Wetland Baseline and Risk Assessment for the Proposed Harmony Valley Tailings Storage Facility (TSF) Project

Welkom, Free State Province, South Africa

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CLIENT

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1 Introduction

1.1 Background

The Biodiversity Company (TBC) was appointed to undertake a wetland baseline and risk assessment for the proposed Valley TSF Expansion Project, Harmony Gold Mining Company Limited (Harmony) own and operate a number of Gold Mines and Plants located in Welkom, Free State province. Harmony currently deposit tailings onto the Free State South (FSS) 2 Tailings Storage Facility (TSF), St. Helena 4 TSF, St. Helena 123 TSF, Dam 23 TSF, Brand D TSF and Target 1&2 TSF. The current planned Life of Mine (LOM) of the Free State Operations exceed the available deposition capacity of these TSFs and Harmony is undertaking a feasibility assessment to construct the new Valley TSF.

In order to assess the baseline ecological state of the area and to present a detailed description of the receiving environment, a desktop assessment as well as a field survey was conducted during March 2023. Both levels of assessment entailed the detection, identification, and description of any locally relevant water resources. Furthermore, the manner in which these sensitive features may be affected by the proposed development was also investigated. A 500 m radius around of the proposed activities, which is the suggested regulation area for the identification of water resources in terms of the proposed project, has been demarcated and is referred to hereafter as the Project Area of Influence (PAOI).

This assessment was conducted in accordance with the amendments to the Environmental Impact Assessment Regulations, 2014 (No. 326, 7 April 2017) of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998). The approach has taken cognisance of the recently published Government Notice 320 in terms of NEMA dated 20 March 2020 as well as the Government Notice 1150 in terms of NEMA dated 30 October 2020: “Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation”.

This assessment has also been completed in accordance with the requirements of the published General Notice (GN) 509 by the Department of Water and Sanitation (DWS). This notice was published in the Government Gazette (no. 40229) under Section 39 of the National Water Act (Act no. 36 of 1998) in August 2016, for a Water Use Licence (WUL) in terms of Section 21(c) & (i) water uses. The GN 509 process provides an allowance to apply for a WUL for Section 21(c) & (i) under a General Authorisation (GA), as opposed to a full Water Use Licence Application (WULA). A water use (or potential) qualifies for a GA under GN 509 when the proposed water use/activity is subjected to analysis using the DWS Risk Assessment Matrix (RAM). This assessment will implement the RAM and provide a specialist opinion on the appropriate water use authorisation.

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

1.2 Design Description

The following is the executive summary as provided by Geotheta in the Design Report (February, 2024):

Geotheta was appointed by Harmony Gold to complete the design of the proposed new Valley Tailings Storage Facility (TSF) in Welkom, South Africa.

Key Parameters of the Valley TSF design are:

- Maximum final height: 36m

- Footprint area: 163.5 Ha
- Total capacity: 56.8 million tons
- Deposition period at 600 000 tons per month: 8 years
- Maximum rate of rise (Basin): 4.12m/year
- Maximum rate of rise (Embankment): 3.99m/year
- Deposition method: Cyclone

The Valley TSF provides a storage capacity of 56.8 million tons over a deposition period of 8.0 years at the target deposition rate of 600 000tpm with a maximum rate of rise of 4.12m/year (basin) and 3.99m/year (embankment). This rate of rise will be achieved by cyclone deposition.

Valley TSF will be developed with an intermediate outer slope of 1V:3H between benches. The overall slope with benches is 1V:4H. The inter-bench height is 8.0m and the benches are 8.0m wide.

The maximum toe wall embankment height is 3m with a 3m wide crest, outer slope of 1V:1.5H and 1V:2H inner slope. The toe wall embankment will be constructed in 150mm layers to 95% Proctor density at 0% to +2% Optimum Moisture Content (OMC). The toe wall material will be obtained from the basin of the facility.

The cyclone walls will be constructed 50m away from the toe wall on the northwest, eastern and southern flanks of the Valley TSF. The other flanks butt up against the dormant FSN1 and FSN2 facilities and no cyclone deposition will occur from these flanks. Spigotting or open-end deposition will be done for pool control only when required.

These cyclone walls will provide an elevated platform to allow for overflow tailings deposition. The cyclone wall is 3m high with a 3m wide crest, outer slope of 1V:2H and 1V:2H inner slope.

According to GISTM, the Valley TSF has a Very High Consequence Classification rating.

Based on SANS 10286, the Valley TSF has a High Hazard classification rating.

The minimum Factor of Safety against failure, based on the Limit Equilibrium method of stability analysis, is 2.0 under drained conditions, 1.6 under undrained conditions, 1.2 under post seismic, post liquefaction or residual conditions and 1.3 under pseudo static conditions. These Factors of Safety comply with the local legislation and international slope stability standards.

Most dormant up-stream deposited facilities, including FSN1 and FSN2, do not meet new legislated Factor of Safety requirements. To ensure the entire complex complies at closure, remedial works for FSN1 and FSN2 may be incorporated into the Valley TSF closure plan. Conceptual-level work has been carried out to assess the required remedial work based on the limit equilibrium method for stability calculations. This work will be updated once the proposed stability assessments using finite element analyses are conducted on Harmony's dams.

The gold tailings material classified as a Type 3 waste according to the waste classification report by Jones and Wagner. This necessitates a Class C barrier system. However, as per an independent review by Legge and Associates, an 'inverted barrier' system can be used. The inverted barrier reduces seepage by changing the flow through the liner from Bernoulli flow at discontinuities to D'Arcian flow controlled by the tailings permeability at these points. The stability of the TSF is also improved by omitting lower strength compacted clay layers and the geomembrane cushion layer (replaced by tailings). The inverted barrier system is used in the design of the Valley TSF barrier system.

The Valley TSF barrier system has two different areas. Liner area 1 is within the central area of the dam basin. This liner system comprises (from top down), a 300mm thick layer of tailings, above liner drains, 1.5mm smooth HDPE liner underlain by a 300mm ripped and recompacted in-situ base layer.

Liner area 2 is present at the outer walls of the facility where high liner stresses exist and a 150T geogrid (or similar approved) is required. The geogrid (or similar approved) will be placed from the toe wall inwards for 50m. This liner system comprises (from top down), a 300mm thick layer of tailings, a 150T size geogrid (or similar approved), a 300mm thick layer of tailings, above liner drains, 1.5mm double textured HDPE liner underlain by a 300mm ripped and recompacted in-situ base layer.

The TSF underdrainage system is provided above the liner to intercept seepage through the facility. The above liner drains lower the phreatic surface, thereby improving the overall stability of the facility. The above liner drains comprise of blanket drains and herringbone drains.

The herringbone drains pipes comprise of 160mm slotted Drainex HDPE pipes surrounded in 19mm stone which is enclosed in a geofabric. These drains are spaced 100m apart. The blanket drains comprise of 160mm slotted Drainex HDPE pipes surrounded in 19mm stone overlain by a layer of 6mm stone and graded filter sand which is enclosed in a geofabric.

All above liner drains in the south-east section discharge into the solution trench located to the south of Valley TSF and water will flow to the existing Return Water Dam (RWD). The above liner drains on the north-western section discharge into the solution trench located to the north-west of Valley TSF and will flow to the new RWD.

The under-liner leakage detection drains on the Valley TSF comprise of 160mm slotted Drainex HDPE pipes surrounded in 19mm stone which is enclosed in a geofabric. Similarly to the above-liner drains, the south-eastern under liner drains flow to the existing RWD and the north-western section discharges into the new RWD.

A 150mm thick reinforced concrete lined solution trench is provided along the north-west, south and south-eastern sections of the TSF. The trapezoidal solution trench is 1m deep with side slopes of 1V:1.5H and a base width of 1m. The solution trench on the north-western section of the TSF will accommodate the maximum peak discharge from the penstock of 1.02m3/sec and flows into the new RWD. The solution trench on the south and south-eastern sections of the TSF will accommodate drain flow only of 46.14m3/day and flows into the existing RWD.

A hydrotechnical assessment was done to determine climatic and meteorological data. This data was used to size the new RWD situated north-west of the TSF and the associated water infrastructure. A capacity assessment was carried out on the existing RWD, situated south-west of the TSF.

The new Return Water Dam has a total storage capacity of 220 000m3 which is sufficient to ensure that it does not spill more than once every 50 years with the inflow from the penstock and underdrains on the north-west of the TSF, when operated at a level of 0.3m.

The new Return Water Dam liner system comprises 200mm high geocells filled with 20Mpa concrete, underlain by a 1.5mm thick smooth HDPE liner and a 300mm in-situ base preparation layer. The underdrainage comprises 160mm slotted HDPE pipes encased in 19mm washed stone. The stone will be wrapped in geofabric.

A concrete lined spillway is provided at the new RWD to safely discharge excess water without overtopping of the RWD embankment walls. The RWD spillway has a freeboard of 800mm and has been designed to discharge the 1:10 000 24-hour Probable Maximum Flood volume of 9.9m3/sec.

A silt trap is installed upstream of the new RWD. The silt trap includes infrastructure to enable cleaning. The silt trap allows solids to settle out of the water before entering the RWD, thereby minimising sedimentation in the RWD. The silt trap is a 2.0m deep reinforced concrete water retaining structure with a concrete spillway to route de-silted water to the RWD.

A capacity assessment was done on the existing RWD, which has a capacity of 300 000m3. The inputs to this dam are low, as only drain water and rainfall will flow to the RWD. Due to evaporation and seepage, the dam is not expected to hold more than 50 000m3 and easily accommodates the expected inputs.

Concrete poles with warning signs will be installed around the TSF. A 5m wide access road is provided around the facility for operational and monitoring requirements.

The facility is to be constructed and operated to ensure that the future designed outer slope profile is achieved and to ensure the safe, efficient and environmentally responsible management of the Valley TSF and associated infrastructure.

