# Wetland Baseline & Risk Assessment for the proposed Phala Photovoltaic (PV) Facility

# Bela Bela, Limpopo Province, South Africa

November 2022

**CLIENT**

ENVIRONAMICS

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# 1 Introduction

## 1.1 Background

The Biodiversity Company (TBC) was appointed to undertake a wetland baseline and risk assessment for the proposed Phala Solar Power Plants (SPP) Photovoltaic (PV) project. The proposed project involves the development of a solar facility and associated infrastructure, located approximately 500 m from the Bela Bela town centre and transverse the R 101 and the R 516 roads in the Limpopo province (Figure 1-1 and Figure 1-2).

To assess the baseline ecological state of the area and to present a detailed description of the receiving environment, both a desktop assessment as well as a field survey were conducted during October 2022. Furthermore, the desktop assessment and field survey both involved the detection, identification and description of any locally relevant water resources, and the manner in which these sensitive features may be affected by the proposed development was also investigated. A 500 m radius has been demarcated for the cluster for the identification of wetlands within the prescribed regulation area. This demarcated area is referred to as the Project Area of Influence (PAOI).

This assessment was conducted in accordance with the amendments to the Environmental Impact Assessment Regulations, 2014 (No. 326, 7 April 2017) of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998). The approach has taken cognisance of the recently published Government Notice 320 in terms of NEMA dated 20 March 2020 as well as the Government Notice 1150 in terms of NEMA dated 30 October 2020: “Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation”. The National Web based Environmental Screening Tool has characterised the aquatic biodiversity theme for the area as predominantly ‘Low’, with limited areas designated ‘Very High’ sensitivity due to the presence of wetlands (National Environmental Screening Tool, 2022).

The purpose of conducting the specialist study is to provide relevant input into the overall Environmental Authorisation application process, with a focus on the proposed project activities and their associated impacts. This report, after taking into consideration the findings and recommendations provided by the specialist herein, should inform and guide the Registered Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making as to the ecological viability of the proposed project.

## 1.2 Technical Information

The following technical information was provided by Environamics:

The term photovoltaic describes a solid-state electronic cell that produces direct current electrical energy from the radiant energy of the sun through a process known as the Photovoltaic Effect. This refers to light energy placing electrons into a higher state of energy to create electricity. Each PV cell is made of silicon (i.e., semiconductors), which is positively and negatively charged on either side, with electrical conductors attached to both sides to form a circuit. This circuit captures the released electrons in the form of an electric current (direct current). The key components of the proposed project are described below:

- PV Panel Array - To produce up to 350MW, the proposed facility will require numerous linked cells placed behind a protective glass sheet to form a panel. Multiple panels will be required to form the solar PV arrays which will comprise the PV facility. The PV panels will be tilted at a northern angle in order to capture the most sun.
- Wiring to Inverters - Sections of the PV array will be wired to inverters. The inverter is a pulse width mode inverter that converts direct current (DC) electricity to alternating current (AC) electricity at grid frequency.

- Connection to the grid - Connecting the array to the electrical grid requires transformation of the voltage from 480V to 33kV to 132kV. The normal components and dimensions of a distribution rated electrical substation will be required. Output voltage from the inverter is 480V and this is fed into step up transformers to 132kV. An onsite substation will be required on the site to step the voltage up to 132kV, after which the power will be evacuated into the national grid via the proposed power line. It is expected that generation from the facility will connect to the national grid via the existing Eskom Warmbad 275/132/66kV MTS Substation. The grid connection route will be assessed within a 200m wide (up to 550m wide in some instances) corridor. The Project will inject up to 300MW into the National Grid. The installed capacity will be approximately 350MW
- Electrical reticulation network – An internal electrical reticulation network will be required and will be lain ~2-4m underground as far as practically possible.
- Supporting Infrastructure – The supporting infrastructure such as the auxiliary buildings will be situated in an area measuring up to 1.3 ha.
- Battery storage – A Battery Storage Facility with a maximum height of 8m and a maximum volume of 1,740 m3 of batteries and associated operational, safety and control infrastructure.
- Roads – Access will be obtained via the R101 regional road to the west of the site. An internal site road network will also be required to provide access to the solar field and associated infrastructure. The access and internal roads will be constructed within a 25-meter corridor. Access Points: coordinates 24°55'19.96"S 28°18'18.58"E
- Fencing - For health, safety and security reasons, the facility will be required to be fenced off from the surrounding farm. Fencing with a height of 2.5 meters will be used

***Table 1-1 Technical details for the proposed facility***

| Component | Description / dimensions |
|---|---|
| **Height of PV panels** | 6 meters |
| **Area of PV Array** | 550 hectares (Development footprint) |
| **Number of inverters required** | Minimum 50 |
| **Area occupied by inverter / transformer stations / substations / BESS** | Central inverters + LV/MV trafo: 750 m2<br>HV/MV substation with switching station: 15 000m2<br>BESS: 40 000 m2 |
| **Capacity of on-site substation** | 132kV |
| **Capacity of the power line** | 132kV |
| **Area occupied by both permanent and construction laydown areas** | Total Footprint Area: 570 hectares<br>Construction laydown area: within ~ 3.7 ha |
| **Area occupied by buildings** | Security Room: ~150 $m^2$<br>O&M laydown: Within 1.3 ha |
| **Battery storage facility** | Maximum height: 8m<br>Maximum volume: 1740 $m^3$<br>Capacity: Up to 500 MW |
| **Length of internal roads** | Approximately 30 km |
| **Width of internal roads** | Between 4 to 6 meters |
| **Proximity to grid connection** | The grid connection route will be assessed within a 200m wide (up to 550m wide in some instances) |
| **Grid connection corridor width** | 200m wide but up to 550m wide in some instances |
| **Grid connection corridor length** | ± 2,6 km |
| **Power line servitude width** | 15 – 25 m |
| **Height of fencing** | Approximately 2.5 meters |

