Proposed Bushveld Vametco's Phase 2 Solar PV Park Project, near Brits, North-West Province.

Aquatic Biodiversity Assessment Report

June 2023

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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

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Project name:	Proposed Bushveld Vametco's Phase 2 Solar PV Park Project, near Brits, North-West Province.		
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Document number	**Checked by:**	**Electronic Signature:**	**Date**
Author	Rudi Bezuidenhoudt		2022.04.21
Client Review			
Final Report			

EXECUTIVE SUMMARY

Limosella Consulting was appointed by Nsovo Environmental Consulting for specialist input for the proposed development of the Proposed Bushveld Vametco's Phase 2 Solar PV Park Project, near Brits, North-West Province. A site visit was conducted in May 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.

Three watercourse 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
- Non-Perennial Episodic Riparian Area
- Seepage Wetland

The construction and operation of Photovoltaic (PV) solar installations on or adjacent to watercourses pose several risks that warrant meticulous scrutiny. One of the primary concerns is the potential alteration of hydrological patterns, including water flow and sediment transport, which could have cascading effects on aquatic ecosystems. The construction process itself may lead to soil erosion and the subsequent sedimentation of water bodies, affecting water quality and aquatic life. Additionally, the materials used in solar panels and associated infrastructure may contain hazardous substances such as heavy metals, which could leach into the watercourse, thereby posing a risk of water contamination. Furthermore, the shading effect of solar panels could alter the thermal and light conditions of the watercourse, impacting the natural behaviours and life cycles of aquatic organisms. Lastly, the presence of these structures could pose a barrier to the movement of aquatic and semi-aquatic species, thereby affecting their distribution and breeding.

List of particular mitigation measures that should be included in the Impact/Risk Assessment

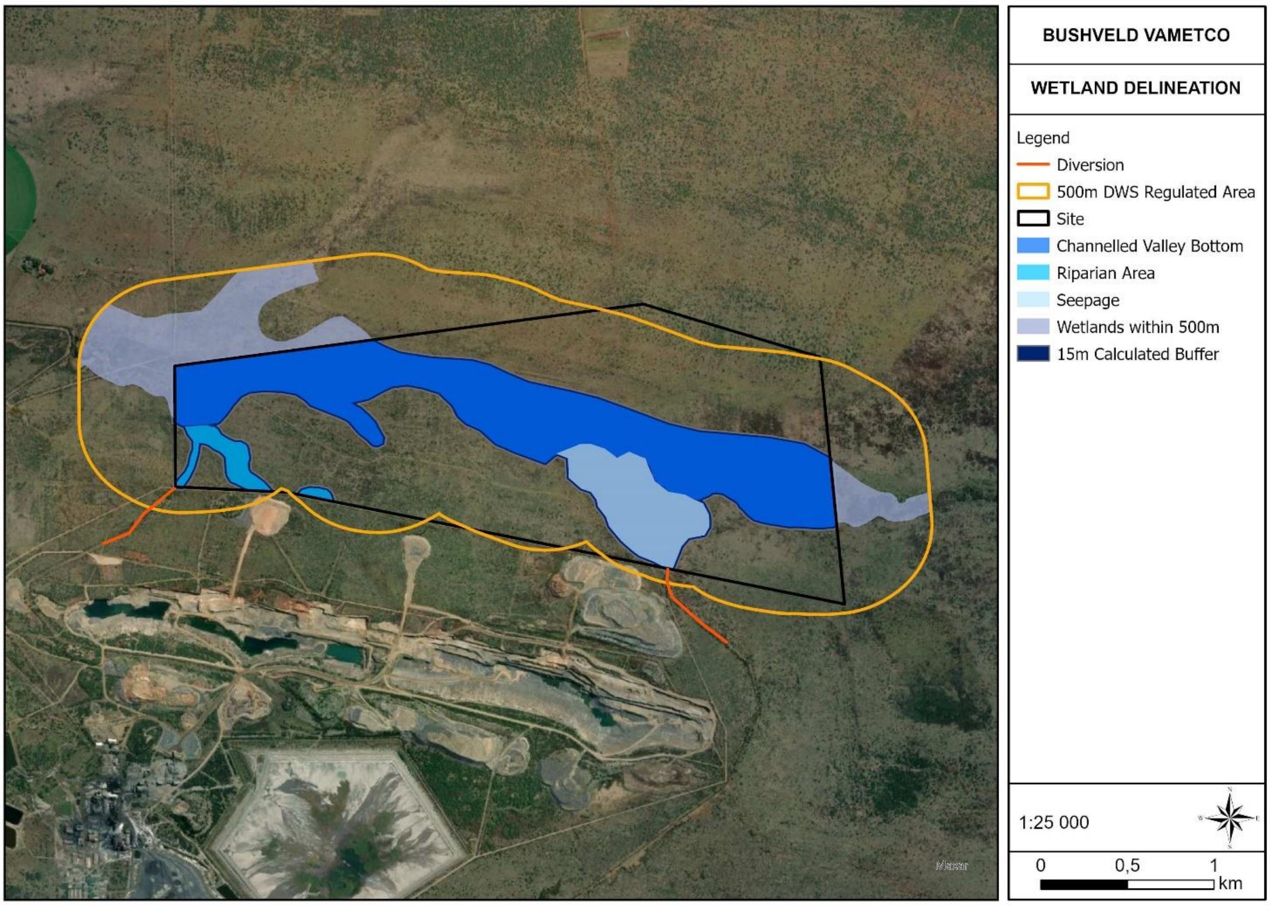
- Avoiding the perennial and non-perennial areas.
- Ensuring impacts remain away from the riparian area with an emphasis on stormwater releases.
- Attenuation of stormwater

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

	Quaternary Catchment and WMA areas		Important Rivers within 500 m
	A21J - WMA #1: Limpopo: Major rivers include the Limpopo, Matlabas, Mokolo, Lephalale, Mogalakwena, Sand, Nzhelele, Mutale, and Luvuvhu.		The watercourses of the study site are associated with or flow into the Rosespruit which then flows into the Crocodile River.
Classification (SANBI, 2013)	**Channelled Valley Bottom Wetland**	**Seepage Wetland**	**Episodic Stream**
EC Scores (PES - WetHealth Version 2 (Macfarlane *et al*., 2020) VEGRAI	**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	**E – Seriously Modified.** 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 The condition of this wetland is likely to likely to remain stable over the next 5 years	**D – Largely modified.** A large loss of natural habitat, biota and basic ecosystem functions has occurred.
WetEcoServices (Kotze *et al*., 2020) –	**High**	**Moderate**	
REC (Rountree *et al*, 2013)	**REC of B/C**. This means that the development should be done in such a way as to try and improve the EC values if possible.	**REC of E/F** This means that the development should be done in such a way as to try and maintain the EC values if possible.	**REC of D**. This means that the development should be done in such a way as to try and maintain the EC values if possible.
Calculated Buffer Zone (Macfarlane *et al*, 2015)	**15 m**		

<table>
<tr><td rowspan="3">In situ Water Quality</td><td colspan="4" rowspan="3">No flowing water observed. Ideally this should be revisited after high rainfall events.</td></tr>
<tr></tr>
<tr></tr>
<tr><td>Instream Habitat assessment:</td><td colspan="4"></td></tr>
<tr><td>Aquatic macroinvertebrate assemblages:</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Order Of Preference</td><td>Layout Option 1</td><td>Layout Option 2</td><td colspan="2">Layout Option 3</td></tr>
<tr><td>Most Preferred – Likely to result in the least amount of impact/loss of wetlands. However, the proposed option has several technical difficulties.</td><td>Least Preferred – Will impact and or cause the loss of approximately 42.86 ha (excluding Buffer Zones) of wetland.</td><td colspan="2">Second Preferred – Will result in less wetland impact/loss of 38.93 ha (excluding buffer zones) of wetlands. This option entails the rerouting of the sewage spillway to the southern portion of the site and the diversion of a smaller stream towards the west, actions that are likely to result in a reduction of the wetland's overall dimensions (likely to a more natural state prior to water inputs)</td></tr>
<tr><td colspan="4">It is imperative to clarify that the dimensions of two of these watercourses (sections that are proposed to be developed over) have been significantly augmented due to anthropogenic water inputs. Consequently, the size of the wetlands is likely to diminish if these water inputs are eliminated. Furthermore, the natural historical size of these wetland is significantly smaller from the current state based on historical aerial imagery.</td></tr>
<tr><td rowspan="12">NEMA 2014 Impact Assessment for the Bushveld Vametco – Option 1</td><td rowspan="2">Changes to flow dynamics</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Sedimentation</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Establishment of alien plants</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Loss of wetland habitat</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Pollution of watercourses</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Loss of Aquatic Biota</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">NEMA 2014 Impact Assessment for the</td><td rowspan="2">Changes to flow dynamics</td><td>Construction</td><td>H</td><td>M</td></tr>
<tr><td>Operational</td><td>M</td><td>L</td></tr>
</table>

Bushveld Vametco – Option 3	Sedimentation	Construction	H	M
		Operational	M	L
	Establishment of alien plants	Construction	M	L
		Operational	M	L
	Loss of wetland habitat	Construction	H	M
		Operational	H	M
	Pollution of watercourses	Construction	M	L
		Operational	M	L
	Loss of Aquatic Biota	Construction	H	M
		Operational	M	L
DWS 2016 Risk Assessment	• Structure currently located within wetlands and buffer zones should not be included in the final layout and must be moved. • Designs should consider regional hydrological dynamics. • Stabilise erosion where required. • Establishing buffer zones and setbacks along watercourses to protect them from direct impacts and minimize disturbance. • Implementing sediment and erosion control measures during construction to prevent sediment runoff and reduce erosion into watercourses. • Implementing spill prevention and response protocols to minimize the risk of accidental spills or releases of hazardous substances into watercourses. • Conducting regular water quality monitoring to assess the condition of watercourses and promptly address any issues or exceedances. • Incorporating native vegetation and riparian restoration efforts to enhance the natural filtration capacity of watercourses and provide habitat for aquatic organisms. • Adhering to environmental regulations and permit requirements related to watercourse protection and engaging with regulatory agencies for guidance and compliance. • Implementing fish-friendly screens and fish passage solutions to enable the movement of fish through the solar plant area and minimize barriers to migration. • Engaging with stakeholders and experts to incorporate best practices and ensure the adoption of effective mitigation measures. • Developing and implementing an environmental management plan specific to the solar plant, outlining measures to minimize impacts on watercourses and promote their long-term health and functionality.			
Does the specialist support the development?	Yes, Although Option 1 is preferred it is likely not viable for the developer. Thus option 3 can be considered. Large sections of the areas where the structures will be placed within wetlands are artificial in nature due to anthropogenic activities. Should this option be authorized, a wetland rehabilitation and/or offset plan should be done.			


BUSHVELD VAMETCO
WETLAND DELINEATION
Legend
Diversion
500m DWS Regulated Area
Site
Channelled Valley Bottom
Riparian Area
Seepage
Wetlands within 500m
15m Calculated Buffer
1:25 000
0
0,5
1
km

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1 INTRODUCTION

Limosella Consulting was appointed by Nsovo Environmental Consulting for specialist input for proposed Bushveld Vametco's Phase 2 Solar PV Park Project, near Brits, North-West Province. A site visit was conducted in May 2023.

1.1 Project Description (Taken Verbatim)

1.1.1 Introduction

The Vametco Phase 2 Renewable Energy Facility builds upon the foundational concepts established in Phase 1 of the project, which encompasses a 3.5 MW solar photovoltaic (PV) plant and a 1 MW / 4 MWh Vanadium Redox Flow Battery (VRFB). Phase 2 of the project is dedicated to the development of a solar PV plant with a potential capacity of up to 400 MWp and a battery energy storage system (BESS) facility with a capacity of up to 200 MW / 800 MWh. To accommodate this expansion, a 400-hectare land parcel located to the north of the Vametco mine was carefully selected. The choice of this location was primarily influenced by the availability of land, in consideration of future mining expansion plans, and the advantageous fact that the land is situated within the mining rights leased area.

1.1.2 Project Overview

- **Project Location**: The project is situated within the licensed mining area of Bushveld Vametco, in the Brits region, South Africa.
- **Project Purpose**: The project's primary objectives are to:

a) Reduce the Bushveld Vametco Alloys mine's dependence on traditional energy sources, thereby ensuring a sustainable and cost-effective energy supply.
b) Facilitate the distribution of excess power to third-party off-takers through the Eskom network.

1.1.3 Project Description

The Vametco Hybrid Mini Grid project comprises the following key components:

- **Phase 2**:
    - Solar PV Array: Up to 400 MWp capacity.
    - BESS: Up to 200 MW / 800 MWh capacity.
    - Associated activities: Earthworks, Civils, Substations, Transmission Lines etc
    - The project aims to power a significant portion of Bushveld Vametco's load, reducing dependence on Eskom. Wheel power to third party off takers through the Eskom network.

1.1.3.1 Renewable Energy Benefits

The project will:

- Reduce greenhouse gas emissions.
- Promote clean energy production.

- Create job opportunities for local communities during construction and operation.

1.1.3.2 Technical considerations

The renewable energy facility will consist of the following:

1.1.3.3 Key Components of a Solar PV System:

a) **Solar Panels (Photovoltaic Modules):** These are the heart of the solar PV system. Solar panels are made up of multiple solar cells that contain semiconductor materials, typically silicon. When sunlight strikes these cells, it excites electrons, generating a flow of electricity known as direct current (DC).

b) **Inverters:** Solar panels produce DC electricity, but most appliances and the grid use alternating current (AC). Inverters are used to convert DC power into AC power, making it compatible with the electrical grid and usable by appliances.

c) **Mounting Structures:** Solar panels need to be securely positioned to capture sunlight optimally. There are two primary types of mounting structures used in solar PV installations:

   - **Fixed Tilt (Fixed-Angle Mounting):** In fixed tilt systems, solar panels are mounted at a fixed angle to the ground or rooftop. This angle is usually set to maximize energy production based on the average sun position throughout the year. While cost-effective and low-maintenance, fixed tilt systems do not adjust to follow the sun's path, which means they are most efficient during specific times of the day.

   - **Tracking Systems:** Tracking systems, also known as solar trackers, are designed to move solar panels to follow the sun as it moves across the sky. This dynamic adjustment optimizes the angle at which sunlight strikes the panels, resulting in higher energy production throughout the day. Although tracking systems are more expensive and require regular maintenance, they can significantly increase the overall energy output of a solar PV system.

The choice between fixed tilt and tracking systems depends on factors such as project budget, available space, and the desired energy output. In the case of the Vametco Hybrid Mini Grid project, the specific solar PV design will be decided during detailed design phase.

1.1.3.4 Substation Design and Functionality:

a) **Voltage Compatibility:** The substation is designed to step up the voltage of the electricity generated by the solar PV and VRFB system to a level suitable for transmission through the high-voltage grid. In this case, the voltage level is planned to be up to 132 kV, matching Eskom local transmission line voltage.

b) **Transformers:** Transformers play a central role in the substation by converting the voltage from the medium voltage level generated by the solar PV and VRFB system to the high-voltage level required for grid connection. The substation will incorporate transformers with appropriate ratings to ensure safe and efficient voltage transformation.

c) **Switchgear and Circuit Breakers:** The substation is equipped with switchgear and circuit breakers that allow for the control, protection, and isolation of electrical circuits. These components ensure that the system can be safely connected to and disconnected from the grid when necessary.

d) **Metering and Monitoring Equipment:** To monitor the flow of electricity, ensure grid stability, and facilitate accurate billing, the substation will include metering equipment to measure the amount of energy exported to the grid and other relevant electrical parameters.

The substation and high-voltage connection are fundamental elements of the Vametco Hybrid Mini Grid project, enabling the efficient integration of renewable energy into the local electrical grid at up to 132 kV. The robust design and adherence to industry standards reflect our commitment to safe, reliable, and sustainable electricity generation and distribution.

1.1.3.5 Key Aspects of Civil Works:

a) **Foundation Construction:** To support heavy equipment and ensure structural stability, reinforced concrete foundations are constructed. These foundations are tailored to the specific needs of various project components, including batteries, transformers, and electrical equipment. The design adheres to engineering standards and factors in load-bearing capacity and soil conditions at the site.

b) **Access Roads and Paths:** A network of access roads, pathways, and driveways is built to facilitate the transportation of equipment, materials, and personnel to and from various project locations, including battery sites and the substation. These pathways ensure efficient project operations during construction, maintenance, and emergencies.

c) **Plinths for Batteries:** Plinths are constructed to support the installation of the BESS units. These plinths are engineered to accommodate the weight and configuration of the batteries, ensuring a stable and secure platform for their operation.

d) **Spares and Security Rooms:** Infrastructure such as security rooms and storage facilities for spare parts and maintenance equipment are constructed. These rooms serve as critical components for operational efficiency, equipment maintenance, and overall project security.

e) **Drainage Systems:** Proper drainage is vital to prevent water accumulation around project components, safeguarding equipment from potential damage and operational disruptions. Stormwater drainage systems, including culverts and ditches, are designed and implemented to manage rainwater effectively.

f) **Security Measures:** Security measures, including fencing, access control systems, surveillance cameras, and intrusion detection systems, are implemented to protect critical project infrastructure, deter unauthorized access, and mitigate potential security risks.

g) **Environmental Considerations:** Environmental preservation and mitigation measures are an integral part of civil works. Erosion control measures, soil stabilization, and landscaping are employed to minimize the environmental impact of construction activities and promote sustainability.

h) **Compliance with Regulatory Standards:** All civil works adhere rigorously to relevant regulatory and safety standards, ensuring the safety of project personnel, the surrounding community, and the environment.

1.1.3.6 Key Aspects of the BESS:

Height and Electrolyte Quantity Considerations:

a) **Height Considerations:** Notably, the BESS, especially when employing VRFB technology, can stand as tall as 10 meters.

b) **Electrolyte Quantity:** It is important to underscore that the BESS involves the use of substantial quantities of electrolyte (hazardous substance), exceeding 500 cubic meters.

c) Layout:

a. Containerized BESS: The BESS may be configured within purpose-built containers, offering modularity and ease of deployment. Containerized solutions provide flexibility in scaling the energy storage capacity as per project requirements.

b. **Bespoke BESS:** Tailored BESS configurations may be designed to suit the specific needs of the project, allowing for optimization of space, capacity, and performance based on site constraints and operational demands.

c. **DC-Coupled BESS:** Alternatively, the BESS can be integrated in a DC-coupled configuration, positioned at the end of strings within the solar PV array. This approach minimizes energy losses and optimizes energy capture by interfacing directly with the PV system.

1.1.4 Activities

- Inverters and Transformers
- Up to 132 kV Transmission Lines and Transmission Towers
- BESS up to 800 MWh (note electrolyte and height requirements)
- Cabling Between Project Components
- Access and Internal Roads
- On-Site Facility Substation
- Borehole for Water Supply
- Telecommunications Mast
- O&M Buildings
- Car Park
- Security, Perimeter Fencing, and Access Control
- Temporary Offices and Construction Yard
- Water and Sewage Pipelines
- Temporary Laydown Area

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. The 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 making 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 perform 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) applies 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; and
(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 near the town of Brits, approximately 10 km northeast. The approximate central coordinates of the study site are 25°33'33.42"S and 27°54'1.98"E (Figure 1).

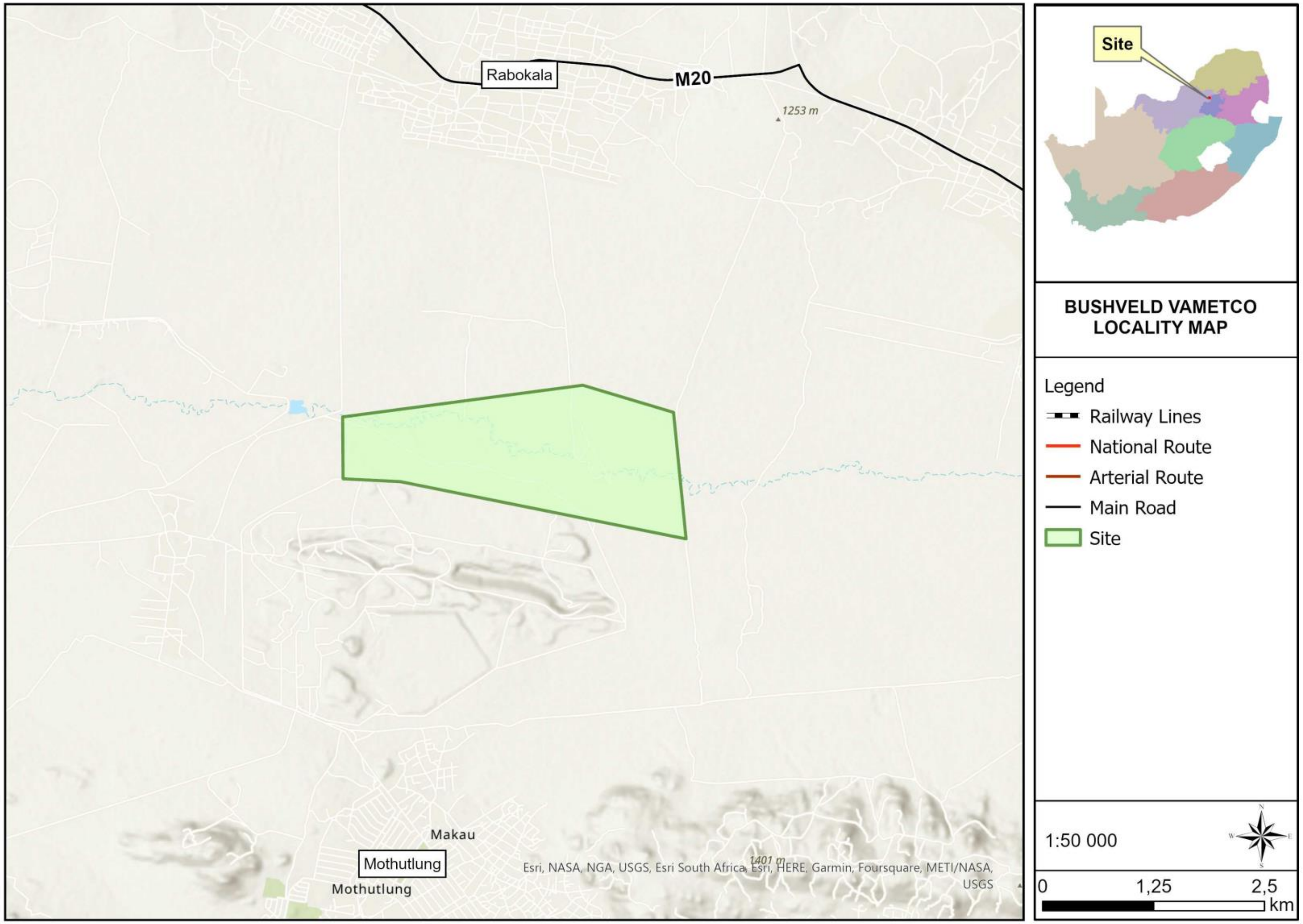
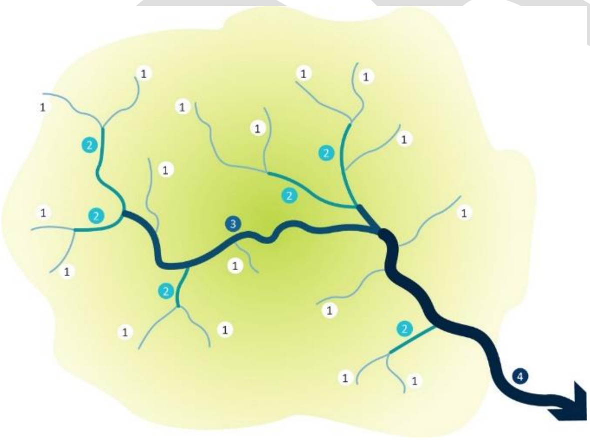