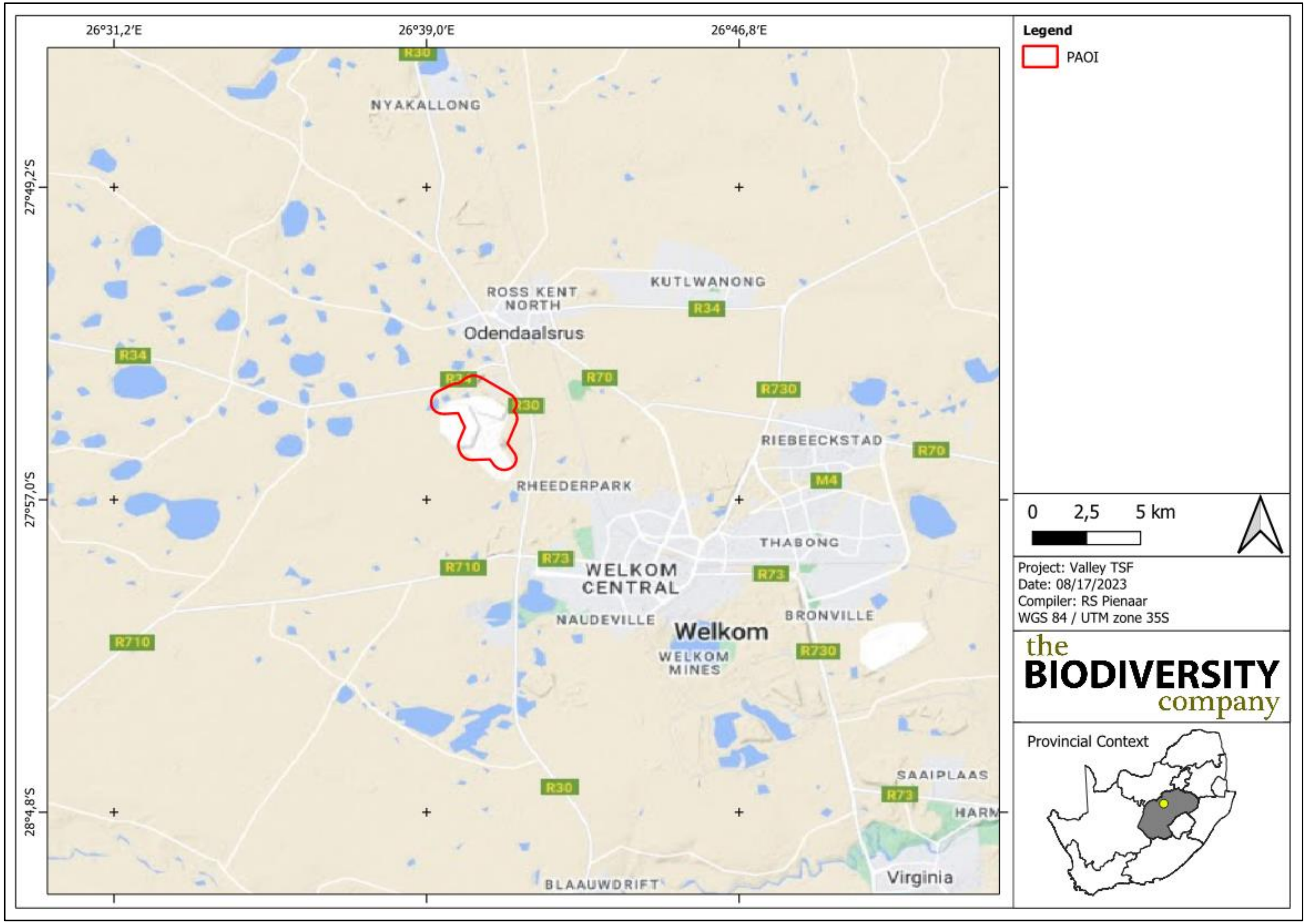

Figure 1-1 Map illustrating the regional context of the project area

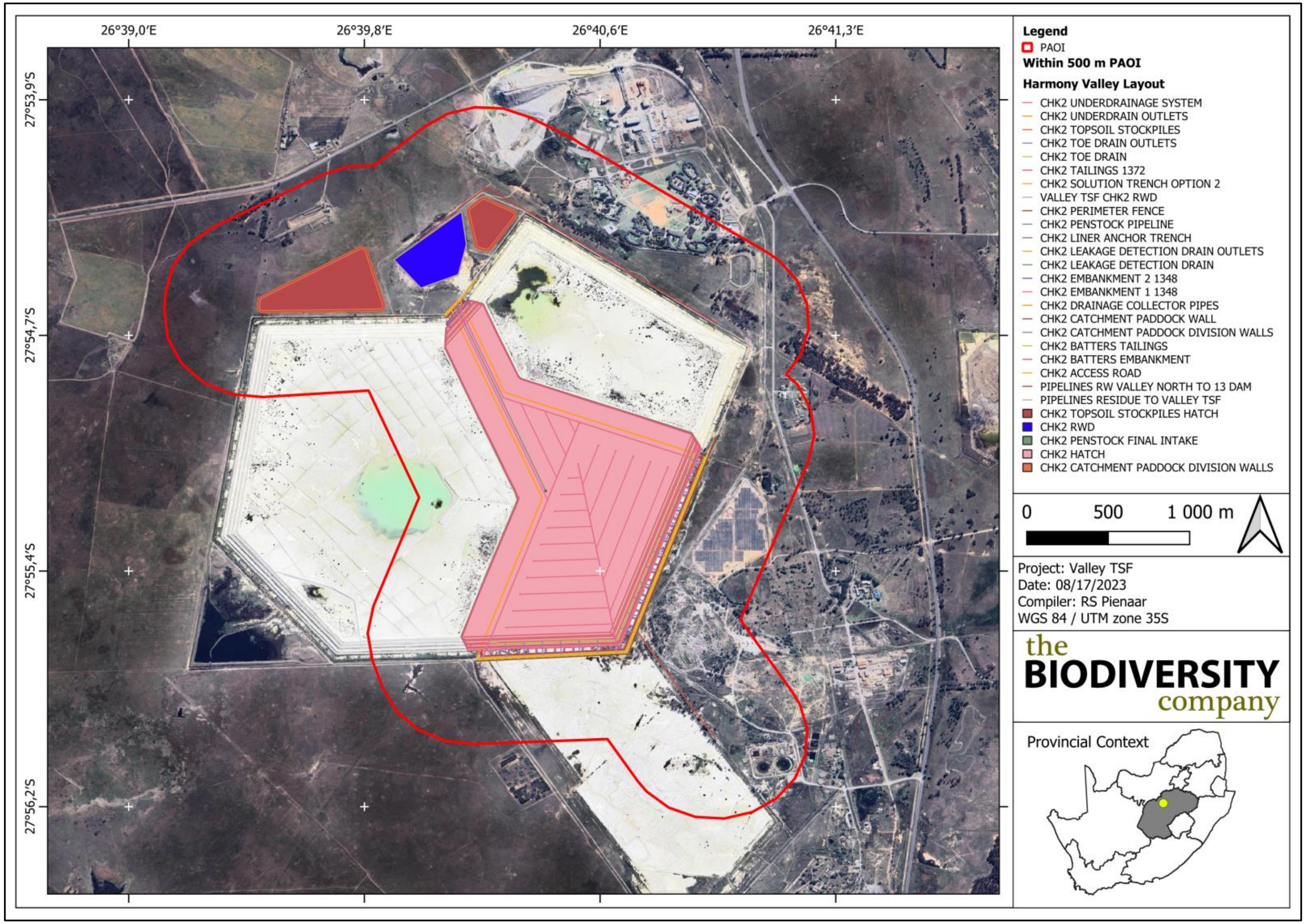

Figure 1-2 Map illustrating the proposed layout

1.3 Specialist Details

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

1.4 Terms of Reference

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

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

1.5 Key Legislative Requirements

1.5.1 National Water Act (NWA, 1998)

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

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

A watercourse means;

- A river or spring;

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

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

1.5.2 National Environmental Management Act (NEMA, 1998)

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

2 Methods

A single wetland site visit was conducted on the 11th to 13th of April 2023, constituting a late wet season survey.

2.1 Identification and Mapping

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

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

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

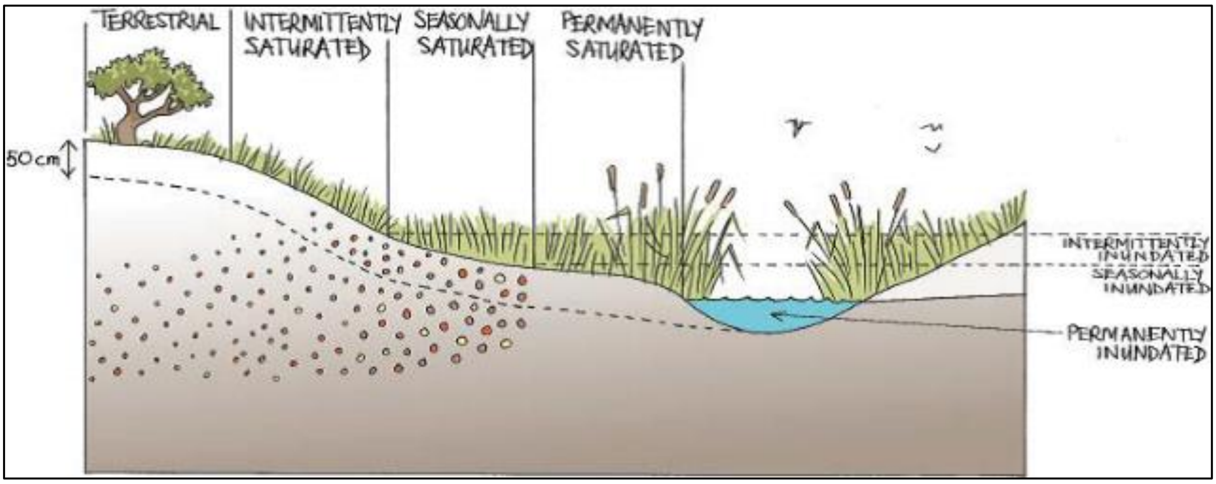

Figure 2-1 Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis et al. 2013)

2.2 Delineation

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

2.3 Functional Assessment

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

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

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

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

2.4 Present Ecological Status

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

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

Impact Category	Description	Impact Score Range	PES
None	Unmodified, natural	0 to 0.9	A
Small	Largely Natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1.0 to 1.9	B
Moderate	Moderately Modified. A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact.	2.0 to 3.9	C
Large	Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4.0 to 5.9	D
Serious	Seriously Modified. The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognizable.	6.0 to 7.9	E
Critical	Critical Modification. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8.0 to 10	F

2.5 Importance and Sensitivity

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

Table 2-3 Description of Importance and Sensitivity categories

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

2.6 Ecological Classification and Description

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

2.7 Buffer Requirements

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

2.8 Assumptions and Limitations

The following assumptions and limitations are applicable for this assessment:

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

3 Results and Discussion

3.1 Desktop Baseline

3.1.1 Vegetation Type

The project area falls within the Western Free State Clay Grassland (Gh 9) vegetation type. This vegetation type is distributed throughout the Free State province and stretches from Bloemfontein in the south to Wesselsbron in the north and from Brandfort in the east to Hertzogville in the west. The latitude suited for this vegetation type is between 1 200 meters above sea level to 1 420 meters above sea level (Mucina & Rutherford, 2006).

This vegetation type is restricted to flat bottoms supporting dry, species-poor grassland with a high abundance of salt pans (playas) within the grassland. The vegetation type is characterised by dwarf karoo shrublands surrounding the salt pans within disturbed areas.

