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

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Declaration of Independence by Specialists

We, **Rowena Harrison** and **Byron Grant**, hereby declare that we -

- Act as independent wetland and aquatic consultants.
- 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 our disposal regarding the application, whether such information is favourable to the applicant or not.
- Based on information provided to us 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 our professional ability.

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EXECUTIVE SUMMARY

Malachite Ecological Services and Ecology International were appointed by Environmental Management Assistance to undertake a Baseline 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.

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

- Identify and delineate any wetland/watercourse systems within the defined study site at a desktop level. This includes the use of historic and current aerial imagery, the Freshwater Ecosystem Priority Areas (FEPA) wetland database, the National Wetland Map 5 database, and information gathered from the wetland assessment of phase 1[1] of the Ergo Gold PV project.
- 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).
- Determine the Present Ecological State score (PES) using the Level 1 WET-Health approach. Wet-Health is a a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition (Kotze et al. 2020). A Level 1 assessment is a broad-scale desktop-based assessment to gain a general understanding of the impacts on the health of the wetland system.
- Conduct a desktop aquatic assessment on any watercourses within the assessment area.
- Determine any appropriate buffers for any of the identified wetlands/watercourses within the study site.
- Provide recommendations for the impact assessment phase of this study as well as any measures to limit any impacts on the identified wetlands/watercourses from the proposed project.

Wetland Findings

A desktop assessment was conducted for the entire proposed study area based on historic and current aerial imagery. It should be noted that a portion of the proposed site as assessed in this report has been ground truthed by the author through a separate wetland assessment undertaken for phase 1 (a 19.9MW PV facility). This desktop assessment was added to the delineations undertaken from the phase 1 wetland assessment, which concluded four Hydrogeomorphic (HGM) units were delineated within the proposed study area and a 500m assessment buffer. These were classified as an unchannelled valley bottom wetland, a seep system, and a depression wetland, while a fourth HGM unit, a channelled valley bottom wetland, was delineated to the south of the study site but within the 500m assessment buffer (Malachite Ecological Services, 2021).

Apart from the four 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 during the phase 1 assessment of the Ergo Gold

[1] Phase 1, a 19.9MW PV facility with a 22kV Overhead power line and 100MWh Battery Energy Storage System (BESS) has previously assessed through a Basic Assessment Process).

PV project as well as on the aerial images examined. During phase 1 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 completely modified and are now classified as the Hydric Technosol, Stilfontein form. These soils show signs of saturation but are not natural wetland soils. The '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 examination of aerial imagery of the proposed site for phase 2, within and adjacent to areas that have been extensively modified by historic and current mining activities and the subsequent rehabilitation of these areas.

The four natural HGM units were assessed with regards to their health according to the Wet-Health methodology. A level 1B assessment (desktop scale) was conducted for the wetlands delineated at a desktop level for the proposed site, while the wetlands delineated and evaluated during phase 1 of the Ergo Gold PV project and within this study site were assessed at a level 2 (detailed) scale. 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), HGM 3, the depression system has been classified as Moderately Modified (PES Category C), and HGM 4, the channelled valley bottom wetland has been classified as Largely Modified (PES Category D).

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. Dams associated with HGM 2 and HGM 4, the seep wetlands, have also had an impact on the flow dynamics of these systems. The damming of wetland systems has long-term negative impacts on the hydrology, geomorphology, and vegetation dynamics of these systems. The depression wetland, HGM 3 has a smaller catchment area, and this has limited the impacts to these wetlands to a degree. However, the wetland has still been impacted through the use of the adjacent area as a tailing's storage facility. Sediment from this storage facility can easily be deposited within 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 2021.

Aquatic Findings

In general, valley bottom wetlands and depressional systems such as those 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. 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 expected to 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. As such, only a limited acquired diversity of aquatic biota is expected to be associated with the wetlands present within the study area.

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 at HGM 3.
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 the *Enteromius cf. anoplus* (Chubbyhead Barb complex), and the *Enteromius cf. pallidus* (Goldie Barb). Determination of the ecological state from an aquatic perspective is not considered suitable, and therefore reliance should be placed on that as determined from a wetland perspective. This is also applicable to the determination of the ecological importance and ecological sensitivity of the wetland systems.

Buffer Requirements
The proposed project involves the construction of solar panels for a 40MW PV plant and associated infrastructure. The solar panels will be situated in areas that are cleared of vegetation and paved and this will change the storm water flow dynamics of the impacted areas. 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. As such a buffer was calculated for the protection of the natural wetland systems delineated and assessed as part of this scoping assessment. The buffer may need to be refined during the impact assessment and once the field investigation has taken place. The buffer takes into account the proposed activity, climatic factors, topographical factors, the nature of the soils, and the sensitivity of the water resource. A 21m buffer has been calculated for the protection of the natural wetland systems.

Recommendations
It is recommended that a more in-depth study, with the inclusion of field sampling takes place during the impact assessment phase of this study. This is particularly so for the wetlands delineated via a desktop approach. The PES scores will be updated, if required after the field investigation and the functional integrity and ecological importance and sensitivity included in the assessment. It is furthermore recommended that the artificial ‘wetland’ areas be studied in more detail to determine the nature of these ‘wetland’ areas as well as any mitigation measures needed for their protection.

During construction activities mitigation measures to lessen the impact of the development on the receiving environment and particularly on the wetlands delineated and assessed within the study area must be implemented. These include:

- Erosion control measures such as sandbags, hessian sheets, silt fences, retention or replacement of vegetation and geotextiles such as soil cells which can be placed along slopes for their protection.
- No stockpiling of soil adjacent to wetlands.

- Minimising the development footprint.
- Waste disposal controls for litter and contaminants utilised during construction.
- No release of chemicals adjacent to wetlands, and
- Aline invasive plant control within disturbed areas.

The determined buffer is recommended to 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.

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1. INTRODUCTION

1.1 Project Description and Locality

Malachite Ecological Services and Ecology International were appointed by Environmental Management Assistance to undertake a Baseline 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.

The proposed project is situated off the R23 (Heidelberg Road) Portions 183, 272 and 283 of the Farm Witpoortje No. 117IR; Portions 9 of the Farm Withok No. 131IR; and Holdings 203-208, 240-245, 296-303 and 348-355 of the Withok Estates I.R.[2], within the Ekurhuleni Local Municipality, Gauteng. The project site is furthermore situated within the quarter degree square 2628AD (Figure 1 and 2).

This Baseline 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.

[2] Please note that a larger area was scoped for inclusivity and to ensure that any sensitive areas within the larger area were identified. This area will be refined for the impact assessment phase based on the proposed PV layout.

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 at a desktop level. This includes the use of historic and current aerial imagery, the FEPA wetland database, the National Wetland Map 5 database, and information gathered from phase 1 of the Ergo Gold PV project.
- 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).
- Determine the Present Ecological State score (PES) using the Level 1 WET-Health approach. Wet-Health is a a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition (Kotze et al. 2020). A Level 1 assessment is a broad-scale desktop-based assessment to gain a general understanding of the impacts on the health of the wetland system.
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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:

i. Wetland mapping was largely undertaken at a desktop level which did not involve any ground-truthing of wetland boundaries apart for the HGMs identified in the phase 1 assessment. This desktop mapping was undertaken outside of areas investigated as part of phase 1 of the Ergo Gold PV project. Refined wetland mapping using the methodologies from the Department of Water Affairs and Forestry[3] "Practical field procedure for the identification and delineation of wetlands and riparian areas is still required during the impact assessment phase of this study in the areas assessed at a desktop level.
ii. The assessment of the Present Ecological State (PES) was undertaken at a desktop scale (Level 1B), in areas assessed at a desktop level. Wetlands which were delineated in phase 1 of the Ergo Gold PV project, and which form part of this assessments study site were assessed at a Level 2 scale (detailed assessment). The assessment of the functional integrity and Ecological Importance and Sensitivity (EIS) of all wetlands will be included during the impact assessment phase of this study, once the final layout has been compiled.

1.4 Reporting Conditions

The findings 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. No form of this report may be amended without the prior written consent of the authors.

[3] Department of Water Affairs and Forestry (DWAF) is now named the Department of Water and Sanitation (DWS).