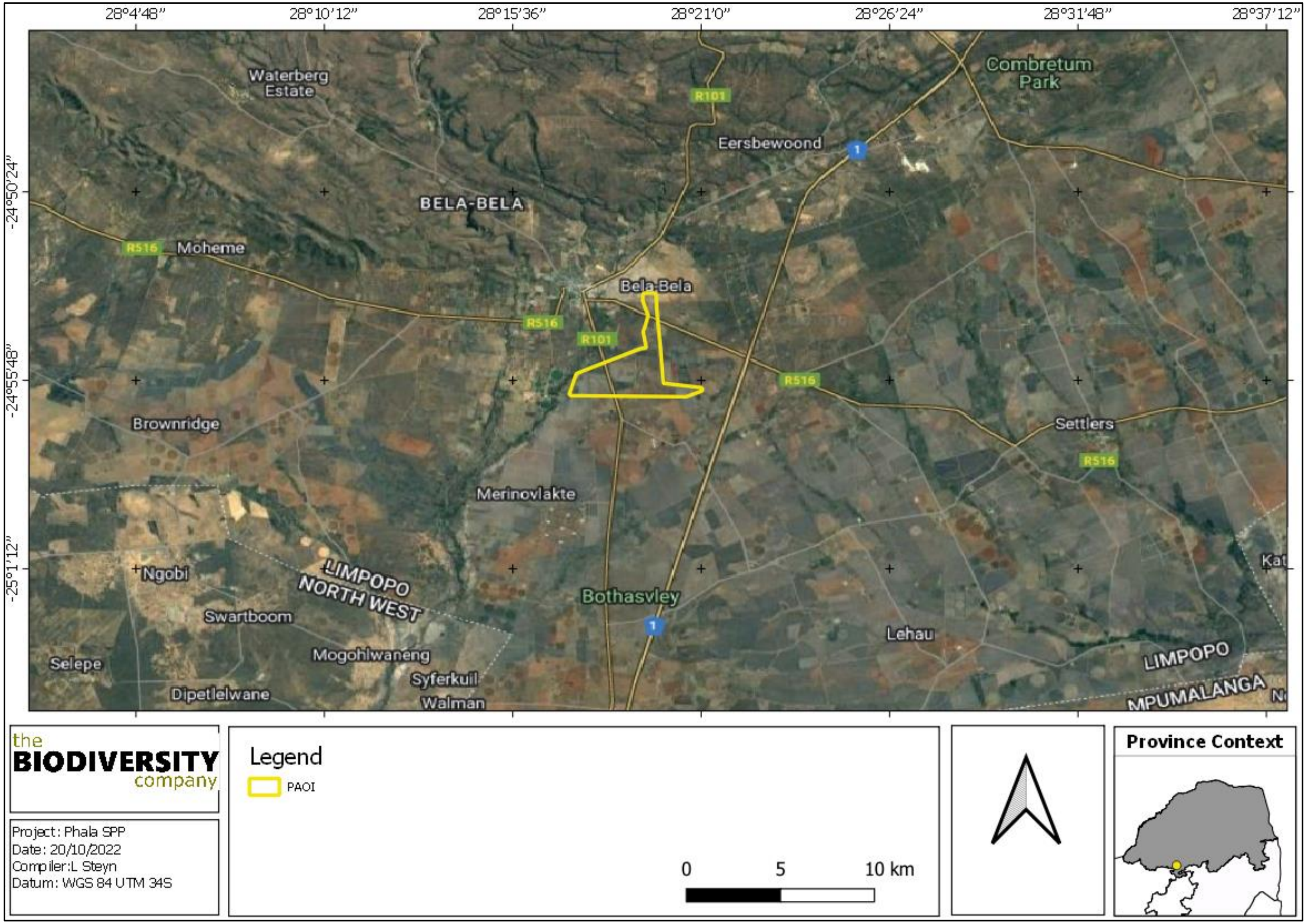


***Figure 1-1 Map illustrating the location of the proposed PV Project***

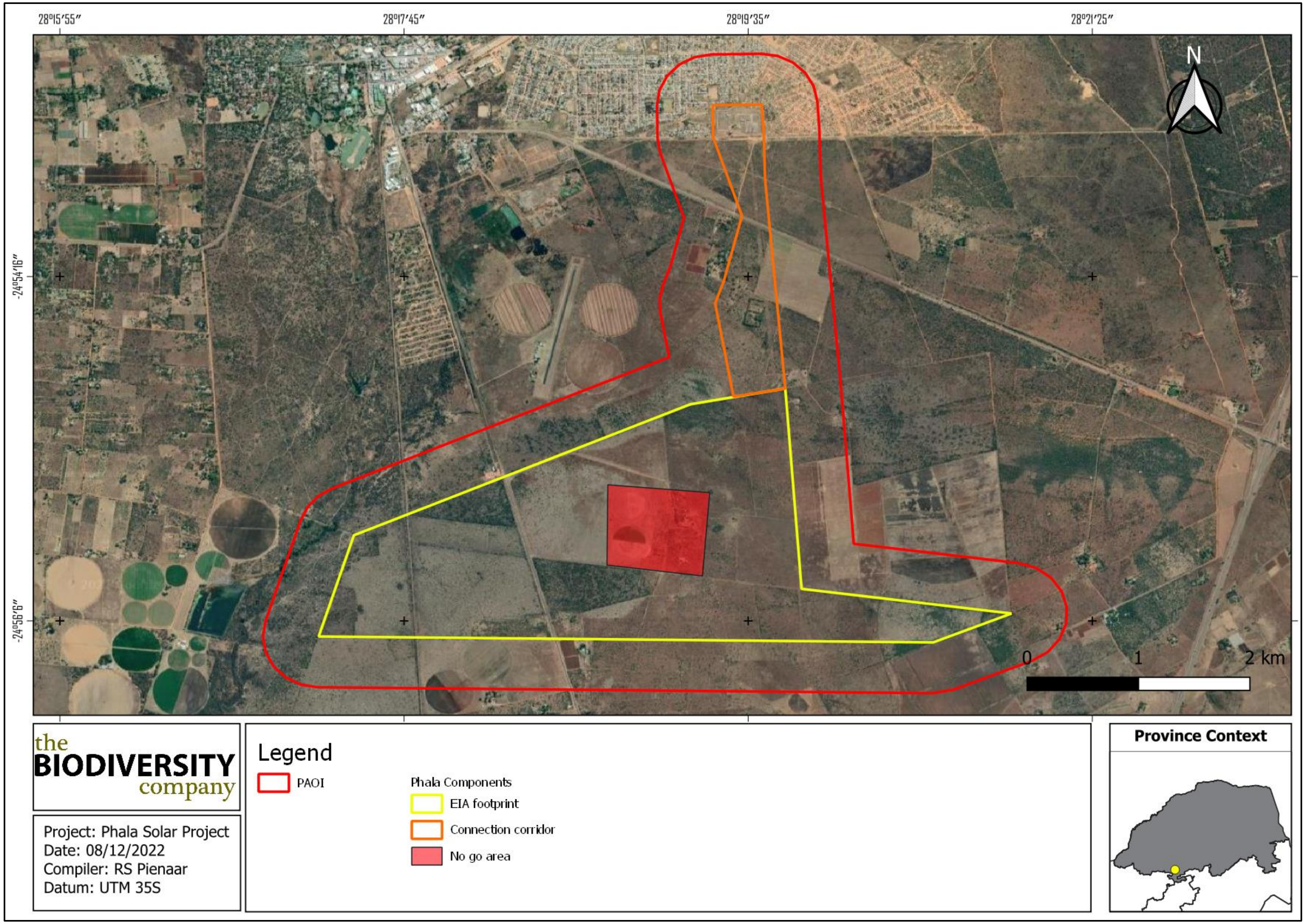


***Figure 1-2 Phala SPP Solar Energy Facility broad layout***

## 1.3 Specialist Details

| | | |
|---|---|---|
| Report Name | **Wetland Baseline & Risk Assessment for the proposed Phala Solar Project** | |
| Reference | **Phala Solar PV** | |
| Submitted to | ENVIRONAMICS | |
| Report Writer & Fieldwork | **Rian Pienaar** | [signature] |
| | Rian Pienaar is an aquatic ecologist (Cand. Sci. Nat. 135544) with experience in wetland identification and delineations. Rian completed his M.Sc. in environmental science at the North-West University Potchefstroom Campus. Rian has been part of wetland studies for road and culvert upgrades, power station and dam construction. | |
| Reviewer | **Andrew Husted** | [signature] |
| | Andrew Husted is Pr Sci Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 13 years' experience in the environmental consulting field. | |
| Declaration | The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, 2017. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principals of science. | |

## 1.4 Terms of Reference

The following tasks were completed in fulfilment of the terms of reference for this assessment:

- The delineation, classification and assessment of wetlands within 500 m of the project area;
- Conduct risk assessments relevant to the proposed activity;
- Recommendations relevant to associated impacts; and
- Report compilation detailing the baseline findings.

## 1.5 Key Legislative Requirements

### 1.5.1 National Water Act (NWA, 1998)

The DWS is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (Act No. 36 of 1998) (NWA) allows for the protection of water resources, which includes:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse means;

- A river or spring;
- A natural channel in which water flows regularly or intermittently;

- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The NWA recognises that the entire ecosystem and not just the water itself, and any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the DWS. Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) and (i).

### 1.5.2 National Environmental Management Act (NEMA, 1998)

The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations as amended in April 2017, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Environmental Impact Assessment (EIA) process depending on the scale of the impact

# 2 Methods

A single wetland site visit was conducted from the 18th to the 20th of October 2022, this would constitute a dry season survey.

## 2.1 Identification and Mapping

The wetland areas were delineated in accordance with the DWAF (2005) guidelines, a cross section is presented in Figure 2-1. The outer edges of the wetland areas were identified by considering the following four specific indicators:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
  - The soil forms (types of soil) found in the landscape were identified using the South African soil classification system namely; Soil Classification: A Taxonomic System for South Africa (Soil Classification Working Group, 1991);
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

Vegetation is used as the primary wetland indicator. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role.

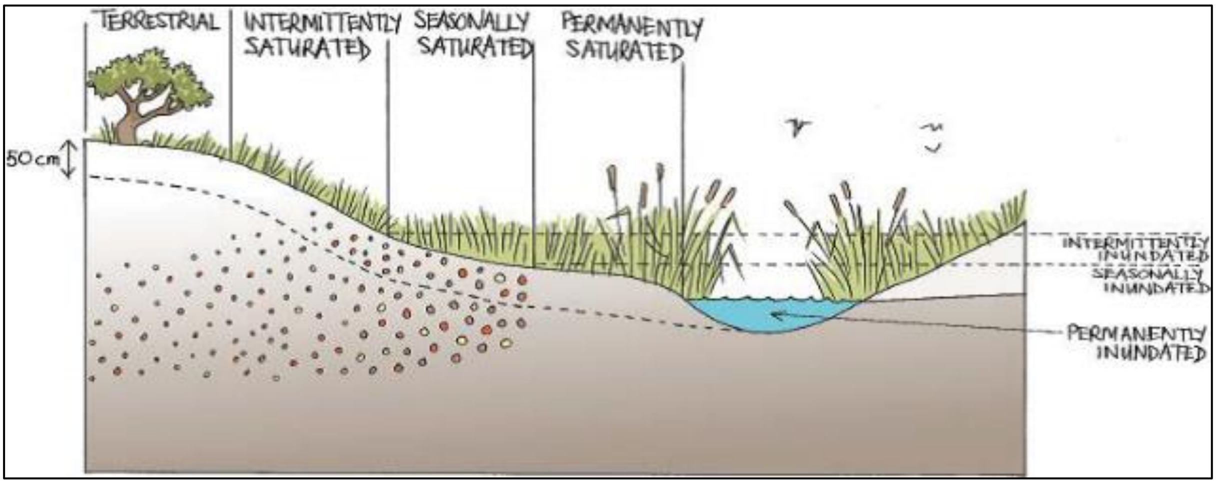


***Figure 2-1 Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis et al. 2013)***

## 2.2 Delineation

The wetland indicators described above are used to determine the boundaries of the wetlands within the project area. These delineations are then illustrated by means of maps accompanied by descriptions.

## 2.3 Functional Assessment

Wetland Functionality refers to the ability of wetlands to provide healthy conditions for the wide variety of organisms found in wetlands as well as humans. Eco Services serves as the main factor contributing to wetland functionality.

The assessment of the ecosystem services supplied by the identified wetlands was conducted per the guidelines as described in WET-EcoServices (Kotze *et al*. 2008). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the services are provided (Table 2-1).

***Table 2-1 Classes for determining the likely extent to which a benefit is being supplied***

| Score | Rating of likely extent to which a benefit is being supplied |
|---|---|
| < 0.5 | Low |
| 0.6 - 1.2 | Moderately Low |
| 1.3 - 2.0 | Intermediate |
| 2.1 - 3.0 | Moderately High |
| > 3.0 | High |

## 2.4 Present Ecological Status

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present Ecological Status (PES) score. This takes the form of assessing the spatial extent of impact of individual activities/occurrences and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact. The Present State categories are provided in Table 2-2.

***Table 2-2 The Present Ecological Status categories (Macfarlane, et al., 2008)***

| Impact Category | Description | Impact Score Range | PES |
|---|---|---|---|
| None | Unmodified, natural | 0 to 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. | 1.0 to 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. | 2.0 to 3.9 | C |
| Large | Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred. | 4.0 to 5.9 | D |
| Serious | Seriously Modified. The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognizable. | 6.0 to 7.9 | E |
| Critical | Critical Modification. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota. | 8.0 to 10 | F |

## 2.5 Importance and Sensitivity

The importance and sensitivity of water resources is determined to establish resources that provide higher than average ecosystem services, biodiversity support functions or are particularly sensitive to impacts. The mean of the determinants is used to assign the Importance and Sensitivity (IS) category as listed in Table 2-3.

***Table 2-3 Description of Importance and Sensitivity categories***

| IS Category | Range of Mean | Recommended Ecological Management Class |
|---|---|---|
| **Very High** | 3.1 to 4.0 | **A** |
| **High** | 2.1 to 3.0 | **B** |
| **Moderate** | 1.1 to 2.0 | **C** |
| **Low Marginal** | < 1.0 | **D** |

## 2.6 Ecological Classification and Description

The National Wetland Classification Systems (NWCS) developed by the South African National Biodiversity Institute (SANBI) will be considered for this study. This system comprises a hierarchical classification process of defining a wetland based on the principles of the hydrogeomorphic (HGM) approach at higher levels, and then also includes structural features at the lower levels of classification (Ollis *et al.,* 2013).