The conservation status of this vegetation type is least threatened with a target percentage of 24. There is currently 0 % statutory conserved within conservation areas. Approximately twenty percent of the vegetation type have been transformed for wheat and maize cultivation (Mucina & Rutherford, 2006).

3.1.2 Soils and Geology

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by the Dc 9 land type. The Dc 9 landtype is prismacutanic and/or pedocutanic diagnostic horizons with the addition of one or more of the following; Vertic, melanic and red structured diagnostic horizons.

The geology of this area is characterised by deposits of sandstone, shale, and mudstone (Volksrust Formation, Ecca Group) and is found in flat areas with some undulating plains. No rivers or streams drain these plains thus all water drains into the salt pans. Dry, clayey, duplex soils are typically found within this geology (Mucina and Rutherford, 2006).

3.1.3 Climate

This region is characterised by a cool temperature regime with a MAP ranging between 16 and 17°C with the average annual precipitation being approximately 451 mm (see Figure 3-1) (Mucina & Rutherford, 2006).

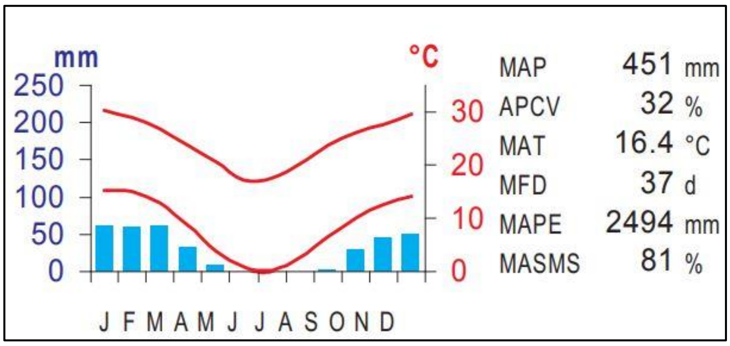

Figure 3-1 Climate for the Western Free State Clay Grassland (Mucina & Rutherford, 2006)

3.1.4 South African Inventory of Inland Aquatic Ecosystems

The South African Inventory of Inland Aquatic Ecosystems (SAIIAE) wetland dataset is a recent outcome of the National Biodiversity Assessment (NBA, 2018) and, was a collaborative project by the South African National Biodiversity Institute (SANBI) and the Council for Scientific and Industrial

Research (CSIR). The SAIIAE dataset provides further insight into wetland occurrences and extents building on the information from the NFEPA, as well as other datasets.

Two wetland types were identified by means of this dataset which incorporate multiple depression wetlands and a wetland seep within the project area of influence (Figure 3-2).

3.1.5 National Freshwater Ecosystem Priority Areas

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

The NFEPA dataset represents three wetland types classified as depression wetlands, wetland flats and valley head seeps (Figure 3-2).

3.1.6 Topographical Inland Water and River Lines

The topographical inland and river line data for the “2726” quarter degree was used to identify potential wetland areas within the PAOI. This data set indicates multiple inland water areas classified as dams, large reservoirs, marsh vlei, non-perennial pans and, sewerage works (Figure 3-4). Furthermore, no river lines can be found inside the project area of influence.

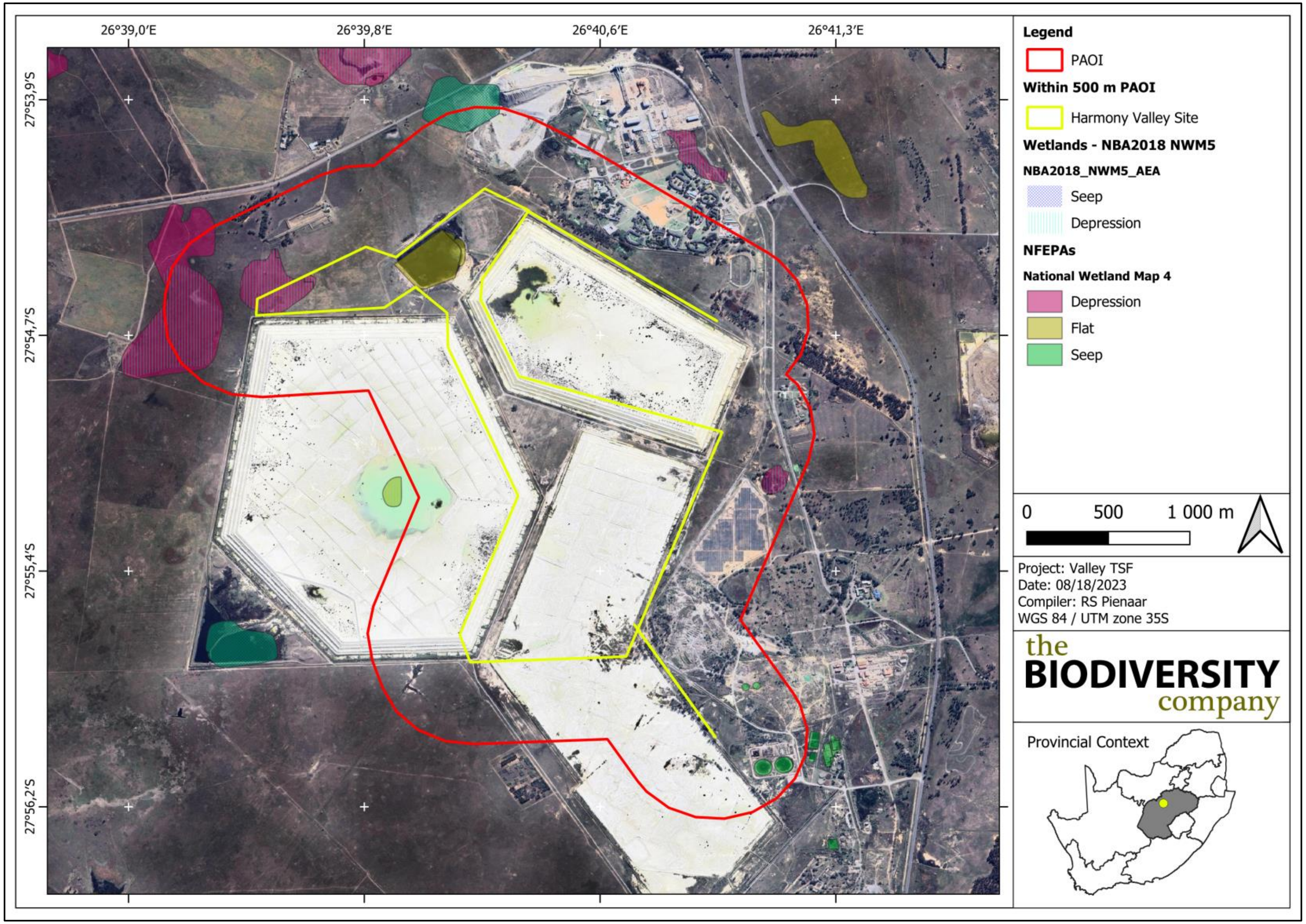

Figure 3-2 NFEPA and SAIIAE wetlands located within PAOI

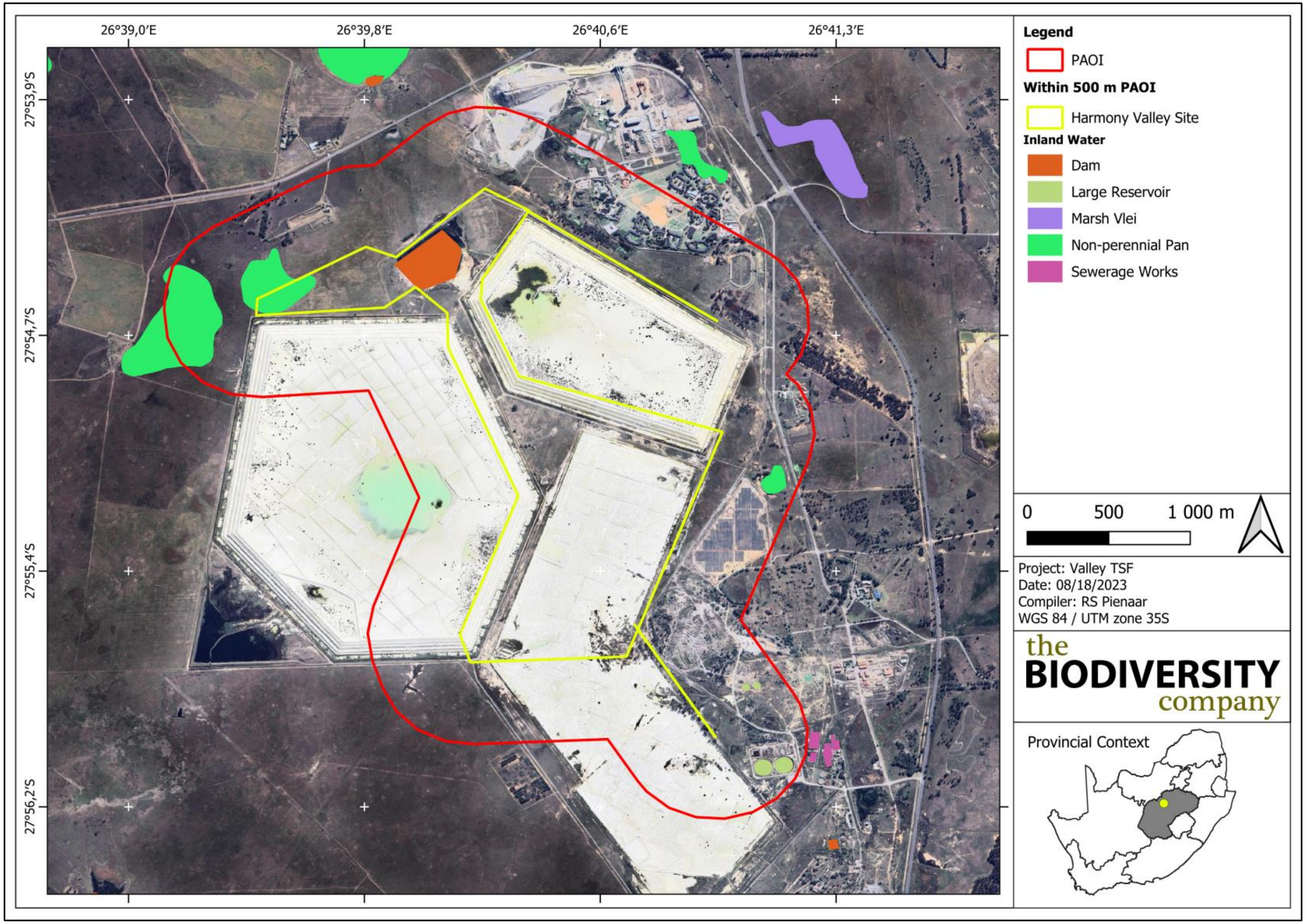

Figure 3-4 Topographical Inland water areas located within the PAOI

3.1.7 Terrain

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

Majority of the PAOI consists of mild gradient land, with the exception of some hillier and steeper terrain located in the north-east and south of the proposed pipeline.