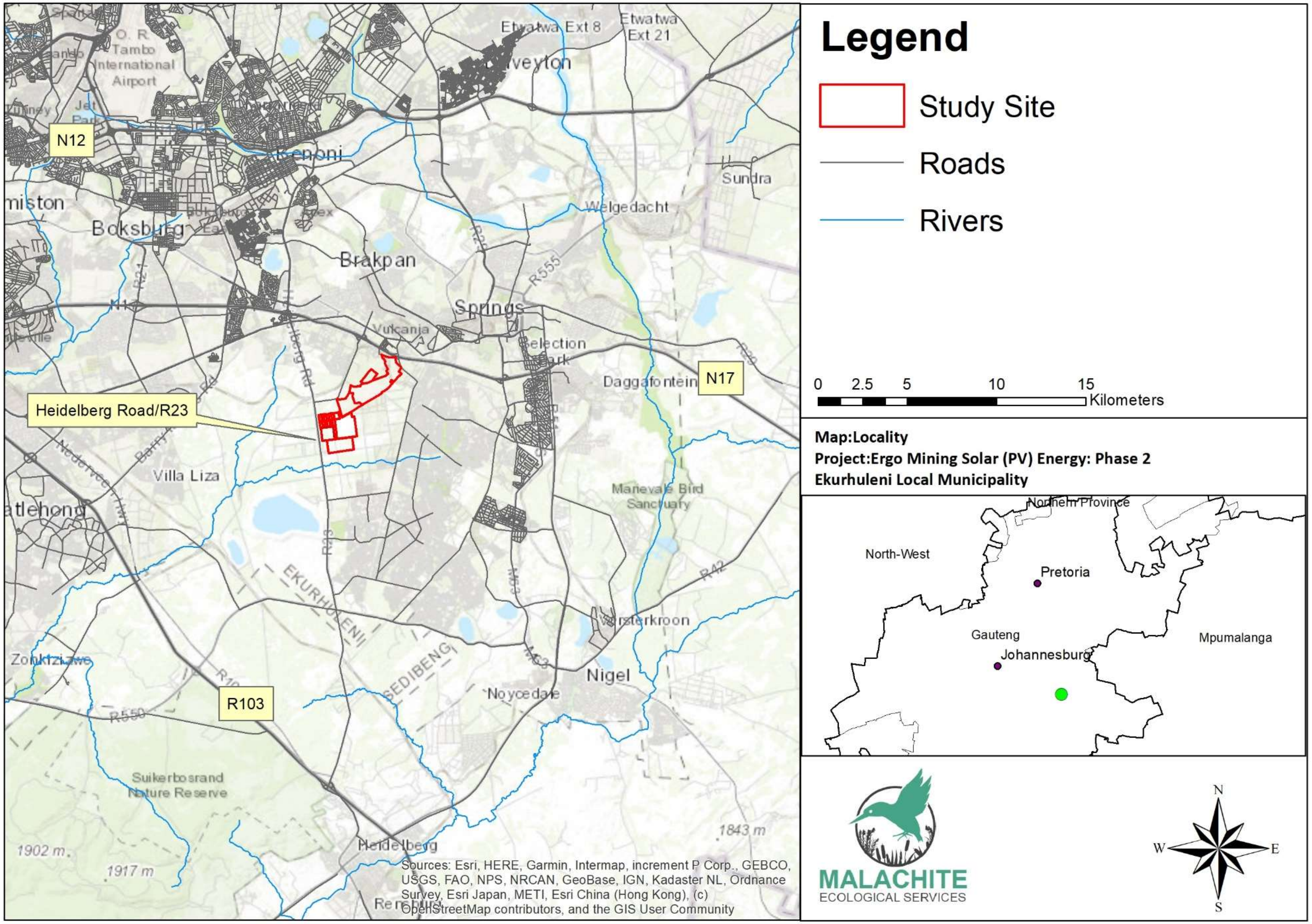


Figure 1: Locality of the study area

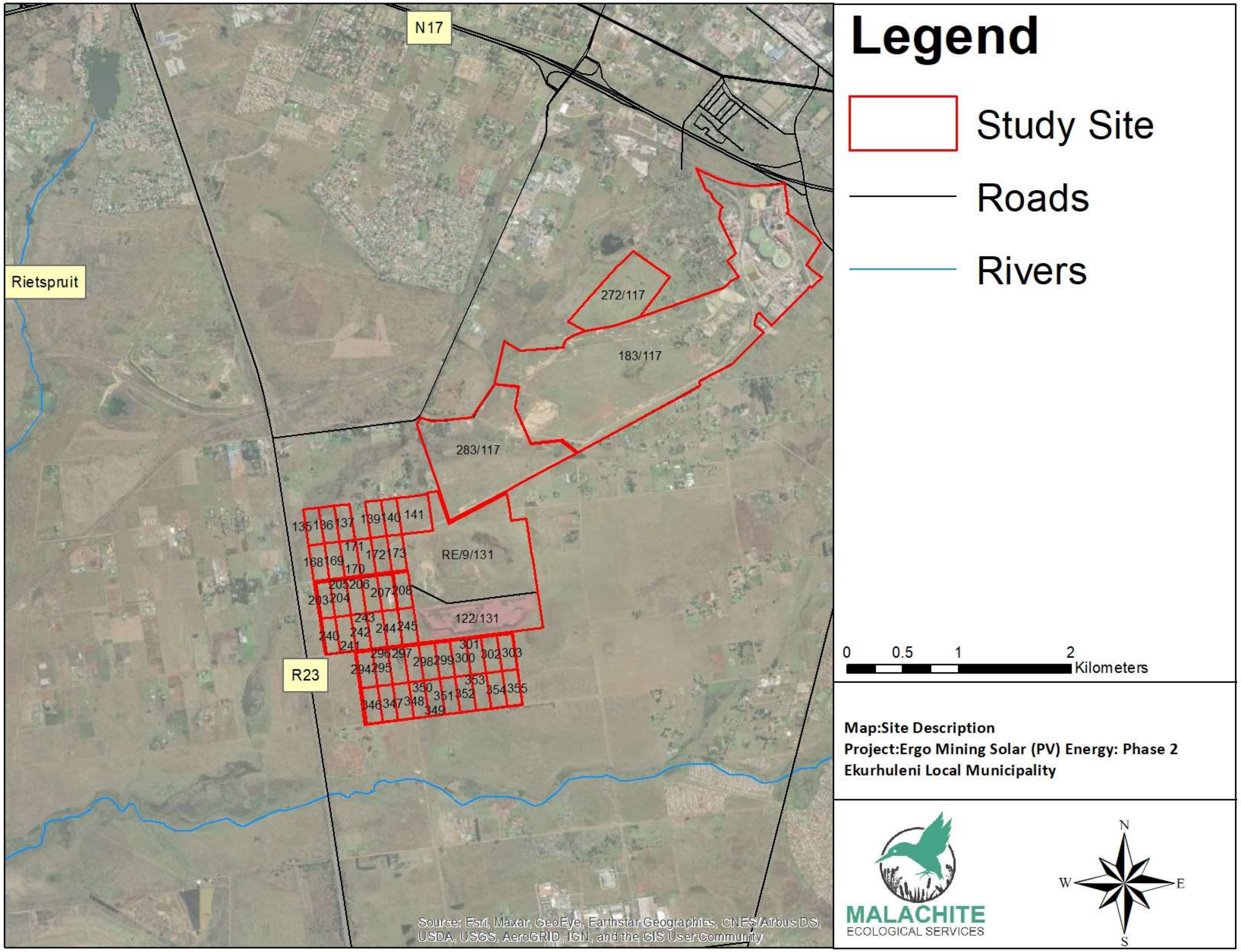


Figure 2: Aerial imagery of the study site

2. METHODOLOGY

2.1 Wetland Assessment

The following techniques and tools were used in the assessment.

2.1.1. Baseline data

The desktop 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[4].
- 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.
- Wetlands were delineated in phase 1 of the Ergo Gold PV project and are included in this study area.

2.1.2. 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.

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."*

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

Furthermore, the Ramsar Convention[5] 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 3).

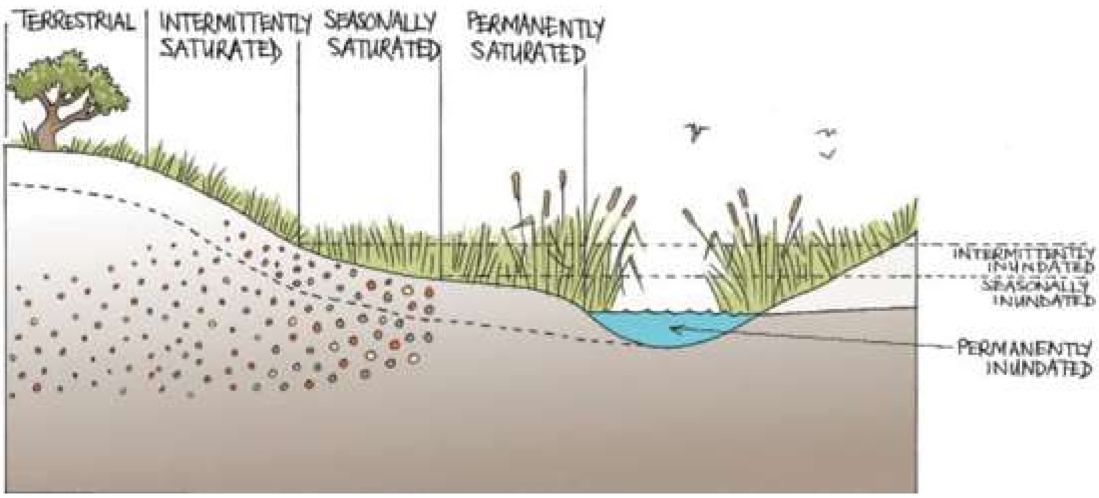


Figure 3: Increasing soil wetness zones identified within various wetland systems

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.
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.

[5] 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.

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 using available GIS data sources, the examination of historic and current aerial imagery, as well as knowledge of the area gained during phase 1 of the Ergo Gold PV project, to identify wetland areas that could potentially be affected by the proposed project. The WET-Health model was utilised to facilitate the rapid assessment of the integrity of wetland systems.

2.1.3. Wetland Health Assessment Techniques

A Wet-Health Assessment to determine the Present Ecological State was undertaken (Kotze et al. 2020). This assessment takes into account impacts on the hydrology, geomorphology, vegetation and water quality of both the individual HGM unit as well as each HGM unit's catchment. A level 1B assessment was undertaken on the units delineated during the desktop assessment of this study. Wetlands that were delineated during phase 1 of the Ergo Gold PV project and are situated within this study area were assessed through a detailed assessment (Level 2).

Detailed methodology for the determination of the Present Ecological Score (PES) is provided 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 to be identified for the purposes of the relevant environmental process. Being a desktop-based exercise, extensive use was made 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

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 Soweto Highveld Grassland and the Tsakane Clay Grassland vegetation types, with the majority of the site with the latter vegetation type (Figure 4).

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.

A small portion of the north-eastern extent of the study site is located within the Soweto Highveld Grassland vegetation type (Figure 3). This vegetation type is also present largely in Gauteng and Mpumalanga on gently to moderately undulating landscapes on the Highveld Plateau. It supports short to medium-high dense tufted grassland dominated almost entirely by *Themeda triandra*. Other grasses are also present including *Elionurus muticus, Eragrostis racemose, Heteropogon contortus* and *Tristachya leucothrix*. This vegetation type is classified as Vulnerable within the NBA (2018) database with only a handful of patches statutorily or privately conserved. Over 50% has been transformed by cultivation, urbanisation, mining, dam-building and roads. Erosion is generally very low.

