WETLAND AND DESKTOP AQUATIC IMPACT ASSESSMENT

FOR AN ENVIRONMENTAL IMPACT ASSESSMENT APPLICATION FOR THE ERGO MINING SOLAR PV FACILITY (PHASE 2), WITH A PLANT CAPACITY OF 40MW, WITHIN THE EKURHULENI LOCAL MUNICIPALITY, GAUTENG

Prepared for:

Environmental Management Assistance (Pty) Ltd
c/o Alicia Govender
Tel: 083 784 0460
Email: alicia@hunadigroup.co.za

Prepared by:

MALACHITE ECOLOGICAL SERVICES

Rowena Harrison
Tel: 078 0230532
Email: rowena@malachitesa.co.za

In collaboration with

Ecology International
Sustainability through Collaboration

Byron Grant
Tel: 082 863 0769
Email: byron@ecologyinternational.net

Final Version

August 2022

Declaration of Independence by Specialists

I, Rowena Harrison, hereby declare that I -

- Act as an independent wetland 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).
- Have and will not have vested interest in the proposed activity proceeding.
- Have no, and will not engage in, conflicting interests in the undertaking of the activity.
- 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).
- Will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.
- 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 ability.

An abridged CV of the author is provided in Appendix C as per the 'Minimum Report Content Requirements' for Specialist Reports (as per GN 320 GG 43110, dated 20 March 2020)

Rowena Harrison
Soil Scientist
SACNASP Reg. No. 400715/15
Date: 26th August 2022

Declaration of Independence by Specialists

I, Byron Grant, hereby declare that I -

- Act as an independent aquatic 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).
- Have and will not have vested interest in the proposed activity proceeding.
- Have no, and will not engage in, conflicting interests in the undertaking of the activity.
- 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).
- Will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.
- 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 ability.

An abridged CV of the author is provided in Appendix C as per the 'Minimum Report Content Requirements' for Specialist Reports (as per GN 320 GG 43110, dated 20 March 2020)

Byron Grant
Aquatic Scientist
SACNASP Reg. No. 400275/08
Date: 26th August 2022

EXECUTIVE SUMMARY

Malachite Ecological Services and Ecology International were appointed by Environmental Management Assistance to undertake a Wetland and Aquatic Impact Assessment for the proposed construction of a Solar Photovoltaic (PV) plant, with a capacity of 40MW to supply power to the existing Ergo Mining (Pty) Ltd Brakpan Plant and the Brakpan/Withok Tailings Dam facility.

Two alternative layouts were assessed, with the preferred layout occurring on Portions 183 and 272 of the farm Witpoortje No. 117IR (Figure 2), and the alternative layout occurring on Potion 183 of the farm Witpoortje No. 117R and the Remainder of Portion 9 of the farm Withok No. 131IR (Figure 3). An additional access point to the northern portion of the preferred layout (Ptn 272 of the Farm Witpoortje No. 117IR) will also be utilised. This access point was approved as Phase 1 of the project and will utilise an existing road.

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

- Identify and delineate any wetland/watercourse systems within the defined study site. This includes the ground truthing of wetlands delineated during the desktop Scoping Assessment phase utilising the "Practical field procedure for the identification and delineation of wetlands and riparian areas" manual.
- Classify the identified wetland habitats in accordance with the latest approach; 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis et al., 2013).
- To determine the Present Ecological State score (PES) and Functional Integrity of any identified wetlands using the WET-Health and Wet-EcoServices approach respectively.
- To determine the Ecological Importance and Sensitivity (EIS) of the identified wetlands.
- Conduct a desktop aquatic assessment on the potential aquatic biodiversity within the assessment area.
- To identify negative impacts on any identified wetlands from the proposed development.
- To recommend mitigation and suitable rehabilitation measures to lessen these impacts on the wetland systems.

Wetland Findings

A thorough ground truthing delineation exercise was conducted following the desktop Scoping Assessment for this project. Based on the four wetland indicators identified on site, three HGM units were delineated in both the preferred and alternative layout sites as well as the 500m regulated area. HGM 1 was classified as an unchannelled valley bottom system, HGM 2 is classified as a seep, HGM 3 is classified as a depression. HGM 1 flows along the western edge of the preferred layout, HGM 2 was delineated within the 500m regulated area and a portion of HGM 3 was delineated at the south-eastern boundary of the alternative layout.

Apart from the three natural HGM units delineated within the study site and 500m regulated area, a number of artificial wetlands, functional dams, discarded dams, and seepage from dams were delineated. These wetland areas were identified both within phase 1 of the Ergo Gold PV project as well as during the current assessment. During both phases of the Ergo Gold PV project, these areas were confirmed to be artificial in nature and have been created by the extensive anthropogenic modifications throughout the study site. As a result of these disturbances, the soils of the site have been completed modified and are now classified as the Hydric Technosol, Stilfontein form. These soils show signs of saturation but are not natural wetland soils. The artificial ‘wetlands’ were delineated during phase 1 of the Ergo Gold PV project based on the presence of hydric characteristics of the soil, at the surface of the soil profile or within the first 10cm. Similar ‘wetland’ areas were identified during the current assessment, within and adjacent to areas that have been extensively modified by historic and current mining activities and the subsequent rehabilitation of these areas.

The three natural HGM units were assessed with regards to their health according to the Wet-Health methodology. A level 2 assessment (detailed) was conducted. HGM 1, the unchannelled valley bottom wetland, was classified as Seriously Modified (PES Category E), HGM 2, the seep system has been classified as Largely Modified (PES Category D), and HGM 3, the depression system has been classified as Moderately Modified (PES Category C).

Aquatic Findings
In general, valley bottom wetlands and depressional systems such as was determined to be present within the study area are unlikely to support a diverse array of aquatic biota given the lack of diverse hydraulic habitat relative to true riverine reaches of watercourses. In addition, prevailing and historic land uses are likely to present a further limiting factor to the ability of the associated watercourses to support representative taxa, with much of the intrinsic biodiversity elements being lost and only a depauperate diversity likely to the present. Further, a total of four indigenous fish species and one alien fish species are expected to be associated with the larger study area. Such diversity may however be considered optimistic, and only limited fish diversity is expected to be associated with HGM 1 (if any), while no fish species are expected HGM 3.

Buffer requirements and Impacts
Even though the solar panels will be situated in areas where vegetation has been maintained, in order to reduce the risks of erosion, there is additional infrastructure associated with the project. These include a BES laydown area, a warehouse, an office, a switch room, internal roads to allow access to all the panels as well as a fence which will surround the entire infrastructural area. Stormwater emanating from the developed areas can have an impact on the receiving environment and particularly the wetland systems, through the increase in sediment transportation, the increase in flow into the receiving environment and the decrease in stormwater infiltration into the soil profile. Further to this the proposed storm water management plan includes the use of drainage channels to remove excess stormwater from the Stilfontein soils where stormwater will collect during the summer season in particular. A buffer was therefore calculated taking these factors into consideration and a 21 m buffer is recommended for the protection of the natural wetland systems. It is recommended that the buffer be planted with indigenous grasses and maintained as part of the construction and operational phases of the Environmental Management Programme for the development. A high basal cover of indigenous grass species will aid in the buffering out of sediment and pollutants from the development

before stormwater enters into any of the wetland systems. Furthermore, stormwater control from the development is key in reducing impacts to the downstream and adjacent wetland systems.

It must be noted that there are some small areas in which the solar panels will encroach into the 21 m buffer but not into the wetland system. The outfall from the storm water drainage channels is located within the wetland system (HGM 1). Furthermore, a bridge is proposed to cross HGM 1 in order to gain access to both portions (Ptn 272 and Ptn 183 of the Farm Witpoortje No. 117R) of the preferred layout site.

The activities for both the preferred and alternative layout identified within the study site include:

- The clearing of portions of the PV facility site for the establishment of the solar panels, and associated infrastructure.
- The construction of the bridge over HGM 1.
- The construction of the storm water drains.
- Maintenance of the PV facility during the operational phase.

Negative impacts therefore associated with this project potentially include:

- Soil erosion and sedimentation of the wetland systems.
- Pollution potential.
- Encroachment of invasive alien species into the wetlands as a result of the additional disturbances to the area caused by the construction and operational phases of the project.

Several general and specific measures are proposed to mitigate these impacts.

The Risk Assessment for the proposed project was undertaken in accordance with the General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in Section 21 (c) and (i) (Notice 509 of 2016). From a wetland and aquatic perspective, impact scores (for both the preferred and alternative layouts) received are both Low and Moderate. This is due to the PV facility site being located on a site completed disturbed from historic mining operations. Impacts to the wetland systems range from being small and easily mitigable to requiring mitigation measures on a higher level with associated costs

Conclusions and Recommendations

From a wetland perspective, the specialist is of the opinion that impacts arising from the proposed project can be mitigated to an acceptably low level. This is attributed to the historically and currently disturbed nature of the area coupled with the modified to seriously modified nature of the wetlands assessed within the study site. Even though there will be some encroachment of the solar panels into the 21m buffer, this impact is expected to be low and the storm water flow from these sites into the HGM 1 can be effectively managed. Furthermore impacts regarding the bridge and storm water drains can also be effectively managed.

In consideration of the aquatic habitat availability within the study area, it is expected that the aquatic biota assemblages present will be dominated by taxa with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. Further, given the likely seasonal availability of water within the unchannelled and depressional wetland systems present, it is expected that the period of inundation of the watercourse will result in temporal variations of aquatic assemblages within these systems. As such the risk of impact from the proposed activity on the associated aquatic ecosystem is expected to be low.

It is therefore the opinion of both authors that either the preferred or alternative layouts be approved from a wetland and aquatic perspective.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Project Description and Locality

Malachite Ecological Services (Pty) Ltd and Ecology International (Pty) Ltd were appointed by Environmental Management Assistance (Pty) Ltd to undertake a Wetland and Aquatic Impact Assessment for the proposed construction of a Solar Photovoltaic (PV) plant and associated infrastructure, with a capacity of 40MW to supply power to the existing Ergo Mining (Pty) Ltd Brakpan Plant and the Brakpan/Withok Tailings Dam facility.

Two alternative layouts were assessed, with the preferred layout occurring on Portions 183 and 272 of the farm Witpoortje No. 117IR (Figure 2), and the alternative layout occurring on Potion 183 of the farm Witpoortje No. 117R and the Remainder of Portion 9 of the farm Withok No. 131IR (Figure 3). The project infrastructure consists of:

- the solar panels,
- a BES laydown area,
- a warehouse,
- an office,
- a switch room,
- internal roads to allow access to all the panels, as well as
- a fence which will surround the entire infrastructural area.

An additional access point to the northern portion of the preferred layout (Ptn 272 of the Farm Witpoortje No. 117IR) will also be utilised. This access point was approved as Phase 1 of the project and will utilise an existing road.

This wetland and aquatic assessment forms part of the environmental requirements in the Environmental Impact Assessment and Water Use License applications. These are undertaken in compliance with the National Environmental Management Act (Act 107 of 1998) and the Environmental Impact Assessment (EIA) Regulations, 2014 (amended 2017), GN R. 327, R.325 and R. 324; as well as the Water Use Licence Application (WULA) in terms of the National Water Act (Act 36 of 1998).

Surface water attributed to wetland systems, rivers and riparian habitats comprise an important component of natural landscapes. These systems are often characterised by high levels of biodiversity and fulfil various ecosystems functions. As a result, these systems are protected under various pieces of legislation including the National Water Act, 1998 (Act No. 36 of 1998) and the National Environmental Management Act, 1998 (Act No. 107 of 1998). The primary aim of the study is to provide a description of the current ecological integrity and impacts pertaining to any water resources occurring within the assessment area as well as providing appropriate management recommendations to reduce any identified impacts on the delineated systems.

1.2 Scope of the Assessment

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

- Identify and delineate any wetland/watercourse systems within the defined study site. This includes the ground truthing of wetlands delineated during the desktop Scoping Assessment phase utilising the "Practical field procedure for the identification and delineation of wetlands and riparian areas" manual.
- Classify the identified wetland habitats in accordance with the latest approach; 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis et al., 2013).
- To determine the Present Ecological State score (PES) and Functional Integrity of any identified wetlands using the WET-Health and Wet-EcoServices approach respectively.
- To determine the Ecological Importance and Sensitivity (EIS) of the identified wetlands.
- Conduct a desktop aquatic assessment on the potential aquatic biodiversity within the assessment area.
- To identify negative impacts on any identified wetlands from the proposed development.
- To recommend mitigation and suitable rehabilitation measures to lessen these impacts on the wetland systems.

1.3 Assumptions and Limitations

It is difficult to apply pure scientific methods within a natural environment without limitations or assumptions. The following apply to this study:

- The wetlands within the study site were delineated based on GPS coordinate waypoints taken of onsite indicator features. The accuracy of the GPS device used was 3-6m and thus this may affect the accuracy of the maps produced.
- In order to obtain definitive data regarding the biodiversity, hydrology and functioning of rivers and wetlands, studies should ideally be conducted over a number of seasons and over a number of years. This study was undertaken during a two-day field investigation conducted on the 30th and 31st May 2022. An assessment of some of the same wetland systems was undertaken from the 5th to 7th February 2021 for Phase 1 of the Ergo Gold PV project. While these short-term assessments may potentially miss certain ecological information, thus limiting accuracy, detail, and confidence, this limitation is regarded as being small to non-significant.

1.4 Reporting Conditions

The findings, results, observations, conclusions, and recommendations provided in this report are based on the authors best scientific and professional knowledge as well as information available at the time of compilation. The authors, however, accept no liability for any actions, claims, demands, losses, liabilities, costs, damages, and expenses arising from or in connection with services rendered, and by the use of the information contained in this document. No form of this report may be amended without the prior written consent of the authors.

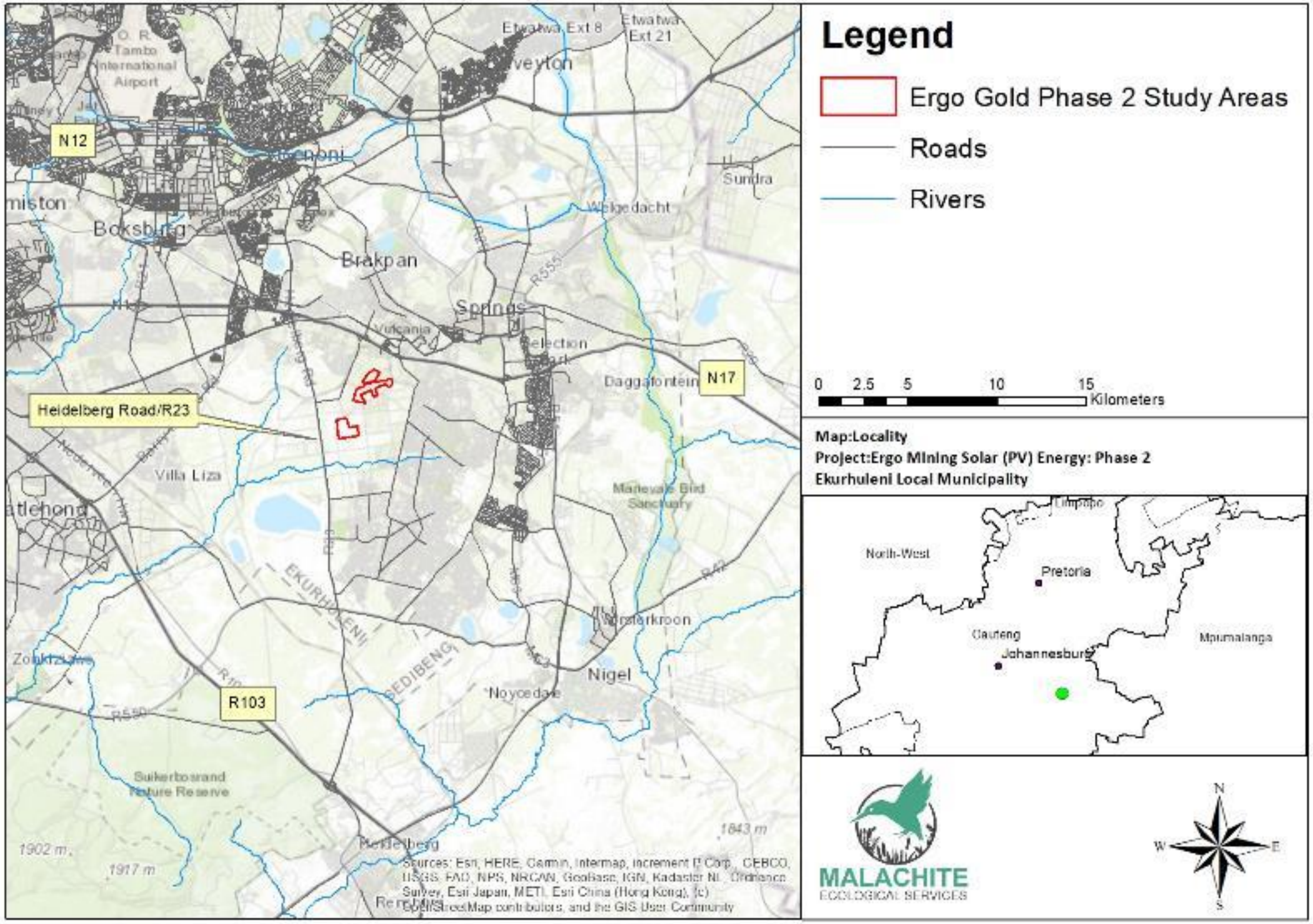


Figure 1: Locality of the study area

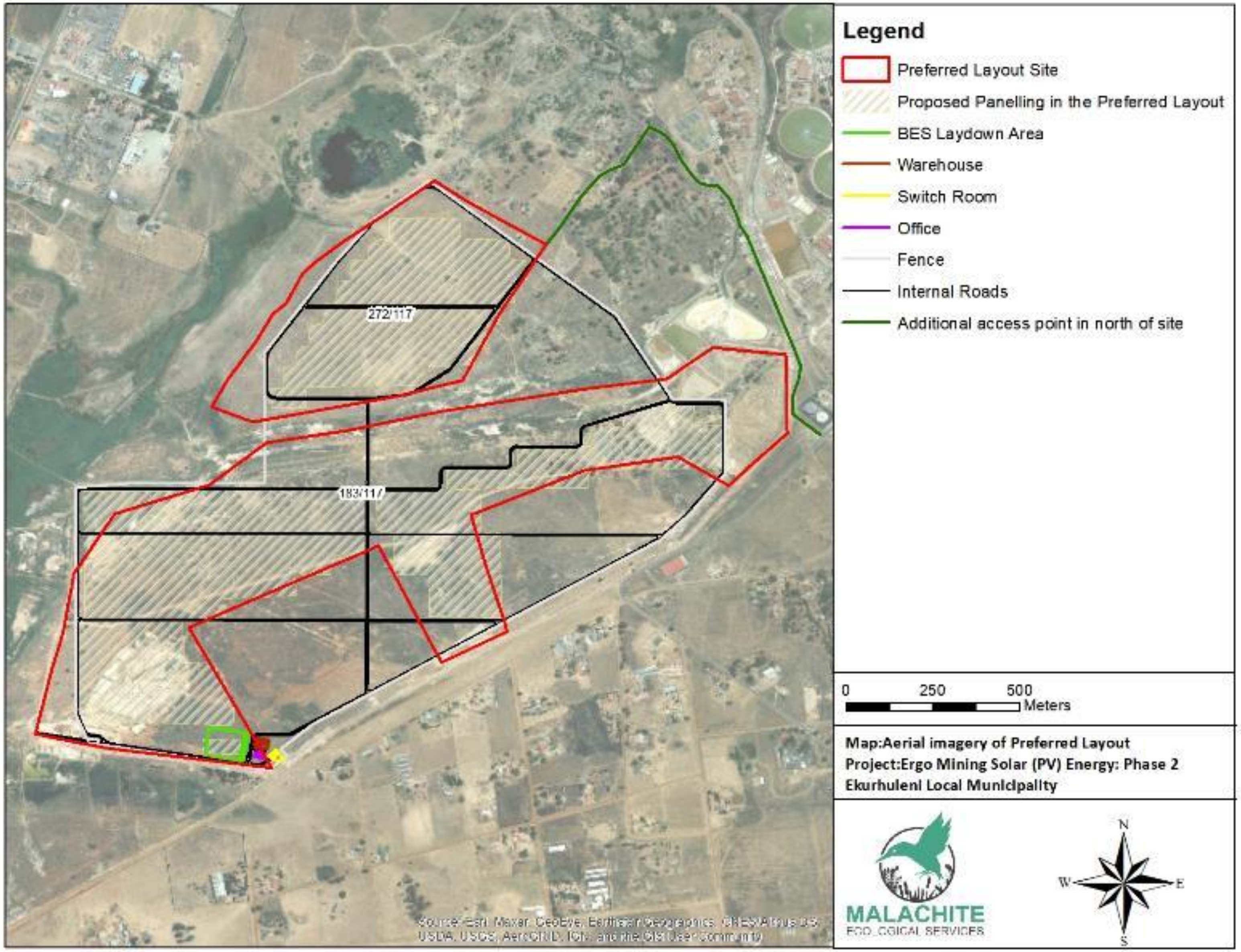


Figure 2: Aerial imagery showing the preferred layout and study site

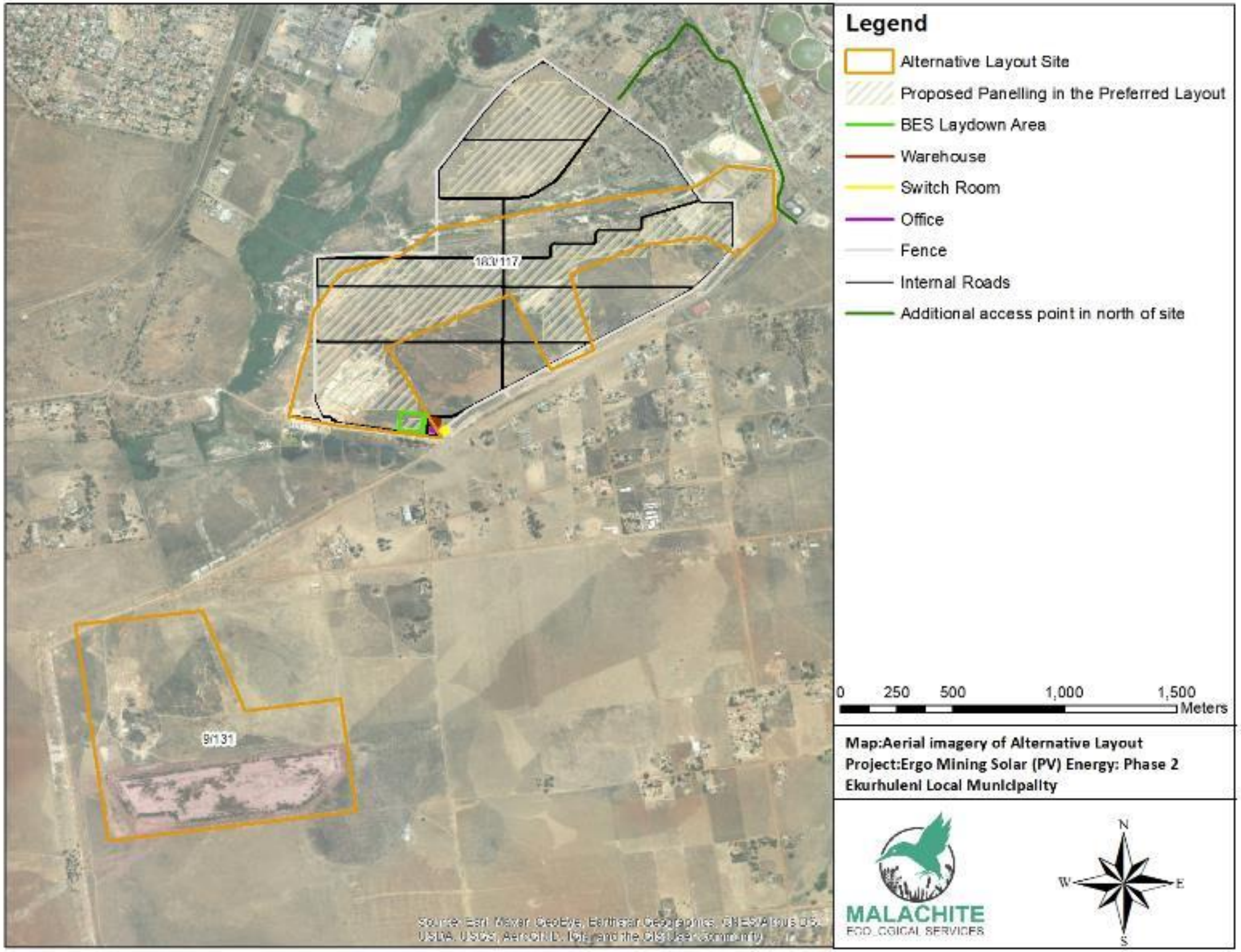


Figure 3: Aerial imagery showing the alternative layout and study site

2. METHODOLOGY

2.1 Wetland Assessment

The following techniques and tools were used in the assessment.