3.1.7.1 Digital Elevation Model (DEM)

A Digital Elevation Model (DEM) has been created to identify lower laying regions as well as potential convex topographical features which could point towards preferential flow paths. The PAOI ranges from 1 321 to 1 397 meters above sea level (MASL). The lower lying areas (generally represented in dark blue) represent the area that will have the highest potential to be characterised as wetlands (see Figure 3-3).

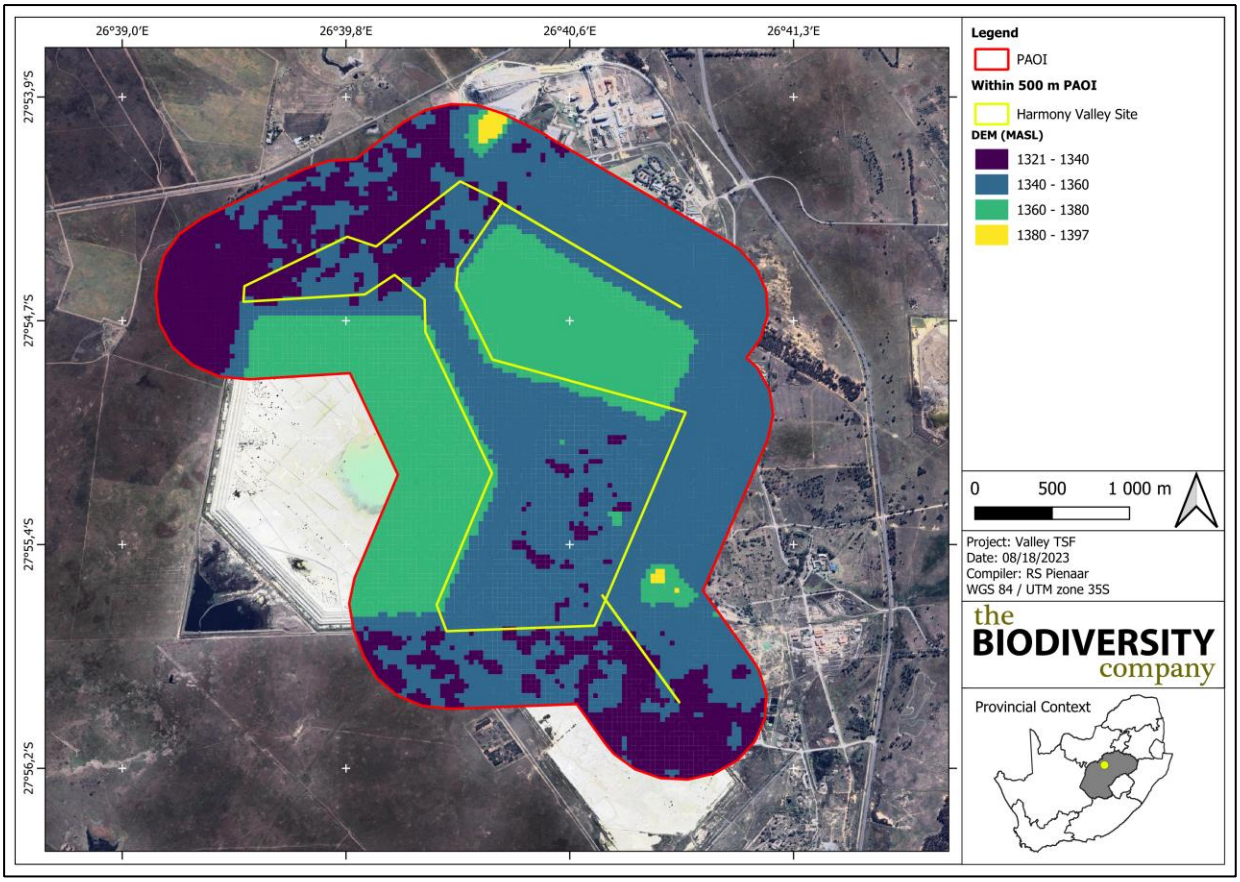

Figure 3-3 Digital Elevation Model of the PAOI

4 Field Assessment

4.1 Delineation and Description

During the site visit, six HGM units were identified within the PAOI that relate to the proposed development (Figure 4-2). The wetland types were classified as three unchannelled valley bottoms (HGM 1, 3 and 4), two depressions (HGM 2 and 5) and one hillslope seep (HGM 6) (Figure 4-1). Multiple artificial wetlands, mostly seepage from the tailing's facilities were identified within the PAOI. According to Ollis *et al* (2013) a dam is classified as '*an artificial body of water formed by the unnatural accumulation of water behind an artificial barrier that has been constructed across a river channel or an unchannelled valley bottom wetland'*. Although these systems do not classify as a natural wetland system it is important to note where the dams are for any planned development in the area. The delineation of the wetland systems and functional assessment have been completed for the unchanneled valley bottom wetland in which the dam is located.

Drainage features (or lines) were also identified throughout the PAOI. These features are referred to as 'A' Section channels that convey surface runoff immediately after a storm event and are not associated with a baseflow (DWAF, 2005).

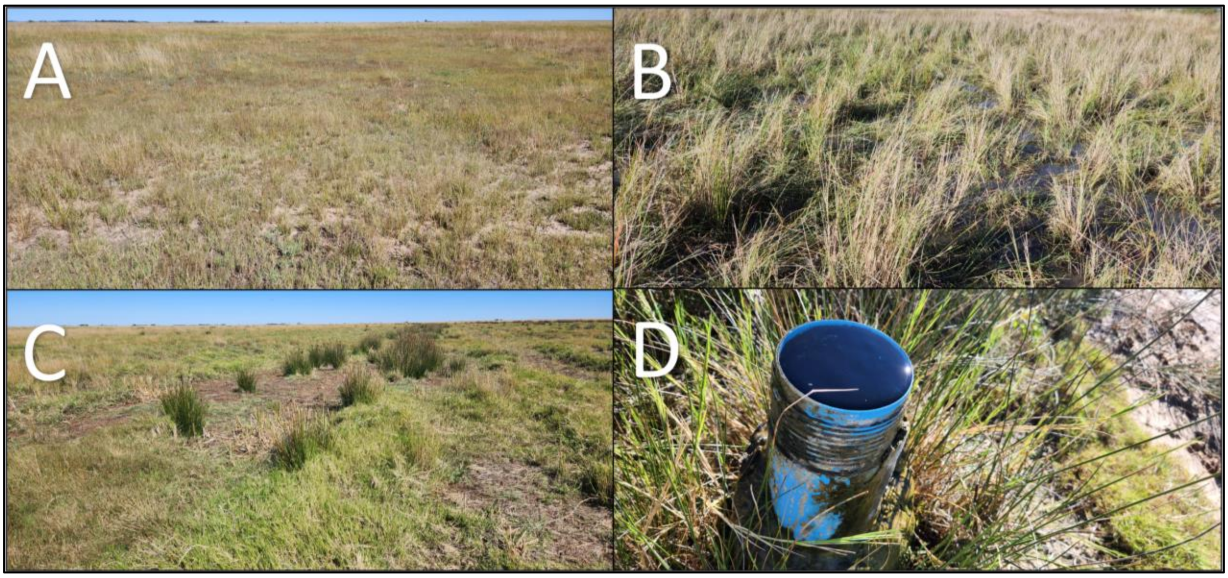

Figure 4-1 ***Photographical evidence of the different HGM units found within the PAOI. A) HGM 1., B) Seep wetland., C) Unchannelled valley bottom., D) Source of some of the artificial wetlands***

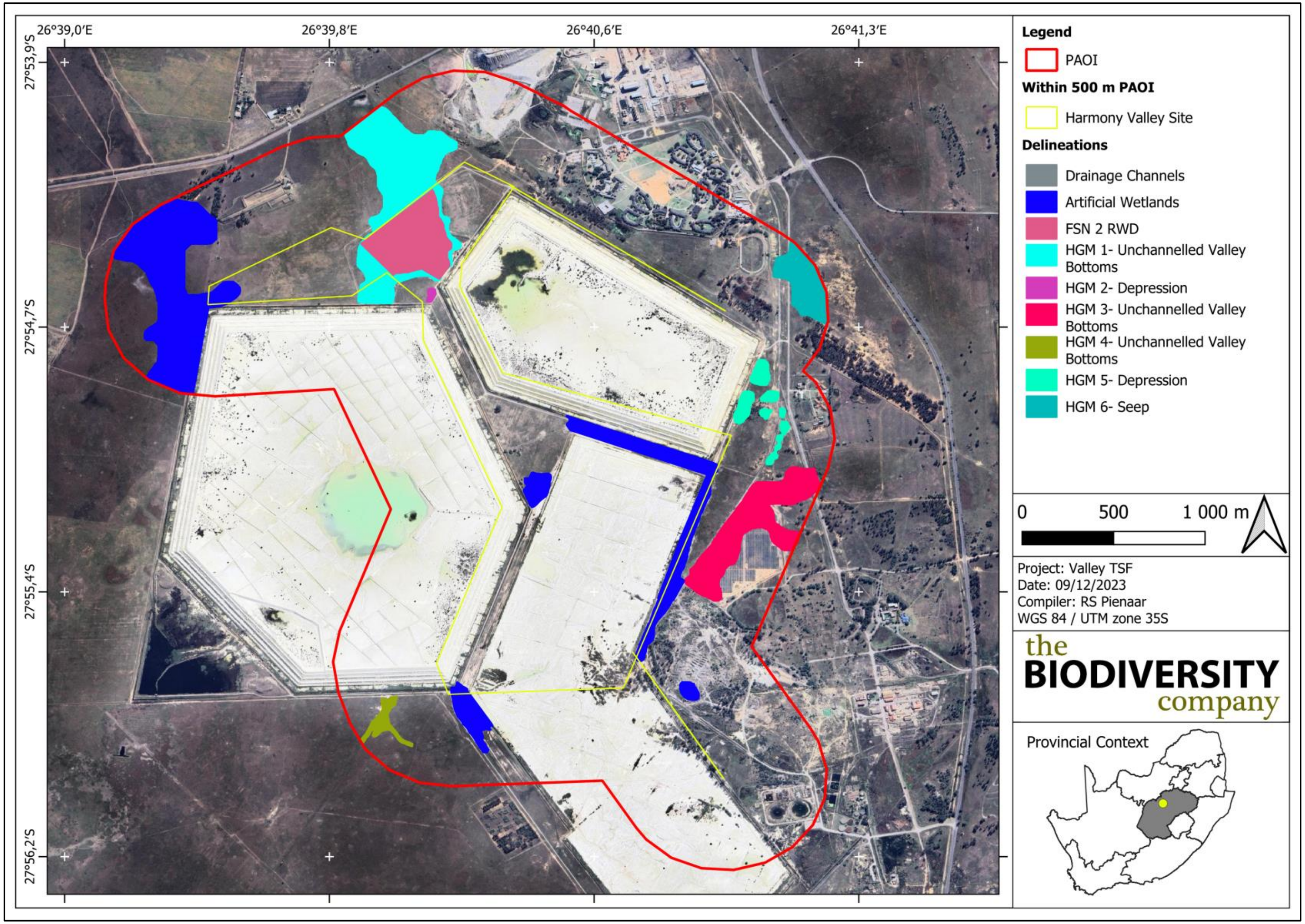

Figure 4-2 Delineation and location of the different HGM units identified within the PAOI

4.2 Unit Setting

Unchannelled valley-bottom wetlands are typically found on valley floors where the landscape does not allow high energy flows and supports the diffuse flow of water. Figure 4-4 presents a diagram of a typical unchannelled valley-bottom wetland, showing the dominant movement of water into, through and out of the system.

