HYDROPEDOLOGICAL ASSESSMENT AS PART OF THE WATER USE AUTHORISATION PROCESS FOR THE PROPOSED MINING ACTIVITIES AT EXXARO LEEUWPAN COAL MINE NEAR DELMAS, MPUMALANGA PROVINCE

Prepared for

Nsovo Environmental Consulting

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DOCUMENT GUIDE

The table below provides the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) Regulations 2017 (as amended in 2014) for Specialist Reports and also the relevant sections in the reports where these requirements are addressed.

NEMA Regulations (2017) - Appendix 6	Relevant section in report
(1) A specialist report prepared in terms of these Regulations must contain -	
(a) details of -	
(i) the specialist who prepared the report; and	Appendix D
(ii) the expertise of that specialist to compile a specialist report, including a curriculum vitae;	Appendix D
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix D
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 2
(cB) a description of existing impacts on site, cumulative impacts of the proposed development and levels of acceptable change;	Section 4
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 2
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 2
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying alternative;	Section 3 and 4
(g) an identification of any areas to be avoided, including buffers;	Section 5.4
(h) a map superimposing the activity, including the associated structures and infrastructure on the environmental sensitivities of the site, including areas to be avoided, including buffers;	Section 5.4
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.2
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment or activities;	Section 5.4
(k) any mitigation measures for inclusion in the EMPr;	Section 7
(l) any conditions for inclusion in the environmental authorisation;	Section 7
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	N/A
(n) a reasoned opinion -	
(i) as to whether the proposed activity, activities or portions thereof should be authorised;	Section 7
(iA) regarding the acceptability of the proposed activity or activities; and	Section 7
(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 7
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report	N/A
(p) a summary and copies, if any, comments received during any consultation process and, where applicable all responses thereto; and	N/A
(q) any other information requested by the competent authority.	No other information requested

EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to conduct a hydropedological assessment as part of the Water Use Authorisation (WUA) process for the proposed expansion of the existing opencast mine at Exxaro Lueewpan Coal Mine near Delmas, Mpumalanga Province.

The proposed mine expansion includes open cast mining through some wetlands. Thus, it was deemed necessary to investigate the recharge mechanism of the wetland systems within and in close proximity to the proposed mining activity areas to ensure informed mine design and planning as well as to support the decision-making process in line with the principles of sustainable development and Integrated Environmental Management.

According to the risk assessment conducted by Limosella Consulting (2019), the study area comprises three wetlands systems, two pan wetlands surrounded by a hillslope seep wetland. The results are summarised on the table below.

Table: Summary of the results of the assessments of the wetland systems occurring in study area (Limosella, 2019)

Wetland (HGM types)	PES Status	EIS
Pans	D (Largely modified)	C/D
Hillslope Seep	E (Seriously Modified)	

Based on the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) results presented above, the wetland systems have been impacted to some degree, owing to ongoing mining as well as current and historical agricultural activities within the catchment, vegetation clearing, and road infrastructure.

The presence of a hillslope seep surrounding the pan wetlands and the dominance of interflow soils may be indicative that hillslope processes are significant drivers of the wetlands within the study area. Furthermore, several geohydrological studies have reported on the presence of aquifers in the Mpumalanga coalfields, therefore it is highly likely that the wetlands are largely driven both by hillslope processes and shallow fractured aquifer/s which have a direct interaction with the wetlands, with specific mention of the pan wetlands. It should be noted that the presence of aquifers was not confirmed as part of this investigation, however, based on previous studies which have been conducted in a similar regional geological setting. The contribution of overland flow and precipitation (rainfall) is considered significant during rainy seasons due to limited rainfall days to generate adequate runoff to sustain the wetlands.