2.1.1. Baseline data

The desktop component of this study involved the examination of both historic and current aerial photography, Geographical Information System (GIS) databases including the National Freshwater Ecosystem Priority Areas (NFEPA) and South African National Wetland Map 5 as well as literature reviews of the study site, to determine the likelihood of wetland systems within the study site. The study made use of the following data sources:

- Google Earth™ satellite imagery.
- Relief dataset from the Surveyor General, used to calculate slope.
- Climatic data was obtained using a dataset on the climate-data.org website and was supplemented by information gathered in Mucina and Rutherford (2006).
- Historical imagery was obtained from the Department of Rural Development and Land Reform and the National Geospatial Information website (http://cdngiportal.co.za/cdngiportal/)
- Geology dataset was obtained from AGIS[1].
- Vegetation type dataset from Mucina & Rutherford (2006), with amendments by SANBI (NBA, 2018) were used in determining the vegetation type of the study area.
- The National Freshwater Ecosystem Priority Areas (NFEPA) were used in determining any priority wetlands.
- National Wetland Map 5 (NBA, 2018) was utilised at a desktop level to determine if there are any wetlands on the site and the classification of these wetland systems.
- Storm water management plan was obtained from the Phase 2 Hydrological Assessment for the Proposed Tshedza 3 Investments (Pty) Ltd Development of a 40 MW solar photovoltac and associated infrastructure development, Gauteng Province (Highlands Hydrology, 2022)
- Proposed bridge design was obtained from the proposed access way over the central drain line and adjacent flood plain: design description (Inqubeko Consulting Engineers, 2022).

2.1.2. Site Investigation

In field data collection was taken on the 30th and 31st May 2022. This included the ground truthing delineation exercise of wetland systems identified during the desktop Scoping Phase Assessment, the topographical setting, soil sampling techniques, identification of current land use and the identification of impacts and dominant vegetation units present.

2.1.3. Wetland Definition & Delineation Technique

South Africa has a strong legislative framework enforcing the country's obligations to numerous international conservation agreements for the protection of freshwater/wetland resources. These frameworks include several Acts, Ordinances, and treaties.

[1] Geological information was obtained from the Department of Agriculture's Global Information Service (AGIS) January 2014 – www.agis.agric.za

For the purpose of this assessment, wetlands are considered as those ecosystems defined by the National Water Act (Act 36 of 1998) 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."

Furthermore, the Ramsar Convention[2] defines wetlands as:

"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6m"

These habitats are found where the topography and geological parameters impede the flow of water through the catchment, resulting in the soil profiles of these habitats becoming temporarily, seasonally or permanently wet. Further to this, wetlands occur in areas where groundwater or surface water discharges to the surface forming seeps and springs. Soil wetness and vegetation indicators change as the gradient of wetness changes (Figure 4).

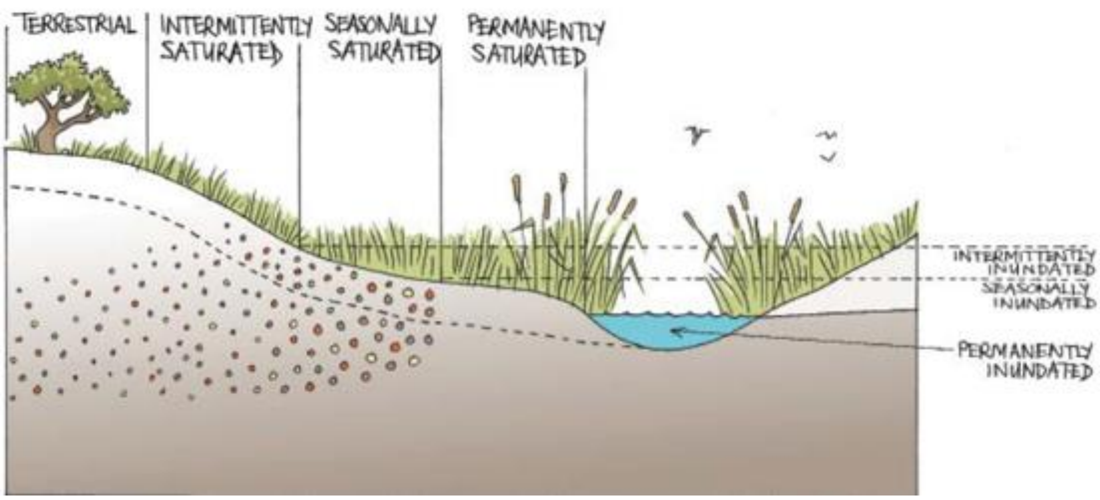


Figure 4: Increasing soil wetness zones identified within various wetland systems

Based on definition presented in the National Water Act (Act 36 of 1998), three vital concepts govern the presence of a wetland namely:

i. Hydrology- Land inundated by water or displays saturated soils when these soils are biologically active (the growth season).
ii. Hydric soils- Soils that have been depleted of oxygen through reduction resulting in the presence of redoximorphic features.

[2] The Ramsar Convention is legally named the Convention on Wetlands of International Importance Especially as waterfowl Habitat and was adopted by the International Conference on the Wetlands and Waterfowl at Ramsar, Iran, 2 February 197 I in order to recognise amongst others that wetlands constitute a resource of great economic, cultural, scientific and recreational value, the loss of which would be irreparable.

iii. Hydrophytic vegetation- Plant species that are adapted to growing in saturated soils and subsequent anaerobic conditions (hydrophytes).

The conservation of wetland systems is vital as these habitats provide numerous functions that benefit not only biodiversity but provide an array of ecosystem services. These services are further divided into direct and indirect and are detailed in Table 1. These transitional habitats also provide refugia for a variety of terrestrial and semi-aquatic fauna, plants and invertebrates.

Table 1: Direct and indirect benefits of wetland systems (Kotze et al. 2005)

WETLAND GOODS AND SERVICES	
DIRECT	**INDIRECT**
Hydrological Water purification Flood reduction Erosion control Groundwater discharge	*Socio-economic* Socio-cultural significance Tourism and recreation Education and Research
Biodiversity conservation	Water supply
Chemical cycling	Provision of harvestable resources

The study site was assessed with regards to the determination of the presence of wetland and watercourse areas according to the procedure described in 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas –Edition 1' (DWAF, 2005).

2.1.4. Wetland Health Assessment Techniques

A Wet-Health Assessment to determine the Present Ecological State (PES) was undertaken. The Wet-Health Version 2 (Kotze et al. 2020) was utilised for the PES of the wetlands. This version takes into account impacts on the hydrology, geomorphology, vegetation and water quality of both the individual wetland unit as well as each wetland's catchment. A level 2 assessment (detailed) was undertaken on the units delineated. A Level 2 Wet-EcoServices Assessment to determine the Functional Integrity of the identified wetlands was carried out. Further to this, the Ecological Importance and Sensitivity of each delineated wetland unit was ascertained. Detailed methodology for the wetland delineation, health, provision of ecosystem goods and services (functional integrity), ecological importance and sensitivity is given in Appendix A.

2.2 Aquatic Assessment

The purpose of this element of the proposed study was for the determination of potential aquatic biodiversity characteristics and sensitivities of the proposed project area. Given the lack of watercourses within both the preferred and alternative layouts, a desktop-based exercise was conducted. This made use of available literature and the latest spatial databases associated with the area of interest in order to identify threats and opportunities regarding aquatic biodiversity features relating to the proposed activities. Such databases included (but not limited to the National Freshwater Ecosystem Priority Areas (NFEPA), Global Biodiversity Information Facility database, Freshwater Biodiversity Information System, the Department of Water and Sanitation's PESEIS (Present Ecological State, Ecological Importance and Ecological Sensitivity) database, fish collection records of the South African Institute of Aquatic Biodiversity and the Albany Museum, as well as any other recent academic studies or national/provincial assessments associated with the area of interest. This information was then cross-referenced with the findings from the wetland component of the study in order to provide a spatial understanding of the likely aquatic features associated with the wetland units identified.

3. BIOPHYSICAL CHARACTERISTICS

3.1 Climate

The Ergo Gold Mine is situated within an area characterised by summer rainfall patterns with sporadic rainfall events during the winter months. The mean annual precipitation is 692mm, with the bulk of the rainfall occurring between September and March (summer months). These high intensity rainfall conditions are conducive to high levels of surface runoff and subsequent erosion where soils are shallow, occur on steep slopes or are overgrazed. The wettest time of the year is January with an average of 123mm and the driest is June and July with 7mm (Table 2). The seasonality of precipitation is a driving factor behind the hydrological cycles of water resources within the area. Typically, watercourses have a higher flow rate during the summer months.

Mean temperatures vary between 9.7^{O}C to 19.7^{O}C for the Brakpan region (Table 3). The area is coldest in July with average minimum temperatures of 2.8^{O}C and hottest in November and December with average maximum temperature of 25.2^{O}C on average (Climate-data.org; Mucina & Rutherford, 2006; updated 2018).

Table 2: Mean annual rainfall data for the Brakpan area

	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Mean Rainfall (mm)	123	96	86	42	19	7	7	9	24	65	105	109

Table 3: Temperature data for the Brakpan area

	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Mean Temperature (^{O}C)	19.7	19.6	18.4	15.7	12.8	10	9.7	13	16.8	18.5	18.9	19.7
Max Temperature (^{O}C)	25	24.9	23.9	21.5	19.6	17.3	17.4	20.9	24.6	25.7	25.2	25.2
Min Temp (^{O}C)	14.8	14.6	13.2	10.2	6.5	3.5	2.8	5.6	9.1	11.6	12.9	14.6

3.2 Geology

Water resources in South Africa are the products of erosional and depositional processes, as well as the presence of geological influences controlled by the variable environment across the country. South Africa is a semi-arid country with differences in rainfall patterns, topography, and geology. The geological characteristic of an area influences the topography, soil types and textures, vegetation communities and faunal assemblages present.

The study area is underlain predominantly by the Ecca Group of the Madzaringwe Formation of the Karoo Supergroup. The geology of this region is primarily known to be sedimentary strata and is a very thick sequence of carbonaceous siltstone, mudstone, shale, sandstone and coal (www.agis.agric.za).

3.3 Regional Vegetation Structure and Composition

The study area is located within the Grassland Biome. According to the latest regional vegetation classification for South Africa (Mucina & Rutherford, 2006; updated 2018), the study area falls within the Tsakane Clay Grassland vegetation type (Figure 5). The Tsakane Clay Grassland unit is distributed throughout Gauteng and Mpumalanga in areas characterised by flat to slightly undulating plains and low hills. The community structure is comprised of short, dense grassland dominated by a mixture of common highveld grasses such as *Themeda triandra, Heteropogon contortus*, *Elionurus muticus* and a number of *Eragrostis* species. The dominant forbs are of the families Asteraceae, Rubiaceae, Malvaceae, Lamiaceae and Fabaceae. Disturbances within these grasslands changes the vegetation dynamics, with an increase in the abundance of *Hyparrhenia hirta* and *Eragrostis chloromelas* noted. Erosion is generally very low.

This vegetation unit is classified as Endangered, with only 1.5% conserved in statutory reserves. The latter was confirmed in the NBA (2018) which indicates that the vegetation type is Poorly Protected, with an estimated over 60% transformed for cultivation, urbanisation, mining, dam-building, and roads.

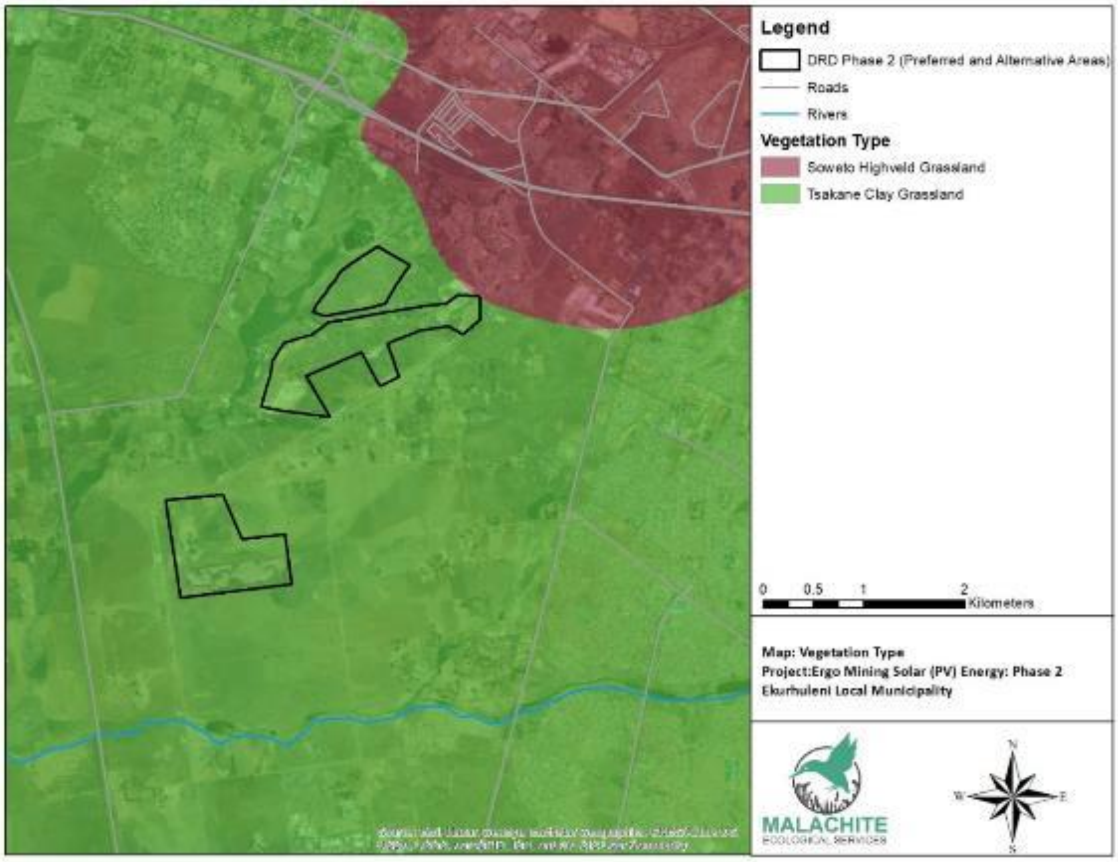


Figure 5: Regional Vegetation associated with the study site

3.4 Conservation Planning Frameworks

Systematic conservation planning is a globally recognised practice which identifies priorities for biodiversity conservation and informs legislation to facilitate the long-term conversion of identified biodiversity (Jewitt, 2018). The biodiversity sector is centred on a data-driven approach and is continually refining the outputs by improving input data (Dayaram et al., 2019).

3.5 National Biodiversity Assessment (NBA; 2018)

The National Environmental Management: Biodiversity Act (NEMBA) (Act 10 of 2004) lists Threatened or Protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Protected. The main purpose of listing Threatened Ecosystems is to reduce the rate of ecosystem and species extinction and includes the prevention of further degradation and loss of structure, function, and composition of Threatened ecosystems.

There are four main types of implications of listed ecosystems on development:

- Planning related implications, linked to the requirement in NEMBA for listed ecosystems to be taken into account in municipal IDPs and SDFs.
- Environmental authorisation implications, especially in terms of NEMA and EIA Regulations.
- Proactive management implications, in terms of NEMBA.
- Monitoring and reporting implications, in terms of NEMBA.

The most recent National Biodiversity Assessment (NBA), dated 2018, is a collaborative effort to synthesise the best available science on South Africa's biodiversity. The NBA is used to inform policy in the biodiversity sector and other sectors that rely on or impact on natural resources, such as water, agriculture, mining, and human settlements. The NBA provides information to help prioritise resources for managing and conserving biodiversity and provides context and information that underpins biodiversity inputs to land use planning processes (Skowno et al., 2019).

The NBA has seven technical reports (of which only the terrestrial component is discussed within this assessment) and relies on two headline indicators:

- **Threat Status**: Degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function, and composition, on which their ability to provide ecosystem services depends. Ecosystem types are categorised as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Concern (LC), based on the proportion of each ecosystem type that remains in good ecological condition relative to a series of thresholds (Skowno et al., 2019).
- **Protection Level**: Addresses the extent to which ecosystems and species are protected. Ecosystem types are categorised as Not Protected, Poorly Protected, Moderately Protected or Well Protected, based on the proportion of each ecosystem type that occurs within a protected area recognised in the NEMPAA (Skowno et al., 2019).

These headline indicators provide important links for data comparison as well as providing a standardised framework that links with policy and legislation. Furthermore, comparing threat status and protection levels for terrestrial ecosystems is useful for identifying ecosystems in particular need of protection (Skowno et al., 2019).

According to the outputs of the NBA (2018), the study site is located in remaining extents of the Tsakane Clay Grassland vegetation type. The ecosystem associated with the vegetation types have a threat status of Endangered, and a poor protection level (Figure 6). The classification implies that these areas have not been previously transformed and are regarded as natural habitat. Ground truthing of this classification however showed that the study site is situated in an urban environment (refer to flora specialist report).

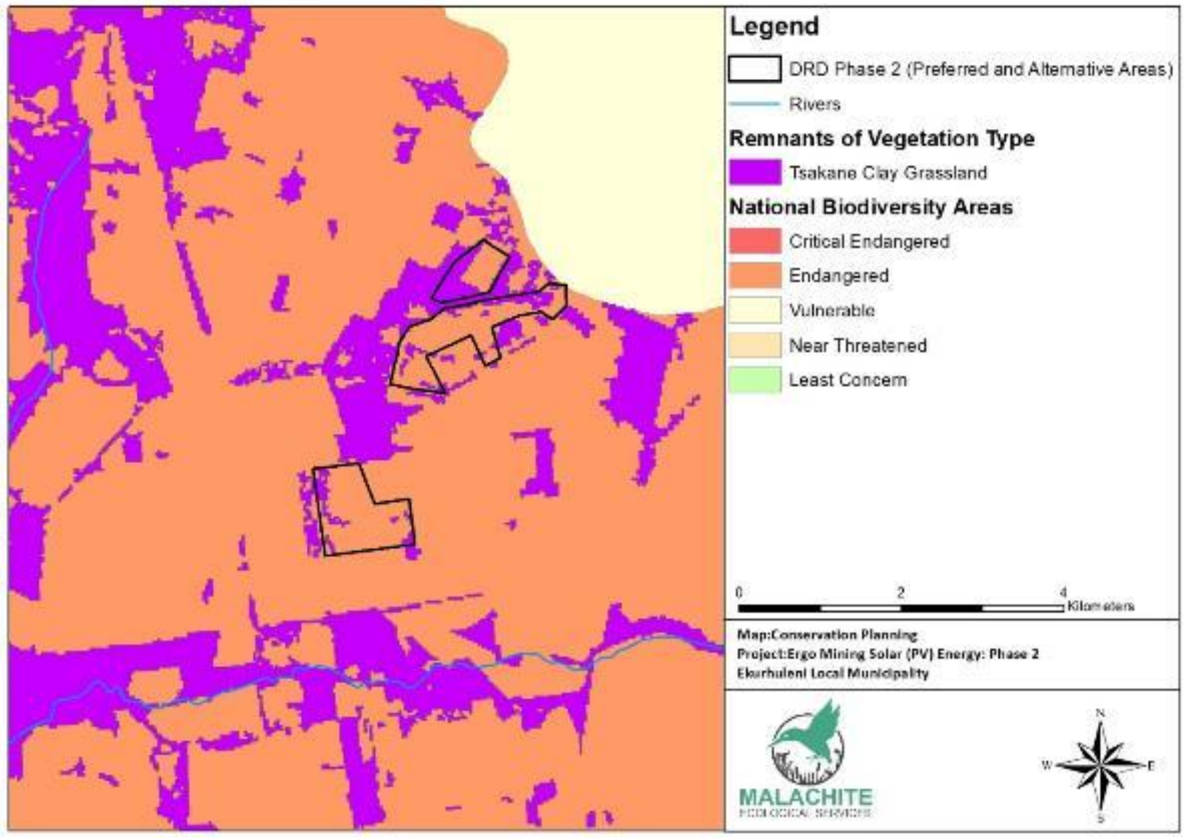


Figure 6: Outcomes of the National Biodiversity Area threat status associated with the study site

3.6 Catchment characteristics and watercourses

The project area lies within the Vaal Water Management Area. Major rivers within this WMA include the Wilge, Liebenbergsvlei, Mooi, Renoster, Vals, Sand, Vet, Harts, Molopo, and Vaal. These rivers experience significant levels of high-water demand related stress, particularly during drought seasons. Many of the surrounding communities rely on fresh water from these rivers throughout the year to supply adequate water for domestic use, stock and irrigation.

More specifically, the project area is situated within the C22C Quaternary Catchment (Figure 7). The Rietspruit flows approximately 2.7km to the west of the study site with a tributary of the Rietspruit flowing approximately 1.5km to the south of the study site. Non-perennial drainage channels are also located within the study site.

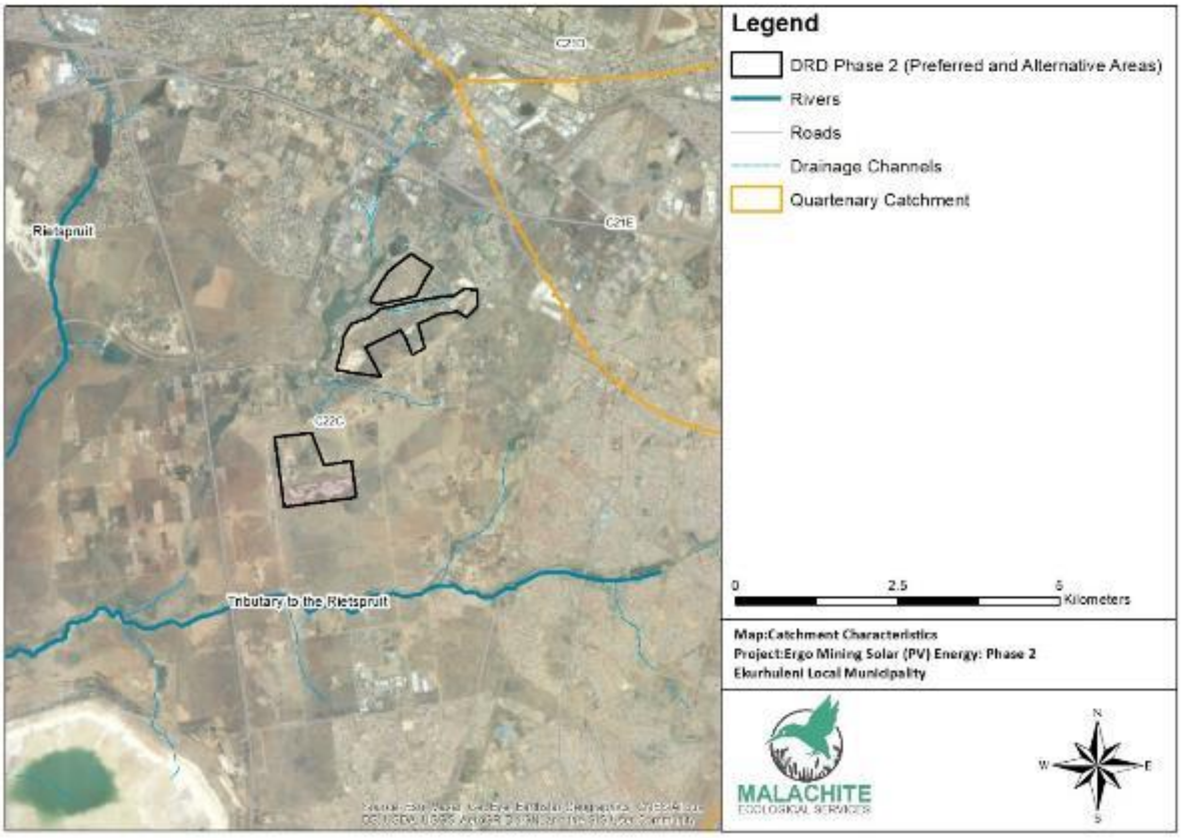


Figure 7: Quaternary catchments and river systems associated with the study area

3.7 Historic and Current Land Use

An investigation into historic aerial imagery of the site was undertaken. Portions of the study site are visible in historical aerial imagery from 1938 (Figure 8). In this imagery, development within the area is apparent with mining operations underway at the current location of the Brakpan Plant. Development is furthermore noted in the form of roads and scattered residential buildings. This development has had an impact on wetlands and watercourses within the study area.

