetlands outside the proposed footprint or that the proposed development will have a significant influence on interflow. Input of water into the small depressions appears to be via sheet flow of water during rainfall events, perhaps via some seepage, but overall if surface water is present it appears to be very temporary in a basin which suggests that significant quantities of interflow do not sustain the wetlands.

<u>Mitigation measures:</u>
In the case of this study no risks or mitigation measures could apply to the wetlands are excluded from the proposed footprint.

5.4 Groundwater

Wetlands are shallow and on a plain in the landscape of an area of which the average annual rainfall is 500 mm or less. Input of water into the small depression appears to be via sheet flow of water during rainfall events, perhaps via some seepage, but overall if surface water is present it appears to be very temporary in a basin which suggests that significant quantities of groundwater do not sustain the wetlands. There is no distinct indication that ground water plays an important role in the maintenance of the wetlands at the site.

<u>Mitigation measures:</u>
In the case of this study no risks or mitigation measures could apply for groundwater at the wetlands that are outside the proposed footprint.

5.5 Flow regime

Hydrodynamics at the small pan depressions are dominated by vertical water level fluctuations, being "dried out" for lengths of time during the absence of rain. It is unlikely that there would be a significant impact on the flow regime of the wetlands outside the proposed footprint owing to the counterbalances in the surface flow regime. In addition upper soils at the site are conspicuously sandy at the plains and proposed footprints next to the wetland basins, which means that infiltration of water into the soil would be relatively high and water runoff being buffered. The existence of the wetland may be slightly enhanced by possible slight increased surface flow, if at all.

Mitigation measures:

- A buffer zone of 30 m from the outer edge of the small wetlands applies.
- Significant decrease in grazing activities to enhance the functioning of the buffer zone around the wetlands.
- Monitoring of any possible sedimentation effects or any significant increases in water runoff owing to the proposed development, if any of these would occur, should take place. If any such impacts occur necessary steps should be introduced to counteract any significant changes in waterflow and erosion.
- If the development is approved, quick revegetation at soil surface at the solar panel areas should take place.
- Sediment capture and stormwater runoff systems should be planned carefully so that the risk of excessive water runoff towards the wetlands is limited.

5.6 Geomorphology

Proposed development implies no changes to the geomorphological setting of the wetlands west and east of the proposed footprint. No implications of mitigation measures apply.

5.7 Wetland habitat

It is highly unlikely that any loss of wetland habitat at the site would take place owing to the proposed development.

Mitigation measures:

- A buffer zone of 30 m from the outer edge of the small wetland patches apply.
- Exotic and invasive plant species should not be allowed to establish, if the development is approved, especially an alien invasive tree species such as *Prosopis*.
- Monitoring of any possible sedimentation effects or any significant increases in water runoff owing to the proposed development, if any occur, should take place. If any such impacts occur necessary steps should be introduced to counteract any significant changes in waterflow and erosion.
- Fuel spillages and any sewage or domestic waste should be avoided at the proposed footprint if the development is approved so that delayed indirect effects of any such pollution to the wetlands further away but within 500 m of the proposed footprints are avoided.

5.8 Wetland biota

5.8.1 Wetland biota; general indigenous diversity

Small wetlands AP 1 and AP 2 outside the proposed footprint but within 500 m of the edge of the proposed footprint contain indigenous plant and animal diversity but in general this indigenous diversity does not appear to be high. Standard mitigation measures apply such as prevention of the establishment of exotic vegetation and avoidance of any trapping or killing of mammalian or bird species during the construction phase.

<u>Mitigation measures:</u>

- Exotic and invasive plant species should not be allowed to establish, if the development is approved, especially an alien invasive tree species such as *Prosopis*.

5.8.2 Wetland plant and animal species that are threatened or of any other particular conservation concern

Presence of any threatened animal or plant species, or any other species of particular conservation concern at the site and the small wetlands are unlikely (see also ecological habitat survey report). No risks or mitigation measures apply for particular sensitive species. No threats to any Threatened or Near Threatened plant or animal species or any distinct impact on migratory species of particular conservation concern at the wetlands are anticipated if the development is approved.

6 CONCLUSION

There appears to be no wetlands at the proposed footprint.