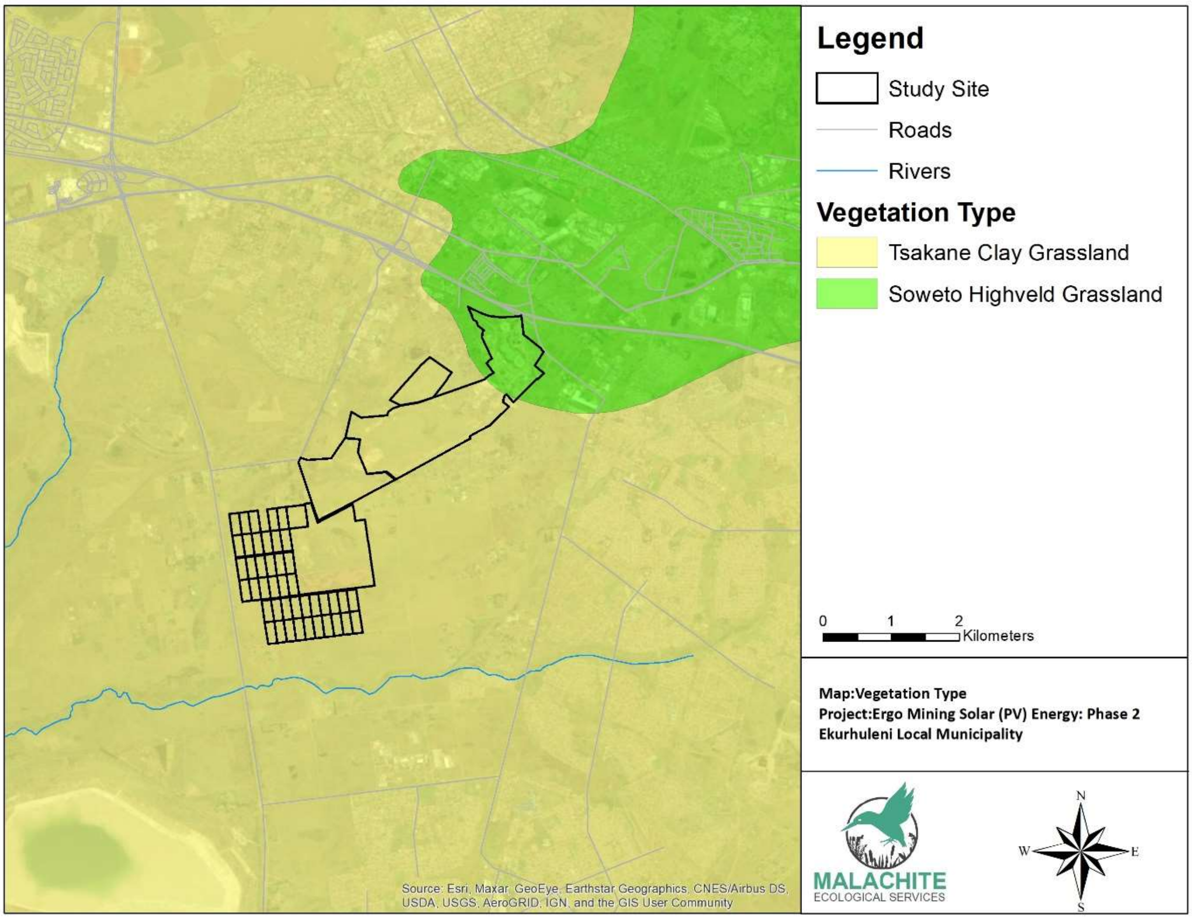


Figure 4: Regional Vegetation associated with the study site

3.4 Topography

The project area is situated on a gently undulating 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 5).

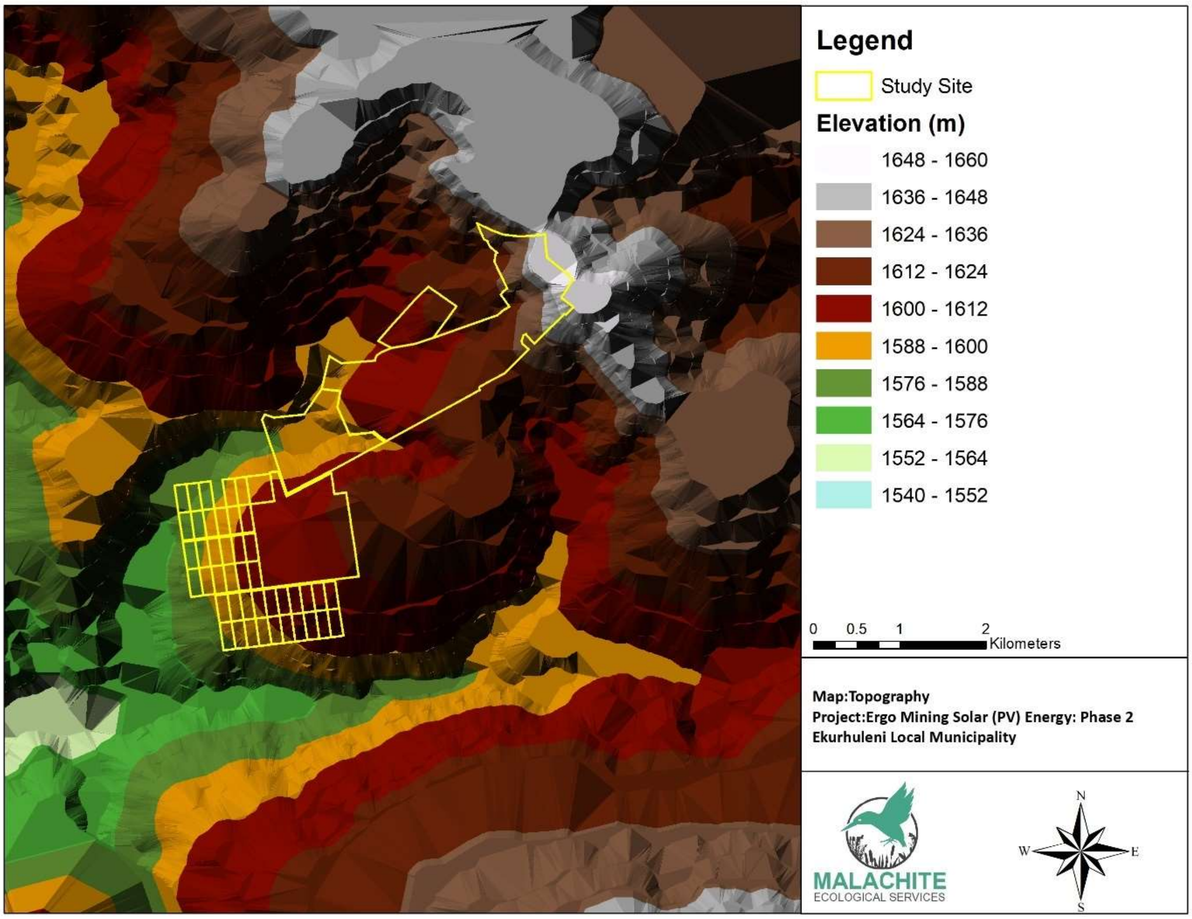


Figure 5: Topography of the site showing the range in altitude

3.5 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).

3.5.1. 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 both the Tsakane Clay Grassland and Soweto Highveld Grassland vegetation types. The ecosystems associated with the vegetation types have a threat status of Endangered and Vulnerable respectively, and a poor protection level. The classification implies that these areas have not been previously transformed and are regarded as natural habitat. This would however need to be ground truthed as the study site is situated in an urban environment (refer to flora specialist report).

The majority of the extent of the study area is also located within the Klipriver Highveld Grassland Ecosystem Type and this is listed as Critically Endangered. Of further relevance is that a tributary identified to the south of the study site, as well as all the wetland systems, are classified within the latest National Biodiversity Assessment as being Critically Endangered and not sufficiently protected (Van Deventer et al., 2019).

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 6). 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.

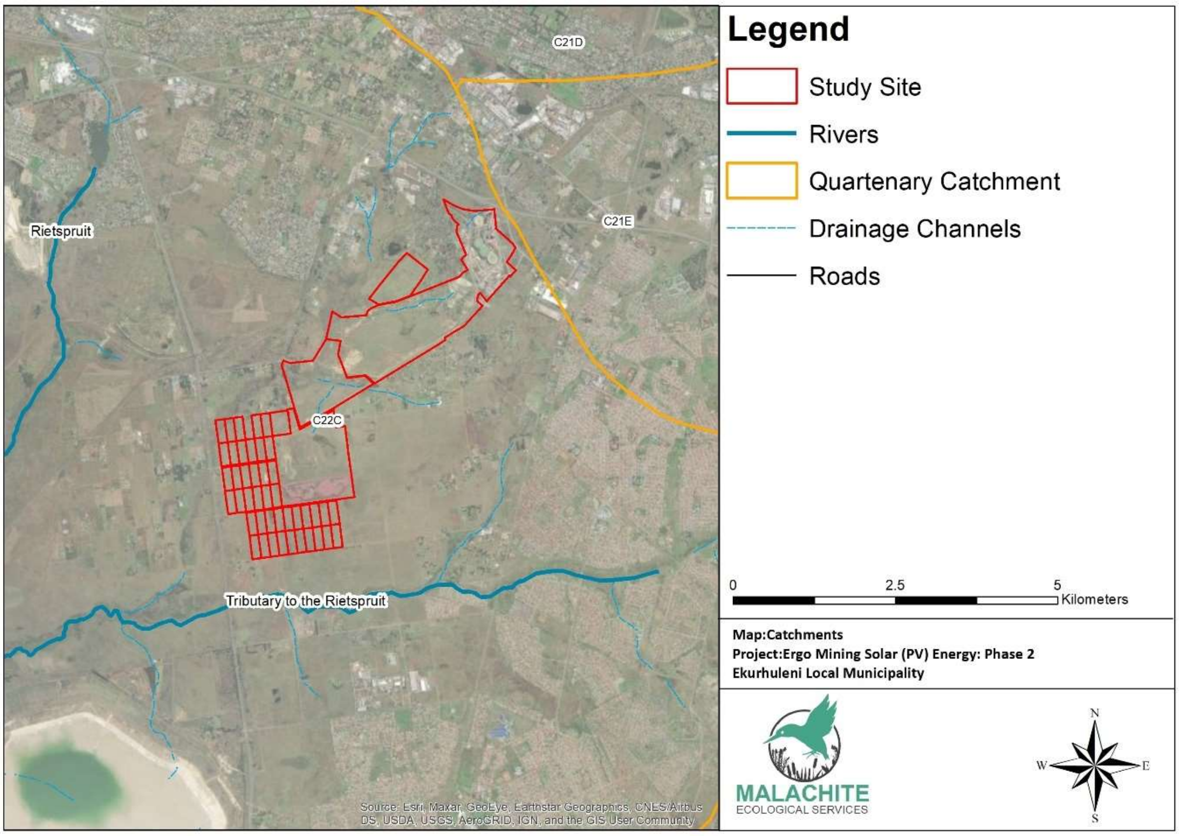


Figure 6: Quaternary catchments and river systems associated with the study area

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 7). 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 7: 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 8). 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 8: 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 9). Haul roads, mining operations, and the continued transformation of the site is apparent in the aerial imagery.