Figure 8: Historic aerial imagery from 1938 showing portions of the study site, with mining already underway, the creation of road networks and the cultivation of crops

In imagery from 1985 the use of large portions of the site as mining areas and/or tailings dams is clearly evident (Figure 9). These dams are indications of the disturbed nature of the study site as a result of the use of this area for mining activities.

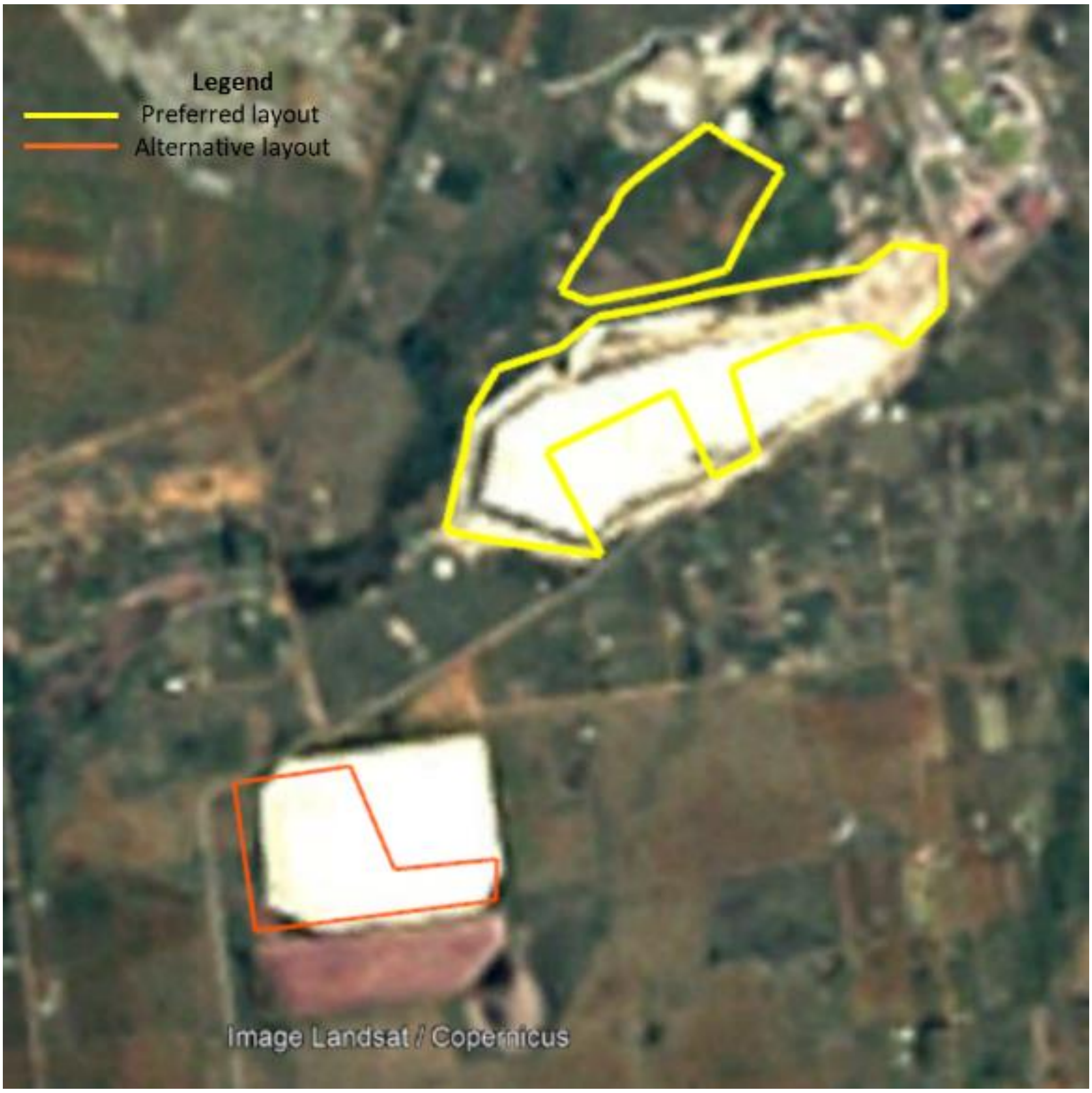


Figure 9: Historic aerial imagery from 1985

Aerial imagery from 2002 shows the mining and remining of the central to southern portions of the study site (Figure 10). Haul roads, mining operations, and the continued transformation of the site is apparent in the aerial imagery.

Figure 10: Aerial imagery from 2002

Mining was then discontinued within the study site and the rehabilitation of the area undertaken, from approximately 2004/2005. The tailings dam was re-processed from this time and slimes material is noted in the southwest of the site. This is shown in aerial imagery from 2008 (Figure 11). Topsoil stockpiles are still evident in the southern portion of the study area.

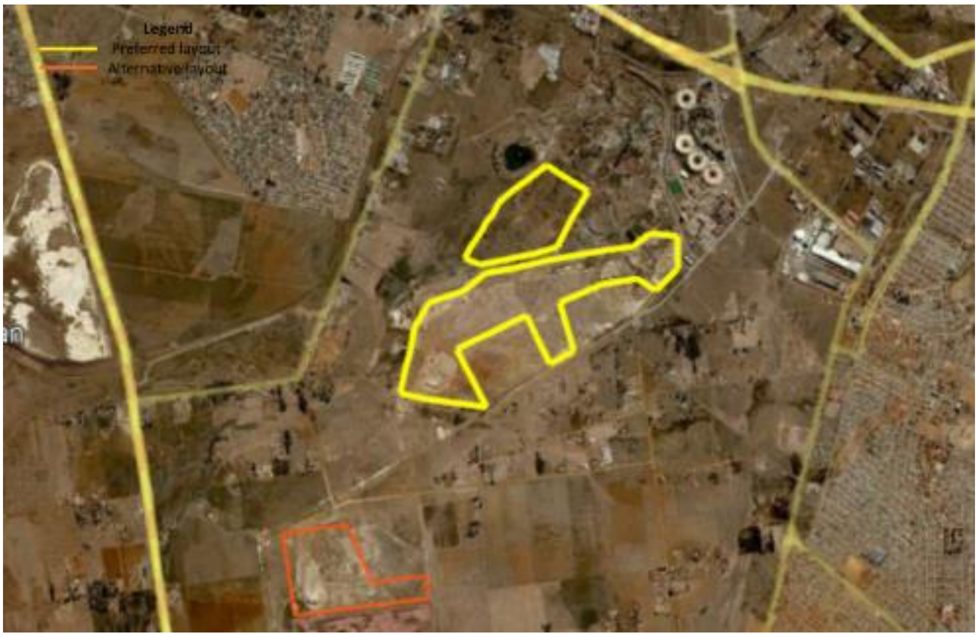


Figure 11: Aerial imagery from 2008

The most current aerial imagery available on Google Earth^{Tm} is from March 2022 (Figure 12). This shows large portions of the site re-grassed. The operations associated with historic and current mining activities as well as agricultural activities dominate the area and have had an impact on the watercourses and wetlands within the study site. This is detailed further in the following sections.

Figure 12: Current imagery from 2022

3.8 National Freshwater Ecosystem Priority Areas (NFEPA) and the National Wetland Map 5

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

According to the outputs of the NFEPA project (Figure 13) a number of wetland systems are located within the assessment area, however these are not classified as FEPA wetlands. No FEPA wetlands are located within the assessment area or within the 500m regulated area. The wetlands are classified as an unchannelled valley bottom wetland, seep systems as well as depression and flat systems. These are furthermore classified as both natural and artificial, with the natural systems categorised as Moderately Modified.

As an additional database to the NFEPA database layer, the more recent National Wetland Map 5 (Van Deventer et al, 2018) database was furthermore utilised to assess the project area. The National Wetland Map 5 (NWM5) forms part of the National Biodiversity Assessment (2018), within the category of the Inland Aquatic (Freshwater) Realm. This project is a multi-partner project through the CSIR and SANBI. The NWM5 has significantly improved the representation of inland wetland ecosystem types. The representation of the extent of inland wetlands has improved by 123%, facilitating the reduction in the incorrect representation of terrestrial ecosystems as wetlands (Van Deventer et al, 2018).

The NWM5 was utilised to assess the project area. As shown in Figure 14, an unchannelled valley bottom wetland flows along the western and northern boundary of the larger study site, and a depression/pan is located on the south-eastern boundary of the alternative layout site. According to the National Biodiversity Assessment (2018) the unchannelled valley bottom is classified as Critically Endangered, and not protected. The depression is classified as Least Concern and not protected. Both system types are at a high risk to loss within the catchment area. The aim of investigating these wetland databases is to gain a general idea of where certain systems may be located. These wetlands were therefore delineated more accurately during the current field assessment.

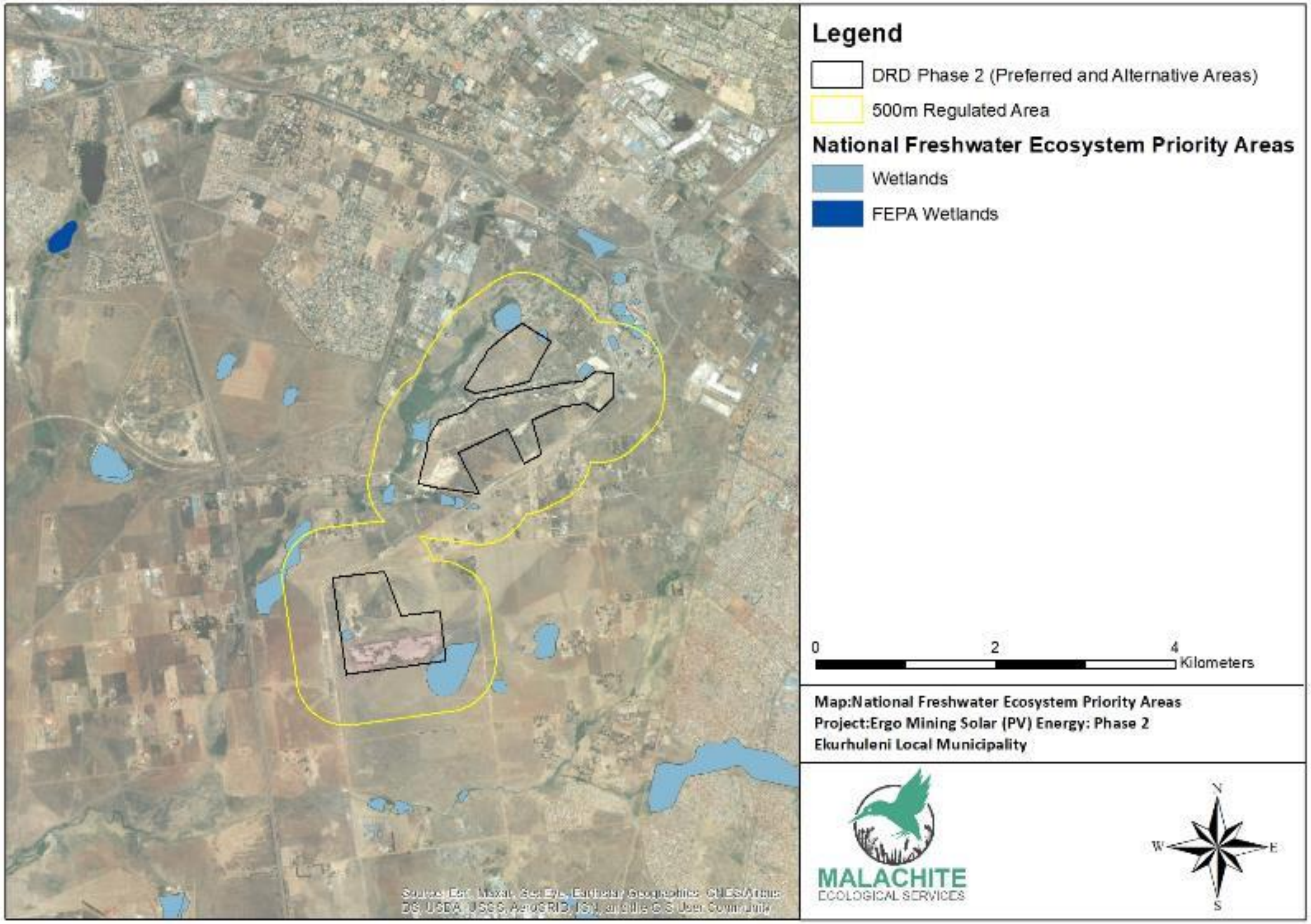


Figure 13: FEPA wetlands identified within the assessment area

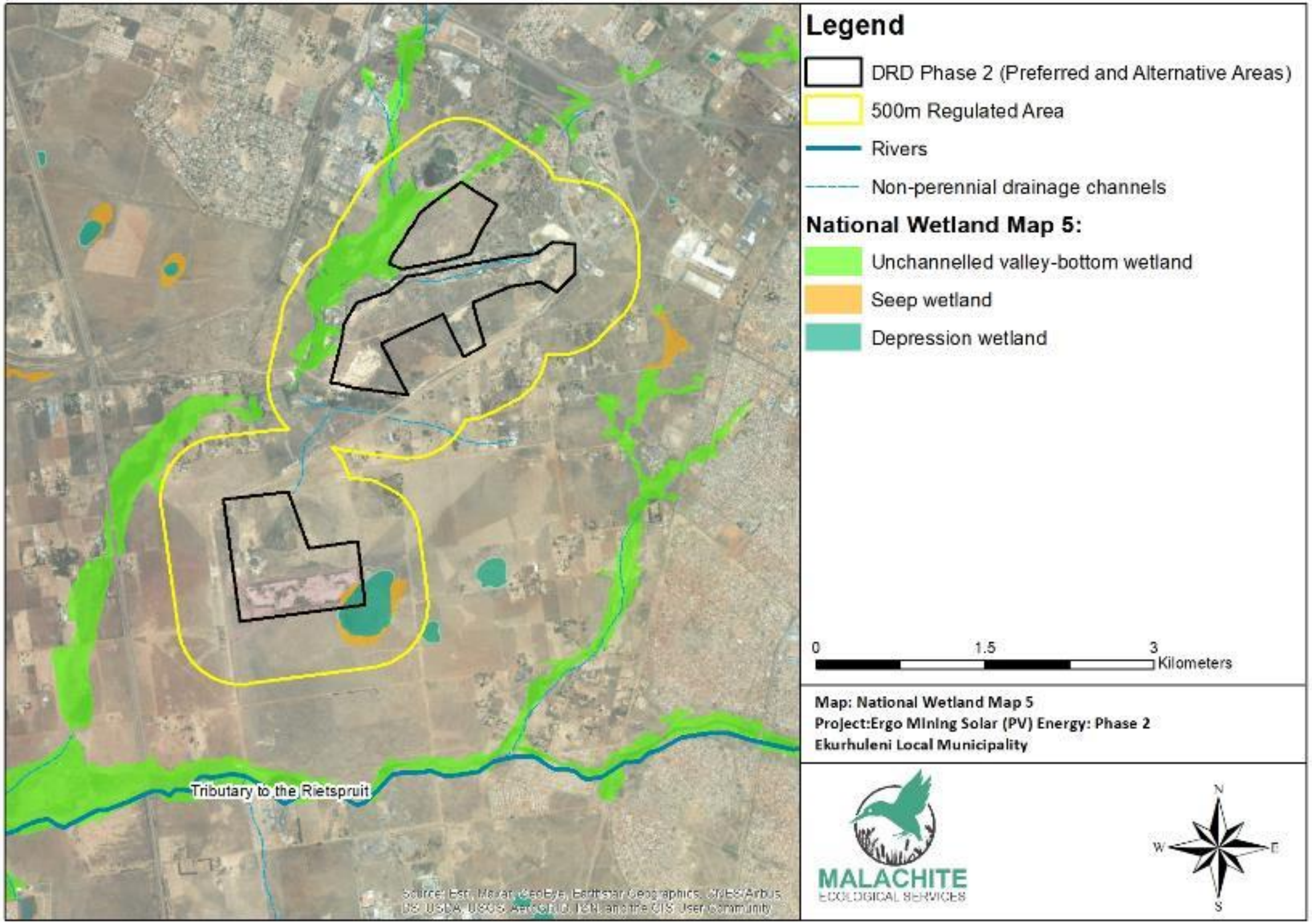


Figure 14: Wetland systems within the assessment area as per the National Wetland Map 5 database

4. WETLAND ASSESSMENT RESULTS

4.1 Wetland Delineation

The South African classification system categorises wetland systems based on the characteristics of different Hydrogeomorphic (HGM) Units. An HGM unit is a recognisable physiographic wetland-unit based on the geomorphic setting, water source of the wetland and the water flow patterns (Macfarlane et al., 2008). There are five broad recognised wetland systems based on the abovementioned system and these are depicted in Figure 15. The classification of these wetlands is then further refined as per the 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis et al., 2013).

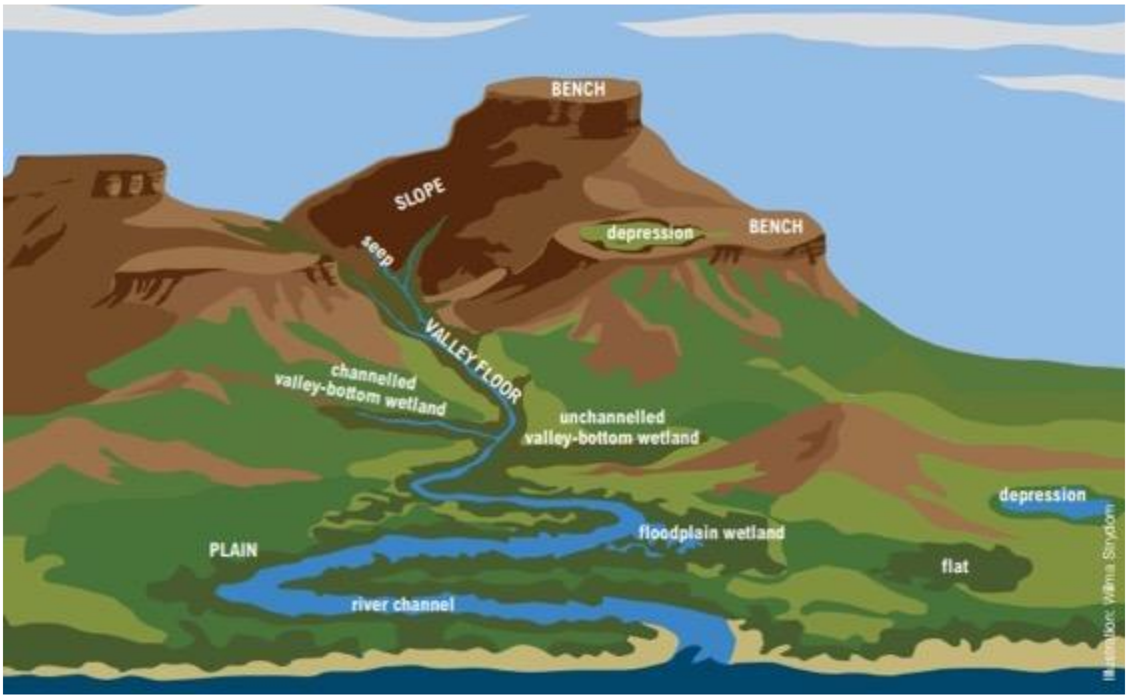


Figure 15: Diagrammatic representation of common wetland systems identified in Southern Africa

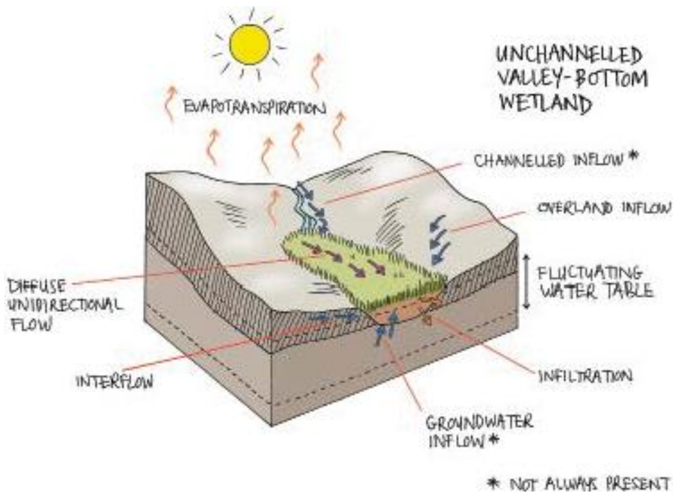
A thorough ground truthing delineation exercise was conducted following the desktop Scoping Assessment for this project. Based on the four wetland indicators identified on site, three HGM units were delineated in both the preferred and alternative layout sites as well as the 500m regulated area. HGM 1 was classified as an unchannelled valley bottom system, HGM 2 is classified as a seep, HGM 3 is classified as a depression. HGM 1 flows along the western edge of the preferred layout, HGM 2 was delineated within the 500m regulated area and a portion of HGM 3 was delineated at the south-eastern boundary of the alternative layout. The HGM units are detailed in Table 4 and displayed in Figures 16 to 19.

Table 4: Summary table of delineated wetlands

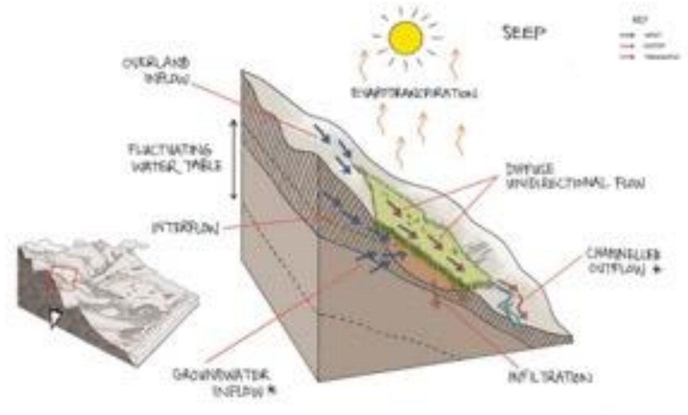
HGM unit number	Wetland Type
HGM 1	Unchannelled Valley Bottom
HGM 2	Seep
HGM 3	Depression

The various wetland classifications are explained in more detail below.

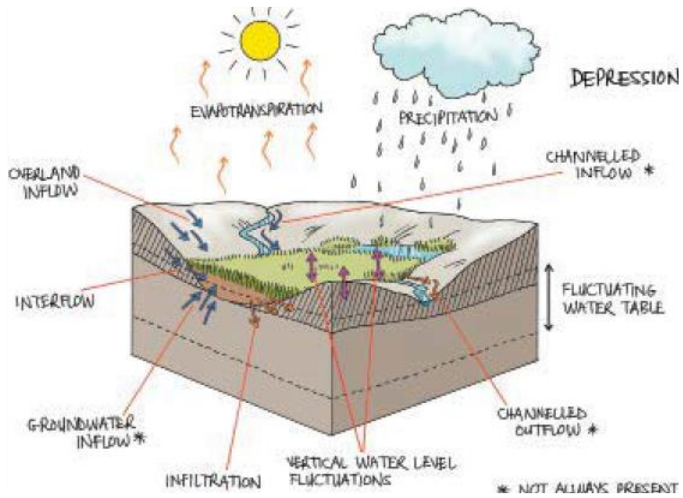
Unchanneled valley bottom wetlands are characterised by their location on valley floors and the absence of distinct channel banks and the prevalence of diffuse flows. These wetlands are generally formed when a river or stream channel loses confinement and spreads out over a wider area causing the concentrated flow associated with a river channel to change to diffuse flow (Ollis et al., 2013). Dominant water inputs to these wetlands are derived from the channels flowing through the wetland, either as surface flows resulting from flooding or as subsurface flow. Water generally moves through the wetland as diffuse surface flow although occasionally as short-lived concentrated flows during flood events (Ollis et al., 2013).



