Proposed Renewable Energy Cluster Development, Emakhazeni Local Municipality, Mpumalanga Province.

Aquatic Biodiversity Assessment Report

May 2023

Drafted by
Limosella Consulting Pty Ltd
Reg No: 2014/023293/07
Email: antoinette@limosella.co.za
Cell: +27 83 4545 454
www.limosella.co.za

Prepared for:
SiVEST
5th Floor Building A, Loftus Park, 416 Kirkness Street,
Pretoria 0063
Phone: +27 11 798 0600
Email: info@sivest.com

Declaration of Independence

I, **Rudi Bezuidenhoudt**, in my capacity as a specialist consultant, hereby declare that I -

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

______________________	2022.05.23
Rudi Bezuidenhoudt (PrSciNat)	Date
Ecologist/Botanist	
SACNASP Reg. No. 008867	

Disclaimer:

The actions and recommendations contained in this report remain the responsibility of the client as the custodian of the property discussed in this report.

Limosella Consulting and the authors of this report are protected from any legal action, possible loss, damage or liability resulting from the content of this report. This report remains confidential until requested by a court of law.

This report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken. The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge, as well as available information. Information utilised and contained in this report is based on data/information supplied to Limosella Consulting (Pty) Ltd by the client and other external sources (including previous site investigation data and external specialist studies). Limosella Consulting (Pty) Ltd exercises due care and diligence in rendering services and preparing documents, however it has been assumed that the information provided to Limosella Consulting (Pty) Ltd is correct and as such the accuracy of the conclusions made are reliant on the accuracy and completeness of the data supplied. The author reserves the right to modify aspects of the report, including the recommendations, if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

No responsibility is accepted by Limosella Consulting (Pty) Ltd for incomplete or inaccurate data supplied by the client and/or other external sources. Opinions expressed in this report apply to the site conditions and features that existed at the time of the start of the investigations and the production of this document. Limosella Consulting (Pty) Ltd and the authors and directors therefore accept no liability, and the client, by receiving this document, indemnifies Limosella Consulting (Pty) Ltd and the authors and directors against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the author and by the use of this document.

The document may not be altered or added to without the prior written consent of the author. This also refers to electronic copies of the report which are supplied for the purposes of inclusion as part of other reports.

Document and Quality Control:

Project name:	Proposed Renewable Energy Cluster Development, Emakhazeni Local Municipality, Mpumalanga Province.		
Nature of Signoff	**Responsible Person**	**Role/Responsibility**	**Qualifications**
Author Wetland Aspect	Rudi Bezuidenhoudt	Senior Wetland Specialist	BSc Hons Pr.Sci.Nat (008867)
Author Aquatic aspect	Bertus Fourie	Aquatic Specialists	MSc Aquatic Science Pr.Sci.Nat: (400126/17)
Document number	**Checked by:**	**Electronic Signature:**	**Date**
Author	Rudi Bezuidenhoudt		2022.04.21
Client review			
Final Report	Rudi Bezuidenhoudt	Rudi Bezuidenhoudt	2023.07.25

EXECUTIVE SUMMARY

Limosella Consulting was appointed by SiVEST for specialist input into Basic Assessment Environmental for the proposed development of a Solar Energy Facility within the Emakhazeni Local Municipailty, Mpumalanga Province. The project footrpint fall within the Emalahleni Renewable Energy Development Zone (REDZ) but outside of the strategic transmission corridor. The site visit was conducted in March and April 2023.

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

- Delineate the wetland and riparian areas to inform the placement of infrastructure;
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant,
- Undertake functional and integrity assessment of wetlands and riparian areas as specified in General Notice 267 of 24 March 2017;
- Assess the aquatic instream parameters of the potentially affected watercourses, including SASS5 and Ichthyofauna assessments if relevant;
- Undertake an impact assessment as specified in the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Recommend suitable calculated buffer zones, as specified in General Notice 267 of 24 March 2017, following Macfarlane *et al* 2015; and
- Discuss appropriate mitigation and management procedures relevant to the conserving wetland areas on the site as specified in the NEMA 2014 regulations, as amended and GN320, March 2020.

Two wetland types were recorded on the study site. The watercourses are further classified into the following according to the classification guidelines (Ollis *et al,* 2013):

- Channelled Valley Bottom Wetland
- 2 Hillslope Seepage Wetlands

The current footprint of the Solar and associated infrastructure does not encroach into the wetland and associated buffer areas. Although the exact footprint positions of the pylons were not known during the writing of this report it is assumed that it will span the wetlands and buffer zones with no pylons located in these areas. The proposed substations are not located on any wetland or wetland buffer zone. Prior to the proposed mitigation measures most impacts rated moderate and post mitigation they ranked low in both the construction and operational phase

The important factors relevant to Environmental Authorisation for the project are summarised in below:

	Quaternary Catchment and WMA areas		**Important Rivers within 500 m**
	B41A - WMA #2: Olifants Major: Rivers include the Elands, Steelpoort, Olifants, Wilge and Letaba Rivers.		One of the seepage wetlands were not directly connected to a nearby river. The remainder of the wetlands flow north into the Grootspruit which flows into the Steelpoort River.
Classification (SANBI, 2013)	**Channelled Valley Bottom Wetland**	**Seepage Wetland 1**	**Seepage Wetland 2**
EC Scores (PES - WetHealth Version 2 (Macfarlane *et al*., 2020)	**B - Largely Natural with few modifications.**	**B - Largely Natural with few modifications.**	**Moderately Modified.**
WetEcoServices (Kotze *et al*., 2020) –	3.5 – **Very High** category.	**2.5 - Moderately High.**	
EIS	3.5 – **Very High** category	**2.5 - Moderately High.**	
REC (Rountree *et al*, 2013)	**REC of A**.	**REC of A**.	**REC of A/B**.
Calculated Buffer Zone (Macfarlane *et al*, 2015)	**17 m**	**18m**	
In situ Water Quality	**In situ water quality:** The in-situ water quality results showed somewhat elevated TDS and EC- indicative of possibly the geology of the area and or cultivation soil amelioration impacts. The pH is circumneutral with the temperature indicative of late summer.		
Instream Habitat assessment:	**Instream habitat:** The habitat suitability score of the sample sites were calculated to B for sample site A and B and A for sample site C. This indicates the sample sites to be sufficient for supporting diverse aquatic macroinvertebrates.		

Aquatic macroinvertebrate assemblages:	Aquatic macroinvertebrate assemblages: Overall, the biomonitoring assessments based on the SASS scores of 94, 73, and 65 for the three sites indicate varying levels of water quality and biological integrity. While the first site shows good water quality and healthy ecosystem conditions, the second and third sites may require further investigation to identify any potential impacts and implement appropriate management measures to protect and restore the aquatic ecosystems. Regular biomonitoring assessments and ongoing monitoring efforts are essential for tracking changes in water quality and ecosystem health over time and guiding effective management decisions for the conservation and restoration of aquatic ecosystems. Biomonitoring assessments based on the average SASS scores per taxon of 5.5, 4.9, and 5.0 for the three sites indicate varying levels of water quality and biological integrity. While the first site shows relatively good water quality and healthy ecosystem conditions, the second and third sites may require further investigation to identify any potential impacts and implement appropriate management measures to protect and restore the aquatic ecosystems. Regular biomonitoring assessments, along with other complementary data, are essential for tracking changes in water quality and ecosystem health over time and guiding effective management decisions for the conservation and restoration of aquatic ecosystems.			
NEMA 2014 Impact Assessment for the Roos PV Developemnt	Changes to flow dynamics	Construction	M	L
		Operational	M	L
	Sedimentation	Construction	M	L
		Operational	M	L
	Establishment of alien plants	Construction	M	L
		Operational	M	L
	Loss of wetland habitat	Construction	M	L
		Operational	M	L
	Pollution of watercourses	Construction	M	L
		Operational	M	L
DWS 2016 Risk Assessment	• Structure currently located within wetlands and buffer zones should not be included in the final layout and moved. • Designs should consider regional hydrological dynamics. • Have a contingency plan ready for potential spills • A temporary fence or demarcation must be erected around No-Go Areas outside the proposed works area prior to any construction taking place as part of the contractor planning phase when compiling work method statements to prevent access to the adjacent portions of the watercourse. • Effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP. High energy stormwater input from the site into the watercourses should be prevented at all cost. • Steps/ weirs to be included to facilitate species movement- migration functionality can be improved. • Stabilise erosion where required			
Does the specialist support the development?	Yes, given that the structures remain outside of the wetlands and associated buffer zones. The risk scores fall in the Low category.			

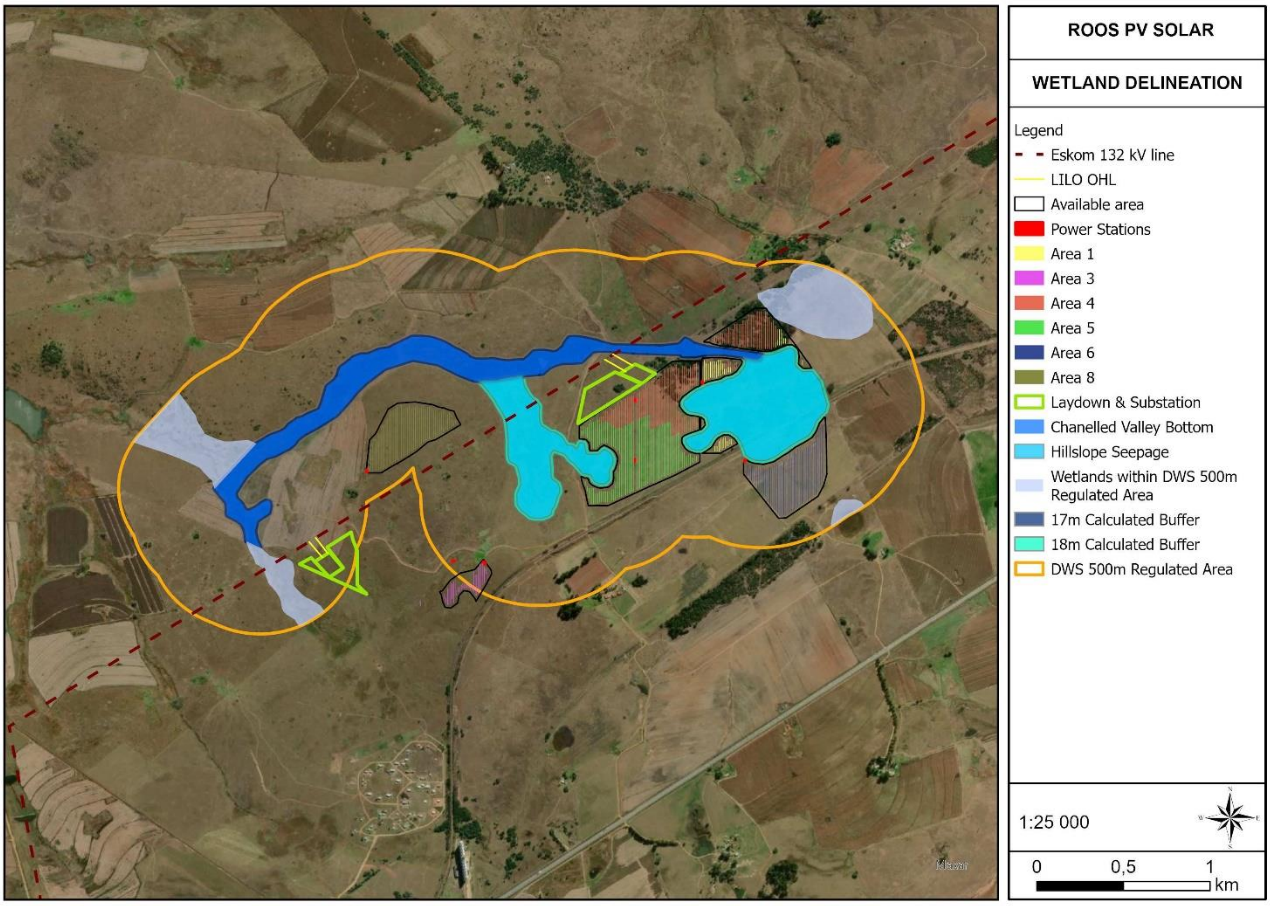

ROOS PV SOLAR
WETLAND DELINEATION
Legend
Eskom 132 kV line
LILO OHL
Available area
Power Stations
Area 1
Area 3
Area 4
Area 5
Area 6
Area 8
Laydown & Substation
Chanelled Valley Bottom
Hillslope Seepage
Wetlands within DWS 500m Regulated Area
17m Calculated Buffer
18m Calculated Buffer
DWS 500m Regulated Area
1:25 000
0
0,5
1
km

Table of Contents

Figures

Tables

1 INTRODUCTION

Limosella Consulting was appointed by SiVEST for specialist input into Basic Assessment Environmental for the proposed development of a renewable energy cluster within the Emakhazeni Local Municipailty, Mpumalanga Province. The project footrpint fall within the Emalahleni Renewable Energy Development Zone (REDZ) but outside of the strategic transmission corridor. The site visit was conducted in March and April 2023.

1.1 Project Description (Taken Verbatim)

The Roos PV facility is envisioned to be the solar PV component of a hybrid wind and solar facility The intention is to develop (through one BA process) a single facility with a maximum output capacity of 50MW. The joint PV cluster will be located on the portions of the properties not used for wind energy development. So far these are in the west of the area. This will be confirmed prior to commencement of the EIA process – overall 270Ha of PV development area should be authorised. The associated infrastructure would include a BESS, site camp, substation and OHL, and O&M building, roads, fencing, civil works and bulk services. The 132kV OHL route will be confirmed prior to the commencement of the BA. Based on desktop analysis, the focus area for PV development is the western section of the property, as indicated in the white shaded area in the figure.

1.2 Terms of Reference

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

- Delineate the wetland and riparian areas to inform the placement of infrastructure;
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant,
- Undertake functional and integrity assessment of wetlands and riparian areas as specified in General Notice 267 of 24 March 2017;
- Assess the aquatic instream parameters of the potentially affected watercourses, including SASS5 and Ichthyofauna assessments if relevant;
- Undertake an impact assessment as specified in the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Recommend suitable calculated buffer zones, as specified in General Notice 267 of 24 March 2017, following Macfarlane *et al* 2015; and
- Discuss appropriate mitigation and management procedures relevant to the conserving wetland areas on the site as specified in the NEMA 2014 regulations, as amended and GN320, March 2020.

1.3 Assumptions and Limitations

- Sampling by its nature means that the entire study area cannot be assessed. In this case, the entirety of the study site could not be assessed due to time constraints and access restrictions. Therefore, the assessment findings are only applicable to the areas sampled and extrapolated to the rest of the study site. Some reliance was also made on a previous wetland assessment done in the area and current and historical aerial imagery.

- Formal vegetation sampling was not done by the specialist. All vegetation information recorded was based on the onsite visual observations of the author. Furthermore, only dominant, and noteworthy plant species were recorded. Thus, the vegetation information provided has limitations for true botanical applications.
- The information provided by the client forms the basis of the planning and layouts discussed.
- It should be noted that at the time of the assessment, the exact location of the infrastructure was not available.
- All watercourses within 500 m of any developmental activities should be identified as per the DWS authorization regulations. In order to meet the timeframes and budget constraints for the project, watercourses within the study sites were delineated on a fine scale based on detailed soil and vegetation sampling. Watercourses that fall outside of the site, but that fall within 100 m of the proposed activities were delineated based on desktop analysis of vegetation gradients visible from aerial imagery.
- Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage.
- The specialist responsible for this study reserves the right to amend this report, recommendations and/or conclusions at any stage should any additional or otherwise significant information come to light.
- Description of the depth of the regional water table and geohydrological and hydropedological processes falls outside the scope of the current assessment
- Floodline calculations fall outside the scope of the current assessment.
- A Red Data scan, fauna and flora, and aquatic assessments were not included in the current study
- Species composition described for landscape units aimed at depicting characteristic species and did not include a survey for cryptic or rare species.
- The recreation grade GPS used for wetland and riparian delineations is accurate to within five meters.
- Watercourses delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, while converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries. The scale at which maps and drawings are presented in the current report may become distorted should they be reproduced by for example photocopying and printing.
- The calculation of buffer zones does not consider climate change or future changes to watercourses resulting from increasing catchment transformation.

1.4 Definitions and Legal Framework

This section outlines the definitions, key legislative requirements and guiding principles of the wetland study and the Water Use Authorisation process.

The National Water Act, 1998 (Act No. 36 of 1998) [NWA] provides for Constitutional water demands including pollution prevention, ecological and resource conservation and sustainable utilisation. In terms of this Act, all water resources are the property of the State and are regulated by the Department of Water and Sanitation (DWS). The NWA sets out a range of water use related principles that are to be applied by DWS when taking decisions that significantly affect a water resource. The NWA defines a water resource as including a watercourse, surface water, estuary or aquifer. A watercourse includes a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake, pan or dam, into which or from which water flows; any collection of water that the Minister may declare to be a watercourse; and were relevant its beds and banks.

The NWA defines a wetland as “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.” In addition to water at or near the surface, other distinguishing indicators of wetlands include hydromorphic soils and vegetation adapted to or tolerant of saturated soils (DWA, 2005).

Riparian habitat often times performs important ecological and hydrological functions, some similar to those performed by wetlands (DWA, 2005). Riparian habitat is also the accepted indicator used to delineate the extent of a river’s footprint (DWAF, 2005). It is defined by the NWA as follows: “Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas”.

Water uses for which authorisation must be obtained from DWS are indicated in Section 21 of the NWA. Section 21 (c) and (i) is applicable to any activity related to a watercourse:

Section 21(c): Impeding or diverting the flow of water in a watercourse; and

Section 21(i): Altering the bed, banks, course or characteristics of a watercourse.

Authorisations related to wetlands are regulated by Government Notice 509 of 2016 regarding Section 21(c) and (i). This notice grants General Authorisation (GA) for the above water uses should the Risk Assessment matrix (DWS, 2016) reflect a Low score. Activities that obtain a Medium or High-risk score requires authorisation through a Water Use Licence (WUL) from the Department.

Conditions for impeding or diverting the flow of water or altering the bed, banks, course or characteristics of a watercourse (Section 21(c) and (i) activities) include:

9. (3) (b). The water user must ensure that the selection of a site for establishing any impeding or diverting the flow or altering the bed, banks, course or characteristics of a watercourse works:

(i) is not located on a bend in the watercourse;
(ii) avoid high gradient areas, unstable slopes, actively eroding banks, interflow zones, springs, and seeps;.

In addition to the above, the proponent must also comply with the provisions of the following relevant national legislation, conventions and regulations applicable to wetlands and riparian zones:

- Convention on Wetlands of International Importance - the Ramsar Convention and the South African Wetlands Conservation Programme (SAWCP).
- National Environmental Management Act, 1998 (Act No. 107 of 1998) [NEMA].
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003).
- Regulations GN R.982, R.983, R. 984 and R.985 of 2014, promulgated under NEMA.
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983).
- Regulations and Guidelines on Water Use under the NWA.
- South African Water Quality Guidelines under the NWA.
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 287 of 2002).
- GN 267 (Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals)

1.5 Locality of the study site

The study site is located on various land parcels, near the town of Belfast within the Emakhazeni Local Municipality, Mpumalanga Province. The N4 is directly south of the site. The approximate central coordinates of the study site is 25°46'15.54"S and 29°54'46.76"E (Figure 1).

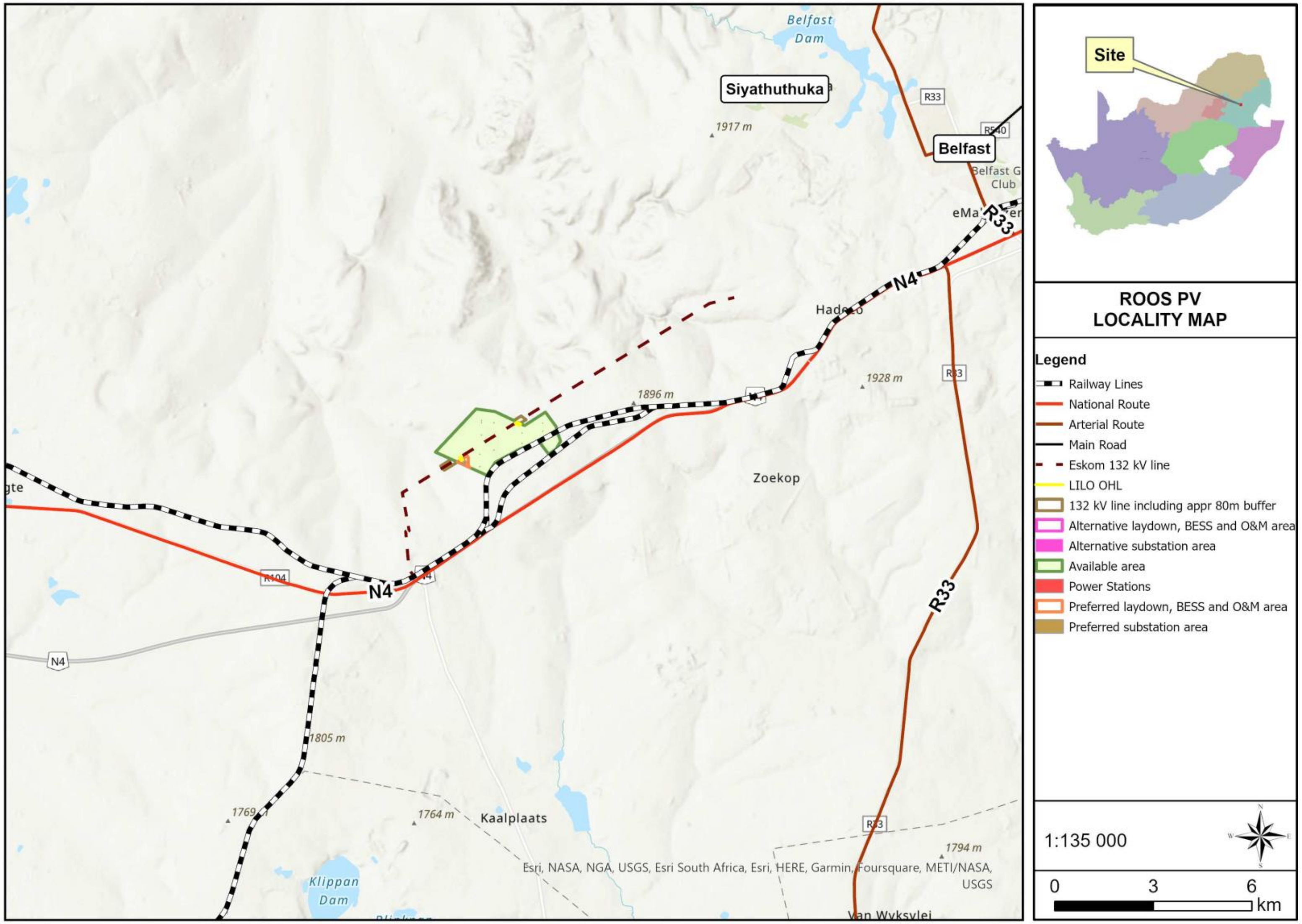
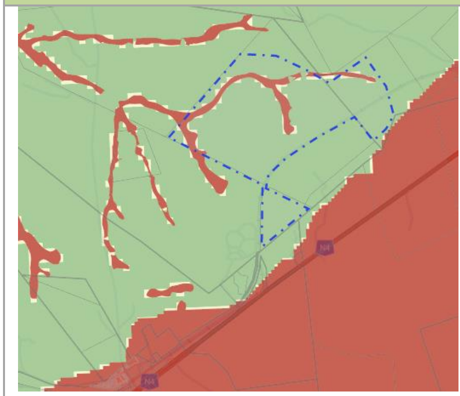


Figure 1: Locality Map

1.6 Description of the Receiving Environment

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state. Table 1 below provides a summary of the important aspects.

Table 1: A summary of relevant site information obtained from a review of available spatial data

National Screening Tool (Https://screening.environment .gov.za/screeningtool) - Aquatic		
	The watercourses associated with the study site are classified as highly sensitive, with the reminder of the study site classified as having low sensitivity. The area south of the N4 is classified as having high sensitivity.	
Hydrology and National Freshwater Ecosystem Priority Area (NFEPA) (2011) Database		
Important Rivers (CDSM, 1996)	One of the seepage wetlands were not directly connected to a nearby river. The remainder of the wetlands flow north into the Grootspruit which flows into the Steelpoort River.	
Quaternary Catchment	B41A	
WMA (Government Gazette, 16 September 2016)	WMA #2: Olifants Major: Rivers include the Elands, Steelpoort, Olifants, Wilge and Letaba Rivers.	
NFEPA, NBA Wetlands and Mpumalanga Highveld Wetland (MPHG) (Mbona et al., 2015) (Figure 2)	A few small impoundments and pans are listed as NFEPA wetlands. Large sections of the study site are listed as Seepage wetlands on the study site.	
Wetland Ecosystem Type (Figure 3)	Mesic Highveld Grassland Group 6 (Northernmost and southern sections)	Mesic Highveld Grassland Group 4 (Majority of the study site)
Aquatic habitat	Aquatic habitat suitable for a SASS5 and/or FRAI for majority of the year	
General Description (Mucina & Rutherford, 2006)		
GPS Coordinates	25°46'15.54"S and 29°54'46.76"E	
Broad Vegetation Units (Figure 4)	Gm 12 -Eastern Highveld Grassland (Small area in the north and southern sections)	Gm 18 - Steenkampsberg Montane Grassland (Majority of the study site)
Topography	Slightly to moderately undulating plains, including some low hills and pan depressions.	High-altitude plateaus, undulating plains, mountain peaks and slopes, hills and deep valleys of the Northern Escarpment
Climate	Strongly seasonal summer rainfall, with very dry winters. MAP 650–900 mm	Orographic precipitation and mists throughout most months of the year
Conservation Status	Endangered	Vulnerable
Geology (Figure 5)	Red to yellow sandy soils of the Ba and Bb land types found on shales	The soils are mostly

	and sandstones of the Madzaringwe Formation (Karoo Supergroup).	derived from shale and quartzite as wellas lavas and dolomites of the PretoriaGroup of the Transvaal Supergroup (Vaalian Erathem).
	Northern Section underlain by Basalt with the southern section underlain by Arenite.	
Soils (Figure 6)	Ib 34 - Miscellaneous land classes, rocky areas with miscellaneous soils	Ad 1 - Red-yellow apedal, freely drained soils; yellow, dystrophic and/or mesotrophic
Land Use(from available aerial imagery)	Transformed by current and historical agriculture and grazing. The wetlands has seen a large increase in impoundments	
Mpumalanga Critical Biodiversity Sector Plan (Figure 7) and other Threatened Ecosystems (Figure 7)		
• Other Natural Area – Northern and north-eastern sections of the study site • CBA Optimal – Eastern and central sections of the study site • Vegetation is listed as vulnerable and endangered.		