Figure 9: Aerial imagery from 2002

Mining was then discontinued within the study site and the rehabilitation of the area undertaken, from approximately 2004/2005. Soil is seen to be deposited within the disturbed sites as well as the re-grassing of these areas. This is shown in aerial imagery from 2008 (Figure 10). Topsoil stockpiles are still evident in the southern portion of the study area.

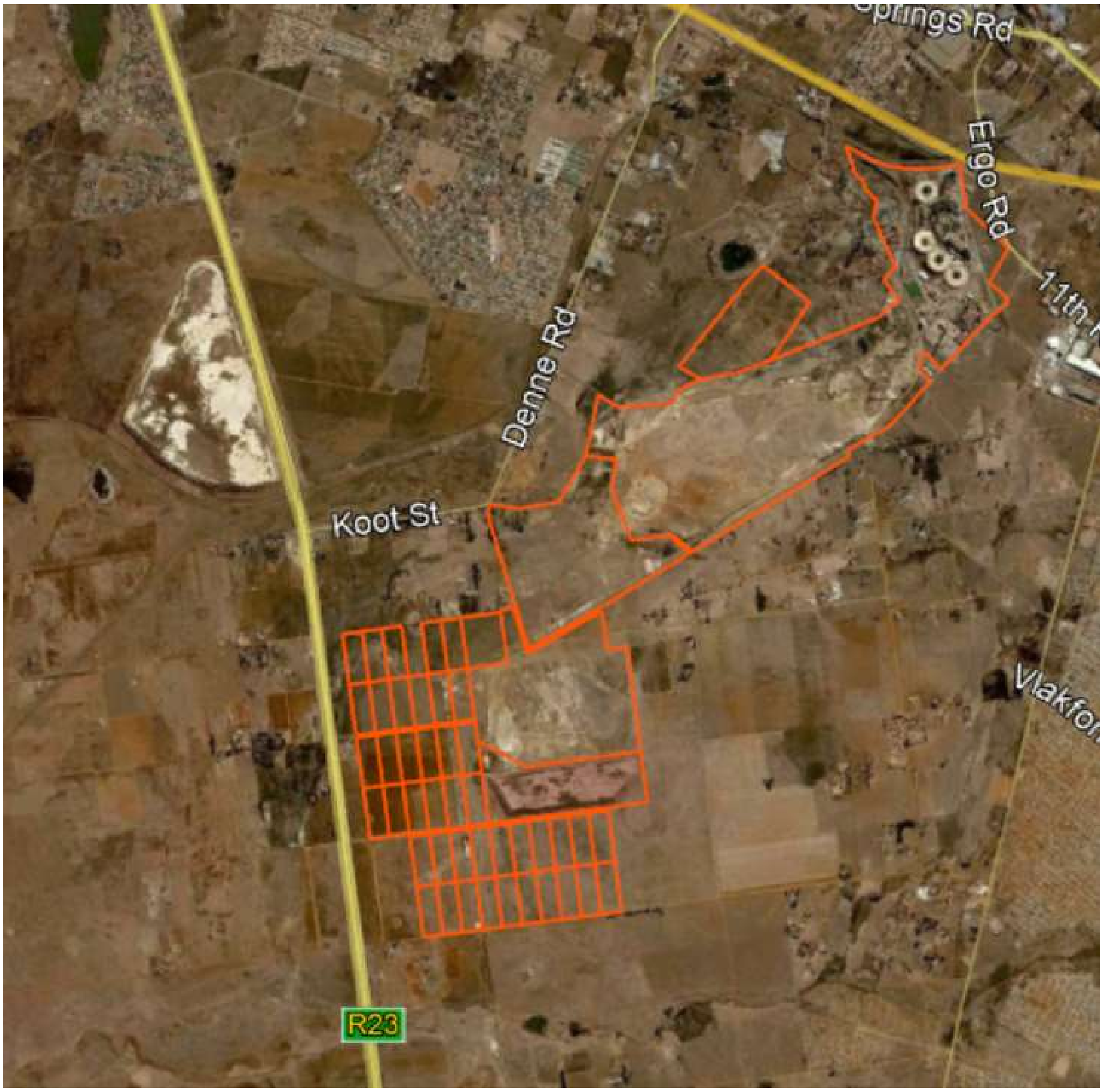


Figure 10: Aerial imagery from 2008

The most current aerial imagery available on Google Earth[Tm] is from April 2021 (Figure 11). This shows the completed rehabilitation process of the disturbed portions of the study site, with these areas now grassed. The operations associated with historic and current mining 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.

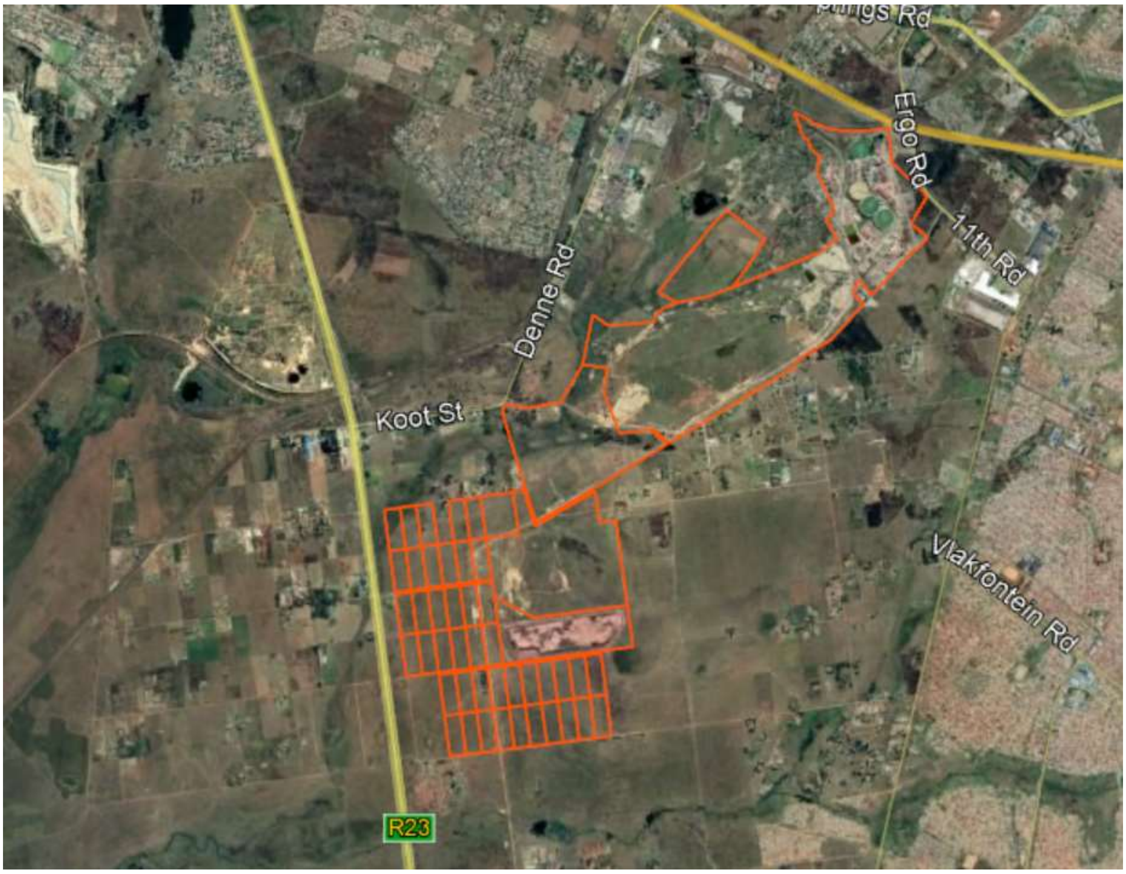


Figure 11: Current imagery from April 2021

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 12) a number of wetland systems are located within the assessment area. These 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 (PES Category C).

As an additional database to the NFEPA database layer, the more recent National Wetland Map 5 (Van Deventer et al, 2019) 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 13, unchannelled valley bottom wetlands are located along the northern and western boundary of the study site as well as a depression wetland located in the southern area adjacent to the mining stockpile.