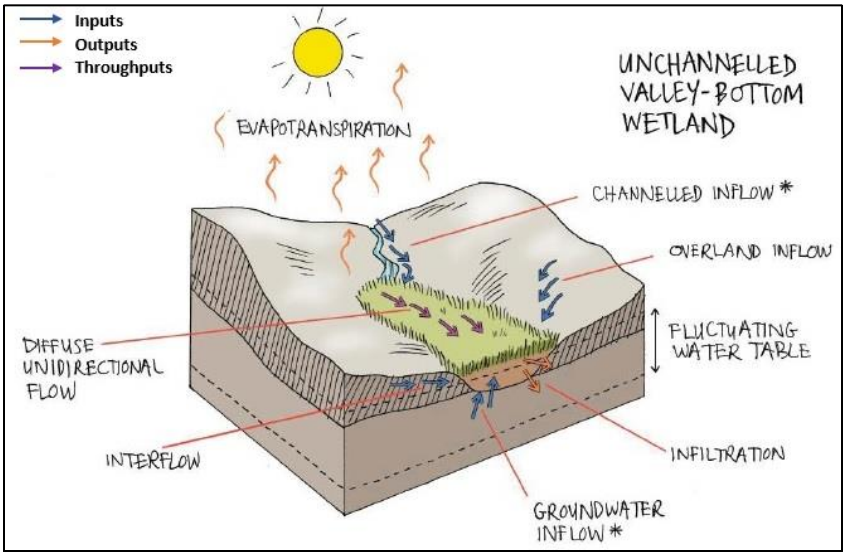

Figure 4-4 Amalgamated diagram of a typical unchannelled valley-bottom, highlighting the dominant water inputs, throughputs, and outputs, SANBI guidelines (Ollis et al. 2013)

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

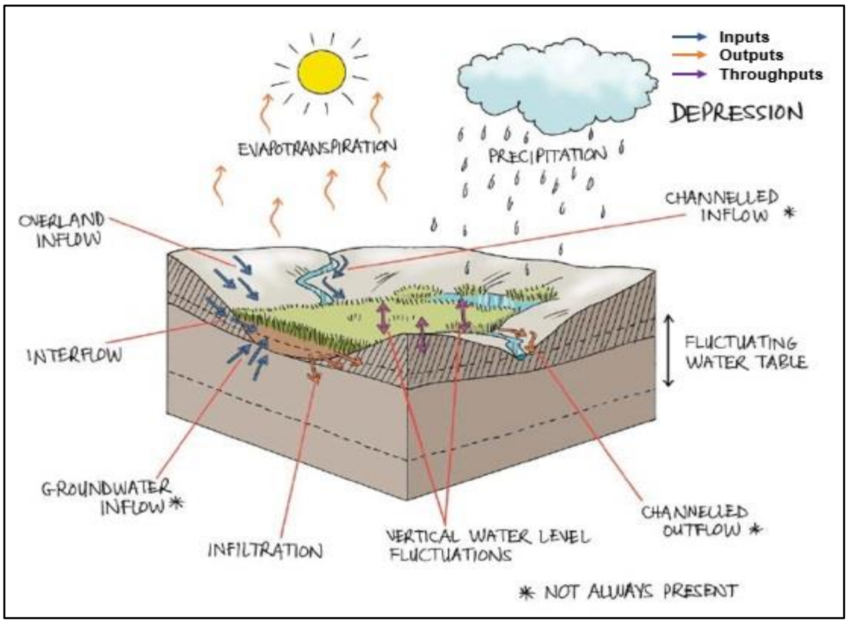

Figure 4-3 Amalgamated diagram of atypical depression wetland, highlighting the dominant water inputs, throughputs and outputs, SANBI guidelines (Ollis et al. 2013)

A typical hillslope seep is located within slopes, as mentioned in Figure 4-4. Isolated hillslope seeps are characterised by colluvial movement of material. These systems are fed by very diffuse sub-surface flows which seep out at very slow rates, ultimately ensuring that no direct surface water connects this wetland with other water courses within the valleys. Figure 4-4 illustrates a diagram of the hillslope seeps, showing the dominant movement of water into, through and out of the system.

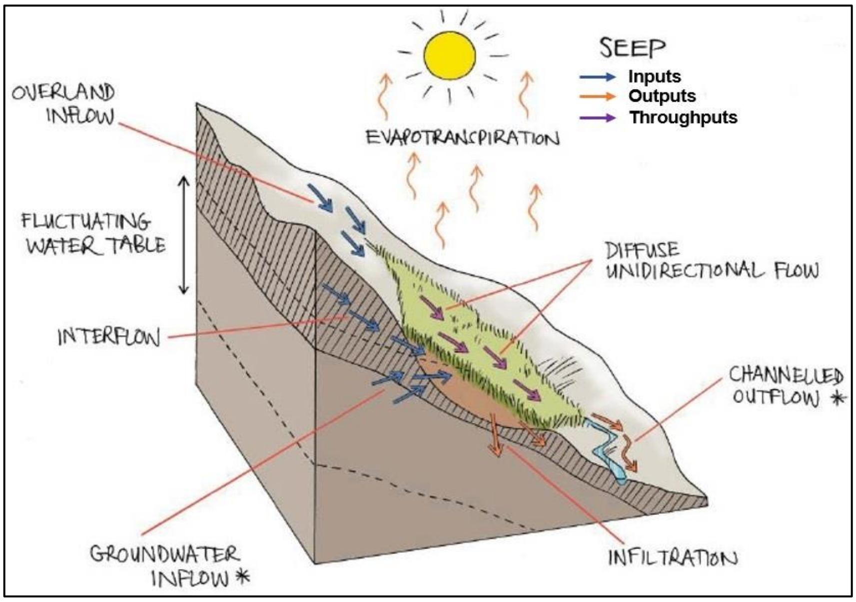

Figure 4-4 Amalgamated diagram of a typical hillslope seep, highlighting the dominant water inputs, throughputs and outputs, SANBI guidelines (Ollis et al. 2013)

The DWAF (2005) manual separates the classification of watercourses into three (3) separate types of channels or sections defined by their position relative to the zone of saturation in the riparian area. The classification system separates channels into:

- those that do not have baseflow (‘A’ Sections);
- those that sometimes have baseflow (‘B’ Sections) or non-perennial; or

- those that always have baseflow (‘C’ Sections) or perennial.

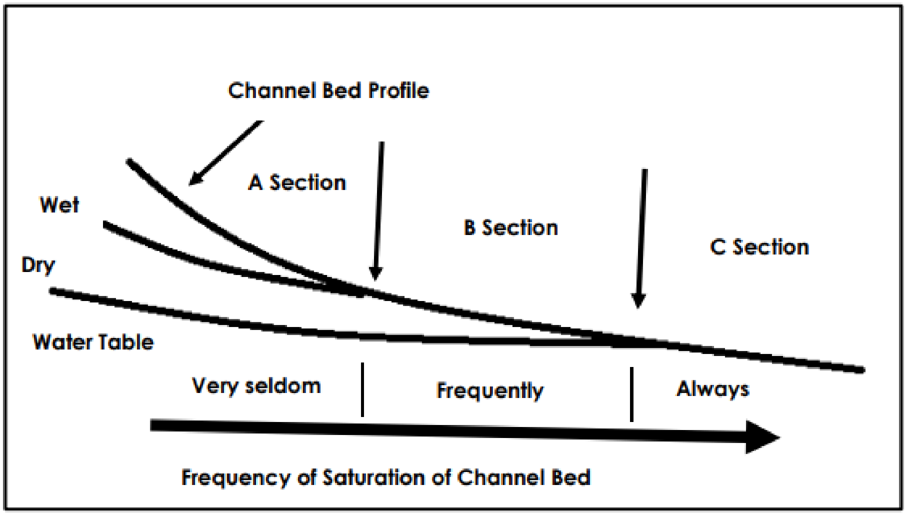

Figure 4-5 The watercourse classifications (DWAF, 2005)

4.3 General Functional Description

Unchanneled valley-bottoms are characterised by sediment deposition, a gentle gradient with streamflow generally being spread diffusely across the wetland, ultimately ensuring prolonged saturation levels and high levels of organic matter. The assimilation of toxicants, nitrates and phosphates are usually high for unchanneled valley-bottom wetlands, especially in cases where the valley is fed by sub-surface interflow from slopes. The shallow depths of surface water within this system adds to the degradation of toxic contaminants by means of sunlight penetration.

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

Hillslope seeps are well documented by (Kotze et al., 2009) to be associated with sub-surface ground water flows. These systems tend to contribute to flood attenuation given their diffuse nature. This attenuation only occurs while the soil within the wetland is not yet fully saturated. The accumulation of organic material and sediment contributes to prolonged levels of saturation due to this deposition slowing down the sub-surface movement of water. Water typically accumulates in the upper slope (above the seep). Additionally, organic matter accumulation is essential in the denitrification process involved with nitrate assimilation. Seeps generally also improve the quality of water by removing excess nutrient and inorganic pollutants originating from agriculture, industrial or mine activities. The diffuse nature of flows ensures the assimilation of nitrates, toxicants and phosphates with erosion control being one of the Eco Services provided very little by the wetland given the nature of a typical seep's position on slopes.

It is however important to note that the descriptions of the above-mentioned functions are merely typical expectations. All wetland systems are unique therefore, the ecosystem services ratings for the wetlands on site may differ slightly to the general expectation given by the nature of the wetland type in relation to its topographic setting.