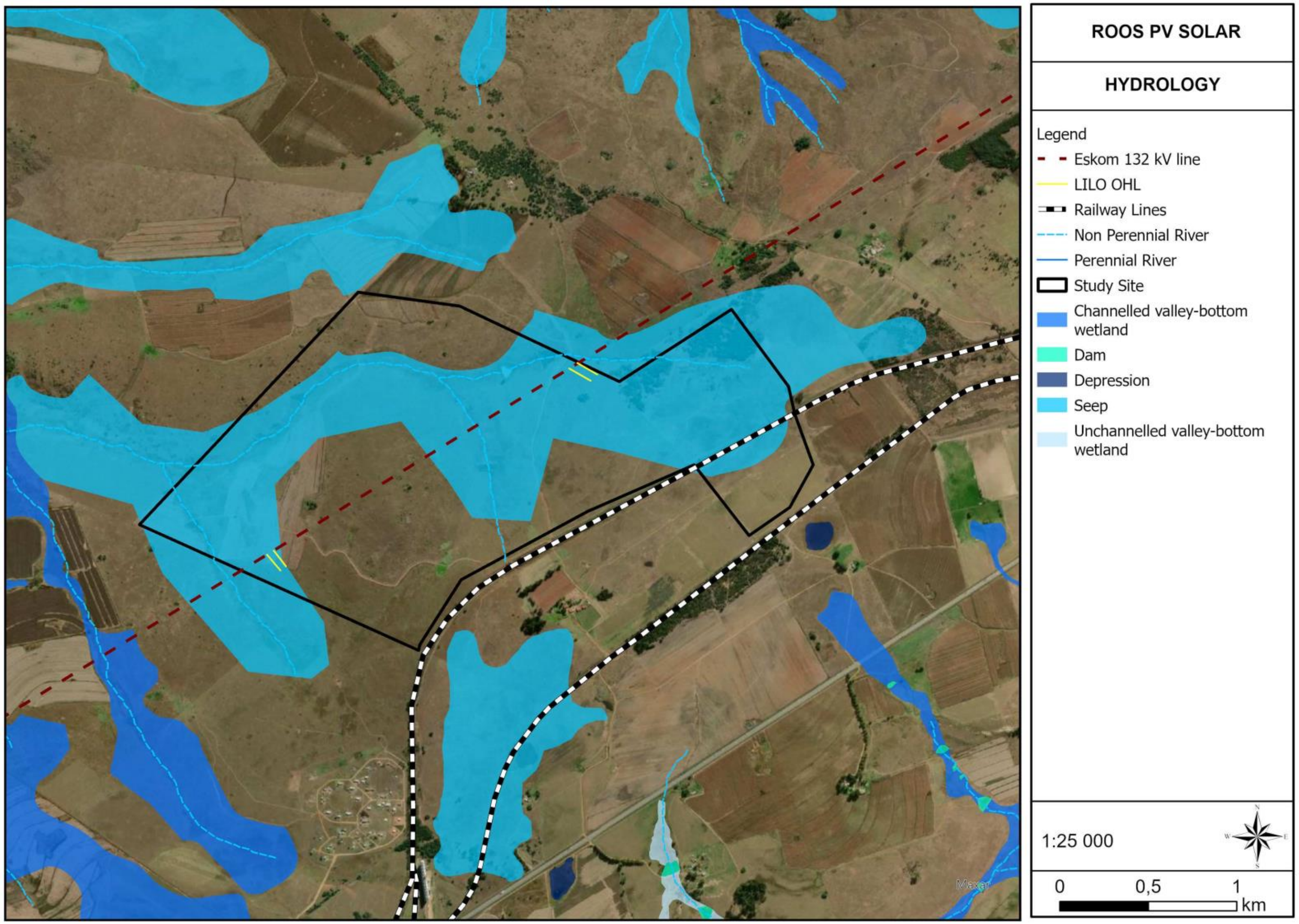


Figure 2: Mpumalanga Highveld Wetlands (MPHG) associated with the study site (Mbona et al., 2015)

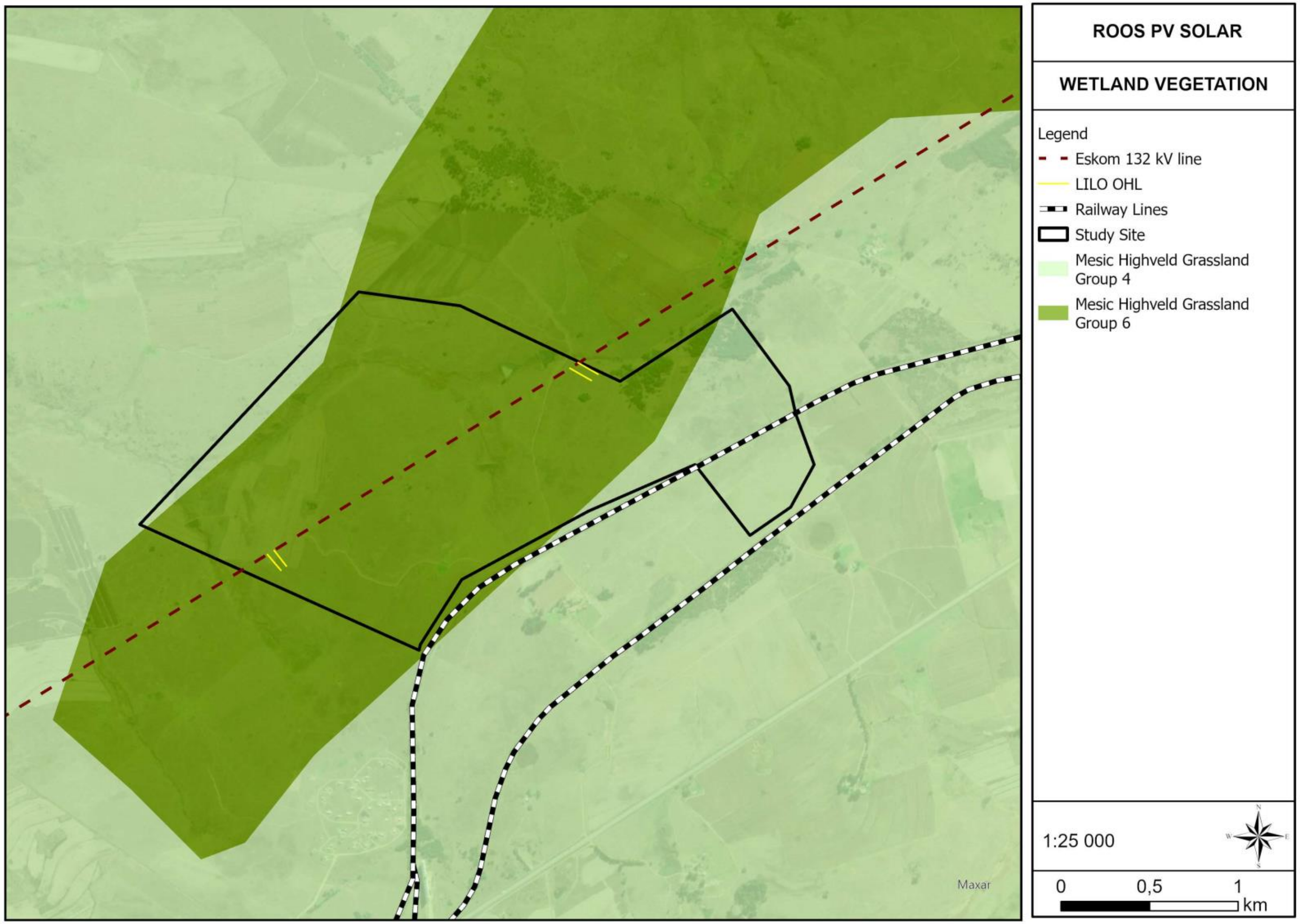


Figure 3: Wetland Vegetation types associated with the study site.

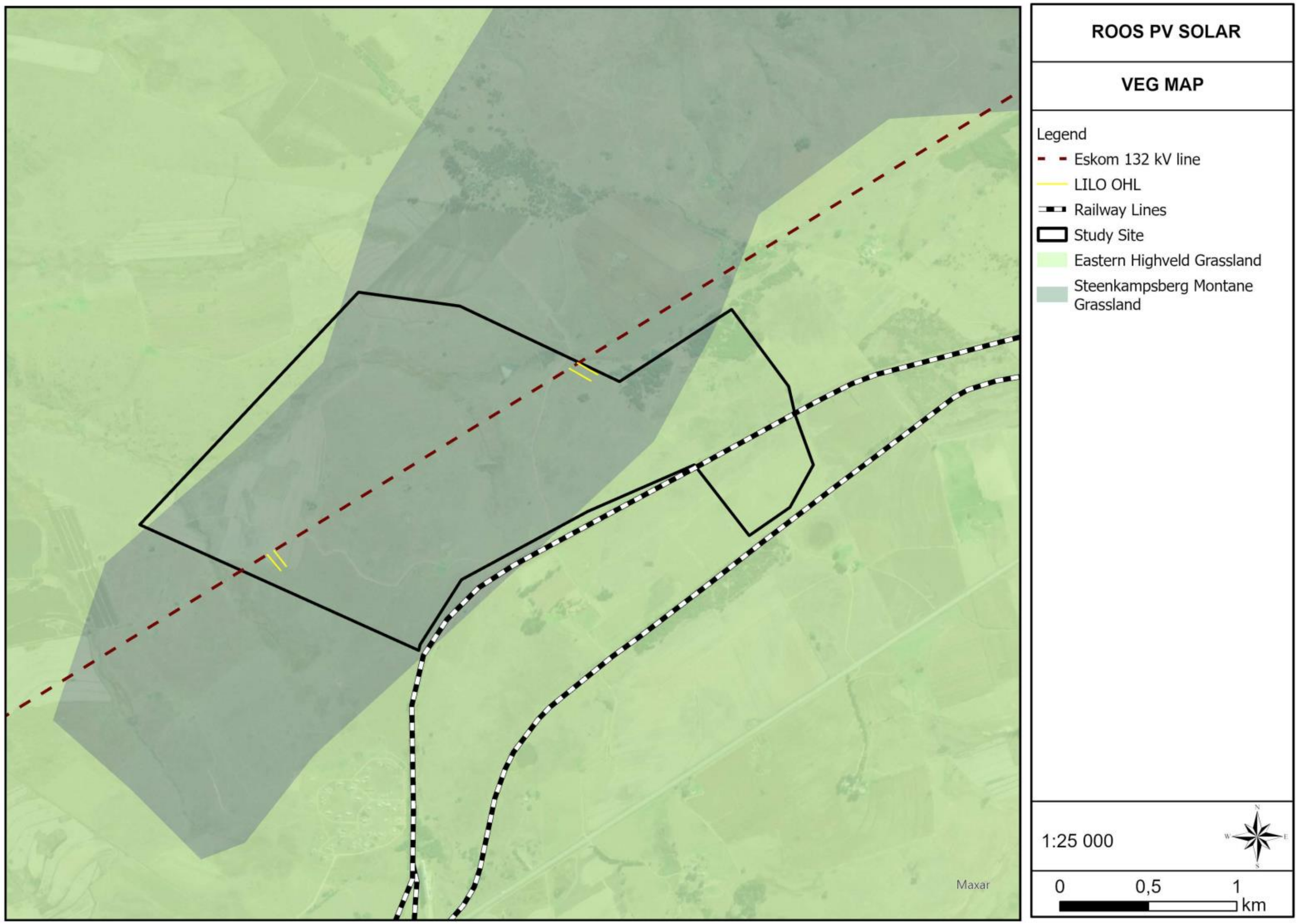


Figure 4: Vegetation units of the study site and surroundings.

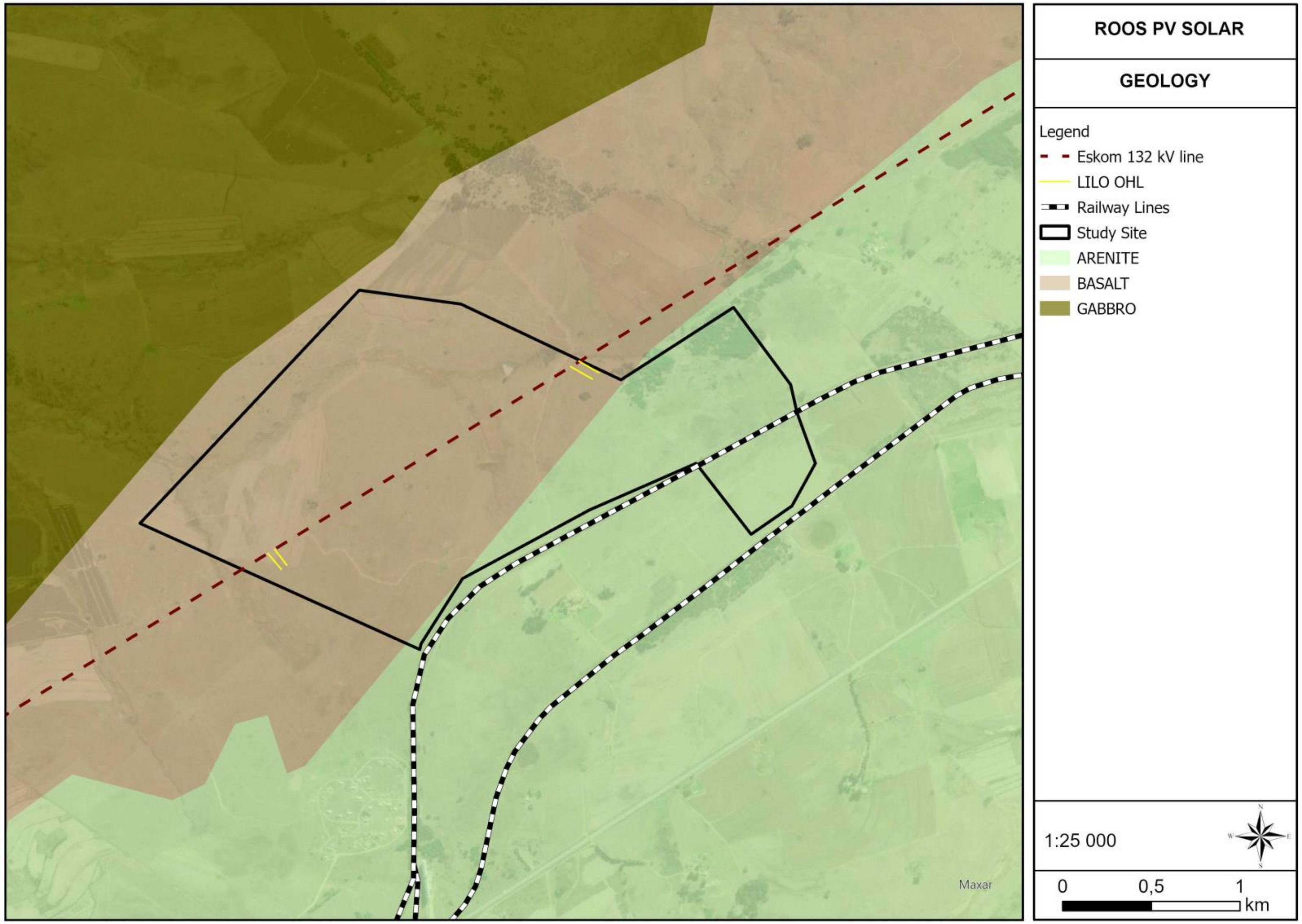


Figure 5: Geology of the study site.

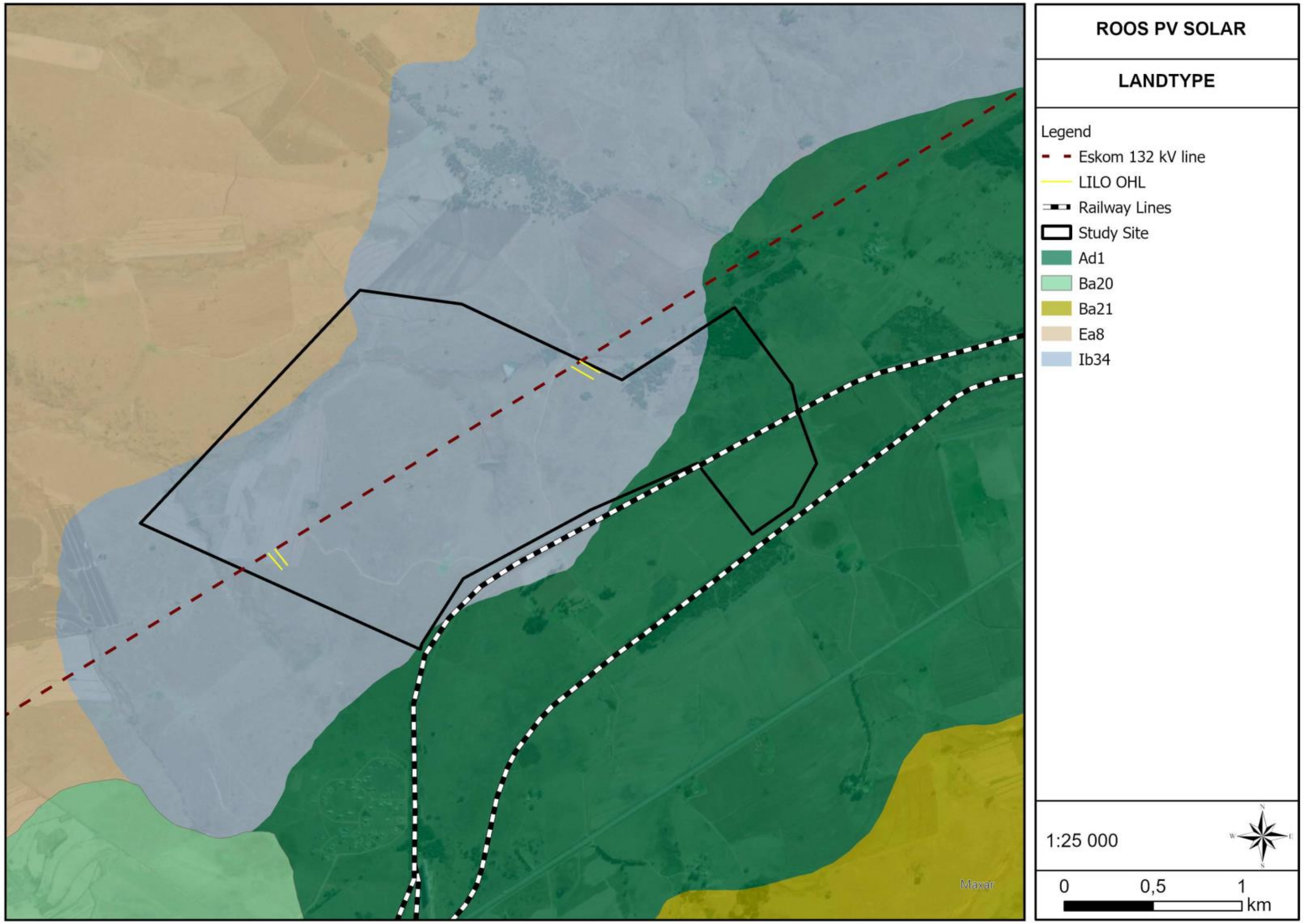


Figure 6: Landtype soil of the study site.

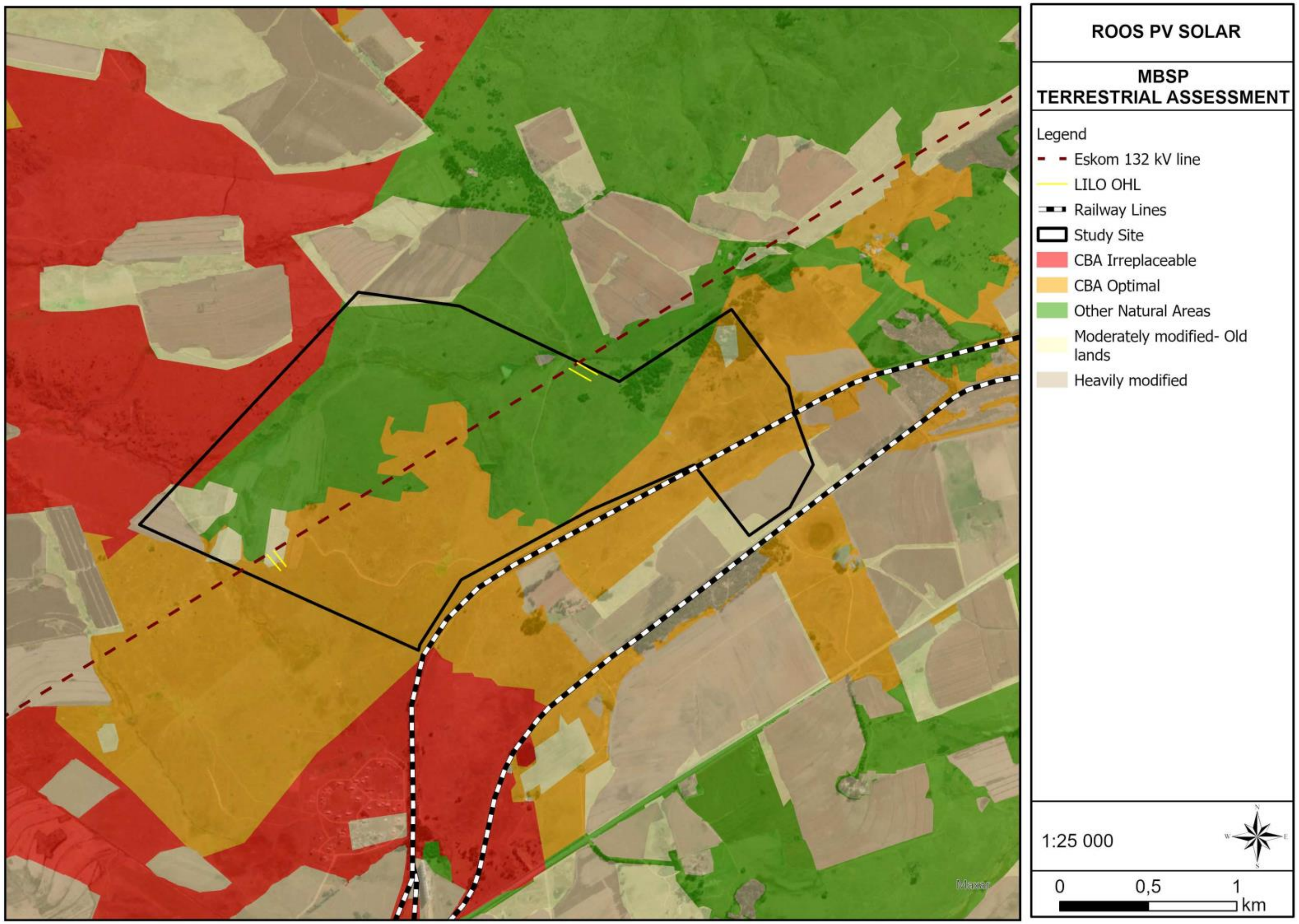


Figure 7: Mpumalanga Critical Biodiversity Areas

2 METHODOLOGY

The delineation method documented by the DWS in their document "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2014) as well as the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al*, 2013) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held Garmin Montana 650 and/or a Samsung S10 smartphone will be used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary watercourse boundaries. These will be converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey. Applications used on the smartphone includes GPX Viewer Pro and Google Earth.

Following the initial desktop assessment that highlighted wetland or riparian boundaries to be groundtruthed in the field, soil and vegetation sampling on site informed a fine scale delineation. Functional and integrity assessments were conducted to indicate the baseline status of the wetlands identified. In the current study the wetland area was assessed using, WET-Health (Macfarlane *et al*, 2020), EIS and WetEcoServices, (Kotze *et al*, 2020). The assessment of potential impacts follows the 2014 NEMA regulations (as amended) and the DWS 2016 Risk Assessment.

In order to ease the legibility of the report, details regarding the methods used in each phase of the wetland assessment are presented in Appendix B.

2.1 Conducting the 2022 Baseline Aquatic Assessment

In South Africa, the River Health Programme (under the Department of Water and Sanitation) has developed a suite of different programs to rapidly assess the quality of aquatic systems. One of the most popular and robust indicators of aquatic ecology health is the South African Scoring System or SASS currently in version 5 (SASS5).

The South African Scoring System is a biotic index initially developed by Chutter (1998). It has been tested and refined over several years and the current version is SASS5 (Dickens and Graham, 2002). This technique is based on a British biotic index called the Biological Monitoring Working Party (BMWP) scoring system and has been modified to suit South African aquatic micro-invertebrate fauna and conditions. SASS5 is a rapid biological assessment method developed to evaluate the impact of changes in water quality using aquatic macro-invertebrates as indicator organisms. SASS is widely used as a bio-assessment tool in South Africa because of the following reasons:

- It does not require sophisticated equipment
- Method is rapid and relatively easy to apply.

This method is very cheap in comparison to chemical analysis of water samples and analysis and interpretation of output data is simple. Sampling is generally non-destructive, except where representative collections are required, (the biodiversity index of SASS5 is described in Dickens and Graham (2002).

It provides some measure of the biological status of rivers in terms of water quality.

SASS is therefore a method for detection of current water quality impairment and for monitoring long-term trends in water from an aquatic invertebrate's perspective. Although SASS5 is user-friendly and cheap, it has some limitations. The method is dependent on the sampling effort of the operator and the total SASS score is greatly affected by the number of biotopes sampled.

SASS5 is not accurate for lentic conditions (standing water) and should be used with caution in ephemeral rivers (systems that do not always flow) (Dickens and Graham, 2002) The resolution of SASS5 is at family level; therefore, changes in species composition within the same family due to environmental changes cannot be detected.