Figure 1: Locality Map

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 on 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/screening tool) - Aquatic	
	The watercourses associated with the study site are classified as highly sensitive, with the remainder of the study site classified as having low sensitivity.
Hydrology and National Freshwater Ecosystem Priority Area (NFEPA) (2011) Database	
Important Rivers (CDSM, 1996) (Figure 2)	The watercourse associated with the study site is known as the Rosespruit River which flows into the Crocodile River west of the study site.
Quaternary Catchment	A21J
WMA (Government Gazette, 16 September 2016)	WMA #1: Limpopo: Major rivers include the Limpopo, Matlabas, Mokolo, Lephalale, Mogalakwena, Sand, Nzhelele, Mutale, and Luvuvhu.
Strahler Stream Order 	The Strahler stream order is a method used to classify and understand the hierarchy of a river or stream network. It assigns a numerical value to each stream segment based on the number of tributaries it receives. The classification starts with the smallest streams, assigned an order of 1, and increases as streams combine. When two streams of the same order meet, the resulting stream segment is assigned an order that is one level higher. If two different order streams join, the order remains the same as the larger of the two streams. In terms of the watercourses located on the study site, most of the non-perennial streams are classified as 1st order streams
NFEPA, NBA Wetlands	The main watercourse located on the study site is classified as an NBA wetland. No NFEPA wetlands are located on the study site.
DWAF (2014) http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx	Reach 980 (PES=D)(EI=High)(ES=High)

Aquatic habitat	Aquatic habitat not suitable for a SASS5 and/or FRAI for majority of the year.	
General Description (Mucina & Rutherford, 2006)		
GPS Coordinates	25°33'33.42"S and 27°54'1.98"E	
Broad Vegetation Units (Figure 3 Error! Reference source not found.**)**	SVcb 6 –Marikana Thornveld	
Topography	Open *Acacia karroo* woodland, occurring in valleys and slightly undulating plains, and some lowland hills. Shrubs are denser along drainage lines, on termitaria and rocky outcrops or in other habitat protected from fire	
Climate	Summer rainfall with very dry winters. MAP between about 600- and 700-mm. Frost fairly frequent in winter	
Conservation Status	Endangered	
Geology (Figure 4)	Ferrogabbro, ferrodiorite and diorite of the Upper zone and gabbro, norite and anorthosite of the Main and Lower zones of the Bushveld Complex; some enclosed quartzite, hornfels and shale of the Pretoria Group.	Norite, gabbro, pyroxenite and anorthosite of the Bushveld Complex. Occasional dykes of syenite and diabase.
Soils	Ae21 - Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep (no dunes)	Ae3 - One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated
Land Use(from available aerial imagery)	Transformed by current and historical agriculture and mining.	
North West Critical Biodiversity Sector Plan (Figure 5)		
• Study area not currently listed • Vegetation is listed as endangered.		

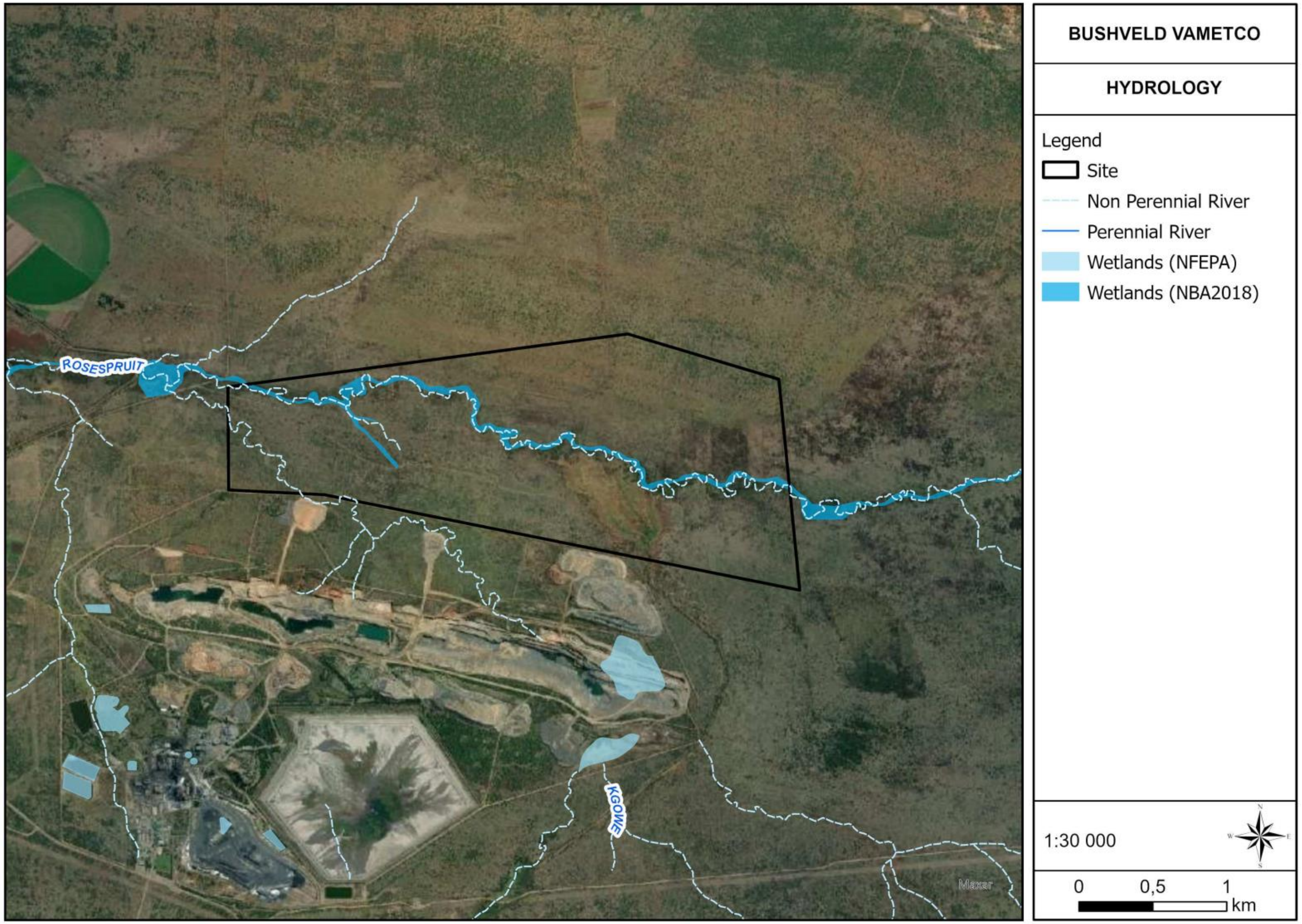


Figure 2: Regional hydrological features relative to the study site.

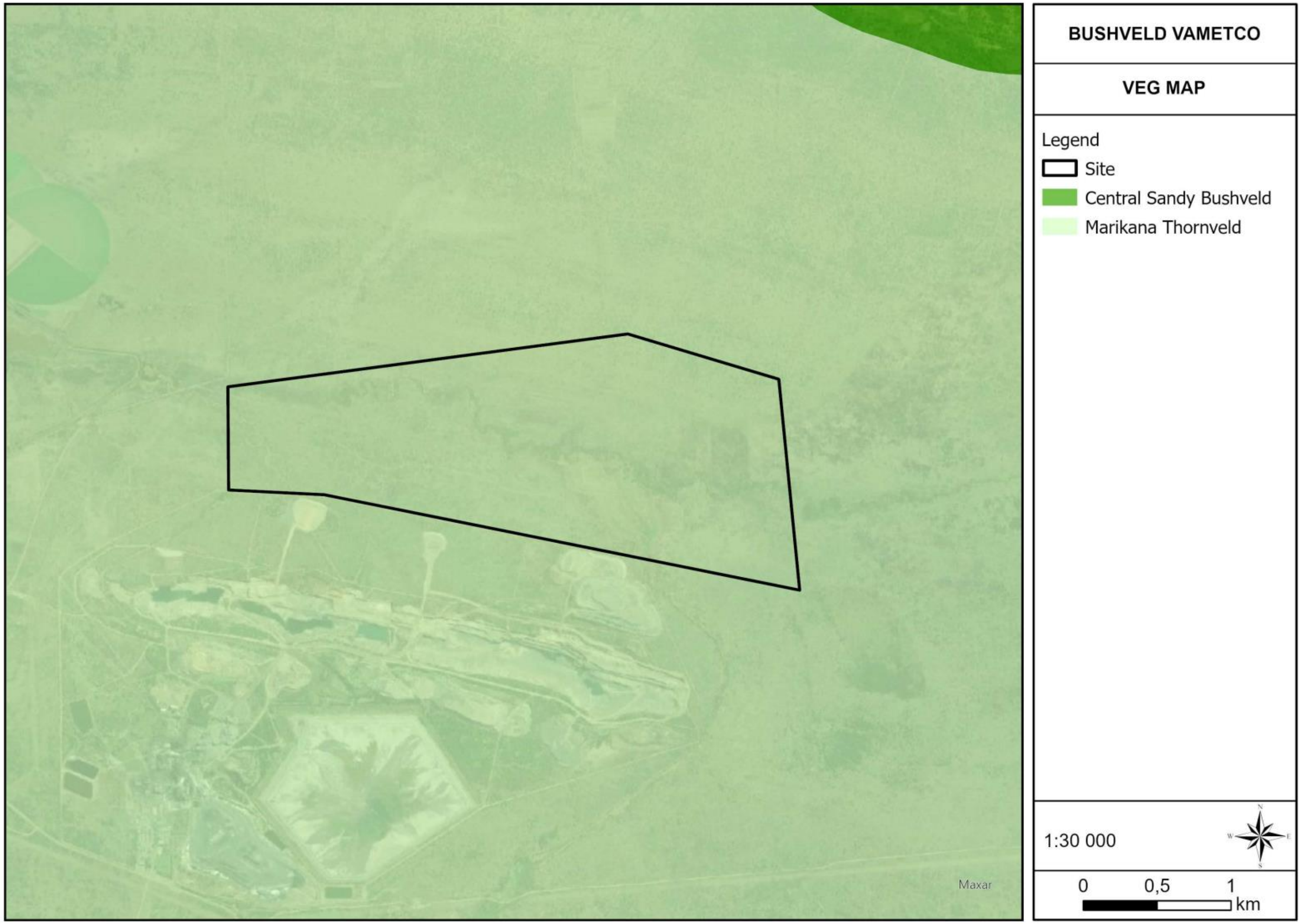


Figure 3: Vegetation units of the study site and surroundings.

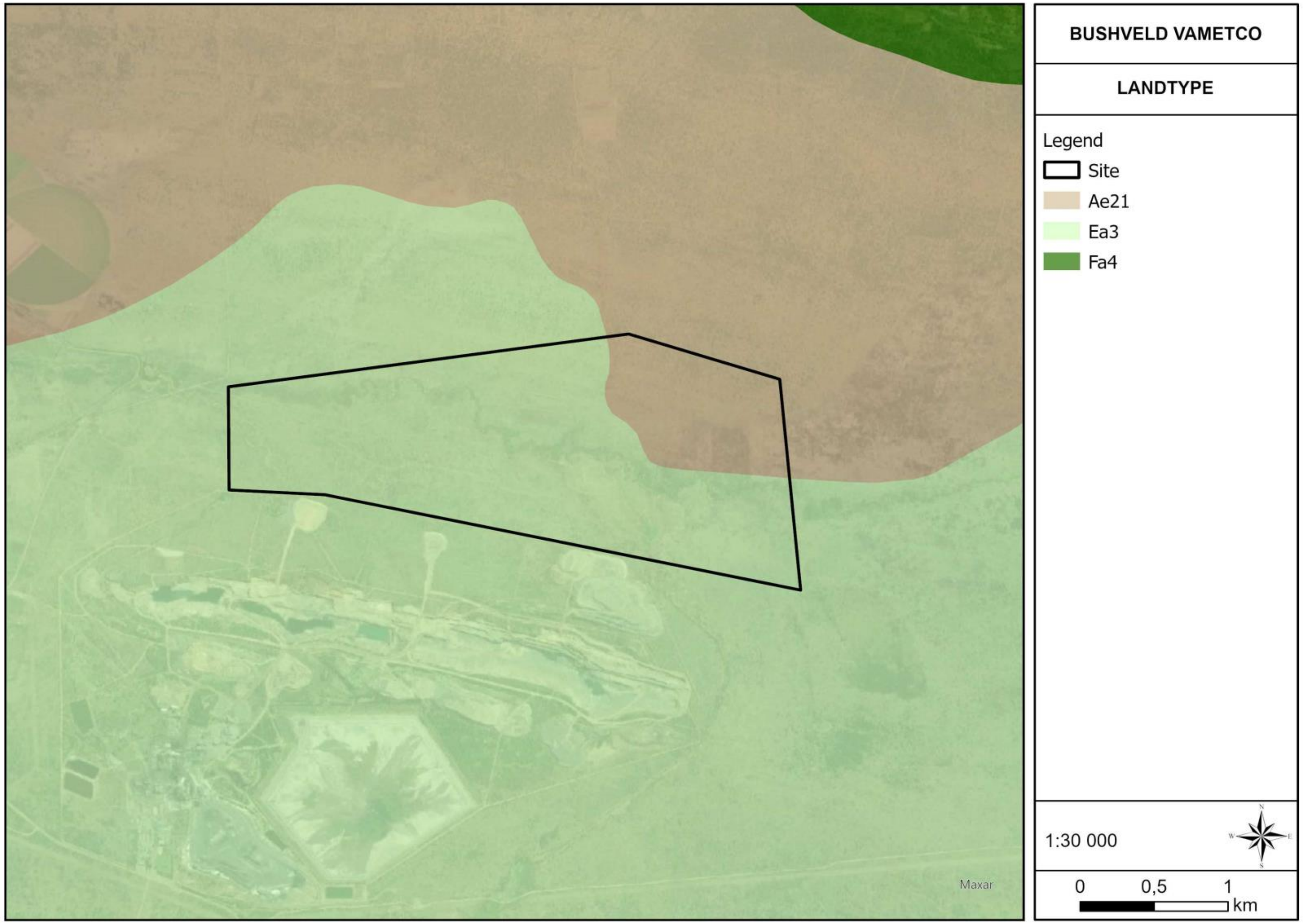


Figure 4: Geology of the study site.

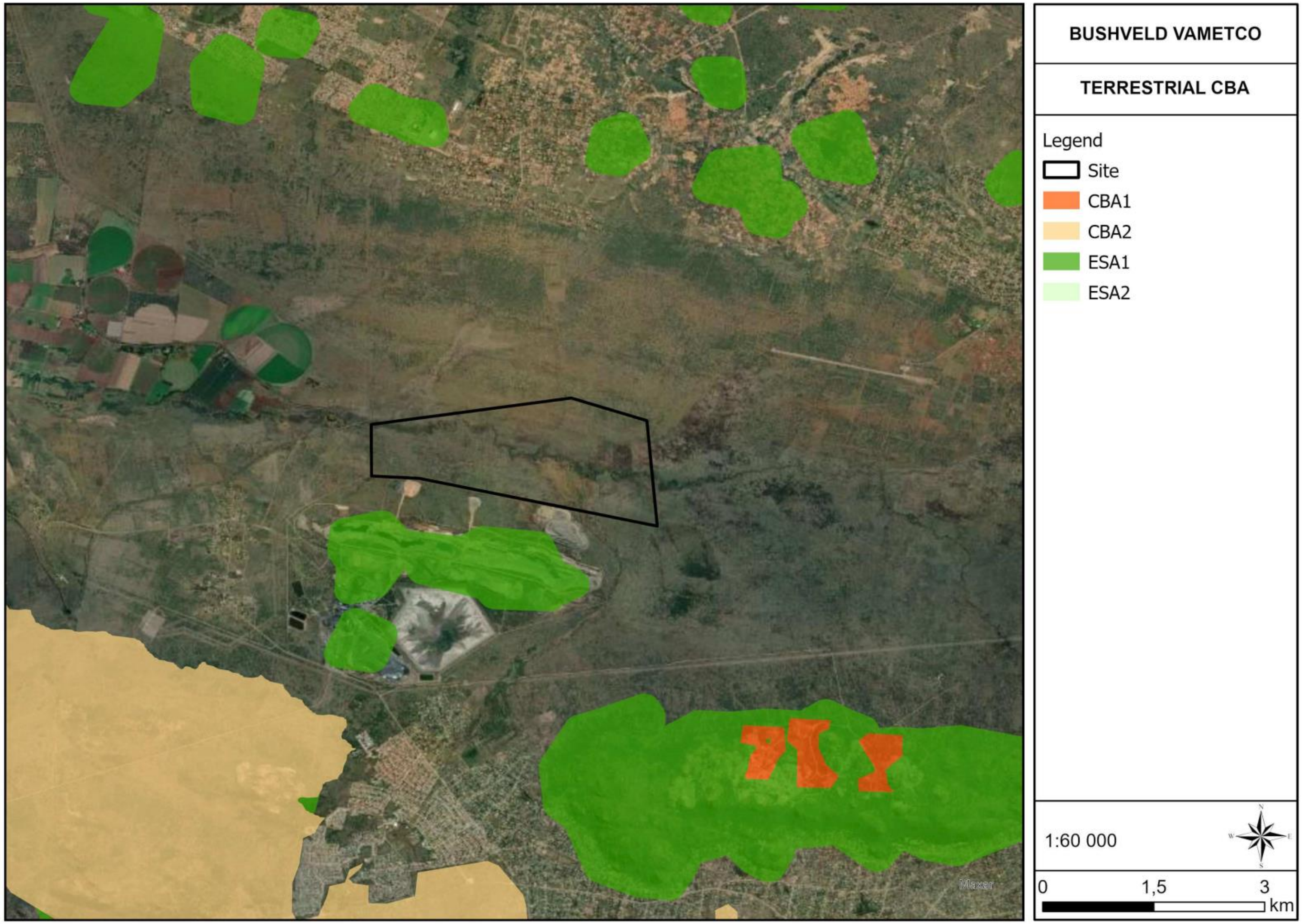


Figure 5: North West Critical Biodiversity Areas

2 METHODOLOGY

The delineation method is documented by the DWS "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 Ground truthed 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.

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 the 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 the 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) requires 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 a few families) are used in the interpretation of the status of the site or river being assessed depending 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 habitats 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 is to aid the interpretation of SASS data.

3 RESULTS

3.1 Land Use, Cover, and Ecological State

The proximity of agricultural fields to wetlands in the 1949 aerial image (Figure 6) suggests a historical interaction between agriculture and the wetlands and surrounding watercourses. The use of fertilizers, pesticides, and irrigation practices in agriculture can lead to the accumulation of chemicals in the soil. Over time, these substances may have been transported to the wetland through runoff or infiltration, potentially causing water pollution and affecting the quality of the wetland habitat. Excessive nutrient runoff from agricultural fields, such as nitrogen and phosphorus, can lead to eutrophication in the wetland, resulting in the proliferation of algae and aquatic plants, and subsequent oxygen depletion in the water, harming the overall ecosystem. Moreover, agricultural practices often involve land modification, such as drainage and irrigation systems, which can alter the hydrology of the area. If wetlands were drained or their natural water flow disrupted to accommodate agricultural activities, it could have had a negative impact on the wetland's hydrological cycle, affecting water availability, water table levels, and the overall functioning of the wetland ecosystem. Changes in water flow patterns can also impact the downstream watercourses, potentially causing changes in water quantity, sediment transport, and habitat availability for aquatic species.It is important to note that although the agriculture has decreased in recent years, the woody vegetation has increased adjacent to the main channel of the wetland. Additionally, the increase in water inputs has dramatically increased the size and wetness regime of sections of the wetland, especially in the south-eastern corner.

The low elevation of the study site, as indicated by an aerial elevation profile (Figure 7), is highly relevant to the understanding of wetlands in the landscape. Low-lying areas are often prime locations for the formation and persistence of wetlands due to their hydrological characteristics. Wetlands typically occur in areas where water accumulates or remains stagnant for extended periods. The low elevation allows water to naturally collect and form wetland habitats, creating favourable conditions for the growth of hydrophilic vegetation and the establishment of unique ecosystems. The low elevation contributes to the water dynamics of the landscape, as it affects the flow and retention of water within the study site. The hydrological processes in such areas often involve the movement of water from higher elevations to low-lying regions, where it collects and forms wetland features. Additionally, the low elevation can create a convergence point for water from surrounding higher areas, acting as a natural catchment for precipitation, surface runoff, and groundwater discharge. This convergence of water in low-lying areas provides the necessary moisture for wetland formation and sustains the hydrological balance within these ecosystems. Furthermore, the low elevation of the study site may also make it susceptible to flooding events.

Wetlands in low-lying areas can act as natural floodplains, effectively storing and absorbing excess water during periods of high precipitation or runoff. They serve as important buffers that help regulate water flow and mitigate the impacts of flooding on surrounding areas. Wetlands can act as natural sponges, reducing the peak flows and attenuating floodwaters, which helps protect downstream areas and prevent erosion.

Additionally, the current and historical open-cast vanadium mine can have significant impacts on wetlands. The excavation and extraction activities associated with mining can disrupt the hydrological balance of the area, leading to changes in water flow patterns and water availability within wetlands. The removal of vegetation and soil layers during mining operations can result in increased erosion and sedimentation, affecting the water quality and habitat suitability for wetland species. Additionally, the release of pollutants and contaminants, such as heavy metals and chemicals used in the mining process, can contaminate the water sources, posing a threat to the wetland ecosystem and potentially causing long-term damage.

The noise, dust, and increased human activity associated with mining operations can also disturb wildlife, disrupt breeding patterns, and alter the overall ecological dynamics of the wetland. The cumulative effects of these impacts can lead to the degradation, fragmentation, or loss of wetland habitats and the services they provide, highlighting the need for careful planning, mitigation measures, and monitoring to minimize the adverse effects on wetlands.