4.4 Functional Assessment

The ecosystem services provided by the wetland units identified on site were assessed and rated using the WET-EcoServices method (Kotze *et al.,* 2008). The average ecosystem service scores for the delineated systems are illustrated in Table 4-1 and Figure 4-6. The ecosystem services scores of the delineated wetlands ranges from intermediate to moderately high. Ecosystem services contributing to these scores include flood attenuation, streamflow regulation, sediment trapping, phosphate assimilation, nitrate assimilation, toxicant assimilation and, erosion control.

Table 4-1 Average ecosystem service scores for delineated wetlands

Moderately High	Intermediate	Moderately Low
HGM 1	HGM 2	HGM 3
HGM 4		HGM 6
HGM 5		

HGM 1, 4 and 5 scored “Moderately High” on the provision of ecosystem services due to the nature of the wetlands, being valley-bottoms and a depression wetland respectively. The valley bottom wetlands will play a major role in streamflow regulation and flood attenuation which is important in terms of runoff from the tailing’s facilities. The wetlands will use their hydrophytes to remove toxicants from the runoff/seepage from the water to produce cleaner water downstream. The depression wetlands have high hydrophyte vegetation to provide habitat and resources for many different animals as well as humans. The depression will also act as sinks where toxicants, nitrates and phosphates from the environment.

HGM 2 scored “Intermediate” ecosystem services scores. The wetland has been modified to such an extent that they have lost some of their function. The wetland has loss many of their hydrophyte vegetation with only a few hydrophyte species present within the wetland. The wetland does still play an important role in flood attenuation and streamflow regulation. The wetland will also still purify the water flowing through them. This is attributed to much of the wetland being modified, leaving only a narrow spans of wetland vegetation intact in some reaches of the wetland.

HGM 3 and 6 scored “Moderately Low” for the ecosystem services score due to the low volumes of hydrophyte vegetation present inside the wetland. Hydrophytes help with the accumulation of toxicants as well as phosphates and nitrates from the environment as well as provides habitat and resources so the removal of them lower the ecosystem services dramatically. The construction of a solar farm inside HGM 6 lowered the ecosystem services score of the wetland.

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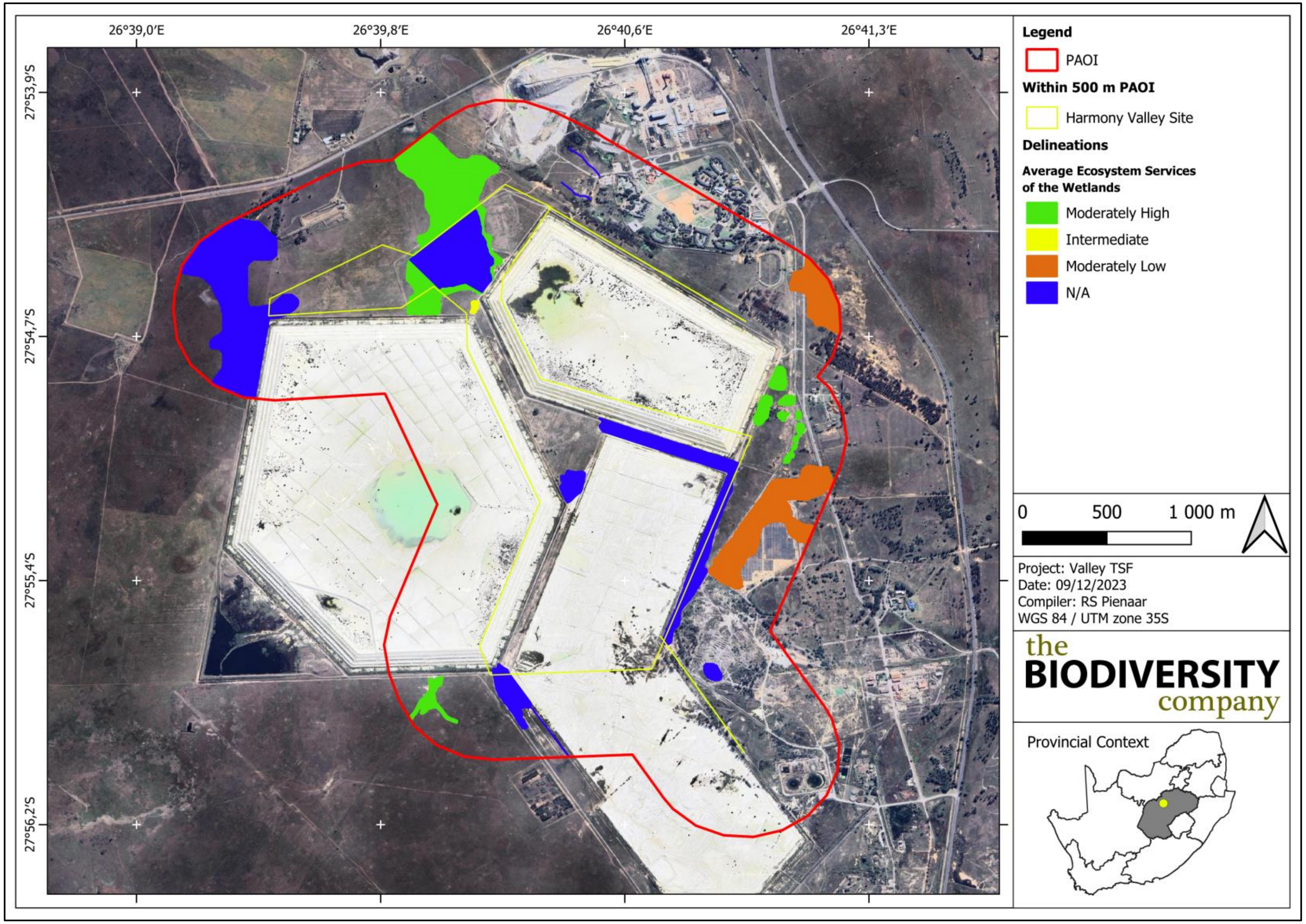

Figure 4-6 Average ecosystem services scores for the delineated wetlands

4.5 Present Ecological Status

The PES for the assessed HGM units is presented in Figure 4-7. The ecological state of the wetlands located within the project area of influence were rated as “E”- Seriously Modified. These scores are due to the magnitude of anthropogenic impacts such as mining and agricultural activities as well as the construction of roads and pipelines inside the wetlands and wetland catchments.

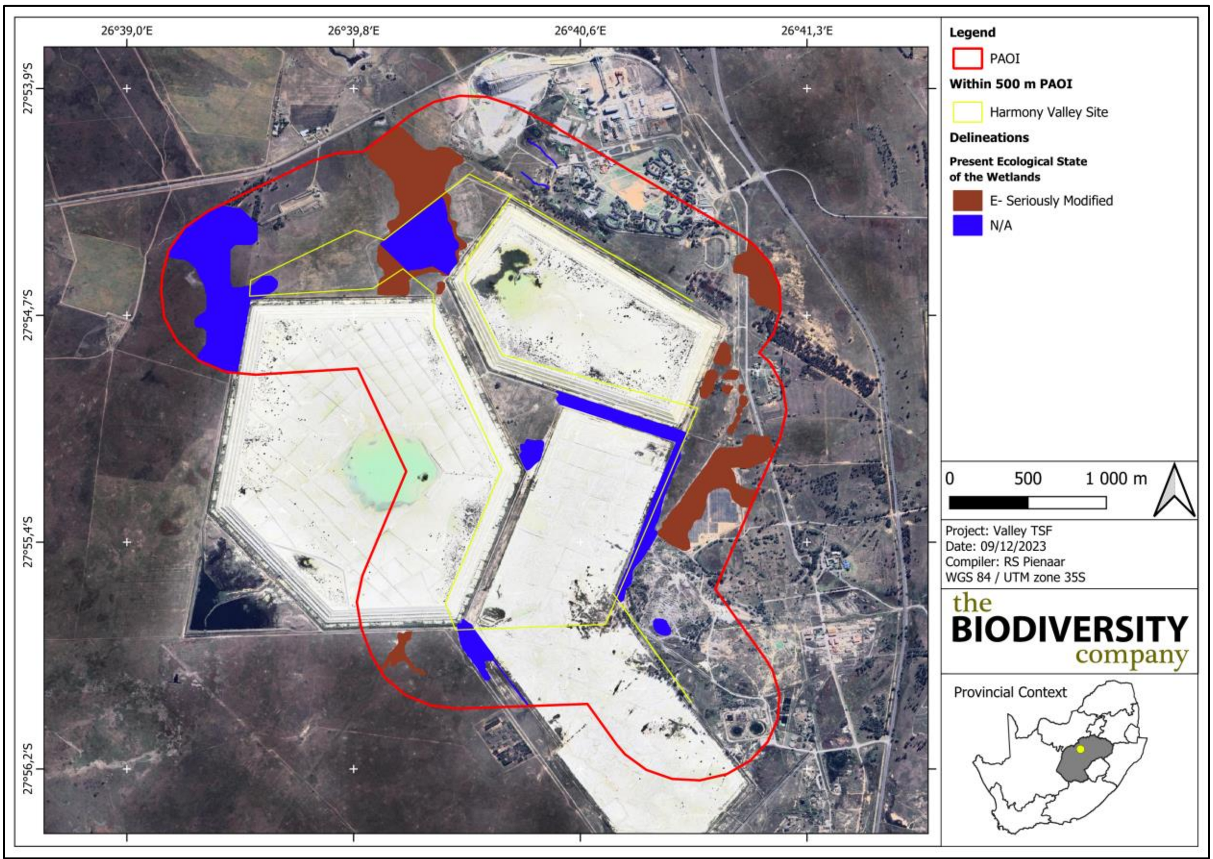

Figure 4-7 Overall present ecological state of delineated wetlands

4.6 Importance and Sensitivity

The results of the ecological IS assessment are shown in Table 4-. Various components pertaining to the protection status of a wetland are considered for the IS, including Strategic Water Source Areas (SWSA), the NFEPA wetland vegetation (wet veg) threat status and the protection status of the wetland. The IS for both the valley bottoms and the seep wetlands were calculated to be “High”, which combines the low protection status of the wet veg and the and the high threat status of the wetlands themselves. The depression wetlands scored “Moderate” sensitivities due to the low threat status of the wet veg and the low threat status of the wetlands themselves.