Although the SASS5 score acts as a warning 'red flag' for water quality deterioration, it cannot pinpoint the exact cause and quantity of a change. SASS5 does not cover all invertebrate taxa. SASS also cannot provide information about the degradation of habitat, so habitat assessment also indices, to show the state of the habitat. The initial SASS protocol was described by Chutter (1998) and refined by Dickens and Graham (2002) require collections of macro-invertebrates from a full range of biotopes available at each site.

The biotopes sampled include vegetation both in and out of current (VG- aquatic and marginal), stones (S- both stones in current and out of current) and gravel, sand and mud (GSM) (Dickens & Graham, 2002). The standardised sampling methods allow comparisons between studies and sites. Macro-invertebrate sampling is done using a standard SASS net (mesh size 1000 mm, and a frame of 30 cm x 30 cm). There are nineteen (19) possible macro-invertebrates from each biotope that are tipped into a SASS tray half filled with water and families are identified for not more than 15 minutes/biotype at the streamside.

Invertebrates encountered from each biotope are recorded on a SASS5 score sheet, with their abundance being noted on the sheet. Each taxon (usually a family) of invertebrates from South African rivers has been allocated a score ranging from 1 for those taxa that are most tolerant of pollutants, to 15 for those that are most sensitive to pollutants (Chutter, 1998). To complete the SASS exercise the scores for all the taxa are added together (total score). The average score per taxon (ASPT) is calculated by dividing the total score by the number of taxa. All three scores (SASS5, ASPT and number of families) are used in the interpretation of the status of the site or river being assessed dependant on operator choice (Table 2).

Table 2: Ecological Categories for interpreting SASS data

Ecological Category	Ecological Category Name	Description	Colour
A	Natural	Unmodified natural	Blue
B	Good	Largely natural with few modifications	Green
C	Fair	Moderately modified	Yellow
D	Poor	Largely modified	Red
E	Seriously modified	Seriously modified	Purple
F	Critically modified	Critically or extremely modified	Black

2.2 Invertebrate Habitat Assessment System (IHAS)

Invertebrate Habitat Assessment System (IHAS) was specifically developed to be used in conjunction with SASS, based on habitat availability (McMillan, 1998). The scoring system is based on sampling habitat (i.e. availability of a range of habitats, which could be utilized by in-stream invertebrates) and more general stream characteristics such as anthropogenic or natural impacts (McMillan, 1998). This habitat scoring system is based on 100 points (or percentage) and is divided into two sections reflecting the sampling habitat (50 points) and stream characteristics (50 points).

The sampling habitat section is further broken down into three subsections: stones in current (20 points), vegetation (15 points) and other habitats (15 points) (McMillan, 1998). Very specific questions and answers score between 0 and 5. Higher scores indicate better habitat for macro-invertebrates. The ideal condition is not based on the ultimate pristine stream, but rather on the representation of all habitats adequately and in reasonable conditions. The IHAS form must be completed for each site sampled during each sampling season. This index is mostly subjective with the data collected dependent on the assessor's visual observation and level of expertise. IHAS data was to aid the interpretation of SASS data.

3 RESULTS

3.1 Land Use, Cover and Ecological State

The elevation profile of the study site indicates that southern portion of the study site is located on a high elevation sloping towards a lower elevation in the north (Figure 8). Low landscape settings are one of several tools to measure the likelihood of wetlands in the area (Ollis *et al,* 2013). Historical and recent imagery indicate that the area has been impacted by long term agriculture and forestry. The south-western corner of the study site has been used for agriculture circa 1955 (

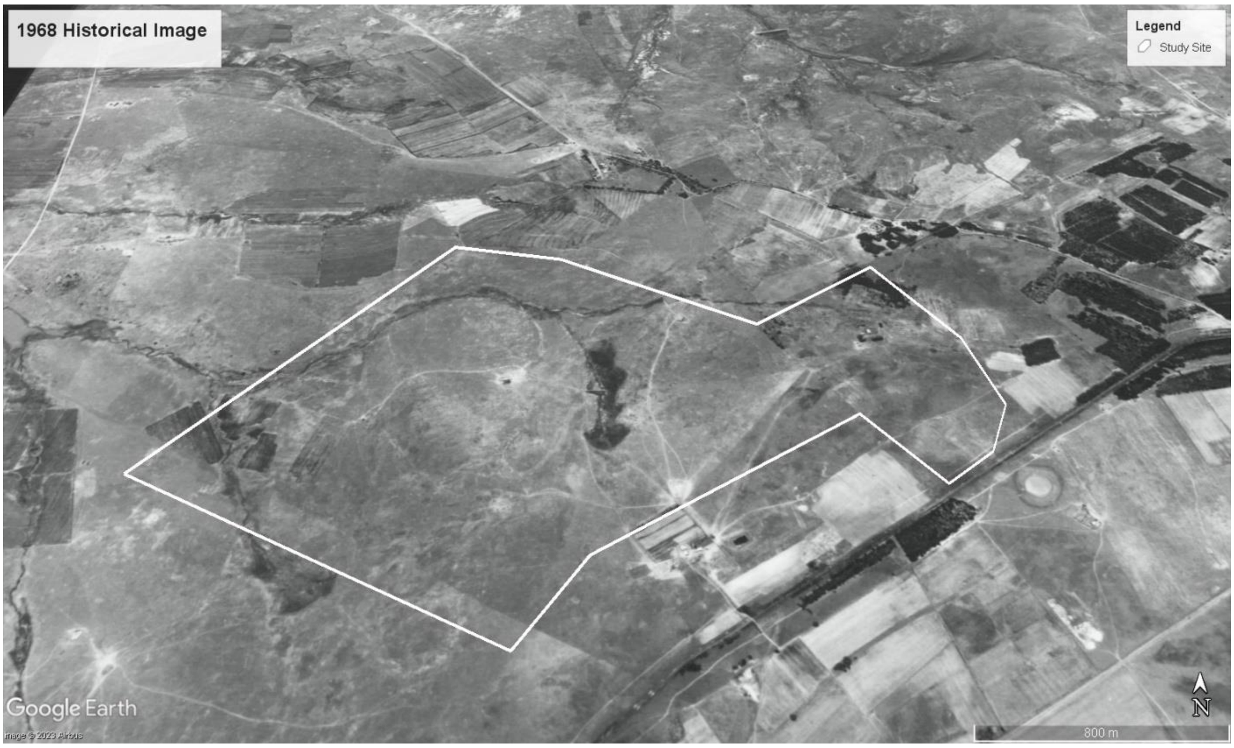


Figure 9). Impoundments can be seen in the wetlands since 1955, with two impoundments and increasing to 7 impoundments in the recent aerial imagery of 2023 (Figure 10). No other historical large scale impacts can be seen with regards to wetland on the study site.

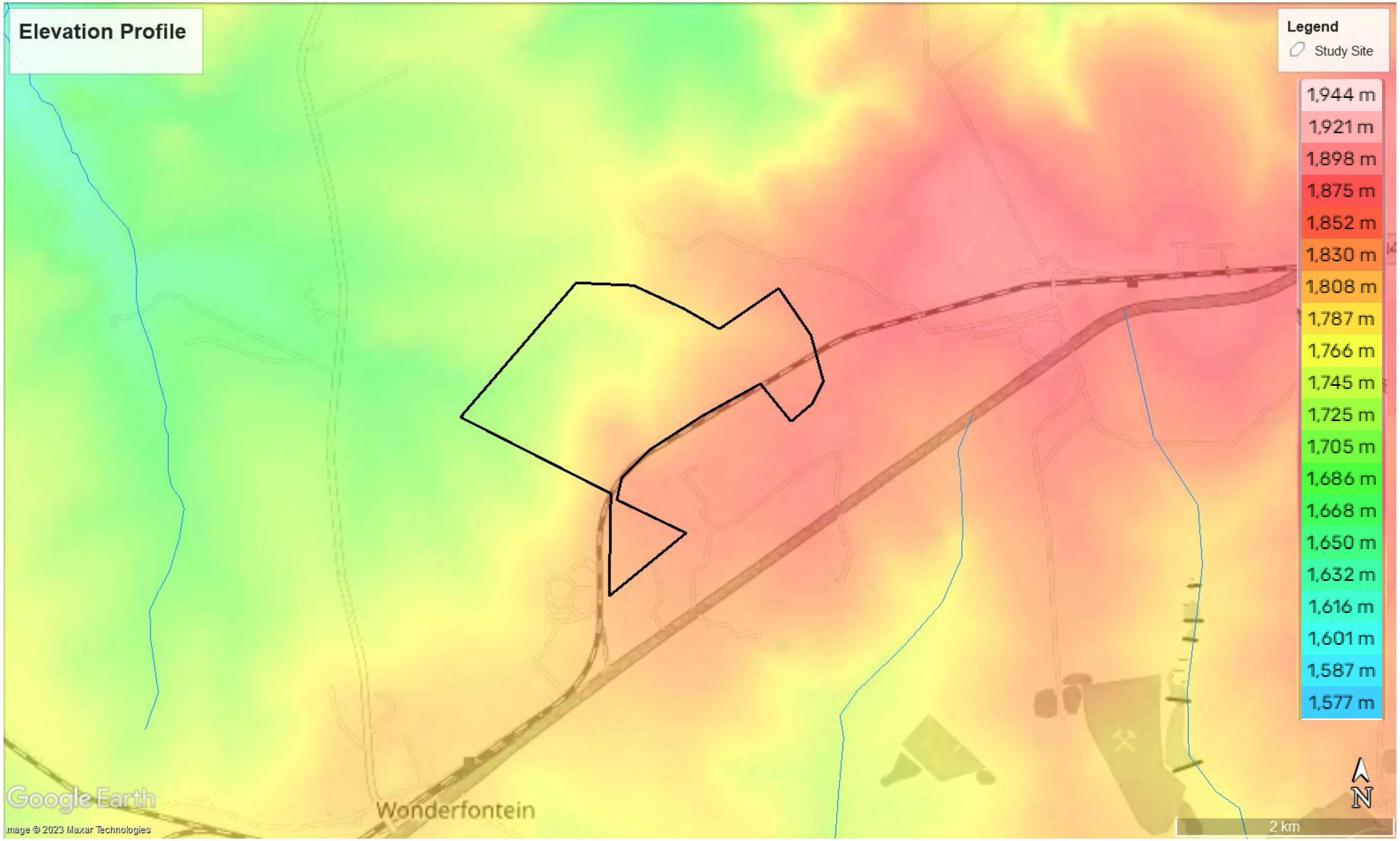


Figure 8: Elevation Profile of the study site (https://tessadem.com/)

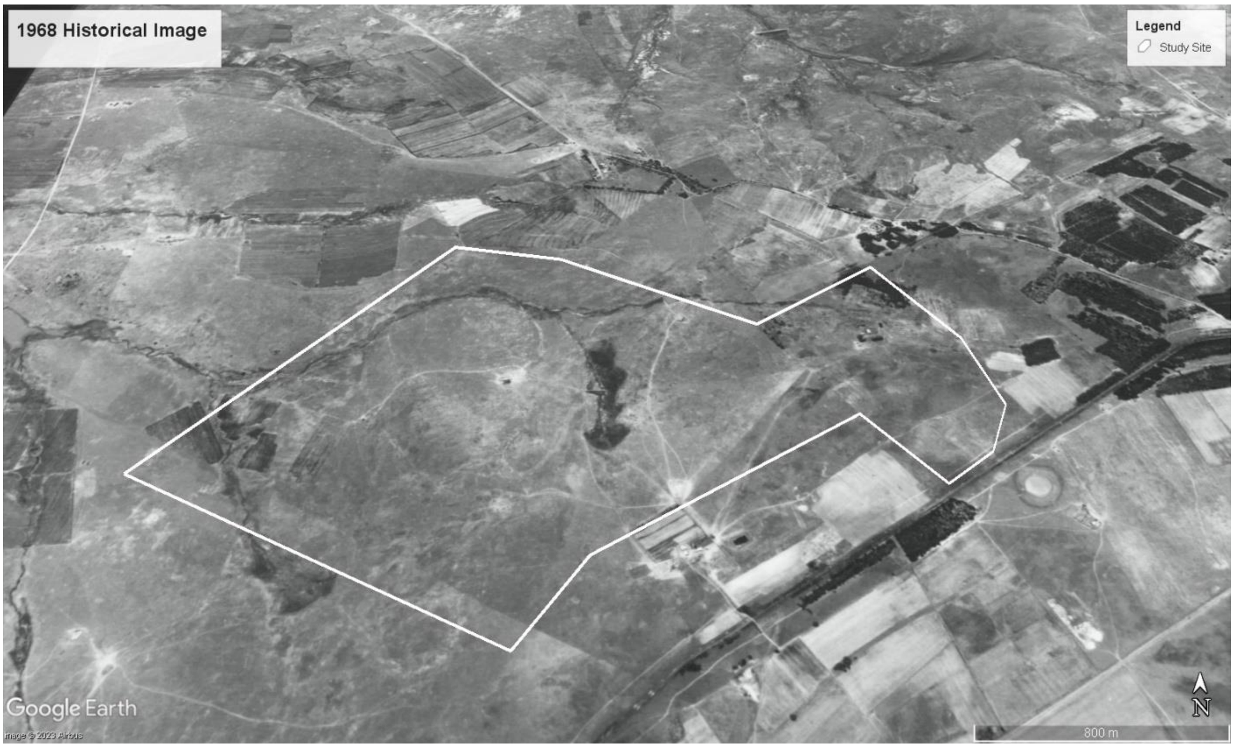


Figure 9: Historical Map of 1955 (Top) compared to a recent map of 1964 (Bottom) indicating a large some agricultural activities in the study site.

Figure 10: Historical Map of 1986 (Top) compared to a recent map of 2023 (Bottom) indicating a large increase the number of impoundments in the wetlands on the study site.

3.2 Wetland/Riparian Classification and Delineation

Two wetland types were recorded on the study site (Figure 11). The watercourses are further classified into the following according to the classification guidelines (Ollis *et al,* 2013):

- Channelled Valley Bottom Wetland
- 2 Hillslope Seepage Wetlands

The wetlands are further classified per level according to the classification guidelines (Ollis *et al,* 2013) in Table 3.

Table 3: Summary of the result of the application of Levels 1- 4 of the classification System of the Channelled Valley Bottom Wetland (Ollis *et al*, 2013)

Wetland Name	Level 1	Level 2	Level 3	Level 4:HGM unit
	System	NFEPA Wetland Vegetation Group	Landscape Unit	Level 4A
Channelled Valley Bottom	Inland	Mesic Highveld Grassland Group 6	Valley Floor	Channelled Valley Bottom
Hillslope Seepage 1		Mesic Highveld Grassland 6	Slope (high)	Hillslope Seepage
Hillslope Seepage 2		Mesic Highveld Grassland Group 4		

A level 5 application was conducted for the wetland inundation period (Ollis *et al,* 2013) in (Table 4).

Table 4: Summary of the dominant Level 5 hydroperiod of the Channelled Valley Bottom Wetland (Ollis *et al*, 2013)

Wetland Name	Dominant Hydroperiod	
	Level 5A: Inundation Period	Level 5B: Saturation Period
Channelled Valley Bottom Wetland	Seasonally Inundated	Seasonally Saturated
Hillslope Seepage 1	Seasonal and Temporarily Inundated	Seasonal and Temporarily Saturated
Hillslope Seepage 2		

3.3 Buffer Zones

GN509 requires that a site specific buffer zone be calculated following Macfarlane et al., 2015. This excel-based tool reflected a recommended a minimum calculated buffer zone of 18 m for the Channelled Valley Bottom wetland and 17 m for the Hillslope Seepage Wetlands.

A 500m regulated area around wetlands as required by the Department of Water and Sanitation is also reflected. Figure 11 shows current wetland conditions, generic and calculated buffer zones and the DWS regulated area relative to the site boundaries. It should be noted that the excel-based tool currently does not have an option for Solar generation works, and some of the expected impacts such as sedimentation was manually lowered to accommodate a more realistic impact measurement.

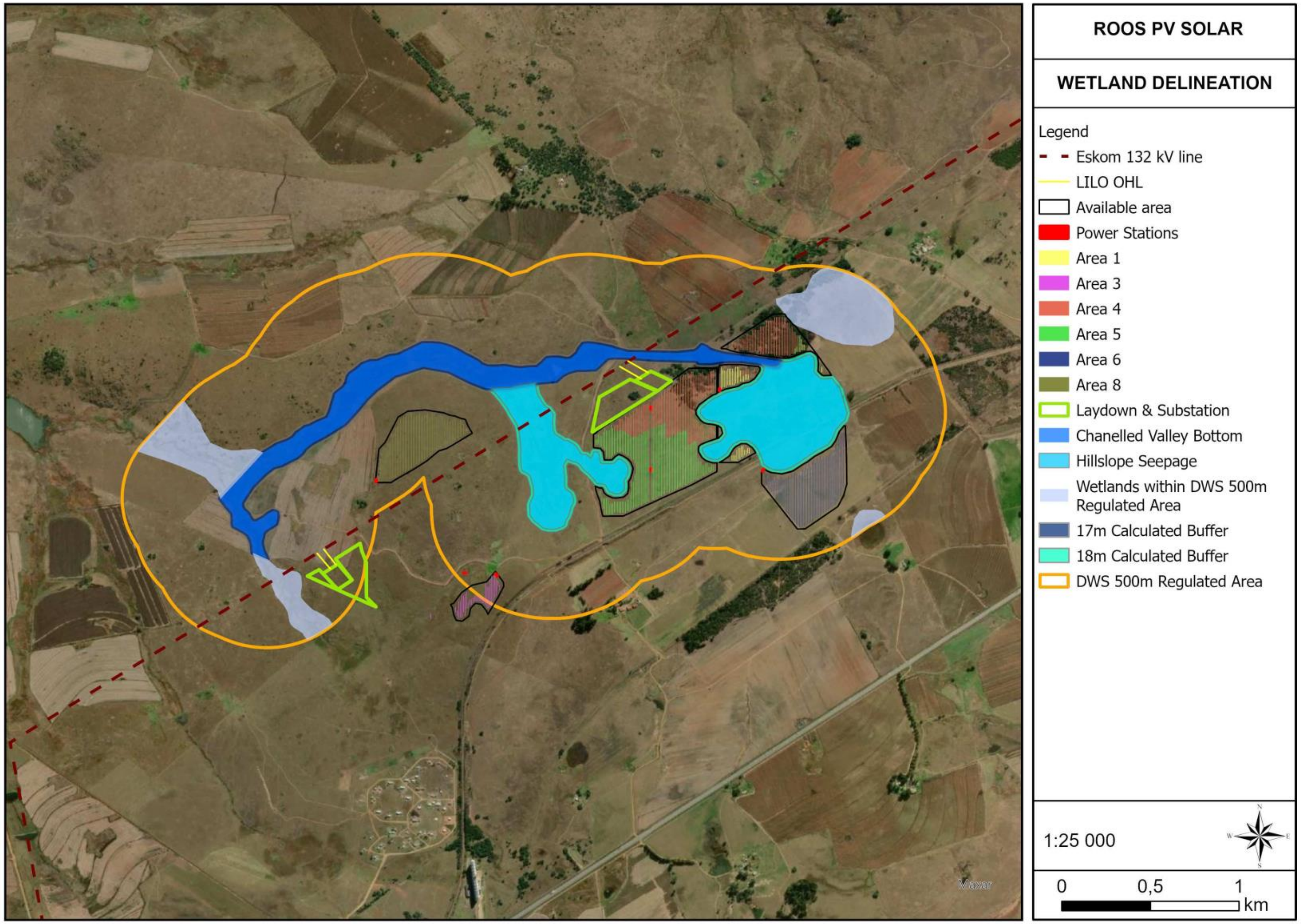


Figure 11: Delineated watercourses, their calculated buffers and the DWS regulated area relative to the study site.

3.3.1 Vegetation and Soil

Hillslope seepage wetlands are commonly linked to a raised groundwater table. When rainfall occurs in the larger catchment, it is stored in the soil profile temporarily due to an impermeable layer in the soil, as explained by Kotze et al. in 2007. This impermeable layer is usually composed of an unweathered parent material or swelling clays associated with sandstones, granites, or shales. Hillslope seepage wetlands are apparent in areas where the soil profile is shallow enough for the impermeable layer and stored water to be visible on the surface. The soil in the region must be saturated with water long enough for oxygen to be removed through a chemical process, resulting in radoximorphic characteristics in the soil. Hillslope seepage wetlands are created and sustained by infiltration processes occurring in non-wetland areas within the catchment. Wetland systems associated with watercourses are directly linked to them on the surface. This type of system contributes to water flow in the watercourses, even if the contribution is only seasonal.

In the case of the seepage wetland located on the study site, the orthic soil layer was underlain by a shallow layer of ferricrete often with exposed areas (Figure 12). An Orthic soil layer is a type of soil horizon that is relatively undifferentiated or unaltered, and lacks distinct characteristics such as color, texture, structure or chemical composition. Orthic soil layers are commonly found in areas where there is limited soil development due to environmental conditions like poor drainage, shallow soil depth, or low nutrient availability. These soils are usually composed of mineral materials and may contain some organic matter, but they lack the distinct features that characterize more developed soils. Orthic soil layers are often found at the surface or just below the surface of soils, and they can be important indicators of the type and quality of soil in a particular area. A shallow orthic layer underlain by hard rock (Ferricrete) is classified as the soil form Mispah (Ms). The Mispah soil series, particularly those that are linked with soil-rock complexes, are generally categorized as discharge soils. This implies that they do not significantly contribute to underground aquifers situated in the phreatic zone, if at all. These soils are typically found in higher elevations where rainwater infiltration is minimal, resulting in pronounced surface run-off. The Mispah soil associated with the Seepage areas create seasonal and temporary wetland areas with supporting wetland vegetation.

The channelled valley bottom wetland and some sections of the seepage wetlands were characterised by dark clay soils with redoximorphic sings such as small mottling (Figure 12). The dark hue of soil in wetland systems is attributed to the accumulation of organic carbon that occurs over extended periods of moisture exposure. However, when the soil dries out, the carbon and other organic matter lose their dark colour, and the grey colour of the soil particles becomes more apparent. This grey colour arises from the removal of soluble constituents such as iron oxides and silicate clay by water that seeps through the soil. The A-horizon, which has a dark grey shade, is frequently observed in permanent, seasonal, and temporary wetland areas.

The non-wetland soils were characterised by deep red soils.

The wetlands were characterised by the following dominant species (Figure 13) such as *Agrostis lachnantha Andropogon eucomus, Berkeya spp, Eragrostis gummiflua, Eragrostis plana, Leersia hexandra, Paspalum dilatatum, Setaria sphacelata, Juncus effesus, Persicaria lapathoflia, , Typha capensis, Cyperus denudatus, Juncus lomatophyllus, Schoenoplectus brachyceras, Centella asiatica, Haplocarpha scaposa, Gladioulus spp, Helichrysum aureonitens, Helichrysum pilosellum, Hypoxis spp, Hypochaeris radicata, Kyllinga erecta, Lobelia flaccida, Monopsis decipiens, Ranunculus multifidus, Senecio erubescens, Senecio consanguineus* and *Senecio inornatus*.

Although the channelled valley bottom wetland shared similar vegetation communities the main channel with flowing water included species such as *Phragmites australis* and *Limosella maior* not recorded in the seepage wetlands.

Alien Invasive Species (AIS) such as *Bidens pilosa, Cirsium vulgare, Cosmos bipinnata, Verbena bonariensis, Tagetes minuta* and *Oxalis latifolia.* Woody AIS recorded include *Acacia dealbata, Acaciamearnsii*, *Eucalyptus camaldulensis.* On the edges of the wetland the species *Stoebe plumosum* was recorded in high densities. *Stoebe plumosum* is known to proliferates in disturbed or overgrazed areas

According to the Mpumalanga Nature Conservation Act (Act No. 10 of 1998) *Eucomis autumnalis* listed as threatened are known to occur in the area which is listed as Declining on the Mpumalanga Red List. Although not a wetland plan *Boophane disticha* was also recorded on the study site.

A summary of the dominant vegetation and soil characteristics for a level 6 assessment are described in the table below (Table 5) and illustrated in the images below (Figure 12 - Figure 13).

Table 5: Summary of the Level 6 dominant soil and vegetation characteristics of the channelled valley bottom wetland.

Wetland Name	Dominant Descriptor Categories (Level 6)					
	6A: Natural vs Artificial	Vegetation Cover, Form and Status			Substratum Type	
		6A: Veg Cover	6B, C & D Primary Form	6E: Veg Conditions	6A: Primary Category	6B: Secondary Category
Channelled Valley Bottom	Natural Wetland	Vegetated	Herbaceous, Sedge and Grass dominant	Predominantly indigenous	Clay Soil	Dark Clay
Hillslope Seepage 1					Loamy Soil	Sandy loam with a hard rock layer
Hillslope Seepage 2						

Figure 12: Wetland soil indicated the shallow ferricete layer associated with the seepage wetlands and the dark clay soil of the valley bottom wetland and sections of the seepage wetlands.

Figure 13: Vegetation of the wetlands including a seepage wetland seen from the north. .

3.4 Watercourse Functional Assessment

To reflect a comprehensive suite of assessments appropriate the watercourse type and characteristics, the following assessments are discussed in the sections below (Table 6).

Table 6: Assessments undertaken in the current assessment

Watercourse Type	Assessment Method
Channelled Valley Bottom Wetland and Seepage Wetlands	• **Present Ecological Status (PES)** - WetHealth Version 2 (Macfarlane *et al.*, 2020) • **Ecosystem Services:** WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020); • **Ecological Importance and Sensitivity (EIS) -** (Kotze *et al.*, 2020); and • **Water Quality:** In situ water quality assessments was completed for select parameters. Interpretation of the results will be completed using SOUTH AFRICAN WATER QUALITY GUIDELINES Volume 7: Aquatic Ecosystems (DWAF, 1996) • **Instream Habitat Assessment:** Completed using the automatic habitat assessment calculator of the SASS 5 excel spreadsheet. • **Aquatic macroinvertebrate assemblages:** DICKENS CWS and GRAHAM PM (2002) The South African Scoring System (SASS) Version 5 rapid bioassessment method for rivers • **Recommended Ecological Category** (REC) Rountree et al., (2013).