Seepage wetlands are characterised by their association with topographic positions that either cause groundwater to discharge to the land surface or rain-derived water to seep down-slope as subsurface interflow. Water movement through the seep is primarily attributed to interflow, with diffuse overland flow often being significant during and after rainfall events (Kotze et al., 2008; Ollis et al., 2013). Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.



Depression wetlands have closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates. They may be flat-bottomed, or round bottomed and have any combination of inlets and outlets or lack them Completely. Most depressions occur either where the water table intercepts the land surface, or in semi-arid settings where a lack of sufficient water inputs prevents areas where water accumulates from forming a connection with the open drainage network.



The delineation exercises were conducted based on the dominant indicators, including soil type (i.e., soil form and the presence of hydric characteristics); vegetation; and topographic position within a landscape. These are discussed in more detail in the following sections.

4.2 Artificial Wetland systems

Apart from the three natural HGM units delineated within the study site and 500m assessment area, a number of artificial wetlands, functional dams, discarded dams, and seepage from dams were delineated. These wetland areas were identified both within phase 1 of the Ergo Gold PV project as well as during the current assessment.

During both phases of the Ergo Gold PV project, these areas were confirmed to be artificial in nature and have been created by the extensive anthropogenic modifications throughout the study site. As a result of these disturbances, the soils of the site have been completed modified and are now classified as the Hydric Technosol, Stilfontein form. These soils show signs of saturation but are not natural wetland soils. This soil form is discussed in more detail in Section 4.3. The artificial 'wetlands' were delineated during phase 1 of the Ergo Gold PV project based on the presence of hydric characteristics of the soil, at the surface of the soil profile or within the first 10cm. Similar 'wetland' areas were identified during the current assessment, within and adjacent to areas that have been extensively modified by historic and current mining activities and the subsequent rehabilitation of these areas. These artificial wetland areas are depicted in Figures 16 to 19.

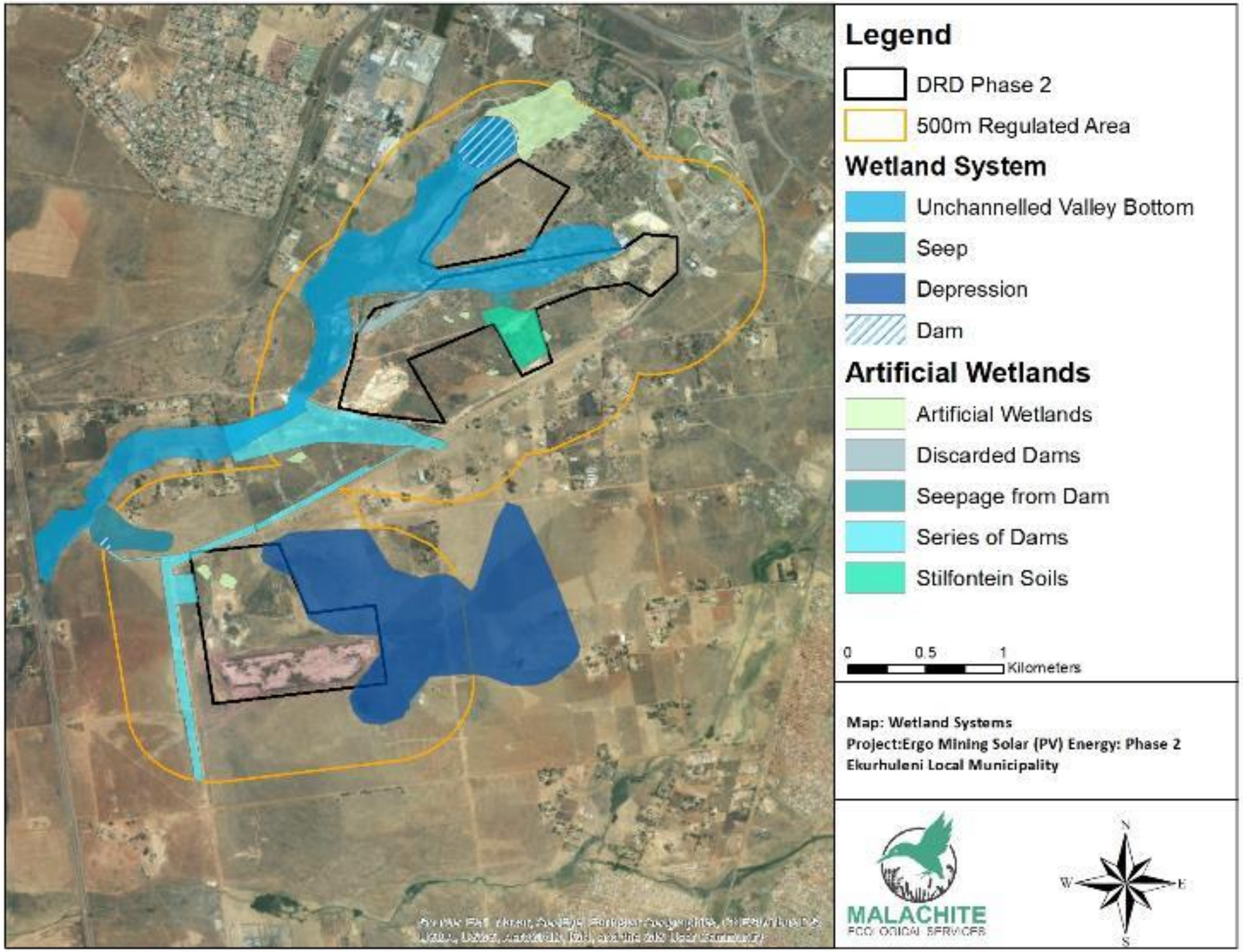


Figure 16: Wetland systems delineated within the assessment area

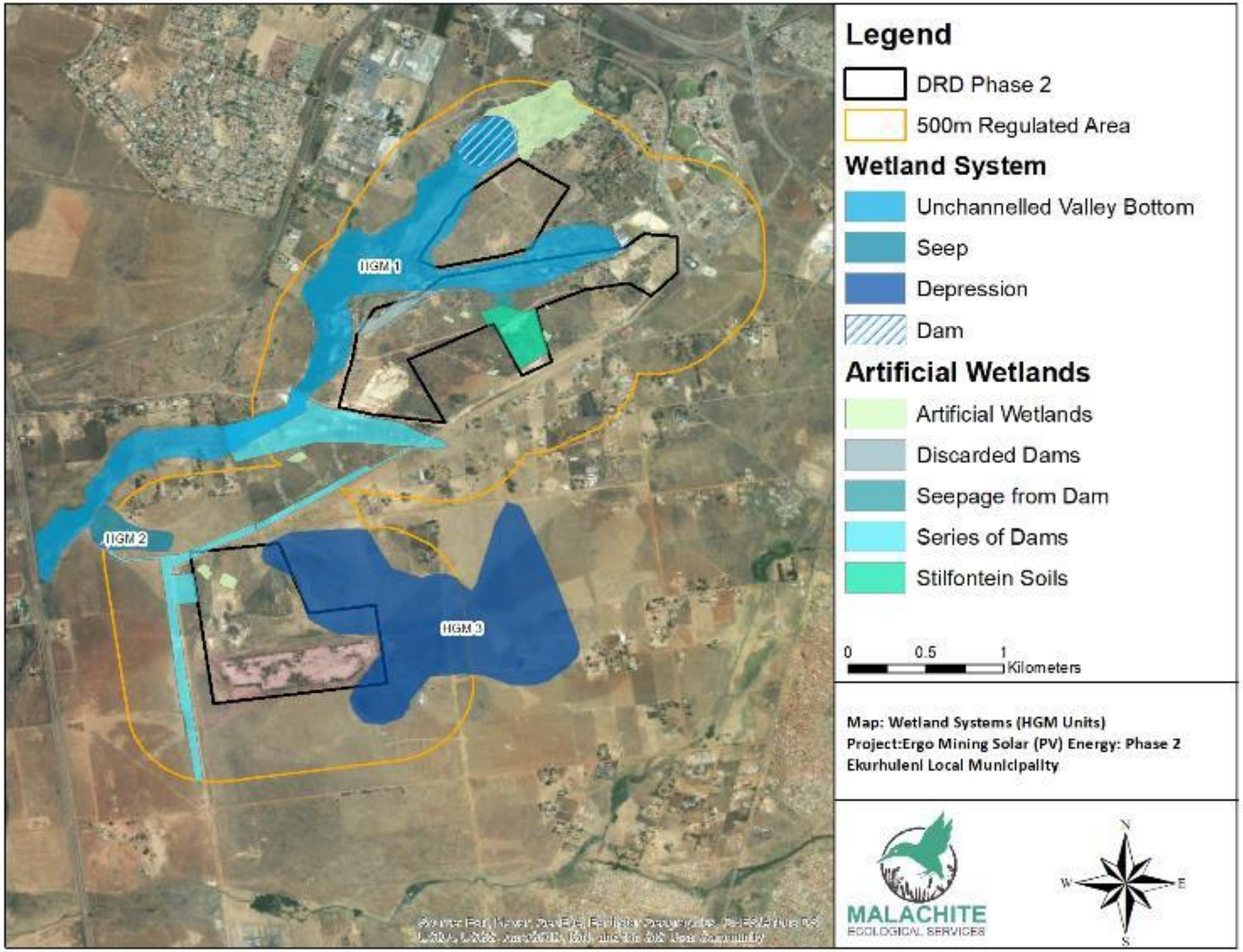


Figure 17: HGM units delineated within the assessment area

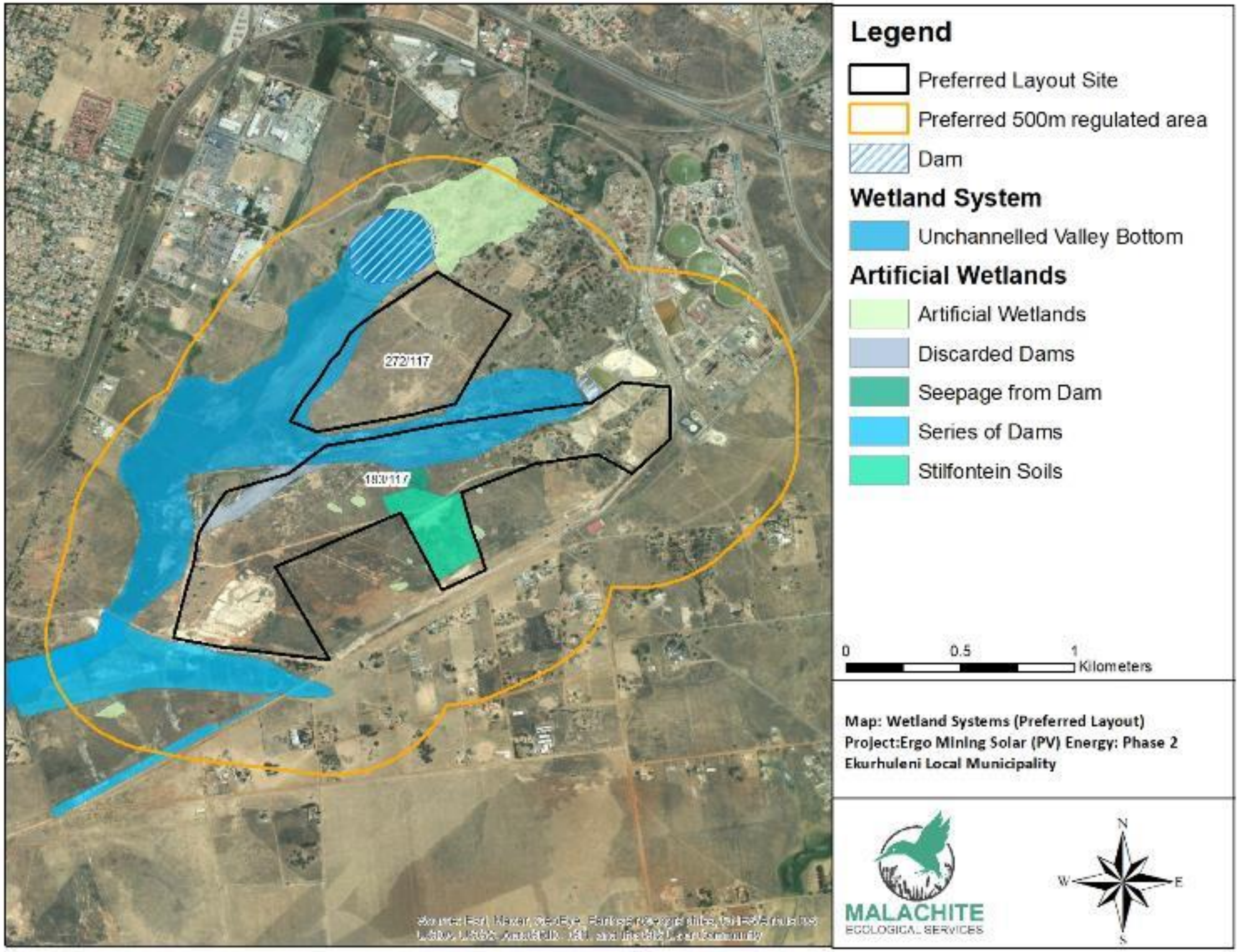


Figure 18: Closer view of the wetland systems delineated within the preferred layout site

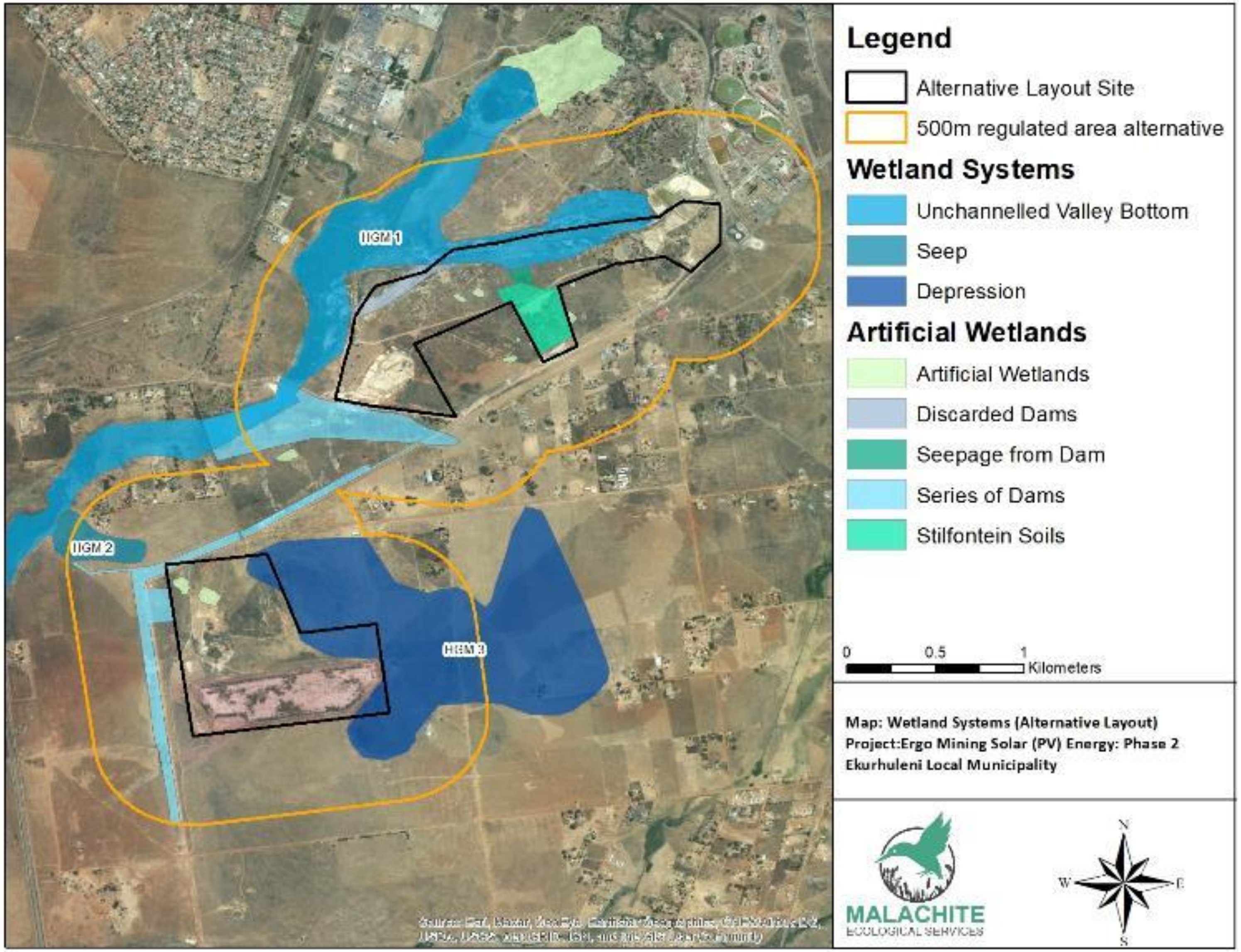


Figure 19: Closer view of the wetland systems delineated within the alternative layout site

4.3 Soil Wetness and Soil Form Indicator

Soil samples were taken throughout both layout sites (preferred and alternative) and auger points were examined for the presence of hydric (wetland) properties. Hydric soils are defined as those that typically show characteristics resulting from prolonged and repeated saturation. These characteristics are called redoximorphic features and include the presence of mottling (i.e., bright insoluble iron compounds); a gleyed matrix; and/or Manganese (Mn)/Iron (Fe) concretions (Figure 20).

The presence of redoximorphic features is the most important indicator of wetland occurrence, as these soil wetness indicators remain in wetland soils, even if they are degraded or desiccated (DWAF, 2005). It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric, or non-hydric and that a soil horizon does not have to be 100% saturated for this reduction reaction to begin and to show within the profile as either mottling, a gleyed matrix or a concretion. A hydric soil will therefore not necessarily contain all the diagnostic horizons associated with redoximorphic features; however, all hydric soils will contain at least one of these features within the upper 500mm of the soil profile (Collins, 2005).

Figure 20: Generic examples of hydric characteristics used as indicators for wetland conditions

Further to the identification of hydric properties, it is important to consider the soil form. The type of soil (or the soil form) has a significant influence on the formation and functioning of a wetland system and its location within a catchment. This includes the way in which water enters and flows through a wetland (Ollis et al., 2013). Soil forms are not randomly distributed in a landscape and therefore hydrological soil types typically occupy specific positions in the hillslope. This means that certain soils play more of a releasing or receiving role related to water movement within a hillslope or topographic position. This has important implications in landscape hydrology (van Tol, et al., 2013).

Terrestrial and hydric soils were identified within the study area. Natural hydric soils were dominated by the gleyic soils and included the Katspruit soil form identified in the seasonal and permanent zones of saturation associated with all three HGM units. The Katspruit soil form consists of an orthic topsoil which overlays a gley horizon. This soil form is the most widely encountered hydric soil form in South Africa. It displays ‘reduction’ and not ‘oxidation’ as the soils are formed in an anaerobic environment. Thus, little to no mottling is identified but rather the soil matrix is displayed as a gleyed (gray) matrix. These soils are indicative of permanent to seasonal saturation. The Tukulu soil was furthermore identified in the seasonal to temporary zone of HGM 1 (the unchannelled valley bottom wetland). Tukulu soils are made up of an orthic topsoil overlying a neocutanic (structureless) B horizon which overlies a gleyic horizon. It is indicative of a shallow fluctuating water table (Figure 21)

Due to significant anthropogenic modifications to both the layout sites (preferred and alternative), large portions of the study area were classified as the Hydric Technosol, Stilfontein. Hydric Technosols are soils which have undergone saturation for an extended period of time. The classification was applied to this area as hydric properties were identified both at the surface of the soil as well as within the lower reaches of all soil profiles. Hydric properties included a gleying of the soil matrix as well as distinct and a high concentration of mottles and concretions. The presence of the Stilfontein soils in the proposed layout alternative are a result of the transformation of this area from historic mining activities including the establishment of tailings dams. The area was remined and then rehabilitated, leaving behind saturated soils as well as an alteration to the natural drainage of the area, causing current ponding of stormwater (Figure 22).

Outside of both natural and artificial wetland areas, terrestrial soils were identified. These were also classified as both natural as well as anthropogenically modified. Natural soils were dominated by the Hutton soil form while anthropogenic soils included the Anthrosols and Technosols, namely the Grabouw and Witbank soil forms. A full description of the soils identified is provided in the Soils, Land Capability and Agricultural Potential Assessment (Malachite Ecological Services, 2021).

Figure 21: Hydric soils identified within the assessment area including the (A) Katspruit and (B) Tukulu soil forms

Figure 22: Stilfontein soils which create ponding of stormwater

4.4 Vegetation Indicator

According to DWAF (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands as distinct changes in vegetation assemblages can be noted when moving through wetland systems, from the permanent zone to the temporary zone. Vegetation also forms a central part of the wetland definition in the National Water Act (Act 36 of 1998).

Hydrophytic vegetation are plant species that are adapted to growing in permanently or temporarily water-logged conditions (elevated water conditions in wetland soils). This is further subdivided into species that are obligate and facultative wetland species (Table 5). The composition of a plant community is determined by the complex interactions between climate, soil type, position in the landscape and competition between plant species.

Wetland plant species perform a variety of functions including:

- Maintaining water quality by filtering out nutrients and sediments.
- Providing food, shelter and breeding habitat for both aquatic and terrestrial fauna.
- Preventing erosion.

Table 5: The classification of plants according to occurrence in wetlands (DWAF, 2008)

VEGETATION COMPONENTS	DESCRIPTION
Obligate wetland species	Almost always grow in wetlands (> 99% of occurrences)
Facultative wetland species	Usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas
Facultative species	Are equally likely to grow in wetlands and non-wetland areas (34- 66% of occurrences)

Facultative dry-land species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% of occurrences)

These wetland “indicator” species assist in the identification of wetland systems and associated boundaries. However, using vegetation as a primary wetland indicator requires undisturbed conditions (DWAF, 2005). The alteration of habitat and associated floral communities has a detrimental impact on the ability to confidently rely on vegetation as wetland indicators. In these instances, it makes scientific sense to utilise a combination of terrain and soil characteristics in determining wetland boundaries around transformed areas.

The study site has been largely transformed as a result of historic and present mining as well as urban activities and development. This made the reliance on indicator vegetation species to delineate wetland boundaries difficult. Hydrophytic species however were noted within areas where saturated soils were identified whether these soils were anthropogenically modified (Stilfontein soils) or natural (Katspruit). Hydrophytic vegetation included Juncus effuses, Phragmites sp., Cyperus congestus, and Pycreus macranthus. Other species identified in both the wetlands and terrestrial portions of the study site included Cynodon dactylon, Imperata cylindrica, various Helichrysum species, Paspalum species, Eragrostis species, and Digitaria eriantha (Figure 23). For a more comprehensive report on the vegetation of the study area, please refer to the Terrestrial Biodiversity (Vegetation) Assessment

Figure 23: Hydrophytic vegetation identified within both the natural and artificial wetland systems

4.5 Terrain Indicator

The topography of an area is generally a good practical indicator for identifying those parts in the landscape where wetlands/watercourses are likely to occur. Generally, these occur as valley bottom units however, wetlands can also occur on steep to mid slopes where groundwater or surface water discharge is taking place through seeps (DWAF, 2005). In order to classify a wetland system and/or a watercourse the localised landscape setting must be taken into consideration through ground-truthing of the study site after initial desktop investigations (Ollis et al., 2014).

The project area is situated on a gently undulating to flat landscape. Average slopes are between 2% to 2.5% with maximum slopes of 11% within the northern section of the study site, where the existing Ergo Gold Mine Brakpan Plant is located. The altitude ranges from 1583m above sea level (absl) in the south-eastern portion of the study site and rises to 1659m absl in the northern extent of the study site (Figure 24). This gentle topography generally gives rise to slow hydological dynamics and associated unchallenned valley bottom and depression systems.