## 2.7 Buffer Requirements

The "Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries" (Macfarlane *et al.,* 2014) was used to determine the appropriate buffer zone for the proposed activity.

## 2.8 Assumptions and Limitations

The following assumptions and limitations are applicable for this assessment:

- The focus area was based on the spatial files provided by the client and any alterations to the area and/or missing GIS information would have affected the area surveyed;
- Only the outline area of the proposed site was provided to the specialist; and
- The GPS used for the survey has a 5 m accuracy and therefore any spatial features may be offset by 5 m.

# 3 Results and Discussion

## 3.1 Desktop Baseline

### 3.1.1 Vegetation Type

The project area falls within two vegetation types namely the Springbokvlakte Thornveld (SVcb 15) and vegetation type. The distribution of the vegetation unit is located in Limpopo, Mpumalanga, North-West, and Gauteng Provinces. Within the Gauteng Province, it spreads across flats from Zebediela in the northeastern region, to Hammanskraal and Assen in the southwestern region, and Bel-Bela and Mookgophong in the northwest to Marble Hall and Rust de Winter in the southeastern region. It occurs on altitude ranges from 900 m to 1 200 m.

The vegetation and landscape features are mainly dominated by open to dense, low thorn savanna, and the landscape is dominated by Acacia species, or shrubby grassland with a low shrub layer. The landscape is mostly flat, with gently undulating plains. The conservation status of the vegetation type is Endangered.

### 3.1.2 Soils and Geology

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by the Ae 18, Dc 1 and Ea 146 land types. The Ae 18 and Ba 13 land types mainly have Hutton and Arcadia soil forms according to the Soil classification working group, (1991), with the occurrence of other soils within the landscape. The Ae land type is dominated with red and yellow apedal soils. These soils have a high drainage potential with a high base status. The profiles are mostly deeper that 300 mm without the occurrence of dunes. The Dc 1 land type is characterised with occurrence of Sterkspruit soil forms associated to other soils occurring in the terrain. The Ea land types are characterised of vertic, melanic and red structured diagnostic horizons with are usually undifferentiated. The land terrain units for the featured Ae 18 land type are illustrated in Figure 3-3 with the expected soils listed in **Error! Reference source not found.**; the Dc 1 land types are illustrated i n **Error! Reference source not found.** and the soils are shown in **Error! Reference source not found.**; the Ea 146 land types in Figure 3-3 and **Error! Reference source not found.** .

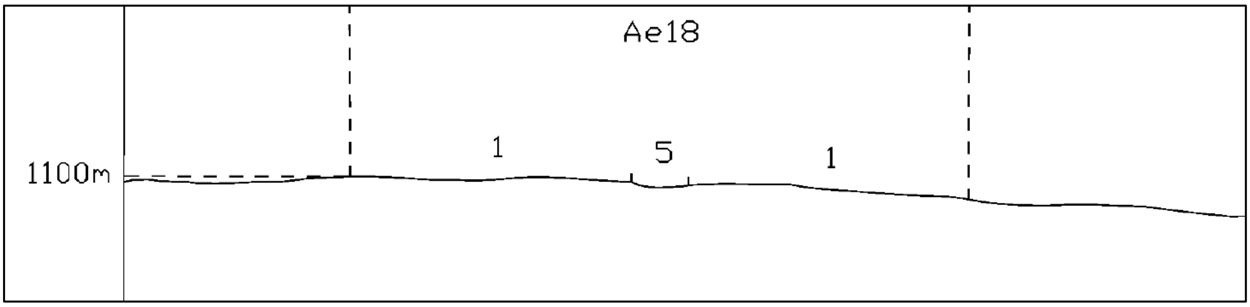


***Figure 3-1 Illustration of land type Ae 18 terrain unit (Land Type Survey Staff, 1972 - 2006)***

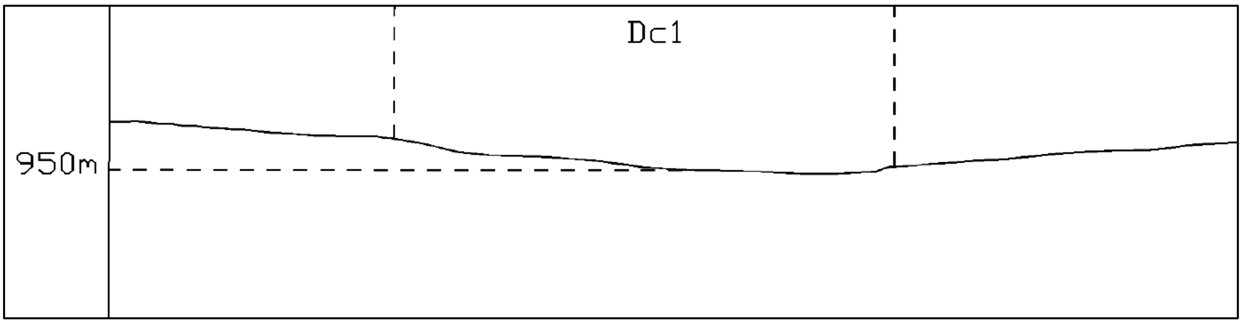


***Figure 3-2 Illustration of land type Dc terrain unit (Land Type Survey Staff, 1972 - 2006)***

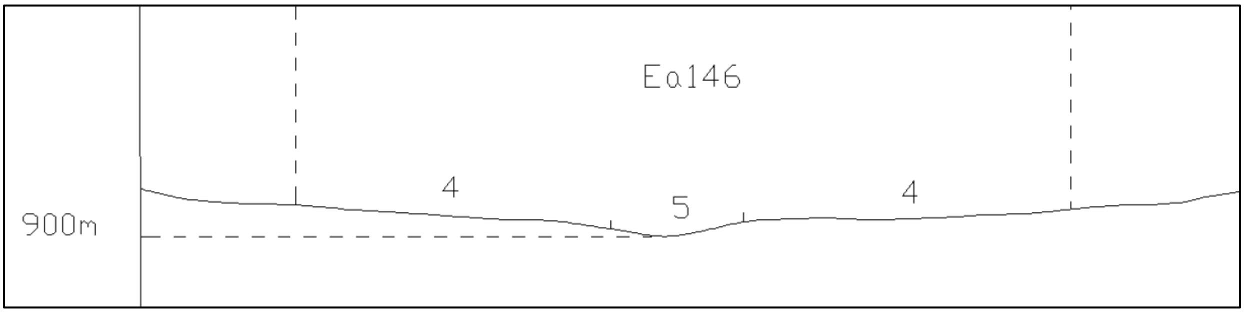


***Figure 3-3 Illustration of land type Ea 146 terrain unit (Land Type Survey Staff, 1972 - 2006)***

### 3.1.3 Climate

The vegetation type is characterised by a summer rainfall with very dry winters. The Mean Annual Precipitation (MAP) ranged netween about 500–650 mm. Mean monthly maximum and minimum temperatures for Warmbaths–Towoomba are 35.2°C and –2.0°C for October and July, respectively. Corresponding values are 36.8°C and –1.2°C for Marble Hall for January and June.

### 3.1.4 South African Inventory of Inland Aquatic Ecosystems

This spatial dataset is part of the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) which was released as part of the National Biodiversity Assessment (NBA 2018). National Wetland Map 5 includes inland wetlands and estuaries, associated with river line data and many other data sets within the South African Inventory of Inland Aquatic Ecosystems (SAIIAE, 2018).

The data set indicated no SAIIAE wetlands located within the PAOI.

### 3.1.5 NFEPA Wetlands

The NFEPA database is a collaborative project between multiple stakeholders such as CSIR, the WRC and SANBI. The objective of the project was to identify priority areas to conserve and protect as well as to promote sustainable water use, thereby assisting in meeting the biodiversity goals for freshwater habitats set out in all levels of government (Nel et al. 2011).

No wetlands were identified within the PAOI by means of this dataset.

### 3.1.6 Topographical Inland Water and River Lines

The topographical inland and river line data for “2428” quarter degree was used to identify potential wetland areas within the PAOI. This data set indicates a single non-perennial river line located within the PAOI (see Figure 3-4).