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

HGM Type	NFEPA Wet Veg			NBA Wetlands			SWSA (Y/N)	Calculated IS
	Type	Ecosystem Threat Status	Ecosystem Protection Level	Wetland Condition	Ecosystem Threat Status 2018	Ecosystem Protection Level		
Unchannelled Valley Bottom	Dry Highveld Grassland Group 3	Least Threatened	Not Protected	D/E/F Largely Modified	Critically	Not Protected	N	**High**
Depression	Dry Highveld Grassland Group 3	Least Threatened	Not Protected	A/B Largely Natural	Least Concerned	Not Protected	N	**Moderate**

Hillslope Seep	Dry Highveld Grassland Group 3	Least Threatened	Not Protected	D/E/F Largely Modified	Critically	Not Protected	N	**High**

4.7 Buffer Requirements

It is worth noting that the scientific buffer calculation (Macfarlane *et al*., 2014) was used to determine the size of the buffer zones relevant to the proposed project. A pre-mitigation buffer of 56 m and a post-mitigation wetland and watercourse buffer of 46 m (Figure 4-9) is recommended for the delineated systems. This is attributed to pre-existing modifications of the catchments around the wetlands and the nature of the project, which has the potential of minimally impacting on the wetland systems.

The suggested buffer in this report does not qualify as a relaxation to any other legislated buffers managed by the respective authorities (e.g., DEA and DWS). Therefore, the relevant authorisations are still a requirement prior to project commencement.

4.8 Regulatory Zone

The following regulatory zones are applicable and pertains to the project area being within 100 m from the Vaal River and wetland systems (Table 4-2).

Table 4-2 The zone of regulation for the project

Regulatory authorisation required	Zone of applicability
Water Use License Application in terms of the National Water Act, 1998 (Act No. 36 of 1998). Department of Water and Sanitation (DWS)	Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998) in accordance with GN509 of 2016 as it relates to the National Water Act, 1998 (Act 36 of 1998), a regulated area of a watercourse in terms of water uses as listed in Section 21c and 21i is defined as: • the outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; • in the absence of a determined 1 in 100 year flood line or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench; or • a 500m radius from the delineated boundary (extent) of any wetland or pan in terms of this regulation.

5 Risk Assessment

5.1 Potential Impacts

The impact assessment considered the anticipated direct and indirect impacts to the wetland systems as a result of the proposed tailings facility (Table 5-1). The mitigation hierarchy as discussed by the Department of Environmental Affairs (2013) will be considered for this component of the assessment. In accordance with the mitigation hierarchy, the preferred mitigatory measure is to avoid impacts by considering options in project location, sitting, scale, layout, technology and project/activity phasing to avoid impacts.

Three levels of risk have been identified and considered for the overall risk assessment, these include high, medium, and low risks. Due to the destructive characteristics of a new tailing's facility on wetlands, High risks are expected for the project. Medium risk refers to wetland areas where the impacts will only occur inside the wetlands buffer and not on the wetlands themselves. Low risks are wetland systems where both the wetlands and their buffers are avoided by die proposed activities. The High risks were the priority for the risk assessment, focussing on the expected potential for these direct risks.

Due to the fact that direct impacts to the wetlands (and buffers) will not be avoided, the risk assessment will consider all direct and indirect risks posed to these systems as a result of the project. The figure below illustrates various aspects that are expected to impact upon the delineated wetlands during the respective project phases.

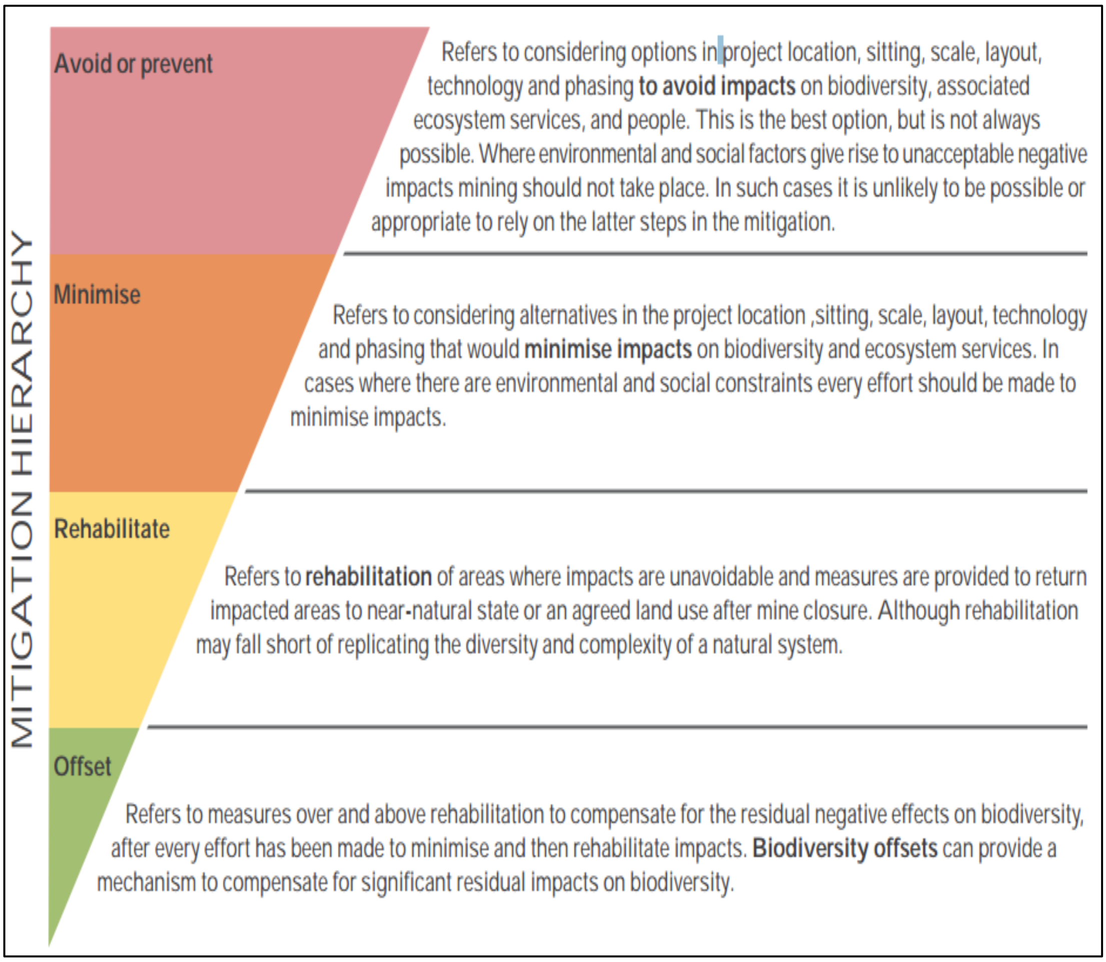

Figure 5-1 The mitigation hierarchy as described by the DEA (2013)

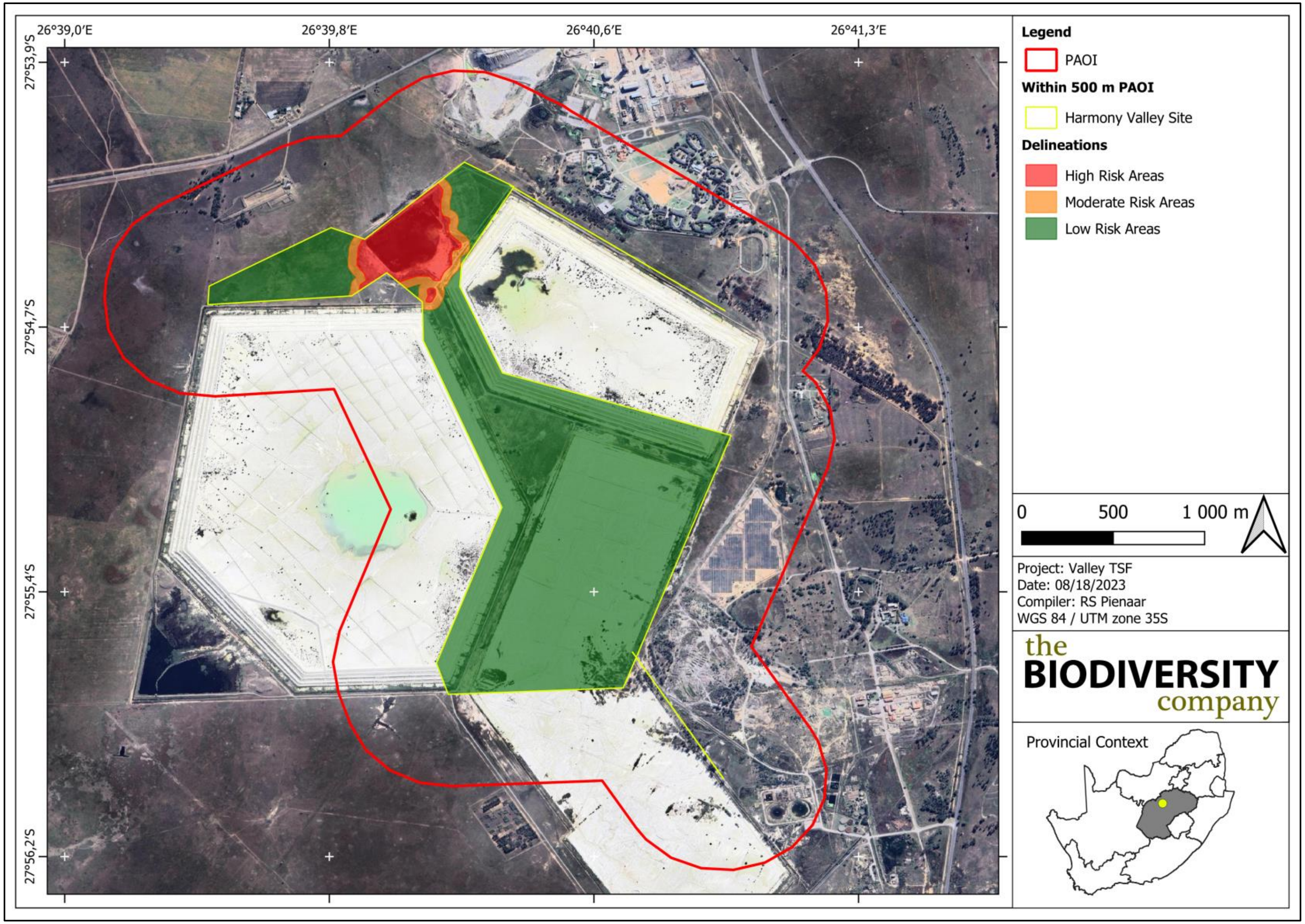

Figure 5-2 The identified risk areas within the PAOI

Table 5-1 DWS Risk Impact Matrix for the proposed pipelines (Andrew Husted Pr Sci Nat 400213/11)