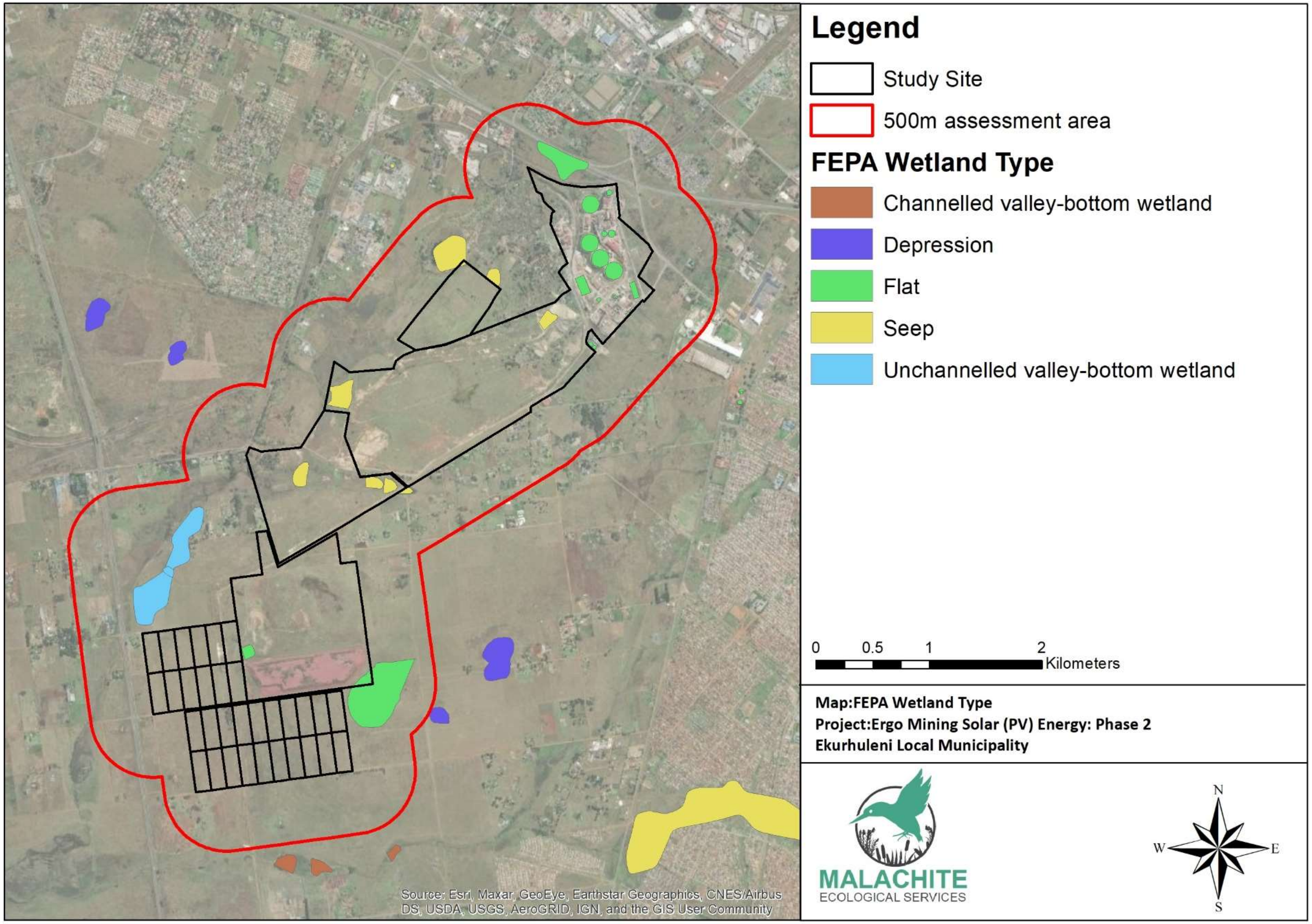


Figure 12: FEPA wetlands identified within the assessment area

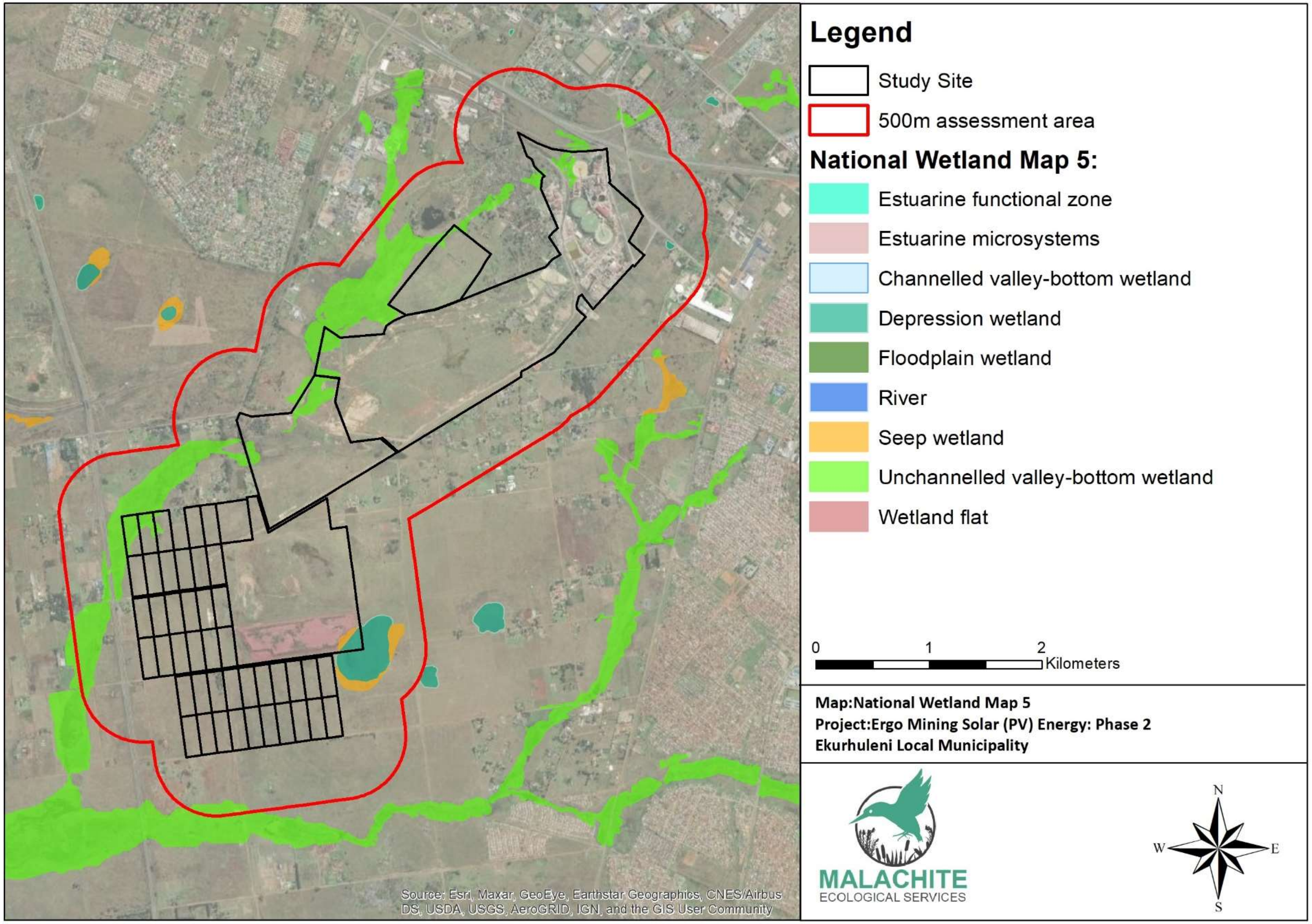


Figure 13: Wetland systems within the assessment area as per the National Wetland Map 5 database

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 14. 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).

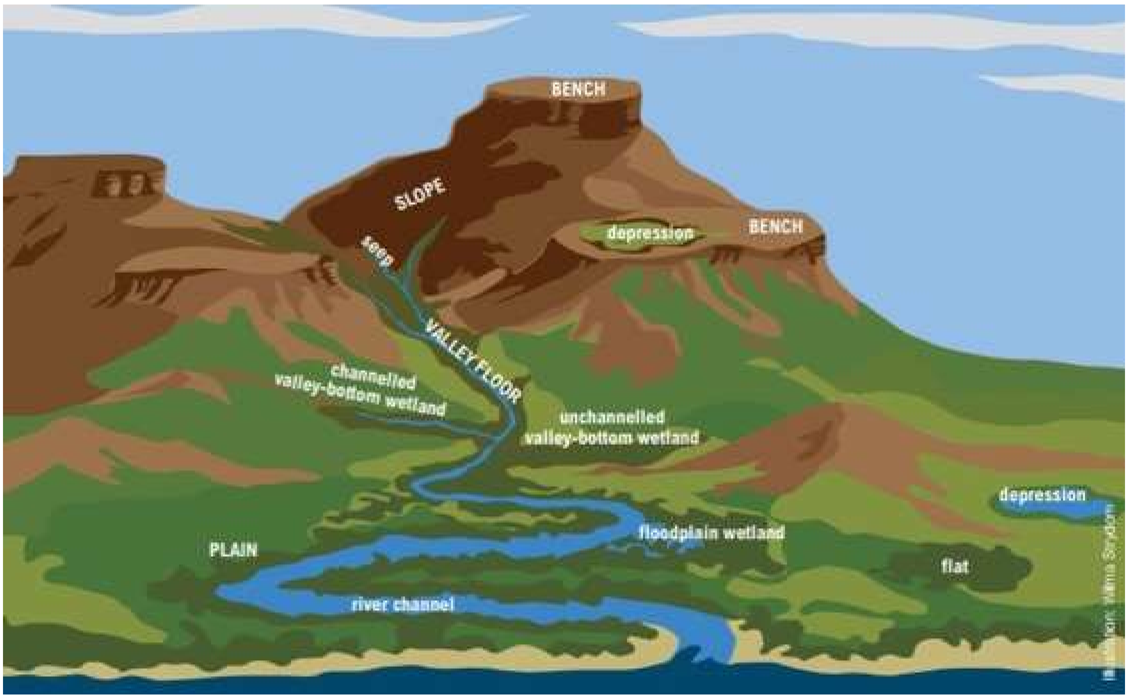


Figure 14: Diagrammatic representation of common wetland systems identified in Southern Africa

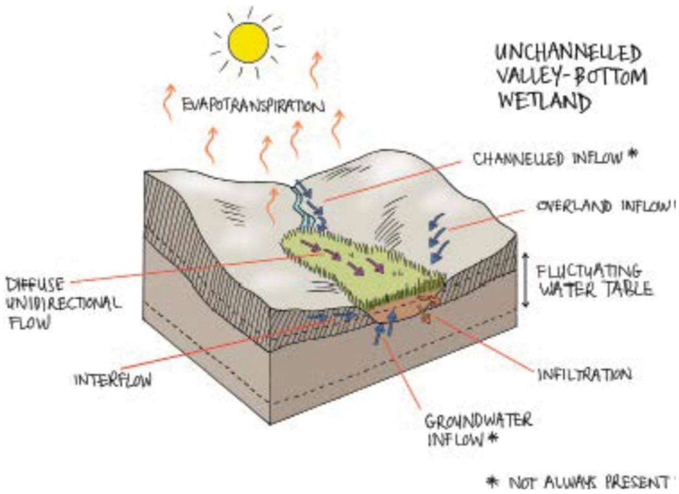
A desktop assessment was conducted within the study area based on historic and current aerial imagery. This desktop assessment was added to the delineations undertaken during phase 1 of the Ergo Gold PV project. Four HGM units were delineated within the study area and 500m assessment buffer. These were classified as an unchannelled valley bottom wetland, a seep system, and a depression wetland, while a fourth HGM unit, a channelled valley bottom wetland, was delineated to the south of the study site but within the 500m assessment buffer. These HGM units are detailed in Table 4 and displayed in Figures 15 to 17.

Table 4: Summary table of delineated wetlands

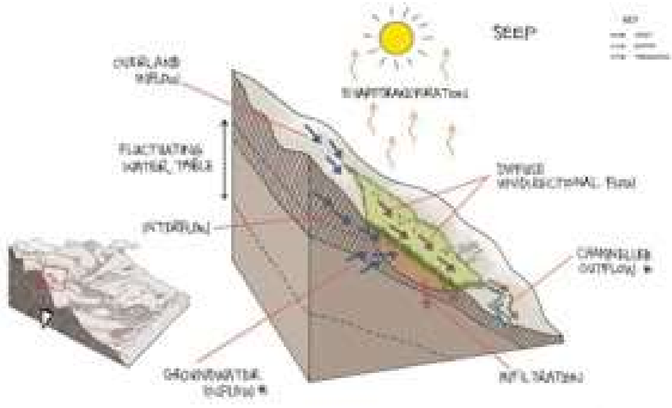
HGM unit number	Wetland Type
HGM 1	Unchannelled Valley Bottom
HGM 2	Seep
HGM 3	Depression
HGM 4	Channelled Valley Bottom

The various wetland classifications are explained in more detail below.