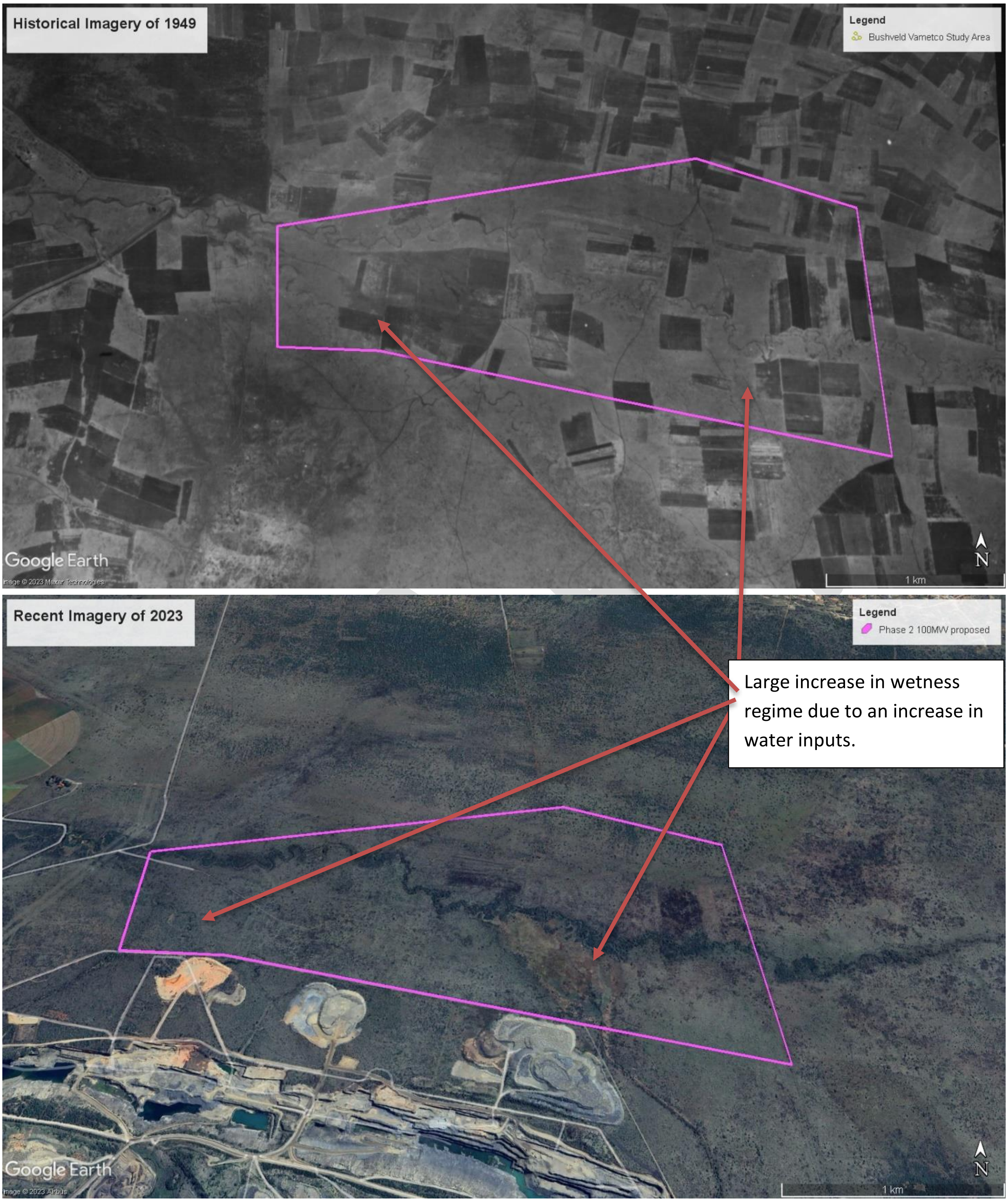


Figure 6: Indicating the historical impacts in 1949 (Top) compared to recent images of 2023 (Bottom) (Google Earth, 2023)

Figure 7: Elevation Profile of the study site (https://tessadem.com/

3.2 Wetland/Riparian Classification and Delineation

Three watercourse types were recorded on the study site (Figure 8). The watercourses are classified as per the following classification guidelines (Ollis *et al,* 2013):

- Channelled Valley Bottom Wetland
- Non-Perennial Episodic Riparian Area
- Seepage Wetland

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 Watercourses (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	Central Bushveld Group 2	Valley Floor	Channelled Valley Bottom
Non-Perennial Episodic Riparian Area			Slope (Low)	Lower Foothill Stream
Seepage			Valley Floor	Seepage

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 Watercourses (Ollis *et al*, 2013)

Wetland Name	**Dominant Hydroperiod**	
	Level 5A: Inundation Period	**Level 5B: Saturation Period**
Channelled Valley Bottom Wetland	Seasonally Inundated	Seasonally Saturated
Non-Perennial Episodic Riparian Area	Temporarily Inundated	Temporarily Saturated
Seepage	Seasonally Inundated	Seasonally Saturated

3.3 Buffer Zones

GN509 requires that a site-specific buffer zone be calculated following Macfarlane et al., 2015. This Excel-based tool recommend a minimum calculated buffer zone of 15 m for the Channelled Valley Bottom wetland, and Seepage Wetland and 15 m for the Episodic Stream.

A 500m regulated area around wetlands as required by the Department of Water and Sanitation is also reflected. Figure 8 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.

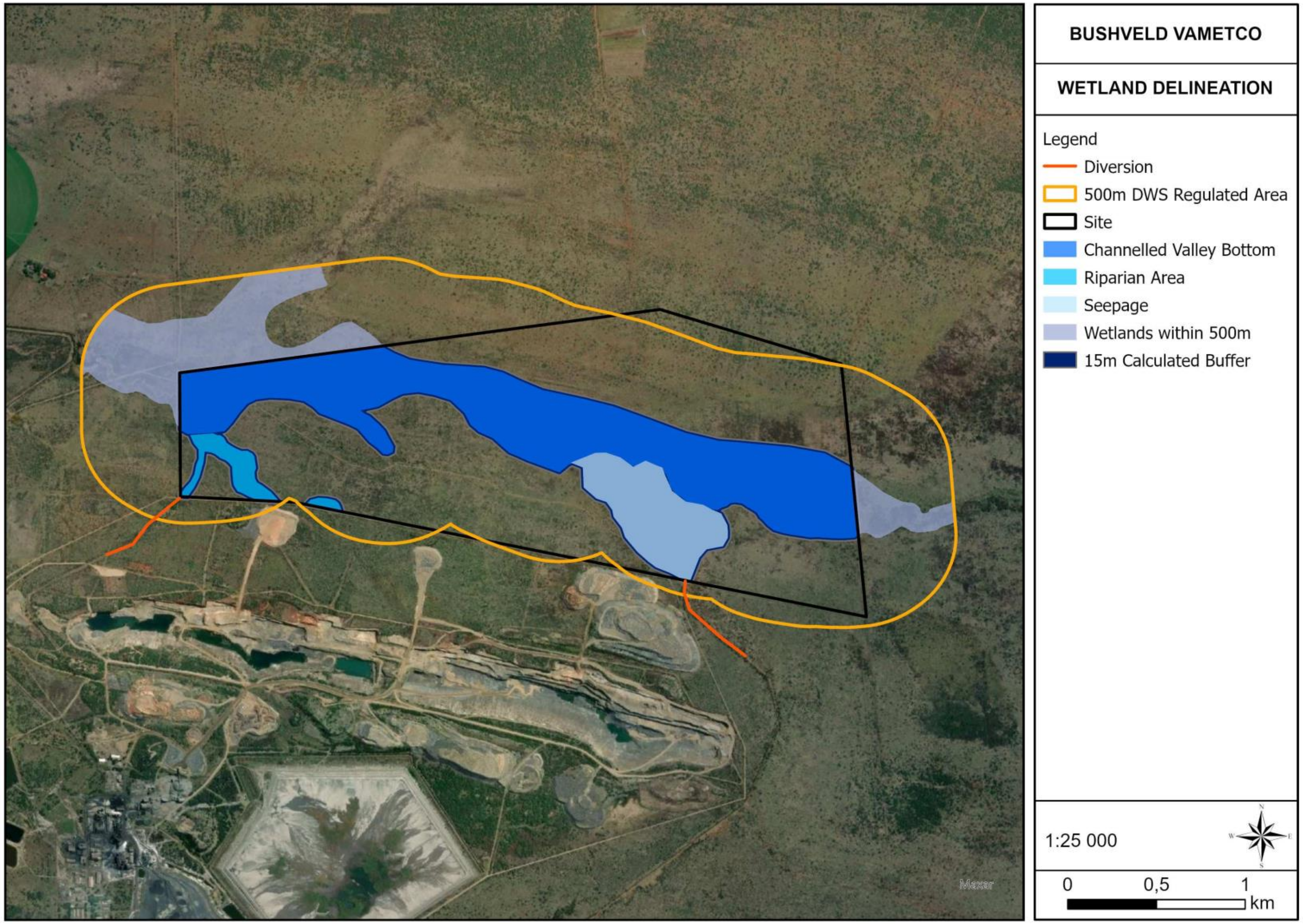


Figure 8: Delineated watercourses, their calculated buffers, and the DWS-regulated area relative to the study site.

3.3.1 Vegetation and Soil (Figure 9)

The soil within the study site is dominated by vertic dark clay soils. The predominant soil forms identified in the study area were the Arcadia and Rensburg soil forms. Vertic dark clay soils have a profound influence on wetlands due to their specific properties. These soils, characterised by their high clay content and unique behaviour of swelling and shrinking with changes in moisture levels, play a crucial role in shaping wetland ecosystems. The high clay content allows these soils to retain water, creating and maintaining moist conditions essential for wetland formation. This water retention capacity contributes to the development of saturated soil conditions, which are necessary for supporting wetland vegetation and facilitating the growth of wetland-dependent species. Additionally, the shrinkage and swelling characteristics of vertic dark clay soils contribute to the formation of cracks and fissures in the soil, creating microhabitats and channels that aid in water movement and exchange within the wetland. The Episodic streams did not indicate clear redoximoprhic signs.

Most of the watercourses are seasonally or temporarily inundated and/or saturated, therefore hydrophilic vegetation although present were not abundant. It should also be noted that at the time of the fieldwork, the area was very dry with large areas recently burnt. The dominant hydrophilic vegetation of the watercourses includes *Typha capensis, Persicaria lapathifolia*, *Imperata cylindrical and Phragmites australis.* The Episodic streams were dominated by terrestrial species occurring in the area. Common grasses identified during the field survey included *Aristida congesta* subsp. *congesta, Cynodon dactylon, Digitaria eriantha, Enneapogon cenchroides, Fingerhuthia africana, Heteropogon contortus, Melinis repens, Setaria sphacelata, Sporobolus nitens, Themeda triandra* and *Urochloa mossambicensis*.Additional woody species found in the area include *Asparagus laricinus, Diospyros lycioides* subsp. *lycioides, mucronata*, *Euclea crispa, Gymnosporia buxifolia, Vachellia karroo, Vachellia nilotica, Vachellia tortilis*, and *Ziziphus mucronata*. Furthermore, it was noted that *Dichrostachys cinerea*, an indigenous invasive species, had formed dense thickets in the area. Although Alien Invasive Species (AIS) were not dominant in the area some of the AIS recorded were *Pennisetum setaceum and Xanthium strumarium.*

A summary of the dominant vegetation and soil characteristics for a level 6 assessment is described in the Table 5 below and illustrated in the images below (Figure 9 .

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

<table>
<tr><th rowspan="3">Wetland Name</th><th colspan="6">Dominant Descriptor Categories (Level 6)</th></tr>
<tr><th rowspan="2">6A: Natural vs Artificial</th><th colspan="3">Vegetation Cover, Form and Status</th><th colspan="2">Substratum Type</th></tr>
<tr><th>6A: Veg Cover</th><th>6B, C & D Primary Form</th><th>6E: Veg Conditions</th><th>6A: Primary Category</th><th>6B: Secondary Category</th></tr>
<tr><td>Channelled Valley Bottom</td><td rowspan="3">Natural</td><td rowspan="3">Vegetated</td><td rowspan="2">Woody and Grass dominant</td><td rowspan="3">Predominantly indigenous</td><td rowspan="3">Clay Soil</td><td rowspan="3">Dark Clay</td></tr>
<tr><td>Non-Perennial Episodic Riparian Area</td></tr>
<tr><td>Seepage Wetland</td><td>Herbaceous and Grass with hydrophilic species</td></tr>
</table>

Figure 9: Watercourses vegetation characteristics including aerial images (bottom row)

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3.4 Watercourse Functional Assessment

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

Table 6: Assessments undertaken in the current assessment.

Watercourse Type	Assessment Method
Channelled Valley Bottom Wetland and Seepage Wetland	• **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).
Non-Perennial Episodic Streams	• **Ecological Category**: Riparian Vegetation Response Assessment Index (VEGRAI), (Kleynhans *et al.*, 2008), • **Ecosystem Services:** WetEcosystem Services V2 (ES) (Kotze *et al*., 2020); • **Ecological Importance and Sensitivity (EIS) -** (Kotze *et al*., 2020) and. • **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 (Figure 10). 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). It is important to note that these sample points will detect the impact of the solar farm on the aquatic ecosystem.

During the site visit, it was found that the proposed sample sites were dry. The system showed signs of flotsam- a clear indicator of ephemeral systems with sporadic flows during high rainfall events. Ideally, the area should be revisited after sufficient rainfall.

Figure 10: Sample sites of the study site

3.4.2 Present Ecological Status (PES)

The Present Ecological Status of each wetland on the study site are illustrated in Figure 11. The hydrology of the site is clearly altered with what seems to be a diversion around the mining operations. Water was observed in various areas where water was not expected, and it is suspected that this water is from artificial origins.

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

The Channelled Valley Bottom 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 7).

Table 7: 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	3.1	2.2	2.3	5.8
PES Score (%)	69%	78%	77%	42%
Ecological Category	C	C	C	D
Trajectory of change	→	→	→	→
Confidence (revised results)	Moderate			
Combined Impact Score	3.3			
Combined PES Score (%)	67%			
Combined Ecological Category	C			

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

The Seepage wetland has been greatly impacted by increased water input from a diversion channel to the south. Due to the increased water input, the wetland has expanded from its initial size. The wetland achieved a Combined Impact Score of **6.8 – 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. The condition of this wetland is likely to remain stable over the next 5 years (Table 8). As previously described the seepage wetland has dramatically increased in size due to anthropogenic increase in water inputs. It is no longer possible to distinguish between artificial wet areas and natural wet areas. However, it is likely that the wetland will decrease in size should the water inputs be stopped.

Table 8: Summary of the results of the WetHealth (Version 2) assessment conducted for the Seepage Wetland.

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	6.9	7.1	6.3	6.5
PES Score (%)	31%	29%	37%	36%
Ecological Category	E	E	E	E
Trajectory of change	→	→	→	→
Confidence (revised results)	Moderate			
Combined Impact Score	6.8			
Combined PES Score (%)	32%			
Combined Ecological Category	E			

3.4.2.3 Ecological Category (VEGRAI) for the Episodic Stream

The Episodic Streams scored an EC of **D** was calculated for the Non-Perennial Episodic Stream (Table 9). This score refers to watercourses that are **Largely modified.** A large loss of natural habitat, biota, and basic ecosystem functions has occurred. (Kleynhans, 1996 & Kleynhans, 1999). As previously described the riparian area has also dramatically increased in size due to anthropogenic increase in water inputs. It is no longer possible to distinguish between artificial wet areas and natural wet areas. However, it is likely that the wetland will decrease in size should the water inputs be stopped.

Table 9: Results of the VEGRAI scores obtained by the Episodic Stream (Kleynhans *et al.*, 2008).

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	55.4	15.8	2.5	2.0	40.0
NON-MARGINAL	53.3	38.1	2.5	1.0	100.0
	2.0				140.0

LEVEL 3 VEGRAI (%)	53.9
VEGRAI EC	**D**
AVERAGE CONFIDENCE	2.5

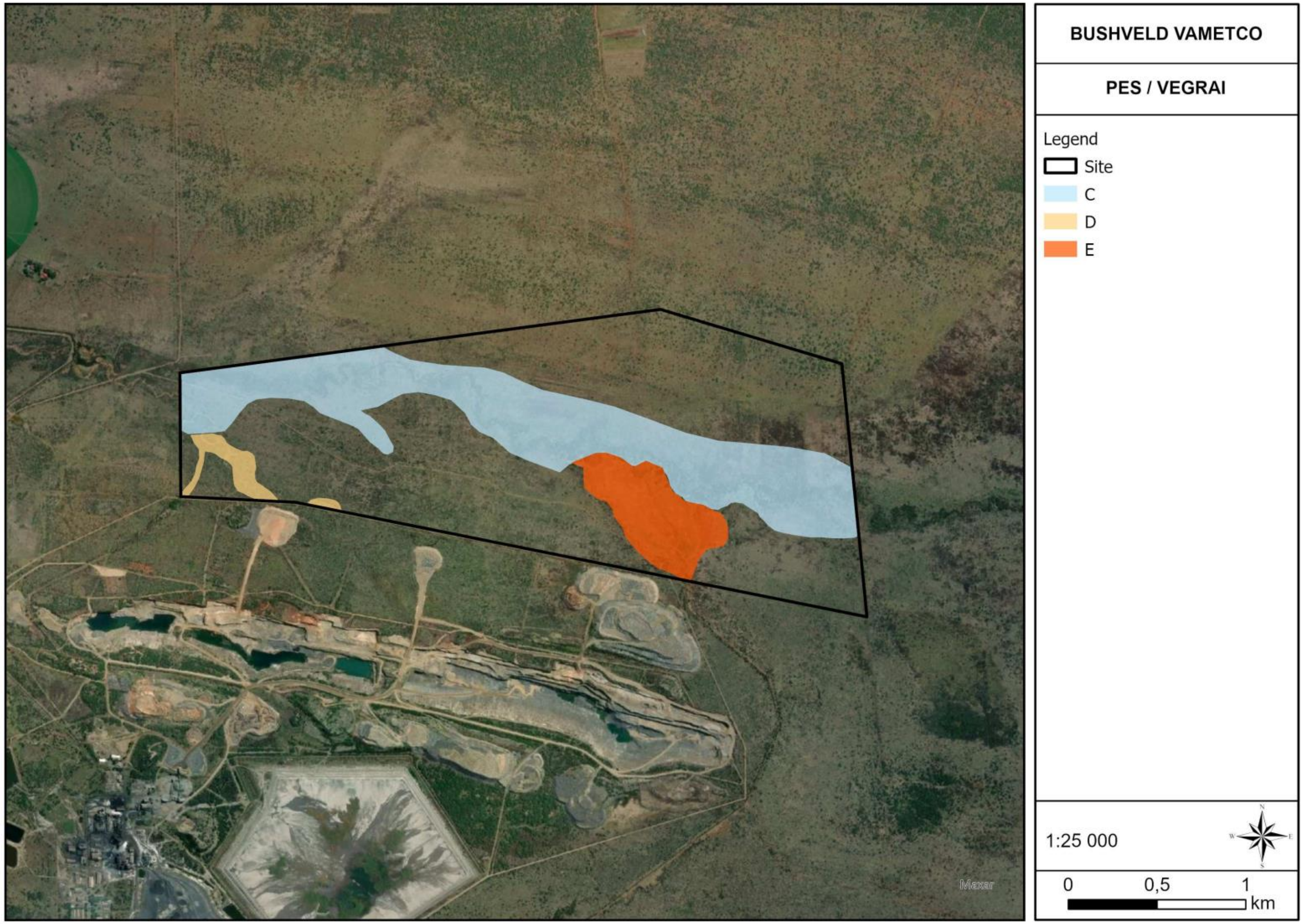

Figure 11: Present Ecological Status (PES) of the wetlands recorded on the study site.

3.4.2.4 WetEcoServices Kotze et al., (2020) for the Channelled Valley Bottom (Figure 12)

The ecosystem services provided by Channelled Valley Bottom wetlands are presented in Table 10 below. The highest scores were obtained for Flood attenuation, Sediment trapping, Erosion control , and Biodiversity maintenance.

Table 10: Summary of the Ecosystem Services provided by Channelled Valley Bottom Wetland

		Present State			
ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	3.1	2.3	2.8	High
	Stream flow regulation	2.0	1.3	1.2	Low
	Sediment trapping	3.1	2.2	2.7	High
	Erosion control	3.4	2.0	2.9	High
	Phosphate assimilation	2.1	2.0	1.6	Moderately Low
	Nitrate assimilation	2.2	1.0	1.2	Low
	Toxicant assimilation	2.3	2.0	1.8	Moderate
	Carbon storage	2.0	1.9	1.5	Moderately Low
	Biodiversity maintenance	3.2	2.0	2.7	High
PROVISIONING SERVICES	Water for human use	0.6	2.7	0.4	Very Low
	Harvestable resources	2.5	0.3	1.2	Low
	Food for livestock	2.3	0.3	0.9	Low
	Cultivated foods	2.0	1.3	1.2	Low
CULTURAL SERVICES	Tourism and Recreation	0.8	0.0	0.0	Very Low
	Education and Research	0.8	0.3	0.0	Very Low
	Cultural and Spiritual	2.0	0.0	0.5	Very Low

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

The highest EIS score of 2.8 falls in the **High** category. 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 from major rivers. The importance of services supplied is high relative to that supplied by other wetlands.

- ***Biodiversity maintenance importance***: 2.7 (High)
- ***Regulating services importance***: 2.9 (High)
- ***Provisioning and cultural services importance:*** **1**.2 (Low)

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

Following the method set out in Rountree *et al.,* (2013), the PES value of C and a High EIS class, leads to the identification of an REC of A (Table 11). This means that the development should be done in such a way as to try and improve the EC values if possible, to a B/C.

Table 11: 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

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

The ecosystem services provided by the Seepage wetlands are presented in Table 12 below. The highest scores were obtained for Toxicant assimilation and Phosphate assimilation this is, likely due to the increased water inputs into the wetland.

Table 12: Summary of the Ecosystem Services provided by Seepage Wetland

		Present State			
ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.1	0.2	0.0	Very Low
	Stream flow regulation	1.7	1.3	0.8	Low
	Sediment trapping	2.1	1.0	1.1	Low
	Erosion control	0.8	0.4	0.0	Very Low
	Phosphate assimilation	2.2	1.5	1.5	Moderately Low
	Nitrate assimilation	2.0	1.5	1.3	Low
	Toxicant assimilation	2.3	2.0	1.8	Moderate
	Carbon storage	1.1	0.0	0.0	Very Low
	Biodiversity maintenance	1.9	0.0	0.4	Very Low
PROVISIONING SERVICES	Water for human use	0.4	0.0	0.0	Very Low
	Harvestable resources	2.0	0.0	0.5	Very Low
	Food for livestock	1.0	0.0	0.0	Very Low
	Cultivated foods	3.0	0.0	1.5	Moderately Low
CULTURAL SERVICES	Tourism and Recreation	0.4	0.0	0.0	Very Low
	Education and Research	0.8	0.0	0.0	Very Low
	Cultural and Spiritual	2.0	0.0	0.5	Very Low

3.4.2.8 Ecological Importance and Sensitivity (EIS) of the Seepage Wetland

The highest EIS score of 1.8 falls in the **Moderate** category for the Seepage wetland. Based on these calculation the Seepage wetlands 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 (DWAF, 1999). The importance of services supplied is moderately-high relative to that supplied by other wetlands (Kotze, *et al* 2020)

- ***Biodiversity maintenance importance***: 0.4 (Very Low)
- ***Regulating services importance***: **1.8 (Moderate)**

- ***Provisioning and cultural services importance:*** **1.5 (**Moderately Low**)**

3.4.2.9 Recommended Ecological Category (REC) of the Seepage Wetland

Following the method set out in Rountree *et al.,* (2013), the PES value of E and a Moderate EIS class, leads to the identification of an REC of E/F (Table 13). This means that the development should be done in such a way as to try and maintain the EC values if possible.