Activity	Aspect	Impact	Mitigation Scenario	Severity				Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Control Measures
				Flow Regime	Water Quality	Habitat	Biota												
Construction																			
Site clearing and preparation	Clearing of vegetation and stripping and stockpiling topsoil as well as storage of equipment.	Direct loss, disturbance and degradation of wetlands.	Without	4	5	4	4	4.25	2	4	10.25	5	5	5	1	16	164	H	• Make sure that the function of HGM 1 will be the same after the upgrades are done. The RWD facility replacing HGM 1 should have the same vegetation surrounding as currently present in HGM 1. Make sure that all the other HGM units and their buffers are avoided as far as possible to limit the impacts on them. • Adhere to the prescribed wetland buffers. Restrict all non-essential activities (e.g. cement mixing and equipment wetland machinery storage) to outside of wetlands and their prescribed buffers. • Contain wastewater in a RWD Contaminated water must not be discharged into watercourses untreated. • Request the wetland spatial data, load it onto a GPS and use it to mark out the positions where the proposed activities will take place and exits the prescribed m buffer on the boundary of a wetland. • Demarcate the avoidance areas with wooden poles. • Try to reduce the disturbance footprint and the unnecessary clearing of vegetation on either side of the TSF facility when traversing wetlands. • Construct as far as possible during winter when runoff from storms are lowest, prioritise this for crossing sites. This will reduce impacts to wetlands due to soil poaching and vegetation trampling under peak saturation levels. Additionally, the risk of vehicles getting stuck and further degrading the vegetation integrity is lowest during this time.
			With	4	5	4	4	4.25	2	4	10.25	5	5	5	1	16	164	H	

Activity	Aspect	Impact	Mitigation Scenario	Severity				Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Control Measures
				Flow Regime	Water Quality	Habitat	Biota												
		Increased bare surfaces, runoff and potential for erosion	Without	3	3	3	3	3	2	2	7	3	3	1	1	8	56	M	• Keep the TSF activities to the proposed site and only access the tailings facility from the South to prevent greater loss to the wetlands northern parts. • Prevent run-off by subsurface drainage channels. Channels must direct subsurface drainage as well as run-off to the respective RWDs. • Mixing of concrete must under no circumstances take place in any wetland or their buffers. Scrape the area where mixing and storage of sand and concrete occurred to clean once finished. • Do not situate any of the construction material laydown areas within any wetland. • No machinery should be allowed to be parked in any wetlands. • Flatten and lightly till (no deeper than 30 cm) excavated / cleared areas to encourage vegetation establishment as soon as possible.
			With	2	2	2	2	2	2	2	6	3	1	1	1	6	36	L	
		Degradation of wetland vegetation and the introduction and spread of alien and invasive vegetation	Without	2	2	4	4	3	2	5	10	3	3	5	1	12	120	M	• Promptly remove all alien and invasive plant species that may emerge during construction (i.e. weedy annuals and other alien forbs) must be removed. • The use of herbicides is not recommended in or near wetlands (opt for mechanical removal). • Appropriately stockpile topsoil cleared from the project area. This can be used for rehabilitation of the impacted wetlands. • Clearly demarcate construction footprint, and limit all activities to within this area. • Minimize unnecessary clearing of vegetation. • Landscape and re-vegetate all denuded areas as soon as possible.
			With	1	1	2	1	1.25	1	2	4.25	3	1	5	1	10	43	L	
Installation of infrastructure	Dumping of material on TSF	Increased sediment loads to downstream reaches	Without	4	5	4	4	5	2	5	12	4	4	5	1	14	168	H	• See mitigation for increased bare surfaces, runoff and potential for erosion • Re-instate topsoil and lightly till disturbance footprint. • Install sandbags on downstream side of the footprint, where necessary, to trap sediment until the site has been constructed and vegetation has re-established.
			With	3	3	3	3	5	2	2	9	3	3	5	1	12	108	M	

Activity	Aspect	Impact	Mitigation Scenario	Severity				Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Control Measures
				Flow Regime	Water Quality	Habitat	Biota												
		Contamination of wetlands with hydrocarbons due to machinery leaks and eutrophication of wetland systems with human sewerage and other waste.	Without	2	2	2	3	2.25	2	2	6.25	3	2	5	1	11	69	M	• Make sure all excess consumables and building materials / rubble is removed from site and deposited at an appropriate waste facility. • Appropriately contain any generator diesel storage tanks, machinery spills (e.g. accidental spills of hydrocarbons oils, diesel etc.) or construction materials on site (e.g. concrete) in such a way as to prevent them leaking and entering the north-western seep. • Regularly maintain stormwater infrastructure, pipes, pumps and machinery to minimise the potential for leaks. Check for oil leaks, keep a tidy operation, install bins and promptly clean up any spills or litter. • Provide appropriate sanitation facilities during construction and service them regularly.
			With	1	2	1	2	1.5	2	2	5.5	3	1	5	1	10	55	L	
	Backfilling	Disruption of wetland soil profile and alteration of hydrological regime	Without	3	2	2	2	5	2	3	10	3	3	5	3	14	140	M	• Ensure that topsoil is appropriately stored and re-applied during trench backfilling. • Make sure that the soil is backfilled and compacted to accepted geotechnical standards to avoid conduit formation along the trench.
			With	1	1	1	1	5	2	3	10	2	1	5	1	9	90	L	
Operation																			
Routine operation and monitoring		Increased water inputs (clean) to downstream wetlands	Without	1	1	1	1	1	2	1	4	3	1	5	1	10	40	L	• Conduct regular inspections along the TSF to ensure the integrity of the facility.
			With	1	1	1	1	1	2	1	4	3	1	5	1	10	40	L	
Decommissioning																			
Removal of infrastructure	Vehicle access	Degradation of wetland vegetation and proliferation of alien and invasive species	Without	2	2	2	2	2	1	2	5	3	2	5	1	11	55	L	• See mitigation for the impacts on direct loss, disturbance and degradation of wetlands and spread of alien and invasive plants.
			With	2	2	2	2	2	1	2	5	3	1	5	1	10	50	L	

Activity	Aspect	Impact	Mitigation Scenario	Severity: Flow Regime	Severity: Water Quality	Severity: Habitat	Severity: Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Control Measures
	Re-excavation of trench and backfilling of wetland soils	Disruption of wetland soil profile, hydrological regime and increased sediment loads	Without	3	2	2	2	2.25	2	1	5.25	3	2	5	2	12	63	M	• See mitigation for increased bare surfaces, runoff and potential for erosion and increased sediment loads during construction. • See mitigation for Disruption of wetland soil profile and alteration of hydrological regime.
			With	1	1	1	1	1	2	1	4	3	1	5	2	11	44	L	

6 Impact Assessment

The development of the project will result in the loss of watercourse habitats where infrastructure traverses or is placed inside of the wetland. The clearing topsoil and vegetation will be required for the installation and placement of infrastructure. The development across and/or within wetlands can also cause a disruption to the biotic community structure due to the fragmentation and deterioration of habitat. Thus, the loss, fragmentation and/or deterioration of wetland habitat will reduce the level of ecosystem service benefit provide by the affected systems. The development of the area in proximity of the watercourses would also create erosion hotspots which could contribute to the sedimentation of any receiving watercourses. Infrastructure in proximity to watercourses and located on a suitable slope could create preferential flow paths, causing increased surface run-off volumes and velocities causing erosion to the area.

The impacts associated with the proposed activities, was assessed in the impact matrix provided by EIMS and the results are given in Table 6-1.

Table 6-1 Impact assessment for the proposed project

Impact	Phase	Pre-mitigation ER	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Final score
Direct loss, disturbance and degradation of wetlands.	Construction	-11	-7,5	High	2	2	-9,375
Increased bare surfaces, runoff and potential for erosion	Construction	-6,75	-6	High	2	2	-7,5
Degradation of wetland vegetation and the introduction and spread of alien and invasive vegetation	Construction	-10	-6,75	High	2	2	-8,4375
Increased sediment loads to downstream reaches	Operation	-6,75	-6	High	2	2	-7,5
Contamination of wetlands with hydrocarbons due to machinery leaks and eutrophication of wetland systems with human sewerage and other waste.	Construction	-4,5	-4	High	2	2	-5
Disruption of wetland soil profile and alteration of hydrological regime	Construction	-6,75	-6	High	2	2	-7,5
Increased water inputs (clean) to downstream wetlands	Operation	-8,25	-8,25	High	2	2	-10,3125
Degradation of wetland vegetation and proliferation of alien and invasive species	Decommissioning	-10	-6,75	High	2	2	-8,4375
Disruption of wetland soil profile, hydrological regime and increased sediment loads	Decommissioning	-6,75	-6	High	2	2	-7,5

7 Conclusion and Recommendation

7.1 Baseline Ecology

During the site assessment, six HGM units were identified and assessed within the project area of influence. These comprise of three unchannelled valley bottoms, multiple depression wetlands and a seep wetland. The systems scored an overall PES score of E – "Seriously Modified", due to the modifications arising from anthropogenic influences and surrounding mining activities. The IS for both the valley bottoms and the seep wetlands were calculated to be "High", which combines the low protection status of the wet veg and the and the high threat status of the wetlands themselves. The depression wetlands scored "Moderate" sensitivities due to the low threat status of the wet veg and the low threat status of the wetlands themselves. The average ecosystem service score was determined to range between "Moderately Low" and "Moderately High". A post-mitigation buffer of 42 m was assigned to the systems.

7.2 Risk Assessment

A risk assessment was conducted in line with Section 21 (c) and (i) of the National Water Act, 1998, (Act 36 of 1998) to investigate the level of risk posed by proposed project. High risk post mitigation risks are expected on HGM 1 and HGM 2 with HGM 1 being drained and lined before being filled again. HGM 2 will be lost but its function will be taken over by the upgrades done on HGM 1. HGM 3 – 6 will not be impacted on by the proposed activities and will have low impacts.

7.3 Impact Assessment

The impact assessment considered both direct and indirect impacts, to the water resources. It is evident that the proposed activities will encroach into the delineated wetland areas.

The option to include or exclude a liner for the TSF project has no bearing on the wetland assessment. The proposed development, and either option can be favourably considered for authorisation. This is further supported by the geohydrological assessment that concluded *"It is, however, expected that remediation, of which phyto-remediation is recommended, and the very slow contaminant migration rates will negate the need for a liner system*".

7.4 Specialist Statement

Considering the above-mentioned information, it is important that the mitigations measures are adhered to when constructing within the HGM 1 wetland. No significant wetland loss is foreseen. It is the opinion of the specialist that the project may be favourably considered, on condition all prescribed mitigation measures and supporting recommendations are implemented.

In accordance with the GA in terms of section 39 of the NWA, for water uses as defined in section 21 (c) or section 21 (i), a GA does not apply *"to any water use in terms of section 21 (c) or (i) of the Act associated with the construction, installation or maintenance of any sewer pipelines, pipelines carrying hazardous materials and to raw water and wastewater treatment works".* Owing to the fact that this project will include the installation of pipelines to accommodate the flow of hazardous materials, **a water use license will be required.**

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