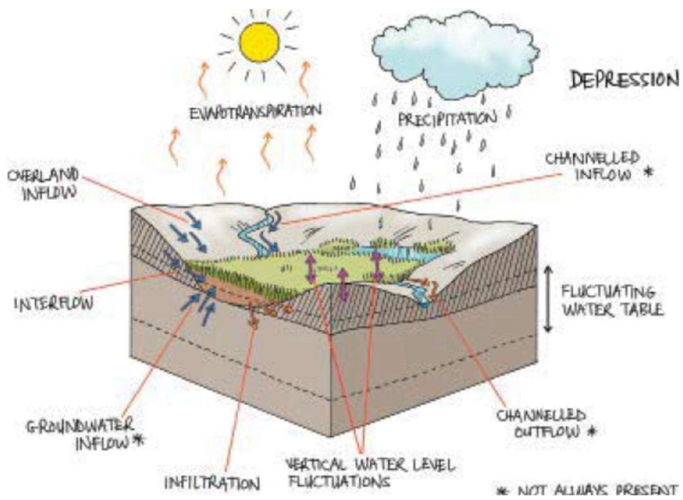
Unchanneled valley bottom wetlands are characterised by their location on valley floors and the absence of distinct channel banks and the prevalence of diffuse flows. These wetlands are generally formed when a river or stream channel loses confinement and spreads out over a wider area causing the concentrated 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).



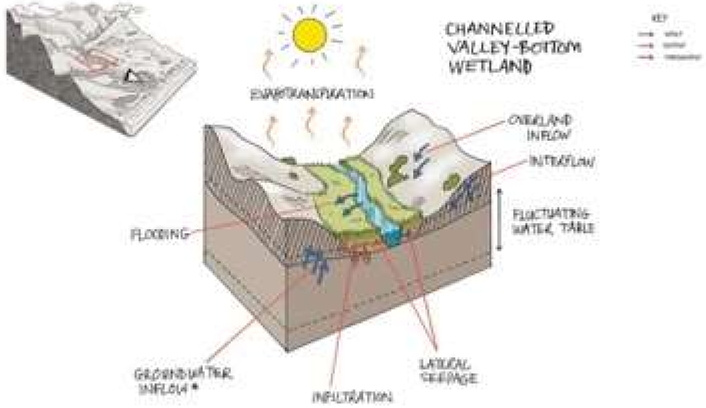
Seepage wetlands are characterised by their association with topographic positions that either cause groundwater to discharge to the land surface or rain-derived water to seep down-slope as subsurface interflow. Water movement through the seep is primarily attributed to interflow, with diffuse overland 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.



Channelled valley bottom wetlands are characterised by their location on valley floors and the presence of a river or stream channel flowing through the wetland (but lacking characteristic floodplain features). This may be gently sloped and characterised by the net accumulation of alluvial deposits or have steeper slopes and be characterised by the net loss of sediment. 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).



Apart from the four 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 on the aerial images examined.

During phase 1 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 '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 examination of aerial imagery of the site, within and adjacent to areas that have been extensively modified by historic and current mining activities and the subsequent rehabilitation of these areas.

It is recommended that these artificial 'wetland' areas are studied in more detail during the impact assessment phase of this assessment. A detailed field investigation of the boundary of these systems, their ecological integrity and functionality within their catchment will aid in determining the nature of the 'wetland' areas as well as any mitigation measures needed for their protection.

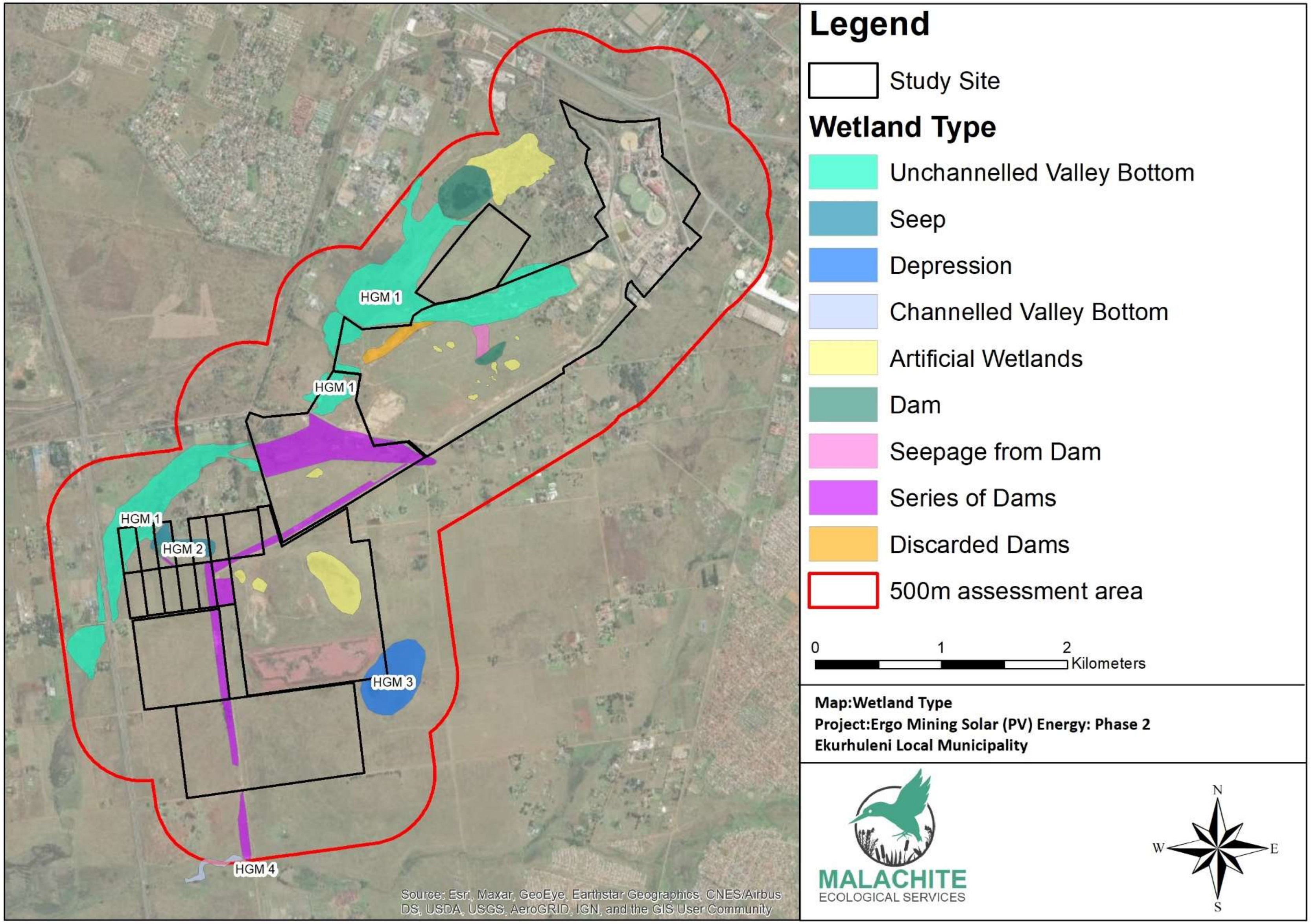


Figure 15: Wetland systems delineated within the assessment area

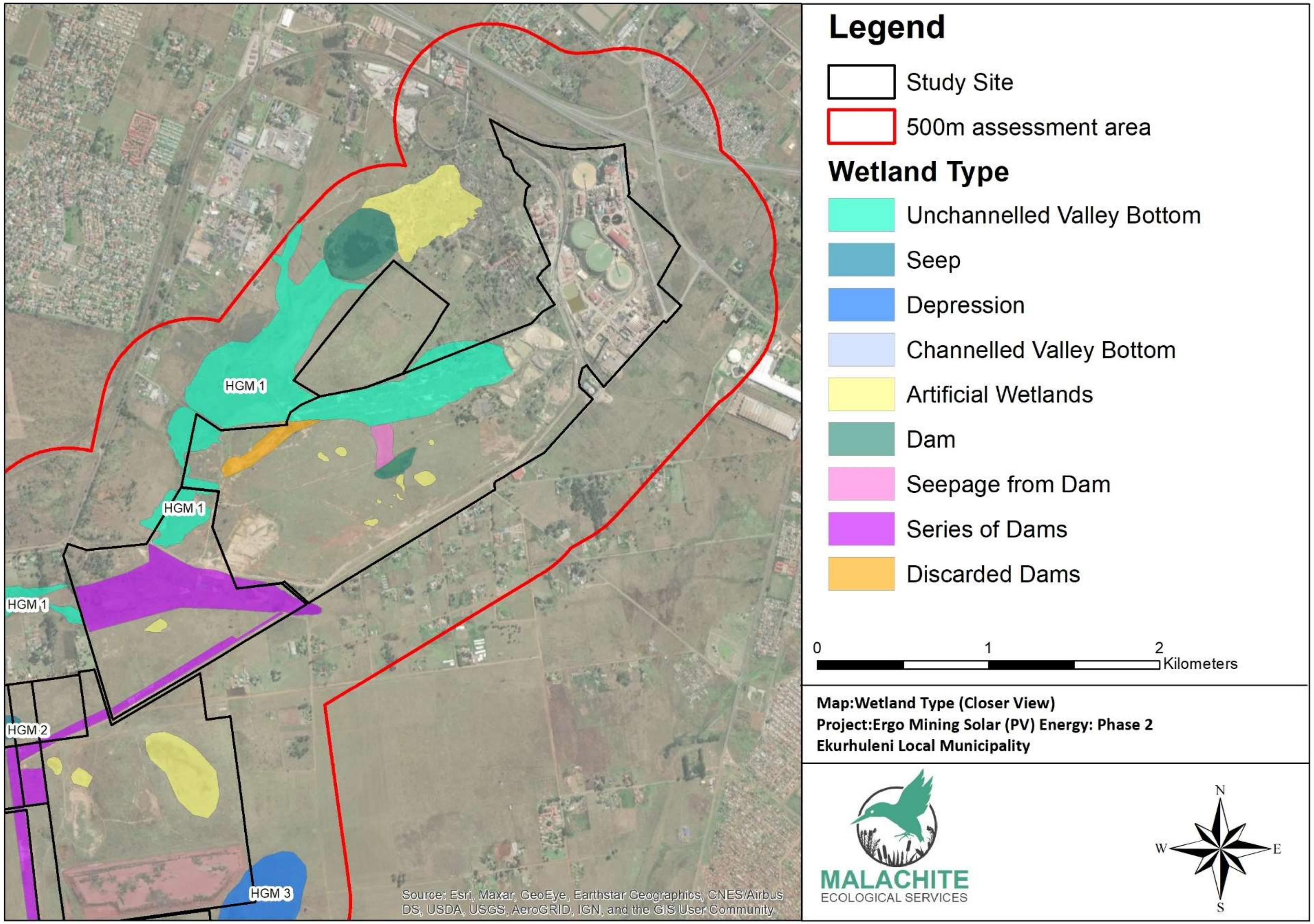


Figure 16: Closer view of the wetland systems delineated within the assessment area