Table 13: 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

3.4.2.10 WetEcoServices Kotze et al., (2020) for the Riparian Episodic Stream

The ecosystem services provided by the Episodic Stream are presented in Table 14 below. The highest scores were obtained for Cultivated foods due to the presence of farms downstream of the watercourse.

Table 14: Summary of the Ecosystem Services provided by Episodic Stream

		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	-	-	-	-
	Sediment trapping	0.9	0.8	0.0	Very Low
	Erosion control	0.3	0.8	0.0	Very Low
	Phosphate assimilation	0.9	0.8	0.0	Very Low
	Nitrate assimilation	1.0	0.8	0.0	Very Low
	Toxicant assimilation	1.0	0.8	0.0	Very Low
	Carbon storage	1.3	0.0	0.0	Very Low
	Biodiversity maintenance	0.5	0.0	0.0	Very Low
PROVISIONING SERVICES	Water for human use	0.0	0.7	0.0	Very Low
	Harvestable resources	1.5	0.3	0.2	Very Low
	Food for livestock	1.0	0.3	0.0	Very Low
	Cultivated foods	3.5	0.3	2.2	Moderate
CULTURAL SERVICES	Tourism and Recreation	0.4	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	2.0	0.0	0.5	Very Low

3.4.2.11 Ecological Importance and Sensitivity (EIS) of the Episodic Stream

The highest EIS score of 2.2 falls in the **Moderate** category. These Wetlands that are 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 (DWAF, 1999). The importance of services supplied is moderately-high relative to that supplied by other wetlands (Kotze, *et al* 2020)

- ***Biodiversity maintenance importance***: 0.0 (Very Low)
- ***Regulating services importance***: 0.0 (Very Low)
- ***Provisioning and cultural services importance:* 2.2 (Moderate)**

3.4.2.12 Recommended Ecological Category (REC) of the Episodic Stream

Following the method set out in Rountree *et al.,* (2013), the PES value of D and a Moderate EIS class, leads to the identification of an REC of E/F (Table 15Table 13). This means that the development should be done in such a way as to try and maintain the EC values if possible.

Table 15: 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 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 examined in this report should thus be regarded as having a High Sensitivity (Table 16):

Table 16: 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 habitats.	Based on BI – Medium and RR – Very Low = High

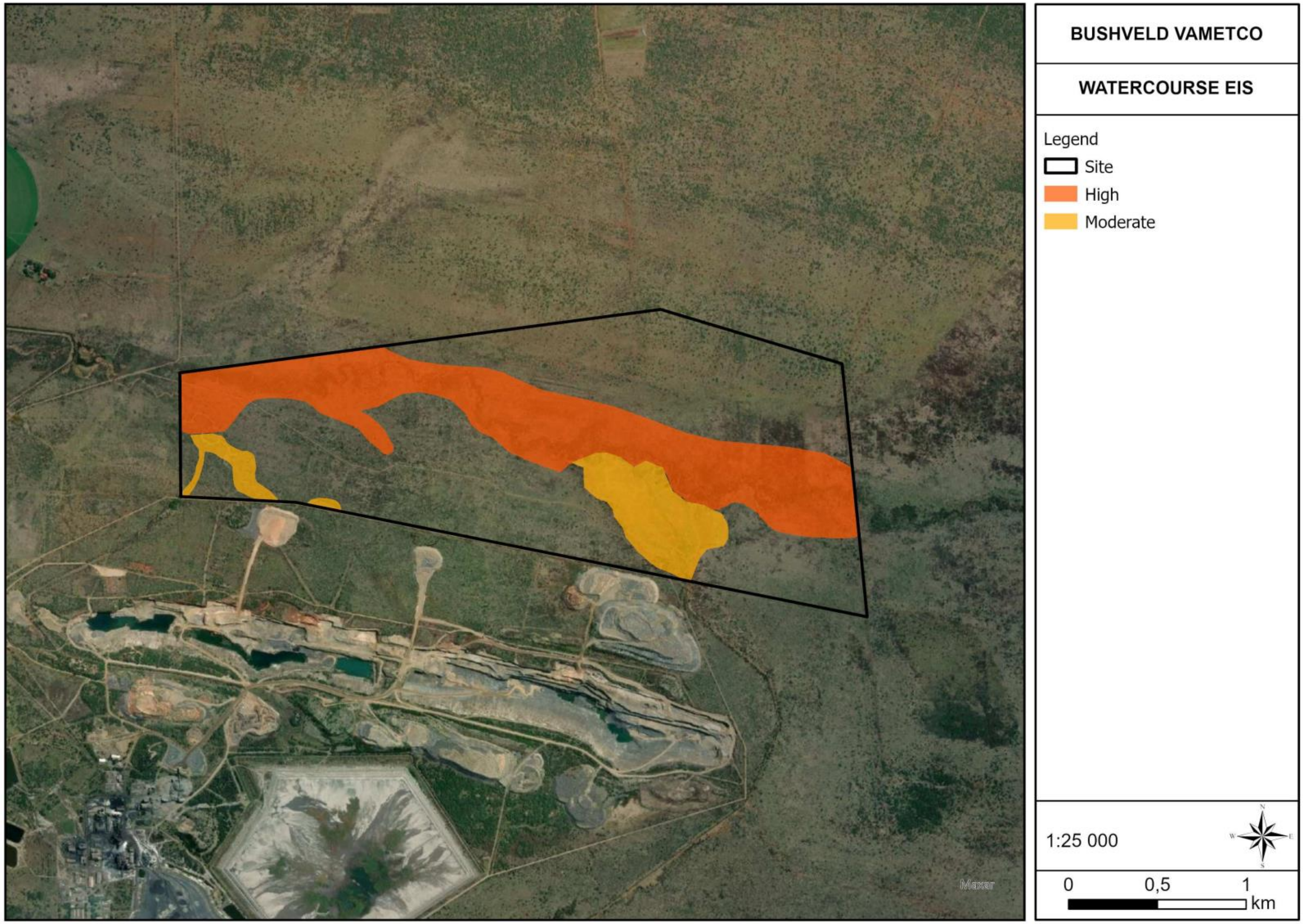

Figure 12: The EIS of each wetland on the study site

3.5 Site Layout Considerations (Taken Verbatim)

3.5.1 Option 1 (Figure 13)(low feasibility)

The viability of the project is notably impacted by the limited size of the site, which is further complicated by its division into three sub-areas. This division necessitates the establishment of multiple substations, connections between sites, and the construction of additional roadways and bridges.

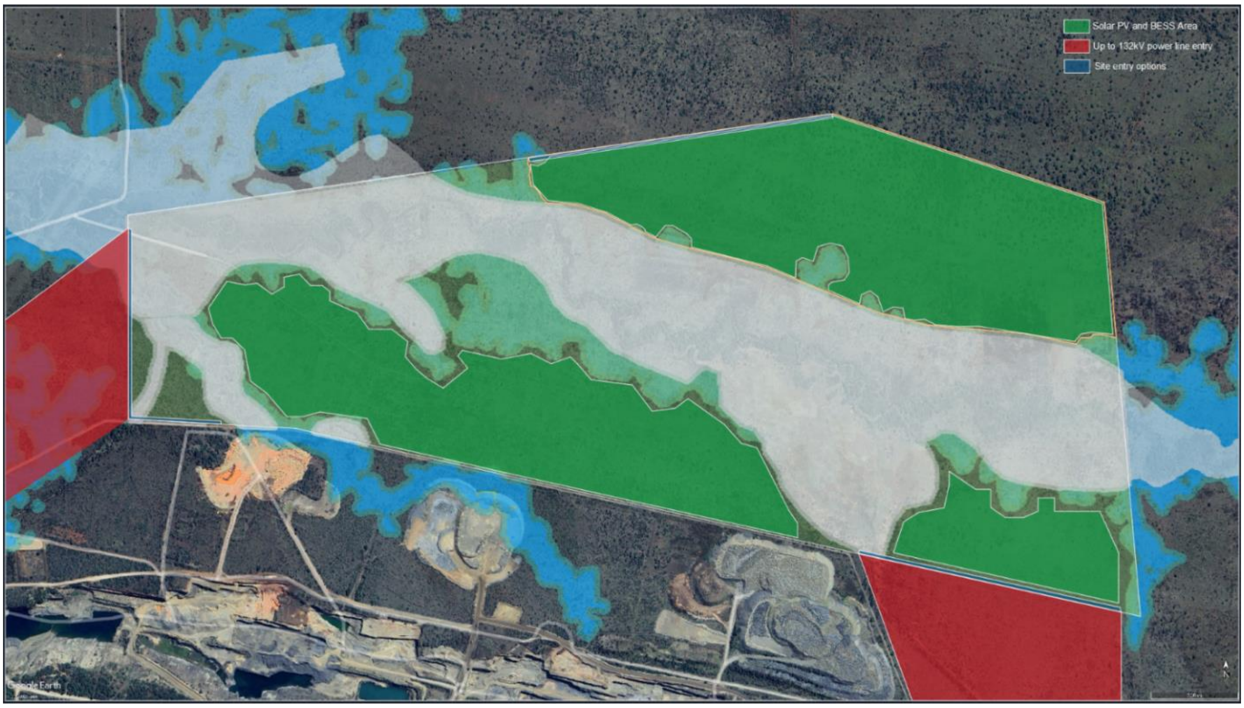

Figure 13: Option 1 - Avoidance of all wetland areas.

3.5.2 Option 2 (obstructive)

The figure below illustrates Option 2 (Figure 14), which strategically avoids the primary wetland/river area. The site is divided into two main sections, north and south, with access to the northern section facilitated by a bridge from the south. The green areas denote the locations designated for the two solar PV and BESS installations, while the red areas mark potential entry points for the transmission line. The corridor to the south measures 925 meters at its widest point, while the western corridor spans 660 meters at its widest. Small blue blocks on the figure indicate the potential site entry points. It's important to note that this option introduces its own set of challenges, including the construction of a bridge and the need to navigate areas designated as wetlands.

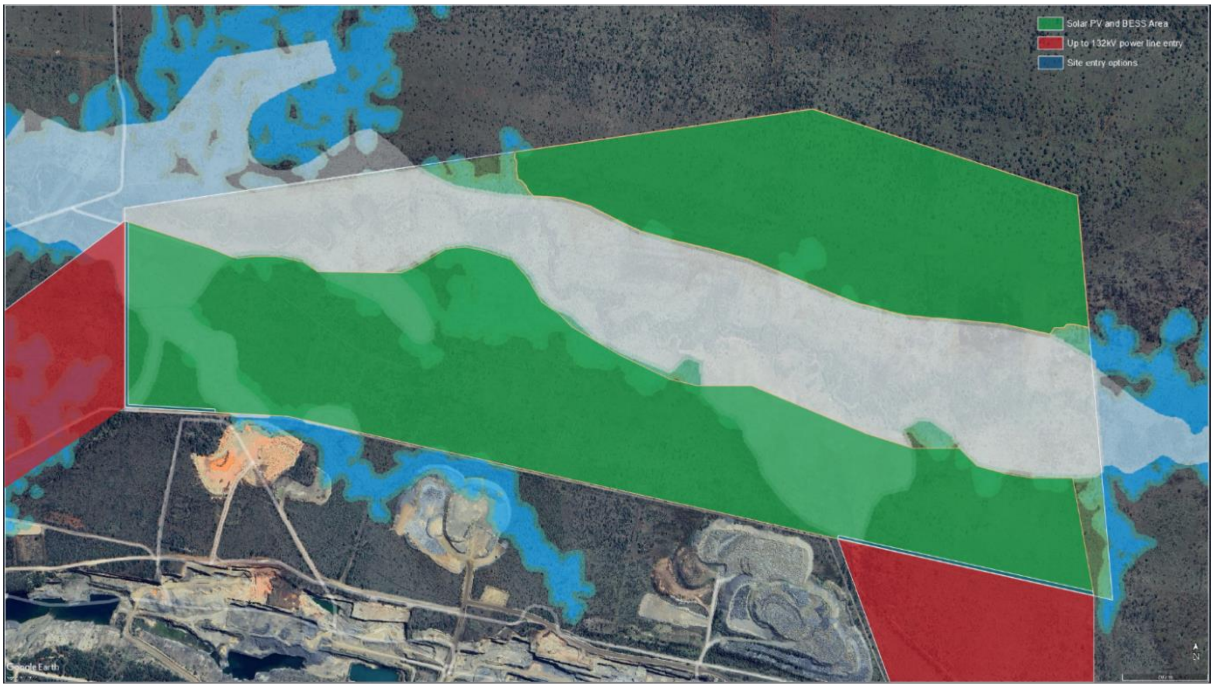

Figure 14; Option 2 - Avoids main wetland section.

3.5.3 Option 3 (proposed Option)

Option 3, as illustrated in the figure below (Figure 15), includes the diversion of the sewerage spillway to the south of the site and redirects a smaller stream to the west. Additionally, this option excludes a smaller portion of the wetland area in the central-western region, effectively minimizing the environmental impact on crucial wetland areas. Access to the site will be facilitated by a road to the north, leveraging existing road infrastructure and eliminating the need for a bridge

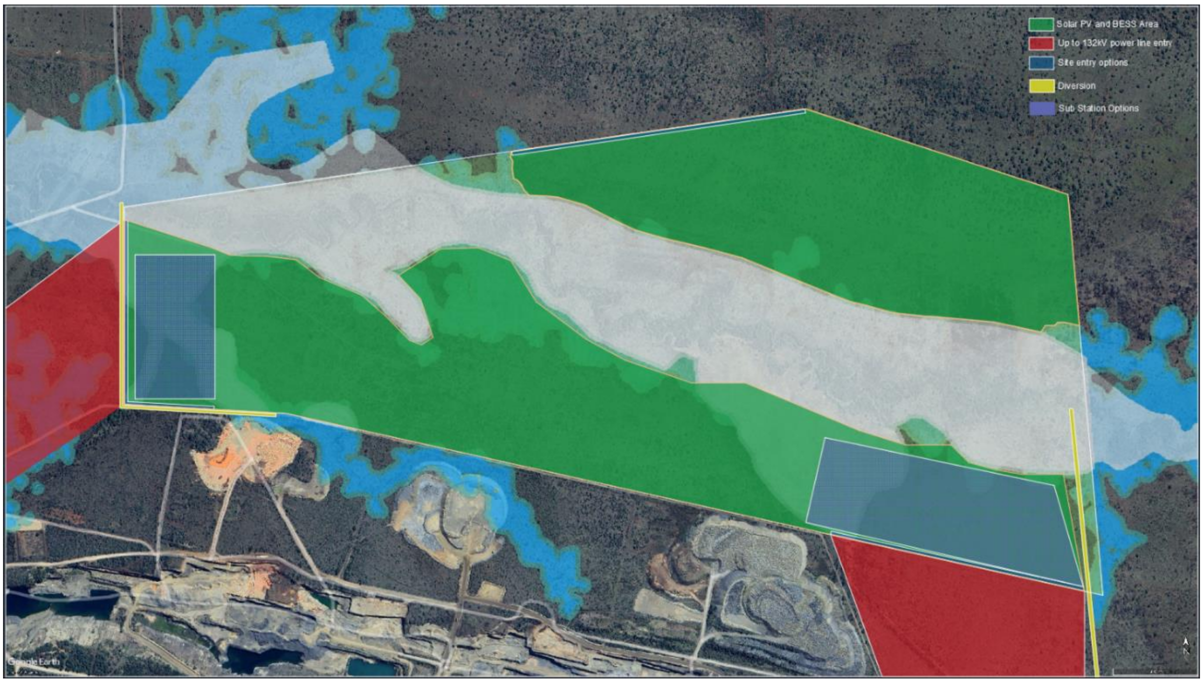

Figure 15: Option 3 - Avoids main wetland and additional smaller section.

Necessity of Diversion:

The decision to propose a river diversion within the scope of the Vametco Hybrid Mini Grid project is driven by the imperative to ensure project viability and effectiveness. While alternatives were indeed considered, the fundamental need arises from the project's requirement for a continuous and uninterrupted expanse of land within the project site. This continuity is essential for the efficient placement and integration of critical infrastructure, including solar photovoltaic (PV) arrays and battery energy storage systems (BESS). The alternatives examined revealed that any division of the project site due to the anthropogenic water features would significantly limit the available area for renewable energy installations. To maximize the project's energy generation capacity and uphold its economic feasibility, the river diversion becomes a strategic and necessary solution.

3.6 Site Layout Considerations – Discussion

3.6.1 Option 1

From the perspective of wetland conservation, Option 1 is **favoured** as it minimises the environmental impact on the wetlands by circumventing any development within the wetlands or their associated buffer zones. Nevertheless, the feasibility of this option is significantly constrained by the limited spatial dimensions of the site. The complexity is further exacerbated by the site's subdivision into three distinct sub-areas. Such a division mandates the installation of multiple electrical substations, the establishment of inter-site connections, and the construction of supplementary roadways and bridges.

3.6.2 Option 2

From a wetland conservation standpoint, Option 2 emerges as the **least favourable** alternative, given that it would impact or result in the loss of approximately **42.86 hectares** of wetland area, excluding buffer zones. It is imperative to clarify that the dimensions of two of these watercourses have been significantly augmented due to anthropogenic water inputs. Consequently, the size of the wetlands is likely to diminish if these water inputs are eliminated. The site under consideration will be partitioned into two primary sections, namely the northern and southern areas. Access to the northern section will be facilitated via a bridge originating from the southern section. It is noteworthy that this option introduces its own set of complexities, including the construction of a bridge and the necessity to manoeuvre through areas designated as wetlands.

3.6.3 Option 3

From the vantage point of wetland conservation, Option 3 ranks as the **second most** advantageous choice, as it is projected to have a lesser impact on, or loss of, wetlands, affecting an estimated **38.93 hectares** (*sans* buffer zones). It is crucial to point out again that the size of two of these watercourses has been substantially augmented due to anthropogenic water inputs. This option entails the rerouting of the sewage spillway to the southern portion of the site and the diversion of a smaller stream towards the west, actions that are likely to result in a reduction of the wetland's overall dimensions (likely to a more natural state prior to water inputs). Furthermore, this alternative omits a smaller section of the wetland situated in the central-western region, thereby effectively minimising the environmental repercussions on critical wetland areas. Access to the site will be provided through a northern roadway, capitalising on existing road infrastructure and obviating the necessity for bridge construction.

3.7 Summary of Findings

A summary of the findings is represented in the Table 17 below.

Table 17: Summary of scores obtained for the wetlands on the study site

Classification (SANBI, 2013)	Channelled Valley Bottom Wetland	Seepage Wetland	Episodic Stream
EC Scores (PES - WetHealth Version 2 (Macfarlane *et al*., 2020)/ VEGRAI	**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.	**E – Seriously Modified.** Seriously Modified. The change in ecosystem processes and loss of natural habitat and biota is excessive, but some remaining natural habitat features are still recognizable. The condition of this wetland is likely to remain stable over the next 5 years	**D – Largely modified.** A large loss of natural habitat, biota, and basic ecosystem functions has occurred.
WetEcoServices (Kotze *et al*., 2020) –	**High category.**	**Moderate Category**	
REC (Rountree *et al*, 2013)	**REC of B/C**. This means that the development should be done in such a way as to try and improve the EC values if possible.	**REC of E/F** This means that the development should be done in such a way as to try and maintain the EC values if possible.	**REC of D**. This means that the development should be done in such a way as to try and maintain the EC values if possible.
Calculated Buffer Zone (Macfarlane *et al*, 2015)	**15 m**		
In situ Water Quality	No flowing water was observed during the site visit. This should ideally be revisited after sufficient rainfall in the area.		
Instream Habitat assessment:			
Aquatic macroinvertebrate assemblages:			
	Layout Option 1	Layout Option 2	Layout Option 3

Order Of Preference	**Most Preferred** – Likely to result in the least amount of impact/loss of wetlands. However, the proposed option has several technical difficulties.	**Least Preferred** – Will impact and or cause the loss of approximately 42.86 ha (excluding Buffer Zones) of wetland.	**Second Preferred –** Will result in less wetland impact/loss of 38.93 ha (excluding buffer zones) of wetlands. This option entails the rerouting of the sewage spillway to the southern portion of the site and the diversion of a smaller stream towards the west, actions that are likely to result in a reduction of the wetland's overall dimensions (likely to a more natural state prior to water inputs)
	It is imperative to clarify that the dimensions of two of these watercourses (sections that are proposed to be developed over) have been significantly augmented due to anthropogenic water inputs. Consequently, the size of the wetlands is likely to diminish if these water inputs are eliminated. Furthermore, the natural historical size of these wetland is significantly smaller from the current state based on historical aerial imagery.		

4 General Principles of Watercourse Protection

Should Option 1 not be plausible, it is suggested that Option 2 be used. This will however result in some wetland loss. However, these wetland areas have increased in size due to anthropogenic water inputs and are larger than the natural historical conditions and the rerouting of these water inputs will likely reduce the overall size of the current wetland footprint. The following mitigation hierarchy indicates the preferred hierarchy when considering watercourse protection (Figure 16).

1. Avoid/Prevent: This is the highest priority in the hierarchy and involves avoiding or preventing impacts to watercourses altogether. It focuses on identifying and selecting alternative actions or locations that do not pose a risk to watercourses. This may involve changing the design or selecting a different site altogether to avoid potential negative impacts.
2. Minimise: If avoidance is not possible, the next step is to minimize the potential impacts on watercourses. This involves employing measures and techniques to reduce the extent, magnitude, duration, or intensity of the impacts. Examples include implementing erosion and sediment control measures, using best management practices for stormwater management, and adopting sustainable water use practices.
3. Rehabilitate: If impacts occur despite avoidance and minimisation efforts, the next step is to rehabilitate or restore the affected watercourses. This involves taking action to improve the ecological, hydrological, and geomorphological functions of the impacted areas. It may include restoring natural vegetation, improving water quality, stabilising banks, and enhancing habitat for aquatic species.
4. Offset: If complete avoidance, minimisation, or rehabilitation is not feasible or insufficient to mitigate the impacts, offsetting measures can be considered. Offset measures aim to compensate for the residual impacts by restoring or creating new watercourse features elsewhere. This may involve

creating or enhancing watercourses, establishing buffer zones, or implementing other habitat restoration projects to achieve a net benefit for watercourses and their associated ecosystems.