The hydropedological contribution to the wetland systems was calculated using simple hydrological principles in an effort to quantify the hydropedological percentage loss due to the proposed project both on a local and catchment scale. The impacts are summarised as follows:

- The wetlands located within the proposed open cast footprint will be completely destroyed since coal deposits underlie these wetlands as well as their associated flow drivers;
- The remaining portion of the hillslope seep located outside and upgradient of the study area will likely remain functional and be sustained by water input, including hydropedological input from catchment areas to the south of the study area, assuming that water input into this system is not intercepted for some unrelated reason;
- Although the remaining portion of hillslope seep will remain functional, mitigation measures are imperative, particularly reinstating the soil back to its original sequence and backfilling to a free draining scenario post mining to restore recharge to these drainage features and reduce the duration of impact;
- If the hydropedological processes in the landscape are considered, a scientifically derived buffer can be determined. The results of this determination are presented in Figure 17. The key principles of the plan are to avoid the Westleigh while the Glencoe is sacrificed along with the deep recharge Hutton soils. If the proposed mine plan was adapted to avoid this defined buffer, the loss of hydropedological contribution to the affected wetlands is calculated to be approximately 5.7% which will have a low to moderate impact on the wetlands which are then left unmined.

Key mitigation measures include:

- It is strongly recommended that concurrent rehabilitation be undertaken to ensure that the duration that any pit or extent thereof is left unrehabilitated is minimised;
- Restrict the amount of mechanical handling of soils, as each excision increases the compaction level;
- Separate stockpiling of different soils such that soils which are regarded as important for wetland recharge (i.e. Longlands, Wasbank, Westleigh, Glencoe) are separated from ground water recharge soils (i.e. Hutton);
- A very well designed, managed and executed topsoil (separate from soft overburden) management program is highly recommended where separate stripping, stockpiling and replacing of soil horizons in the original sequence to combat hard setting is ensured;
- The A (0-30cm) and B (30-60cm) horizons of topsoil should be stripped separately and replaced in the same sequence on top of the backfilled areas to ensure that the hydropedological functioning of wetland recharge soils is reinstated post mining;
- Stockpile height should be restricted to that which can deposited without additional traversing by machinery. A maximum height of 2-3 m is therefore proposed, and the stockpile should be treated with temporary soil stabilisation methods such are Geotextile; and
- At rehabilitation replace soil to appropriate soil depths in the correct order, and cover areas to achieve an appropriate topographic aspect and elevation profile so as to achieve a free draining landscape that is as close as possible the pre-mining conditions. Should this not be feasible, recommendations in the wetland report compiled by Limosella Consulting should be considered (Limosella, 2019)

Based on the findings of this study, the proposed project will lead a high impact on the wetlands within the study area, particularly during the operational phase, since the wetlands will be mined. It should be noted however that from a hydropedological point of view, the proposed project is not anticipated to impact on surrounding wetlands located outside of the study area since they are not hydropedologically linked to wetlands associated with the proposed mine expansion.

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GLOSSARY OF TERMS

Alluvial soil:	A deposit of sand, mud, etc. formed by flowing water, or the sedimentary matter deposited thus within recent times, especially in the valleys of large rivers.
Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials e.g. gravel, sand, or silt, that contains and transmits groundwater
Base flow:	Long-term flow in a river that continues after storm flow has passed.
Catena	A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic condition, but having different characteristics due to variation in relief and drainage.
Catchment:	The area where water is collected by the natural landscape, where all rain and run-off water ultimately flows into a river, wetland, lake, and ocean or contributes to the groundwater system.
Chroma:	The relative purity of the spectral colour which decreases with increasing greyness.
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants
Fluvial:	Resulting from water movement.
Gleying:	A soil process resulting from prolonged soil saturation which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix.
Groundwater:	Subsurface water in the saturated zone below the water table.
Hydromorphic soil:	A soil that in its undrained condition is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).
Hydro period	Duration of saturation or inundation of a wetland system.
Hydrology:	The study of the occurrence, distribution and movement of water over, on and under the land surface.
Hydromorphy:	A process of gleying and mottling resulting from the intermittent or permanent presence of excess water in the soil profile.
Intermittent flow:	Flows only for short periods.
Eluviation	Transport of soil material from upper layers of soil to lower levels by downward precipitation of water across soil horizons
Mottles:	Soils with variegated colour patterns are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.
Perched water table:	The upper limit of a zone of saturation that is perched on an unsaturated zone by an impermeable layer, hence separating it from the main body of groundwater
Regolith	The layer of unconsolidated solid material covering the bedrock
Runoff	Surface runoff is defined as the water that finds its way into a surface stream channel without infiltration into the soil and may include overland flow, interflow and base flow.
Vadose zone	The unsaturated zone between the ground surface and the water table (groundwater level) within a soil profile
Watercourse:	In terms of the definition contained within the National Water Act, a watercourse means: • A river or spring; • A natural channel which water flows regularly or intermittently; • A wetland, dam or lake 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