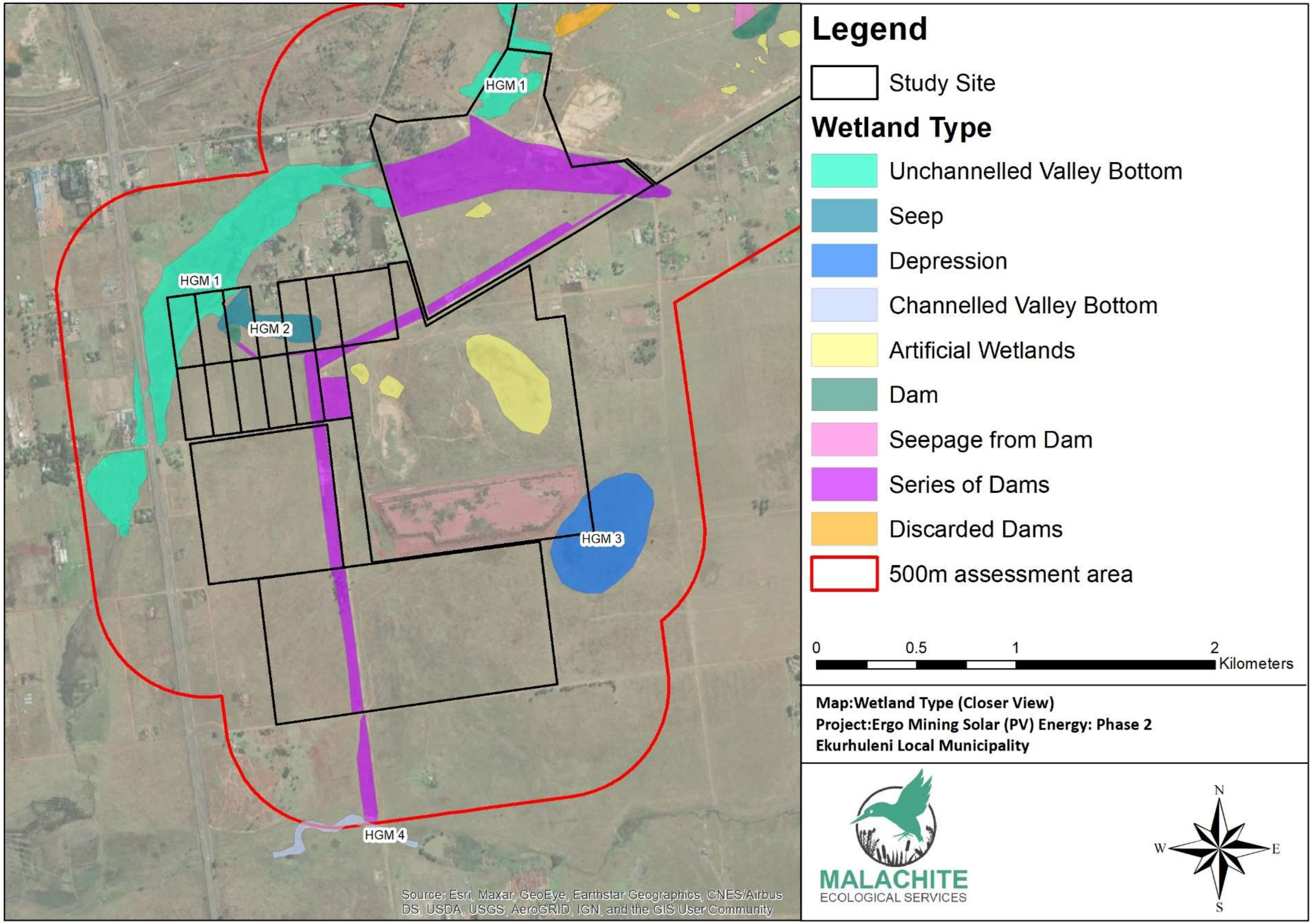


Figure 17: Closer view of the wetland systems delineated within the assessment area

5. WETLAND HEALTH ASSESSMENT

5.1 Present Ecological State (PES)

The four natural HGM units were assessed with regards to their health according to the Wet-Health methodology[6]. A level 1B assessment (desktop scale) was conducted for the wetlands delineated at a desktop level, while the wetlands delineated and evaluated during phase 1 of the Ergo Gold PV project and within this study site were assessed at a level 2 (detailed) scale.

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), HGM 3, the depression system has been classified as Moderately Modified (PES Category C), and HGM 4, the channelled valley bottom wetland has been classified as Largely Modified (PES Category D).

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.

Dams associated with HGM 2, the seep wetland, and HGM 4, the channelled valley bottom wetland, have also had an impact on the flow dynamics of these systems. 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, has a smaller catchment area and this has limited the impacts to this wetland to a degree. However, the wetland has still been impacted through the use of the adjacent area as a tailing's storage facility. Sediment from this storage facility can easily be deposited within 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 2021.

[6] 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.

A summary of the PES scores obtained for the delineated systems following application of the Wet-Health approach is provided in Table 5.

Table 5: Summary of PES score

HGM Unit	Extent Delineated (Ha)	Hydrology	Geomorphology	Water Quality	Vegetation	PES Score (Category)
HGM 1	138.04	6.5	4.7	7.5	7.5	**E (6.5)**
HGM 2	5.15	5.2	4.0	3.4	6.0	**D (4.70)**
HGM 3	21.57	3.9	2.5	6.3	2.7	**C (3.80)**
HGM 4	2.70	4.2	3.0	4.8	4.4	**D (4.10)**

6. 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, HGM1 has a relatively small, low-gradient catchment and thus a low accumulation of flow, resulting in slow-flowing hydraulic habitat. Consequently, it is expected that aquatic habitat within HGM 1 would comprise almost solely of dense stands of emergent vegetation of *Phragmites* sp. and *Typha capensis* with slow-flowing water and a mud-based substrate. The expected 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 expected to be limited, with water only likely to be present during the rainfall season and emergent vegetation being 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 are expected to present limiting factors to the occurrence of diverse aquatic biota.

6.2 Aquatic Macroinvertebrates

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 during even unimpacted conditions given the lack of diverse hydraulic habitat relative to true riverine reaches of watercourses. 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 expected to 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. As such, only a limited acquired diversity of aquatic biota is expected to be 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 6). 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.

Table 6: 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. Stormwater emanating from 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. However the solar panels will be situated within an area where vegetation is maintained to control stormwater runoff and reduce the impact of erosion.

The solar panels will be situated in areas where vegetation has been maintained, in order to reduce the risks of erosion. A buffer was calculated for the protection of the natural wetland systems delineated and assessed as part of this scoping assessment. The buffer may need to be refined during the impact assessment and once the field investigation has taken place. The buffer takes into account the proposed activity, climatic factors, topographical factors, the nature of the soils, and the sensitivity of the water resource. A 21m buffer has been calculated for the protection of the natural wetland systems (Figure 18).

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.