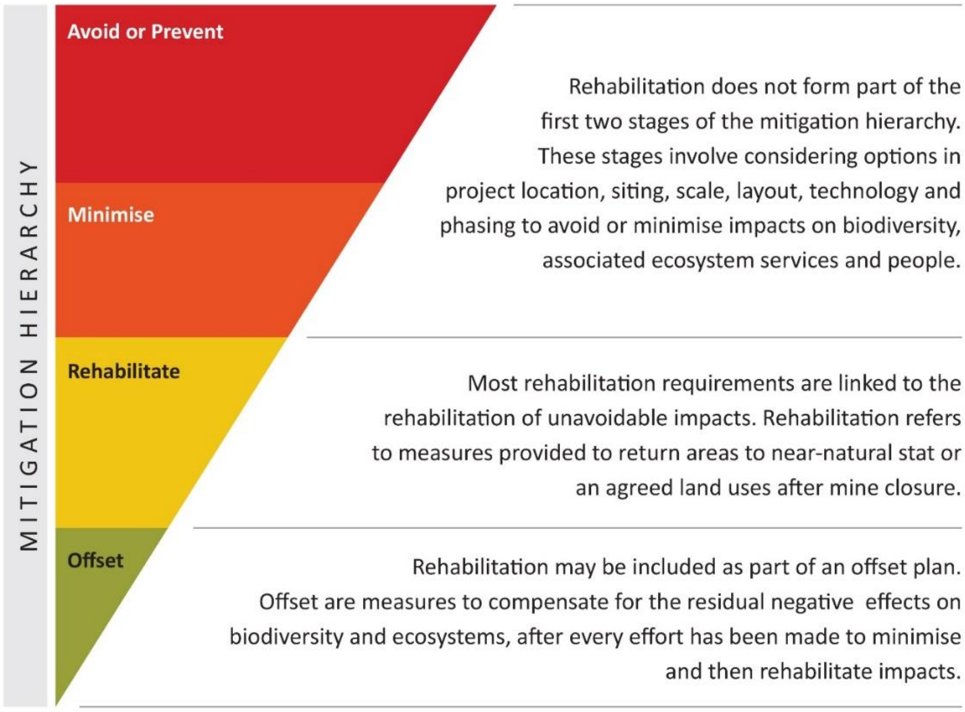

Figure 16: Mitigation Hierarchy (SANBI, 2016):

5 Expected Impacts and Mitigations

<u>Photovoltaic Development</u>

Potential impacts from the solar plant and related activities to watercourses include the following:

- Water Usage: Solar plants typically require water for cleaning solar panels, cooling systems, and other operational needs. Depending on the size of the plant and local water availability, significant water withdrawals may occur, leading to reduced water availability for nearby watercourses and ecosystems.
- Changes in Hydrological Regimes: Construction activities related to the solar plant, such as grading and excavation, can disrupt natural water flow patterns and alter the hydrological regime of nearby watercourses. This can impact water quantity, timing, and velocity, potentially affecting aquatic habitats and species.
- Sedimentation and Erosion: Construction activities and land disturbance during the installation of solar panels can result in increased erosion and sediment runoff into nearby watercourses. This can lead to sedimentation, reduced water clarity, and potential impacts on aquatic ecosystems and species.

- Habitat Loss and Fragmentation: The installation of solar panels and associated infrastructure will require the clearing of vegetation, leading to habitat loss and fragmentation along watercourses. This can disrupt the connectivity of habitats and impact aquatic biodiversity.
- 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.
- Alteration of Water Quality: Runoff from solar panel cleaning activities or other operational processes may contain chemicals, detergents, or cleaning agents that can impact water quality in nearby watercourses. It is crucial to properly manage and treat any potential wastewater discharges to mitigate adverse effects.
- Land Use Changes: The construction and operation of a solar plant can result in land use changes in the surrounding area. This may include the conversion of agricultural land or natural habitats to industrial land, which can indirectly affect watercourses through changes in land cover, drainage patterns, and nutrient runoff.
- Reduced Riparian Vegetation: Solar plants will require clearing of vegetation, including riparian vegetation along watercourses. The removal of riparian vegetation will have negative impacts on bank stability, erosion control, and nutrient cycling, potentially affecting the health and resilience of watercourse ecosystems.

<u>Powerline and Substations</u>

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. 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, 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.

It should be noted that the risk assessment assumes that no structures would be placed within the watercourses and their associated buffer zones. The impacts to the aquatic environment (as required in GN320 of March 2020) is summarised in
Table **18**, and the impact scores as set out in the NEMA 2016 Impact Assessment are presented in Section 5.1.1 below.

Table 18: 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.	The establishment of a solar plant and its associated infrastructure will have significant impacts on both fixed and dynamic aquatic ecological processes within and across its site. At the landscape level, hydrological functioning can be affected, leading to various consequences. These include changes to flood regimes such as the suppression of floods, loss of flood attenuation capacity, unseasonal flooding, or the disruption of floodplain processes. Additionally, there can be alterations to the sediment regime, which can influence the overall aquatic ecosystem. The extent of modification depends on the specific design and location of the solar plant, as well as the measures taken to mitigate environmental impacts. It is crucial to assess the potential risks associated with water uses and related activities, as these may change due to the presence of the solar plant and its infrastructure. Proper evaluation and management strategies are necessary to minimize any adverse effects and ensure the long-term sustainability of the aquatic ecosystem. However, 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, and 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:	it can affect base flows, which are the minimum flow rates in rivers and streams. Depending on the water requirements of the solar plant and the extraction methods used, base flows may decrease, potentially, impacting aquatic organisms that rely on consistent water levels for their survival. Secondly, the quantity of water available in the aquatic ecosystem can be influenced. Changes in the hydrological regime, such as altered runoff patterns or water extraction for the solar plant, can result in a decrease or increase in the overall quantity of water. This can have cascading effects
	a) Base flows (e.g. too little/too much water in terms of characteristics and requirements of the system)	
	b) Quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; the 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).	on the hydroperiod, which is the seasonal timing and duration of inundation in wetlands and floodplains, affecting the breeding and feeding patterns of species. Moreover, the hydrogeomorphic typing of the aquatic ecosystem, which categorises habitats based on their hydrological and geomorphic features, may be altered. Construction activities and modifications to water flow can lead to changes in the physical structure and connectivity of the ecosystem, potentially impacting the distribution and diversity of species. The quality of water can also be affected by the solar plant and its infrastructure. Runoff from construction sites and the release of pollutants from operations can introduce contaminants into nearby water bodies, impacting water quality and the health of aquatic organisms. Lastly, the construction of a solar plant and associated infrastructure can result in the fragmentation of the aquatic ecosystem. Physical barriers such as dams, canals, or access roads can disrupt the natural movement of organisms, impeding migration, gene flow, and the ecological functioning of the ecosystem. The management of the site in terms of vegetation, roads, and stormwater needs to be guided by an ecologist to ensure the impacts are minimized. Mitigation measures are expected to be mostly operational and easy to implement.
	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	The establishment of a solar plant and its associated infrastructure will have various impacts on different aspects of the ecosystem. Firstly, flood attenuation, which refers to the ability of an ecosystem to absorb and slow down floodwaters, may be affected. Reduction of the flood attenuation capacity of the surrounding area,
	b) Stream flow regulation	
	c) Sediment trapping	
	d) Phosphate assimilation	
	e) Nitrate assimilation	

Number	Impact question	Expected impact
	f) Toxicant assimilation g) Erosion Control h) Carbon Storage?	potentially leading to increased flood risk downstream. Secondly, stream flow regulation can be influenced by the presence of a solar plant. Water extraction for plant operations or changes in water management practices can alter the natural flow patterns of streams, potentially impacting downstream water availability and ecological processes. Additionally, the construction of a solar plant and associated infrastructure can lead to changes in sediment trapping. Sediment can accumulate behind dams or other structures, affecting downstream ecosystems and altering the natural transport of sediment in rivers and streams. Regarding nutrient assimilation, the impact of a solar plant and its infrastructure can vary. Phosphate assimilation, which is the uptake and utilization of phosphates by aquatic organisms, may be influenced by changes in water quality due to construction activities or pollutant runoff. Similarly, the assimilation of nitrates and toxicants can be affected by the presence of the solar plant, potentially impacting the health of the aquatic ecosystem and its ability to process and detoxify these substances. In terms of erosion control, the construction of the solar plant and associated infrastructure can have both positive and negative effects, i.e.,. the physical disturbance associated with construction can increase erosion if not properly managed. However,, if proper erosion control measures are implemented during construction, they can help mitigate erosion and sedimentation in nearby water bodies. Lastly, the impact on carbon storage will depend on the specific characteristics of the site. In some cases, the installation of a solar plant will involve the removal of vegetation, potentially reducing carbon storage capacity. However, if appropriate land management practices are implemented, such as reforestation or conservation measures,

Number	Impact question	Expected impact
		the overall carbon storage potential of the site can be maintained or even enhanced. Overall, proper planning, environmental assessments, and mitigation measures are essential to minimize the potential negative impacts of a solar plant and associated infrastructure on flood attenuation, stream flow regulation, sediment trapping, nutrient assimilation, erosion control, carbon storage, and other important ecological processes.

5.1.1 NEMA (2014) Impact Assessment –

Table 19 to Table 24 below indicate the impact scores for the potential impacts relevant to the proposed activities for the Option 1 layout. These impacts include aspects of the aquatic environment as specified in GN350 of March 2020. It should be noted that the risk assessment assumes that no structures will be located within the watercourses and their associated buffer zones.

Table 19: Impacts on hydrological function at a landscape level

Nature: Changes to hydrological function at a landscape level 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).		
ACTIVITY: 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 the construction and operation of the solar plant.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)

Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
The irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes, with exceptional effort	

Mitigation:

- Implementing effective stormwater management systems: Designing and implementing proper stormwater management systems, such as detention basins, vegetated swales, or permeable surfaces, can help mitigate the impact of increased runoff from the solar plant site. These measures can reduce the volume and velocity of stormwater runoff, minimizing the risk of downstream flooding and erosion.
- Preserving natural drainage patterns: By preserving the natural drainage patterns and avoiding the alteration of existing watercourses, the hydrological regime can be maintained to a greater extent. This approach helps to sustain natural flow patterns and minimize disruptions to aquatic ecosystems.
- Implementing water conservation practices: Incorporating water conservation practices within the solar plant operations can help reduce water demand. This includes utilizing water-efficient technologies and practices such as drip irrigation, efficient cooling systems, and water recycling, which can help minimize the impact on water resources.
- Designing and maintaining erosion control measures: Implementing erosion control measures, such as installing sediment barriers, stabilizing slopes, and revegetating disturbed areas, can help minimize soil erosion and sedimentation in nearby water bodies. This reduces the potential negative impacts on water quality and aquatic ecosystems.
- Implementing best management practices (BMPs): Utilising BMPs specifically designed for solar plant development can help minimize the impact on hydrological functioning. These practices may include minimizing impervious surfaces, incorporating green infrastructure, promoting soil conservation practices, and establishing buffer zones along water bodies to filter runoff.

• Conducting regular monitoring and maintenance: Regular monitoring of hydrological conditions, including water flow rates, water quality parameters, and sediment deposition, can help identify any potential issues and enable timely interventions. Regular maintenance of stormwater management systems, erosion control measures, and other infrastructure is crucial to ensure their effectiveness and prevent unintended impacts. • Engaging with stakeholders and local communities: Engaging with stakeholders, including local communities, environmental organizations, and regulatory agencies, can provide valuable insights and ensure that potential hydrological impacts are adequately addressed. Collaboration and transparency in the decision-making process can lead to the implementation of more effective mitigation measures. Predictions of stormwater flows should take into consideration expected climate change related catchment changes. • Effective control of stormwater from access roads should be undertaken
Cumulative impacts: Medium - The cumulative impacts of a solar plant on hydrological function encompass a range of negative impacts that can occur over time. These impacts can include changes in water availability, alterations in surface and groundwater flow patterns, and modifications to the overall hydrological regime of the surrounding area. The construction of a solar plant involve land clearing and grading, which can increase surface runoff and potentially lead to increased erosion and sedimentation in nearby water bodies. Additionally, the installation of infrastructure such as access roads and transmission lines can disrupt natural drainage patterns and impede water flow. Water extraction for plant operations, if not properly managed, can reduce base flows and impact downstream ecosystems. The cumulative effects of these various factors can influence the hydrological function of the area, affecting water quantity, quality, and the overall ecological processes and services provided by the hydrological system. Proper planning, monitoring, and implementation of mitigation measures are crucial to minimize and address these cumulative impacts and ensure the long-term sustainability of the hydrological function.
Residual Risks: Expected to be Low. The residual risks of a solar plant on hydrological function refer to the potential risks that may remain even after the implementation of mitigation measures. These risks can arise from various factors and can have implications for water resources and the surrounding ecosystems. For example, despite implementing stormwater management systems, there may still be a residual risk of increased runoff during extreme weather events, leading to localized flooding or erosion. Additionally, the alteration of natural drainage patterns and watercourses due to the construction and infrastructure of the solar plant may result in residual risks of disrupted water flow and potential impacts on aquatic habitats. Water extraction for plant operations, if not carefully regulated and monitored, may pose residual risks of reduced water availability and potential harm to downstream ecosystems. It is important to recognize these residual risks and continually assess and manage them through regular monitoring, adaptive management strategies, and ongoing collaboration with relevant stakeholders and regulatory bodies to minimize any potential adverse impacts on hydrological function.

Table 20: Changes in sediment regime

Nature: Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns for example.

Activity: 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 an increase in 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 the creation of roads and tracks adjacent to the watercourse
- Erosion (e.g. gully formation, bank collapse)

	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly probable (4)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Regional (3)	Local (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**16 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Limited to Local Area (2)	Regional (3)
Magnitude	Moderate (6)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative

Reversibility	Low	Moderate
Irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Consider the various methods and equipment available and select whichever method(s) that will have the least impact on watercourses.
- 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.
- Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover.
- 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 weekly to demonstrate compliance with upstream conditions.
- Any excavated soil/ stockpiles may not exceed 1 m in height. 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 resulting from activities within and adjacent to the construction camp and work areas.
- Monitoring should be done to ensure that sediment pollution is timeously addressed.
- Sediment Control Measures: Implement sediment control measures during construction to prevent sediment runoff into nearby water bodies. This can include installing sediment barriers, sediment ponds, and erosion control structures to capture and retain sediment on-site.
- Stormwater Management: Develop and implement effective stormwater management systems to control and treat runoff from the solar plant site. Properly designed detention basins, vegetated swales, and sediment traps can help reduce the transport of sediment into watercourses.
- Site Design and Grading: Carefully plan and design the solar plant site to minimize soil disturbance and erosion. Avoid unnecessary grading and maintain natural land contours to reduce erosion potential and preserve the stability of the surrounding soil.
- Revegetation and Erosion Control: Establish vegetation and stabilize disturbed areas as soon as possible. This can be achieved through the use of erosion control blankets, matting, and native vegetation to stabilize soils, promote infiltration, and reduce sediment transport.
- Sediment Removal and Management: Implement sediment removal practices to maintain the capacity of sediment control measures, such as sediment ponds. Regular maintenance and sediment removal will prevent sediment buildup and ensure the continued effectiveness of sediment control measures.
- Monitoring and Adaptive Management: Regularly monitor sediment transport and deposition patterns in nearby water bodies to assess the effectiveness of mitigation measures. If necessary, adapt management strategies based on the monitoring data to address any emerging sediment-related issues.
- Environmental Training and Best Management Practices (BMPs): Ensure that all personnel involved in the construction and operation of the solar plant receive proper training on sediment control and management. Implement and adhere to established BMPs to minimize sediment-related impacts.

• Compliance with Regulatory Requirements: Follow all relevant environmental regulations and permit requirements regarding sediment control and management. Engage with regulatory agencies and obtain necessary permits to ensure compliance and minimize potential impacts
Cumulative impacts: Expected to be low. The construction phase of a solar plant involves site preparation, grading, and clearing, which can result in increased soil erosion and sediment runoff. This initial disturbance can lead to the mobilization and transport of sediment into nearby water bodies, affecting their sediment regime. Additionally, ongoing maintenance activities, such as vegetation management or equipment operation, may further contribute to sedimentation risks. Over time, these cumulative impacts can alter the natural sediment dynamics, potentially leading to increased sedimentation rates, changes in sediment composition, and the potential for downstream impacts on water quality, aquatic habitats, and ecosystems. Proper sediment control measures, regular monitoring, and adaptive management strategies are crucial to mitigate these cumulative impacts and ensure the long-term health and sustainability of the sediment regime.
Residual Risks: Expected to be limited. Despite best efforts, some residual risks can still arise. For example, during extreme weather events, such as heavy rainfall or intense storms, there may be an increased risk of sediment runoff and erosion that could overwhelm sediment control measures. Natural processes such as erosion from adjacent areas or changes in upstream land use patterns may also contribute to sedimentation risks. Inadequate maintenance or failure to regularly remove accumulated sediment from control structures could reduce their effectiveness. Furthermore, improper construction practices or accidental spills during plant operations could introduce additional sediment into nearby water bodies. It is essential to recognize these residual risks and continually monitor sedimentation patterns, regularly maintain sediment control measures, and adapt management strategies to minimize and address any potential adverse impacts on the sediment regime.

Table 21: Introduction and spread of alien vegetation impact ratings.

Nature: Introduction and spread of alien vegetation.		
Activity: The moving of soil and vegetation will result in opportunistic invasions after disturbance and the introduction of seed in building materials and 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 introduced in an area, the 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (3)	Probable (3)
Duration	Long-term (4)	Short term (2)
Extent	Regional (3)	Local (2)

Magnitude	Moderate (6)	Low (4)
Significance	**39 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Possible (2)
Duration	Medium-term (3)	Medium term (3)
Extent	Regional (4)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- 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 construction / earthworks in that area and returning it where possible afterwards.
- 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 Plan.
- Rehabilitate or revegetate disturbed areas.
- Seed Control and Prevention: Develop and implement seed control measures to prevent the transportation and spread of alien plant seeds. This includes inspecting and cleaning construction equipment, vehicles, and personnel clothing to remove any seeds before entering or leaving the site.
- Vegetation Management and Restoration: Implement a comprehensive vegetation management plan that includes regular monitoring and removal of alien species. Promote the restoration of native vegetation through the establishment of native plant communities that are well-suited to the local ecosystem.

- Early Detection and Rapid Response: Establish protocols for early detection and immediate response to newly introduced alien species. Regular monitoring and rapid removal of any identified alien plants can help prevent their establishment and spread.
- Education and Training: Provide education and training to personnel, contractors, and stakeholders involved in the solar plant project about the risks and impacts of alien vegetation. Promote awareness and understanding of the importance of preventing the introduction and spread of Alien Invasive species.
- Collaboration with Local Authorities: Collaborate with local environmental agencies and authorities to develop and implement invasive species management strategies. Work together to share information, coordinate efforts, and implement best practices in controlling and eradicating alien vegetation.
- Continued Monitoring and Adaptive Management: Establish a long-term monitoring program to assess the effectiveness of mitigation measures and detect any new introductions of alien species. Use the monitoring data to inform adaptive management strategies and make necessary adjustments to minimize the impacts of alien vegetation

Cumulative impacts: Low. The construction and maintenance activities associated with a solar plant can inadvertently introduce AI plant species to the site through the transportation of seeds, soil, or equipment. Over time, these alien plants may establish and spread, potentially displacing native vegetation and altering the plant community composition. The cumulative impacts of alien vegetation can lead to reduced biodiversity, changes in habitat structure, and disruption of ecosystem processes. Additionally, the presence of alien vegetation can create challenges for habitat restoration and management efforts. To mitigate these cumulative impacts, it is crucial to implement effective prevention measures, such as seed control, monitoring, and prompt eradication of newly established alien plants. Ongoing monitoring and invasive species management are essential for early detection and rapid response to limit the spread and establishment of non-native vegetation associated with the solar plant.

Residual Risks: Expected to be limited. Despite best efforts, there is a possibility that alien vegetation may still be introduced and spread within and around the solar plant site. Factors such as seed dispersal by wind, water, or animals, inadvertent transportation of alien plant propagules during construction or maintenance activities, and the persistence of seed banks in the soil could contribute to the residual risks. Once established, alien vegetation can outcompete native species, disrupt natural ecosystems, and alter ecological processes. Ongoing monitoring, early detection, and rapid response strategies are crucial to mitigate these residual risks and ensure effective management of alien vegetation.

Additionally, maintaining a robust invasive species management plan and promoting awareness among personnel and stakeholders can help minimise the introduction and spread of non-native plants associated with the solar plant.

Table 22: Loss and disturbance of watercourse/habitat and fringe vegetation impact ratings.

Nature: Loss and disturbance of watercourse habitat and fringe vegetation.		
Activity: 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Definite (5)	Probable (3)
Duration	Medium-term (3)	Medium-term (3)
Extent	Local (2)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**45 (moderate)**	**27 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Definite (5)	Possible (2)
Duration	Medium-term (3)	Short-term (2)
Extent	Local (2)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**45 (moderate)**	**16 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
Mitigation: • The development footprint should remain outside the delineated wetland, riparian areas, and buffer zones. • Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas.		

- Implement an Alien Plant Control Plan.
- Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed.
- 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.
- Site Design and Layout: Carefully plan the solar plant layout to avoid or minimize the disturbance of watercourses and sensitive fringe vegetation. Consider setbacks and buffer zones to protect these areas from direct impacts.
- Vegetation Surveys and Assessment: 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.
- Environmental Buffer Zones: Establish buffer zones along watercourses and sensitive fringe vegetation areas to protect them from construction activities. These buffer zones can help prevent soil erosion, sedimentation, and damage to vegetation.
- Construction Best Practices: Implement construction best practices to minimize soil disturbance and vegetation damage. This includes using proper equipment, avoiding unnecessary grading, or clearing, and employing erosion control measures to prevent sediment runoff into watercourses.
- Restoration and Replanting: 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.
- Sediment and Erosion Control: 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.
- Environmental Monitoring: Establish a monitoring program to assess the effectiveness of mitigation measures and monitor the condition of watercourses and fringe vegetation during and after construction. This helps ensure early detection of any adverse impacts and allows for timely corrective actions.

Cumulative impacts: Expected to be Low. Construction activities associated with the solar plant, such as land clearing, grading, and infrastructure installation, can lead to the direct loss and disturbance of watercourses, habitats, and fringe vegetation. This can disrupt the natural hydrological and ecological processes, affecting the integrity and functioning of these ecosystems.

The cumulative impacts may include altered water flow patterns, increased sedimentation, reduced water quality, and habitat fragmentation. Furthermore, ongoing maintenance activities and the presence of access roads and transmission lines can continue to disturb or restrict the natural movement and distribution of watercourse and fringe vegetation species.

To minimize these cumulative impacts, it is important to carefully plan and design the solar plant, implement appropriate mitigation measures, conduct restoration efforts, and engage in ongoing monitoring and adaptive management practices to protect and restore watercourse/habitat and fringe vegetation integrity.

Residual Risks: Expected to be limited. Despite best efforts, there is a possibility of residual risks associated with the operation and maintenance of the solar plant. These risks may include accidental spills or leaks of hazardous substances that could impact watercourses and vegetation, disturbances caused by routine maintenance activities, or the potential for invasive species to colonize disturbed areas. Inadequate monitoring or failure to promptly respond to changes in the condition of watercourses and vegetation can also contribute to residual risks. Additionally, extreme weather events such as heavy rainfall or flooding can pose challenges in maintaining the integrity of watercourses and vegetation.