ACRONYMS

°C	Degrees Celsius.
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
ET	Evapotranspiration
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
HGM	Hydrogeomorphic
m	Meter
MAP	Mean Annual Precipitation
MPRDA	Minerals and Petroleum Resources Development Act, Act 28 of 2002
NEMA	National Environmental Management Act
NWA	National Water Act
PSD	Particle Size Distribution
SACNASP	South African Council for Natural Scientific Professions
SAS	Scientific Aquatic Services
subWMA	Sub-Water Management Area
WMA	Water Management Areas
WULA	Water Use Licence Application

1 INTRODUCTION

Scientific Aquatic Services (SAS) was appointed to conduct a hydropedological assessment as part of the Water Use Authorisation (WUA) process for the proposed expansion of the existing opencast mine at Exxaro Leeuwpan Coal Mine near Delmas, within the jurisdiction of the Victor Khanye Local Municipality in the Mpumalanga Province. The proposed opencast mining expansion will occur on the Farm Kenbar 257 IR Portion 0 and will hereafter be referred to as the "study area".

The study area is located approximately 6.8 km southeast of Delmas. The old R50 provincial road borders the northern boundary, whilst the new R50 road is located immediately adjacent the southern boundary. Refer to Figure 1 and 2.

The proposed mining expansion includes mining of three (3) wetlands as well as areas which are terrestrial in nature and predominantly comprise landuses associated with agriculture. Thus, it is deemed necessary to investigate the recharge mechanism of the wetland systems within and in close proximity to the proposed mining activity areas to ensure that mine planning takes cognizance of the hydropedologically important areas and subsequently support informed decision making and sustainable development.

A hydropedological survey and soil sampling activities were conducted on 9^{th} and 24^{th} January 2019 to assess the hydropedological characteristics of the landscape and associated soils within the study area and immediate vicinity. A soil sampling exercise was undertaken at selected representative points, considering the various soil types, in order to deduce the wetland recharge potential and identify the anticipated hydropedological impacts of the proposed mine expansion on the wetland resources that will be affected by the proposed activities.

This study aimed to quantify the percentage loss of hydropedological recharge to the wetlands based on simple hydropedological principles. It was deemed important to determine a suitable buffer, in line with the DWS latest thinking, to ensure that appropriate consideration is given to the proposed mining activities, the perceived impacts thereof on the affected wetlands and the associated hydropedological drivers in the study area.

In addition to the buffer determination, the Department of Water and Sanitation (DWS) Risk Assessment Matrix (2016) was also applied to determine the significance of perceived impacts on the key drivers and receptors (hydrology, water quality, geomorphology, habitat and biota) of the wetlands associated with the study area. It should be noted that the risk assessment presented in this document primarily focused on the risks presented by mining of wetlands within the study area.

Figure 1: Digital satellite image depicting the study area in relation to the surrounding areas.