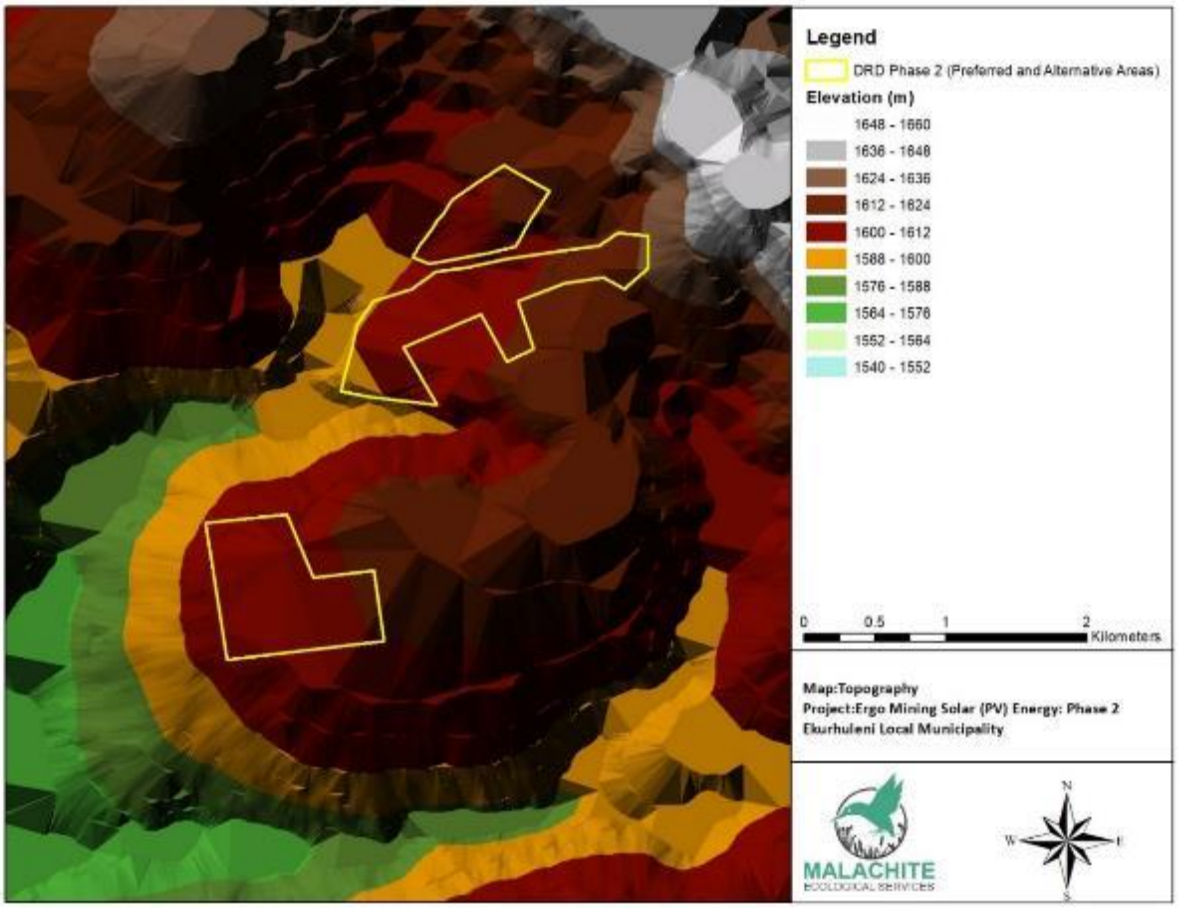


Figure 24: Topography (altitude) of the site

5. WETLAND HEALTH ASSESSMENT

5.1 Present Ecological State (PES)

The three natural HGM units were assessed with regards to their health according to the Wet-Health methodology[3]. A level 2 assessment (detailed) was conducted. HGM 1, the unchannelled valley bottom wetland, was classified as Seriously Modified (PES Category E) (Figure 25), HGM 2, the seep system has been classified as Largely Modified (PES Category D) (Figure 26), and HGM 3, the depression system has been classified as Moderately Modified (PES Category C) (Figure 27).

Impacts to the wetland systems stem from the use of the catchments associated with each wetland for historic and current mining activities as well as urban development. These developments have impacted the hydrological flow of the wetlands as well as the geomorphic setting. HGM 1 has been particularly disturbed as a result of mining within the catchment. This wetland has been dammed during historic mining within the area and while much has been rehabilitated through the decommissioning of the dams, the wetland remains seriously impacted. The existing Ergo Gold Mine Brakpan Plant is situated within the catchment of this HGM unit, with tailings facilities in the upper reaches of the valley bottom wetland. These have had a serious impact on the flow dynamics of the wetland, leading to erosion, desiccation, and encroachment of alien invasive species.

An earthen dam associated with HGM 2, the seep wetland, has also had an impact on the flow dynamics of this system. The damming of wetland systems has long-term negative impacts on the hydrology, geomorphology, and vegetation dynamics of these systems. Dams cause a decrease in the quantity of water reaching downstream wetland areas as well as the increase in flooding of the upstream wetland systems, leading to changes in the hydrological flow through the channels as surface flow and through the soil profile as subsurface flow. Further to this, impoundments act as sediment sinks, reducing the sediment load of water released downstream of the dam. This results in water that is regarded as ‘sediment hungry’, having an increased capacity for erosion.

The depression wetland, HGM 3, is an extensive system that is situated both within a portion of the alternative layout (Ptn 9/131) as well as to the east of the study site. Despite the large size of the depression system, it has a smaller catchment area, compared to the other two HGM units and this has limited the impacts to this wetland to a degree. The depression system has still been impacted through the use of the adjacent area as a tailing’s storage facility, crop cultivation, low density housing and the construction of dirt roads through the system. Sediment deposition from this anthropogenic activities has been within areas of the depression, affecting the hydrology, geomorphology, and vegetation dynamics of the system. A general desiccation of the wetland is apparent in the series of aerial imagery from 1985 to 2022.

A summary of the PES scores obtained for the delineated systems following application of the Wet-Health approach is provided in Table 6.

[3] The current size of the delineated wetlands was recorded. It must be noted that this is not the entire size of the wetland but rather the portion of the system delineated within the assessment area.

Table 6: Summary of PES score

HGM Unit	Extent Delineated (Ha)	Hydrology	Geomorphology	Water Quality	Vegetation	PES Score (Category)
HGM 1	117.40	6.5	5.0	7.5	7.5	**E (6.6)**
HGM 2	8.33	5.2	3.8	3.4	5.5	**D (4.50)**
HGM 3	128.66	3.5	2.5	5.5	2.7	**C (3.50)**

Figure 25: Portions of HGM 1 showing the impacted nature of this system as well as the lack of flowing water

Figure 26: Portions of HGM 2, the seep system located within the 500m assessment area

Figure 27: Portions of the large depression system, HGM 3, delineated in the south-western extent of the alternative layout

5.2 Functional Assessment (Ecosystem Goods and Services)

Ecosystem goods and services were calculated for the HGM units (Figure 28). All HGM units received generally low to moderate scores for the ecosystem services. Highest scores received were associated with flood attenuation (particularly for HGM 1), streamflow regulation, erosion control, sediment trapping and filtration (in the form of nitrate, phosphate, and toxicant trapping). The depression wetland, (HGM 3) received higher scores for the maintenance of biodiversity due mainly to its large size and the presence of open water. The system also provides functions sediment control and filtration.

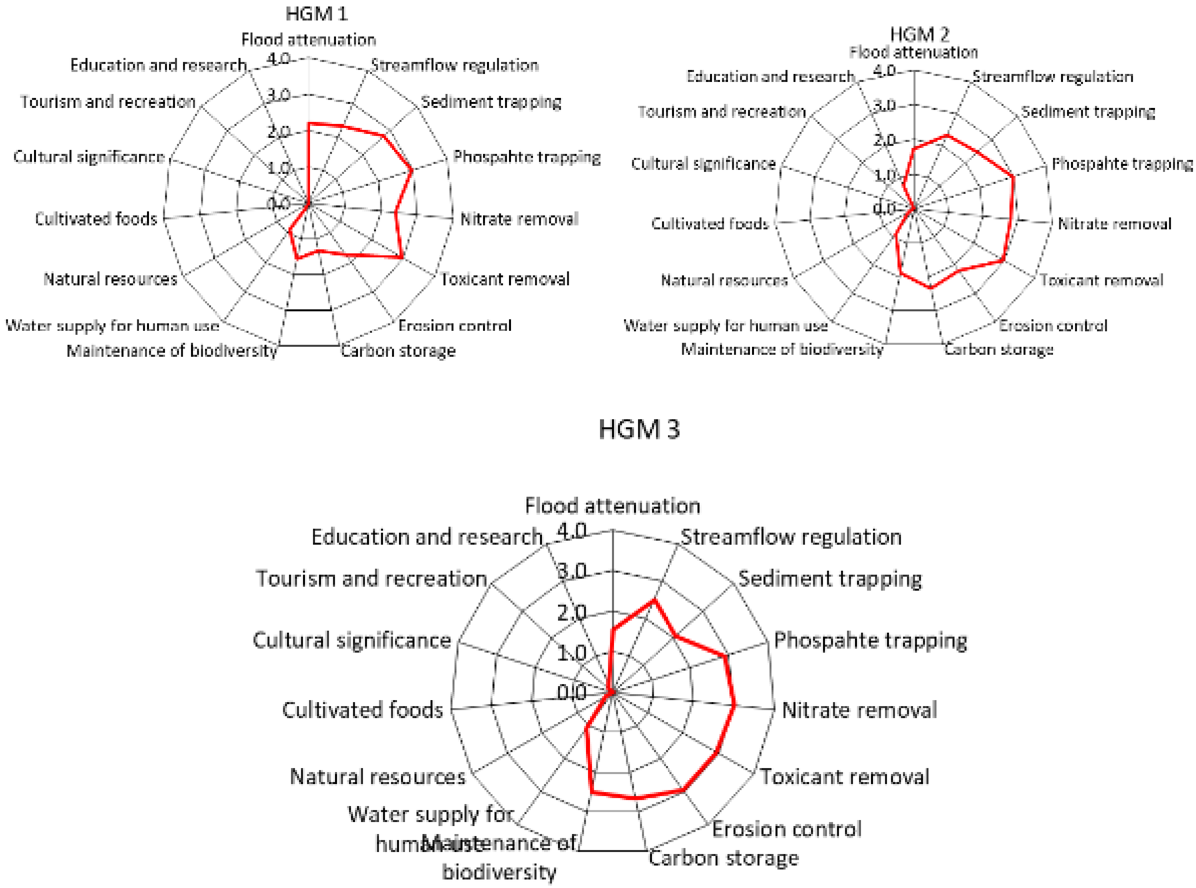


Figure 28: Results of the WET-EcoServices assessments for all HGM units

5.3 Ecological Importance and Sensitivity (EIS)

The EIS scores received for all HGM units was Low[4] (Table 7). The location of the wetlands within an urban landscape that has been largely disturbed limits the ability of the wetlands to provide suitable habitat for faunal and floral species. The depression wetland (HGM 3) received a higher score as a result of the presence of open water within this system which provides habitat for semi-aquatic and aquatic species. All systems received Moderate scores for the Hydrological Functional Importance, and this supports the scores received in the Present Ecological State scores as well as the Wet-

[4] A low score indicates that features about the wetland are regarded as somewhat ecologically important and sensitive at a local scale. The functioning and/or biodiversity features have low-medium sensitivity to anthropogenic disturbances. They typically play a very small role in providing ecological services at the local scale.

Ecosystem services scores. The systems provide numerous ecological services to the surrounding community as well as their catchments. Socio-economic importance of the wetlands is low and is limited to grazing for livestock as well as the presence of dams in some of the systems.

Table 7: Summary of the Ecological Importance and Sensitivity

HGM UNIT	EIS	SCORE (0-4)	CONFIDENCE (0-5)	CATEGORY
HGM 1	Ecological Importance and Sensitivity	1.47	4	**Low**
	Hydrological Functional Importance	2.34	4	**Moderate**
	Direct Human Benefits	0.67	4	**Very Low**
HGM 2	Ecological Importance and Sensitivity	1.54	4	**Low**
	Hydrological Functional Importance	2.47	4	**Moderate**
	Direct Human Benefits	0.67	4	**Very Low**
HGM 3	Ecological Importance and Sensitivity	1.87	4	**Low**
	Hydrological Functional Importance	2.94	4	**Moderate**
	Direct Human Benefits	1.33	4	**Low**

6. DESKTOP AQUATIC ASSESSMENT RESULTS

6.1 Aquatic Habitat

In general, a low diversity of aquatic habitats is expected within HGM 1 due to the unchanneled valley-bottom wetland nature as well as the underlying geology which has resulted in a notable lack of stones habitat. Further, HGM 1 has a relatively small, low-gradient catchment and thus a low accumulation of flow, resulting in slow-flowing hydraulic habitat. Consequently, the aquatic habitat within HGM 1 comprises of dense stands of emergent vegetation of *Phragmites* sp. and *Typha capensis* with slow-flowing water and a mud-based substrate. The physico-chemical properties of HGM 1 are further likely to present a limiting factor to the occurrence of aquatic biota within the wetland.

Aquatic habitat within HGM 3 (depression wetland) is also limited, as standing water is only present during the rainfall season and emergent vegetation is the dominant habitat structure. However, the shallow depth and lack of flowing water as well as possible water quality impairment from seepage of contaminated water from the tailing's storage facility located within the wetland's boundary present limiting factors to the occurrence of diverse aquatic biota.

6.2 Aquatic Macroinvertebrates

In general, valley bottom wetlands (particularly unchannelled valley bottom wetlands) and depressional systems are unlikely to support a diverse array of aquatic biota during even unimpacted conditions given the lack of diverse hydraulic habitat relative to true riverine reaches of watercourses, as well as the often-limited volume of surface water present in such systems. Accordingly, given the water quality of the generally reducing environmental conditions associated with wetlands and the possible impacts from historic gold mining activities within the area, as well as hydrological dynamics of such systems and the lack of diverse habitat, the aquatic macroinvertebrate assemblage is dominated by taxa with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. As such, only a limited acquired diversity of aquatic biota is associated with the wetlands present within the study area.

On the other hand, the intrinsic aquatic macroinvertebrate diversity associated with a depressional system such as HGM 3 is largely based on the egg bank which is supported by such a system, as well as the extent and duration of inundation at any given time. Variability in terms of the total number of hatched nauplii and the temporal variability of the hatching from depressional systems is expected, as successful hatching is a function of conditions of exposure, the species present and the fraction of quiescent and diapausing eggs (Henri et al., 2014). Branchiopod eggs have been found to exhibit different states of dormancy. Diapause is one state of dormancy where the arrest in development is initiated by internal factors - eggs do not hatch even when environmental conditions are favourable as diapause termination is also internally controlled (Lavens & Sorgeloos, 1987; Drinkwater & Clegg, 1991; Brendonck et al., 1993; cited in Henri et al. 2014). Quiescence is an alternate state of dormancy where the arrest in development is initiated by external factors, is induced by unfavourable external conditions, and is terminated as soon as conditions are permissible (Lavens & Sorgeloos, 1987; Drinkwater & Clegg, 1991; Brendonck, 1996; cited in Henri et al. 2014). Both forms of dormancy have been found to occur in a single brood of eggs. Quiescent eggs respond rapidly to a change in environmental conditions giving species a quick start to colonisation before the pan dries up (Brendonck, 1996; cited in Henri et al. 2014). Diapause is most likely the phenomenon which ensures some eggs always remain dormant in the sediment to ensure the continuation of the species over long periods of time and is most likely responsible for the long-term viability of eggs in the egg bank.

Hatching of individuals is also known to vary under identical conditions and only a fraction of the total viable egg banks are likely to hatch during the inundation period (Brendonck et al., 1996; Vanderkerkhove et al., 2004; cited in Henri et al., 2014). According to Henri et al. (2014), a temporal succession in the diversity of invertebrates was noted during the hatching period following inundation, and the rate of nauplii hatching therefore appeared to be related to the diversity of the egg bank, with pans that had a peak in hatching within the 4-16 day interval having an abundance of Anostraca, while those pans where hatching peaked in the 16-18 day interval had high numbers of Cladocera and Ostracoda.

However, the impacts of mine-affected water on HGM 3 are likely to significantly decrease the intrinsic biodiversity features associated with the wetlands. According to studies conducted by Henri et al. (2014), mine-affected water in the form of Acid Mine Drainage had a negative effect on the hatching success from egg banks of depressional wetlands systems within the Highveld region. Furthermore, such impacted depressional wetlands had lower recovery rates, suggesting that such wetlands will suffer a loss of biodiversity.

6.3 Ichthyofauna

A total of four indigenous fish species and one alien fish species are expected to be associated with the larger study area (Table 8). Such diversity may however be considered optimistic, and only limited fish diversity is expected to be associated with HGM 1 (if any), while no fish species are expected to be associated with HGM 3.

Table 8: Fish species expected to be associated with the study area

Scientific Name	Common Name	Conservation Status
Indigenous species		
Clarias gariepinus	Sharptooth Catfish	Least Concern
Enteromius cf. anoplus	Chubbyhead Barb	Least Concern
Enteromius cf. pallidus	Goldie Barb	Least Concern
Tilapia sparrmanii	Banded Tilapia	Least Concern
Non-native Species		
Gambusia affinus	Mosquitofish	Alien

It should be noted that there are current taxonomic uncertainties with several species of fish expected to occur within the larger study area which may have implications on assigned conservation status. These include:

- *Enteromius cf. anoplus* (Chubbyhead Barb complex). Genetic studies done on the Chubbyhead Barb complex by Da Costa (2012) suggested this group to have significant genetic variation and to represent multiple potential species. The study by Da Costa (2012) showed the separation of the complex into distinct lineages, with the species likely to occur within the present study area corresponding with Lineage A which represents the largest of the lineages identified. Four sub-groups were observed within Lineage A by Da Costa (2012), with those specimens present within the Upper Vaal catchments corresponding to sub-group 1, again the largest of the sub-groups identified. Nevertheless, if further taxonomic studies confirm that there are separate species, the assessment as Least Concern may need revision in some cases.
- *Enteromius cf. pallidus* (Goldie Barb). According to Chakona et al. (2015), genetic analyses of *Enteromius pallidus* collected from the currently known distribution range of the species within South Africa grouped into two distinct lineages, namely a southern lineage from where the original type specimen was collected, and a northern lineage. Further, the deep genetic divergence between the northern and southern lineages of *E. pallidus* suggests a long history of isolation, raising two taxonomic possibilities: The first possibility is that the northern lineage of *E. pallidus* may represent an undescribed species. A second possibility is that the 'true' *E. pallidus* is confined to coastal rivers of the Eastern Cape, and the northern lineage belongs to a different, but known species or species complex. However, further research is required to resolve this taxonomic uncertainty between the two genetically distinct lineages to determine implications on conservation priorities.

6.4 Present Ecological State

Based on the nature of the watercourses associated with the study area, determination of the ecological state from an aquatic perspective is not considered suitable. Reliance should therefore be placed on that as determined from a wetland perspective.

6.5 Ecological Importance and Sensitivity

As with the determination of the ecological state, determination of the ecological importance and ecological sensitivity of HGM 1 and HGM 3 from an aquatic perspective is not considered suitable. Reliance should therefore be placed on that as determined from a wetland perspective.

7. BUFFER REQUIREMENTS

Wetland buffers are areas that surround a wetland and reduce adverse impacts to wetland functions and values from adjacent development. Buffer zones outside the boundary of wetlands are required to ensure that the ecotones between aquatic and terrestrial environments are effectively managed and conserved. These ecotones have a high ecological significance and have been shown to perform a wide range of functions, and on this basis, have been proposed as a standard measure to protect water resources and associated biodiversity (Macfarlane & Bredin, 2016). Literature indicates that buffers reduce wetland impacts by moderating the effects of stormwater runoff including stabilising soil to prevent erosion; filtering suspended solids, nutrients, and harmful or toxic substances; and moderating water level fluctuations (Castelie et al., 1992).

Buffers also provide essential foraging, roosting, refugia, and breeding habitat for wetland-associated species. Finally, buffers reduce the adverse impacts of human disturbance on wetland habitats including blocking noise and glare; reducing sedimentation and nutrient input; reducing direct human disturbance from dumped debris, cut vegetation, and providing visual separation.

The proposed project involves the construction of solar panels and associated infrastructure for a 40MW PV plant. Even though the solar panels will be situated in areas where vegetation has been maintained, in order to reduce the risks of erosion, there is additional infrastructure associated with the project. These include a BES laydown area, a warehouse, an office, a switch room, internal roads to allow access to all the panels as well as a fence which will surround the entire infrastructural area. Stormwater emanating from the developed areas can have an impact on the receiving environment and particularly wetland systems, through the increase in sediment transportation, the increase in flow into the receiving environment and the decrease in stormwater infiltration into the soil profile. Further to this the proposed storm water management plan includes the use of drainage channels to remove excess stormwater from the Stilfontein soils where stormwater will collect during the summer season in particular.

A buffer was therefore calculated taking the proposed activity into consideration, as well as climatic factors, topographical factors, the nature of the soils, and the sensitivity of the water resource. A 21 m buffer has been calculated for the protection of the natural wetland systems (Figure 29 and Figure 30). It is recommended that the buffer be planted with indigenous grasses and maintained as part of the construction and operational phases of the Environmental Management Programme for the development. A high basal cover of indigenous grass species will aid in the buffering out of sediment and pollutants from the development before stormwater enters into any of the wetland systems. Furthermore, stormwater control from the development is key in reducing impacts to the downstream and adjacent wetland systems.

It must be noted that there are some small areas in which the solar panels will encroach into the 21 m buffer but not into the wetland system. The outfall from the storm water drainage channels is located within the wetland system (HGM 1). Furthermore, a bridge is proposed to cross HGM 1 in order to gain access to both portions (Ptn 272 and Ptn 183 of the Farm Witpoortje No. 117R) of the preferred layout site (Figure 30).