To address these residual risks, ongoing monitoring, prompt response, and adaptive management strategies are necessary to minimize any potential adverse impacts on the loss and disturbance of watercourse/habitat and fringe vegetation.

Table 23: Changes in water quality.

Nature: Changes in water quality due to input of foreign materials e.g., due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication		
Activity: 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Locate the infrastructure outside the calculated buffer zone.
- 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.
- Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone.
- The development footprint must be fenced off from the watercourses and no related impacts may be allowed into the watercourse e.g. water runoff from cleaning of equipment, vehicle access etc.
- It should be ensured that regular maintenance takes place to prevent failure of any infrastructure associated with the proposed development;
- The managing authority should test the integrity of the sewer pipelines at least once every five years or more often should there be any sign or reports of a leak.
- A detailed rehabilitation plan should be drawn up with the input from a water quality, soil contamination assessment and ecologist should any spills occur.
- 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
- Sediment and Erosion Control: Implement sediment and erosion control measures during the construction phase to prevent sediment runoff and erosion into nearby water bodies. This can include the use of erosion control blankets, sediment barriers, and sediment ponds.
- Spill Prevention and Response: Develop and implement spill prevention and response protocols to minimize the risk of accidental spills or releases of hazardous substances. This includes proper storage, handling, and disposal of chemicals and fuels, as well as having spill containment measures and emergency response plans in place.
- Stormwater Management: 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.
- Monitoring and Reporting: 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.
- Vegetation Buffers and Riparian Zones: Establish and maintain vegetative buffers and riparian zones along water bodies to help filter runoff, reduce erosion, and provide habitat for aquatic organisms. Planting native vegetation can enhance the natural filtration and nutrient uptake capacity of these areas.
- Training and Education: 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.

Cumulative impacts: Expected to be low. Construction activities, such as land clearing, grading, and infrastructure installation, can lead to sediment runoff, increased erosion, and potential contamination of nearby water bodies. Ongoing maintenance activities, including the use of chemicals and the management of hazardous materials, can also contribute to cumulative impacts on water quality. Additionally, the alteration of hydrological patterns and the disruption of natural water flow regimes may influence the distribution and transport of pollutants, further exacerbating the cumulative impacts. The residual risks associated with a solar plant on changes in water quality pertain to the potential risks that may persist even after implementing mitigation measures. These risks include accidental spills, leaks, or releases of pollutants, as well as the persistence of long-term contamination from operational activities. It is essential

to implement rigorous water quality monitoring, adopt appropriate treatment measures, and adhere to environmental regulations to minimize both the cumulative impacts and residual risks associated with changes in water quality.
Residual Risks: Can be controlled and largely prevented.

Table 24: Loss of aquatic biota

Nature: 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 and in flow		
Activity: 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative

Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- 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.
- Other than approved and authorized 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.
- Weed control in aquatic ecosystem and buffer zone.
- 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.
- Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.
- Habitat Preservation and Restoration: 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.
- Water Quality Management: 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.
- Fish and Wildlife Conservation Measures: Develop and implement fish and wildlife conservation plans to minimize the impact on sensitive and protected species. This may include establishing exclusion zones, installing fish-friendly screens in water intake structures, and creating fish passage solutions to enable the movement of fish through the solar plant area.
- Riparian Buffer Zones: Establish and maintain vegetative riparian buffer zones along water bodies to provide shade, stabilize banks, and reduce erosion. These buffer zones can offer important habitat and food sources for aquatic biota.
- Invasive Species Management: Develop an invasive species management plan to prevent the introduction and spread of non-native species that can negatively impact aquatic biota. Regular monitoring and prompt eradication of invasive species should be implemented.

Cumulative impacts: Expected to be low

Residual Risks: Expected to be low.

5.1.2 NEMA (2014) Impact Assessment – Option 3

Table 25 to Table 30Table 24 below indicate the impact scores for the potential impacts relevant to the proposed activities for the Option 3 layout. These impacts include aspects of the aquatic environment as specified in GN350 of March 2020. It should be noted that the risk assessment assumes that will be placed in approximately 38.93 ha of wetland habitat. From the information received it is not clear if the vegetation underneath the PV structures will be removed. It is thus assumed that water will be allowed to flow freely and that vegetation will remain underneath these structures.

Table 25: Impacts on hydrological function at a landscape level

Nature: Changes to hydrological function at a landscape level 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).		
ACTIVITY: 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 the construction and operation of the solar plant.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Definite (5)	Highly probable (4)
Duration	Long term (4)	Long term (4)
Extent	Regional (4)	Regional (4)
Magnitude	High (8)	High (8)
Significance	**80 (high)**	**64 (moderate)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)

Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
The irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes, with exceptional effort	

Mitigation:

- Implementing effective stormwater management systems: Designing and implementing proper stormwater management systems, such as detention basins, vegetated swales, or permeable surfaces, can help mitigate the impact of increased runoff from the solar plant site. These measures can reduce the volume and velocity of stormwater runoff, minimizing the risk of downstream flooding and erosion.
- Preserving natural drainage patterns: By preserving the natural drainage patterns and avoiding the alteration of existing watercourses, the hydrological regime can be maintained to a greater extent. This approach helps to sustain natural flow patterns and minimize disruptions to aquatic ecosystems.
- Implementing water conservation practices: Incorporating water conservation practices within the solar plant operations can help reduce water demand. This includes utilizing water-efficient technologies and practices such as drip irrigation, efficient cooling systems, and water recycling, which can help minimize the impact on water resources.
- Designing and maintaining erosion control measures: Implementing erosion control measures, such as installing sediment barriers, stabilizing slopes, and revegetating disturbed areas, can help minimize soil erosion and sedimentation in nearby water bodies. This reduces the potential negative impacts on water quality and aquatic ecosystems.
- Implementing best management practices (BMPs): Utilising BMPs specifically designed for solar plant development can help minimize the impact on hydrological functioning. These practices may include minimizing impervious surfaces, incorporating green infrastructure, promoting soil conservation practices, and establishing buffer zones along water bodies to filter runoff.
- Conducting regular monitoring and maintenance: Regular monitoring of hydrological conditions, including water flow rates, water quality parameters, and sediment deposition, can help identify any potential issues and enable timely interventions. Regular maintenance of stormwater management systems, erosion control measures, and other infrastructure is crucial to ensure their effectiveness and prevent unintended impacts.
- Engaging with stakeholders and local communities: Engaging with stakeholders, including local communities, environmental organizations, and regulatory agencies, can provide valuable insights and ensure that potential hydrological impacts are adequately addressed. Collaboration and transparency in the decision-making process can lead to the implementation of more effective mitigation measures. Predictions of stormwater flows should take into consideration expected climate change related catchment changes.
- Effective control of stormwater from access roads should be undertaken

Cumulative impacts: Medium - The cumulative impacts of a solar plant on hydrological function encompass a range of negative impacts that can occur over time. These impacts can include changes in

water availability, alterations in surface and groundwater flow patterns, and modifications to the overall hydrological regime of the surrounding area. The construction of a solar plant involve land clearing and grading, which can increase surface runoff and potentially lead to increased erosion and sedimentation in nearby water bodies. Additionally, the installation of infrastructure such as access roads and transmission lines can disrupt natural drainage patterns and impede water flow. Water extraction for plant operations, if not properly managed, can reduce base flows and impact downstream ecosystems. The cumulative effects of these various factors can influence the hydrological function of the area, affecting water quantity, quality, and the overall ecological processes and services provided by the hydrological system. Proper planning, monitoring, and implementation of mitigation measures are crucial to minimize and address these cumulative impacts and ensure the long-term sustainability of the hydrological function.
Residual Risks: Expected to be Low. The residual risks of a solar plant on hydrological function refer to the potential risks that may remain even after the implementation of mitigation measures. These risks can arise from various factors and can have implications for water resources and the surrounding ecosystems. For example, despite implementing stormwater management systems, there may still be a residual risk of increased runoff during extreme weather events, leading to localized flooding or erosion. Additionally, the alteration of natural drainage patterns and watercourses due to the construction and infrastructure of the solar plant may result in residual risks of disrupted water flow and potential impacts on aquatic habitats. Water extraction for plant operations, if not carefully regulated and monitored, may pose residual risks of reduced water availability and potential harm to downstream ecosystems. It is important to recognize these residual risks and continually assess and manage them through regular monitoring, adaptive management strategies, and ongoing collaboration with relevant stakeholders and regulatory bodies to minimize any potential adverse impacts on hydrological function.

Table 26: Changes in sediment regime

Nature: Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns for example.

Activity: 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 an increase in 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 the creation of roads and tracks adjacent to the watercourse
- Erosion (e.g. gully formation, bank collapse)

	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Definite (5)	Highly probable (4)
Duration	Long term (4)	Long term (4)
Extent	Regional (4)	Regional (4)
Magnitude	High (8)	High (8)
Significance	**80 (high)**	**64 (moderate)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Limited to Local Area (2)	Regional (3)
Magnitude	Moderate (6)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative

Reversibility	Low	Moderate
Irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Consider the various methods and equipment available and select whichever method(s) that will have the least impact on watercourses.
- 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.
- Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover.
- 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 weekly to demonstrate compliance with upstream conditions.
- Any excavated soil/ stockpiles may not exceed 1 m in height. 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 resulting from activities within and adjacent to the construction camp and work areas.
- Monitoring should be done to ensure that sediment pollution is timeously addressed.
- Sediment Control Measures: Implement sediment control measures during construction to prevent sediment runoff into nearby water bodies. This can include installing sediment barriers, sediment ponds, and erosion control structures to capture and retain sediment on-site.
- Stormwater Management: Develop and implement effective stormwater management systems to control and treat runoff from the solar plant site. Properly designed detention basins, vegetated swales, and sediment traps can help reduce the transport of sediment into watercourses.
- Site Design and Grading: Carefully plan and design the solar plant site to minimize soil disturbance and erosion. Avoid unnecessary grading and maintain natural land contours to reduce erosion potential and preserve the stability of the surrounding soil.
- Revegetation and Erosion Control: Establish vegetation and stabilize disturbed areas as soon as possible. This can be achieved through the use of erosion control blankets, matting, and native vegetation to stabilize soils, promote infiltration, and reduce sediment transport.
- Sediment Removal and Management: Implement sediment removal practices to maintain the capacity of sediment control measures, such as sediment ponds. Regular maintenance and sediment removal will prevent sediment buildup and ensure the continued effectiveness of sediment control measures.
- Monitoring and Adaptive Management: Regularly monitor sediment transport and deposition patterns in nearby water bodies to assess the effectiveness of mitigation measures. If necessary, adapt management strategies based on the monitoring data to address any emerging sediment-related issues.
- Environmental Training and Best Management Practices (BMPs): Ensure that all personnel involved in the construction and operation of the solar plant receive proper training on sediment control and management. Implement and adhere to established BMPs to minimize sediment-related impacts.

• Compliance with Regulatory Requirements: Follow all relevant environmental regulations and permit requirements regarding sediment control and management. Engage with regulatory agencies and obtain necessary permits to ensure compliance and minimize potential impacts
Cumulative impacts: Expected to be low. The construction phase of a solar plant involves site preparation, grading, and clearing, which can result in increased soil erosion and sediment runoff. This initial disturbance can lead to the mobilization and transport of sediment into nearby water bodies, affecting their sediment regime. Additionally, ongoing maintenance activities, such as vegetation management or equipment operation, may further contribute to sedimentation risks. Over time, these cumulative impacts can alter the natural sediment dynamics, potentially leading to increased sedimentation rates, changes in sediment composition, and the potential for downstream impacts on water quality, aquatic habitats, and ecosystems. Proper sediment control measures, regular monitoring, and adaptive management strategies are crucial to mitigate these cumulative impacts and ensure the long-term health and sustainability of the sediment regime.
Residual Risks: Expected to be limited. Despite best efforts, some residual risks can still arise. For example, during extreme weather events, such as heavy rainfall or intense storms, there may be an increased risk of sediment runoff and erosion that could overwhelm sediment control measures. Natural processes such as erosion from adjacent areas or changes in upstream land use patterns may also contribute to sedimentation risks. Inadequate maintenance or failure to regularly remove accumulated sediment from control structures could reduce their effectiveness. Furthermore, improper construction practices or accidental spills during plant operations could introduce additional sediment into nearby water bodies. It is essential to recognize these residual risks and continually monitor sedimentation patterns, regularly maintain sediment control measures, and adapt management strategies to minimize and address any potential adverse impacts on the sediment regime.

Table 27: Introduction and spread of alien vegetation impact ratings.

Nature: Introduction and spread of alien vegetation.		
Activity: The moving of soil and vegetation will result in opportunistic invasions after disturbance and the introduction of seed in building materials and 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 introduced in an area, the 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (3)	Probable (3)
Duration	Long-term (4)	Short term (2)
Extent	Regional (3)	Local (2)

Magnitude	Moderate (6)	Low (4)
Significance	**39 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Possible (2)
Duration	Medium-term (3)	Medium term (3)
Extent	Regional (4)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- 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 construction / earthworks in that area and returning it where possible afterwards.
- 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 Plan.
- Rehabilitate or revegetate disturbed areas.
- Seed Control and Prevention: Develop and implement seed control measures to prevent the transportation and spread of alien plant seeds. This includes inspecting and cleaning construction equipment, vehicles, and personnel clothing to remove any seeds before entering or leaving the site.
- Vegetation Management and Restoration: Implement a comprehensive vegetation management plan that includes regular monitoring and removal of alien species. Promote the restoration of native vegetation through the establishment of native plant communities that are well-suited to the local ecosystem.

- Early Detection and Rapid Response: Establish protocols for early detection and immediate response to newly introduced alien species. Regular monitoring and rapid removal of any identified alien plants can help prevent their establishment and spread.
- Education and Training: Provide education and training to personnel, contractors, and stakeholders involved in the solar plant project about the risks and impacts of alien vegetation. Promote awareness and understanding of the importance of preventing the introduction and spread of Alien Invasive species.
- Collaboration with Local Authorities: Collaborate with local environmental agencies and authorities to develop and implement invasive species management strategies. Work together to share information, coordinate efforts, and implement best practices in controlling and eradicating alien vegetation.
- Continued Monitoring and Adaptive Management: Establish a long-term monitoring program to assess the effectiveness of mitigation measures and detect any new introductions of alien species. Use the monitoring data to inform adaptive management strategies and make necessary adjustments to minimize the impacts of alien vegetation

Cumulative impacts: Low. The construction and maintenance activities associated with a solar plant can inadvertently introduce AI plant species to the site through the transportation of seeds, soil, or equipment. Over time, these alien plants may establish and spread, potentially displacing native vegetation and altering the plant community composition. The cumulative impacts of alien vegetation can lead to reduced biodiversity, changes in habitat structure, and disruption of ecosystem processes. Additionally, the presence of alien vegetation can create challenges for habitat restoration and management efforts. To mitigate these cumulative impacts, it is crucial to implement effective prevention measures, such as seed control, monitoring, and prompt eradication of newly established alien plants. Ongoing monitoring and invasive species management are essential for early detection and rapid response to limit the spread and establishment of non-native vegetation associated with the solar plant.

Residual Risks: Expected to be limited. Despite best efforts, there is a possibility that alien vegetation may still be introduced and spread within and around the solar plant site. Factors such as seed dispersal by wind, water, or animals, inadvertent transportation of alien plant propagules during construction or maintenance activities, and the persistence of seed banks in the soil could contribute to the residual risks. Once established, alien vegetation can outcompete native species, disrupt natural ecosystems, and alter ecological processes. Ongoing monitoring, early detection, and rapid response strategies are crucial to mitigate these residual risks and ensure effective management of alien vegetation.

Additionally, maintaining a robust invasive species management plan and promoting awareness among personnel and stakeholders can help minimise the introduction and spread of non-native plants associated with the solar plant.

Table 28: Loss and disturbance of watercourse/habitat and fringe vegetation impact ratings.

Nature: Loss and disturbance of watercourse habitat and fringe vegetation.		
Activity: 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Definite (5)	Highly probable (4)
Duration	Long term (4)	Long term (4)
Extent	Regional (4)	Regional (4)
Magnitude	High (8)	High (8)
Significance	**80 (high)**	**64 (moderate)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Definite (5)	Highly probable (4)
Duration	Long term (4)	Long term (4)
Extent	Regional (4)	Regional (4)
Magnitude	High (8)	High (8)
Significance	**80 (high)**	**64 (moderate)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
Mitigation: • The development footprint should remain outside the delineated wetland, riparian areas, and buffer zones. • Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas.		

- Implement an Alien Plant Control Plan.
- Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed.
- 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.
- Site Design and Layout: Carefully plan the solar plant layout to avoid or minimize the disturbance of watercourses and sensitive fringe vegetation. Consider setbacks and buffer zones to protect these areas from direct impacts.
- Vegetation Surveys and Assessment: 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.
- Environmental Buffer Zones: Establish buffer zones along watercourses and sensitive fringe vegetation areas to protect them from construction activities. These buffer zones can help prevent soil erosion, sedimentation, and damage to vegetation.
- Construction Best Practices: Implement construction best practices to minimize soil disturbance and vegetation damage. This includes using proper equipment, avoiding unnecessary grading, or clearing, and employing erosion control measures to prevent sediment runoff into watercourses.
- Restoration and Replanting: 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.
- Sediment and Erosion Control: 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.
- Environmental Monitoring: Establish a monitoring program to assess the effectiveness of mitigation measures and monitor the condition of watercourses and fringe vegetation during and after construction. This helps ensure early detection of any adverse impacts and allows for timely corrective actions.

Cumulative impacts: Expected to be Low. Construction activities associated with the solar plant, such as land clearing, grading, and infrastructure installation, can lead to the direct loss and disturbance of watercourses, habitats, and fringe vegetation. This can disrupt the natural hydrological and ecological processes, affecting the integrity and functioning of these ecosystems.

The cumulative impacts may include altered water flow patterns, increased sedimentation, reduced water quality, and habitat fragmentation. Furthermore, ongoing maintenance activities and the presence of access roads and transmission lines can continue to disturb or restrict the natural movement and distribution of watercourse and fringe vegetation species.

To minimize these cumulative impacts, it is important to carefully plan and design the solar plant, implement appropriate mitigation measures, conduct restoration efforts, and engage in ongoing monitoring and adaptive management practices to protect and restore watercourse/habitat and fringe vegetation integrity.

Residual Risks: Expected to be limited. Despite best efforts, there is a possibility of residual risks associated with the operation and maintenance of the solar plant. These risks may include accidental spills or leaks of hazardous substances that could impact watercourses and vegetation, disturbances caused by routine maintenance activities, or the potential for invasive species to colonize disturbed areas. Inadequate monitoring or failure to promptly respond to changes in the condition of watercourses and vegetation can also contribute to residual risks. Additionally, extreme weather events such as heavy rainfall or flooding can pose challenges in maintaining the integrity of watercourses and vegetation.

To address these residual risks, ongoing monitoring, prompt response, and adaptive management strategies are necessary to minimize any potential adverse impacts on the loss and disturbance of watercourse/habitat and fringe vegetation.

Table 29: Changes in water quality.

Nature: Changes in water quality due to input of foreign materials e.g., due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication		
Activity: 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation: • Locate the infrastructure outside the calculated buffer zone. • 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. • Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone. • The development footprint must be fenced off from the watercourses and no related impacts may be allowed into the watercourse e.g. water runoff from cleaning of equipment, vehicle access etc. • It should be ensured that regular maintenance takes place to prevent failure of any infrastructure associated with the proposed development; • The managing authority should test the integrity of the sewer pipelines at least once every five years or more often should there be any sign or reports of a leak. • A detailed rehabilitation plan should be drawn up with the input from a water quality, soil contamination assessment and ecologist should any spills occur. • 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 • Sediment and Erosion Control: Implement sediment and erosion control measures during the construction phase to prevent sediment runoff and erosion into nearby water bodies. This can include the use of erosion control blankets, sediment barriers, and sediment ponds. • Spill Prevention and Response: Develop and implement spill prevention and response protocols to minimize the risk of accidental spills or releases of hazardous substances. This includes proper storage, handling, and disposal of chemicals and fuels, as well as having spill containment measures and emergency response plans in place. • Stormwater Management: 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. • Monitoring and Reporting: 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. • Vegetation Buffers and Riparian Zones: Establish and maintain vegetative buffers and riparian zones along water bodies to help filter runoff, reduce erosion, and provide habitat for aquatic organisms. Planting native vegetation can enhance the natural filtration and nutrient uptake capacity of these areas. • Training and Education: 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.
Cumulative impacts: Expected to be low. Construction activities, such as land clearing, grading, and infrastructure installation, can lead to sediment runoff, increased erosion, and potential contamination of nearby water bodies. Ongoing maintenance activities, including the use of chemicals and the management of hazardous materials, can also contribute to cumulative impacts on water quality. Additionally, the alteration of hydrological patterns and the disruption of natural water flow regimes may influence the distribution and transport of pollutants, further exacerbating the cumulative impacts. The residual risks associated with a solar plant on changes in water quality pertain to the potential risks that may persist even after implementing mitigation measures. These risks include accidental spills, leaks, or releases of pollutants, as well as the persistence of long-term contamination from operational activities. It is essential

to implement rigorous water quality monitoring, adopt appropriate treatment measures, and adhere to environmental regulations to minimize both the cumulative impacts and residual risks associated with changes in water quality.
Residual Risks: Can be controlled and largely prevented.

Table 30: Loss of aquatic biota

Nature: 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 and in flow		
Activity: 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.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Definite (5)	Highly probable (4)
Duration	Long term (4)	Long term (4)
Extent	Regional (4)	Regional (4)
Magnitude	High (8)	High (8)
Significance	**80 (high)**	**64 (moderate)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative

Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- 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.
- Other than approved and authorized 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.
- Weed control in aquatic ecosystem and buffer zone.
- 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.
- Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.
- Habitat Preservation and Restoration: 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.
- Water Quality Management: 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.
- Fish and Wildlife Conservation Measures: Develop and implement fish and wildlife conservation plans to minimize the impact on sensitive and protected species. This may include establishing exclusion zones, installing fish-friendly screens in water intake structures, and creating fish passage solutions to enable the movement of fish through the solar plant area.
- Riparian Buffer Zones: Establish and maintain vegetative riparian buffer zones along water bodies to provide shade, stabilize banks, and reduce erosion. These buffer zones can offer important habitat and food sources for aquatic biota.
- Invasive Species Management: Develop an invasive species management plan to prevent the introduction and spread of non-native species that can negatively impact aquatic biota. Regular monitoring and prompt eradication of invasive species should be implemented.

Cumulative impacts: Expected to be low

Residual Risks: Expected to be low.