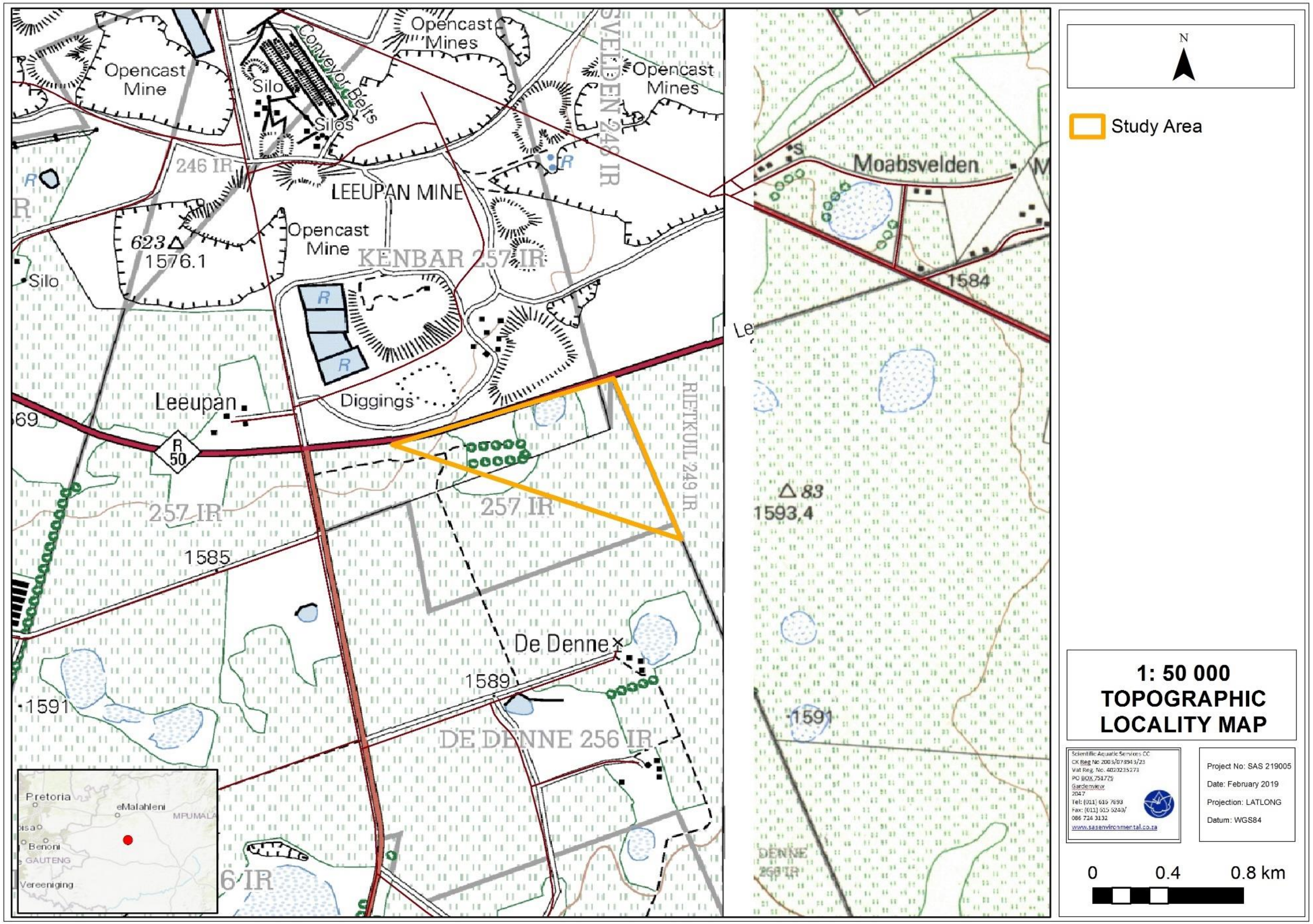

Figure 2: 1:50 000 topographic map of the study area in relation to the surrounds.

1.1 Objectives

The purpose of this assessment is to investigate the hydropedological properties of the soils in the vicinity of the wetland systems within the study area, to infer the potential recharge mechanisms and destination of the transferred water of the surrounding soils that may be affected during the life of the proposed mining activity. It was also the objective of this assessment to investigate whether surrounding wetlands located outside of the study area will be impacted or will remain unimpacted from a hydropedological point of view. Recommendations on mitigation were then considered and presented.

1.2 Assumptions and Limitations

Hydropedological science and research is rapidly evolving and there are currently no standard methods to assess and/or model the recharge capacity of soils. As a result, the findings of this assessment are a combination of qualitative and quantitative results and are based on the specialist's opinion and experience with the hydrological properties of the identified soil types.