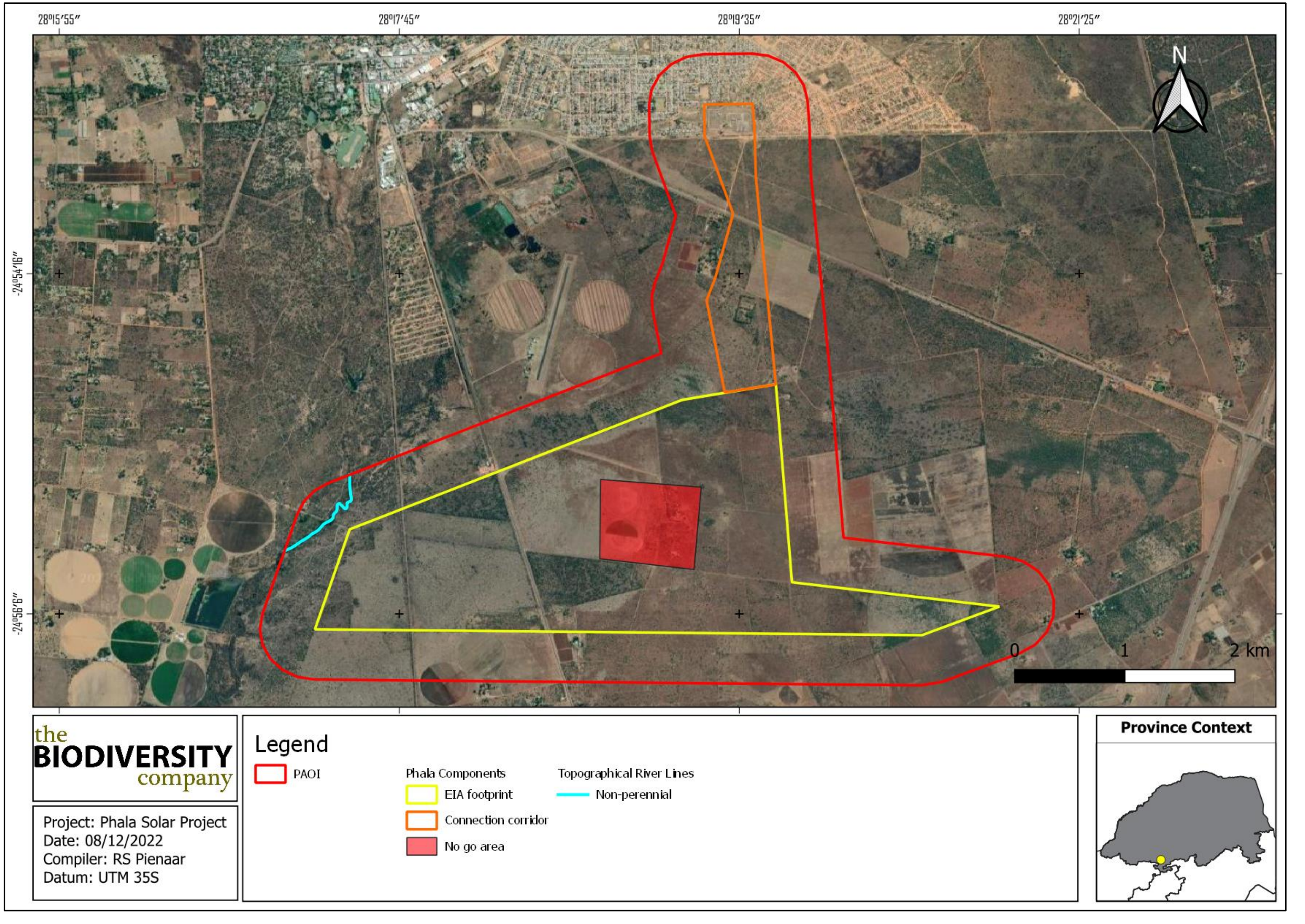


***Figure 3-4 Topographical River line and inland water areas located within the PAOI***

### 3.1.7 Terrain

The terrain of the PAOI has been analysed to determine potential areas where water is more likely to accumulate (due to convex topographical features, preferential pathways, or more gentle slopes).

#### 3.1.7.1 Digital Elevation Model (DEM)

A Digital Elevation Model (DEM) has been created to identify lower laying regions as well as potential convex topographical features which could point towards preferential flow paths. The PAOI ranges from 1 093 to 1 146 metres above sea level (MASL). The lower laying areas (generally represented in dark blue) represent the area that will have the highest potential to be characterised as wetlands (see Figure 3-5).

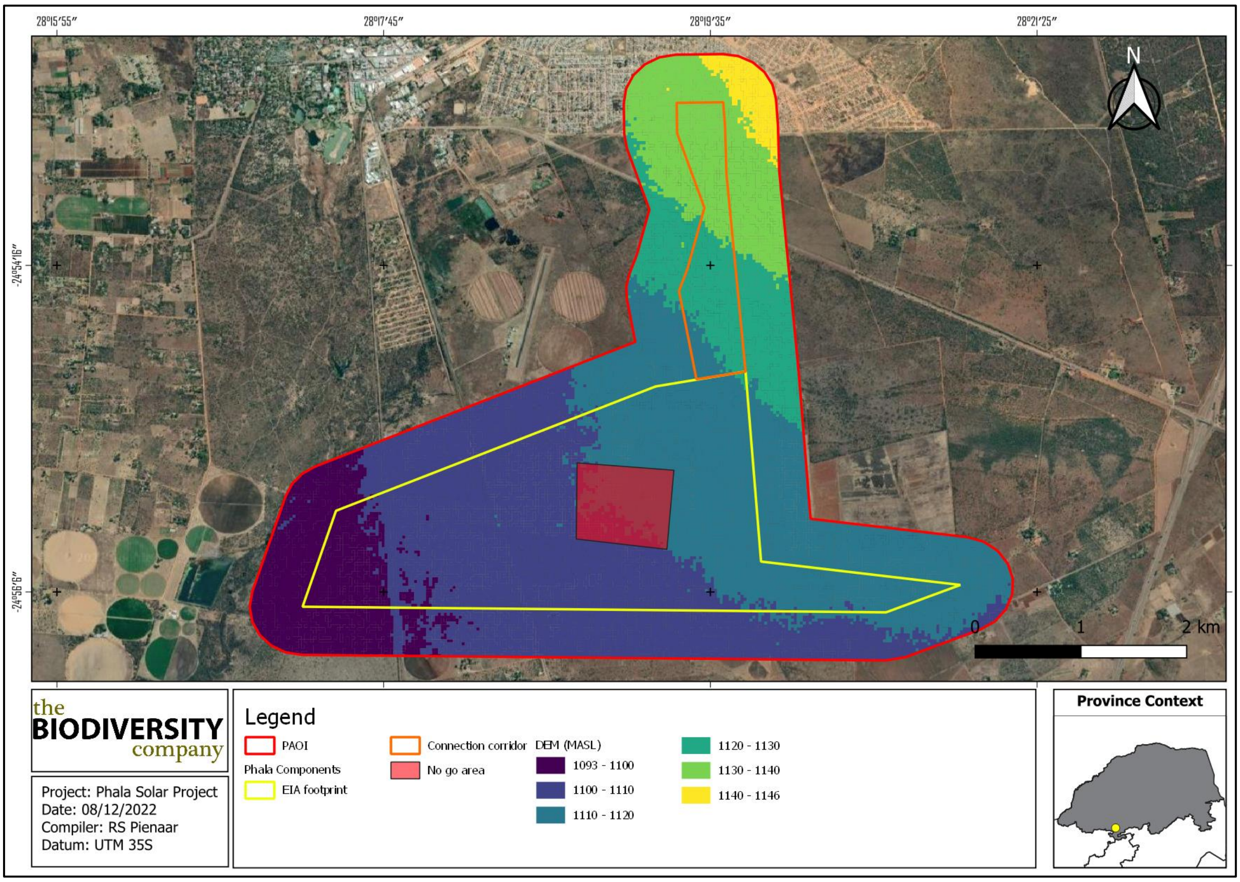


***Figure 3-5 Digital Elevation Model of the PAOI***

# 4 Field Assessment

## 4.1 Delineation and Description

During the site visit, four HGM units were identified within the PAOI (see Figure 4-2). The wetland areas were delineated in accordance with the DWAF (2005) guidelines (see Figure 4-1 and Figure 4-2). HGM units have been classified as three depression wetlands and one channelled valley bottom system. Multiple artificial wetlands, namely dams were identified to the within the PAOI. According to Ollis *et al* (2013) a dam is classified as '*an artificial body of water formed by the unnatural accumulation of water behind an artificial barrier that has been constructed across a river channel or an unchannelled valley bottom wetland'*. Although these systems do not classify as a natural wetland system it is important to note where the dams are for any planned development in the area. No watercourses were identified within the powerline corridor. The delineation of the wetland systems and functional assessment have been completed for the natural depressions and the channelled valley bottom wetland.

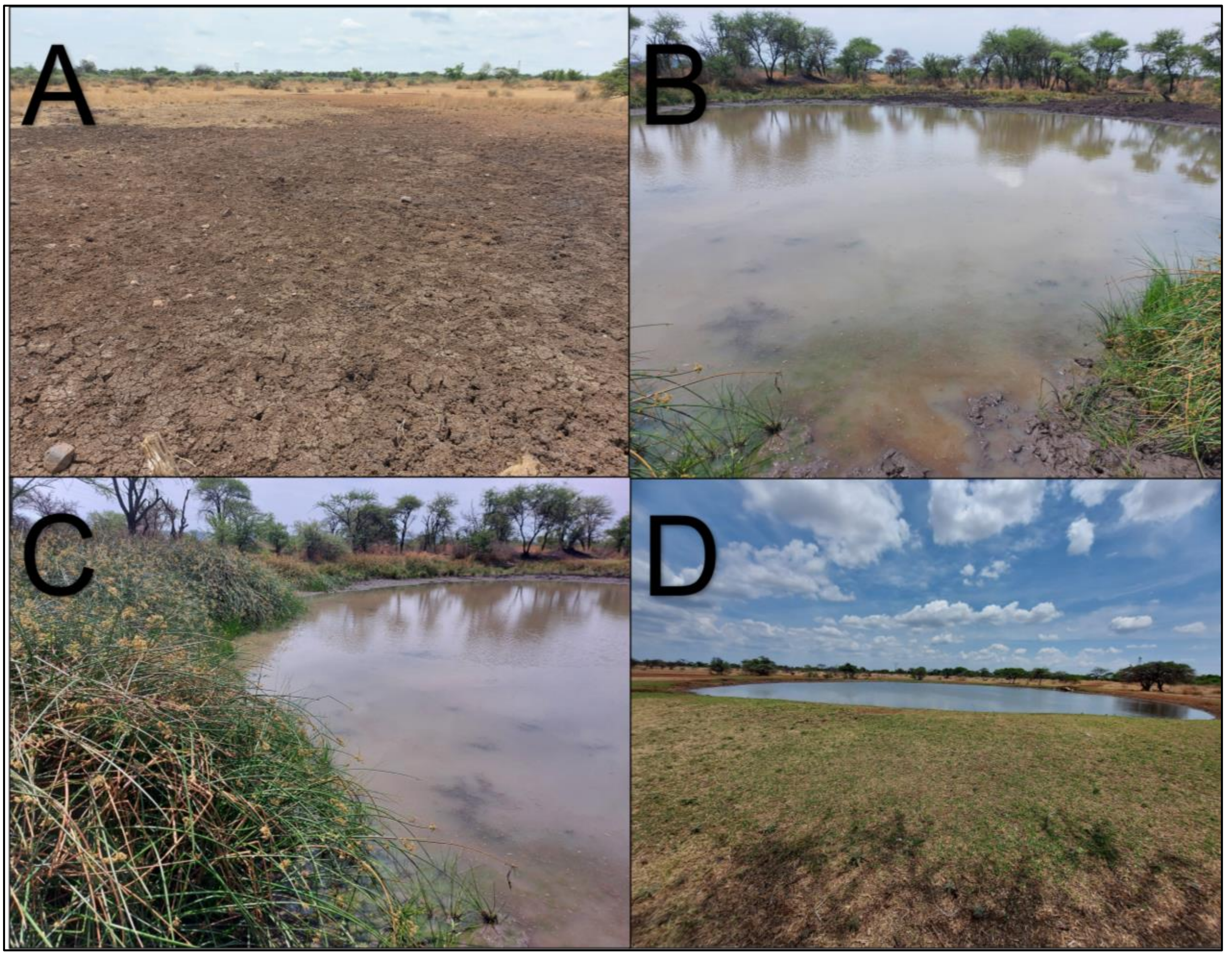


***Figure 4-1 Photographical evidence of the different wetland types found within the project area of influence, A, B, & C) Depression wetlands, D) Artificial dam.***