6 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 31, Table 33 and Table 40 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. Option 1 assumes no structures will be placed within the delineated wetlands, while Option 2 assumes structures will be placed within approximately 39 ha of wetland habitat. For the Grid it is assumed that the wetlands will be avoided an no structures will be placed within the wetlands. 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 31: The severity score derived from the DWS (2016) risk assessment matrix for the Bushveld Vametco Development – Option 1

RISK MATRIX (Based on DWS 2016 publication: Section 21 c and I water use Risk Assessment Protocol): Bushveld Vametco Solar PV - Option 1

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%**	Described in Report	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	1	2	2	5	2	1	5	2	**10**	**50**	**L**	**80%**		N	
O	Operation of the photovoltaic plant	Day to day activities of the PV Structures 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%**	Described in Report	N	Not expected to decrease scores
		Thermal Pollution		2	4	1	1	2	2	3	7	3	1	1	2	**7**	**49**				n	
		Maintenance of infrastructure		1	1	1	1	1	1	1	3	1	1	5	2	**9**	**27**	**L**	**80%**		N	

Table 32: The severity score derived from the DWS (2016) risk assessment matrix for the Bushveld Vametco Development – Option 3

RISK MATRIX (Based on DWS 2016 publication: Section 21 c and I water use Risk Assessment Protocol): Bushveld Vametco Solar PV - Option 3

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+Vege tation)	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	3	2	3	1	3	1	2	6	1	2	5	3	**11**	**66**	**M**	**80%**	Described in Report	N	**Expected to decrease scores**
		Earthwork activities		3	2	3	1	3	1	2	6	1	2	5	3	**11**	**66**	**M**	**80%**		N	
		Storm Water Management		2	2	1	2	2	1	3	6	2	1	5	3	**11**	**66**	**M**	**80%**		N	
O	Operation of the photovoltaic plant	Day to day activities of the PV Structures 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	3	3	5	2	**13**	**68**	**M**	**80%**	Described in Report	N	Expected to decrease scores
		Thermal Pollution		2	4	1	1	2	2	3	7	3	3	1	2	**9**	**63**	**M**			n	
		Maintenance of infrastructure		1	1	1	1	1	1	1	3	1	1	5	2	**9**	**27**	**L**	**80%**		N	

Table 33: 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 - Vametco 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 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 infrastructure near wetlands	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	

7 CONCLUSION

Three watercourse types were recorded on site (Figure 8). The watercourses are further classified into the following classification guidelines (Ollis *et al,* 2013):

- Channelled Valley Bottom Wetland
- Non-Perennial Episodic Riparian Area
- Seepage Wetland
- As described both the riparian area and the seepage wetland has dramatically increased in size due to anthropogenic increase in water inputs. It is no longer possible to distinguish between artificial wet areas and natural wet areas. However, it is likely that the wetland will decrease in size should the water inputs be stopped.

Three layout options were considered:

Option 1

From the perspective of wetland conservation, Option 1 is favoured as it minimises the environmental impact on the wetlands by circumventing any development within the wetlands or their associated buffer zones. Nevertheless, the feasibility of this option is significantly constrained by the limited spatial dimensions of the site. The complexity is further exacerbated by the site's subdivision into three distinct sub-areas. Such a division mandates the installation of multiple electrical substations, the establishment of inter-site connections, and the construction of supplementary roadways and bridges.

Option 2

From a wetland conservation standpoint, Option 2 emerges as the least favourable alternative, given that it would impact or result in the loss of approximately 42.86 hectares of wetland area, excluding buffer zones. It is imperative to clarify that the dimensions of two of these watercourses have been significantly augmented due to anthropogenic water inputs. Consequently, the size of the wetlands is likely to diminish if these water inputs are eliminated. The site under consideration will be partitioned into two primary sections, namely the northern and southern areas. Access to the northern section will be facilitated via a bridge originating from the southern section. It is noteworthy that this option introduces its own set of complexities, including the construction of a bridge and the necessity to manoeuvre through areas designated as wetlands.

Option 3

From the vantage point of wetland conservation, Option 3 ranks as the second most option, as it is projected to have a lesser impact on, or loss of, wetlands, affecting an estimated 38.93 hectares (sans buffer zones). It is crucial to point out again that the size of two of these watercourses has been substantially augmented due to anthropogenic water inputs. This option entails the rerouting of the sewage spillway to the southern portion of the site and the diversion of a smaller stream towards the west, actions that are likely to result in a reduction of the wetland's overall dimensions (likely to a more natural state prior to water inputs). Furthermore, this alternative omits a smaller section of the wetland situated in the central-western region, thereby effectively minimising the environmental repercussions on critical wetland areas. Access to the site will be provided through a northern roadway, capitalising on existing road infrastructure and obviating the necessity for bridge construction

Potential impacts from the solar plant and related activities to watercourses include the following:

- Water Usage: Solar plants typically require water for cleaning solar panels, cooling systems, and other operational needs. Depending on the size of the plant and local water availability, significant water withdrawals may occur, leading to reduced water availability for nearby watercourses and ecosystems.
- Changes in Hydrological Regimes: Construction activities related to the solar plant, such as grading and excavation, can disrupt natural water flow patterns and alter the hydrological regime of nearby watercourses. This can impact water quantity, timing, and velocity, potentially affecting aquatic habitats and species.
- Sedimentation and Erosion: Construction activities and land disturbance during the installation of solar panels can result in increased erosion and sediment runoff into nearby watercourses. This can lead to sedimentation, reduced water clarity, and potential impacts on aquatic ecosystems and species.
- Habitat Loss and Fragmentation: The installation of solar panels and associated infrastructure will require the clearing of vegetation, leading to habitat loss and fragmentation along watercourses. This can disrupt the connectivity of habitats and impact aquatic biodiversity.
- 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.
- Alteration of Water Quality: Runoff from solar panel cleaning activities or other operational processes may contain chemicals, detergents, or cleaning agents that can impact water quality in nearby watercourses. It is crucial to properly manage and treat any potential wastewater discharges to mitigate adverse effects.
- Land Use Changes: The construction and operation of a solar plant can result in land use changes in the surrounding area. This may include the conversion of agricultural land or natural habitats to industrial land, which can indirectly affect watercourses through changes in land cover, drainage patterns, and nutrient runoff.
- Reduced watercourse Vegetation: Solar plants will require clearing of vegetation, including riparian vegetation along watercourses. The removal of riparian vegetation can have negative impacts on bank stability, erosion control, and nutrient cycling, potentially affecting the health and resilience of watercourse ecosystems.

The important factors relevant to Environmental Authorisation for the project are summarised in Table 34 below:

Table 34: Summary of the findings.

<table>
<tr><td rowspan="2"></td><td colspan="2">Quaternary Catchment and WMA areas</td><td>Important Rivers within 500 m</td></tr>
<tr><td colspan="2">A21J - WMA #1: Limpopo: Major rivers include the Limpopo, Matlabas, Mokolo, Lephalale, Mogalakwena, Sand, Nzhelele, Mutale, and Luvuvhu.</td><td>The watercourses of the study site are associated with or flow into the Rosespruit which then flows into the Crocodile River.</td></tr>
<tr><td>Classification (SANBI, 2013)</td><td>Channelled Valley Bottom Wetland</td><td>Seepage Wetland</td><td>Episodic Stream</td></tr>
<tr><td>EC Scores (PES - WetHealth Version 2 (Macfarlane et al., 2020) VEGRAI</td><td>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</td><td>E – Seriously Modified. 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 The condition of this wetland is likely to likely to remain stable over the next 5 years</td><td>D – Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.</td></tr>
<tr><td>WetEcoServices (Kotze et al., 2020) –</td><td>High</td><td colspan="2">Moderate</td></tr>
<tr><td>REC (Rountree et al, 2013)</td><td>REC of B/C. This means that the development should be done in such a way as to try and improve the EC values if possible.</td><td>REC of E/F This means that the development should be done in such a way as to try and maintain the EC values if possible.</td><td>REC of D. This means that the development should be done in such a way as to try and maintain the EC values if possible.</td></tr>
<tr><td>Calculated Buffer Zone (Macfarlane et al, 2015)</td><td colspan="3">15 m</td></tr>
<tr><td>In situ Water Quality</td><td colspan="3" rowspan="3">No flowing water observed. Ideally this should be revisited after high rainfall events.</td></tr>
<tr><td>Instream Habitat assessment:</td></tr>
<tr><td>Aquatic macroinvertebrate assemblages:</td></tr>
</table>

NEMA 2014 Impact Assessment for the Bushveld Vametco – Option 1	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
	Loss of Aquatic Biota	Construction	M	L
		Operational	M	L
NEMA 2014 Impact Assessment for the Bushveld Vametco – Option 3	Changes to flow dynamics	Construction	H	M
		Operational	M	L
	Sedimentation	Construction	H	M
		Operational	M	L
	Establishment of alien plants	Construction	M	L
		Operational	M	L
	Loss of wetland habitat	Construction	H	M
		Operational	H	M
	Pollution of watercourses	Construction	M	L
		Operational	M	L
	Loss of Aquatic Biota	Construction	H	M
		Operational	M	L

DWS 2016 Risk Assessment	• Structure currently located within wetlands and buffer zones should not be included in the final layout and must be moved. • Designs should consider regional hydrological dynamics. • Stabilise erosion where required. • Establishing buffer zones and setbacks along watercourses to protect them from direct impacts and minimize disturbance. • Implementing sediment and erosion control measures during construction to prevent sediment runoff and reduce erosion into watercourses. • Implementing spill prevention and response protocols to minimize the risk of accidental spills or releases of hazardous substances into watercourses. • Conducting regular water quality monitoring to assess the condition of watercourses and promptly address any issues or exceedances. • Incorporating native vegetation and riparian restoration efforts to enhance the natural filtration capacity of watercourses and provide habitat for aquatic organisms. • Adhering to environmental regulations and permit requirements related to watercourse protection and engaging with regulatory agencies for guidance and compliance. • Implementing fish-friendly screens and fish passage solutions to enable the movement of fish through the solar plant area and minimize barriers to migration. • Engaging with stakeholders and experts to incorporate best practices and ensure the adoption of effective mitigation measures. • Developing and implementing an environmental management plan specific to the solar plant, outlining measures to minimize impacts on watercourses and promote their long-term health and functionality.
Does the specialist support the development?	Yes, Although Option 1 is preferred it is likely not viable for the developer. Thus option 3 can be considered. Large sections of the areas where the structures will be placed within wetlands are artificial in nature due to anthropogenic activities. Should this option be authorized, a wetland rehabilitation and/or offset plan should be done.

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APPENDIX A: Requirements for Aquatic Biodiversity Assessments

The NEMA regulations of 2014 (as amended) specify required information to be included in specialist reports. Table 35 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 35 presents a summary of the requirements of this protocol with notes on sections of the report applicable to each aspect.

Table 35: 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 1.2
(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 **Error! Reference source not found.**
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 1.2
(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 8
(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 **Error! Reference source not found.**
(l) any conditions for inclusion in the environmental authorisation;	Section **Error! Reference source not found.**
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section **Error! Reference source not found.**
(n) a reasoned opinion—	
(i) whether the proposed activity, activities or portions thereof should be authorised;	Section 7
(iA) regarding the acceptability of the proposed activity or activities; and	Section 7
(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 7
(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 ground truthing.

Desktop Delineation

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.

Ground Truthing

Field investigations confirmed fine-scale wetland and riparian boundaries.

Wetland Indicators

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

- 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.

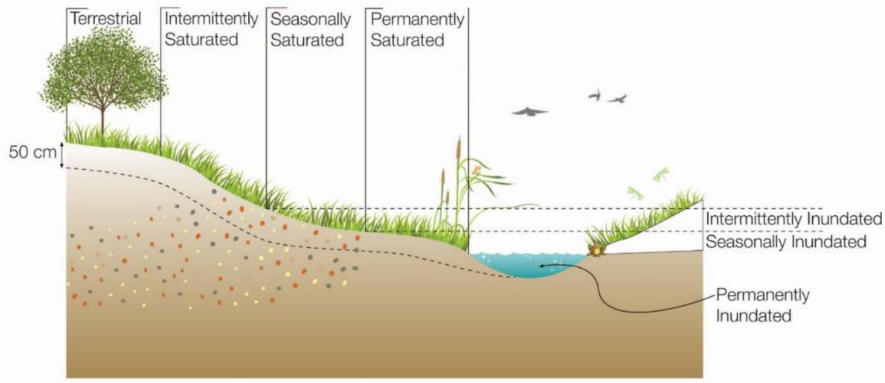


Figure 17: Typical cross section of a wetland (Ollis, 2013)

<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 19 and Figure 18).

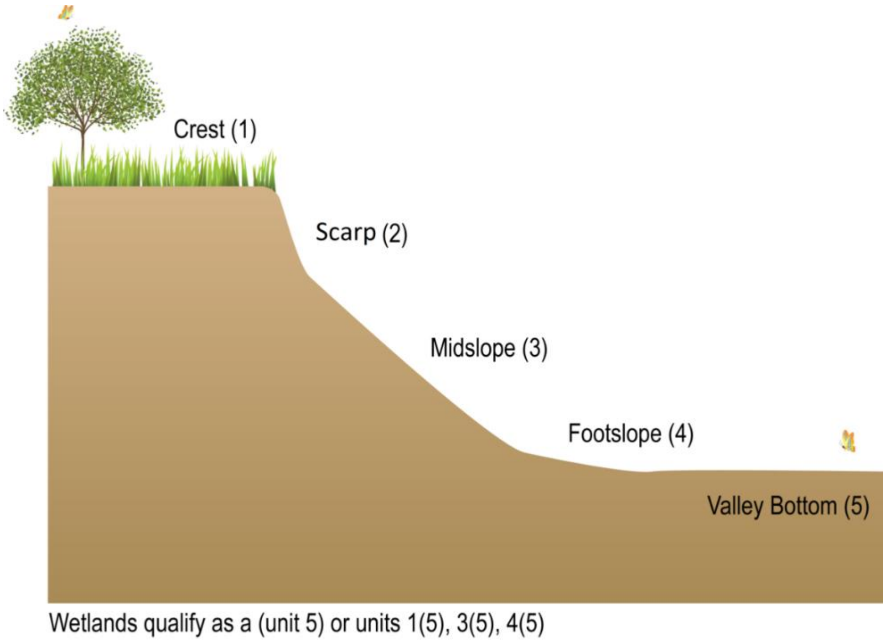


Figure 18. Terrain units (DWAF, 2005).

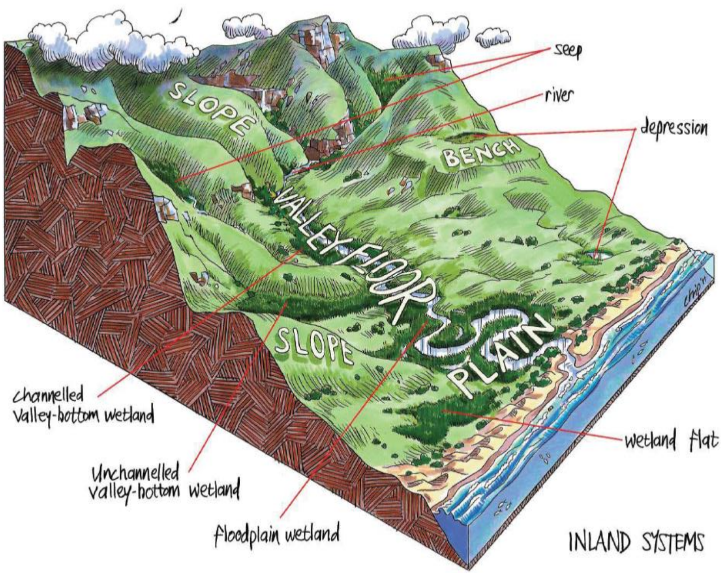


Figure 19: Wetland Units based on hydrogeomorphic types (Ollis *et al.* 2013)

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 20).

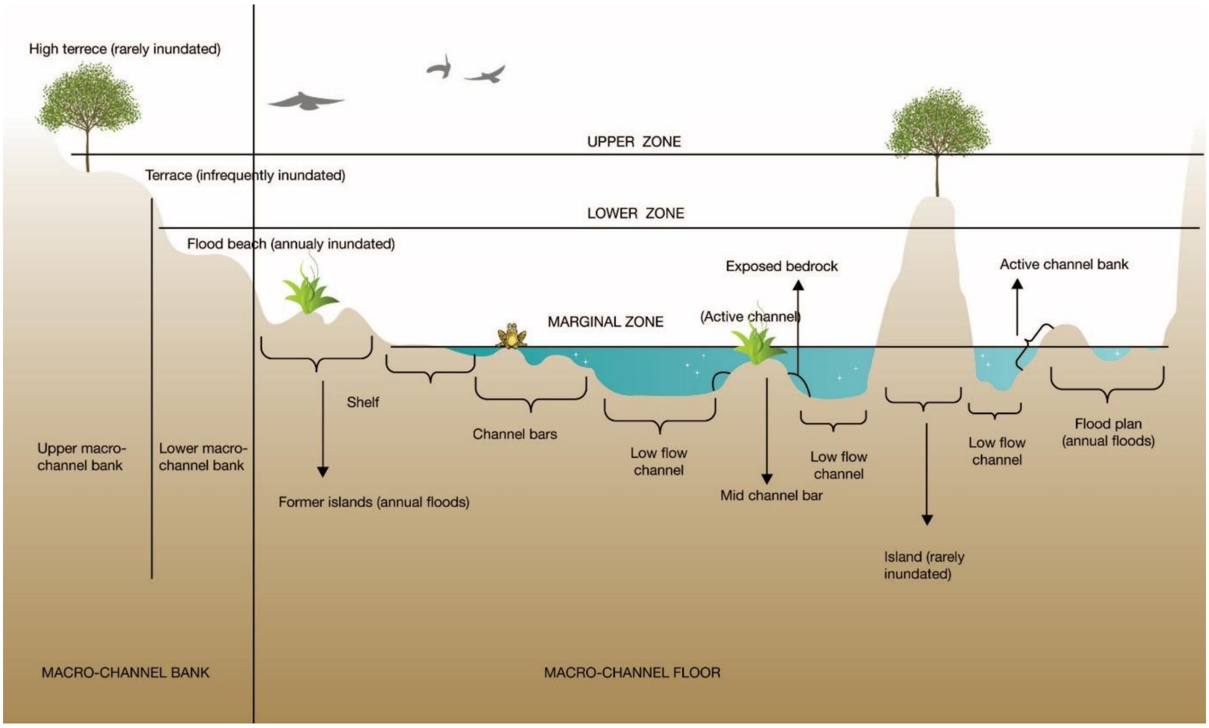


Figure 20: Schematic diagram illustrating an example of where the 3 zones would be placed relative to geomorphic diversity (Kleynhans *et al*, 2007)

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 21). 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).

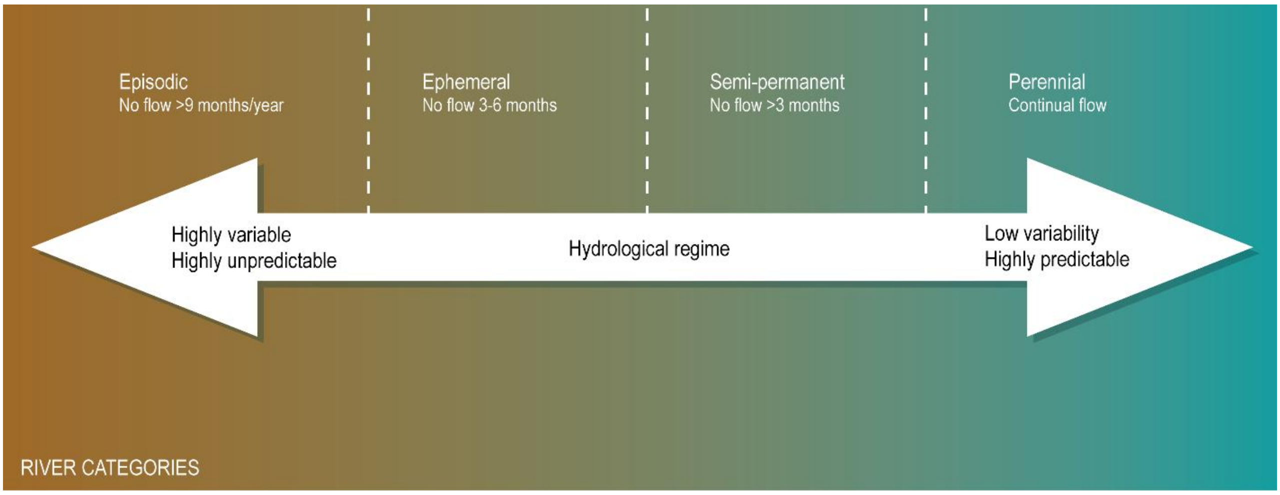


Figure 21: The four categories associated with rivers and the hydrological continuum. Dashed lines indicate that boundaries are not fixed (Seaman *et al*, 2010).

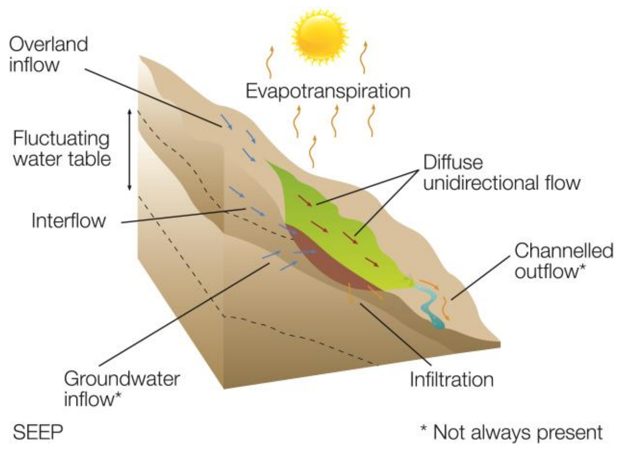
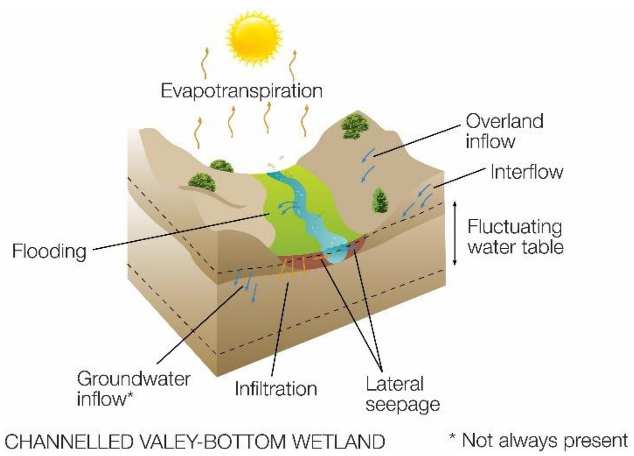
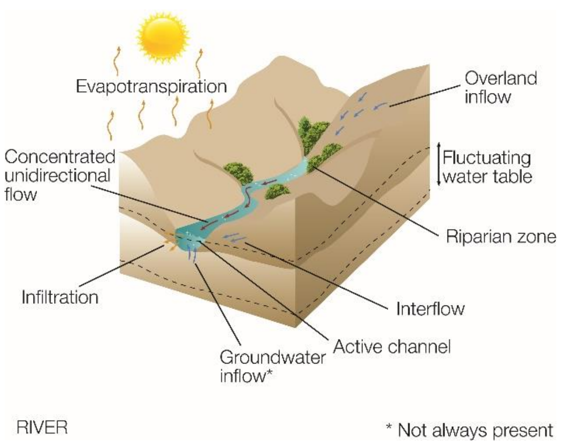
Wetland/Riparian Classification

The classification system developed for the National Wetlands Inventory is based on the principles of the hydrogeomorphic (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 watercourse 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 36):

Table 36: 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 foot slopes of hillsides; either as isolated systems or connected to downslope valley bottom wetlands. 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 oxbows 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.
Riparian habitat 	Linear fluvial, eroded landforms which carry channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The "river" includes both the active channel (the portion which carries the water) as well as the riparian zone.