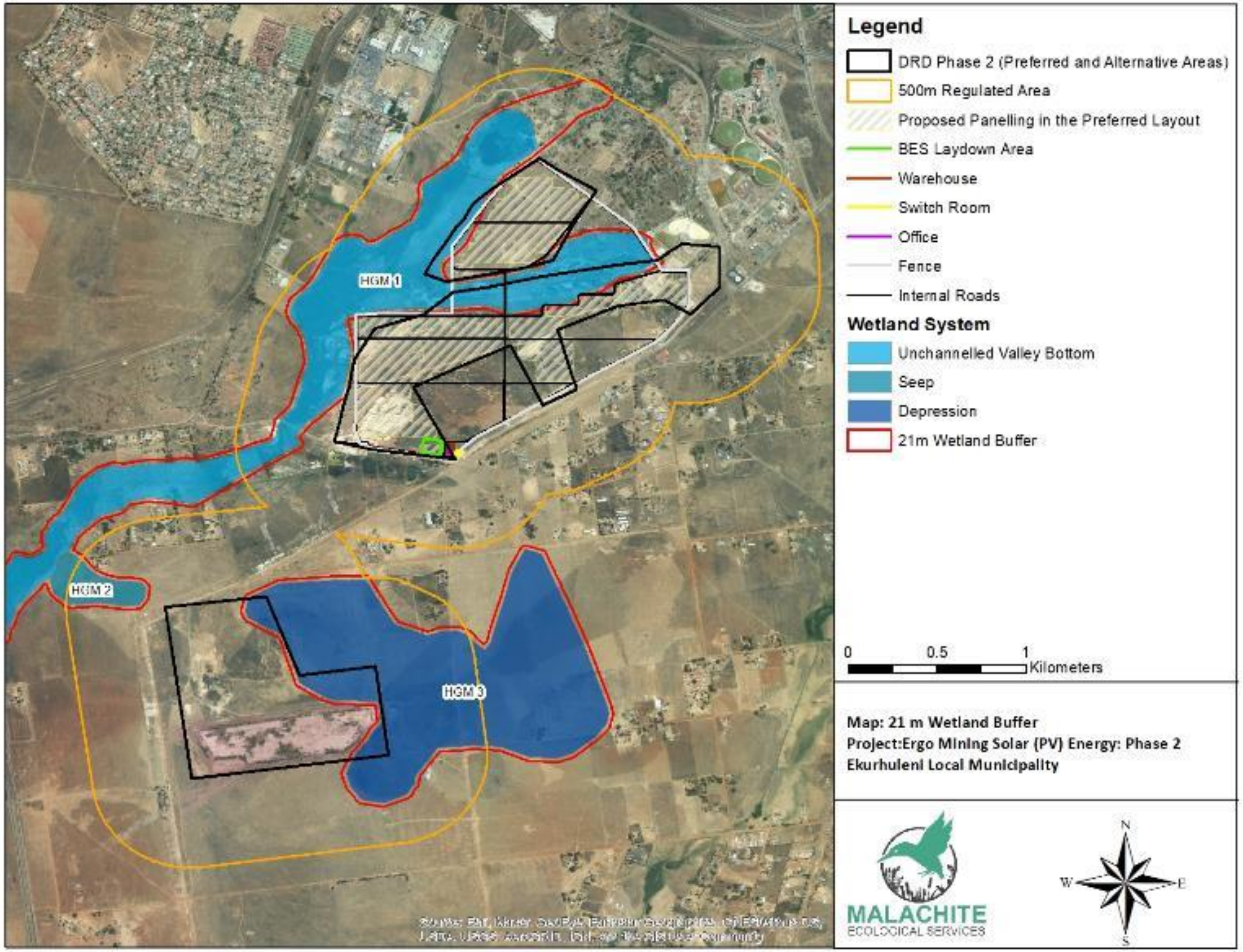


Figure 29: 21m wetland buffer recommendations for the natural wetlands delineated within the study site

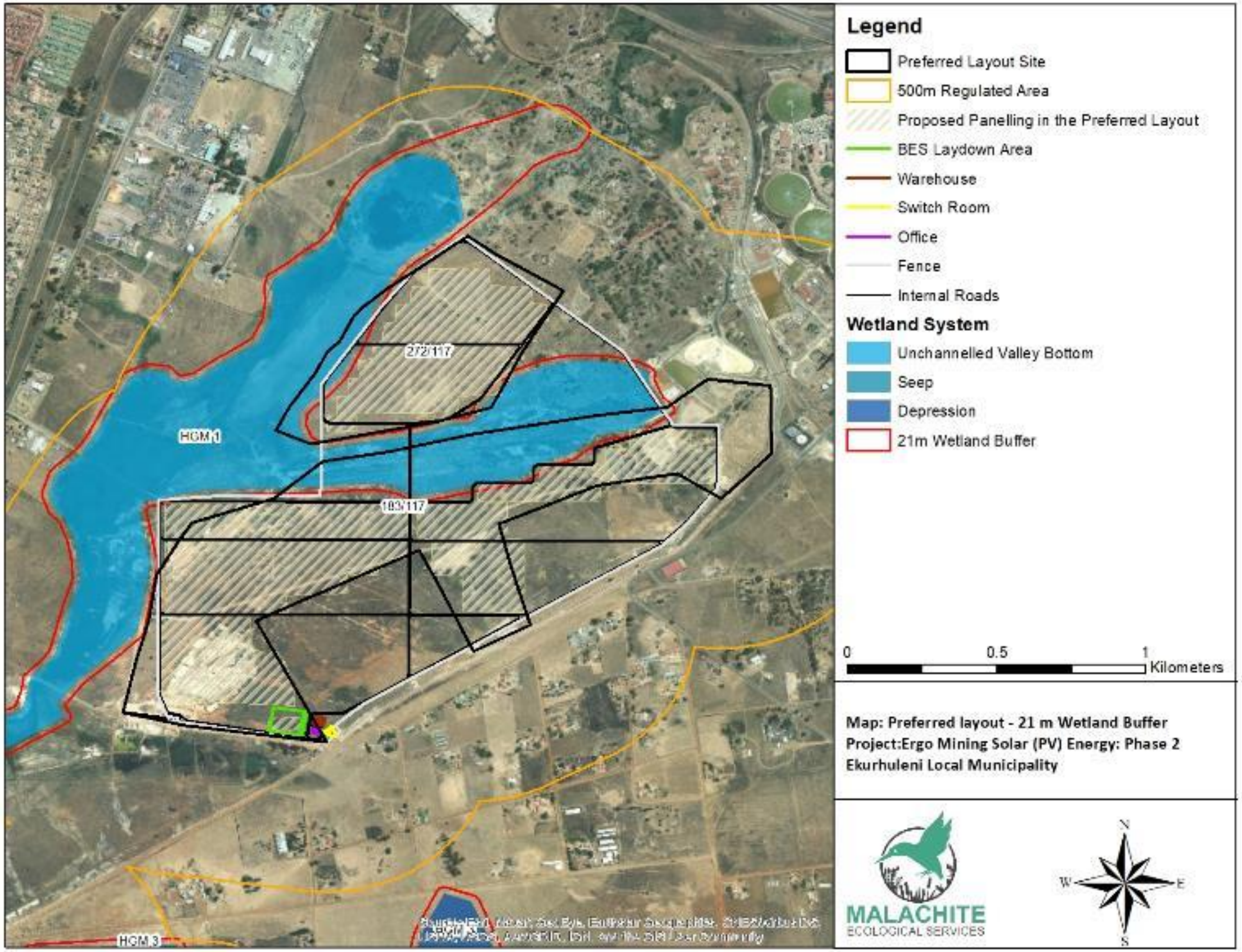


Figure 30: Closer view of the recommended 21m wetland buffer in relation to the proposed PV facility infrastructure

8. IMPACT ASSESSMENT

Any development activity in a natural system will have an impact on the surrounding environment, usually in a negative way. The purpose of this phase of the study was to identify and assess the significance of the impacts caused by the proposed project on the delineated and assessed wetland systems. Furthermore, mitigation measures are recommended to limit the identified negative impacts on the receiving environment.

The project will involve the clearing of portions of the site for the establishment of the 40MW power PV facility. The preferred location of the panels and associated infrastructure in relation to the wetlands is provided in Figure 29.

Both layout alternatives (preferred and alternative) have been considered in the impact assessment. The preferred layout will have an impact on HGM 1, while the alternative layout will have an impact on HGM 1 and HGM 3. The proposed positioning of the panels in both the preferred and alternative layouts will encroach into small portions of the 21 m buffer. Further to this the outfall from the storm water drainage channels is located within HGM 1. Furthermore, a bridge is proposed to cross HGM 1 in order to gain access to both portions (Ptn 272 and Ptn 183 of the Farm Witpoortje No. 117R) of the preferred layout site (Figure 31).

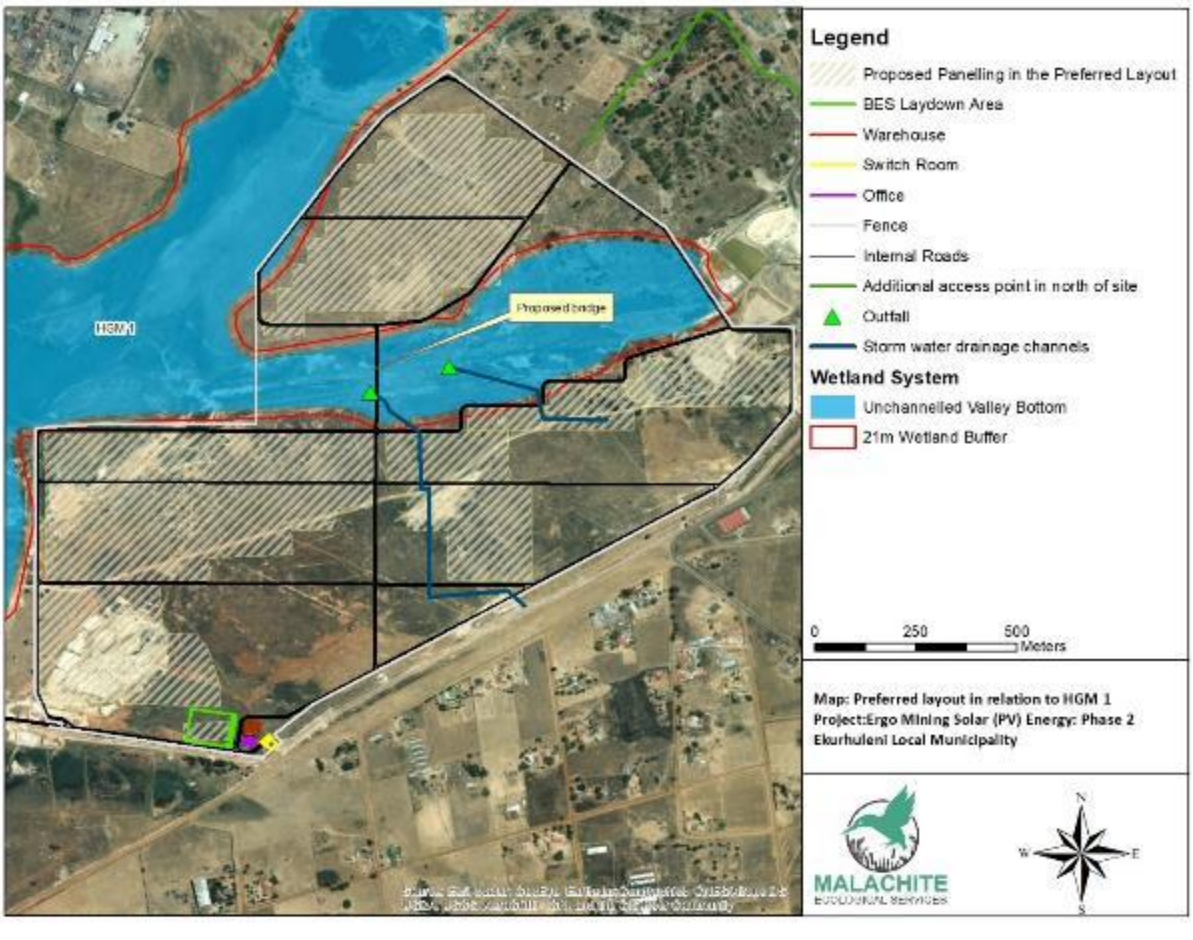


Figure 31: Depiction of all infrastructure in relation to HGM 1

Potential impacts on the receiving natural environment have been identified. Such impacts are likely to include the following:

- Direct impacts: Impacts directly associated with the project. These impacts can be temporary or remain as residual impacts, i.e., the clearing of natural vegetation within PV facility site footprint.
- Indirect impacts: Impacts that are not a direct result of the project and often extend beyond the project boundary, i.e., encroachment of invasive alien vegetation outside of the project area.
- Residual impacts: Impacts that remain following the implementation of mitigation measures, and that may remain after the project has been completed.
- Cumulative impacts: Impacts occurring from the project combined with impacts from past, existing and future projects that will affect the same natural resources e.g. a number of impacts occurring in the same ecosystem.

The section below provides an indication and summary of potential impacts associated with the construction and operation of the proposed project.

The activities identified within the study site for both the preferred and alternative layouts include:

- The clearing of portions of the PV facility site for the establishment of the solar panels, and associated infrastructure.
- Installation of the solar panels and associated infrastructure.
- Maintenance of the PV facility during the operational phase.

Negative impacts therefore associated with this project include:

- Soil erosion, sedimentation of the wetland systems.
- Pollution potential.
- Encroachment of invasive alien species into the wetlands as a result of the disturbance.

Several general and specific measures are proposed to mitigate these impacts.

8.1 Methodology

Potential impacts of the proposed activity on the wetlands of the site were assessed utilising a standard method from Environmental Management Assistance (Pty) Ltd. Using this methodology, the impacts are described in terms of their characteristics, including the impact's spatial and temporal features (namely extent, duration, probability, and magnitude). While an impact assessment typically focuses on the negative impacts, an impact can also be positive. The definitions of the terms used in this assessment are described in Table 9 below.

Table 9: Impact Characteristics used in this assessment

Characteristic	Definition	Terms	Scoring
Duration	The time period over which a resource / receptor is affected.	**Temporary** - (period of less than 1 year - negligible/ pre-construction/ construction) **Short term** - period of less than 5 years ie commissioning/operational period **Medium term** - period of less than 15 years ie operational period **Long term** - period of less than 20 years ie life of project **Permanent** - a period that exceeds the life of project– ie irreversible.	Temporary – 1 Short term – 2 Medium term – 3 Long term – 4 Permanent – 5
Extent	The reach of the impact (ie physical distance an impact will extend to)	**On-site** - impacts that are limited to the Project site. **Local** - impacts that are limited to the Project site and adjacent properties. **Regional** - impacts that are experienced at a regional scale, ie Gauteng. **National** - impacts that are experienced at a national scale. **Trans-boundary/International** - impacts that are experienced outside of South Africa.	On-site – 1 Local – 2 Regional – 3 National – 4 International – 5
Probability	Measure of the probability with which the impact is expected to occur	**Unlikely -** probably will not happen **Improbable -** some possibility, but low likelihood **Probable -** distinct possibility) **Highly probable -** most likely **Definite -** impact will occur regardless of any prevention measures	Unlikely – 1 Improbable – 2 Probable – 3 Highly probable – 4 Definite – 5
Magnitude	A measure of the damage that the impact will cause if it does occur	**No effect** - will have no effect on the environment **Minor** – minor and will not result in an impact on processes **Low** – low and will cause a slight impact on processes **Moderate** – moderate and will result in processes continuing but in a modified way **High** - processes are altered to the extent that they temporarily cease	No effect – 0 Minor – 2 Low – 4 Moderate – 6 High – 8 Very high – 10

Characteristic	Definition	Terms	Scoring
		Very high - results in complete destruction of patterns and permanent cessation of processes	

The significance (quantification) of potential environmental impacts identified during the assessment have been determined using a ranking scale, based on the following (terminology has been taken from the Guideline Documentation on EIA Regulations, of the Department of Environmental Affairs and Tourism, April 1998):

Occurrence

- Probability of occurrence (how likely is it that the impact may occur?)
- Duration of occurrence (how long may it last?)

Severity

- Magnitude (severity) of impact (will the impact be of high, moderate, or low severity?)
- Scale/extent of impact (will the impact affect the national, regional, or local environment, or only that of the site?)

The environmental significance of each potential impact is assessed using the following formula:

Significance Points (SP) = (Magnitude + Duration + Extent) x Probability

The maximum value is 100 Significance Points (SP). Potential environmental impacts were rated as high, moderate, or low significance on the following basis:

- < 30 significance points = **LOW** environmental significance.
- 30- 60 significance points = **MODERATE** environmental significance
- >60 significance points = **HIGH** environmental significance

The significance of an impact gives one an indication of the level of mitigation measures required in order to minimise negative impacts and reduce environmental damage during the construction, operational and decommissioning / closure phases. Suitable and appropriate mitigation measures were identified for each of the potential impacts.

8.2 Summary of Impacts

8.2.1. Significance ratings tables for the Construction Phase

Activity:	**Soil erosion and sedimentation of wetland systems (Both layout alternatives are considered).**				
Impact:	Construction activities expose soil to environmental factors including rainfall and wind. The exposure to these factors can result in the formation of erosion gullies and sheet erosion in disturbed areas. This is particularly so, in areas where soil will be compacted by heavy machinery. The eroded soil will quickly be washed downstream into wetland systems. This increased high-suspended particulate matter within the wetlands can accumulate particularly during the wetter months. Sedimentation poses a risk to the geomorphological/functional integrity of wetlands, reducing the ecological integrity of the water resource outside of the impacted area. Given the proposed installation of drainage channels within the site and the outfall of these channels within HGM 1, as well as the encroachment of the buffer in certain section, the impact of potential erosion is high during the construction phase, if no mitigation measures are implemented. From an aquatic perspective, various impacts have been attributed to sedimentation of aquatic ecosystems, including reduction of light penetration (resulting in reduction in photosynthesis and subsequently, productivity), alteration of foraging dynamics of both carnivores and herbivores, impacting on predator and prey relationships, clogging of gills, rendering the water resource unfit for various aquatic organisms, truncating and shifting the trophic pyramid, absorption of nutrients onto suspended particles, rendering them unavailable and thereby reducing the productivity of the water resource, and filling of interstitial spaces, thereby destroying habitat for macro invertebrates and vertebrates owing to sedimentation, etc. This impact is more of a concern for HGM 3. HGM 3, the depression system, will seasonally hold more water than HGM 1, and this increases the likelihood of the use of this system by aquatic species.				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	2	2	10	5	**High (70)**
Post-Mitigation	2	2	6	3	**Moderate (30)**
Alternative Layout					
Pre-Mitigation	2	2	10	5	**High (70)**
Post-Mitigation	2	2	6	3	**Moderate (30)**

Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented. Rehabilitation of any compacted areas, as a result of the construction, but outside of the infrastructural footprint must occur once construction is complete.
Mitigation Measures:	• No stockpiling of any materials may take place adjacent to any of the natural wetland systems. Erosion control measures must be implemented in areas sensitive to erosion and where erosion has already occurred. These measures include but are not limited to - the use of sandbags, hessian sheets, silt fences, retention or replacement of vegetation and geotextiles such as soil cells which must be used in the protection of slopes. • Topsoil stockpiles must be appropriately protected using for example silt fences or sandbag barriers. • Do not allow surface water or storm water to be concentrated, or to flow down slopes without erosion protection measures being in place. • Make use of existing access roads as much as possible and plan additional access routes if required to avoid wetland systems. • Minimise the extent of the work footprint. • Install sediment barriers across the entire construction right-of-way, to prevent sediment flow, particularly into HGM 1 and HGM 3 (should the alternative layout be approved).
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to a decrease in infiltration rates of stormwater and the increased likelihood of erosion gully formation. Given the limited footprint of the project the cumulative impact is expected to be low.
Residual impacts:	• Residual impacts from the construction phase are associated with the formation of erosion gullies from compacted soils that are not remediated. Over time this will increase in size and will impact areas downstream of the project site
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the topsoil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

Activity:	**Pollution of wetland systems (Both layout alternatives are considered).**				
Impact:	Sediment release into a watercourse is one of the most common forms of waterborne pollution. Furthermore, mismanagement of waste and pollutants including hydrocarbons, construction waste and other hazardous chemicals will result in these substances entering and polluting wetland systems either directly through surface runoff during rainfall events, or subsurface water movement				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	2	2	10	5	**Moderate (70)**

Post-Mitigation	2	1	6	3	**Low (27)**
Alternative Layout					
Pre-Mitigation	2	2	10	5	**Moderate (70)**
Post-Mitigation	2	1	6	3	**Low (27)**
Is the Impact Reversible?	• Impacts regarding potential soil pollution as a result of leakage from chemicals can be reversed. Soils that have been contaminated would need to be remediated either on site or removed to a secure location. A spill team would need to be contacted to conduct the remediation exercise.				
Mitigation Measures:	• All waste generated during construction is to be disposed of as per an Environmental Management Programme (EMPr) and washing of containers, wheelbarrows, spades, picks, or any other equipment that has been contaminated with cement or chemicals within any water resources, must be strictly prohibited. • Do not locate chemical storage areas associated with the construction camp or construction site on any of the hydric soils (whether natural or artificially saturated), without ensuring that these chemicals cannot leak or spill into these soil profiles. • Management and disposal of construction waste as per the Environmental Management Programme must occur during the construction of the development. • Waste disposal during the construction phase must ensure no litter or other contaminants particularly chemicals stored on site are deposited into HGM 1 or HGM 3. • No release of any substance i.e. cements or oil that could be toxic to fauna or faunal habitats; Wet cement and/ or concrete must not be allowed to enter any of the wetland systems. • Portable toilets must be placed outside of a 100m buffer from any of the delineated wetlands.				
Cumulative impacts:	• Cumulative impacts relating to the pollution of wetland systems are associated with the continued development of the larger area. As development occurs soils can and are contaminated with chemicals, hydrocarbons, and sediments from a variety of sources such as the existing mine, existing roads and leakage and spillage from construction activities. These soils are not remediated and are therefore changed from their natural state, making it difficult to utilise them in the future. Given the limited footprint of the project area, cumulative impacts of this project are low.				
Residual impacts:	• Residual impacts occur if leakage or spillage of chemicals occur during the construction phase, and these soils are not remediated. These soils will continue to release these chemicals into the environment after construction has ended. Provided the recommendations of this report are adhered to this impact is expected to be low.				

Climate Change:	• Soil pollution leads to a decrease in soil health and changes to the microbial populations of soil ecosystems. This can affect nutrient and carbon cycling leading to an effect on climate change in the long term.

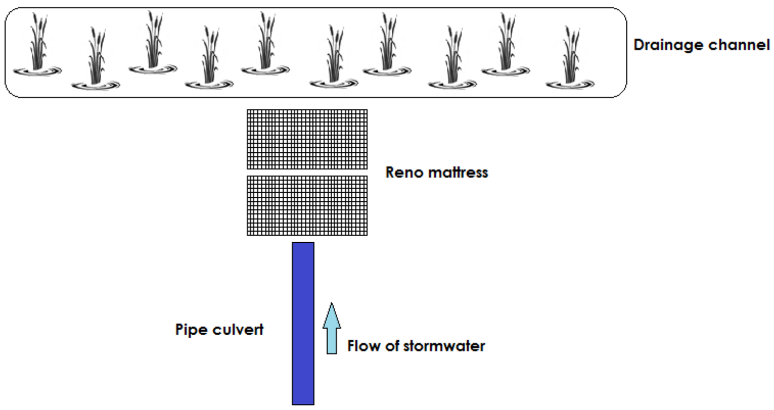
Activity:	**Encroachment of alien invasive vegetation. (Both layout alternatives are considered).**				
Impact:	The clearing of vegetation within portions of the PV Facility site (either the preferred or alternative layout) will lead to the disturbance to the vegetation of these areas. This will lead to the encroachment of alien invasive vegetation species which do occur within the area, if not managed with the implementation of alien invasive management programme. Alien species generally out-compete indigenous species for water, light, space and nutrients as they are adaptable to changing conditions and are able to easily invade a wide range of ecological niches (Bromilow, 2010). Alien invader plant species pose an ecological threat as they alter habitat structure, lower biodiversity (both number and "quality" of species), change nutrient cycling and productivity, and modify food webs (Zedler, 2004).				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	3	2	6	3	**Moderate (33)**
Post-Mitigation	2	1	4	2	**Low (14)**
Alternative Layout					
Pre-Mitigation	3	2	6	3	**Moderate (33)**
Post-Mitigation	2	1	4	2	**Low (14)**
Is the Impact Reversible?	• Impacts regarding the encroachment of alien invasive vegetation within the disturbed portions of the project site can be reversed provided ongoing alien vegetation clearing forms part of the environmental management programme for the construction phase.				
Mitigation Measures:	• Alien invasive species, that were identified within the study area must be removed, prior to construction. By removing these species, the spread of seeds will be prevented into disturbed soils which could have a positive impact on the surrounding natural vegetation. • An alien invasive management programme must be incorporated into an Environmental Management Programme. • Ongoing alien plant control must be undertaken after the construction phase and during the operational phase. Areas which have been disturbed will be quickly colonised by invasive alien species. An ongoing management plan must be implemented for the clearing/eradication of alien species. Recommendations of the botanical specialist assessment must also be adhered to.				

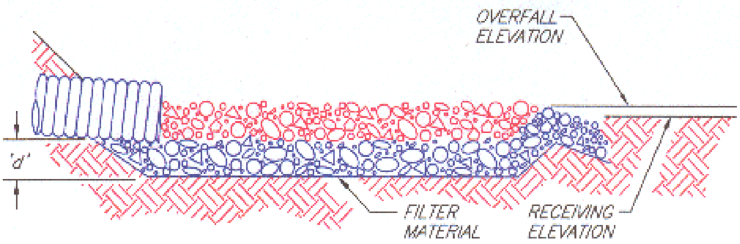
Cumulative impacts:	• Cumulative impacts will only stem from a lack of alien invasive vegetative control. Should alien invasive plants be allowed to continue encroaching the disturbed areas as a result of the construction related activities these will quickly invade areas outside of the project footprint and lead to a decline in the vegetation conditions of the larger area.
Residual impacts:	• Residual impacts will occur should ongoing alien invasive vegetation monitoring not continue throughout the construction phase of the project and alien vegetation spread outside of the project footprint.
Climate Change:	• Large scale encroachment of alien invasive species leads to changes to the biomass and a loss of indigenous species as well as has negative knock-on effects to the broader soil nutrient cycles affecting gaseous emissions. This has long term impacts on climate change.