Hydropedology is largely qualitative, with no standard method of approach to quantify the impact significance of various activities on the hydropedological drivers of wetland systems. For the purpose of this assessment, a model was developed using basic hydrological principles in an effort to quantify the percentage loss of hydrological drivers due to the proposed activities. Although the model outcomes correlate with expected results and results obtained using other methods, the model used remains untested.

Sampling by definition means that not all areas are assessed, and therefore some aspects of soil and hydropedological characteristics may have been overlooked in this assessment. However, it is the opinion of the professional study team that this assessment was carried out with sufficient sampling and in adequate detail to enable the proponent, the Environmental Assessment Practitioner (EAP) and the regulating authorities to make an informed decision regarding the proposed activity.

The effects of climate change dynamics were not considered as part this assessment; however, it is acknowledged that this might exacerbate the anticipated reduction in water inputs and the resultant hydrological function of the freshwater resources beyond the extent of the proposed mining project.

2 ASSESSMENT METHODOLOGY

Field assessments were conducted on 9th and 24th of January 2019 to investigate the hydropedological properties of the soils in the vicinity of the wetlands which will be directly impacted by the proposed mining activities, in order to infer the recharge potential of the surrounding soils as best possible, based on their intrinsic pedological characteristics. Subsurface soil observations were made by means of a standard hand auger method.

Field assessment data included a description of physical soil properties, including the following parameters, in order to characterise the various recharge mechanisms of the investigated wetlands:

- Diagnostic soil horizon sequence;
- Landscape position in relation to the investigated wetlands (recorded on Global Positioning System);
- Depth to saturation (water table), if encountered; and
- Analysis of selected soil samples at a SANAS accredited analytical laboratory (see below for details of the parameters analysed).

Analysis of the following parameters was undertaken by a SANAS accredited laboratory:

- Particle size distribution (PSD) analyses to verify textural composition. The textural class was thereafter assigned according to the relative percentage fractions of clay, silt, and sand particles, as illustrated in the textural classification triangle in Figure 4. The permeability of the soils and their ability to transmit water through the landscape was thereafter estimated according to Table 1 and 2, commonly used in the Agricultural Industry; and
- Soil moisture content to determine the quantity of water contained in the soil as a percentage, using the oven-dried weight method.

Field assessment data was subsequently used to carry out the following assessments and investigation:

- Verification of the spatial extent of the identified soil forms using a Geographical Information System (GIS) software programme;
- Estimation of the hydraulic conductivity according to soil texture according to the Food and Agriculture Organization (FAO, 1980) and DWS method (DWS, 2011);
- Identify the potential impacts of the proposed mining project on the unsaturated flow processes, and implications thereof on the functionality of the wetland systems;

- Compile a brief report on the conceptual hydropedological regime of the assessed wetlands based on the soil types within the study area under current conditions;
- Apply the DWS Risk Assessment Matrix (2016) to identify potential impacts that may affect the wetland systems as a result of the proposed development, and aim to quantify the significance thereof; and
- Recommend suitable mitigation and management measures to alleviate the identified impacts on the wetland hydropedological conditions.

Table 1: Average permeability for different soil textures in cm/hour Food and Agriculture Organization (FAO), 1980.

Soil Texture	Permeability (cm/hour)
Sand	5
Sandy loam	2.5
Loam	1.3
Clay loam	0.8
Silty clay	0.25
Clay	0.05

Table 2: Soil permeability classes for agriculture and conservation (Food and Agriculture Organization (FAO), 1980.

Soil permeability classes	Permeability rates*	
	cm/hour	cm/day
Very slow	Less than 0.13	Less than 3
Slow	0.13 - 0.3	3 - 12
Moderately slow	0.5 - 2.0	12 - 48
Moderate	2.0 - 6.3	48 - 151
Moderately rapid	6.3 - 12.7	151 - 305
Rapid	12.7 - 25	305 - 600
Very rapid	> 25	> 600

****Saturated samples under a constant water head of 1.27 cm***

Table 3 : DWS range of hydraulic conductivities in different soil types (DWS Groundwater Dictionary, 2011)