3.4.1 Baseline Freshwater Aquatic Invertebrate Assessment

3.4.1.1 Overview of Sampling Points

During the desktop assessment three sample points were identified to assess the in-situ conditions of the aquatic ecosystem (Figure 14). The sample points were placed to firstly provide in-situ conditions and secondly to serve as monitoring points to assess the impact of the development on the aquatic ecosystem (post development). These points will serve as baseline to determine the condition of the aquatic ecosystems and to assist with the impact assessment.

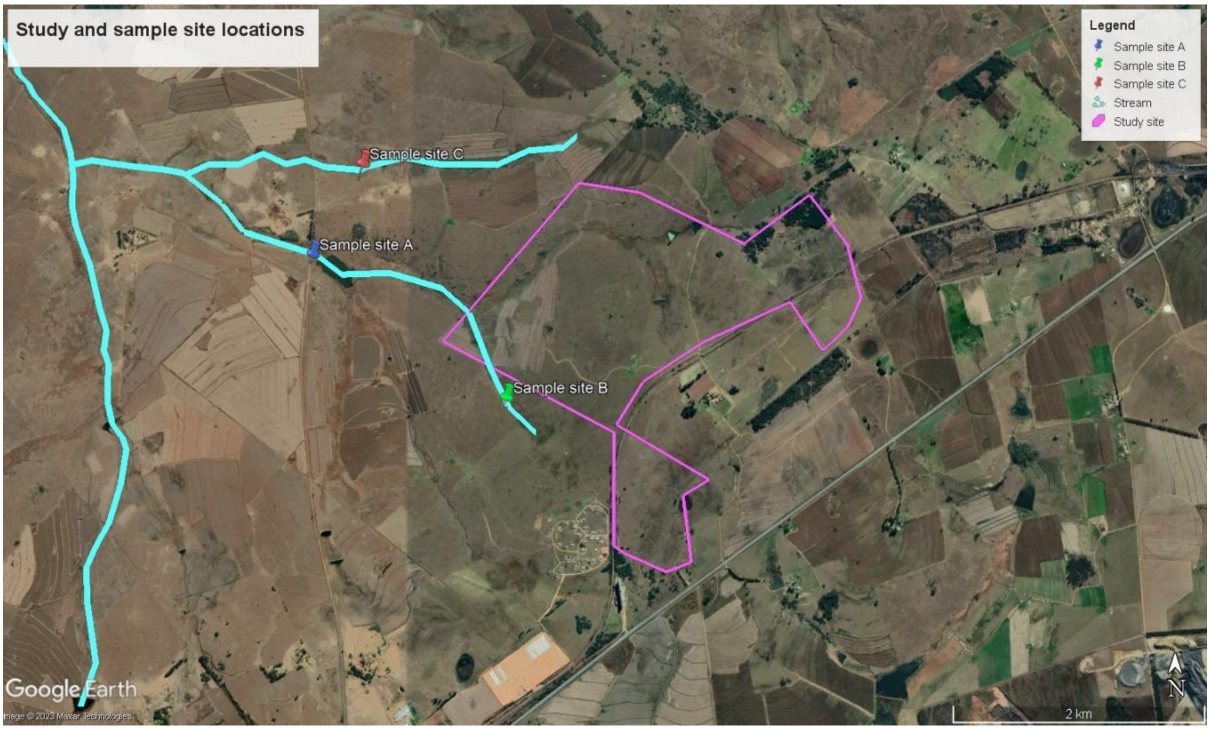


Figure 14: Sample sites of the study site

3.4.1.2 In situ drivers

In situ water quality sampling points was completed as per the sample site locations (Figure 14). The results are given in Table 7 below.

Table 7: The water quality test results for the study site

	pH	TDS (ppm)	EC (mS)	Temperature (°C)
Sample site A	7.2	321	0.64	18.2
Sample site B	7.1	264	0.52	17.9
Sample site C	6.9	289	0,57	17.5

The in-situ water quality results showed somewhat elevated TDS and EC- indicative of possibly the geology of the area and or cultivation soil amelioration impacts. The pH is circumneutral with the temperature indicative of late summer.

3.4.1.3 Habitat assessment

The habitat assessment was completed using the SASS5 score sheet (version 2). The system sets various weight ratings based on the ecoregion description, geomorphological zonation. For the project in the Highveld Ecoregion with A: Source Zonation and low flow was selected. The habitat assessment for the sample sites was completed in Table 8, Table 9 and Table 10. The habitat suitability score of the sample sites were calculated to B for sample site A and B and A for sample site C. This indicates the sample sites to be sufficient for supporting diverse aquatic macroinvertebrates.

Table 8: The habitat assessment of the Sample A site

Biotopes Sampled (tick & rate	Rating	Weight		
Stones In Current (SIC)	4	1.5		
Stones Out Of Current (SOOC)	4	1.0		
Bedrock	2	0.5		
Aquatic Veg	4	2.5		
MargVeg In Current	3	2.5		
MargVeg Out Of Current	3	2.5		
Gravel	3	1.0		
Sand	4	0.5		
Mud	3	1.5		
Hand picking/Visual observation	5	1.5		
OVERALL BIOTOPE SUITABILITY	35	0,0	66%	B

Table 9: The habitat assessment of the Sample B site

Biotopes Sampled (tick & rate	Rating	Weight		
Stones In Current (SIC)	3	1.5		
Stones Out Of Current (SOOC)	3	1.0		
Bedrock	4	0.5		
Aquatic Veg	3	2.5		
MargVeg In Current	3	2.5		
MargVeg Out Of Current	3	2.5		
Gravel	4	1.0		
Sand	4	0.5		
Mud	4	1.5		
Hand picking/Visual observation	5	1.5		
OVERALL BIOTOPE SUITABILITY	36	0,0	69%	B

Table 10: The habitat assessment of the Sample C site

Biotopes Sampled (tick & rate	Rating	Weight		
Stones In Current (SIC)	3	1.5		
Stones Out Of Current (SOOC)	3	1.0		
Bedrock	4	0.5		
Aquatic Veg	4	2.5		
MargVeg In Current	4	2.5		
MargVeg Out Of Current	4	2.5		
Gravel	4	1.0		
Sand	4	0.5		
Mud	4	1.5		
Hand picking/Visual observation	5	1.5		
OVERALL BIOTOPE SUITABILITY	39	0,0	72%	A

3.4.1.4 Aquatic macroinvertebrates using the SASS 5 methodology.

A summary of the results area given in Table 11. The SASS 5 scoring sheet is given in (Table 12 - Table 14). The number of taxa identified is an important factor in biomonitoring assessments. Taxa refers to the different groups of organisms identified in a sample, such as insects, crustaceans, and molluscs. A higher number of taxa typically indicates greater biodiversity and healthier ecosystem conditions. In this assessment, a total of 17, 15 and 13 taxa were identified, which is a relatively moderate number. While it may not be the highest number of taxa observed, it still suggests a reasonable level of biodiversity in the waterbody.

Overall, the biomonitoring assessment based on the SASS score and the identification of taxa indicates good water quality and relatively healthy ecological conditions in the assessed waterbody. However, it is important to consider other factors, such as habitat quality, chemical analysis, and historical data, to obtain a comprehensive understanding of the overall health of the ecosystem. Regular biomonitoring assessments can provide valuable information for tracking changes in water quality over time and guiding management decisions to protect and restore aquatic ecosystems.

Table 11: Comparative Sass Results

	SASS Score	No of Taxa	ASPT
Sample site A	94	17	5,5
Sample site B	73	15	4,9
Sample site C	65	13	5.0

Table 12: SASS5 results of sample site A

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1		A		A
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3	A			A
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4	A			
Baetidae 2 sp	6		1		
Baetidae > 2 sp	12	A			A
Caenidae (Squaregills/Cainfles)	6	A			A
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4				
Lestidae (Emerald Damselflies/Spreadwin	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8		A		A
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6			B	B
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5			A	A
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3		A		A
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4	A			A
Veliidae/M...veliidae* (Ripple bugs)	5		A		A
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8			A	A
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10		A		A
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5		A		A
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles	5				
Limnichidae (Marsh-Loving Beetles)	10	A			A
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5			A	A
Chironomidae (Midges)	2	A			A
Culicidae* (Mosquitoes)	1		A		A
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					94
No. of Taxa					17
ASPT					5,5
Other biota:					
Comments/Observations:					

Table 13: SASS5 results of sample site B

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3					Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5			A	A	Ceratopogonidae (Biting midges)	5			A	A
Oligochaeta (Earthworms)	1		A		A	Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2	A			A
Hirudinea (Leeches)	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1		A		A
CRUSTACEA						Nepidae* (Water scorpions)	3		A		A	Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3	A			A	Pleidae* (Pygmy backswimmers)	4	A			A	Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5				
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8			A	A	**GASTROPODA (Snails)**					
Baetidae 1sp	4	A				Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6		1		A	Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6	A			A	Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalves)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					73
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					15
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					4,9
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13										
Lestidae (Emerald Damselflies/Spreadwin	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8		A		A	Gyrinidae* (Whirligig beetles)	5		A		A	**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5										
Gomphidae (Clubtails)	6			B	B	Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10	A			A						
						Psephenidae (Water Pennies)	10										

Table 14: SASS5 results of sample site C

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3					Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5			A	A	Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1					Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2	A	B		A
Hirudinea (Leeches)	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1		A		A
CRUSTACEA						Nepidae* (Water scorpions)	3		A		A	Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4	A			A	Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5	A			A
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					**GASTROPODA (Snails)**					
Baetidae 1sp	4	A				Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6		B		B	Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6	A			A	Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalvles)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					65
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					13
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					5,0
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13										
Lestidae (Emerald Damselflies/Spreadwin	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8		A		A	Gyrinidae* (Whirligig beetles)	5	A			A	**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5										
Gomphidae (Clubtails)	6			B	B	Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4	A			A	Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10			A	A						
						Psephenidae (Water Pennies)	10										

Sample site A: SASS score of 94 The first site assessed had a SASS score of 94, which indicates good biological integrity and high water quality. The high SASS score suggests that the assessed waterbody has a diverse and abundant assemblage of indicator taxa, indicating healthy ecosystem conditions. The average SASS score per taxon of 5.5, which indicates relatively good biological integrity and water quality. The higher score per taxon suggests a healthy assemblage of indicator taxa, indicating good ecosystem conditions and potentially low impacts on water quality

Sample site B: SASS score of 73 The second site assessed had a SASS score of 73, which is moderately high and suggests relatively good water quality. However, the score is slightly lower compared to the first site, indicating a potential slight impairment in biological integrity. Further investigation may be needed to identify the specific factors that may be affecting the ecosystem health at this site. The site had an average SASS score per taxon of 4.9, which is slightly lower compared to the first site. The lower score per taxon may suggest a potential slight impairment in biological integrity and water quality at this site. Further investigation may be needed to identify any specific stressors or impacts that may be affecting the ecosystem health.

Sample site C: SASS score of 65 The third site assessed had a SASS score of 65, which is relatively lower compared to the previous two sites. The lower score may indicate potential impairment in water quality and reduced biological integrity. Further investigation and monitoring may be needed to identify the potential stressors or impacts affecting the ecosystem health at this site. The site assessed had an average SASS score per taxon of 5.0, which is relatively similar to the first site but slightly lower compared to the second site. The score per taxon suggests moderate biological integrity and water quality. Further monitoring and investigation may be needed to better understand the overall health of the ecosystem and identify any potential changes over time.

3.4.1.5 SASS5 EC

Dallas (2007) used available SASS5 Score and ASPT values for each eco-region in South Africa to generate biological bands on standardised graphs that are used as a guideline for interpreting any data obtained during the study. For the study site the “Highveld Ecoregion Bands Lower” was used (Figure 15). It is important to note that the data used by Dallas (2007) is older data and interpretation of the results must be used with a side of caution. Using the results, the sample sites can be classified as PES “E/F” for the system.

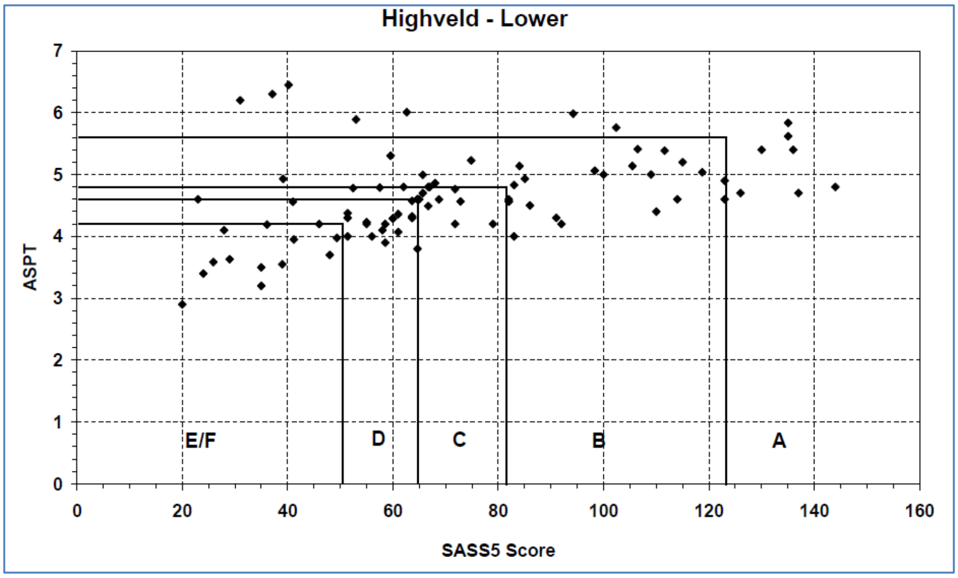


Figure 15: Dallas bands for the Highveld Ecoregion

Based on the results of the SASS assessment, the present ecological score for the site ranges between B and C (Figure 14Table 11).

Table 15: PES of the sample sites using Dallas Bands

	SASS Score	ASPT	PES
Sample site A	94	5,5	B
Sample site B	73	4,9	C
Sample site C	65	5.0	B

The present ecological score, falling within the range of B to C, suggests a moderate state of ecological health. This score indicates that the current ecological conditions are not in the best state, but they are not severely degraded either.

A score within the B to C range may indicate that some ecological parameters are functioning fairly well, while others may require attention and improvement. It could signify a mix of positive and negative ecological indicators, with some elements showing resilience and stability, while others may exhibit signs of stress or degradation.

Further analysis and assessment of specific ecological factors would be necessary to determine the exact condition of the ecosystem. For example, factors such as biodiversity, water quality, air quality, soil health, and habitat integrity would need to be evaluated to gain a comprehensive understanding of the ecosystem's health.

The interpretation of the present ecological score within the B to C range should be used as a signal for cautious monitoring and potential intervention to prevent further ecological decline. It may also indicate a need for conservation efforts, habitat restoration, and sustainable resource management practices to improve the overall health and resilience of the ecosystem.

3.4.2 Present Ecological Status (PES)

The Present Ecological Status of each wetland on the study site are illustrated in Figure 16.

3.4.2.1 Present Ecological Status (PES) (Kotze et al., 2020) for the Channelled Valley Bottom and Seepage Wetland 1

The Channelled Valley Bottom and associated Seepage wetland 1 have been impacted by numerous impoundments and achieved a Combined Impact Score of **1.6 – B - 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. The condition of this wetland is likely to likely to remain stable over the next 5 years (Table 16).

Table 16: Summary of the results of the WetHealth (Version 2) assessment conducted for the Channelled Valley Bottom Wetland.

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	1.9	1.8	0.6	1.8
PES Score (%)	81%	82%	94%	82%
Ecological Category	**B**	**B**	**A**	**B**
Trajectory of change	→	→	→	→
Confidence (revised results)	Moderate			
Combined Impact Score	1.6			
Combined PES Score (%)	84%			
Combined Ecological Category	**B**			

3.4.2.2 Present Ecological Status (PES) (Kotze et al., 2020) for the Seepage Wetland 2

The Seepage wetland 2 has been impacted by overgrazing and AIS agriculture, forestry, orchards and impoundments and achieved a Combined Impact Score of **2.0 – C – Moderately Modified.** A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact. The condition of this wetland is likely to likely to remain stable over the next 5 years (Table 17).

Table 17: Summary of the results of the WetHealth (Version 2) assessment conducted for the Seepage Wetland 2.

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	2.0	1.9	1.8	2.4
PES Score (%)	80%	81%	82%	76%
Ecological Category	**C**	**B**	**B**	**C**
Trajectory of change				
Confidence (revised results)	Not rated	Not rated	Not rated	Not rated
Combined Impact Score	2.0			
Combined PES Score (%)	80%			
Combined Ecological Category	**C**			

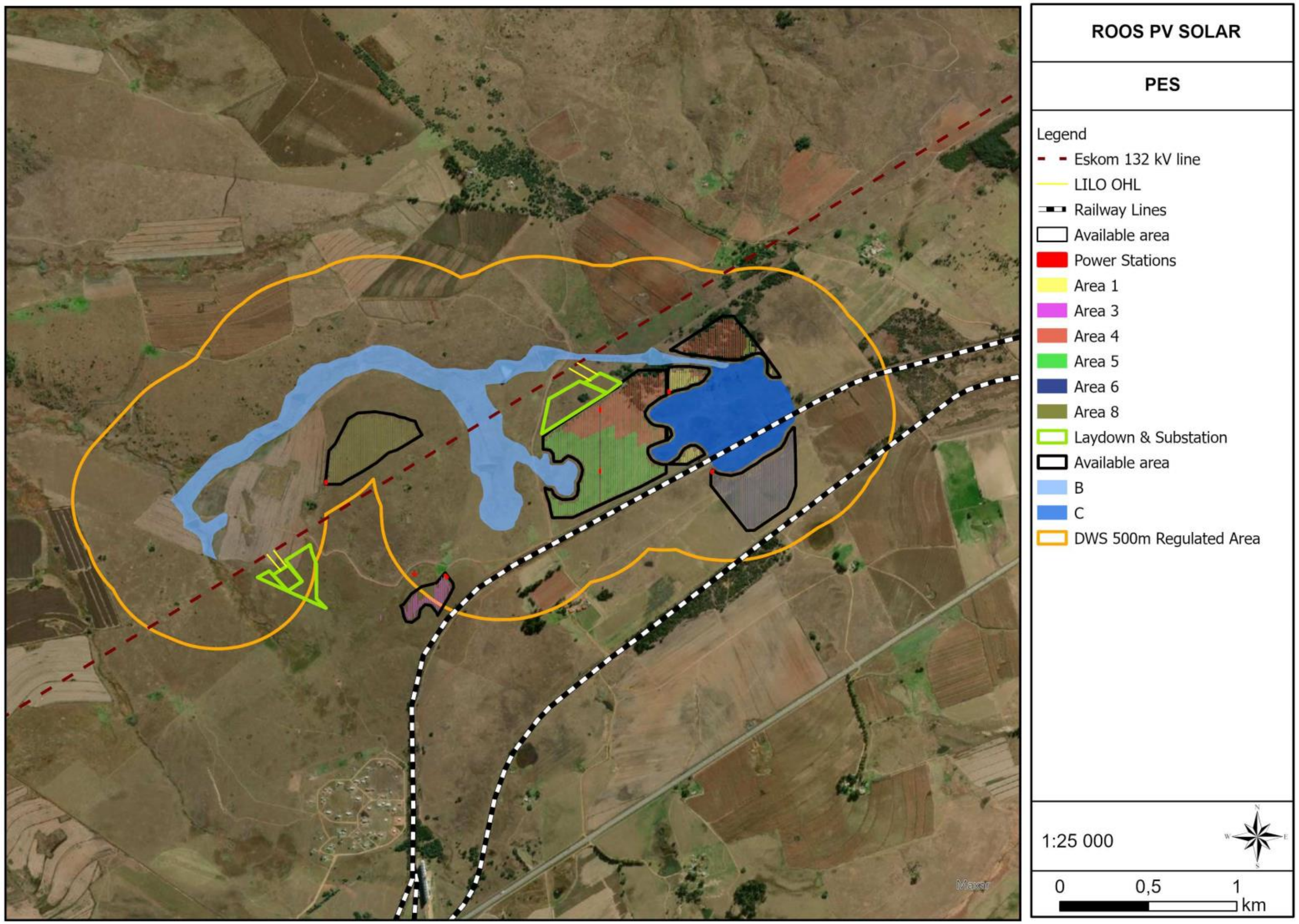


Figure 16: Present Ecological Status (PES) of the wetlands recorded on the study site.

3.4.3 WetEcoServices Kotze et al., (2020)

3.4.3.1 WetEcoServices Kotze et al., (2020) for the Channelled Valley Bottom

The ecosystem services provided by Channelled Valley Bottom wetlands are presented in Table 18 below. The highest scores were obtained for Water for Human Use and Biodiversity Maintenance.

Table 18: Summary of the Ecosystem Services provided by Channelled Valley Bottom Wetland

ECOSYSTEM SERVICE		Present State			
		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.3	0.0	0.0	Very Low
	Stream flow regulation	2.3	0.3	0.9	Low
	Sediment trapping	1.9	0.0	0.4	Very Low
	Erosion control	0.4	0.0	0.0	Very Low
	Phosphate assimilation	1.8	0.5	0.6	Very Low
	Nitrate assimilation	1.9	0.5	0.6	Very Low
	Toxicant assimilation	1.9	0.0	0.4	Very Low
	Carbon storage	2.0	0.0	0.5	Very Low
	Biodiversity maintenance	4.0	1.0	3.0	High
PROVISIONING SERVICES	Water for human use	4.0	2.0	3.5	Very High
	Harvestable resources	2.5	0.3	1.2	Low
	Food for livestock	1.5	0.7	0.3	Very Low
	Cultivated foods	2.0	0.7	0.8	Low
CULTURAL SERVICES	Tourism and Recreation	2.5	0.0	1.0	Low
	Education and Research	1.3	0.0	0.0	Very Low
	Cultural and Spiritual	3.0	0.0	1.5	Moderately Low

3.4.3.2 Ecological Importance and Sensitivity (EIS) of the Channelled Valley Bottom

The highest EIS score of 3.5 falls in the **Very High** category. Very High - Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers. The importance of services supplied is high relative to that supplied by other wetlands

- ***Biodiversity maintenance importance***: 3.0 (High)
- ***Regulating services importance***: 3.0 (High)
- ***Provisioning and cultural services importance:* 3.5 (**Very High**)**

3.4.3.3 Recommended Ecological Category (REC) of the Channelled Valley Bottom Wetland

Following the method set out in Rountree *et al.,* (2013), the PES value of B and a Very High EIS class, leads to the identification of an REC of A (Table 19). This means that the development should be done in such a way as to try and improve the EC values if possible.

Table 19: Generic Matrix for the determination of REC and RMO for water resources

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	**A Improve**	A/B Improve	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

3.4.3.4 WetEcoServices Kotze et al., (2020) for the Seepage Wetlands

The Seepage wetlands share similar characteristics and were assessed together. The ecosystem services provided by the Seepage wetlands are presented in Table 20 below. The highest scores were obtained for biodiversity management, food for livestock and cultivated food.

Table 20: Summary of the Ecosystem Services provided by Seepage Wetlands

		Present State			
ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.2	0.0	0.0	Very Low
	Stream flow regulation	1.8	0.3	0.4	Very Low
	Sediment trapping	1.8	0.0	0.3	Very Low
	Erosion control	1.7	0.6	0.5	Very Low
	Phosphate assimilation	1.8	0.5	0.5	Very Low
	Nitrate assimilation	1.5	0.5	0.3	Very Low
	Toxicant assimilation	1.7	0.0	0.2	Very Low
	Carbon storage	0.9	0.0	0.0	Very Low
	Biodiversity maintenance	4.0	0.0	2.5	Moderately High
PROVISIONING SERVICES	Water for human use	0.8	2.0	0.3	Very Low
	Harvestable resources	2.5	0.3	1.2	Low
	Food for livestock	3.0	0.7	1.8	Moderate
	Cultivated foods	3.0	0.7	1.8	Moderate
CULTURAL SERVICES	Tourism and Recreation	2.2	0.0	0.7	Very Low
	Education and Research	1.3	0.0	0.0	Very Low
	Cultural and Spiritual	3.0	0.0	1.5	Moderately Low

3.4.3.5 Ecological Importance and Sensitivity (EIS) of the Seepage Wetlands

The highest EIS score of 2.5 falls in the **Moderately High** category. High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. The importance of services supplied is moderately-high relative to that supplied by other wetlands

- ***Biodiversity maintenance importance***: **2.5 (Moderately High)**
- ***Regulating services importance***: **2.5 (Moderately High)**
- ***Provisioning and cultural services importance:*** **1.8 (**Moderate**)**

3.4.3.6 Recommended Ecological Category (REC) of the Seepage Wetlands

Following the method set out in Rountree *et al.,* (2013), the PES value of B (Seepage wetland 1) and C (Seepage Wetland 2) and a Moderately High EIS class, leads to the identification of an REC of A/B (Seepage wetland 1) and B/C (Seepage Wetland 2) (Table 21). This means that the development should be done in such a way as to try and improve the EC values if possible.