Activity:	**Construction of bridge across HGM 1**				
Impact:	The construction of the bridge over HGM 1, will lead to the removal of topsoil within the disturbed footprint. This will subsequently lead to soil erosion within the wetland system if not managed. Sedimentation poses a risk to the geomorphological/functional integrity of wetland systems, reducing the ecological integrity of these systems. Furthermore, the use of any polluting materials such as hydrocarbons, cement, and other hazardous chemicals can lead to the release of these substances entering and polluting the receiving environment either directly through surface runoff during rainfall events, or subsurface water movement. Given the design of the proposed bridge crossing, which will involve the installation of pylons and the laying of the bridge on these pylons, as well as the current degraded state of the HGM unit, the impact is considered low. In the longer term a lack of rehabilitation of any compacted soils as a result of construction activities (i.e., the movement of a LDV vehicles, and the drilling process) will lead to the formation of erosion gullies and the further long-term degradation of the wetland system should these areas not be rehabilitated.				
Preferred and Alternative Layouts					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	2	2	8	4	**Moderate (48)**
Post-Mitigation	2	1	6	3	**Low (27)**
Is the Impact Reversible?	• The impacts relating to the construction of the bridge are reversible should the mitigation measures recommended below be implemented. Rehabilitation of any compacted areas, as a result of the construction must occur once construction is complete. Should compaction of soils occur during the operational phase these must be remediated as soon as possible.				

Mitigation Measures:	• Effective rehabilitation of the development footprint as well as the implementation of erosion control measures is imperative to mitigate risks to the wetland system. • Use vehicular digging within the wetland system, only if deemed absolutely necessary and stick to one access road. Do not drive all over the wetland system. • Working during the winter months will reduce soil erosion potential in disturbed areas. • There shall be no mining of soil/sand required for construction purposes from the wetland system. Soil must be brought in, if needed for construction purposes. This must also be stockpiled away from the wetland's edge. • No stockpiling of any materials may take place adjacent to the wetland. • Vegetation clearing must only be undertaken when construction activity is actually underway at the bridge point and this area of the wetland must be rehabilitated as soon as construction activities have ended utilising indigenous grasses. • Install sediment barriers across the entire construction right-of-way immediately upslope and downslope of the bridge to prevent sediment flow into the wetland. • Rehabilitation must be aimed at improving the status and function of the ecosystem, through the removal of invasive alien species and the planting of indigenous species. • No release of hazardous substances i.e., cement, oil, that could be toxic to within the wetland system. • Spillages of fuels, oils and other potentially harmful chemicals must be cleaned up immediately and contaminants properly drained and disposed of using correct solid/hazardous waste facilities (not to be disposed of within the natural environment). Any contaminated soil must be removed, and the affected area rehabilitated immediately – consult with a wetland/ecological specialist if spills occur.
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to an increase in soil compaction, a decrease in stormwater management, and therefore an increase in the likelihood for erosion gully formation. Mitigation measures recommended in this report will decrease the cumulative impacts of this project on the larger landscape.
Residual impacts:	• Residual impacts are associated with the formation of erosion gullies from compacted soils that are not remediated. Over time this will increase in size and will impact areas downstream of the project site.
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the topsoil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

Activity:	**Construction of drainage channels for the stormwater management of the area**
Impact:	Internal drains are proposed to be installed within the PV Facility site to drain excess storm water which ponds on the Stilfontein soils. These drains are proposed to have an outfall within HGM 1 (Figure 31). Impacts associated with this proposed storm water

	management infrastructure relate mainly to the potential for the formation of erosion gullies both along the channels as well as at the outfall site. The storm water management plan however includes this potential risk in the design of the channels as described in the mitigation measures section below				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	2	2	4	4	**Moderate (32)**
Post-Mitigation	2	1	2	2	**Low (10)**
Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented. Rehabilitation of any compacted areas, as a result of the construction must occur once construction is complete.				
Mitigation Measures:	• The design concept as provided in the storm water management plan must be adhered to. This includes the use of grassed trapezoidal channels, which is similar to that of a grassed swale. The design follows the principals of a sustainable drainage system (SuDS). The principles behind the use of SuDS encourage flood waters to infiltrate to groundwater as quickly as possible in the immediate area rather than channelling it away. Consideration is given to water quality as well as the amenity and biodiversity values of water, thereby improving the hydrological flow entering the receiving environment. • Once construction of the channels is completed the disturbed footprint including any compacted areas, must be rehabilitated as well as planted with indigenous grass species. • At the outfall sites of the channels, it is recommended that soil erosion measures are implemented. These include but are not limited to sand bags, hessian sheets, silt fences, retention or replacement of vegetation and geotextiles such as soil cells which can be used in the protection of slopes. • Other erosion protection measures can include using energy dissipaters to slow the velocity of water coming from the channels as shown below:  				

	
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to an increase in soil compaction, a decrease in stormwater management, and therefore an increase in the likelihood for erosion gully formation. Mitigation measures recommended in this report will decrease the cumulative impacts of this project on the larger landscape.
Residual impacts:	• Residual impacts are associated with the formation of erosion gullies both from compacted soils that are not remediated as well as from the lack of implementation of erosion control measures, particularly at the outfall location of the drains. Over time erosion gullies will increase in size and will impact areas downstream of the project site.
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the top soil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

8.2.2. Significance ratings tables for the Operational Phase

Activity:	**Soil erosion and sedimentation of wetland systems. (Both layout alternatives are considered).**				
Impact:	In the longer term a lack of rehabilitation of any compacted soils within or adjacent to wetland systems will lead to the formation of erosion gullies and the long-term degradation of wetland systems.				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	4	3	**Moderate (33)**
Post-Mitigation	5	1	2	2	**Low (16)**
Alternative Layout					
Pre-Mitigation	5	2	4	3	**Moderate (33)**
Post-Mitigation	5	1	2	2	**Low (16)**

Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented. Rehabilitation of any compacted areas, as a result of the construction must occur once construction is complete. Should compaction of soils occur during the operational phase these must be remediated as soon as possible.
Mitigation Measures:	• All vehicles must not deviate from designated access roads. Driving within wetland systems during the operational phase must be prohibited. • Follow up and monitoring of rehabilitation measures. • Implementation of additional rehabilitation measures if certain rehabilitation techniques are not successful.
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to an increase in soil compaction, a decrease in stormwater management, and therefore an increase in the likelihood for erosion gully formation. Mitigation measures recommended in this report will decrease the cumulative impacts of this project on the larger landscape.
Residual impacts:	• Residual impacts are associated with the formation of erosion gullies from compacted soils that are not remediated. Over time this will increase in size and will impact areas downstream of the project site.
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the top soil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

Activity:	Pollution of wetland systems. (Both layout alternatives are considered)				
Impact:	During the operational phase, any maintenance of the PV facility can lead to the release of substances into the soil profile, polluting the wetland systems.				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	4	3	**Moderate (33)**
Post-Mitigation	5	1	2	2	**Low (16)**
Alternative Layout					
Pre-Mitigation	5	2	4	3	**Moderate (33)**
Post-Mitigation	5	1	2	2	**Low (16)**
Is the Impact Reversible?	• Impacts regarding potential soil and wetland pollution as a result of leakage from chemicals can be reversed. Soils that have been contaminated would need to be remediated either on site or removed to a secure location. A spill team would need to be contacted to conduct the remediation exercise for both the soils and wetland systems impacted.				

Mitigation Measures:	• All waste generated during construction is to be disposed of as per the EMPr. • Waste disposal during the operational phase must ensure no litter or other chemicals used for maintenance activities are deposited into any of the natural wetland systems. • No release of any substance i.e., cements, oil, or any other substance that could be toxic into the soil profiles. Check vehicles and equipment entering the site for oil and fuel leaks and inspect site for possible spillages. • Spillages of fuels, oils and other potentially harmful chemicals must be contained and cleaned up immediately. Contaminants must be properly drained and disposed of using proper solid/hazardous waste facilities (never to be disposed of within the natural environment). Any contaminated soil must be removed, and the affected area rehabilitated immediately.
Cumulative impacts:	• Cumulative impacts relating to wetland pollution are associated with the continued development of the larger area. As development occurs wetland systems can and are contaminated with chemicals, hydrocarbons, and sediments from a variety of sources such as the existing mine, existing roads and leakage and spillage from maintenance activities. These impacts cause a decline in the health, functional integrity and ecological importance and sensitivity of the affected wetland systems.
Residual impacts:	• Residual impacts occur if leakage or spillage of chemicals occur during maintenance activities and these chemicals make their way into adjacent or downstream wetlands. If affected soils are not remediated, they will continue to release these chemicals into the environment, and these could enter into the wetland systems. This leads to a decline in wetland health, functional integrity, and ecological sensitivity of these systems. Provided the recommendations of this report are adhered to this impact is expected to be low.
Climate Change:	• Soil pollution leads to a decrease in soil health and changes to the microbial populations of soil ecosystems. This can affect nutrient and carbon cycling leading to an effect on climate change in the long term.

Activity:	**Encroachment of alien invasive vegetation (Both layout alternatives are considered)**				
Impact:	Disturbances as a result of maintenance activities as well as a lack of rehabilitation after the completion of construction, will lead to the encroachment of alien invasive vegetation species which do occur within the area, if not managed with the implementation of alien invasive management programme.				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	6	4	**Moderate (52)**
Post-Mitigation	3	1	4	2	**Low (16)**
Alternative Layout					
Pre-Mitigation	5	2	6	4	**Moderate (52)**

Post-Mitigation	3	1	4	2	**Low (16)**
Is the Impact Reversible?	• Encroachment of alien invasive species is reversible provided ongoing alien plant control is undertaken as per the mitigation measure provided below.				
Mitigation Measures:	• An alien invasive management programme must be incorporated into an Environmental Management Programme. • Ongoing alien plant control must be undertaken after the construction phase and during the operational phase. Areas which have been disturbed will be quickly colonised by invasive alien species. An ongoing management plan must be implemented for the clearing/eradication of alien species. Recommendations of the botanical specialist assessment must also be adhered to.				
Cumulative impacts:	• Cumulative impacts will only stem from a lack of alien invasive vegetative control. Should alien invasive plants be allowed to continue encroaching the disturbed areas during the operational phase these will quickly invade areas outside of the project footprint and lead to a decline in the vegetation conditions of the larger area.				
Residual impacts:	• Residual impacts will occur should ongoing alien invasive vegetation monitoring not continue throughout the operational phase of the project and alien vegetation spread outside of the project footprint.				
Climate Change:	• Large scale encroachment of alien invasive species leads to changes to the biomass and a loss of indigenous species as well as has negative knock-on effects to the broader soil nutrient cycles affecting gaseous emissions. This has long term impacts on climate change.				

Activity:	**Existence of bridge across HGM 1**				
Impact:	In the longer-term, sediment movement as a result of inadequately designed roads and bridges can lead to excessive erosion within and adjacent to the structures. This affects the wetland system geomorphic setting and flow dynamics both at the site of the erosion as well as downstream. This has knock-on effects on the use of the wetland systems as ecological corridors in the larger urban landscape. In addition to this, hardened surfaces are recognised as a source of various pollutants which can originate from a wide variety of sources. The pollutant concentration in road runoff can be highly variable and dependant on a wide variety of factors including location, traffic volumes, extent of dry period before a rainfall event, and nature of the surface. The increase in hardened surfaces as a result of the project will lead to the increase in the flushing of these pollutants into the HGM unit during the operational phase of this development. Given the limited access to the PV facility, this impact is expected to be low.				
Preferred and Alternative Layouts					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	4	3	**Moderate (33)**

Post-Mitigation	5	1	2	2	**Low (16)**
Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented. Rehabilitation of any compacted areas once construction has been completed must occur and the area planted with indigenous grasses. Should compaction of soils occur during the operational phase these must be remediated as soon as possible.				
Mitigation Measures:	• All vehicles must not deviate from designated access roads. Driving within wetland systems during the operational phase must be prohibited. • Follow up and monitoring of rehabilitation measures. • Implementation of additional rehabilitation measures if certain rehabilitation techniques are not successful.				
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to an increase in soil compaction, a decrease in stormwater management, and therefore an increase in the likelihood for erosion gully formation. Mitigation measures recommended in this report will decrease the cumulative impacts of this project on the larger landscape.				
Residual impacts:	• Residual impacts are associated with the formation of erosion gullies from compacted soils that are not remediated. Over time this will increase in size and will impact areas downstream of the project site.				
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the top soil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.				

Activity:	**Operation of drainage channels for the stormwater management of the area**				
Impact:	In the longer term a lack of maintenance of erosion control measures as well as maintenance of the grassed lined channels can lead to a failure of these channels, which will ultimately lead to the formation of erosion gullies and the long-term degradation of the already impacted wetland system.				
Preferred Layout					
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	4	3	**Moderate (33)**
Post-Mitigation	5	1	2	2	**Low (16)**
Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented.				

Mitigation Measures:	• All drains must be inspected and maintained. This ensures efficient operation and prevents failure. Usually, SuDS components are on or near the surface and most can be managed using landscape maintenance techniques. • Corrective maintenance to repair defects or improve performance of the drains must be implemented when necessary. • Maintenance must address silt control, vegetation maintenance, inspection of the outfall areas, removal of litter, removal of alien invasive species.
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to an increase in soil compaction, a decrease in stormwater management, and therefore an increase in the likelihood for erosion gully formation. Mitigation measures recommended in this report will decrease the cumulative impacts of this project on the larger landscape.
Residual impacts:	• Residual impacts are associated with the formation of erosion gullies from unmaintained drainage channels. Over time these gullies will increase in size and will impact areas downstream of the project site.
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the top soil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

9. RISK MATRIX

The Risk Assessment for the proposed project was undertaken in accordance with the General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in Section 21 (c) and (i) (Notice 509 of 2016). The risk assessment involves the analysis of the risk matrix provided in appendix 1 of this notice and involves the evaluation of the severity of impacts to the flow regime, water quality, habitat, and biota of the water resource. Based on the outcome of the Risk Assessment Matrix, low risk activities will be generally authorised with conditions, while moderate to high-risk activities will be required to go through a Water Use Licence Application Process. Water use activities that are authorised in terms of the General authorisations will still need to be registered with the DWS.

It must be borne in mind that when assessing the impact significance following the DWS Risk Assessment Matrix, determination of the significance of the impact assumes that mitigation measures as listed within this report as well as within an Environmental Management Programme for the construction and operational phase of the project are feasible and will be implemented, and as such does not take into consideration significance before implementation of mitigation measures.

The risk assessment is provided in Appendix B. From a wetland and aquatic perspective, impact scores (for both the preferred and alternative layouts) received are both Low and Moderate. This is due to the PV facility site being located on a site completed disturbed from historic mining operations.

Impacts to the wetland systems range from being small and easily mitigable to requiring mitigation measures on a higher level with associated costs.

10. RECOMMENDATIONS AND CONCLUSIONS

Wetland Findings

A thorough ground truthing delineation exercise was conducted following the desktop Scoping Assessment for this project. Based on the four wetland indicators identified on site, three HGM units were delineated in both the preferred and alternative layout sites as well as the 500m regulated area. HGM 1 was classified as an unchannelled valley bottom system, HGM 2 is classified as a seep, HGM 3 is classified as a depression. HGM 1 flows along the western edge of the preferred layout, HGM 2 was delineated within the 500m regulated area and a portion of HGM 3 was delineated at the south-eastern boundary of the alternative layout.

Apart from the three natural HGM units delineated within the study site and 500m regulated area, a number of artificial wetlands, functional dams, discarded dams, and seepage from dams were delineated. These wetland areas were identified both within phase 1 of the Ergo Gold PV project as well as during the current assessment. During both phases of the Ergo Gold PV project, these areas were confirmed to be artificial in nature and have been created by the extensive anthropogenic modifications throughout the study site. As a result of these disturbances, the soils of the site have been completed modified and are now classified as the Hydric Technosol, Stilfontein form. These soils show signs of saturation but are not natural wetland soils. The artificial 'wetlands' were delineated during phase 1 of the Ergo Gold PV project based on the presence of hydric characteristics of the soil, at the surface of the soil profile or within the first 10cm. Similar 'wetland' areas were identified during the current assessment, within and adjacent to areas that have been extensively modified by historic and current mining activities and the subsequent rehabilitation of these areas.

The three natural HGM units were assessed with regards to their health according to the Wet-Health methodology. A level 2 assessment (detailed) was conducted. HGM 1, the unchannelled valley bottom wetland, was classified as Seriously Modified (PES Category E), HGM 2, the seep system has been classified as Largely Modified (PES Category D), and HGM 3, the depression system has been classified as Moderately Modified (PES Category C).

Aquatic Findings

In general, valley bottom wetlands and depressional systems such as was determined to be present within the study area are unlikely to support a diverse array of aquatic biota given the lack of diverse hydraulic habitat relative to true riverine reaches of watercourses. In addition, prevailing and historic land uses are likely to present a further limiting factor to the ability of the associated watercourses to support representative taxa, with much of the intrinsic biodiversity elements being lost and only a depauperate diversity likely to the present. Further, a total of four indigenous fish species and one alien fish species are expected to be associated with the larger study area. Such diversity may however be considered optimistic, and only limited fish diversity is expected to be associated with HGM 1 (if any), while no fish species are expected HGM 3.

Buffer Requirements and Impacts

Even though the solar panels will be situated in areas where vegetation has been maintained, in order to reduce the risks of erosion, there is additional infrastructure associated with the project. These include a BES laydown area, a warehouse, an office, a switch room, internal roads to allow access to all the panels as well as a fence which will surround the entire infrastructural area. Stormwater emanating from the developed areas can have an impact on the receiving environment and particularly the wetland systems, through the increase in sediment transportation, the increase in flow into the receiving environment and the decrease in stormwater infiltration into the soil profile. Further to this the proposed storm water management plan includes the use of drainage channels to remove excess stormwater from the Stilfontein soils where stormwater will collect during the summer season in particular. A buffer was therefore calculated taking these factors into consideration and a 21 m buffer is recommended for the protection of the natural wetland systems. It is recommended that the buffer be planted with indigenous grasses and maintained as part of the construction and operational phases of the Environmental Management Programme for the development. A high basal cover of indigenous grass species will aid in the buffering out of sediment and pollutants from the development before stormwater enters into any of the wetland systems. Furthermore, stormwater control from the development is key in reducing impacts to the downstream and adjacent wetland systems.

It must be noted that there are some small areas in which the solar panels will encroach into the 21 m buffer but not into the wetland system. The outfall from the storm water drainage channels is located within the wetland system (HGM 1). Furthermore, a bridge is proposed to cross HGM 1 in order to gain access to both portions (Ptn 272 and Ptn 183 of the Farm Witpoortje No. 117R) of the preferred layout site.

The activities for both the preferred and alternative layout identified within the study site include:

- The clearing of portions of the PV facility site for the establishment of the solar panels, and associated infrastructure.
- The construction of the bridge over HGM 1.
- The construction of the storm water drains.
- Maintenance of the PV facility during the operational phase.

Negative impacts therefore associated with this project potentially include:

- Soil erosion and sedimentation of the wetland systems.
- Pollution potential.
- Encroachment of invasive alien species into the wetlands as a result of the additional disturbances to the area caused by the construction and operational phases of the project.

Several general and specific measures are proposed to mitigate these impacts.

The Risk Assessment for the proposed project was undertaken in accordance with the General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in Section 21 (c) and (i) (Notice 509 of 2016). From a wetland and aquatic perspective, impact scores (for both the preferred and alternative layouts) received are both Low and Moderate. This is due to the PV facility site being located on a site completed disturbed from historic mining operations. Impacts to the wetland systems range from being small and easily mitigable to requiring mitigation measures on a higher level with associated costs

Conclusions and Recommendations

From a wetland perspective, the specialist is of the opinion that impacts arising from the proposed project can be mitigated to an acceptably low level. This is attributed to the historically and currently disturbed nature of the area coupled with the modified to seriously modified nature of the wetlands assessed within the study site. Even though there will be some encroachment of the solar panels into the 21m buffer, this impact is expected to be low and the storm water flow from these sites into the HGM 1 can be effectively managed. Furthermore, impacts regarding the bridge and storm water drains can also be effectively managed.

In consideration of the aquatic habitat availability within the study area, it is expected that the aquatic biota assemblages present will be dominated by taxa with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. Further, given the likely seasonal availability of water within the unchannelled and depressional wetland systems present, it is expected that the period of inundation of the watercourse will result in temporal variations of aquatic assemblages within these systems. As such the risk of impact from the proposed activity on the associated aquatic ecosystem is expected to be low.

It is therefore the opinion of both authors that either the preferred or alternative layouts be approved from a wetland and aquatic perspective.

11. BIBLIOGRAPHY

Bell, M.C. (1973). *Fisheries handbook of Engineering Requirements and Biological Criteria*. Fisheries handbook of Engineering Requirements and Biological Criteria, Portland, Oregon

Berg, L. & Northcote, T.G. (1985). Changes in the territorial, gill-flaring, and feeding behaviour in juvenile coho salmon (Oncohynchus kisutch) following short-term pulses of suspended sediment. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1410–1417

Blackburn, T.M., Pyšek, P., Bacher, S., Carlton, J.T., Duncan, R.P., Jarošík, V., Wilson, J.R.U. & Richardson, D.M. (2011). A proposed unified framework for biological invasions. *Trends in Ecology and Evolution* 26: 333–339

Bunt, C.M., Cooke, S.J., Schreer, J.F. & Philipp, D.P. (2004). Effects of incremental increases in silt load on the cardiovascular performance of riverine and lacustrine rock bass, Ambloplites rupestris. *Environmental Pollution* 128: 137–144

Chakona, A., Malherbe, W.S., Gouws, G. & Swartz, E.R. (2015). Deep genetic divergence between geographically isolated populations of the goldie barb (Barbus pallidus) in South Africa: potential taxonomic and conservation implications. *African Zoology* 50: 5–10

Collins, N.B. (2005). Wetlands: The basics and some more. Free State Department of Tourism, Environment and Economic Affairs

Da Costa, L.D.M. (2012). Systematic studies on the Chubbyhead Barbs Species Complex (Osteichthyes, Cyprinidae) from southern Africa Systematic studies on the Chubbyhead Barbs Species Complex (Osteichthyes, Cyprinidae) from southern Africa. University of Lisbon, Portugal

Driver, A., Nel, J., Snaddon, K., Murray, K., Roux, D., Hill, L. & Swartz, E. (2011). Implementation Manual for Freshwater Ecosystem Priority Areas. WRC Report No. 1801/1/11. Pretoria: Water Research Commission

Department of Water Affairs and Forestry (2005) A Practical Field Procudure for Identification and Delineation of Wetlands and Riparian Areas - Edition 1

Department of Water Affairs and Forestry (2008) Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas, prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa

Department of Water and Sanitation (2014). A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx.

Ellender, B.R. & Weyl, O.L.F. (2014). A review of current knowledge, risk and ecological impacts associated with non-native freshwater fish introductions in South Africa. *Aquatic Invasions* 9: 117–132

Henri, A.J., Wepener, V., Ferreira, M., Malherbe, W. & van Vuren, J.H.J. (2014). The effect of acid mine drainage on the hatching success of branchiopod egg banks from endorheic wetlands in South Africa. *Hydrobiologia* 738: 35–48

Jennings, K., Le Roux, P.A.L., Van Huyssteen, C.W., Hensley, M., and Zere, T.B. (2008). Redox conditions related to interflow in a soil of the Kroonstad form in the Weatherley catchment, South African Journal of Plant and Soil, 25:4, 204-213, DOI: 10.1080/02571862.2008.10639918

Kotze, D.C., Macfarlane, D.M., Edwards, R.J., and Madikizela, B. (2020). WET-EcoServices Version 2: A revised ecosystem services assessment technique, and its application to selected wetland and riparian areas. Water SA. Technical Note. 46(4). 679-688. doi.org/10.17159/wsa/2020.v46.i4.9084

Malachite Ecological Services (2021) Wetland and Desktop Aquatic Impact Assessment for a Basic Assessment Application For The Ergo Mining Solar Pv Facility (Phase 1), Including A Plant Capacity Up To 19.9MW and 11km Of 22kV Overhead Power Line, Located Within The Ekurhuleni Local Municipality, Gauteng

Malachite Ecological Services and Ecology International (2021) . Baseline Wetland and Aquatic Assessment. For an Environmental Impact Assessment Application for the Ergo Mining Solar PV Facility (Phase 2), with a plant capacity of 40MW, within the Ekurhuleni Local Municipality, Gauteng.