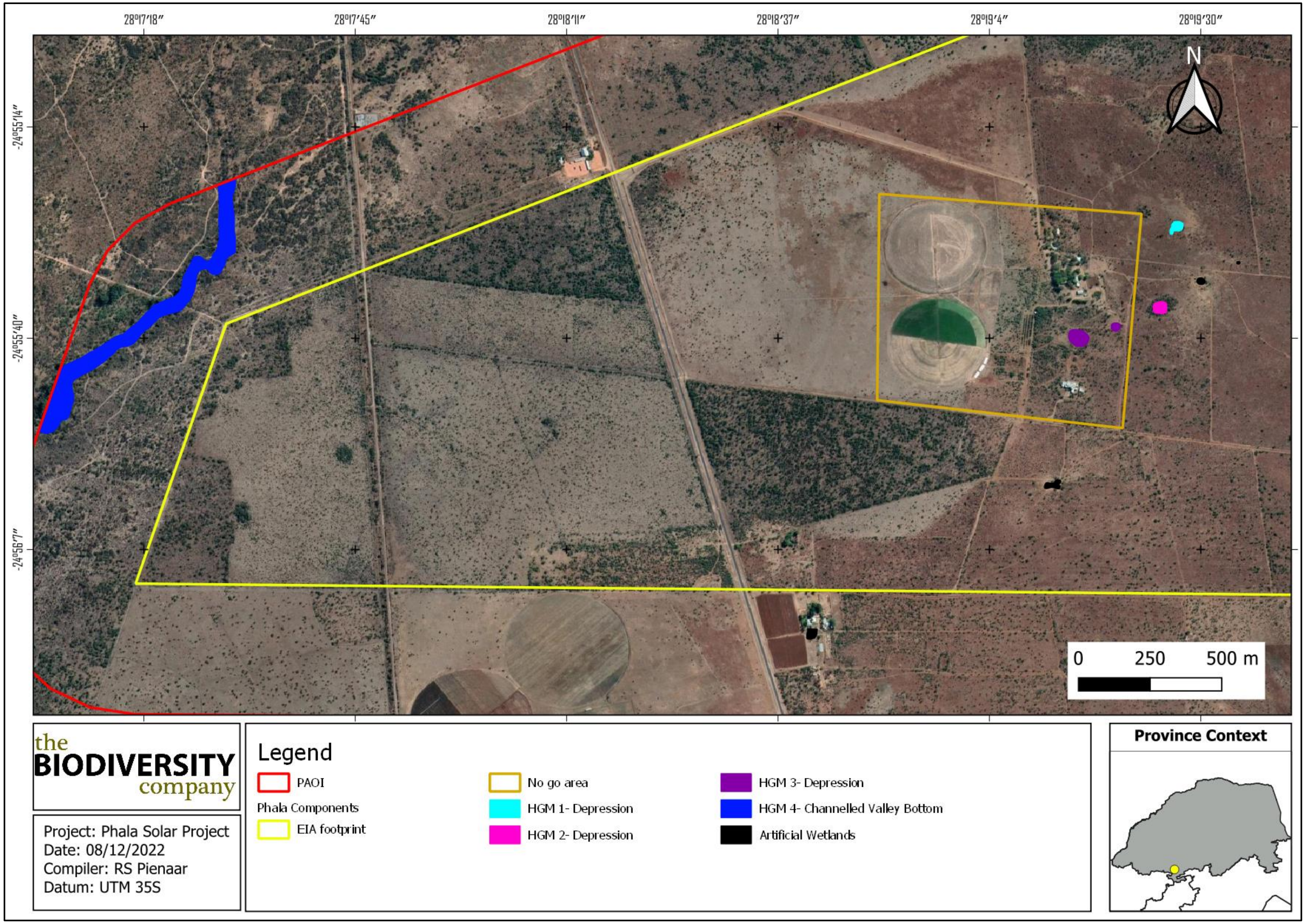


***Figure 4-2 Delineation and location of the different HGM units identified within the PAOI***

### 4.2 Unit Setting

Depression wetlands are located on the "slope" landscape unit. Depressions are inward draining basins with an enclosing topography which allows for water to accumulate within the system. Depressions, in some cases, are also fed by lateral sub-surface flows in cases where the dominant geology allows for these types of flows. Figure 4-3 presents a diagram of a typical depression wetland, showing the dominant movement of water into, through and out of the system.

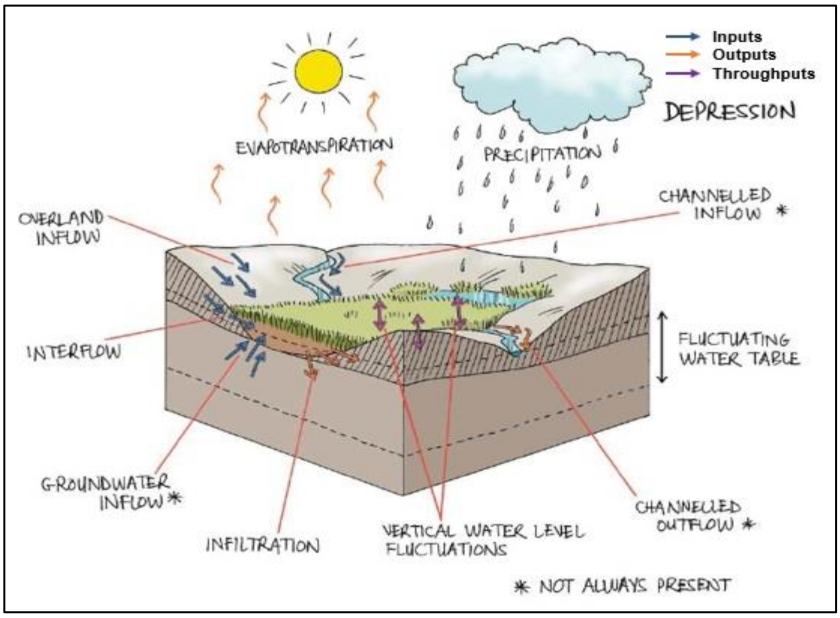


***Figure 4-3*** ***Amalgamated diagram of atypical depression wetland, highlighting the dominant water inputs, throughputs and outputs, SANBI guidelines (Ollis et al. 2013)***

Channelled valley bottom wetlands are typically found on valley floors with a clearly defined, finite stream channel and lacks floodplain features, referring specifically to meanders. Channelled valley bottom wetlands are known to undergo loss of sediment in cases where the wetlands' slope is steep and the deposition thereof in cases of low relief. Figure 4-4 presents a diagram of a typical channelled valley bottom, showing the dominant movement of water into, through and out of the system.

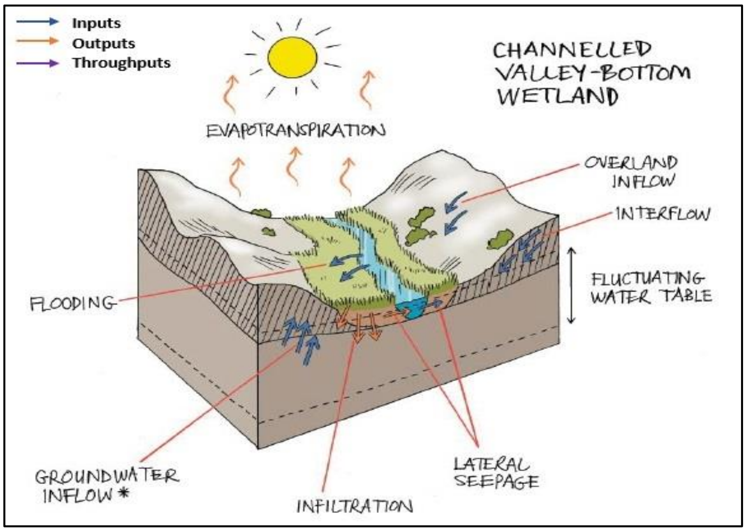


***Figure 4-4*** ***Amalgamated diagram of a typical channelled valley bottom, highlighting the dominant water inputs, throughputs and outputs, SANBI guidelines (Ollis et al. 2013)***

### 4.3 General Functional Description

Channelled valley bottom wetlands tend to contribute less to sediment trapping and flood attenuation than other systems. Channelled valley bottom wetlands are well known to improve the assimilation of toxicants, nitrates and sulphates, especially in cases where sub-surface flows contribute to the system's water source (Kotze et al., 2009).

The generally impermeable nature of depressions and their inward draining features are the main reasons why the streamflow regulation ability of these systems is mediocre. Regardless of the nature of depressions in regard to trapping all sediments entering the system, sediment trapping is another Eco Service that is not deemed as one of the essential services provided by depressions, even though some systems might contribute to a lesser extent. The reason for this phenomenon is due to winds picking up sediments within pans during dry seasons which ultimately leads to the removal of these sediments and the deposition thereof elsewhere. The assimilation of nitrates, toxicants and sulphates are some of the higher rated Eco Services for depressions. This latter statement can be explained the precipitation as well as continues precipitation and dissolving of minerals and other contaminants during dry and wet seasons respectively, (Kotze et al., 2009).

It is however important to note that the descriptions of the above-mentioned functions are merely typical expectations. All wetland systems are unique and therefore, the ecosystem services rated high for these systems on site might differ slightly to those expectations.