There are two small temporary wetlands outside the proposed footprint but within 500 m of the edge of the proposed footprint, one small depression near the western boundary of the proposed footprint labelled **AP 1** (approximately 0.32 ha) and one small depression near the southeastern extension of the proposed footprint labelled **AP 2** (approximately 0.18 ha) (Figure 2). Both are similar in that they are small, rocks surface at the bottom of the shallow basin and a sparse cover of hydrophyte *Persicaria* species is found at the bottom of the shallow basins. There is a waterpoint next to depression AP 1 which leads to more grazing pressure compared to AP 2. Surface water at these small pan depressions is clearly temporal and the soil surface appears dry for most of the year.

The present ecological status (PES) of both the small wetlands outside the proposed footprint is CATEGORY B which means these systems are largely natural with few modifications, but with some loss of natural habitats (Tables 4.2, 4.3, 4.6 and 4.7). The ecological importance and sensitivity (EIS) of both the wetlands are Moderate (Table 4.9 and Table 4.10) because it appears to contain some indigenous biodiversity but it is not high because there are no distinct indications of importance to particular sensitive or threatened species, flocks of migratory species of particular conservation concern or conservation areas of particular importance.

The site is not part of a Freshwater Ecosystem Priority Area (FEPA) or wetland cluster (Nel, Driver, Strydom, Maherry, Petersen, Hill, Roux, Nienaber, Van Deventer, Swartz, & Smith-Adao, 2011; Nel, Murray, Maherry, Petersen, Roux, Driver, Hill, Van Deventer, Funke, Swartz, Smith-Adao, Mbona, Downsborough & Nienaber, 2011). Site is part of the Lower Vaal Water Management Area (WMA 10).

The two wetland depressions (pans) west and east of the proposed footprint could be managed in particular to fulfill its role in providing ecosystem services such as:

- Nutrient cycling and primary production, which are basic prerequisites of other ecosystem services of wetlands,
- Attenuation of water and enhancing water quality by processing water and regulating water run-off,

- Counter erosion which remains important even though slopes in the area are not steep,
- Habitat for some indigenous plant and animal species that favour of visit wetlands.

It is anticipated that the proposed development would not have a major influence on the hydrological regime of the small depressions outside the proposed footprint. There appears to be no distinct reason (such as would have been the case for gatherings of large rare water birds; associated unique wetland vegetation; extensive edge effects of impacts; sensitive extensive wetlands) why the buffer zone should be large.

No threatened plant or animal species are suspected to be present at the site.

The type of development proposed, if approved, does not have the same impact as for example a plantation or buildings in terms of shade effects on the flora and fauna, and more important, on buffer zones or corridors. Upper soils at the plains where the proposed footprint is situated are conspicuously sandy which because of relatively high infiltration, adds to the limiting of water runoff in combination with very gentle slopes. A buffer zone of 30 m is thought to be adequate to maintain the functioning of the wetland systems outside the proposed footprint. Therefore if the development is approved the risks of any significant impacts to the wetlands are decidedly small and most likely to be counteracted or limited owing to the following reasons:

1) A presence of a buffer zone of at least 30 m from the perimeter of the wetlands;
2) The longitudinal slopes at the plains in which the wetlands are situated is very gentle, so that water runoff is likely to remain relatively low,
3) The site is also located in a relatively low rainfall area of which the mean annual precipitation is 500 mm or less. The amount of runoff and the percentage of runoff as a proportion of rainfalll tend to increase with rainfall such that while runoff in the northwest of South Africa is less than 5 mm per annum, there is a fairly systematic increase of runoff towards southwards and eastwards in South Africa (Ellery *et al.,* 2009). Because the site falls in the northwestern parts of the country the water runoff is relatively very low,
4) Water runoff from the plain toward the wetlands, is a sheet flow into the depressions rather than a channeled inflow. Diffusion rather than chanelling of water flow towards the excluded wetland depressions disperses any water runoff or impact on erosion,
5) Soils at the proposed footprint are conspicuously sandy which means relatively high infiltration of water during rainfall events and an additional limitation to water runoff,
6) Mitgation measure of rapid re-vegetation of areas where the proposed solar panels are,

7) A significant decrease of grazing activities at the buffer zone of the wetland patch if the development is approved, resulting in higher cover of vegetation at this buffer zone, counteracting rapid water runoff and erosion effects,
8) Maintaining water quality of the wetlands by practices of avoiding fuel spillages and any sewage or domestic waste onto soils at the plains near the wetlands.
9) Avoidance of establishment of exotic plant species in particular alien invasive species such as *Prosopis,*

Owing to the lack of a vast body of extensive research of the impacts of solar power plants, a relatively new field the present study, one could not absolutely guarentee that no risk of changes to the wetland patch are possible. However, given the factors above, it is unlikely that these wetlands would be significantly altered.

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