Mitsch, W. J. & Gosselink, J. G. (1993) Wetlands (2nd edn) Van Nostrand Reinhold, New York

Mucina, L., Rutherford, M.C. & Powrie, L.W. (eds). (2006). Vegetation Map of South Africa, Lesotho and Swaziland, edn 2, 1:1 000 000 scale sheet maps. South African National Biodiversity Institute, Pretoria. ISBN 978-1-919976-42-6

Nel, J.L., Maree, G., Roux, D., Moolman, J., Kleynhans, C.J., Sieberbauer, M. & Driver, A. (2004). South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 2: River Component. CSIR Report Number ENV-S-I-2004-063. Council for Scientific and Industrial Research, Stellenbosch

Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., van Deventer, H., Swartz, E., and Smith-Adao, L.B. (2011). Atlas of Freshwater ECOSYSTEM Priority Areas in South Africa: Maps to support sustainable development of water resources. Water Research Commission

Ollis, D., Snaddon, K., Job, N. & Mbona, N. (2013). Classification Systems for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. Pretoria: South African National Biodiversity Institute

Rossouw, L., Avenant, M.F., Seaman, M.Y., King, J.M., Barker, C.H., De Preez, P.J., Pelser, A.J., Roos, J.C., Van Staden, J.J., Van Tonder, G.J. & Watson, M. (2005). *Environmental water requirements in non-perennial systems*. WRC Report 1414/1/05. Pretoria, South Africa

Servizi, J.F. & Martens, D.W. (1992). Sublethal responses of coho salmon (Oncohynchus kisutch) to suspended sediments. *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1389–1395

Smit, L., Du Preez, H.H. & Steyn, G.J. (1998). Influence of natural silt on the survival of Oreochromis mossambicus yolk sac larvae. *Koedoe* 41: 57–62

Soil Classification Working Group (1991). Soil Classification: A Taxonomic System for South Africa. Department of Agriculture

Soil Classification Working Group (2018). Soil Classification: A Natural and Anthropogenic System for South Africa. ARC-Institute for Soil, Climate and Water. Pretoria

Van Deventer, H., Smith-Adao, L., Collins, N.B., Grenfell, M., Grundling, A., Grundling, P.-L., Impson, D., Job, N., Lötter, M., Ollis, D., Petersen, C., Scherman, P., Sieben, E., Snaddon, K., Tererai, F. & Van der Colff, D. (2019). *South African National Biodiversity Assessment 2018: Technical Report. Volume 2b: Inland Aquatic (Freshwater) Realm*. CSIR report number CSIR/NRE/ECOS/IR/2019/0004/A. South African National Biodiversity Institute, Pretoria, South Africa

van Tol, J. J. Le Roux, P.A.L., Lorentz, S. A. and Hensley, M. (2013). Hydropedological Classification of South African Hillslopes. Journal of Vadose Zone

Water Resource Commission (2011). Easy Identification of some South African Wetland Plants. WRC Report No TT 479/10

Zedler, J.B. & Kercher, S. (2004). Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes. Critical Reviews in Plant Sciences, 23(5):431–452

12. APPENDICES

Appendix A: Methodology

<u>Assessment of the Wetland's Present Ecological State (PES)</u>

The Present Ecological State (PES) for wetlands which is defined as '*a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition'* is also an indication of each wetland's ability to contribute to ecosystem services within the study area. This was assessed according to the methods contained in the Level 2 WET-Health: *A technique for rapidly assessing wetland health* (Macfarlane et al., 2009).

This document assesses the health status of a wetland through evaluation of three main factors -

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

The WET-Health tool evaluates the extent to which anthropogenic changes have impacted upon the functional integrity or health of a wetland through assessment of the above-mentioned three factors. The deviation from the natural condition is given a rating based on a score of 0-10 with 0 indicating no impact and 10 indicating modifications have reached a critical level. Since hydrology, geomorphology and vegetation are interlinked their scores are then aggregated to obtain an overall PES health score These scores are then used to place the wetland into one of six health classes (A – F; with A representing completely unmodified/natural and F representing severe/complete deviation from natural as depicted in Table 10.

Table 10: Health categories used by WET-Health for describing the integrity of wetlands

DESCRIPTION	IMPACT SCORE	HEALTH CATEGORY
Unmodified, natural.	0 - 1.0	A
Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place	1.1 - 2.0	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2.1 - 4.0	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4.1 - 6.0	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable	6.1 - 8.0	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota	8.1 - 10.0	F

Due to differences in the pattern of water flow through various hydro-geomorphic (HGM) types, the tool requires that the wetland is divided into distinct HGM units at the outset. Ecosystem services for each HGM unit are then assessed separately.

Appendix B: Risk Matrix

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

NAME and REGISTRATION No of SACNASP Professional member: Rowena Harrison Reg no. 400715/15

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

					Severity																		
No.	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
1	Construction phase	Construction of the PV Facility - Soil Erosion and Sedimentation	Exposure of soil from construction activities leading to it being washed away and deposited into wetland systems. Compaction of soils from heavy machinery	Disturbances to the hydrological flow of wetlands; formation of erosion gullies.	3	3	3	3	3	1	1	5	4	3	5	1	13	65	M	80	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
2	Construction Phase	Construction of the PV Facility - Pollution of watercourses and soil	Sediment deposition in downstream wetlands, release of hydrocarbons and other pollutants during construction	Deterioration in water quality affecting aquatic and terrestrial species that utilise these systems as well as downstream systems.	1	2	1	1	1.25	1	1	3.25	4	3	5	1	13	42.25	L	80	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
3	Construction Phase	Construction of the PV Facility - Alien Invasive Species Encroachment	Removal of vegetation within construction footprint leads to disturbances and the encroachment of alien invasive species	Deterioration in vegetation communities associated with the wetland systems	1	1	1	1	1	1	1	3	4	3	5	1	13	39	L	80	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low

4	Construction Phase	Construction of the PV Facility - Construction of bridge across HGM 1	Installation of pylons across HGM 1, laying of bridge, disturbance to soil and vegetation of wetland system	Disturbances to the hydrological flow of wetlands; formation of erosion gullies, pollution potential	**2**		**2**		**1**		**1**		**1.5**	**1**	**1**		**3.5**		**4**	**3**	**5**	**1**		**13**	**45.5**	L	70	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
5	Construction Phase	Construction of the PV Facility – stormwater drains	Construction of trapezoidal grass lined drains that drain water into HGM 1	Potential for the formation of erosion gullies both along the channels as well as at the outfall site.	**2**		**1**		**1**		**1**		**1.25**	**1**	**2**		**4.25**		**4**	**3**	**5**	**1**		**13**	**55.25**	L		As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
6	Operational Phase	Existence, Use and Maintenance of PV facility - Soil Erosion and Sedimentation	Long term deposition of sediment into wetlands from erosion gullies, altering their flow dynamics and impacting their health and functional integrity	Wetland degradation and erosion gully formation	**1**		**1**		**1**		**1**		**1**	**1**	**3**		**5**		**3**	**2**	**5**	**1**		**11**	**55**	L	60	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
7	Operational Phase	Existence, Use and Maintenance of PV facility - Pollution of watercourses and soil	Maintenance activities can lead to pollution of adjacent systems	Long-term deterioration in water quality of wetlands	**1**		**2**		**1**		**2**		**1.5**	**1**	**3**		**5.5**		**1**	**2**	**5**	**1**		**9**	**49.5**	L	60	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low

8	Operational Phase	Existence, Use and Maintenance of PV facility - Encroachment of Alien Invasive Species	Encroachment of alien invasive species within disturbed areas as a result of a lack of monitoring	Deterioration in the vegetation communities of the surrounding areas of the wetlands and possible further invasion of alien invasive species downstream	**1**		**1**		**1**		**1**		**1**	**1**	**3**		**5**		**1**	**2**	**5**	**1**		**9**	**45**	L	60	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
9	Operational Phase	Existence, Use and Maintenance of PV facility – existence and use of bridge over HGM 1	Long term deposition of sediment into wetlands from erosion gullies, altering their flow dynamics and impacting their health and functional integrity	Wetland degradation and erosion gully formation	**2**		**2**		**1**		**1**		**1.5**	**1**	**3**		**5.5**		**2**	**3**	**5**	**1**		**11**	**60.5**	M	**70**	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low
10	Operational Phase	Existence, Use and Maintenance of PV facility – existence and drainage of water in storm water drains	Lack of maintenance of erosion control measures as well as maintenance of the grassed lined channels – leading to failure of these channels,	Formation of erosion gullies and the long-term degradation of the already impacted wetland system	**2**		**1**		**1**		**1**		**1.25**	**1**	**3**		**5.25**		**2**	**2**	**5**	**1**		**10**	**52.5**	L	70	As per Section 8 of the report		3 HGM units within the 500m assessment area. HGM 1 – PES E, HGM 2, PES – D, EIS Low; HGM 3 – PES C, EIS Low

Appendix B: CV of Authors

PERSONAL DETAILS

Name	Rowena Harrison
Date of Birth	21 April 1982
Identity Number	8204210320081
Nationality	South African
Current Position	Director (Wetland Specialist and Soil Scientist)
Office Location	Durban, KwaZulu-Natal
Tel	+27 (0)78 023 0532
Email	rowena@malachitesa.co.za
Website	www.malachitesa.co.za

ACADEMIC QUALIFICATIONS

2019 – present	PhD Soil Science (University of Free State and the University of Burgundy, France)
2015	Certificate in Wetland Rehabilitation – University of the Free State
2009	MSc (Soil Science) – University of KwaZulu-Natal
2008	Certificate course in Wetland Delineation, Legislation and Rehabilitation, University of Pretoria
2006	BSc (Environmental Science) – University of KwaZulu-Natal
2005	BSc (Applied Environmental Science) – University of KwaZulu-Natal

PROFESSIONAL AFFILIATIONS

- South African Council for Natural Scientific Professions – SACNASP (Pr. Sci.Nat 400715/15: Soil Science)
- International Association for Impact Assessments – IAIAsa
- South African Wetland Society

PUBLICATIONS

- Harrison, R.L., van Tol, J., and Toucher, M.L. (2022). Using hydropedological characteristics to improve modelling accuracy in Afromontane catchments. Journal of Hydrology: Regional Studies. 39. https://doi.org/10.1016/j.ejrh.2021.100986.

- Harrison, R., and van Tol, J. (2022). Digital Soil Mapping for hydropedological purposes of the Cathedral Peak research catchments, South Africa. In Remote Sensing of African Mountains. Springer. (in publication)

CONFERENCES ATTENDED AND PRESENTED

NAME	DATE
South African Mountain Conference – Presenter on digital soils mapping as well as using hydropedological methods to improve hydrological models.	March 2022
SAEON Science Seminars – Presenter on gaining insights into hydropedological characteristics of catchment hydrology.	February 2022
Biodiversity Symposium – Presenter on Hydropedology and Carbon Dynamics	November 2019
IAIAsa – KZN Branch – Presenter on wetland offsets from a soil's perspective	October 2019
Zoological Society of Southern Africa Conference	July 2019
Grass Identification Course hosted by African Land-Use Training	March 2019
Groundwater Modelling Course hosted by the Nelson Mandela Metropolitan University	February 2019
Hydropedology Course hosted by TerraSoil Science and the Water Business Academy	November 2018
Wetland National Indaba	October 2018
Wetland National Indaba	October 2017
Wetland Vegetation training course	February 2017
National Biodiversity and Business Network (NBBN). Biodiversity Indaba	March 2017
Certificate course in Wetland Rehabilitation and Management, University of the Free State	March 2015
Gauteng Wetland Forum: Basic Wetland Delineation course	February 2013

EIA Training Course: Real World EIA, Metamorphosis Environmental Consultants	November 2008
Certificate course in Wetland Delineation, Legislation and Rehabilitation, University of Pretoria	May 2008

EMPLOYEMENT RECORD

- April 2016 – Present — Malachite Ecological Services – Director (Soil Scientist)
- March 2014 - March 2016 — Afzelia Environmental Consultants (Pty) Ltd (Soil Scientist and Wetland Specialist)
- September 2012 - February 2014 — Strategic Environmental Focus (Pty) Ltd (Junior Wetland Specialist)
- February 2008 - December 2009 — Afzelia Environmental Consultants cc (Soil Scientist/Junior Wetlands Specialist and Environmental Assessment Practitioner)

PROJECT EXPERIENCE

Rowena has obtained a MSc. In Soil Science from the University of KwaZulu Natal, Pietermaritzburg. She is professionally affiliated to the South African Council for Natural Scientific Professions (Pr. Sci. Nat) and has 13 years consulting experience in the wetland and soil science field. She has conducted numerous wetland, hydropedology and soil assessments for a variety of development types across South Africa, Swaziland, Cameroon, and the Democratic Republic of Congo.

She is a member of the International Association for Impact Assessment (IAIA) as well as a founding member of the South African Wetland Society. She is currently a joint PhD candidate at the University of the Free State and the University of Burgundy in France. Her research is focused on the interactions of dissolved organic carbon and hydropedology at a catchment scale.

CURRICULUM VITAE

Name:	**Byron Grant Pr.Sci.Nat.**
Company:	Ecology International (Pty) Ltd
Years of Experience:	18 years
Nationality:	South African
Languages:	English (mother tongue), Afrikaans
SACNASP Status:	Professional Natural Scientist (Reg. No. 400275/08)
Email address:	byron@ecologyinternational.net
Contact Number:	(+27) 82 863 0769

EDUCATIONAL QUALIFICATIONS

- B. Sc. (Botany & Zoology), Rand Afrikaans University (1997 - 1999);
- B. Sc. (Honours) Zoology, Rand Afrikaans University (2000);
- M. Sc. (Aquatic Health) *cum laude,* Rand Afrikaans University (2001 – 2004);
- Introduction to quantitative research using sample surveys, Rand Afrikaans University (2004);
- SASS5 Field Assessment Accreditation in terms of the River Health Programme, Department of Water Affairs (2005 – present);
- Monitoring Contaminant Levels: Freshwater Fish (*awarded Best Practice*), University of Johannesburg (2005);
- EcoStatus Determination training workshop, Department of Water Affairs and Forestry (2006);
- Multi-disciplinary roles in defining EcoStatus and setting flow requirements during an ecological reserve study, Department of Water Affairs (2008);
- Water Use Licence Applications: Section 21 (c) and (i) training workshop, Department of Water Affairs (2009);
- Advanced Wetland Course, University of Pretoria (2010) (*awarded with Distinction*);
- Determination of the Present Ecological State within the EcoClassification process, University of the Free State (2011);
- River Health Programme Training Workshop, Department of Water and Sanitation – Resource Quality Information Services (2014);
- Tools for Wetland Assessments, Rhodes University (2015);
- RHAM (Rapid Habitat Assessment Model) Training Workshop, Department of Water and Sanitation – Resource Quality Information Services (2015);
- Wetland, River and Estuary Buffer Determination Training Workshop, Institute for Natural Resources (2015);
- Fish Invertebrate Flow Habitat Assessment Model (FIFHA), Department of Water and Sanitation – Resource Quality Information Services (2015);
- Wetland Plant Taxonomy, Water Research Commission (2017);
- Vegetation Response Assessment Index (VEGRAI), Mr. James MacKenzie (co-developer of index) (2018);
- Wetland Soils, Agricultural Research Council in association with the University of the Free State (2018)
- Hydropedology and Wetland Functioning (Short course), Terrasoil Science in association with the Water Business Academy (2018).
- HCV (High Conservation Value) Assessor Training Course, Astra-Academy (2019)

KEY QUALIFICATIONS

- **<u>Project Management:</u>**

  Project management and co-ordination of specialist-related projects, including:
  - Aquatic assessments (see below);
  - Floral and Faunal assessments:
    - Design and implementation of monitoring programmes;
    - Baseline ecological assessments
    - Ecological impact and mitigation assessments;
    - Rescue and relocation assessments;
    - Alien and invasive vegetation management plans;
  - Wetland assessments:
    - Design and implementation of wetland monitoring programmes;
    - Wetland delineation studies;
    - Wetland Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) determination assessments;
    - Wetland management plans;
    - Wetland impact and mitigation assessments;
    - Wetland offset strategies and assessments;
    - Wetland Reserve Determinations;
  - Water quality studies;
  - Dust monitoring studies;
  - Ecological Risk Assessments;
  - Biodiversity Action Plans (BAP);
  - Biodiversity Management Strategies;
  - Water Research Commission projects.

- **<u>Specialist Assessments:</u>**

  Extensive experience in conducting specialist aquatic assessments and providing specialist ecological input, including:
  - Baseline aquatic biodiversity assessments, including the determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) according to latest methodology;
  - Aquatic impact and mitigation assessments;
  - Design, management and implementation of biological monitoring programmes for the aquatic environment;
  - Protocol development;
  - Fish kill investigations;
  - Ecological Flow Requirements;
  - Reserve Determinations;
  - Aquatic toxicity assessments;
  - Bioaccumulation studies;

- Human health risk assessments for the consumption of freshwater fish;
- Surface water quality studies;
- Application of various monitoring indices, including the South African Scoring System version 5 (SASS5), the Macro-Invertebrate Response Assessment Index (MIRAI), the Invertebrate Habitat Assessment System (IHAS), the Index for Habitat Integrity (IHI), the Rapid Habitat Assessment Model (RHAM), the Fish Assemblage Integrity Index (FAII), the Fish Response Assessment Index (FRAI), the Physico-chemical Assessment Index (PAI), Riparian Vegetation Response Index (VEGRAI), Fish Invertebrate Flow Habitat Assessment Model (FIFHA), determination of EcoStatus, etc.;
- Eco-Conditional Requirement (Eco-0) assessments for Green Star Accreditation;
- Watercourse Protection Plans relating to Eco-Conditional Requirement (Eco-0) for Green Star Accreditation.

- **Specialist Review:**
  Specialist and independent review of impact assessment and management reports for all sectors of government, civil society and the scientific and legal fraternity:
  - Member of Technical Advisory Group for the Green Building Council of South Africa;
  - Member of Reference Groups for Water Research Commission;
  - Peer review of specialist biodiversity reports;
  - Peer reviewer for African Journal of Aquatic Science.

PROFESSIONAL REGISTRATIONS

- South African Council for Natural Scientific Professions (SACNASP) – Professional Natural Scientist (Aquatic Science, Ecological Science, Zoological Science), Reg. No. 400275/08

Other Society Memberships

- South African Society of Aquatic Scientists
- South African Wetland Society (Founding Member)
- Zoological Society of Southern Africa

Other Memberships

- Aquatox Forum
- Gauteng Wetland Forum
- Klipriviersberg Sustainability Association – Development Integration Team
- Yellowfish Working Group

COUNTRIES OF EXPERIENCE

- South Africa
- Lesotho
- Swaziland
- Mozambique

- Ghana
- Namibia
- Cameroon
- Namibia

SPECIALIST WORKSHOP PARTICIPATION

- Wetland and Watercourse Buffers Determination workshop. Project for the Department of Water Affairs, Sub-directorate: Water Abstraction and Instream Use;
- NEMBA category 2 alien fish species mapping for Gauteng, Limpopo and Northwest Provinces and a national review workshop, South African Institute for Aquatic Biodiversity (SAIAB);
- National Freshwater Ecosystem Priority Areas project – Specialist Input Workshop, South African National Biodiversity Institute (SANBI);
- Biodiversity Offsets Strategy workshop, Gauteng Department of Agriculture, Conservation and Environment (GDACE);
- Minimum Requirements for Biodiversity Assessments (Version 2) workshop, Gauteng Department of Agriculture, Conservation and Environment (GDACE);
- Gauteng Nature Conservation Bill, Gauteng Department of Agriculture and Rural Development (GDARD);
- Mainstreaming Biodiversity in Mining Training Workshop, SANBI's Grasslands Programme (in partnership with the South African Mining and Biodiversity Forum and the Departments of Environmental Affairs and Mineral Resources);
- National Biodiversity Offset Workshop, Department of Environmental Affairs (DEA), Endangered Wildlife Trust (EWT);
- Accreditation/certification of Wetland Practitioners Workshop, South African Wetland Society.

PRESENTATIONS AND PUBLICATIONS

Brink, K., Gough, P., Royte, J.J., Schollema, P.P. & Wanningen, H. (eds). (2018). From Sea to Source 2.0. Protection and restoration of fish migration in rivers worldwide. World Fish Migration Foundation. *Contributing author.*

Grant, B., Huchzermeyer, D. & Hohls, B. (2014). *A Manual for Fish Kill Investigations in South Africa.* WRC Report No. TT 589/14. Water Research Commission, Pretoria.

Grant, B., Hohls, B. & Huchzermeyer, D. (2013). Development of a Fish Kill Protocol for South Africa. South African Society for Aquatic Scientists - 2013 Conference, Arniston. Oral presentation.

Mlambo, S.S., van Vuren, J.H.J., Basson, R. & Grant, B. (2010). Accumulation of hepatic HSP70 and plasma cortisol in *Oreochromis mossambicus* following sub-lethal metal and DDT exposure. *African Journal of Aquatic Science* 35(1): 47-53.

Grant, B., van Vuren, J.H.J. & Cronjé, M.J. (2004). HSP 70 response of *Oreochromis mossambicus* to Cu^{2+} exposure in two different types of exposure media. South African Society for Aquatic Scientists – 2004 Conference, Cape Town. Poster presentation.

EMPLOYMENT EXPERIENCE

- **Ecology International:** Date: June 2017 - Present
- Role: Director & Principal Biodiversity Specialist
  - Management and co-ordination of staff members and specialists
  - Project management on various scales for environmental and biodiversity specialist-related services;
  - Co-ordinating, implementing and conducting specialist studies for various types of projects, including:
    - Protocol development;
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- **Independent Specialist:** Date: February 2017 – May 2017
- Role: Principal Biodiversity Specialist
  - Project management on various scales for biodiversity specialist-related services;
  - Co-ordinating, implementing and conducting specialist studies for various types of projects, including:
    - Protocol development;
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- **GIBB** (June 2015 – January 2017)

- Role: Principal Specialist
  - Project management on various scales for specialist-related services;
  - Co-ordinating, implementing and conducting studies for various types of projects, including:
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.
-
- Strategic Environmental Focus (August 2009 – June 2015)
- Role: Principal: Specialist Services
  - Management and co-ordination of staff members and specialists;
  - Project management on various scales for specialist-related services;
  - Co-ordinating, implementing and conducting studies for various types of projects, including:
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.
-
- Strategic Environmental Focus (March 2009 – July 2009)
- Role: Senior Natural Scientist
  - Project management for water, aquatic and monitoring-related projects;
  - Management and co-ordination of specialists;
  - Co-ordinating, implementing and conducting studies for various water and monitoring-related projects;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.
- Strategic Environmental Focus (July 2006 – February 2009)
- Role: Aquatic Specialist

- Conducting specialist assessments in the field of aquatic ecology and water science.
- Acting as an information source concerning environmental legislation.

ECOSUN cc. (January 2005 – June 2006)

Role: Aquatic Scientist

- Conducting specialist assessments in the field of aquatic ecology and water science.
- Acting as an information source concerning environmental legislation.

Rand Afrikaans University (January 2003 – December 2004).

Role: Student Mentor / Post-Graduate Research Assistant

- Validation of Antibodies for HSP70 Detection in the Freshwater Snail *Melanoides tuberculata* - B.Sc. (Honours) Student (January 2003 – December 2003);
- The use of genotoxic and stress proteins in the active biomonitoring of the Rietvlei system, South Africa – M.Sc. Student (January 2003 – December 2003);
- A comparison between Whole Effluent Toxicity (WET) testing and Active Biomonitoring (ABM) as indicators of in stream aquatic health – M.Sc. Student (January 2003 – December 2003);
- The use of HSP70 and cortisol as biomarkers for heavy metal exposure - M.Sc. Student (January 2004 – December 2005).

Rand Afrikaans University (January 2000 – December 2004)

Role: Practical Demonstrator

- Field supervisor for B.Sc. Honours (Zoology);
- Aquatic Ecology (3rd year);
- Human Physiology (2nd year); and
- Ecology and Conservation (for Vista University)