### 4.4 Ecological Functional Assessment

The ecosystem services provided by the wetland units identified on site were assessed and rated using the WET-EcoServices method (Kotze *et al.,* 2008). The average ecosystem service scores for the delineated systems are illustrated in Table 4-1. The ecosystem services scores of the delineated wetlands ranges between "Intermediate" and "Moderately High". Ecosystem services contributing to these scores include flood attenuation, streamflow regulation, sediment trapping, phosphate assimilation, nitrate assimilation, toxicant assimilation, erosion control, and provision of cultivated foods.

***Table 4-1 Average ecosystem service scores for delineated wetlands***

| Moderately High | Intermediate |
|---|---|
| HGM 2 | HGM 1 |
| HGM 3 | |
| HGM 4 | |

HGM units 2, 3 and 4 scored the highest ecological services scores due to some hydrophyte vegetation cover present within the HGM units. These HGM units were classified as being depression wetlands that does not play a role in streamflow regulation or flood attenuations. The vegetation cover present inside these wetlands will help with sediment trapping and the assimilation of phosphates, nitrates and toxicants. These HGM units also play an important role in the provision of resources for both humans as well as charismatic species during raining seasons and leading into autumn.

HGM 1 scored the lowest ecological services scores due to the lack of hydrophyte vegetation. The HGM unit does not play an important role in sediment trapping as well as the assimilation of nitrates, phosphates and toxicants due to the lack of hydrophyte vegetations. The lack of hydrophyte vegetation also lowers the HGM units ability to provide resources for both human and other animals.

### 4.5 Ecological Health Assessment

The PES for the assessed HGM units is presented in Table 4-2. The delineated wetland systems have been scored overall PES ratings ranging from largely modified (class D) to seriously modified (class E).

The findings from the PES assessment indicate significant disturbances to HGM 1 that has been rated a seriously modified score. The remaining three HGM units were classified as being largely modified (class D). Some notable modifications to the delineated wetlands include;

- Removal of hydrophyte vegetation;
- Erosion;
- Alien invasive vegetation;
- Dirt roads;
- Dumping of waste; and
- Grazing and trampling of animals.

***Table 4-2 Summary of the scores for the wetland PES***

| Largely Modified (D) | Seriously Modified (E) |
|---|---|
| HGM 2 | HGM 1 |
| HGM 3 | |
| HGM 4 | |

## 4.6 Importance & Sensitivity Assessment

The results of the ecological IS assessment are shown in Table 4-3. Various components pertaining to the protection status of a wetland are considered for the IS, including Strategic Water Source Areas (SWSA), the NFEPA wetland vegetation (wet veg) threat status and the protection status of the wetland. The IS for all the wetlands have been calculated to be "Moderate", which combines the relatively High threat status and the low protection levels of the wetland.

***Table 4-3 The IS results for the delineated HGM units***

| HGM Type | NFEPA Wet Veg | | | NBA Wetlands | | | SWSA (Y/N) | Calculated IS |
|---|---|---|---|---|---|---|---|---|
| | Type | Ecosystem Threat Status | Ecosystem Protection Level | Wetland Condition | Ecosystem Threat Status 2018 | Ecosystem Protection Level | | |
| **Depression** | Central Bushveld Group 2 | Least Threatened | Poorly Protected | N/A | N/A | N/A | N | **Moderate** |
| **Channelled Valley Bottoms** | Central Bushveld Group 24 | Critical | Not Protected | N/A | N/A | N/A | N | **Moderate** |

## 4.7 Buffer Requirements

It is worth noting that the scientific buffer calculation (Macfarlane *et al*., 2014) was used to determine the size of the buffer zones relevant to the proposed project. A pre-mitigation buffer zone for the PV development of 30 m is recommended for the identified wetlands, which can be decreased to 15 m with the addition of all prescribed mitigation measures (see Table 4-4). The pre-mitigation buffer zone pertaining to the powerline were calculated at 24 m, which can be decreased to 15 m with the addition of all the prescribed mitigation measures.

***Table 4-4 Pre- and post-mitigation buffer requirements***

| Aspect | Pre-Mitigation Buffer Size (m) | Post Mitigation Buffer Size (m) |
|---|---|---|
| PV development | 30 | 15 |
| Powerline | 24 | 15 |

# 5 Risk Assessment

A risk assessment was conducted in line with Section 21 (c) and (i) of the National Water Act, 1998, (Act 36 of 1998) to investigate the level of risk posed by proposed project. The impact assessment considered both direct and indirect impacts, if any, to the wetland systems. The mitigation hierarchy as discussed by the Department of Environmental Affairs (2013) will be considered for this component of the assessment (Figure 5-1). In accordance with the mitigation hierarchy, the preferred mitigatory measure is to avoid impacts by considering options in project location, sitting, scale, layout, technology and phasing to avoid impacts. Figure 5-2 below indicates the different levels of risk associated with the PV area and the proposed powerline route.

Two separate risk assessments were completed for the project, the first one being for the PV area and the second one for the powerline route. Three levels of risk have been considered and determined for the overall risk assessment, these include low, moderate and high risk. No high risks are expected for either the PV area or the powerline route since depressions within the development area are in a largely modified state, and no watercourses are located within the powerline corridor. Moderate risk refers to watercourses that will be directly affected by the placement of infrastructure within these systems, or in close (< 30 m) proximity and pose an indirect risk. Low risks are systems more than 15 m from infrastructure that would be avoided, or systems that could be avoided if feasible. The moderate risks were the priority for the risk assessment, focussing on the expected potential for these indirect risks.

For the PV area avoidance will not be achieved and the risk assessment will thus focus on the second step of the mitigation hierarchy namely minimisation of the impacts. Since direct impacts to the wetlands (and buffers) cannot be avoided, the risk assessment will consider both the direct and indirect risks posed to these systems because of the project. Table 5-1 illustrates various aspects that are expected to impact upon the delineated wetlands during the respective project phases. The overall residual risks for the PV area are expected to be low. If avoidance cannot be met when designing the PV layout a wetland compensation plan will likely be required for authorisation.

For the powerline avoidance of watercourses can be achieved. No watercourses were identified within the powerline corridor. Table 5-2 illustrates various aspects considering both pre- and post-mitigation scenarios. The overall residual risks for the PV area are expected to be low.