Table 21: Generic Matrix for the determination of REC and RMO for water resources

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	A Improve	**A/B Improve**	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	**B/C Improve**	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

3.4.4 Site Ecological Importance

Based on the Species Environmental Assessment Guideline (SANBI, 2020) watercourses and specialised habitats should be assessed based on their Site Ecological Importance (SEI). All the wetlands examine in this report should thus be regarded as having a High Sensitivity (Table 22):

Table 22: Ecological Importance of all wetland areas recorded on the study site

Habitat	Conservation Importance (CI)	Functional Integrity (FI)	Biodiversity Importance	Receptor Resilience	Site Ecological Importance
All Watercourses	High – Confirmed occurrence of watercourses within the development footprint	Medium – Some historical impacts and AIS recorded	Medium – Based on CI and FI	Very Low – Watercourses are not easily restored without significant rehabilitation. Many species are dependent on functional wetland habitat.	Based on BI – Medium and RR – Very Low = High

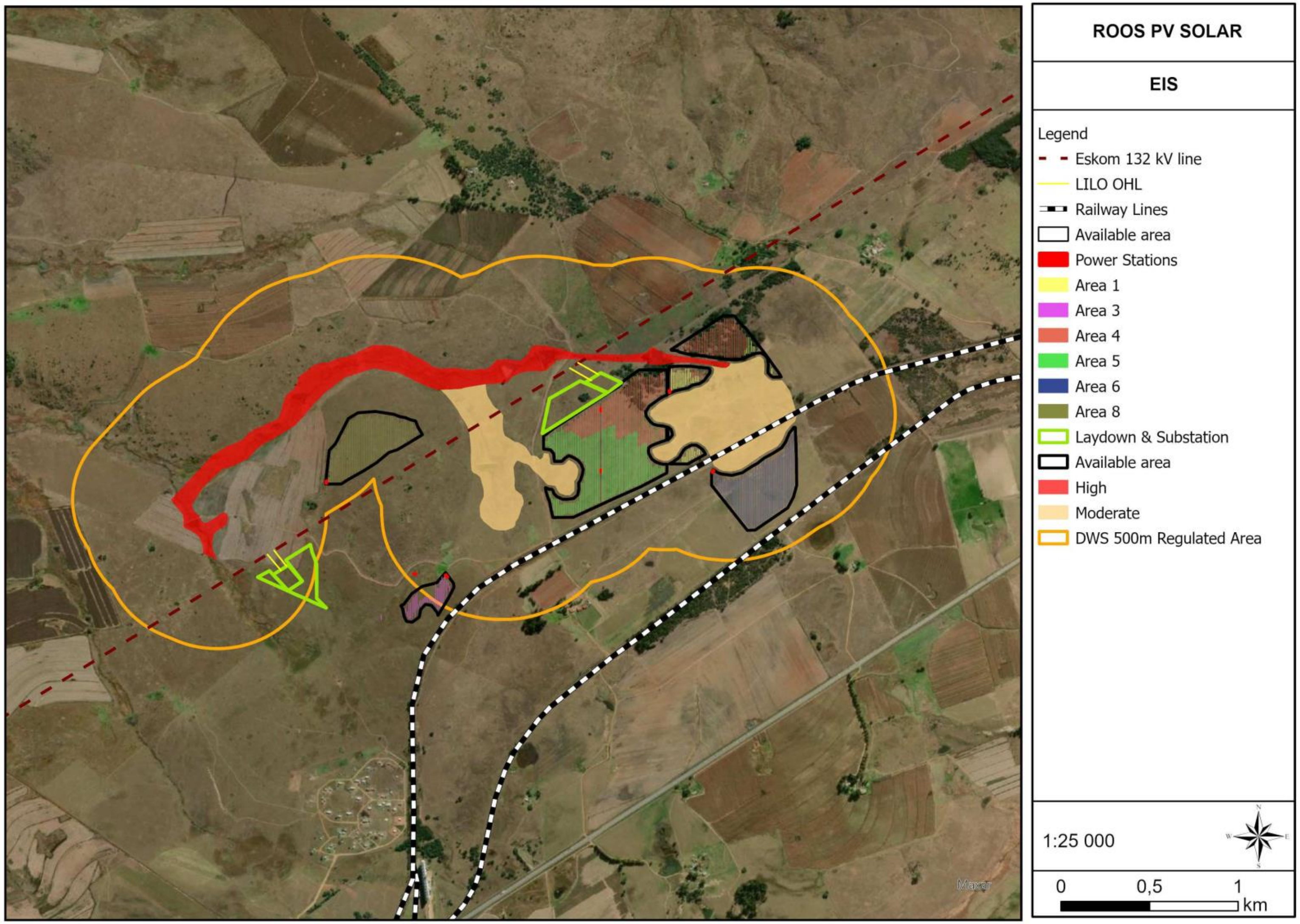


Figure 17: The EIS of each wetland on the study site

3.5 Summary of Findings

A summary of the findings are represented in the table below (Table 23).

Table 23: Summary of scores obtained for the wetlands on the study site

Classification (SANBI, 2013)	**Channelled Valley Bottom Wetland**	**Seepage Wetland 1**	**Seepage Wetland 2**
EC Scores (PES - WetHealth Version 2 (Macfarlane *et al*., 2020)	**B - 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. The condition of this wetland is likely to likely to remain stable over the next 5 years	**B - 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. The condition of this wetland is likely to likely to remain stable over the next 5 years	**Moderately Modified.** A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact. The condition of this wetland is likely to likely to remain stable over the next 5 years
WetEcoServices (Kotze *et al*., 2020) –	3.5 – **Very High** category. The highest scores were obtained for Water for Human Use and Biodiversity Maintenance.	**2.5 - Moderately High.** The highest scores were obtained for biodiversity management, food for livestock and cultivated food.	
EIS	3.5 – **Very High** category	**2.5 - Moderately High.**	
REC (Rountree *et al*, 2013)	**REC of A**. This means that the development should be done in such a way as to try and improve the EC values if possible.	**REC of A**. This means that the development should be done in such a way as to try and improve the EC values if possible.	**REC of A/B**. This means that the development should be done in such a way as to try and improve the EC values if possible.
Calculated Buffer Zone (Macfarlane *et al*, 2015)	**17 m**	**18m**	

In situ Water Quality	**In situ water quality:** The in-situ water quality results showed somewhat elevated TDS and EC- indicative of possibly the geology of the area and or cultivation soil amelioration impacts. The pH is circumneutral with the temperature indicative of late summer.
Instream Habitat assessment:	**Instream habitat:** The habitat suitability score of the sample sites were calculated to B for sample site A and B and A for sample site C. This indicates the sample sites to be sufficient for supporting diverse aquatic macroinvertebrates.
Aquatic macroinvertebrate assemblages:	Aquatic macroinvertebrate assemblages: Overall, the biomonitoring assessments based on the SASS scores of 94, 73, and 65 for the three sites indicate varying levels of water quality and biological integrity. While the first site shows good water quality and healthy ecosystem conditions, the second and third sites may require further investigation to identify any potential impacts and implement appropriate management measures to protect and restore the aquatic ecosystems. Regular biomonitoring assessments and ongoing monitoring efforts are essential for tracking changes in water quality and ecosystem health over time and guiding effective management decisions for the conservation and restoration of aquatic ecosystems. Biomonitoring assessments based on the average SASS scores per taxon of 5.5, 4.9, and 5.0 for the three sites indicate varying levels of water quality and biological integrity. While the first site shows relatively good water quality and healthy ecosystem conditions, the second and third sites may require further investigation to identify any potential impacts and implement appropriate management measures to protect and restore the aquatic ecosystems. Regular biomonitoring assessments, along with other complementary data, are essential for tracking changes in water quality and ecosystem health over time and guiding effective management decisions for the conservation and restoration of aquatic ecosystems.

4 Expected Impacts and Mitigations

Photovoltaic Development

Currently the photovoltaic development layout does infringe on the wetlands as well as their respective buffer areas one of the largest mitigation measures will be to remedy the layout in the design phase of the project and exclude wetlands and their associated buffer zones from the photovoltaic development layout. The area around the photovoltaic development is already altered, large sections of the layout of the photovoltaic development are situated in agricultural fields and previously disturbed areas. Considering the no-go alternative for the photovoltaic development would either be that the solar infrastructure be placed in other areas which might be green field areas or due to the limited energy generation capacity South Africa is facing the use of other forms of energy such as coal or nuclear power. the environmental footprint of coal fired power stations are far greater than that of photovoltaic development.

The advantages of the no-go alternative would be that there will be less disturbance to the aquatic ecosystems than with the proposed photovoltaic development. an advantage of the proposed photovoltaic development would be that adherence to the mitigation measures and the EMPr will be monitored, and corrective measures will be taken where required.

Powerline and Substations

Installation of an overhead power line is generally considered a low-risk operation and the impacts are considered to be low, although all development has the potential to impact the surrounding environment and particularly on a watercourse. A range of management measures is available to address threats posed to water resources. In the context of the proposed powerlines, the mitigation measures proposed below are intended to prevent further degradation to the watercourses resulting from the new powerline construction and operation. It is important to note that this section aims to highlight areas of concern. The details of the mitigation measures that are finally put in place should ideally be based on these issues, but must necessarily take into consideration the physical and economical feasibility of mitigation. Any mitigation must be implemented in the context of an Environmental Management Plan to ensure accountability and ultimately the success of the mitigation.

The impact assessment below follows the structure set out in the requirements for the NEMA (2014) regulations, as amended. It attempts to qualify the intensity of the impacts of the development, operation phase and decommission phase of the development. It should be noted that the risk assessment is done under the assumption that no development will occur within the wetland or the associated wetland buffer zones.

A discussion on impacts to the aquatic environment (as required in GN320 of March 2020) is summarised in

Table 24. Impact scores as set out in the NEMA 2016 Impact Assessment are presented in Section below.

Table 24: Impacts as per GN320 of March 2020

Number	Impact question	Expected impact
2,5,3	How will the development impact on fixed and dynamic ecological processes that operate within or across the site	It is assumed that grass will be allowed to grow in between the panels/ rows. This will mitigate runoff issues into the aquatic ecosystems in terms of the sediments, fixed dynamic processes and minimize the overall extent of modifications.
	a) How will the development impact on fixed and dynamic ecological processes that operate within or across the site a. Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); and	
	b) Change in the sediment regime (e.g. sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns) of the aquatic ecosystem and its sub -catchment;	
	c) The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.).	
	d) to what extent will the risk associated with water uses and related activities change?	See risk assessment (GN509 of NWA) in the accompanying risk assessment report.
2,5,4	How will the proposed development impact on the functioning of the aquatic feature? This must include:	The management of the site in terms of vegetation, roads and stormwater need to be guided by an ecologist to ensure the impacts are minimized. Mitigation measures are expected to be mostly operational and easy to implement.
	a) Base flows (e.g. too little/too much water in terms of characteristics and requirements of system)	
	b) Quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over - abstraction or instream or off -stream impoundment of a wetland or river)	

Number	Impact question	Expected impact
	c) Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchanneled valley -bottom wetland to a channelled valley -bottom wetland).	
	d) Quality of water (e.g. due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication)	
	e) Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).	
	f) The loss or degradation of all or part of any unique or important features (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.) associated with or within the aquatic ecosystem.	
2,5,5,	How will the development impact on key ecosystem regulating and supporting services especially:	
	a) Flood attenuation	Not expected to be impacted. Slight increase in stormwater releases are expected.
	b) Stream flow regulation	Not expected to be impacted
	c) Sediment trapping	The sediment regime is expected to improve as cultivation of fields are replaced with fixed solar systems
	d) Phosphate assimilation	Expected to stabilize and improve over time
	e) Nitrate assimilation	
	f) Toxicant assimilation	
	g) Erosion Control	
	h) Carbon Storage?	

4.1.1 <u>Identification of Potential Impacts/Risks</u>

The largest impact is expected to be during the construction phase. The major impacts are as follow:

Construction Phase:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;

d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

Operational Phase:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

Decommissioning Phase:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

Cumulative Impacts:

a) Alteration in flow regime.

4.1.2 Potential Impacts during the Construction Phase

Changes in flow regime arises from the compaction of soil, the removal of vegetation and surface water redirection. Changes to hydrological function at a landscape level which can arise from changes to flood regimes (i.e. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes). The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flows i.e. too little/too much water in terms of characteristics and requirements of system). Fragmentation (i.e. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).

Changing the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount). Construction and operational activities will result in earthworks and soil disturbance as well as the removal of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourse and increase the turbidity of the water. Possible sources of the impacts include:

- Earthwork activities during construction
- Clearing of surface vegetation will expose the soils, which in rainy events would wash through watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil.

- Disturbance of soil surface
- Disturbance of slopes through creation of roads and tracks adjacent to the watercourse
- Erosion (e.g. gully formation, bank collapse) Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns.

The moving of soil and vegetation resulting in opportunistic invasions after disturbance. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system, alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plants can easily colonise and impact on downstream users.

Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.

Changes in water quality due to input of foreign materials i.e. due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication. During the construction phase a large amount of waste will be produced including sewerage, domestic waste, wash-water, used oils and grease, diesel or lubricant spills, etc. Waste generally contains pollutants and present a potential risk to the water and surrounding environment if not managed effectively. Oil and diesel spillages may occur during the construction phase which can contaminate surface water. Other potential contaminants (i.e. from chemical toilets, domestic waste, storage facilities, workshop facilities, etc.) can reduce surface water quality or result in discharge that exceeds the maximum concentrations permitted by the National Water Act. Changes to the water quality could result in changes to the ecosystem structure and function as well as a potential loss of biodiversity. Water quality deterioration often leads to modification of the species composition where sensitive species are lost and organisms tolerant to environmental changes dominate the community structure.

Aquatic biota can be lost due to the disturbance of the habitat and direct impacts on the watercourse/ rivers/ streams. This can be attributed to Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation.
The impact assessment was conducted using the impact assessment methodology provided as described in Appendix D and below in
Table 25

Table 25: Potential Impacts Associated with the Construction Phase of the proposed Roos PV and Powerline Development.

Environmental Parameter	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	Environmental Significance Before Mitigation									Environmental Significance After Mitigation								
		E	P	R	L	D	I / M	TOTAL	STATUS	S	E	P	R	L	D	I / M	TOTAL	STATUS	S
Changes in sediment entering and exiting the system.	Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns. Construction and maintenance activities will result in earthworks and soil disturbance as well as the disturbance of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourses and pan and increase the turbidity of the water. Possible sources of the impacts include: • Earthwork activities during construction • Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil. • Disturbance of soil surface • Disturbance of slopes through creation of roads and tracks adjacent to the watercourse • Erosion (e.g. gully formation, bank collapse)	3	3	2	2	2	2	24	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

Changes in water flow regime	Changes to hydrological function at a landscape level which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes). The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flows (e.g. too little/too much water in terms of characteristics and requirements of system). Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal). The sources of this impact include the compaction of soil, the removal of vegetation, surface water redirection, changes to watercourse morphology or input of high energy surface water which could occur during construction and operation of the solar plant	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Introduction and spread of alien vegetation	The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users.	3	3	2	2	2	2	24	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

Changes in water quality due to pollution	Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/rivers and a reduction in watercourse function. Chemical and Thermal Pollution: Potential risk of chemical pollution from storage and handling of chemicals used for panel cleaning or maintenance. Additionally, solar plants with concentrated solar power (CSP) technology may release heated water into nearby water bodies, leading to thermal pollution and potential impacts on aquatic organisms	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Loss of aquatic biota	Loss of instream habitat, deposition of wind-blown sand, loss of fringing vegetation and erosion, alteration in base flow, natural fire regimes and subsequent loss of non-marginal and marginal vegetation. Increase in invasive species due to disturbance. Change in water quality. Changes in flow. Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Loss and disturbance of watercourse habitat and fringe vegetation	Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

4.1.3 Potential Impacts during the Operational Phase

During the operational phase the of the PV area and the powerline as well as associated infrastructure as it can potentially have an impact on the watercourses / aquatic ecosystems. The major mitigation measure for the operational phase will still be related to move the pylon and PV infrastructure associated structures currently known to be located in a wetland or within the wetland buffer layout. The impacts expected in the operational phase are expected to be similar to the construction phase but not as severe in most instances.

The impacts are limited to:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

Alteration in flow regime is possible during the operational phase due to the increase in hardened surfaces. Changes in sediment is still likely especially in the early phase

The impact assessment was conducted using the impact assessment methodology provided as described in Appendix D and below in Table 26.

Table 26: Potential Impacts Associated with the Operational Phase of the proposed Roos PV and Powerline

Environmental Parameter	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	Environmental Significance Before Mitigation									Environmental Significance After Mitigation								
		E	P	R	L	D	I / M	TOTA	STAT	S	E	P	R	L	D	I / M	TOTA	STAT	S
Changes in sediment entering and exiting the system.	Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns. Construction and maintenance activities will result in earthworks and soil disturbance as well as the disturbance of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourses and pan and increase the turbidity of the water. Possible sources of the impacts include: • Earthwork activities during construction • Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil. • Disturbance of soil surface • Disturbance of slopes through creation of roads and tracks adjacent to the watercourse • Erosion (e.g. gully formation, bank collapse)	3	2	2	2	2	2	22	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

Changes in water flow regime	Changes to hydrological function at a landscape level which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes). The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flows (e.g. too little/too much water in terms of characteristics and requirements of system). Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal). The sources of this impact include the compaction of soil, the removal of vegetation, surface water redirection, changes to watercourse morphology or input of high energy surface water which could occur during construction and operation of the solar plant	3	2	2	2	2	2	22	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Introduction and spread of alien vegetation	The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users.	3	2	2	2	2	2	22	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

Changes in water quality due to pollution	Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/rivers and a reduction in watercourse function. Chemical and Thermal Pollution: Potential risk of chemical pollution from storage and handling of chemicals used for panel cleaning or maintenance. Additionally, solar plants with concentrated solar power (CSP) technology may release heated water into nearby water bodies, leading to thermal pollution and potential impacts on aquatic organisms	3	2	2	2	2	2	22	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Loss of aquatic biota	Loss of instream habitat, deposition of wind-blown sand, loss of fringing vegetation and erosion, alteration in base flow, natural fire regimes and subsequent loss of non-marginal and marginal vegetation. Increase in invasive species due to disturbance. Change in water quality. Changes in flow. Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation	3	2	2	2	2	2	22	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Loss and disturbance of watercourse habitat and fringe vegetation	Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation	3	2	2	2	2	2	22	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

4.1.4 Potential Impacts during the Decommissioning Phase

The proposed PV area and Gridline and substation will have a lifespan of have a life expectancy of more than 25 years. During the decommissioning phase it is envisaged that all infrastructure will be removed. Should the mitigation measure of the removal of the layout from wetlands be followed, the impact will also be less during decommissioning. The major mitigation measure for the operational phase will still be related to remove the structures from any wetlands or buffer areas. The impacts expected in the decommissioning phase are expected to be similar to the construction phase.

The impacts are limited to:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

The impact assessment was conducted using the impact assessment methodology provided as described in Appendix D and below in Table 27.

Table 27: Potential Impacts Associated with the Decommissioning Phase of the proposed Roos PV and Powerline Development

Environmental Parameter	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	Environmental Significance Before Mitigation									Environmental Significance After Mitigation								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S	E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Changes in sediment entering and exiting the system.	Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns. Construction and maintenance activities will result in earthworks and soil disturbance as well as the disturbance of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourses and pan and increase the turbidity of the water. Possible sources of the impacts include:	3	3	2	2	2	2	24	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

	• Earthwork activities during construction • Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil. • Disturbance of soil surface • Disturbance of slopes through creation of roads and tracks adjacent to the watercourse • Erosion (e.g. gully formation, bank collapse)																		
Changes in water flow regime	Changes to hydrological function at a landscape level which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes). The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flows (e.g. too little/too much water in terms of characteristics and requirements of system). Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal). The sources of this impact include the compaction of soil, the removal of vegetation, surface water redirection, changes to watercourse morphology or input of high	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

	energy surface water which could occur during construction and operation of the solar plant																		
Introduction and spread of alien vegetation	The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users.	3	3	2	2	2	2	24	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Changes in water quality due to pollution	Decommissioning activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/rivers and a reduction in watercourse function.	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Loss of aquatic biota	Loss of instream habitat, deposition of wind-blown sand, loss of fringing vegetation and erosion, alteration in base flow, natural fire regimes and subsequent loss of non-marginal and marginal vegetation. Increase in invasive species due to disturbance. Change in water quality. Changes in flow. Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact
Loss and disturbance of watercourse	Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as	3	3	3	2	2	2	26	-	Medium impact	2	2	2	2	2	2	20	-	Low impact

habitat and fringe vegetation	changes in management, fire regime and habitat fragmentation																		

4.1.5 Mitigation Measures

The following mitigation measures as well as best practice measures and other specialist measures should be implemented to reduce potential risk (Table 28)

Table 28: Description and key monitoring recommendations for each mitigation measure for the design, construction, operation and decommissioning phase or the Solar Facility, Powerline and Substation and other associated infrastructure.

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
Impacts to hydrological function at a landscape level	• During the detailed design phase, the footprint and design of structures (Including Pylons and Solar Structures) should aim to have the least impact on habitat quality and hydrology of the watercourse. • Design should take into account soil properties, slopes and runoff energy. • Where possible Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas • Project engineers should compile a method statement, outlining the construction methodologies. The required mitigation measures to limit the impacts on the watercourse and associated buffers should be contained within the method statement. The method statement must be approved by the ECO and be available on site for reference purposes	Developer and Contractor Environmental Control Officer	Avoid watercourse and buffer area	Best practice, limiting harm as per National Environmental Management Act No. 107 of 1998 Ensure EMPr is adhered to	Design
	• During the construction phase, best practice mitigation measures should be implemented. • Excavated materials should not be contaminated and it should be ensured that the minimum surface area is taken up • Where possible Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas • Where development activities are located upslope from wetlands, effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP.				Construction

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• Do not permit vehicular or pedestrian access into natural areas or into seasonally wet areas during and immediately after rainy periods, until such a time that the soil has dried out • Rehabilitation plans must be submitted and approved for rehabilitation of damage during the construction phase and that plan must be implemented immediately upon completion of construction. • Effective control of stormwater from access roads should be undertaken • Effective culverts should be incorporated into the design of access roads. • Where development activities are located upslope from wetlands, effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP.		Construction Monitoring and Preventative Measures		Operational
	• Effective control of stormwater from access roads should be undertaken • Implement Best Practice with regards to concrete mixing on site and control of waste and pollution • Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Do not increase hardened surfaces and compaction of the soils after the removal of the solar panels and related infrastructure. • Rehabilitation of exposed soil surfaces should commence as soon as practical after completion of removal of removal of the solar panels and related infrastructure. • Culverts must remain in place and must not be removed if the given road is not removed during the decommissioning phase. • Vehicle movement should be restricted to designated decommissioning areas to prevent the increase in hardened surfaces and subsequent increase in runoff.		Monitoring		Decommissioning

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
Sedimentation	• Consider the various methods and equipment available and select whichever method(s) that will have the least impact on watercourses. • Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover.	Developer and Contractor Environmental Control Officer	Avoid watercourse and buffer area	Best practice, limiting harm as per National Environmental Management Act No. 107 of 1998 Ensure EMPr is adhered to	Design
	• Sediment traps should be installed • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area. • During the construction phase measures must be put in place to control the flow of excess water so that it does not impact on the adjacent surface vegetation. • Sediment control should be effective and not allow any release of sediment pollution downstream. This should be audited on a monthly basis to demonstrate compliance with upstream conditions. • Any excavated soil/ should not be stored close to watercourses. Mixture of the lower and upper layers of the excavated soil should be kept to a minimum, so as for later usage as backfill material. • Protect all areas susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas. • Monitoring should be done to ensure that sediment pollution is timeously addressed		Construction Monitoring and Preventative Measures		Construction
	• Sediment control should be effective and not allow any release of sediment pollution downstream. This should be audited on a monthly basis to demonstrate compliance with upstream conditions. • Monitoring should be done to ensure that sediment pollution is timeously addressed		Monitoring		Operational
	• Retain vegetation and soil in position for as long as possible, removing it immediately ahead of earthworks in that area. • Sediment traps should be installed • Sediment control should be effective and not allow any release of sediment pollution downstream. This should be audited on a monthly basis to demonstrate compliance with upstream conditions. • Any excavated soil/ should not be stored close to watercourses. Mixture of the lower and upper layers of the excavated soil should be kept to a minimum, so as for later usage as backfill material.		Monitoring and Preventative Measures and Rehabilitation		Decommissioning

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• Monitoring should be done to ensure that sediment pollution is timeously addressed • Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Vehicle movement should be restricted to the minimum that is required for decommissioning. Unnecessary movement of vehicles will increase the degradation of paths and dirt roads leading to increased erosion risk. • Progressive rehabilitation must occur. Rehabilitation has to be take place as soon as decommissioning commences to prevent soil erosion. • Monitoring should be done to ensure that sediment pollution is timeously dressed.				
Introduction and spread of alien vegetation.	• Undertake an Alien Plant Control Plan which specifies actions and measurable targets	Developer and Contractor Environmental Control Officer	Preventative	Best practice, limiting harm as per National Environmental Management Act No. 107 of 1998 Ensure EMPr is adhered to	Design
	• Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Pan • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area and returning it where possible afterwards.		Construction Monitoring and Preventative Measures		Construction
	• Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Pan • Undertake an Alien Plant Control Plan which specifies actions and measurable targets • Rehabilitate or revegetate disturbed areas • Acquire the necessary equipment for removal and control • Planned sequence of areas to be cleared of invasive plants • A register of the methods used, dates undertaken, as well as herbicides and dosage used must be kept and available on site. The register must also include incidents of poisoning or spillage		Monitoring		Operational

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• Ensure that contractors can identify the relevant plants and are aware of the removal procedures • Construction equipment must be cleaned prior to site access. This will prevent alien invasive seed from other sites to spread into disturbed soils • Manual removal methods are preferred to chemical control • Rehabilitate or revegetate disturbed areas.				
	• Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Pan • Undertake an Alien Plant Control Plan which specifies actions and measurable targets • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of decommissioning /earthworks in that area and returning it where possible afterwards. • Rehabilitation must occur concurrently with decommissioning. • The mixture of vegetation seed must be used during rehabilitation. The mix must include: Annual and perennial species, pioneer species, species which are indigenous to the area to ensure there is no ecological imbalance in the area.		Monitoring and Preventative Measures and Rehabilitation		Decommissioning
Loss and disturbance of watercourse habitat and fringe vegetation.	• The development footprint should remain outside the delineated watercourses areas and buffer zones. Where this is unavoidable a Watercourse offset plan and/or a Water use licence should be developed and authorised. This should be discussed with the relevant authorities, and if deemed necessary an offset plan should be developed and approved. • Where possible Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas • Implement an Alien Plant Control Plan • Conduct thorough vegetation surveys and assessments before construction to identify sensitive habitats, watercourses, and fringe vegetation. Use this information to inform design decisions and avoid or minimise impacts to these areas. • Carefully plan the solar plant layout to avoid or minimize the disturbance of watercourses and sensitive fringe vegetation.	Developer and Contractor Environmental Control Officer	Preventative	Best practice, limiting harm as per National Environmental Management Act No. 107 of 1998 Ensure EMPr is adhered to	Design