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 land uses; (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 22 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 flood flows resulting from transformed catchments. Therefore, a conservative approach to the application of buffer zones is encouraged.

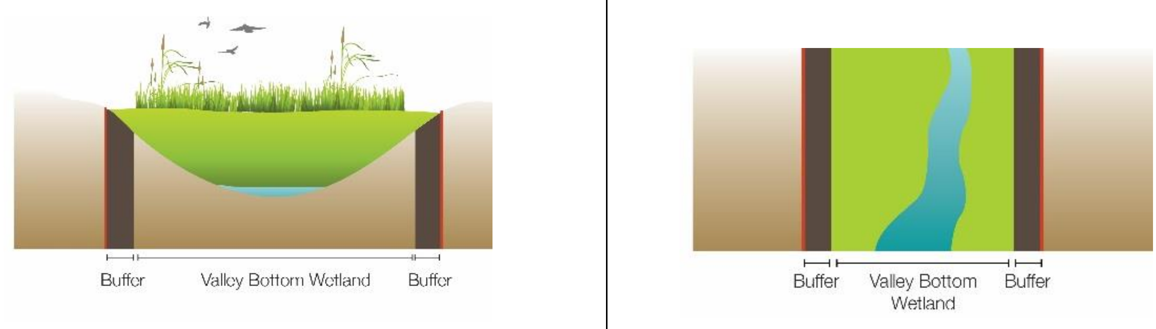


Figure 22: A represent the buffer zone setback for the watercourse discussed in this report

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 flood line 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 flood flows 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).

<u>Present Ecological Status (PES) – WET-Health</u>

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 37).

Table 37: 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 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 38. The trajectory of change is summarised in Table 39.

Table 38: 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 completely with an almost complete loss of natural habitat and biota.	8.0 to 10	0-19

Table 39: 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 40.

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

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 41 and Table 42 describe the categories for integrating scores for supply and demand of ecosystem services and their overall importance.

Table 41: 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 42: 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 43 below.

Table 43: 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 23 below.

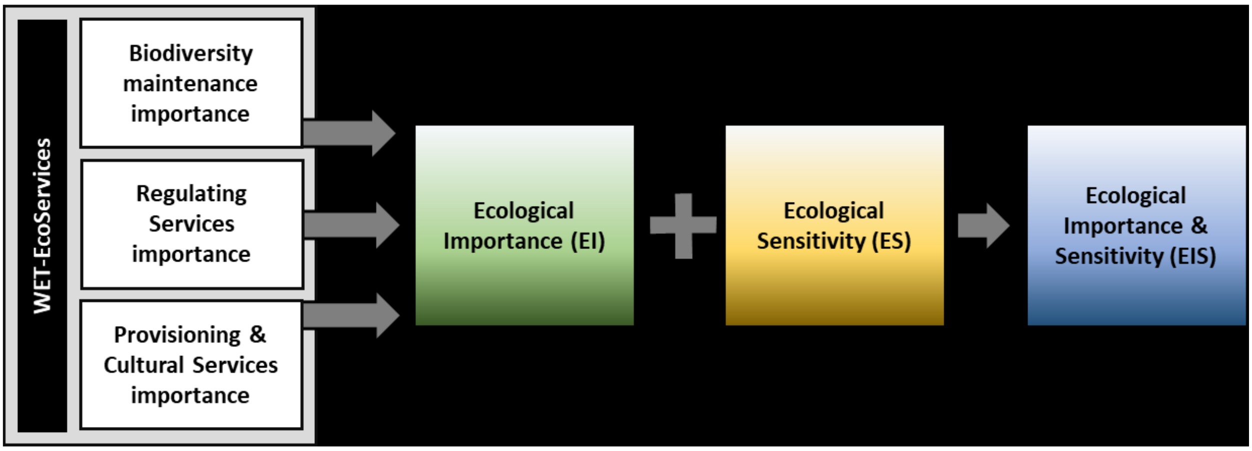


Figure 23: Schematic of the recommended Wetland EIS framework.

<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 44).

Table 44: 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

In Situ Water Quality

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 Photovoltaic Developmental 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 depends 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 Developmental 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 Developmental 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.

<u>SASS5</u>

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 Developmental 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

<u>Physical properties of water</u>

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 45 for a list of physical properties of water and comparative results.

Table 45: 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 46):

- 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 46: 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 24):

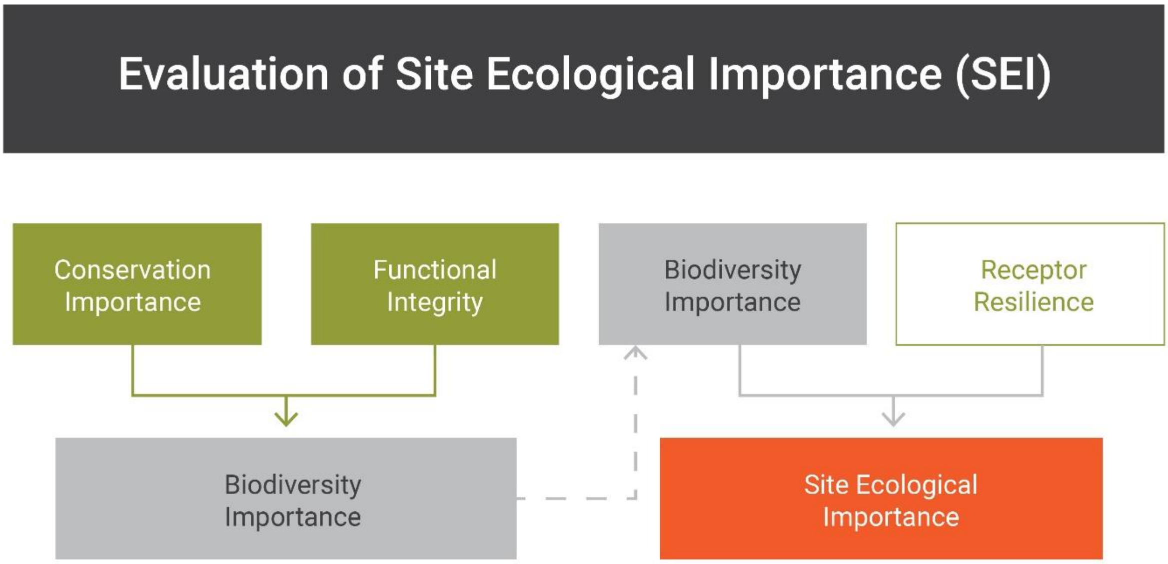


Figure 24: Evaluation of Site Ecological Importance based on CI, FI, BI, RR and SEI (SANBI, 2020).

Conservation Importance (CI) (Table 47) and Functional Integrity (FI) (Table 48) = Biodiversity Importance (Table 49).

Biodiversity Importance (BI) and Receptor Resilience (RR) (Table 50 and Table 47) = Site Ecological Importance (Table 51).

Table 47: 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 48: 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 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 49: 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 50: 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 51: 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 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 52**):

Table 52: 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 DWS has therefore developed a risk assessment matrix to assist in quantifying expected impacts. The scores obtained in this assessment are Photovoltaic Developmental 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 53 below provides a description of the classes into which scores are sorted, and their implication for authorization.

Table 53: 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

ECOLOGIST

Ecologist / Botanist / Aquatic Specialist
SACNASP STATUS: Pr. Sci Nat (Reg. No. 008867)

PHONE
+27 71 602 2994

EMAIL
rudibezdt@gmail.com

LINKEDIN
www.linkedin.com/in/rudi-be-zuidenhoudt-37391684/

ABOUT ME

I am a skilled Scientific Professional with more than 10 years experience in various ecological fields with a specialisation in aquatic ecology and anthropogenic interactions.

EDUCATIONAL QUALIFICATIONS

FORMAL QUALIFICATIONS

- **B.Sc. (Botany & Zoology)**, University of South Africa (2008 - 2012)
- **B.Sc. (Hons) Botany**, University of South Africa (2014 – 2016)

OTHER QUALIFICATIONS

- **Introduction to wetlands**, Gauteng Wetland Forum (2010)
- **Biomimicry and Constructed Wetlands**. Golder Associates and Water Research Commission (2011)
- **Tools for Wetland Assessment**, Rhodes University (2011)
- **Understanding Environmental Impact Assessment**, WESSA (2011)
- **Wetland Seminar**, ARC-ISCW & IMCG (2011)
- **SASS 5**, Groundtruth (2012)
- **Wetland Rehabilitation Principles**, University of the Free State (2012)
- **Wetland Legislation**, University of Free-State (2013)
- **Wetland Plant Identification Course**, SANBI (2015)
- **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)
- **Venomous Snake Handling Course** – African Reptiles and Venom (2015)
- **Invasive Species Training**, SAGIC (2016)
- **Aquatic & Wetland Plant identification**, Cripsis Environment (2019)
- **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)
- **Ecosystem Restoration** - United Nations Development Programme (2022)
- **Green Entrepreneurship** - United Nations Development Programme (2022)
- **Fundamentals on Reducing emissions from deforestation and forest degradation** - United Nations Development Programme (2022)
- **Using Spatial Data for Biodiversity** - United Nations Development Programme (2022)
- **Communicating the Value of Biodiversity** - United Nations Development Programme (2022)
- **Protected Areas and Sustainable Development** - United Nations Development Programme (2022)
- **Applying Resilience Thinking to National Biodiversity Plans** - United Nations Development Programme (2022)
- **New Zealand Landscape as Culture: Wai (Water).** EDx & Victoria University of Wellington (2022)
- **New Zealand Landscape as Culture: Motu (Island).** EDx & Victoria University of Wellington (2022)
- **New Zealand Landscape as Culture: Maunga (Mountains).** EDx & Victoria University of Wellington (2022)
- **Exploring Volcanoes and their hazards: Iceland and New Zealand.** EDx & University of Catenbury.

LOCATION
Pretoria, South Africa
Willing to relocate worldwide

LANGUAGES
English, Afrikaans

MEMBERSHIPS IN SOCIETIES
- **SACNASP** (South African Council for Natural Scientific Professions) (Professional Natural Scientist Reg. No. 008867)
- **SAWS** (South African Wetland Society) Founding member
- **FEN** (Freshwater Ecosystem Network)

PERSONAL INTERESTS
Active CrossFit Member
Hiking
Reading
Music
4x4
Art

REFERENCES
Antoinette Bootsma
+27 83 454 5454

Hannes Badenhorst
+61 41 683 7808

EMPLOYMENT HISTORY

WETLAND SPECIALIST/ECOLOGIST - LIMOSELLA CONSULTING

September 2010 – Ongoing

Tasks include:

- Wetland and Riparian delineation studies, opinions and functional assessments including data collection and analysis.
- Rehabilitation and Restoration Projects
- Correspondence with stakeholders, clients, authorities and specialists.
- Presentations to stakeholders, clients and specialists.
- Project management.
- Planning and executing of fieldwork.
- Analysis of data.
- GIS spatial representation.
- Submission of technical reports containing management recommendations.
- General management of the research station and herbarium.
- Regular site visits.
- Attendance of monthly meetings
- Submission of monthly reports.

GIS SPECIALIST - AFRIGIS

January 2008 – August 2010

Tasks include:

- GIS Spatial layering
- Google Earth Street View Mapping
- Data Input

KEY EXPERIENCE

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 300+ 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.
- Water Quality Test – Lab Test
- SASS5 – South African Scoring System 5 - Methodology used to provide a scientific and credible assessment of the status or health of a river by means of examining the aquatic macroinvertebrates.

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.

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.

KEY EXPERIENCE *(continued)*

ENVIRONMENTAL AUDIT

Audit to comply with Section 21G Water Use Licences (Department of Water Affairs) and Water Use Licence checklists.

INVASIVE SPECIES MANAGEMENT

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

COURSES PRESENTED

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

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.

CONTAMINATED LAND INVESTIGATION

Comparing lab analysed soil (and ash) results to the Norms and Standards to compare the significance of contaminants. Reporting on possible options and remedial actions.

ADDITIONAL SURVEYS

- Several surveys and assistance in Zoological Surveys, including setting up animal, insect, invertebrate and camera traps.
- Avifaunal surveys.
- Visual Impacts Surveys.
- Improving of Rural Road Conditions Reports.

MITIGATION AND OFFSET REPORTS

- Providing recommendations into areas where land has been destroyed or greatly impacted to remediate nearby areas by means of offset and remedial action.
- Mitigation reports as guidelines to minimise possible impacts from proposed activities.

Curriculum Vitae

Bertus Fourie

Personal Information

Surname: Fourie
Full names: Albertus Jacobus (Bertus)
Email: bertusfourie@gmail.com
Telephone: 082 921 5445

Tertiary Education

M. Sc. M.Sc. Aquatic Health at University of Johannesburg, 2014. Research project title: *Biological aspects of the Mutale, Tshinane and Mutshundudi Rivers, Limpopo.*

B Tech. Nature Conservation, 2009 specialising in Environmental Education& Freshwater management. Project title: *Ndumo Game count: A critical review of game count data 1999-2009.*

National Diploma Nature Conservation, 2005

Matric 2001

SACNASP Professional Natural Scientist in the field of Ecology and Aquatic Sciences (Reg. No: 008394)

Accreditation:

SASS 5 (Dickens & Graham, 2002) Valid 2021-2024

Work Experience

Limnology (Pty) Ltd, 2015-present Director/Aquatic Ecologist
Galago Environmental, 2010-2015 Aquatic Ecologist
Aquamulch, June 2007-December 2009 Rehabilitation Specialist and Implementation Manager
Ndumo Community Project, 2005 – May 2007 Environmental Education Facilitator/Project Manager
I have been running my own business Limnology (Pty) Ltd since 2015 and therefore run multiple projects at the same time.
As part of my consulting work on various developments including mining, residential, agricultural, forestry and conservation I have been actively involved in water conservation through my function as Limnologist. At Limnology one of the services that we provide include internal and external audits of Water Use Licenses, EMP's and other authorisations. I have been part of various EIA and Water use license application processes and my involvement include liaisons with various stakeholders to meet stakeholder directives.
My work includes all aspects of ecology including terrestrial and aquatic, with a large emphasis on aquatic ecosystems. I have been involved in several projects and therefore only a select few has been included in the list. Please contact me should you require more information regarding the projects that I have been involved in.

Catchment management and rehabilitation

In 2019 I completed the catchment management and rehabilitation assessment for the Blesbok and Elsburg Catchments for the City of Ekurhuleni. Included in the scope of work:

• Water quality sampling and result analysis,
• Assessment of biological responses,
• Delineation of aquatic ecosystems for the catchments,
• Compilation of monitoring plan for the catchment,
• Recommendations in terms of mayor and minor interventions to improve the ecological condition of the catchment,
• Liaisons with stakeholders through the public participation process

Aquatic Environmental Control Officer (AECO)

• • Polihali Western Access Route construction (ongoing)

- • Ekurhuleni Integrated Rapid Transport Network, Tembisa (2016- 2018)
- • Glenway cable (2016)
- • Klippoortje Development (2011-2013)
- • Secunda Mall Construction wetland ECO auditing as in terms of Water Use License 08/C12D/CI/1852 (2012-2014)
- • Alwyn road extension (2012-2014)
- • Nooitgedaght pipeline installation (2014)

Environmental Control officer
Vergenoeg Mining Company ECO 2019-current
• Development and implementation of water conservation and water demand strategies.
• Development and implementation of Environmental Management Systems.
• Development and Implementation of Standard Operating Procedures (SOP's).
• Assessment of SOP's using PTO systems.
• Management and implementation of waste management systems and record keeping.
• Planning, coordination, development, review and implementation of environmental policies and procedures.
• Development of environmental awareness content, posters and facilitation of training at senior and operational level.
• Weekly and monthly inspections of key infrastructures, waste management sites, water management, dust monitoring and corrective actions where required.
• Sampling of dust outfall and water (surface and groundwater).
• Management and enhancement of strategic relationships and partnerships with local and international business partners regarding environmental issues and projects.
• People Management – Responsible for the tasks and performance management of 3 full-time and contract workers.
• Budget Compilation and Management to the value of R5,4 million.
• Strategic Reporting.

Pomona (Country Life retirement village) (2017)
Forest Hill Mall (2017)
Ekurhuleni Integrated Rapid Transport Network (IRPTN), Tembisa (2016-2018)

Veld and Game management plans (including Veld condition and plant diversity assessments)

- Meyersdal Eco Estate (2015)
- Portion 8 of the farm Diamant 882KQ
- Ndumo Nature Reserve (2007-2008)
- Rietvlei Nature reserve (2018)
- Itala Beef carrying capacity (2015)

Environmental impact assessments

- Crudus waste management- Hazardous waste handling licence (2011)
- Development Bank of South Africa- Solar Energy Application (2011)

Environmental Education

- Rynfield/ Linmed hospital Environmental Education plan (2012)
- Lapalala Wilderness School (2003-2005)
- Jubaweni Eco-School (2002-2003)

Ecological Management Plans

- Ecological Management Plan for the Linmed Hospital (June 2012).
- Ecological Management Plan for the Open Space Area on Portions 150&151 of the farm Doornpoort 295 JR (January 2012).
- Ecological Management Plan for the Open Space Area on Portion 1 of Re 89 Klippoortje Agricultural Lots and Portion 2 of Re 91 Klippoortje Agricultural Lots (August 2011).
- Ecological Management Plan for the Crudus Waste Management Hazardous waste license application (April 2011).
- Golden valley Ecological Management Plan for mineral exploration (May 2011).
- Ecological Management and monitoring plan for Portion 7 of the farm Diamant 771KQ (November 2006).

Monitoring Planning

- Monitoring plan for the Secunda Mall Rehabilitation plan implementation
- Monitoring plan for the Linmed Hospital wetland rehabilitation plan

• Monitoring plan for the proposed Erand Sewer line upgrade
• Monitoring plan for the Farm Pumba (portion 8 of the farm Diamant 228KQ)
• Monitoring plan for the K105 road upgrade
• Monitoring plan for the K69 Road upgrade

Rehabilitation implementation

• Implementation of the rehabilitation plan for Portions 89 & 90 of the farm Klippoortjie, November 2011.
• Implementation of the rehabilitation plan for the Secunda Mall project, September 2012- 2014.
• Rehabilitation and Landscaping of Lynnwood and Simon Vermooten Road, Pretoria (2010).
• Assistance to environmental officer in all duties on the VRESAP project.
• Hydro-seeding of VRESAP project (2009-2010).
• Bapong Weighbridge rehabilitation (2009).

Ridges Ecology assessment

• Alberton Church
• Boschoek Ridge assessment
• K60 road
• K71 road
• K71 Road ridge assessment
• Kenmare sewer line ridge assessment
• Kleinfontein Ridge assessment
• Lindley Waste Water Treatment Works Ridge assessment
• Misgund Development
• Paardeplaats
• Portion 4 of the farm Kleinfontein 368 JR
• Sunderland Ridge bulk water line
• Zandfontein ridge assessment
• Zwavelpoort Ridge assessment

Aquatic studies including SASS5 and fish population assessments (numerous projects)
• Springfield open cast mine
• Baberton gas to power
• N4 Belfast to Machadadorp
• Eloff Sand monitoring
• Lydenburg Sewage assessment
• MCWAP baseline study
• Alberts Farm assessment
• Emmerentia Dam assessment
• Annesley Mine assessment
• Florida lake assessment
• Diepkloof dam assessment
• Hy May dam assessment
• Uitkomst Coal

Wetland rehabilitation planning (numerous projects)
• Alwyn bridge construction
• Erand sewer upgrade
• Hennops lapa rehabilitation
• K113 and K56 Road
• K164 bridge construction
• K69 rehabilitation plan
• KwaMlanga mall wetland rehabilitation plan
• Linmed Hospital wetland rehabilitation plan
• N17 Chrisiesmeer road upgrade
• Olifantsvlei Cemetery Wetland delineation and rehabilitation
• Paulshof rehabilitation plan
• Pietermaritzburg- Cato Ridge fibre optic cable installation
• Portions 89 & 90 of the farm Klippoortjie
• Rosherville wetland rehabilitation
• Sam Malema road upgrade
• Secunda Mall Rehabilitation plan
• Serengeti Wildlife estate wetland rehabilitation plan
• Sibande street extension

• Vogelstruisfontein wetland rehabilitation plan
• Buffelspoort road upgrade

Aquatic ecosystem delineation (including wetlands and riparian of numerous projects)

• More than 500 wetland delineation reports have been completed up to date. A list can be provided.

Computer proficiency in programs designed specifically for ecological assessments

• **Distance 5.0:** used to analyse distance sampling surveys of wildlife populations.
• **FRAI: (**Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2)). Kleynhans CJ. , 2007. WRC Report No. TT330/08
• **FROC:** (Reference frequency of occurrence fish species in South Africa). Kleynhans CJ, Louw MD, Moolman J. 2007. WRC Report No TT331/08.
• Google Earth
• **MIRAI:** Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Thirion, C. 2007. WRC Report No. TT 332/08.
• **VEGRAI:** (Riparian Vegetation Response Assessment Index in River Eco Classification: Manual for Eco Status Determination (version 2)). Kleynhans CJ, MacKenzie J, Louw MD. 2007. WRC Report No. TT 333/08.
• **WET-EcoServices:** A technique for rapidly assessing ecosystem services supplied by wetlands. Kotze DC, Marneweck GC, Batchelor AL, Lindley DS and Collins NB, 2007. WRC Report No TT 339/08.
• **WET-Health**: A technique for rapidly assessing wetland health Macfarlane DM, Kotze DC, Ellery WN, Walters D, Koopman V, Goodman P and Goge C. 2007. WRC Report No TT 340/08.
• **Aquatic ecosystem buffer calculation tool:** Macfarlane, D.M., Bredin, I.P., Adams, J.B., Zungu, M.M., Bate, G.C. and Dickens, C.W.S. (2014). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. Final Consolidated Report. WRC Report No TT 610/14, Water Research Commission, Pretoria.

Membership of Scientific Societies

• Grassland Society of Southern Africa
• South African Society of Aquatic Scientists
• South African Wetland Society
• Society of Wetland Scientist

Training:

Mine closure and land rehabilitation short course University of Pretoria, 2020
Freshwater fish identification course South African Institute of Aquatic Biodiversity, 2016
Wetland Rehabilitation Centre for Environmental Management, University of Free State,
Introduction to wetland soils and delineation South African soil surveyor's organization (SASSO)
Wetland Management: Introduction and Delineation Centre for Environmental Management, University of Free State
SASS 5 training Nepid consultants (2011), Ground Truth (2013)
Environmental Law for Environmental Managers: Centre for environmental studies (CEM) @ Northwest University
FGASA level 1 FGASA 2006

Facilitation of training programmes

• Advanced Wetland course at the Centre for continued education at the University of Pretoria.
• Wetland training for Gr 6 and 7 pupils at the Swartvlei Voortrekker camp.