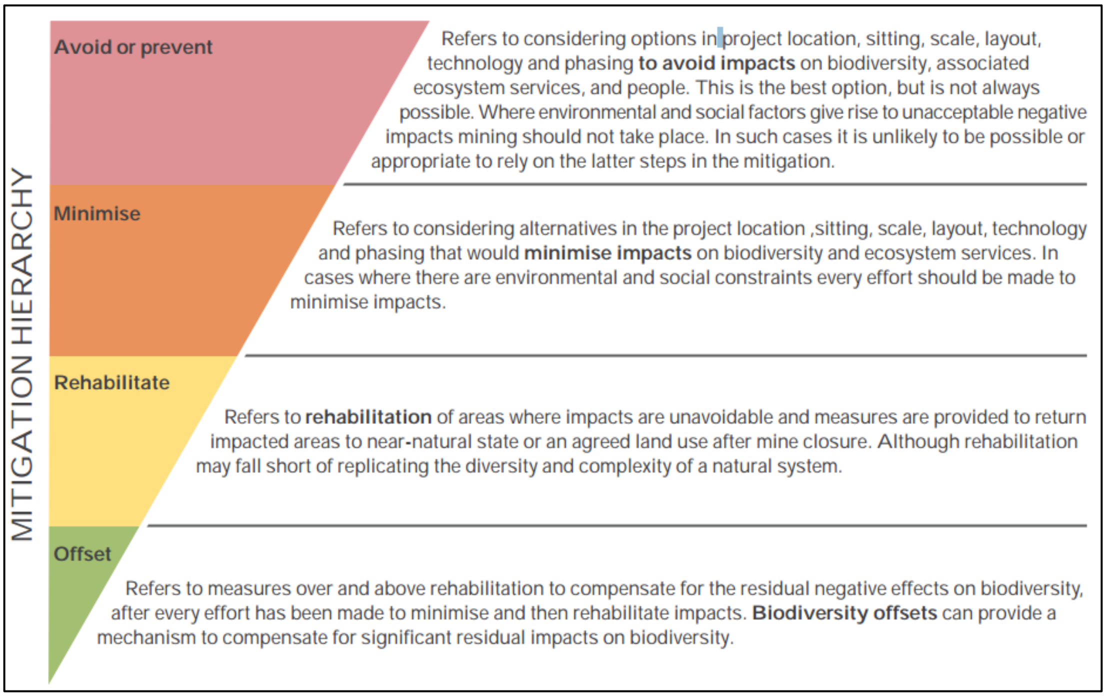


***Figure 5-1 The mitigation hierarchy as described by the DEA (2013)***

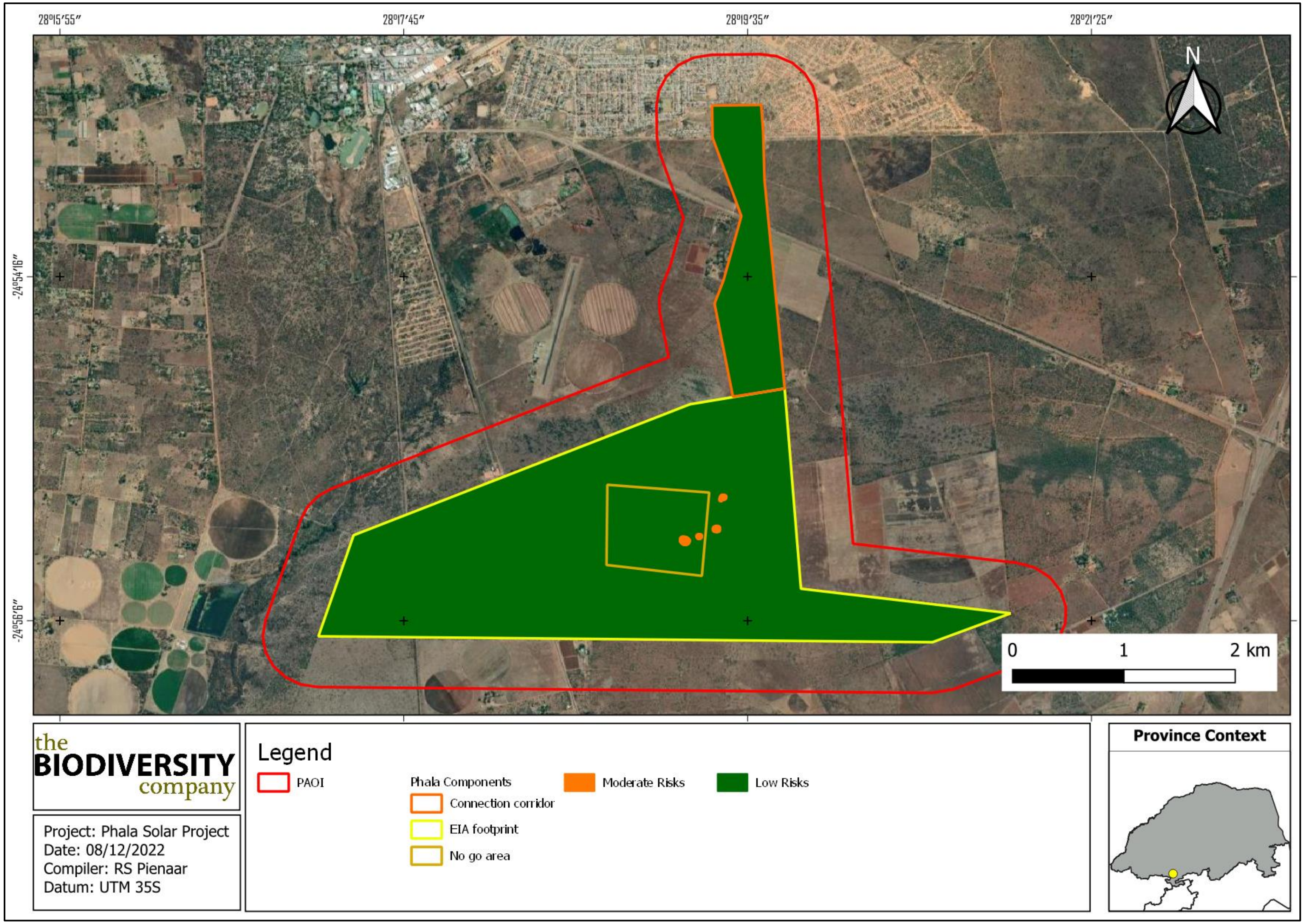


***Figure 5-2 The identified risk areas within the project***

***Table 5-1 DWS Risk Impact Matrix for PV area (Andrew Husted Pr Sci Nat 400213/11)***

| Activity | Aspect | Impact | Mitigation | Severity: Flow Regime | Water Quality | Habitat | Biota | Total | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Construction** | | | | | | | | | | | | | | | | | | | |
| Site clearing and preparation. | Wetland disturbance / loss. | Direct disturbance / degradation / loss to wetland soils or vegetation due to the construction of the solar facility. | Without | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 7 | 3 | 3 | 5 | 1 | 12 | 84 | **M** | • Clearly demarcate the construction footprint and restrict all construction activities to within the proposed infrastructure area.<br>• When clearing vegetation, allow for some vegetation cover as opposed to bare areas.<br>• Minimize the disturbance footprint and the unnecessary clearing of vegetation outside of this area.<br>• Use the wetland shapefiles to signpost the edge of the wetlands closest to site. Place the sign 25 m from the edge (this is the buffer zone). Label these areas as environmentally sensitive areas, keep out.<br>• Educate staff and relevant contractors on the location and importance of the identified wetlands through toolbox talks and by including them in site inductions as well as the overall master plan.<br>• All activities (including driving) must adhere to the 15 m buffer area.<br>• Promptly remove / control all alien and invasive plant species that may emerge during construction (i.e. weedy annuals and other alien forbs) must be removed.<br>• All alien vegetation along the transmission servitude should be managed in terms of the Regulation GNR.1048 of 25 May 1984 (as amended) issued in terms of the Conservation of |
| | | | With | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 6 | 3 | 2 | 1 | 1 | 7 | 42 | **L** | |

| Activity | Aspect | Impact | Mitigation | Flow Regime | Water Quality | Habitat | Biota | Total | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | Agricultural Resources Act, Act 43 of 1983. By this Eskom is obliged to control. • Landscape and re-vegetate all denuded areas as soon as possible. |
| | Water runoff from construction site. | Increased erosion and sedimentation. | Without | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 7 | 3 | 2 | 1 | 2 | 8 | 56 | M | • Limit construction activities near (< 50m) wetlands to winter (as much as possible) when rain is least likely to wash concrete and sand into the wetland. Activities in black turf soils can become messy during the height of the rainy season and construction activities should be minimised during these times to minimise unnecessary soil disturbances. • Ensure soil stockpiles and concrete / building sand are sufficiently safeguarded against rain wash. • No activities are permitted within the wetland and associated buffer areas. • Landscape and re-vegetate all unnecessarily denuded areas as soon as possible. |
| | | | With | 2 | 1 | 1 | 1 | 1.25 | 2 | 2 | 5.25 | 2 | 2 | 1 | 1 | 6 | 31.5 | L | |
| | | Potential contamination of wetlands with machine | Without | 1 | 2 | 2 | 2 | 1.75 | 1 | 2 | 4.75 | 3 | 2 | 1 | 2 | 8 | 38 | L | • Make sure all excess consumables and building materials / rubble is removed from site and deposited at an appropriate waste facility. |

Severity spans Flow Regime, Water Quality, Habitat, Biota, Total.

| Activity | Aspect | Impact | Mitigation | Severity: Flow Regime | Water Quality | Habitat | Biota | Total | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | oils and construction materials. | With | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 1 | 1 | 1 | 2 | 5 | 20 | L | • Appropriately stockpile topsoil cleared from the project area.<br>• Appropriately contain any generator diesel storage tanks, machinery spills (e.g. accidental spills of hydrocarbons oils, diesel etc.) or construction materials on site (e.g. concrete) in such a way as to prevent them leaking and entering the wetlands.<br>• No activities are permitted within the wetland and associated buffer areas. |
| **Operation** | | | | | | | | | | | | | | | | | | | |
| Operation of the solar facility. | Hardened surfaces. | Potential for increased stormwater runoff leading to Increased erosion and sedimentation. | Without | 2 | 2 | 1 | 2 | 1.75 | 3 | 2 | 6.75 | 3 | 2 | 1 | 2 | 8 | 54 | L | • Design and Implement an effective stormwater management plan.<br>• Promote water infiltration into the ground beneath the solar panels.<br>• Release only clean water into the environment.<br>• Stormwater leaving the site should not be concentrated in a single exit drain but spread across multiple drains around the site each fitted with energy dissipaters (e.g. slabs of concrete with rocks cemented in).<br>• Re-vegetate denuded areas as soon as possible.<br>• Regularly clear drains.<br>• Minimise the extent of concreted / paved / gravel areas.<br>• A covering of soil and grass (regularly cut and maintained) below the solar panels is ideal for infiltration. If not feasible then gravel is preferable over concrete or paving. |
| | | | With | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 5 | 1 | 1 | 1 | 1 | 4 | 20 | L | |

| Activity | Aspect | Impact | Mitigation | Severity: Flow Regime | Water Quality | Habitat | Biota | Total | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | • Avoid excessively compacting the ground beneath the solar panels. |
| | Contamination. | Potential for increased contaminants entering the wetland systems. | Without | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 7 | 2 | 2 | 1 | 2 | 7 | 49 | L | • Where possible minimise the use surfactants to clean solar panels and herbicides to control vegetation beneath the panels. If surfactants and herbicides must be used do so well prior to any significant predicted rainfall events. |
| | | | With | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 5 | 1 | 1 | 1 | 1 | 4 | 20 | L | |
| **Closure** | | | | | | | | | | | | | | | | | | | |
| Decommissioning of the solar facility. | Rehabilitation. | Potential loss or degradation of nearby wetlands through inappropriate closure. | Without | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 7 | 3 | 2 | 1 | 1 | 7 | 49 | L | • Develop and implement a rehabilitation and closure plan.<br>• Appropriately rehabilitate the project area by ripping, landscaping and re-vegetating with locally indigenous species. |
| | | | With | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 5 | 1 | 2 | 1 | 1 | 5 | 25 | L | |

***Table 5-2 DWS Risk Impact Matrix for the proposed powerline corridor (Andrew Husted Pr Sci Nat 400213/11)***

| Activity | Aspect | Impact | Mitigation Scenario | Severity | | | | Severity | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flow Regime | Water Quality | Habitat | Biota | | | | | | | | | | | | |
| **Construction** | | | | | | | | | | | | | | | | | | | |
| Clearing and preparation of powerline route including storage of equipment | Wetland vegetation deterioration and soil exposure. | Disturbance and degradation of wetland vegetation | Without | 1 | 1 | 2 | 2 | 1.5 | 1 | 3 | 5.5 | 2 | 2 | 5 | 1 | 10 | 55 | L | • Restrict the disturbance and clearance footprint to within 5 m on either side of the proposed powerline route (10 m disturbance corridor).<br>• Avoid wetlands and buffers where feasible. Implement a rehabilitation plan for any disturbed wetlands. Cleared areas must be rehabilitated and stabilised to avoid impacts to adjacent wetland and buffer areas.<br>• Although the prescribed post-mitigation buffer as per the national buffer determination tool is 15 m attempt wherever possible to maintain a 30 m buffer on the delineated water resources to lower the potential for bird collisions which are highest near water resources.<br>• Reduce the disturbance footprint and the unnecessary clearing of vegetation when traversing the identified drainage lines.<br>• Make use of existing access routes as much as possible, before new routes are considered. Any selected "new" route must not encroach into the wetland areas. |
| | | | With | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 5 | 2 | 1 | 5 | 1 | 9 | 45 | L | |
| | | Increased bare surfaces, runoff and potential for erosion | Without | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 3 | 3 | 1 | 1 | 8 | 48 | L | • Keep tower base excavation and soil heaps neat and tidy.<br>• Limit construction activities in proximity (< 50 m) to wetlands to the dry season when storms are least likely to wash concrete and sand into wetlands. This is only where towers are within wetlands and buffer areas.<br>• Ensure soil stockpiles and concrete / building sand are sufficiently safeguarded against rain wash.<br>• Mixing of concrete must under no circumstances take place in any wetland or their buffers. Scrape the area where mixing and storage of sand and concrete occurred to clean once finished.<br>• Limit the placement of towers within wetlands and buffer areas where feasible.<br>• Do not situate any of the construction material laydown areas within any wetland or buffer area. Try adhere to a 30 m buffer in these instances.<br>• No machinery should be allowed to parked in any wetlands or buffer areas. |
| | | | With | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 5 | 3 | 1 | 1 | 1 | 6 | 30 | L | |