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• Monitor the establishment of alien invasive species within the areas affected by the construction and take immediate corrective action where invasive species are observed to establish. • Develop a restoration and replanting plan to mitigate the loss of habitat and fringe vegetation. This may involve revegetation with native plant species, especially in areas where vegetation has been removed or disturbed during construction.		Construction Monitoring and Preventative Measures		Construction
	• Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. • Implement sediment and erosion control measures to prevent sediment runoff from construction activities into watercourses. This can include sediment barriers, sediment ponds, and erosion control blankets to protect the water quality and vegetation along the watercourses • Establish a monitoring program to assess the effectiveness of mitigation measures and monitor the condition of watercourses and fringe vegetation during and after construction		Monitoring		Operational
	• Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. • Rehabilitate any impacted areas • Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Vehicle movement should be restricted to the minimum that is required for decommissioning. • Rehabilitation of decommissioned areas must commence concurrently with decommissioning. • Monitor the establishment of alien invasive species within the areas affected by the decommissioning and take immediate corrective action where invasive species are observed to establish. • Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed		Monitoring and Preventative Measures and Rehabilitation		Decommissioning
Changes in water quality	• Where possible Locate the infrastructure outside the calculated buffer zone. Where designs do not allow for changes a watercourse offset plan and/or a Water use licence should be developed and authorised. This should be discussed with the relevant authorities, and if deemed necessary an offset plan should be developed and approved. • Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone	Developer and Contractor Environmental Control Officer	Preventative	Best practice, limiting harm as per National Environmental Management Act No. 107 of 1998	Design

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• The development footprint must be fenced off from the watercourses and where possible for the non-perennial watercourses and no related impacts may be allowed into the watercourse e.g. water runoff from cleaning of equipment, vehicle access etc.			Ensure EMPr is adhered to	
	• Implementation of appropriate stormwater management around the excavation to prevent the ingress of run-off into the excavation and to prevent contaminated runoff into the watercourse. • Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases. • Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone • Implement stormwater management practices to control and treat runoff from the solar plant site. This can involve the use of retention ponds, biofiltration systems, or constructed wetlands to capture and treat stormwater runoff before it enters water bodies. • Establish a robust water quality monitoring program to regularly assess the condition of water bodies near the solar plant. This includes monitoring key parameters such as pH, turbidity, dissolved oxygen, and levels of contaminants. Promptly report any deviations or exceedances from established water quality standards. • Control of waste discharges and do not allow dirty water from operational activities to enter the watercourse. • Develop norms and standards for the treatment of spills such as oil or hydraulic fluid. Ensure that the required equipment is available on hand to contain any spills. • Appoint a reliable contractor for the removal of refuse during the construction phase.		Construction Monitoring and Preventative Measures		Construction
	• Independent water quality analyses should be undertaken annually, or as specified by an aquatic specialist, to demonstrate and audit compliance of effective pollution control measures • A detailed rehabilitation plan should be drawn up with the input from a water quality, soil contamination assessment and ecologist should any spills occur.		Monitoring		Operational

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• It should be ensured that regular maintenance takes place to prevent failure of any infrastructure associated with the proposed decommissioning • Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases. • Provide training to personnel involved in the solar plant's operation and maintenance on best practices for water quality protection. Promote awareness and understanding of the potential impacts of the solar plant on water quality and the importance of adhering to mitigation measures • Ensure that no decommissioning activities impact on the watercourse or buffer area. This includes edge effects.				
	• A detailed rehabilitation plan should be drawn up with the input from a water quality assessment		Monitoring and Preventative Measures and Rehabilitation		Decommissioning
Loss of aquatic biota	• Avoid unnecessary aquatic ecosystem crossing - limit work within the stream, river or wetland. The use of single access points for crossings. • The Structure currently located either within a wetland or within the buffer of a wetland should be moved. • Other than approved and authorised structure, no other development or maintenance infrastructure is allowed within the delineated watercourse or its associated buffer zones. • Mark all areas which don't form part of the proposed development within the watercourse as no-go areas. • Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.	Developer and Contractor Environmental Control Officer	Preventative	Best practice, limiting harm as per National Environmental Management Act No. 107 of 1998 Ensure EMPr is adhered to	Design
	• Ensure that no unnecessary vegetation is removed during the construction phase • Avoid unnecessary aquatic ecosystem crossing - limit work within the stream, river or wetland. The use of single access points for crossings.		Construction Monitoring and Preventative Measures		Construction

Aspect/Impact	Impact Management Actions	Responsibility	Method	Impact Management Outcomes	Time period for implementation
	• Implement weed control in aquatic ecosystem and buffer zones. • Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance of the proposed infrastructure and take immediate corrective action where invasive species are observed to establish. • Identify and protect important habitats for aquatic biota, such as wetlands, rivers, and streams, within and near the solar plant site. Implement habitat restoration projects to enhance and create suitable habitats for aquatic organisms. • Implement measures to maintain and improve water quality, such as implementing erosion control practices, managing stormwater runoff, and reducing the discharge of pollutants into water bodies. Regular monitoring of water quality parameters should be conducted to ensure compliance with standards and prompt identification of any issues		Monitoring		Operational
	• Monitor the establishment of alien invasive species within the areas affected during decommissioning		Monitoring and Preventative Measures and Rehabilitation		Decommissioning

5 DWS (2016) Risk Assessment

In addition to the impact ratings presented above, a risk assessment was completed to establish and quantify the ‘uncertainty of the outcome’ associated with a particular section 21(c) or (i) water use as specified in DWS (2016). An extract from the Risk Matrix spreadsheet presented in Table 29 and Table 30 below shows the risk score of the operational phase of the Solar structures and the Gridline and Substations and indicates scores which assumes that effective mitigation is implemented, as well as placing no structures within the wetland areas or associated buffer zones. The lower risk classes are defined as follows:

Low Risk category: The risk and impact on watercourses are acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.

Moderate Risk category: Activities that are notable and require mitigation measures on a higher level, which cost more and require specialist input. Activities which fall within this category should be authorised through a Water Use License.

Table 29: The severity score derived from the DWS (2016) risk assessment matrix for the Roos PV Development

RISK MATRIX (Based on DWS 2016 publication: Section 21 c and I water use Risk Assessment Protocol): Proposed Roos Solar Energy Facility and associated Infrastructure

NAME and REGISTRATION No of SACNASP Professional member: R bezuidenhoudt SACNASP # 008867 Rudi Bezuidenhoudt

				Severity																		
Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph+Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE
C	Construction phase of the photovoltaic development	Preparation for construction, including vegetation clearing,	Changing the water flow characteristics, removal of vegetation, soil compaction, sedimentation and erosion of downstream areas	1	0	2	1	1	1	1	3	1	1	0	2	4	12	L	80%	• Implement best practice and mitigation measures as specified in the rehabilitation plan • Standard best practice mitigation measures should be implemented during the construction phase • Implement effective rehabilitation to reverse construction related impacts	N	**Not expected to decrease scores**
		Earthwork activities		1	0	2	1	1	1	1	3	2	2	0	2	6	18	L	80%		N	
		Storm Water Management		2	2	1	2	2	2	2	6	2	1	5	2	10	58	L	80%		N	
O	Operation of the photovoltaic plant	Day to day activities including stormwater managament	Possible permanent changes to the hydrology of the watercourse and unintended downstream effects such as erosion and sedimentation	2	1	1	1	1	2	2	5	2	1	5	2	10	53	L	80%	• Design of structures should aim to have the least impact on habitat quality and hydrology of the river and should include attenuation structures to contribute to regional flood control and rehabilitation • Maintain sewage ingrastructure to ensure that leaks do not enter the watercourse • Control of alien invasive plants should form part of the maintenance plan • Install litter traps	N	Not expected to decrease scores
		Maintenance of infrastructure		1	1	1	1	1	1	1	3	1	1	5	2	9	27	L	80%		N	

Table 30: The severity score derived from the DWS (2016) risk assessment matrix for the Proposed Powerline on the study site.

RISK MATRIX (Based on DWS 2016 publication: Section 21 c and I water use Risk Assessment Protocol): Proposed Powerlines - Roos PV

NAME and REGISTRATION No of SACNASP Professional member: R Bezuidenhoudt SACNASP # 008867 Rudi Bezuidenhoudt

Phases	Activity	Aspect	Impact	Severity: Flow Regime	Severity: Physico & Chemical (Water Quality)	Severity: Habitat (Geomorph+Vegetation)	Severity: Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes	
C	Construction of overhead poweline	Installation/upgrade of foundation for pylon infrastructure	Loss of vegetation cover, compaction of soils, sedimentation, pollution and alien invasive plant establishment	3	2	2	1	2	1	2	5	1	2	5	2	**10**	**50**	L	**80%**	• Designs should take into account soil properties, slopes and runoff energy with the aim of having a neutral effect on the regional hydrograph. • Construction activities should not be conducted in wet conditions • Minimise the footprint of activities in the wetland and buffer zone by preventing unnecessary access of vehicles and personnel • Implement Eskom best practice policies • Implement effective rehabilitation to reverse construction related impacts	N	Not expected to decrease scores
		Construction of new pylon structures		3	2	2	1	2	1	2	5	1	2	5	2	**10**	**50**	L	**80%**		N	
		Movement of equipment and personell during stringing		2	2	1	1	2	1	2	4.5	1	2	5	2	**10**	**45**	L	**80%**		N	
		Upgrade of access roads		1	2	1	1	1	1	2	4.3	1	2	5	2	**10**	**42.5**	L	**80%**			
O	Operation of the new powerline	Long term presence of upgraded infrastructure in the wetland	Permanent changes to runoff characteristics in the watercourse including the cumulative impact to downstream watercourses	1	2	1	1	1	1	2	4.2	2	2	5	2	**11**	**46.2**	L	**80%**	• Control of alien invasive plants should form part of the maintenance plan • Maintenance activities should follow best practice • Monitoring for downstream degradation and effective rehabilitation where necessary	N	Not expected to decrease scores
		Ad hoc repair and maintenance to structures		1	1	1	1	1	1	1	3	1	2	5	2	**10**	**30**	L	**80%**		N	

6 CONCLUSION

Two wetland types were recorded on the study site. The watercourses are further classified into the following according to the classification guidelines (Ollis *et al,* 2013):

- Channelled Valley Bottom Wetland
- 2 Hillslope Seepage Wetlands

The proposed solar infrastructure and substations are located outside the wetlands and the associated buffer zones. Although the exact footprint positions of the pylons were not known during the writing of this report it is assumed that it will span the wetlands and buffer zones with no pylons located in these areas. The proposed substations are not located on any wetland or wetland buffer zone. Prior to the proposed mitigation measures most impacts rated moderate and post mitigation they ranked low in both the construction and operational phase

The important factors relevant to Environmental Authorisation for the project are summarised in Table 31 below:

Table 31: Summary of the findings.

	Quaternary Catchment and WMA areas		Important Rivers within 500 m
	B41A - WMA #2: Olifants Major: Rivers include the Elands, Steelpoort, Olifants, Wilge and Letaba Rivers.		One of the seepage wetlands were not directly connected to a nearby river. The remainder of the wetlands flow north into the Grootspruit which flows into the Steelpoort River.
Classification (SANBI, 2013)	**Channelled Valley Bottom Wetland**	**Seepage Wetland 1**	**Seepage Wetland 2**
EC Scores (PES - WetHealth Version 2 (Macfarlane *et al*., 2020)	**B - Largely Natural with few modifications.**	**B - Largely Natural with few modifications.**	**Moderately Modified.**
WetEcoServices (Kotze *et al*., 2020) –	3.5 – **Very High** category.	**2.5 - Moderately High.**	
EIS	3.5 – **Very High** category	**2.5 - Moderately High.**	
REC (Rountree *et al*, 2013)	**REC of A.**	**REC of A.** a	**REC of A/B.**

Calculated Buffer Zone (Macfarlane *et al,* 2015)	**17 m**	**18m**		
In situ Water Quality	**In situ water quality:** The in-situ water quality results showed somewhat elevated TDS and EC- indicative of possibly the geology of the area and or cultivation soil amelioration impacts. The pH is circumneutral with the temperature indicative of late summer.			
Instream Habitat assessment:	**Instream habitat:** The habitat suitability score of the sample sites were calculated to B for sample site A and B and A for sample site C. This indicates the sample sites to be sufficient for supporting diverse aquatic macroinvertebrates.			
Aquatic macroinvertebrate assemblages:	Aquatic macroinvertebrate assemblages: Overall, the biomonitoring assessments based on the SASS scores of 94, 73, and 65 for the three sites indicate varying levels of water quality and biological integrity. While the first site shows good water quality and healthy ecosystem conditions, the second and third sites may require further investigation to identify any potential impacts and implement appropriate management measures to protect and restore the aquatic ecosystems. Regular biomonitoring assessments and ongoing monitoring efforts are essential for tracking changes in water quality and ecosystem health over time and guiding effective management decisions for the conservation and restoration of aquatic ecosystems. Biomonitoring assessments based on the average SASS scores per taxon of 5.5, 4.9, and 5.0 for the three sites indicate varying levels of water quality and biological integrity. While the first site shows relatively good water quality and healthy ecosystem conditions, the second and third sites may require further investigation to identify any potential impacts and implement appropriate management measures to protect and restore the aquatic ecosystems. Regular biomonitoring assessments, along with other complementary data, are essential for tracking changes in water quality and ecosystem health over time and guiding effective management decisions for the conservation and restoration of aquatic ecosystems.			
NEMA 2014 Impact Assessment for the Roos PV	Changes to flow dynamics	Construction	M	L
		Operational	M	L
	Sedimentation	Construction	M	L
		Operational	M	L
	Establishment of alien plants	Construction	M	L
		Operational	M	L
	Loss of wetland habitat	Construction	M	L
		Operational	M	L
	Pollution of watercourses	Construction	M	L
		Operational	M	L

DWS 2016 Risk Assessment	• Structure currently located within wetlands and buffer zones should not be included in the final layout and moved. • Designs should consider regional hydrological dynamics. • Have a contingency plan ready for potential spills from the pump house. • A temporary fence or demarcation must be erected around No-Go Areas outside the proposed works area prior to any construction taking place as part of the contractor planning phase when compiling work method statements to prevent access to the adjacent portions of the watercourse. • Effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP. High energy stormwater input from the site into the watercourses should be prevented at all cost. • Steps/ weirs to be included to facilitate species movement- migration functionality can be improved. • Stabilise erosion where required.
Does the specialist support the development?	Yes, given that the structures remain outside of the wetlands and associated buffer zones. The risk scores fall in the Low category.

7 REFERENCES

Department of Water Affairs (2008): Updated Manual for the Identification and Delineation of Wetlands and Riparian areas.

Department of Water Affairs (2010). National Water Act, 1998 (Act No 36 of 1998) S21(c) & (i) Water Uses. Version: February 2010. Training Manual.

Department of Water Affairs and Forestry (1999). Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems Version 1.0. Pretoria

Department of Water Affairs and Forestry (2008). Updated Manual for the identification and delineation of wetlands and riparian areas. Department of Water affairs and Forestry. Pretoria. South Africa Second Edition. September 2008.

Department of Water Affairs and Sanitation (2015) Risk-based Water Use Authorisation Approach and Delegation Protocol for Section 21(c) and (i), Edition 02

Ewart-Smith J., Ollis D., Day J. and Malan H. (2006). National Wetland Inventory: Development of a Wetland Classification System for South Africa. Water Research Council project number K8/652

Kleynhans, C.J. (1999): A procedure for the determination of the determination of the ecological reserve for the purpose of the national water balance model for South African Rivers. Institute for Water Quality Studies Department of Water Affairs and Forestry, Pretoria.

Kotze D C, (1999): A system for supporting wetland management decisions. Ph.D. thesis. School of Applied Environmental Sciences, University of Natal, Pietermaritzburg.

Kotze D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. and Collins, N.B. (2005). WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands

Macfarlane D.M., Kotze D.C., Ellery W.N., Walters D, Koopman V, Goodman P and Goge C. (2008). WET-Health: A technique for rapidly assessing wetland health. Water Research Commission, Pretoria. WRC Rport TT340/08 February 2008

Macfarlane D.M., Teixeira-Leite A., Goodman P., Bate G and Colvin C. (2010) Draft Report on the Development of a Method and Model for Buffer Zone Determination. Water Research Commission project K5/1789. The Institute of Natural Resources and its Associates

MBONA N, JOB N, SMITH J, NEL J, HOLNESS S, MEMANI S and DINI J (2015) Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands. WRC Report No. TT 614/14. Water Research Commission, Pretoria

Mucina L., & Rutherford M. C. (2006). Vegetation Map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. South African National Biodiversity Institute., Pretoria.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. & Nienaber, S. 2011. Technical

Report for the Freshwater Ecosystem Priority Areas Project. WRC Report No. 1801/2/11. Water Research Commission, Pretoria.

Schultze R.E. (1997). South African Atlas of Agrohydrology and Climatology. Water Research Commission, Pretoria, Report TT82/96

APPENDIX A: Requirements for Aquatic Biodiversity Assessments

The NEMA regulations of 2014 (as amended) specify required information to be included in specialist reports. Table 32 presents a summary of these requirements following GNR982 as amended by GN326. In March 2020, the Department of Environmental Affairs issued General Notice 320 set out requirements of the EIA Screening Tool Protocols for the Assessment and Reporting of Environmental Themes including Aquatic Biodiversity. These specifications overlap somewhat with the 2014 EIA regulations as amended (GN 982 as amended by GN326). Table 32 presents a summary of the requirements of this protocol with notes on sections of the report applicable to each aspect.

Table 32: Legislative report requirements GNR982

GNR982 as amended by GN326	Report Section
(1) A specialist report prepared in terms of these Regulations must contain—	
(a) details of—	
(i) the specialist who prepared the report; and	Page 4
(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	APPENDIX C: Abbreviated CVs of participating specialists
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page 2
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 1.6
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 4.1.1
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 1.1
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	APPENDIX B: Detailed methodology
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 3
(g) an identification of any areas to be avoided, including buffers;	Section 3

(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 11
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.3
j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 3
(k) any mitigation measures for inclusion in the EMPr;	Section 4.1.1
(l) any conditions for inclusion in the environmental authorisation;	Section 4.1.1
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 4.1.1
(n) a reasoned opinion—	
(i) whether the proposed activity, activities or portions thereof should be authorised;	Section 6
(iA) regarding the acceptability of the proposed activity or activities; and	Section 6
(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 6
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not Applicable
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not Applicable
(q) any other information requested by the competent authority.	Not Applicable
(2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Not Applicable

APPENDIX B: Detailed methodology

The delineation method documented by the Department of Water affairs and Forestry in their document "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2009) as well as the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al,* 2013) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held Garmin Montana 650 was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary watercourse boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey.

Wetland and Riparian Delineation

Wetlands are delineated based on scientifically sound methods, and utilizes a tool from the DWS 'A practical field procedure for identification and delineation of wetlands and riparian areas' (DWAF, 2005) as well as the "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008). The delineation of the watercourses presented in this report is based on both desktop delineation and groundtruthing.

<u>Desktop Delineation</u>

A desktop assessment was conducted with wetland and riparian units potentially affected by the proposed activities identified using a range of tools, including:

- 1: 50 000 topographical maps;
- Recent, relevant aerial and satellite imagery, including Google Earth;
- NFEPA wetlands and Rivers (http://bgisviewer.sanbi.org/)
- Municipal and DWS spatial datasets.

All areas suspected of being wetland and riparian habitat based on the visual signatures on the digital base maps were mapped using google earth.

<u>Ground Truthing</u>

Field investigations confirmed fine-scale wetland and riparian boundaries.

<u>Wetland Indicators</u>

Wetlands were identified based on one or more of the following characteristic attributes (DWAF, 2005) (Figure 19):

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and

- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

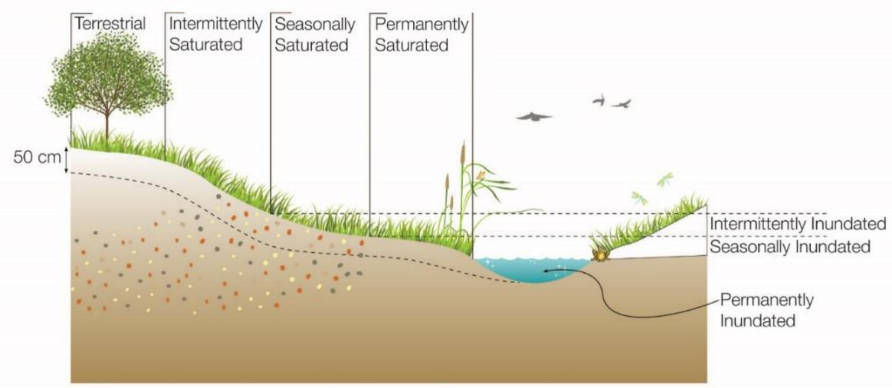


Figure 18: Typical cross section of a wetland (Ollis, 2013)

<u>**The Terrain Unit Indicator**</u>

The terrain unit indicator is an important guide for identifying the parts of the landscape where wetlands might possibly occur. Some wetlands occur on slopes higher up in the catchment where groundwater discharge is taking place through seeps. An area with soil wetness and/or vegetation indicators, but not displaying any of the topographical indicators should therefore not be excluded from being classified as a wetland. The type of wetland which occurs on a specific topographical area in the landscape is described using the Hydrogeomorphic classification which separates wetlands into 'HGM' units. The classification of Ollis, *et al*. (2013) is used, where wetlands are classified on Level 4 as either Rivers, Floodplain wetlands, Valley-bottom wetlands, Depressions, Seeps, or Flats (Figure 20 and Figure 19).

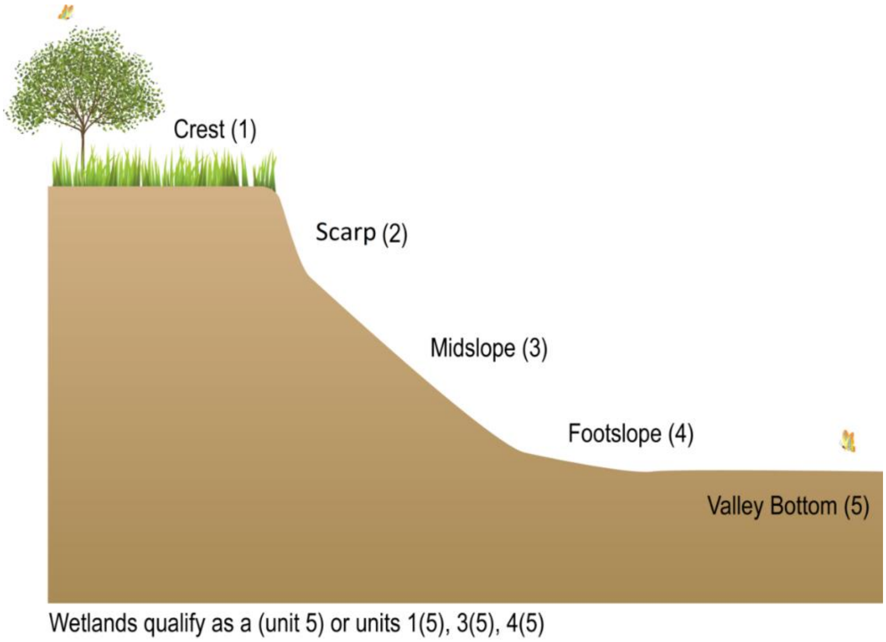


Figure 19. Terrain units (DWAF, 2005).

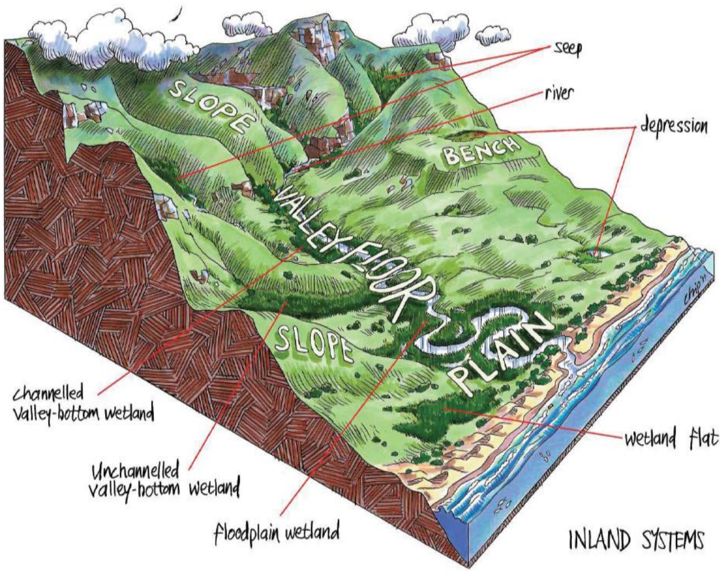


Figure 20: Wetland Units based on hydrogeomorphic types (Ollis *et al.* 2013)

Riparian Indicators

Riparian habitat is classified primarily by identifying riparian vegetation along the edge of the macro stream channel. The macro stream channel is defined as the outer bank of a compound channel and should not be confused with the active river bank. The macro channel bank often represents a dramatic change in the energy with which water passes through the system. Rich alluvial soils deposit nutrients making the riparian area a highly productive zone. This causes a very distinct change in vegetation structure and composition along the edges of the riparian area (DWAF, 2008). The marginal zone includes the area from the water level at low flow, to those features that are hydrologically activated for the greater part of the Year (WRC Report No TT 333/08 April, 2008). The non-marginal zone is the combination of the upper and lower zones (Figure 21).