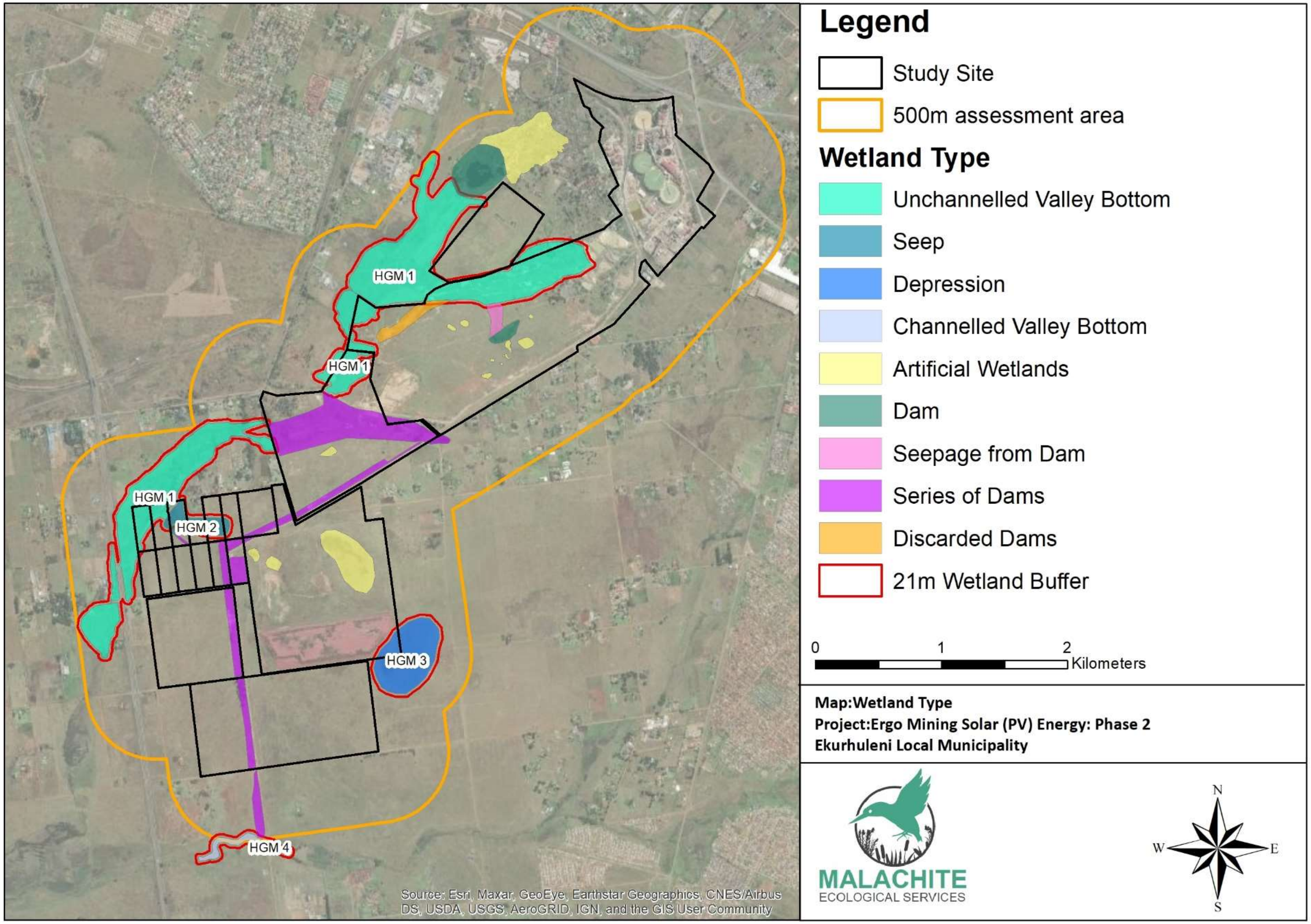


Figure 18: Buffer recommendations for the wetlands delineated within the study site

8. RECOMMENDATIONS AND CONCLUSION

Wetland Findings

A desktop assessment was conducted within the study area based on historic and current aerial imagery. This desktop assessment was added to the delineations undertaken during phase 1 of the Ergo Gold 19.9MW PV project. Four HGM units were delineated within the study area and 500m assessment buffer. These were classified as an unchannelled valley bottom wetland, a seep system, and a depression wetland, while a fourth HGM unit, a channelled valley bottom wetland, was delineated to the south of the study site but within the 500m assessment buffer.

Apart from the four 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. The '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 examination of aerial imagery of the site, within and adjacent to areas that have been extensively modified by historic and current mining activities and the subsequent rehabilitation of these areas.

The four natural HGM units were assessed with regards to their health according to the Wet-Health methodology. 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), HGM 3, the depression system has been classified as Moderately Modified (PES Category C), and HGM 4, the channelled valley bottom wetland has been classified as Largely Modified (PES Category D).

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. As such, only a limited acquired diversity of aquatic biota is expected to be associated with the wetlands present within the study area.

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. Determination of the ecological state from an aquatic perspective is not considered suitable, and therefore reliance should be placed on that as determined from a wetland perspective. This is also applicable to the determination of the ecological importance and ecological sensitivity of the wetland systems.

Buffer Requirements

The proposed project involves the construction of solar panels and associated infrastructure for a 40MW PV plant. A buffer was calculated for the protection of the natural wetland systems delineated and assessed as part of this scoping assessment. The buffer may need to be refined during the impact assessment and once the field investigation has taken place. The buffer takes into account the proposed activity, climatic factors, topographical factors, the nature of the soils, and the sensitivity of the water resource. A 21m buffer has been calculated for the protection of the natural wetland systems.

Plan of Study for the Impact Assessment

Wetland Component

It is recommended that a more in-depth study, with the inclusion of field sampling takes place during the impact assessment phase of this study. This will focus on groundtruthing the desktop delineated boundaries of all wetland systems within the study site. Wetlands within 500m of the finalised location of the infrastructure will either be delineated during the field work or if they are located on private land will remain as delineated from the desktop study. A field-based wetland delineation exercise will be conducted according to: '*A practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas – Edition 1* (DWAF 2005)'. This tool uses various indicators (e.g., soil wetness, vegetation, and terrain unit) to determine the outer edge of the wetland or watercourse systems.

A level 2 Wet-Health assessment will be conducted on all field-based delineated wetlands. This is a more detailed assessment of the health of each wetland system and uses indicators based on geomorphology, hydrology, water quality and vegetation both at a catchment scale and within the wetland system. Furthermore, an indication of the functions and ecosystem services provided by all field based delineated wetlands will be assessed through the WET-EcoServices manual (Kotze *et al*., 2008). This is based on a number of characteristics that are relevant to the particular benefit provided by the wetland. The tool uses biophysical characteristics of the wetland and the level of disturbance within the wetland and its catchment to estimate the level of supply of ecosystem goods and services. Finally, the Ecological Importance and Sensitivity (EIS) of any field-based delineated wetlands will be determined using a rapid scoring system. The system has been developed to assess the EIS of the wetland within the larger landscape; the 'Hydrological Functional Importance' of the wetland; and the 'Direct Human Benefits' obtained from the wetland through either subsistence or cultural practices.

The buffer tool (Macfarlane & Bredin, 2016) will be utilised again after the field work has been conducted and buffers refined taking into account all information gathered during the field work.

Aquatic component

Given the nature of the associated aquatic ecosystem, assessment of the potential impacts associated with the proposed activity will include a review of field data collected during the wetland element (including photographs). Such data will be used to additionally inform the completion of the DWS Risk Matrix for Water Use Licencing Application processes from an aquatic ecosystem perspective.

Impact assessment component

A full assessment of the project's potential direct, indirect, and cumulative impacts will be evaluated on the delineated and assessed wetland/watercourse systems.

Significance scoring will be utilised, and this assesses and predicts the significance of environmental impacts through evaluation of the following factors: probability of the impact; duration of the impact; extent of the impact; and magnitude of the impact. The significance of environmental impacts is then assessed considering any proposed mitigations. The significance of the impact “without mitigation” is the prime determinant of the nature and degree of the remediation that will be required. Each of the above impact factors will be used to assess each potential impact using ranking scales.

The impacts of the proposed project on any impacted wetlands identified within the study area, would be assessed according to the risk assessment methodology as per 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). This is appropriate to DWS standards. Suitable recommendations and mitigation measures will be recommended.

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10. 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 7.

Table 7: 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: 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
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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

CONFERENCES ATTENDED AND PRESENTED

NAME	DATE
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 - 2016 Afzelia Environmental Consultants (Pty) Ltd (Soil Scientist March and Wetland Specialist)
- September 2012 - February 2014 Strategic Environmental Focus (Pty) Ltd (Junior Wetland Specialist)
- February 2008 - 2009 Afzelia Environmental Consultants cc (Soil Scientist/Junior December 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 12 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 the Democratic Republic of Congo, and Cameroon.

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 in an Afromontane setting.

Below is an abridged list of projects completed:

Wetland Impact Assessments

- Wetland and ecological sensitivity of Farm 1287, Mbabane Swaziland
- Ulundi Crossings Shopping Centre, KwaZulu-Natal
- Somkhele Mine, Mtubatuba, KwaZulu-Natal
- Lynton Hall housing development, Pennington KwaZulu-Natal
- Pennington PumpStation – Wetland Monitoring
- Enyathi Water Supply project, Vryheid, KwaZulu-Natal
- Agulhus Vryheid Eskom powerline and Substation, Swellendam, Western Cape
- D1095 road upgrade, KwaZulu-Natal
- Juno-Gromis 230km power line corridor, Northern and Western Cape Provinces
- Mt Albert Mixed Use Development, KwaZulu Natal
- Saldanha Strengthening Project, Saldanha, Western Cape Province
- Intaba Ridge Housing Development, Pietermaritzburg, KwaZulu-Natal
- Yoyo Mixed Use Development, Republic of Cameroon
- Elandspruit Colliery, Middleburg, Mpumalanga
- Bokoko Infrastructure Development, Douala, Republic of Cameroon
- P483 Road Upgrade; KwaZulu- Natal Province
- Paulpietersburg Shopping Centre; KwaZulu- Natal Province
- Tshipi e Borwa Strengthening Projects, Postmasburg, Northern Cape
- Portion 68 Hammarsdale, Wetland Assessment for a Section 24G application
- Esikhumbeni Stand Alone Water Supply System; KwaZulu- Natal Province
- AMI Colliery; Vryheid; KwaZulu- Natal Province
- Ephateni Bulk Water Supply System; KwaZulu- Natal Province
- Samrand Estate; Centurion, Gauteng Province

Rehabilitation Plans

- De JagersKraal Compensation, wetland rehabilitation plan, KwaZulu-Natal
- Intaba Ridge Housing Estate, Pietermaritzburg, KwaZulu-Natal
- Greytown Bulk Water Supply, Greytown, KwaZulu-Natal
- Hluhluwe iMfolozi Park Bitumen Spill Rehabilitation Plan
- Hollingwood Housing Development, Pietermaritzburg, KwaZulu-Natal
- Samrand Estate; Centurion, Gauteng Province
- Paulpietersburg Shopping Centre; KwaZulu- Natal Province
- L1524 Road Upgrade; KwaZulu- Natal Province
- P187/1 Road Upgrade; KwaZulu- Natal Province
- P254/1 Road Upgrade; KwaZulu- Natal Province
- P483 Road Upgrade; KwaZulu- Natal Province
- N2/R56 Interchange
- Hluhluwe iMfolozi Park Bitumen Spill Rehabilitation Plan

Hydropedology Assessments

- Packo Industrial Site, KwaZulu- Natal Province
- St Joseph’s Housing Development. KwaZulu- Natal Province
- Lions River Housing Development, KwaZulu- Natal Province
- Cato Scrap Industrial Site, KwaZulu- Natal Province
- Somkhele Anthracite Mine, Hydropedological Buffers, KwaZulu- Natal Province
- Evergreen Retirement Village, Hilton, KwaZulu-Natal Province
- Amber Valley Retirement Village, Howick, KwaZulu-Natal Province
- Mountain Valley Abattoir, Eston, KwaZulu-Natal Province
- Baynesfield Estate, Richmond Local Municipality, KwaZulu-Natal Province

CURRICULUM VITAE

Name:	**Byron Grant Pr.Sci.Nat.**
Company:	Ecology International (Pty) Ltd
Years of Experience:	17 years
Nationality:	South African
Languages:	English (mother tongue), Afrikaans
SACNASP Status:	Professional Natural Scientist (Reg. No. 400275/08)
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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

- **Project Management:**
  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.

- **Specialist Assessments:**
  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.
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- 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.
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- 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)