| Activity | Aspect | Impact | Mitigation Scenario | Severity | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flow Regime | Water Quality | Habitat | Biota | Severity | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
| | | Introduction and spread of alien and invasive vegetation | Without | 1 | 1 | 2 | 2 | 1.5 | 1 | 2 | 4.5 | 3 | 3 | 5 | 1 | 12 | 54 | L | • Promptly remove all alien and invasive plant species that may emerge during construction (i.e. weedy annuals and other alien forbs) must be removed.<br>• Limit soil disturbance<br>• The use of herbicides is not recommended in or near wetlands (opt for mechanical removal).<br>• Appropriately stockpile topsoil cleared from the powerline footprint.<br>• Clearly demarcate powerline construction footprint, and limit all activities to within this area.<br>• Minimize unnecessary clearing of vegetation beyond the tower footprints and powerline corridors.<br>• Lightly till any disturbed soil around the tower footprint to avoid compaction. |
| | | | With | 1 | 1 | 2 | 1 | 1.25 | 1 | 2 | 4.25 | 3 | 1 | 1 | 1 | 6 | 26 | L | |
| Excavation, levelling and installation of transmission towers. | Soil disturbance, sedimentation | Increased sediment loads to downstream reaches | Without | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 3 | 3 | 1 | 1 | 8 | 48 | L | • See mitigation for increased bare surfaces, runoff and potential for erosion<br>• Re-instate topsoil and lightly till transmission tower disturbance footprint. |
| | | | With | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 3 | 1 | 1 | 1 | 6 | 24 | L | |
| | | Contamination of wetlands with hydrocarbons due to leaks and spillages from machinery, equipment & vehicles as well as Contamination and eutrophication of wetland systems with human sewerage and litter. | Without | 2 | 3 | 2 | 2 | 2.25 | 2 | 2 | 6.25 | 3 | 3 | 1 | 1 | 8 | 50 | L | • Make sure all excess consumables and building materials / rubble is removed from site and deposited at an appropriate waste facility.<br>• Appropriately contain any generator diesel storage tanks, machinery spills (e.g. accidental spills of hydrocarbons oils, diesel etc.) or construction materials on site (e.g. concrete) in such a way as to prevent them leaking and entering wetland or buffer areas.<br>• Mixing of concrete must under no circumstances take place within the wetland or buffer areas.<br>• Check for oil leaks, keep a tidy operation, and promptly clean up any spills or litter.<br>• Provide appropriate sanitation facilities for workers during construction and service them regularly.<br>• The Contractor should supply sealable and properly marked domestic waste collection bins and all solid waste collected must be disposed of at a licensed disposal facility;<br>• The Contractor must be in possession of an emergency spill kit that must be complete and available at all times on site;<br>• Any possible contamination of topsoil by hydrocarbons must be avoided. Any contaminated soil must be treated in situ or |
| | | | With | 1 | 3 | 1 | 1 | 1.5 | 2 | 2 | 5.5 | 3 | 1 | 1 | 1 | 6 | 33 | L | |

| Activity | Aspect | Impact | Mitigation Scenario | Severity: Flow Regime | Severity: Water Quality | Severity: Habitat | Severity: Biota | Severity | Spatial scale | Duration | Consequence | Frequency of activity | Frequency of impact | Legal Issues | Detection | Likelihood | Significance | Risk Rating | Control Measures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | be placed in containers and removed from the site for disposal in a licensed facility; |
| **Operation** | | | | | | | | | | | | | | | | | | | |
| Routine operation and maintenance of power line route | Clearing of wetland vegetation beneath power line | Degradation of wetland vegetation wetland vegetation. | Without | 1 | 1 | 1 | 3 | 1.5 | 2 | 1 | 4.5 | 3 | 1 | 5 | 1 | 10 | 45 | L | • Clear vegetation in line with the 2010 Eskom Environmental Procedure Document entitled "Procedure for vegetation clearance and maintenance within overhead powerline servitudes".<br>• Avoid the use of herbicides and diesel to treat stumps within the wetland and buffer areas.<br>• Make use of existing access routes as much as possible, before new routes are considered. Any selected "new" route must not encroach into the wetland areas. |
| | | | With | 1 | 1 | 1 | 2 | 1.25 | 2 | 1 | 4.25 | 3 | 1 | 5 | 1 | 10 | 42.5 | L | |
| | Alien and Invasive species | Proliferation of alien and invasive species | Without | 1 | 1 | 2 | 2 | 1.5 | 2 | 2 | 5.5 | 2 | 1 | 5 | 1 | 9 | 49.5 | L | • In line with the 2010 Eskom Environmental Procedure Document entitled "*Procedure for vegetation clearance and maintenance within overhead powerline servitudes*" all alien vegetation along the transmission servitude should be managed in terms of the Regulation GNR.1048 of 25 May 1984 (as amended) issued in terms of the Conservation of Agricultural Resources Act, Act 43 of 1983. By this Eskom is obliged to control category 1, 2 and 3 plants to the extent necessary to prevent or to contain the occurrence, establishment, growth, multiplication, propagation, regeneration and spreading such plants within servitude areas. |
| | | | With | 1 | 1 | 1 | 4 | 1.75 | 2 | 1 | 4.75 | 3 | 1 | 5 | 1 | 10 | 48 | L | |
| **Decommissioning** | | | | | | | | | | | | | | | | | | | |
| Removal of transmission towers and lines | Vehicle access | Degradation of wetland vegetation and proliferation of alien and invasive species | Without | 2 | 2 | 2 | 3 | 2.25 | 1 | 2 | 5.25 | 3 | 1 | 5 | 1 | 10 | 53 | L | • See mitigation for the impacts on direct loss, disturbance and degradation of wetlands and spread of alien and invasive plants.<br>• Control should continue for a minimum of three years following decommissioning. |
| | | | With | 1 | 1 | 2 | 3 | 1.75 | 1 | 2 | 4.75 | 3 | 1 | 5 | 1 | 10 | 48 | L | |
| | Re-excavation of Transmission Towers | Increased bare surfaces, runoff and potential for erosion | Without | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 3 | 3 | 1 | 1 | 8 | 48 | L | • See mitigation for increased bare surfaces, runoff and potential for erosion and increased sediment loads during construction |
| | | | With | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 5 | 3 | 1 | 1 | 1 | 6 | 30 | L | |

# 6 Conclusion and Recommendation

## 6.1 Baseline Ecology

During the site visit, four HGM units were identified within the PAOI. HGM units have been classified as three depression wetlands and one channelled valley bottom system. Multiple artificial wetlands, namely dams were identified to the within the PAOI. The functional assessment was only completed for the natural depressions and the channelled valley bottom wetland.

The ecosystem services scores of the delineated depressions were determined to be "Moderately High", whereas the scores for the valley bottom wetland were determined to be "Intermediate". The overall PES ratings ranged from largely modified (class D) to seriously modified (class E), indicating a change in ecosystem processes and loss of natural habitat and biota is considerable. The ecological importance and sensitivity for the wetland unit was calculated to be "Moderate". A 15 m post mitigation buffer was assigned to the wetland systems for both the PV area as well as the powerline corridor.

## 6.2 Risk Assessment

A risk assessment was conducted in line with Section 21 (c) and (i) of the National Water Act, 1998, (Act 36 of 1998) to investigate the level of risk posed by proposed project. No high risks are expected for either the PV area or the powerline route. The overall residual risks for the PV area is expected to be low. No watercourses were identified within the powerline corridor and despite the risk assessment being completed for this, no risks are anticipated for the powerline infrastructure.

## 6.3 Specialist Recommendation

Based on the results and conclusions presented in this report, the specialist recommends that if all mitigation measures can be met with the designing of the PV area, it is expected that the proposed activities will pose low residual risks to water resources and thus no fatal flaws were identified for the project. A General Authorisation (GN 509 of 2016) is required for the water use authorisation. It is recommended that no authorisation be required for the powerline infrastructure.

If the PV design cannot be altered in such a way that the depressions and their associated buffers cannot be avoided a wetland compensation plan should be compiled and a Water Use Licence (WUL) will be required. Compensation may include the rehabilitation and active (conservation) management of the remaining unaffected depressions within the project area.

## 7 References

Department of Water Affairs and Forestry (DWAF). 2005a. A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas.

Department of Water and Sanitation (DWS). 2005b. River Ecoclassification: Manual for Ecostatus Determination. First Draft for Training Purposes. Department of Water Affairs and Forestry.

Department of Water and Sanitation (DWS). 2020. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Draft. Compiled by RQS-RDM.

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.C., and Collins, N.B. 2009. A Technique for rapidly assessing ecosystem services supplied by wetlands, Mondi Wetland Project.

Macfarlane, D.M., Bredin, I.P., Adams, J.B., Zungu, M.M., Bate, G.C. and Dickens, C.W.S. 2014. Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. Final Consolidated Report. WRC Report No TT 610/14, Water Research Commission, Pretoria.

Macfarlane, D.M., Kotze, D.C., Ellery, W.N., Walters, D., Koopman, V., Goodman, P. and Goge, C. 2007. A technique for rapidly assessing wetland health: WET-Health. WRC Report TT 340/08.

Mucina, L. and Rutherford, M.C., 2010. The vegetation of South Africa, Lesotho and Swaziland.

Nel J.L. and Driver A. 2012. South African National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component. CSIR Report Number CSIR/NRE/ECO/IR/2012/0022/A, Council for Scientific and Industrial Research, Stellenbosch.

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L and Nienaber S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Ollis DJ, Snaddon CD, Job NM, and Mbona N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. South African Biodiversity Institute, Pretoria.

SANBI. 2009. Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).