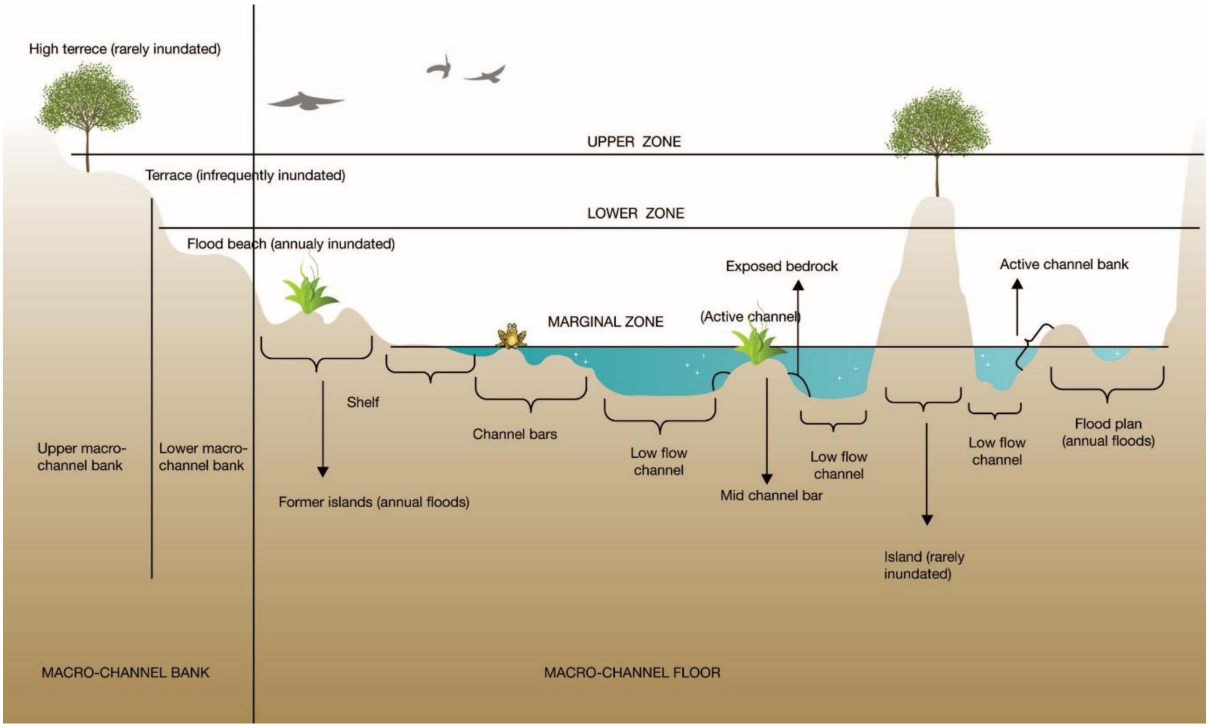


Figure 21: Schematic diagram illustrating an example of where the 3 zones would be placed relative to geomorphic diversity (Kleynhans *et al*, 2007)

Riparian areas can be grouped into different categories based on their inundation period per year. Perennial rivers are rivers with continuous surface water flow, intermittent rivers are rivers where surface flow disappears but some surface flow remains, temporary rivers are rivers where surface flow disappears for most of the channel (Figure 22). Two types of temporary rivers are recognized, namely “ephemeral” rivers that flow for less time than they are dry and support a series of pools in parts of the channel, and “episodic” rivers that only flow in response to extreme rainfall events, usually high in their catchments (Seaman *et al.*, 2010).

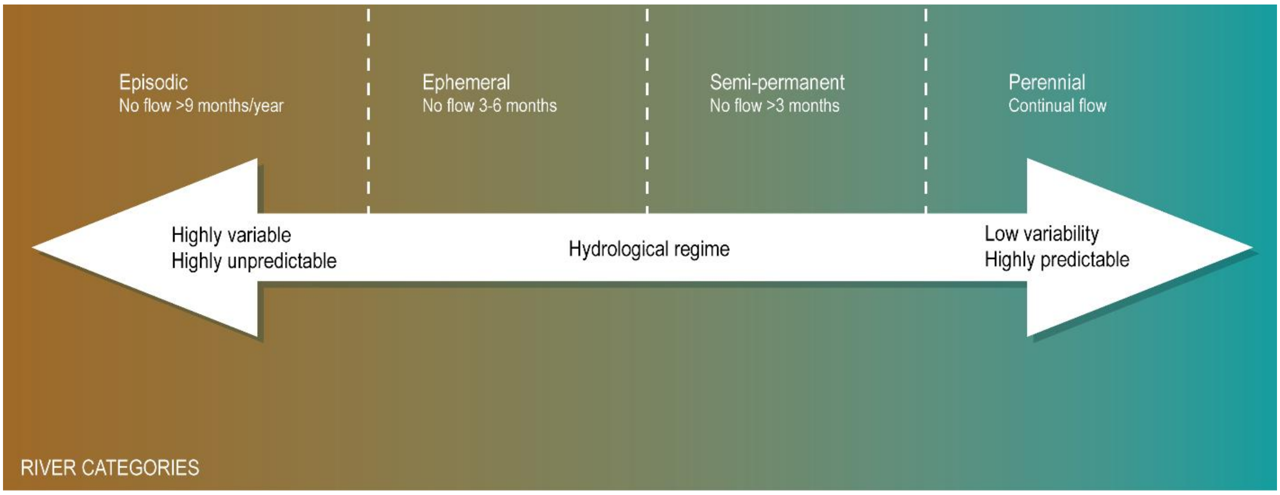


Figure 22: The four categories associated with rivers and the hydrological continuum. Dashed lines indicate that boundaries are not fixed (Seaman *et al*, 2010).

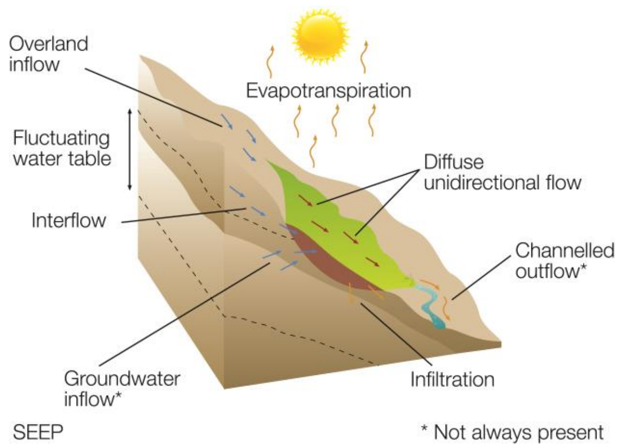
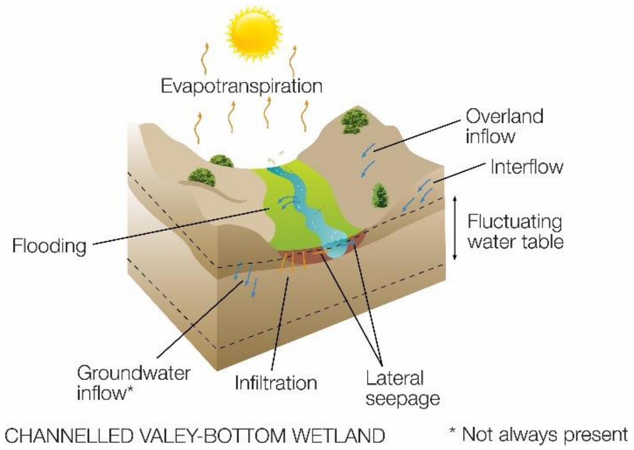
Wetland/Riparian Classification

The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (SANBI, 2013). The current watercourse assessment follows the same approach by classifying watercourses in terms of a functional unit recognised in the classification system proposed in SANBI (2013). HGM units take into consideration factors that determine the nature of water movement into, through and out of the watercuorse system. In general, HGM units encompass three key elements (Kotze *et al.*, 2005):

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

The classification of watercourse areas found within the study site and/or within 500 m of the study site (adapted from Brinson, 1993; Kotze, 1999, Marneweck and Batchelor, 2002 and DWAF, 2005) are as follows (Table 33):

Table 33: Watercourse Types and descriptions

Watercourse Type:	**Description:**
Seepage Wetlands  	Seepage wetlands are the most common type of wetland (in number), but probably also the most overlooked. These wetlands can be located on the mid- and footslopes of hillsides; either as isolated systems or connected to downslope valley bottom weltands. They may also occur fringing depressional pans. Seepages occur where springs are decanting into the soil profile near the surface, causing hydric conditions to develop; or where through flow in the soil profile is forced close to the surface due to impervious layers (such as plinthite layers; or where large outcrops of impervious rock force subsurface water to the surface).
Valley bottom with a channel  	Linear fluvial, net depositional valley bottom surfaces which have a straight channel with flow on a permanent or seasonal basis. Episodic flow is thought to be unlikely in this wetland setting. The straight channel tends to flow parallel with the direction of the valley (i.e. there is no meandering), and no ox-bows or cut-off meanders are present in these wetland systems. The valley floor is, however, a depositional environment such that the channel flows through fluvially-deposited sediment. These systems tend to be found in the upper catchment areas.

Buffer Zones and Regulated Areas

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a watercourse. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is, therefore, often characteristic of transformed catchments. The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land uses / activities planned adjacent to water resources. Although buffer zones can be effective in addressing diffuse source pollution in storm water run-off, they should typically be seen as part of a treatment train designed to address storm water impacts (MacFarlane & Brendin, 2017).

Authorisation from the DWS requires calculation of a site-specific buffer zone (General Notice 267 of 24 March 2017), following Macfarlane *et al* 2015. This Excel-based tool calculates the best suited buffer for each wetland or section of a wetland based on numerous on-site observations. The resulting buffer zone can thus have large differences depending on the current state of the wetland as well as the nature of the proposed development. Developments with a high-risk factor such as mining are likely to have a larger buffer area compared to a residential development with a lower risk factor.

Figure 23 images represent the buffer zone setback for the watercourse types discussed in this report.

It should be noted that the buffer calculation tool does not take into account the effects of climate change or cumulative impacts to floodflows resulting from transformed catchments. Therefore, a conservative approach to the application of buffer zones is encouraged.

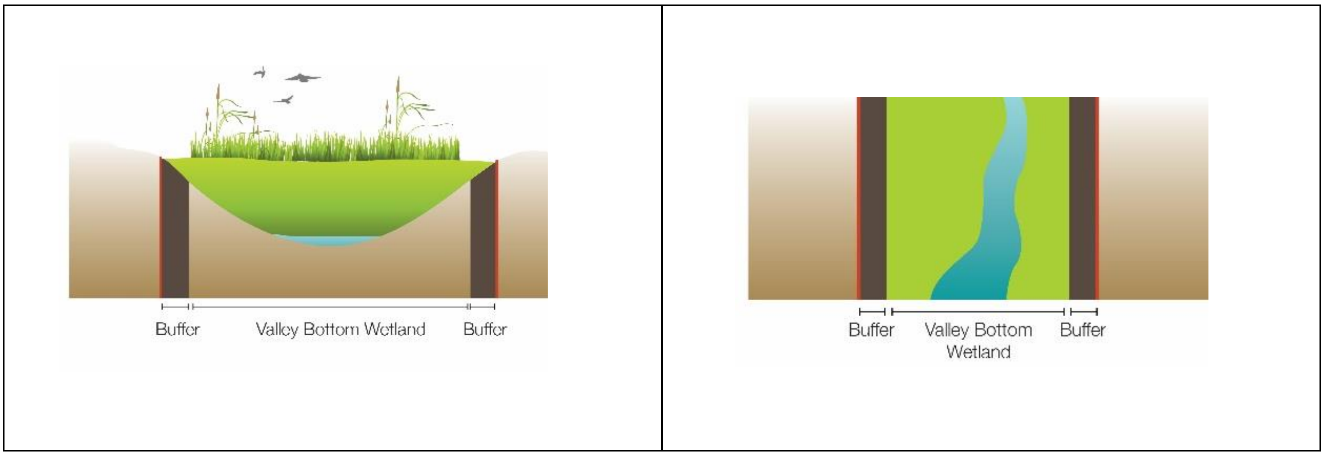


Figure 23: A represent the buffer zone setback for the watercourse discussed in this report

Regulated areas are zones within which authorisation is required. The DWS specify a 500m regulated area around all wetlands and 100m around all riparian zones (unless a fine scale delineation and floodline are available) within which development must be authorised from their department. Development within 32m of the edge of the watercourse triggers the requirement for authorisation under the National Environmental Management Act (NEMA): Environmental Impact Assessment (EIA) Regulations of 2014 (GNR 326) as amended.

It should be noted that the buffer calculation tool does not take into account the effects of climate change or cumulative impacts to floodflows resulting from transformed catchments. Therefore, a conservative approach to the application of buffer zones is encouraged.

Wetland Functionality, Status and Sensitivity

Wetland functionality is defined as a measure of the deviation of wetland structure and function from its natural reference condition. The natural reference condition is based on a theoretical undisturbed state extrapolated from an understanding of undisturbed regional vegetation and hydrological conditions. In the current assessment the hydrological, water quality, geomorphological and vegetation integrity was assessed for the wetland unit associated with the study site, to provide a Present Ecological Status (PES) score (Macfarlane *et al.*, 2020) and an Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020). These impacts are based on evidence observed during the field survey and land use changes visible on aerial imagery including historical images.

The allocations of scores in the functional and integrity assessment are subjective and are thus vulnerable to the interpretation of the specialist. Collection of empirical data is precluded at this level of investigation due to project constraints including time and budget. Water quality values, species richness and abundance indices, surface and groundwater volumes, amongst others, should ideally be used rather than a subjective scoring system such as is presented here.

The functional assessment methodologies presented below take into consideration subjective recorded impacts to determine the scores attributed to each functional Hydrogeomorphic (HGM) wetland unit. The aspect of wetland functionality and integrity that are predominantly addressed include hydrological and geomorphological function (subjective observations) and the integrity of the biodiversity component (mainly based on the theoretical intactness of natural vegetation) as directed by the assessment methodology.

In the current study the wetland was assessed using, WET-Health (Macfarlane *et al.*, 2020), EIS (DWAF, 1999) and WetEcoServices, (Kotze *et al.*, 2020).

Present Ecological Status (PES) – WET-Health

A summary of the four components of the WET-Health (2.0) namely Hydrological; Geomorphological, water quality and Vegetation Health assessment for the wetlands found on site is described in Table 14. For this assessment, WET-Health Version 2.0 was used. This method builds on the WET-Health Version 1.0 (Macfarlane *et al*. 2008) and Wetland-IHI (DWAF 2007) Tool, offering a refined and more robust suite of tools (Macfarlane *et al*. 2020). The WET-Health Version 2 considers four (4) components to assess the PES of wetland ecosystems. Geology, climate and topographic position determines the ecological setting of a wetland. Three (3) core interrelated drivers broadly influence all wetlands, namely Hydrology, Geomorphology and Water Quality (i.e. physico-chemical attributes). Wetland biology, and more specifically vegetation, responds to the changes in these drivers and to the surrounding environment. A level 2 assessment was used for the wetlands recorded on the study site (Table 34).

Table 34: The three levels of assessment to cater for application of the WET-Health Version 2 Tool across different spatial scales and for different purposes (Adapted from Macfarlane *et al*. 2020).

Level of Assessment	Spatial Scale	Description
Level 1A	Desktop-based, low resolution	Entirely desktop-based and only uses pre-existing landcover data. Landcover types within a buffer / “pseudo catchment” around a wetland is used to determine the impacts on the wetland arising from the upslope catchment. Impacts arising from within individual wetlands are inferred from landcover types occurring within desktop-delineated wetlands.
Level 1B	Desktop-based, high resolution	Largely desktop-based using pre-existing landcover data but makes a few finer distinctions than Level 1A in terms of landcover types and usually requires "heads-up" interpretation of the best available aerial imagery in order to do so. Upslope catchment of each wetland can be individually delineated at this level, and landcover in this area is used as a proxy of the impacts on a wetland arising from its upslope catchment. Impacts arising from within individual wetlands are inferred from landcover types occurring within desktop-delineated wetlands. In terms of water quality PES, the option is provided to factor in point-source pollution inputs in a Level 1B assessment.

Level of Assessment	Spatial Scale	Description
Level 2	Rapid field-based assessment	Strongly informed by desktop landcover mapping; refined by assessing a range of catchment and wetland-related indicators known to affect wetland condition. Impacts arising from the upslope catchment of a wetland are inferred from landcover mapping but are refined based on additional information. Landcover types occurring within the wetland are used as the starting point for assessing human impacts arising from within the wetland but are refined through the assessment of additional indicators as part of a rapid field-based assessment. This involves sub-dividing the wetland into relatively homogenous "disturbance units" and assessing a suite of site-based wetland questions that provide a more direct assessment of change. Determination of water quality PES in a Level 2 assessment requires the identification and characterisation of point-source pollution inputs.

A summary of the change class, description and symbols used to evaluate wetland health are summarised in Table 35. The trajectory of change is summarised in Table 36.

Table 35: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al.*, 2020)

Ecological Category	Description	Impact Score	PES Score (%)
A	Unmodified, natural	0 to 0.9	90-00
B	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	80-89
C	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	60-79
D	Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4.0 to 5.9	40-59
E	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	20-39
F	Critical Modification. The modifications have reached a critical level and the ecosystem processes have been modified	8.0 to 10	0-19

completely with an almost complete loss of natural habitat and biota.

Table 36: Trajectory class, change scores and symbols used to evaluate Trajectory of Change to wetland health (Macfarlane *et al*, 2007)

Change Class	Description	Symbol
Improve	Condition is likely to improve over the over the next 5 years	(↑)
Remain stable	Condition is likely to remain stable over the next 5 years	(→)
Slowly deteriorate	Condition is likely to deteriorate slightly over the next 5 years	(↓)
Rapidly deteriorate	Substantial deterioration of condition is expected over the next 5 years	(↓↓)

Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both PES and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.

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

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance;
- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors;
- Basic human needs including subsistence farming and water use.

The Ecological Importance and Sensitivity of the wetlands is represented are described in the results section. Explanations of the scores are given in Table 37

Table 37: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	**Rating**
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers.	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers.	>1 and <=2
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers.	>0 and <=1

Ecosystem Services (ES)

The Department of Water and Sanitation authorisations related to wetlands are regulated by Government Notice 267 published in the Government Gazette 40713 of 24 March 2017 regarding Section 21(c) and (i). Page 196 of this notice provides a detailed terms of reference for wetland assessment reports and includes the requirement that the ecological integrity and function of wetlands be addressed.

WET-EcoServices Version 2 (Kotze, *et al.,* 2020) includes 16 different ecosystem services, which were selected for their specific relevance to the South African situation:

- Flood attenuation
- Streamflow regulation
- Sediment trapping
- Phosphate assimilation
- Nitrate assimilation
- Toxicant assimilation
- Erosion control
- Carbon storage
- Biodiversity maintenance
- Provision of water for human use

- Provision of harvestable resources
- Food for livestock
- Provision of cultivated foods
- Cultural and spiritual experience
- Tourism and recreation
- Education and research

Table 38 and Table 39 describe the categories for integrating scores for supply and demand of ecosystem services and their overall importance.

Table 38: Integrating the scores for ecosystem supply and demand into an overall importance score.

Integrating scores for supply & demand to obtain an overall importance score						
		Supply				
		Very Low	Low	Moderate	High	Very High
Demand		0	1	2	3	4
Very Low	0	0.0	0.0	0.5	1.5	2.5
Low	1	0.0	0.0	1.0	2.0	3.0
Moderate	2	0.0	0.5	1.5	2.5	3.5
High	3	0.0	1.0	2.0	3.0	4.0
Very High	4	0.5	1.5	2.5	3.5	4.0

Table 39: Categories used for reporting the overall importance of ecosystem services.

Importance Category		Description
Very Low	0-0.79	The importance of services supplied is very low relative to that supplied by other wetlands.
Low	0.8 – 1.29	The importance of services supplied is low relative to that supplied by other wetlands.
Moderately-Low	1.3 – 1.69	The importance of services supplied is moderately-low relative to that supplied by other wetlands.
Moderate	1.7 – 2.29	The importance of services supplied is moderate relative to that supplied by other wetlands.
Moderately-High	2.3 – 2.69	The importance of services supplied is moderately-high relative to that supplied by other wetlands.
High	2.7 – 3.19	The importance of services supplied is high relative to that supplied by other wetlands.
Very High	3.2 - 4.0	The importance of services supplied is very high relative to that supplied by other wetlands.

Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both EC and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.

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

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance.
- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors.
- Basic human needs including subsistence farming and water use.

The Ecological Importance and Sensitivity of the riparian units is represented in the results section. Explanations of the scores are given in Table 40 below.

Table 40: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1

Use of WET-EcoServices for assessing the Ecological Importance and Sensitivity (EIS) of wetlands

The term Ecological Importance and Sensitivity (EIS) is well entrenched in water resource management in South Africa. Ecological Importance (EI) is the expression of the importance of wetlands and rivers in terms of the maintenance of biological diversity and ecological functioning at a local and landscape level. Ecological Sensitivity (S) refers to ecosystem fragility or the ability to resist or recover from disturbance (Rountree and Kotze 2013). The purpose of assessing ecological importance and sensitivity of water resources like wetlands, and rivers is to be able to identify those systems that provide valuable biodiversity support functions, regulating ecosystem services, or are especially sensitive to impacts. Knowing what ecosystems are valuable enables the appropriate setting of management objectives (i.e. recommended ecological category - REC) and the prioritization of management actions and interventions to promote effective water resource management.

The tool currently used for assessing wetland EIS (Rountree and Kotze 2013) is somewhat outdated but is typically informed by a WET-EcoServices assessment. The implication is that practitioners involved in wetland assessments typically have to complete both a WET-EcoServices assessment and a stand-alone EIS assessment to inform decision-making processes. Recommendations to refine the wetland EIS tool have been documented (Macfarlane et al. 2019) and includes the need to revise and update the wetland EIS assessment framework to simply integrate the key outputs of the WET-EcoServices tool to produce an overall ecological importance (EI) score.

Specific recommendations for integrating the WET-EcoServices outputs into the wetland EIS assessment have also been documented. These include grouping of ecosystem service scores into broad categories which would then be integrated into an overall ecological importance (EI) score:

- • ***Biodiversity maintenance importance***: This is the importance score derived from the biodiversity maintenance component of WET-EcoServices.
- • ***Regulating services importance***: This would be calculated as the maximum score of all the importance scores for regulating services considered in WET-EcoServices.
- • ***Provisioning and cultural services importance***: This would be calculated as the maximum score of all the importance scores for provisioning and cultural services considered in WET-EcoServices.

The EI would be simply derived based on the maximum of these scores and could then be integrated with the ecological sensitivity (ES) score to produce an overall EIS score. A simple schematic of the proposed Wetland EIS framework is shown in Figure 24 below.

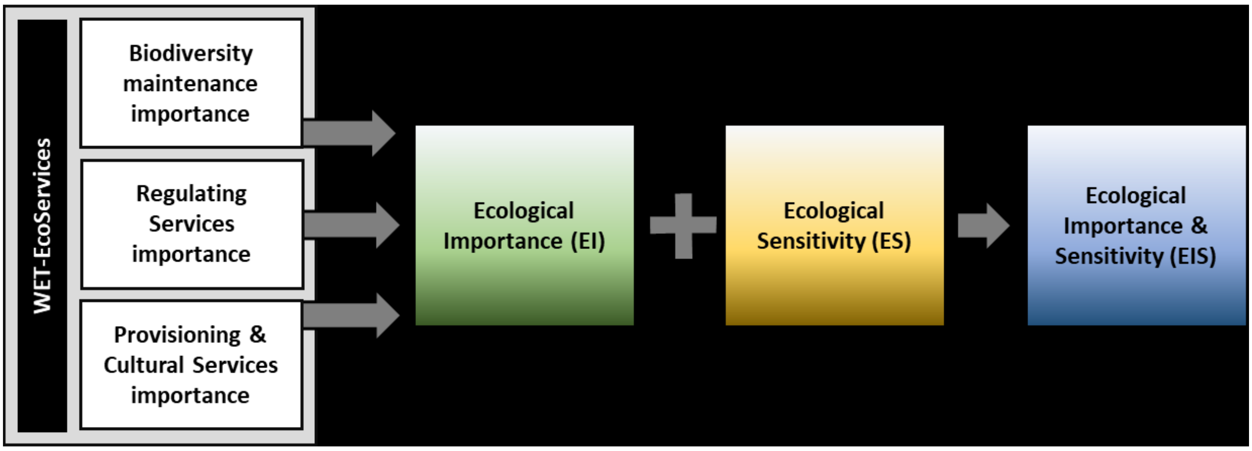


Figure 24: Schematic of the recommended Wetland EIS framework.

<u>Physical Habitat Assessment the IHAS method</u>

The quality of the instream and riparian habitat has a direct influence on the aquatic community. Evaluating the structure and functioning of an aquatic ecosystem must therefore take into account the physical habitat to assess the ecological integrity. The IHAS sampling protocol, of which version 2 is currently used, was developed by McMillan in 1998 for use in conjunction with the SASS5 protocol to determine which habitats are present for aquatic macroinvertebrates.

IHAS consists of a scoring sheet that assists to determine the extent of each of the instream habitats, together with the physical parameter of the stream. For example, the proportion of stones in current and stones out of current will be compared with the presence of instream vegetation. This sampling protocol assists with the interpretation of the SASS5 data.

Data recorded during the site visit concerning sampling habitat and stream condition is uploaded into an excel spreadsheet. The results are then interpreted according to the categories supplied by McMillan (Table 41).

Table 41: IHAS score interpretation table

IHAS SCORE	INTERPRETATION
<65%	Insufficient for supporting a diverse aquatic macro invertebrate community
65%-75%	Acceptable for supporting a diverse aquatic macroinvertebrate community
75%	Highly suitable for supporting a diverse aquatic macroinvertebrate community

<u>**In Situ Water Quality**</u>

Water quality has a direct influence on in stream biota, and can fluctuate, depending on site-specific conditions. The biological monitoring of especially macroinvertebrates and fish thus need to be augmented with the in situ measurement of basic water quality indicator parameters (DWAF 1996), namely:

Temperature, which plays an important role in water by affecting the rates of chemical reactions and therefore the metabolic rates of organisms. Temperature is one of the major factors controlling the distribution of aquatic organisms. The temperatures of inland waters in South Africa generally range from 5 – 30°C. Natural variations in water temperature occur in response to seasonal and diel cycles and organisms use these changes as cues for activities such as migration, emergence and spawning. Artificially-induced changes in water temperature can thus impact on individual organisms and on entire aquatic communities.

pH, which gives an indication of the level of hydrogen ions in water, as calculated by the expression: pH = -$\log_{10}[H^+]$, where $[H^+]$ is the hydrogen ion concentration. The pH of pure distilled water (that is, water containing no other soluble chemicals) at a temperature of 24°C is 7.0, implying that the number of H^+ and OH^- ions are equal and the water is therefore electrochemically neutral. As the concentration of hydrogen ions increases, pH decreases and the solution becomes more acidic. As $[H^+]$ decreases, pH increases and the solution becomes more alkaline. For natural surface water systems, pH values typically range between 4 and 11, and depends on the availability of carbonate and bicarbonate, which influences the buffer capacity of the water, and which are determined by geological and atmospheric circumstances.

Electrical Conductivity ("EC") is the measurement of the ease with which water conducts electricity (in milli-Siemens/meter – mS/m) and can also be used to estimate the total dissolved salts ("TDS"): EC in mS/mx 7 ≈ TDS in mg/ℓ. Changes in the EC values provide uPhotovoltaic Developemntul and rapid estimates of changes in the TDS concentration, which indicates the quantity of all compounds dissolved in the water that carry an electrical charge. Natural waters contain varying concentrations of TDS as a consequence of the dissolution of minerals in rocks, soils and decomposing plant material. TDS thus depends on the characteristics of the geological formations which the water has been in contact with, and on physical processes such as rainfall and evaporation. Plants and animals possess a wide range of physiological mechanisms and adaptations to maintain the necessary balance of water and dissolved ions in cells and tissues. Changes in EC can affect microbial and ecological processes such as rates of metabolism and nutrient cycling. The effect on aquatic organisms depend more on the rate of change than absolute changes in concentrations of salts.

Dissolved Oxygen ("DO") is the measurement of the percentage saturation of water with gaseous oxygen, which is generated by aquatic plants during photosynthesis, or which dissolved into the water from the atmosphere. Gaseous oxygen is moderately soluble in water, and the saturation solubility varies non-linearly with temperature, salinity, atmospheric pressure (and thus altitude), and other site-specific chemical and physical factors. In unpolluted surface waters, dissolved oxygen concentrations are usually close to 100% saturation. Concentrations of less than 100% saturation indicate that DO has been depleted from the theoretical equilibrium concentration. Results in excess of 100% saturation (super-saturation of oxygen) usually indicate eutrophication in a water body. Typical oxygen saturation concentrations at sea level, and at TDS values below 3,000 mg/ℓ, are at around 13 mg/ℓ (@5 °C); 10 mg/ℓ (@15 °C); and 9 mg/ℓ (@20 °C). High water temperatures combined with low dissolved oxygen levels can compound stress effects on aquatic organisms. There is a natural diel (24-hour cycle) variation in DO, associated with the 24-hour cycle of photosynthesis and respiration by aquatic biota. Concentrations decline through the night to a minimum near dawn, then rise to a maximum by mid-afternoon. Seasonal variations arise from changes in temperature and biological productivity. The maintenance of adequate DO saturation levels in water is critical for the survival and functioning of aquatic biota, because it is required for the respiration of all aerobic organisms. Therefore, the DO saturation levels provide a uPhotovoltaic Developemntul measure of the health of an aquatic ecosystem (DWAF 1996). Measuring DO is measuring a dissolved gas, and is thus best measured in situ, to prevent de-oxygenation or oxygenation during transportation.

It should be noted that the in situ measurement of these water quality parameters does not represent the general water quality at the sampling points or the streams. It is not a laboratory analysis of water quality, and does not measure macro anions and cations, metals or organic contaminants, nutrients or pesticides. The in situ measurements of these parameters provide a snapshot of the water quality at the survey site at the time the biological samples were taken, and thus can provide valuable insight into the characteristics at a survey site that could have an influence on the aquatic biota at that site, and at the time of conducting the sampling for biomonitoring.

In situ measurements of pH, temperature (in °C), and EC (in µS/cm) were taken by means of a calibrated hand-held instrument (Hanna - HI 991300) in the main flow of the river or stream sampled, both prior to conducting the sampling for biomonitoring as well as after the completion of conducting the sampling for biomonitoring.

The EC measurements in µS/cm were converted to mS/m (10 µS/cm = 1 mS/m) by dividing with a factor of 10.

Receiving water quality objectives ("RWQOs") based on the water quality requirements for different users, are contained in a set of documents first published by DWAF in 1993, and revised in 1996 (DWAF, 1996). These documents are collectively known as the "South African Water Quality Guidelines" ("SAWQGs") and contain guidelines for specific types of water users, namely:

- SAWQG Volume 1: Domestic Water Use
- SAWQG Volume 2: Recreational Water Use
- SAWQG Volume 3: Industrial Water Use
- SAWQG Volume 4: Agricultural Water Use: Irrigation
- SAWQG Volume 5: Agricultural Water Use: Livestock Watering
- SAWQG Volume 6: Agricultural Water Use: Aquaculture
- SAWQG Volume 7: Aquatic Ecosystems

These guidelines provide uPhotovoltaic Developemntul information on the effects of various chemical substances on water resource quality and establish objectives for the management of the water resource based on the requirements of the different users of the water resource. The water quality requirements for protecting and maintaining the health of aquatic ecosystems differ from those of other water uses. It is difficult to determine the effects of changes in water quality on aquatic ecosystems, as the cause-effect relationships are not well understood. Therefore, water quality guidelines have to be derived indirectly through extrapolation of the known effects of water quality on a very limited number of aquatic organisms. Certain quality ranges are required to protect and maintain aquatic ecosystem health. For each constituent, guideline ranges are specified, including the No Effect Range (Target Water Quality Range or "TWQR"), Minimum Allowable Values, Acceptable Range, and, for some parameters, Intolerable levels.

The SAWQGs for aquatic ecosystems that are applicable to the in situ measurements of water quality, are summarised below (DWAF 1996):

PARAMETER	UNIT	TARGET WATER QUALITY RANGE	MINIMUM ALLOWABLE VALUES
Temperature	°C	should not vary from the background average daily water temperature considered to be normal for that specific site and time of day, by > 2 °C, **or** by > 10 %, whichever estimate is the more conservative	
EC	mS/m	Should not be changed by > 15 % from the normal cycles of the water body	
pH	pH units	Variation from background pH limited to <0.5 of a pH unit, or < 5%, whichever is the more conservative estimate	
DO	% saturation	80 – 120	> 60 (sub lethal) > 40 (lethal)

Data collected during the in situ measurements were compared against these SAWQGs for aquatic ecosystems.

SASS5

SASS5 is a rapid bioassessment method used to identify changes in species composition of aquatic invertebrates to indicate relative water quality (Dickens and Graham 2002). SASS5 requires the identification of invertebrates to a family level in the field.

SASS5 is based on the principle that some invertebrate taxa are more sensitive than others to alterations in ecological drivers such as pollutants or flooding events. Macroinvertebrate assemblages are good indicators of localized conditions in rivers. Many macroinvertebrates have limited migration patterns or are not free moving, which makes them well-suited for assessing site specific impacts with upstream/downstream studies. Benthic macroinvertebrates are abundant in most streams. Even small streams (1st and 2nd order) which may have a limited fish population will support a diverse macroinvertebrate fauna. These groups of species constitute a broad range of trophic levels and pollution tolerances. Thus, SASS5 is a uPhotovoltaic Developemntul method for interpreting the cumulative effects of impacts on aquatic environments.

Using a 'kick net', the SASS5 sampling method entails prescribed time-periods and spatial areas for the kicking of in-current and out-current stones and bedrock; sweeping of in-current and out-current marginal and aquatic vegetation, as well as of gravel, stones and mud ("GSM"); followed by visual observations and hand-picking. The results of each biotope are kept separate, until all observations are noted. The entire sample is then returned to the river, retained alive, or preserved for further identification.

In SASS5 analysis, species abundance is recorded on an SASS5 data sheet which weighs the different taxons common to South African rivers from 1 (pollutant tolerant) to 15 (pollution sensitive). The SASS5 score will be high at a particular site if the taxa are pollution sensitive and low if they are mostly pollution tolerant.

The SASS5 Score, the number of taxa observed, and the average score per taxon ("ASPT") are calculated for all of the biotopes combined. Dallas (2007) used available SASS5 Score and ASPT values for each eco-region in South Africa to generate biological bands on standardised graphs that are used as a guideline for interpreting any data obtained during the study. The meaning of each SASS5 Ecological Category is as follows (Dallas 2007).

EC	ECOLOGICAL CATEGORY	DESCRIPTION
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

Physical properties of water

The physical properties of water are based on the temperature, Electrical conductivity (EC), pH, and oxygen content of the water- using physical methods. The physical properties of water influence the aesthetical – as well as the chemical qualities of water. Relevance of the indicators of the physical properties of water include pH- affects the corrosiveness of water and EC- an indication of the "freshness" of water (indicates the presence of dissolved salts and other dissolved particles). Included in the physical properties of water is the suspendoid's effects on water quality. This includes turbidity, and total suspended solids. Turbidity is measured in Nephelometric Turbidity Units (NTU's) and is the indication of the ability of light to pass through water. See Table 42 for a list of physical properties of water and comparative results.

Table 42: Table for comparative results of physical properties of water

pH Values	
pH > 8.5	Alkaline
pH 6.0-8.5	Circumneutral
pH < 6.0	Acidic
Total Hardness (in **mg CaCO3/l)**	
Hardness < 50 mg/l	Soft
Hardness 50-100 mg/l	Moderately soft
Hardness 100- 150 mg/l	Slightly hard
Hardness 150-200 mg/l	Moderately hard
Hardness 200-300 mg/l	Hard
Hardness 300-600 mg/l	Very hard
Total Dissolved Solids as indicator of salinity of water	
TDS <450 mg/l	Non saline
TDS 450-1000 mg/l	Saline
TDS 1000-2400 mg/l	Very saline
TDS 2400-3400 mg/l	Extremely saline
Total suspended solids (TSS)	
Background TSS concentrations are < 100 mg/l	Any increase in TSS concentrations must be limited to < 10 % of the background TSS concentrations at a specific site and time.

Recommended Ecological Category (REC)

"Upon completion of the EC and EIS assessments for the wetland, a Recommended Ecological Category for the Recommended Ecological Category (REC) of the water resource must be determined according to the methods set out in Roundtree *et al,* (2013).

The REC is determined by the Present Ecological State of the water resource and the importance and/or sensitivity of the water resource. Water resources which have Ecological Categories in an E or F class are deemed unsustainable by the DWS. In such cases the REC must automatically be increased to a D.

Where the PES is in the A, B, C, D or E the EIS components must be checked to determine if any of the aspects of importance and sensitivity (Ecological Importance; Hydrological Functions and Direct Human Benefits) are high or very high. If this is the case, the feasibility of increasing the EC (particularly if the EC is in a low C or D category) should be evaluated. This is recommended to enable important and/or sensitive wetland water resources to maintain their functionality and continue to provide the goods and services for the environment and society.

If (Table 43):

- EC is in an E or F category:
  The REC should be set at at least a D, since E and F EC's are considered unsustainable.
    - The EC category is in a A, B, C or D category, AND the EIS criteria are low or moderate OR the EIS criteria are high or even very high, but it is not feasible or practicable for the EC to be improved:
- The REC is set at the current PES.
    - The EC category is in a B, C or D category, AND the EIS criteria are high or very high AND it is feasible or practicable for the EC to be improved:
- The REC is set at least one Ecological Category higher than the current EC." (Rountree *et al,* 2013)

Table 43: Generic Matrix for the determination of REC and RMO for water resources

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	A Improve	A/B Improve	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

SITE ECOLOGICAL IMPORTANCE

Based on the Species Environmental Assessment Guideline (SANBI, 2020) wetlands and specialised habitats should be assessed based on their Site Ecological Importance (SEI). The SEI is based on several factors (Figure 25):

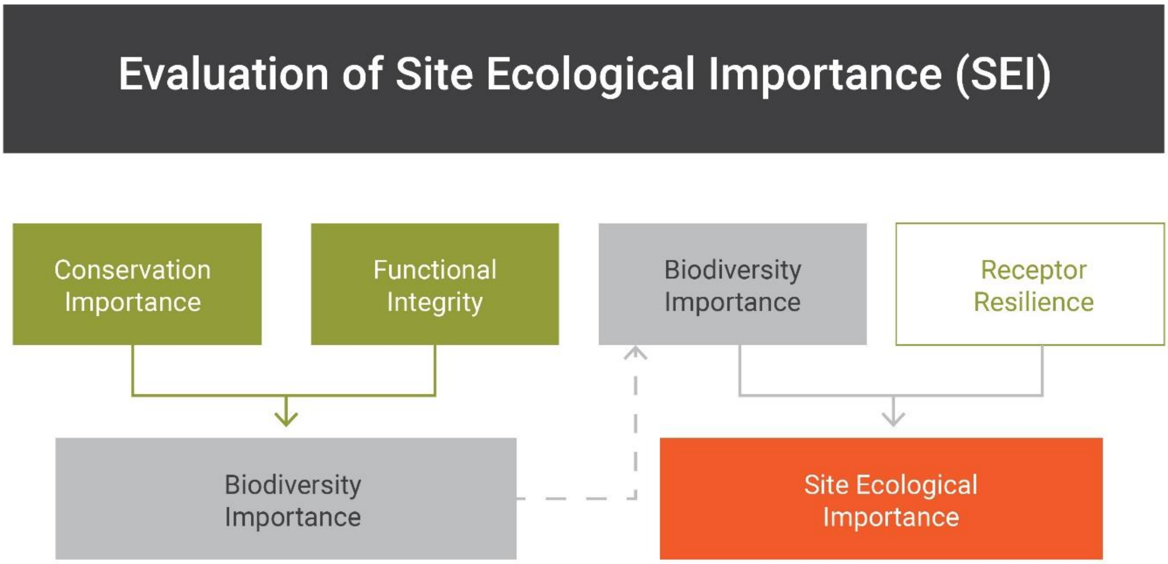


Figure 25: Evaluation of Site Ecological Importance based on CI, FI, BI, RR and SEI (SANBI, 2020).

Conservation Importance (CI) (Table 44) and Functional Integrity (FI) (Table 45) = Biodiversity Importance (Table 46).

Biodiversity Importance (BI) and Receptor Resilience (RR) (Table 47 and Table 44) = Site Ecological Importance (Table 48).

Table 44: Conservation Importance (SANBI, 2020).

Conservation importance	Fulfilling criteria
Very High	Confirmed or highly likely occurrence of CR, EN, VU or Extremely Rare23 or Critically Rare24 species that have a global EOO of < 10 km2. Any area of natural habitat25 of a CR ecosystem type or large area (> 0.1% of the total ecosystem type extent26) of natural habitat of EN ecosystem type. Globally significant populations of congregatory species (> 10% of global population).
High	Confirmed or highly likely occurrence of CR, EN, VU species that have a global EOO of > 10 km2 . IUCN threatened species (CR, EN, VU) must be listed under any criterion other than A. If listed as threatened only under Criterion A, include if there are less than 10 locations or < 10 000 mature individuals remaining. Small area (> 0.01% but < 0.1% of the total ecosystem type extent) of natural habitat of EN ecosystem type or large area (> 0.1%) of natural habitat of VU ecosystem type. Presence of Rare species. Globally significant populations of congregatory species (> 1% but < 10% of global population).
Medium	Confirmed or highly likely occurrence of populations of NT species, threatened species (CR, EN, VU) listed under Criterion A only and which have more than 10 locations or more than 10 000 mature individuals. Any area of natural habitat of threatened ecosystem type with status of VU. Presence of range-restricted species. > 50% of receptor contains natural habitat with potential to support SCC
Low	No confirmed or highly likely populations of SCC. No confirmed or highly likely populations of range-restricted species. < 50% of receptor contains natural habitat with limited potential to support SCC
Very low	No confirmed and highly unlikely populations of SCC. No confirmed and highly unlikely populations of range-restricted species. No natural habitat remaining.

Table 45: Functional Integrity (SANBI, 2020).

Functional Integrity	Fulfilling criteria
Very High	Very large (>100 ha) intact area for any conservation status of ecosystem type or >5 ha for CR ecosystem types Very High High habitat connectivity serving as functional ecological corridors, limited road network between intact habitat patches No or minimal current negative ecological impacts with no signs of major past disturbance (e.g. ploughing)
High	Large (>20 ha but <100 ha) intact area for any conservation status of ecosystem type or >10 ha for EN ecosystem types Good habitat connectivity with potentially functional ecological corridors and a regularly used road network between intact habitat patches Only minor current negative ecological impacts (e.g. few livestock utilising area) with no signs of major past disturbance (e.g. ploughing) and good rehabilitation potential
Medium	Medium (>5 ha but <20 ha) semi-intact area for any conservation status of ecosystem type or > 20 ha for VU ecosystem types Only narrow corridors of good habitat connectivity or larger areas of poor habitat connectivity and a busy used road network between intact habitat patches Mostly minor current negative ecological impacts with some major impacts (e.g.

	established population of alien and invasive flora) and a few signs of minor past disturbance; moderate rehabilitation potential
Low	Small (>1 ha but <5 ha) area Almost no habitat connectivity but migrations still possible across some transformed or degraded natural habitat and a very busy used road network surrounds the area. Low rehabilitation potential Several minor and major current negative ecological impacts
Very low	Very small (<1 ha) area No habitat connectivity except for flying species or flora with wind-dispersed seeds. Several major current negative ecological impacts

Table 46: Biodiversity Importance (SANBI, 2020)..

Biodiversity Importance		Conservation Importance				
		Very High	High	Medium	Low	Very Low
Functional Integrity	Very High	Very High	Very High	High	Medium	Low
	High	Very High	High	Medium	Medium	Low
	Medium	High	Medium	Medium	Low	Very Low
	Low	Medium	Medium	Low	Low	Very Low
	Very Low	Medium	Low	Very Low	Very Low	Very Low

Table 47: Receptor Resilience (SANBI, 2020)..

Resilience	Fulfilling criteria
Very High	Habitat that can recover rapidly (~ less than 5 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a very high likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a very high likelihood of returning to a site once the disturbance or impact has been removed
High	Habitat that can recover relatively quickly (~ 5-10 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a high likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a high likelihood of returning to a site once the disturbance or impact has been removed
Medium	Will recover slowly (~more than 10 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a moderate likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a moderate likelihood of returning to a site once the disturbance or impact has been removed
Low	Habitat that is unlikely to be able to recover fully after a relatively long period: > 15 years required to restore ~less than 50 % of the original species composition and functionality of the receptor functionality, or species that have a low likelihood of remaining at a site even when a

	disturbance or impact is occurring, or species that have a low likelihood of returning to a site once the disturbance or impact has been removed
Very low	Habitat that is unable to recover from major impacts, or species that are unlikely to remain at a site even when a disturbance or impact is occurring, or species that are unlikely to return to a site once the disturbance or impact has been removed

Table 48: Site Ecological Importance (SANBI, 2020).

Site Ecological Importance		**Biodiversity Importance**				
		Very High	High	Medium	Low	Very Low
Receptor Resilience	Very Low	Very High	Very High	High	Medium	Low
	Low	Very High	Very High	High	Medium	Very Low
	Medium	Very High	High	Medium	Low	Very Low
	High	High	Medium	Low	Very Low	Very Low
	Very High	Medium	Low	Very Low	Very Low	Very Low

Impact Assessments

NEMA (2014) Impact Ratings

As required by the 2014 NEMA regulations, impact assessment should provide quantified scores indicating the expected impact, including the cumulative impact of a proposed activity. This assessment follows the format presented below. The impact assessment score below are calculated using the following parameters:

- Direct, indirect and cumulative impacts of the issues identified through the specialist study, as well as all other issues must be assessed in terms of the following criteria:
    - The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
    - The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
    - The **duration**, wherein it will be indicated whether:
        - The lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
        - The lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
        - Medium-term (5–15 years) – assigned a score of 3;
        - Long term (> 15 years) - assigned a score of 4; or
        - Permanent - assigned a score of 5;
    - The consequences (magnitude), quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
    - The probability of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
    - The significance, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
    - The status, which will be described as either positive, negative or neutral.
    - The degree to which the impact can be reversed.
    - The degree to which the impact may cause irreplaceable loss of resources.
    - The degree to which the impact can be mitigated.

The **significance** is calculated by combining the criteria in the following formula:

- S=(E+D+M)P
- S = Significance weighting

- E = Extent
- D = Duration
- M = Magnitude
- P = Probability

The **significance weightings** for each potential impact will be determined as follows (**Table 49**):

Table 49: Significance Weightings

Points	Significant Weighting	Discussion
< 30 points	Low	This impact would not have a direct influence on the decision to develop in the area.
31-60 points	Medium	The impact could influence the decision to develop in the area unless it is effectively mitigated.
> 60 points	High	The impact must have an influence on the decision process to develop in the area.

DWS (2016) Impact Register and Risk Assessment

Section 21(c) and (i) water uses (Impeding or diverting low and/or impacts to the bed and banks of watercourses) are non-consumptive and their impacts more difficult to detect and manage. They are also generally difficult to clearly quantify. However, if left undetected these impacts can significantly change various attributes and characteristics of a watercourse, and water resources, especially if left unmanaged and uncontrolled.

Risk-based management has value in providing an indication of the potential for delegating certain categories of water use "risks" to DHWS regional offices (RO) or Catchment Management Agencies (CMA). Risk categories obtained through this assessment serve as a guideline to establish the appropriate channel of authorisation of these water uses. The DHWS has therefore developed a risk assessment matrix to assist in quantifying expected impacts. The scores obtained in this assessment are Photovoltaic Development in evaluating how the proposed activities should be authorised.

The formula used to derive a risk score is as follows:

RISK = CONSEQUENCE x LIKELIHOOD

CONSEQUENCE = SEVERITY + SPATIAL SCALE + DURATION

LIKELIHOOD = FREQUENCY OF THE ACTIVITY + FREQUENCY OF THE IMPACT +LEGAL ISSUES + DETECTION

Table 50 below provides a description of the classes into which scores are sorted, and their implication for authorization.

Table 50: An extract from DWS (2016) indicating the risk scores and classes as well as the implication for the appropriate authorization process

1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence

APPENDIX C: Abbreviated CVs of participating specialists

RUDI BEZUIDENHOUDT

880831 5038 081

Ecologist / Botanist / Aquatic Specialist

Pr. Sci Nat (Reg. No. 008867)

South African

Single

EDUCATIONAL QUALIFICATIONS

- B.Sc. (Botany & Zoology), University of South Africa (2008 - 2012)
- B.Sc. (Hons) Botany, University of South Africa (2014 – 2016)
- Aquatic & Wetland Plant identification, Cripsis Environment (2019)
- Introduction to wetlands, Gauteng Wetland Forum (2010)
- Biomimicry and Constructed Wetlands. Golder Associates and Water Research Commission (2011)
- Wetland Rehabilitation Principles, University of the Free State (2012)
- Wetland Plant Identification Course, SANBI (2015)
- Tools for Wetland Assessment, Rhodes University (2011)
- Wetland Legislation, University of Free-State (2013)
- Understanding Environmental Impact Assessment, WESSA (2011)
- SASS 5, Groundtruth (2012)
- Wetland Operations and Diversity Management Master Class, Secolo Consulting Training Services (2015)
- Tree Identification, Braam van Wyk – University of Pretoria (2015)
- Wetland Buffer Legislation – Eco-Pulse & Water Research Commission (2015)
- Wetland Seminar, ARC-ISCW & IMCG (2011)
- Invasive Species Training, SAGIC (2016)
- Hydropedology Course. Department of Water and Sanitation (2019)
- Tropical Coastal Ecosystems, edX (2020)
- The Science of Hydropedology – Department of Water and Sanitation (2020)
- Hydropedological Grouping of SA Soil Forms - Department of Water and Sanitation (2020)
- Hydropedological Classification of South Africa Soil Forms - Department of Water and Sanitation (2020)

- Contribution of Hydropedological Assessments to the Availability and Sustainable Management of water for all - Department of Water and Sanitation (2020)

WETLAND SPECIALIST/ECOLOGIST

Experience in the delineation and functional assessment of wetlands and riparian areas in order to advise proposed development layouts, project management, report writing and quality control. This entails all aspects of scientific investigation associated with a consultancy that focuses on wetland specialist investigations. This includes the following:

- Approximately 200+ specialist investigations into wetland and riparian conditions on strategic, as well as fine scale levels in all 9 Provinces of South Africa as well as in bordering countries.
- Ensuring the scientific integrity of wetland reports including peer review and publications.

Major Projects Involve:

- Numerous Eskom Powerline Projects some spanning more than one Province.
- Proposed New Kruger National Camp and Infrastructure (2016)
- Numerous Mining Projects
- Numerous Water infrastructure upgrades
- Numerous Residential and Housing Developments

BIODIVERSITY ACTION PLAN

This entails the gathering of data and compiling of a Biodiversity action plan for various private and government entities.

REHABILITATION

This entailed the management of vegetation and rehabilitation related projects in terms of developing proposals, project management, technical investigation and quality control as well as on-site monitoring.

COURSES PRESENTED

- Riparian Vegetation Response Assessment Index (VEGRAI) Training presented to DWA (Department of Water Affairs) (2017)
- Numerous Wetland Talks

- **ENVIRONMENTAL CONTROLLING OFFICER:**

Routine inspection of construction sites to ensure compliance with the City's environmental ordinances, the Environmental Management Program and other laws and by-laws associated with development at or near wetland or riparian areas.

- Soweto Zola Park 2011-2013
- Orange Farm Pipeline 2010-2011
- Juksei River Rehabilitation 2018- 2020
- Ga-Mawela Bridge 2019-2020

- **ENVIRONMENTAL AUDIT:**

Audit of Eskom Kusile power station to comply with the Kusile Section 21G Water Use Licence (Department of Water Affairs, Licence No. 04/B20F/BCFGIJ/41, 2011), the amended Water Use Licence (Department of water affairs and forestry, Ref. 27/2/2/B620/101/8, 2009) and the WUL checklist provided by Eskom.

- Kusile Powerstation 2012-2013.

- **INVASIVE SPECIES MANAGEMENT**

- Identifying and classifying invasive species on numerous sites.
- Creating invasive species control and management plans
- Monitoring invasive species control measures

PUBLICATIONS

Bezuidenhoudt. R., De Klerk. A. R., Oberholster. P.J. (2017). Assessing the ecosystem processes of ecological infrastructure on post-coal mined land. COALTECH RESEARCH ASSOCIATION NPC. University of South Africa. Council for Scientific Industrial Research.