Soil Type	Saturated Hydraulic Conductivity, K_s (cm/s)
Gravel	3×10^{-2} – 3
Coarse Sand	9×10^{-5} – 6×10^{-1}
Medium Sand	9×10^{-5} – 5×10^{-2}
Fine Sand	2×10^{-5} – 2×10^{-2}
Loamy Sand	4.1×10^{-3}
Sandy Loam	1.2×10^{-3}
Loam	2.9×10^{-4}
Silt, Loess	1×10^{-7} – 2×10^{-3}
Silt Loam	1.2×10^{-4}

Soil Type	Saturated Hydraulic Conductivity, K_s (cm/s)
Till	$1x10^{-10} – 2x10^{-4}$
Clay	$1x10^{-9} – 4.7x10^{-7}$
Sandy Clay Loam	$3.6x10^{-4}$
Silty Clay Loam	$1.9x10^{-5}$
Clay Loam	$7.2x10^{-5}$
Sandy Clay	$3.3x10^{-5}$
Silty Clay	$5.6x10^{-6}$
Unweathered marine clay	$8x10^{-11} – 2x10^{-7}$

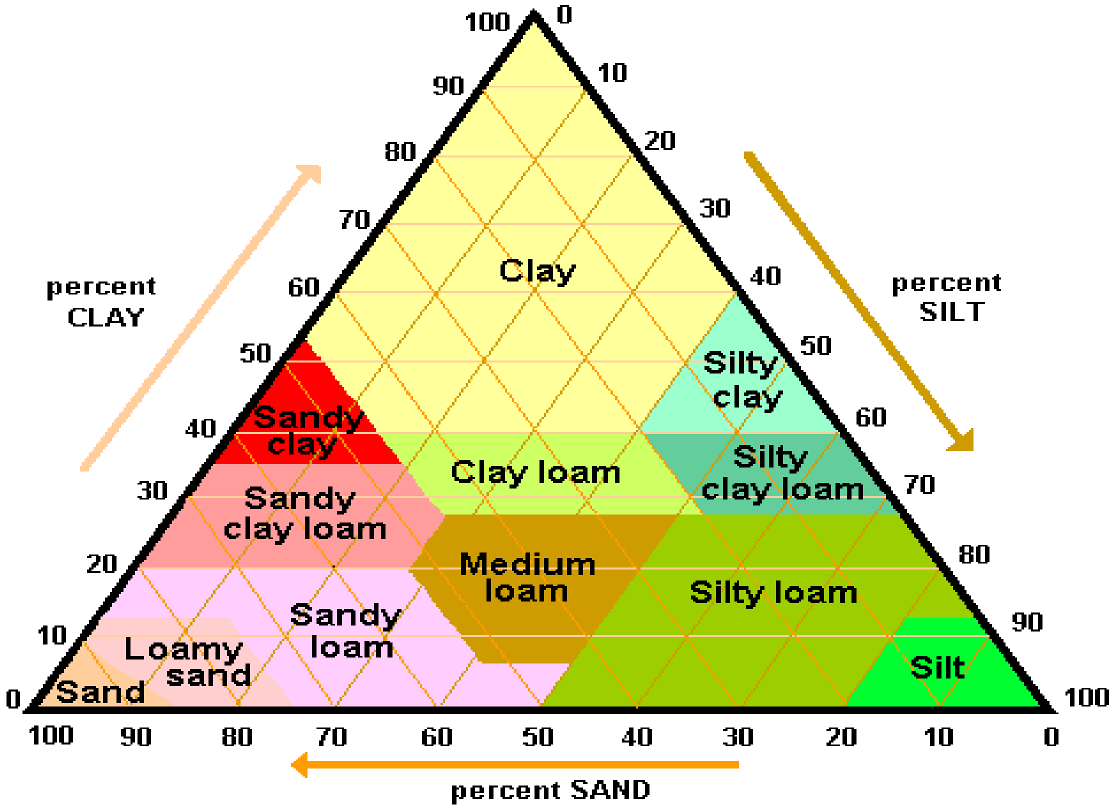

Figure 3: Soil texture classification chart (Food and Agriculture Organization (FAO), 1980).

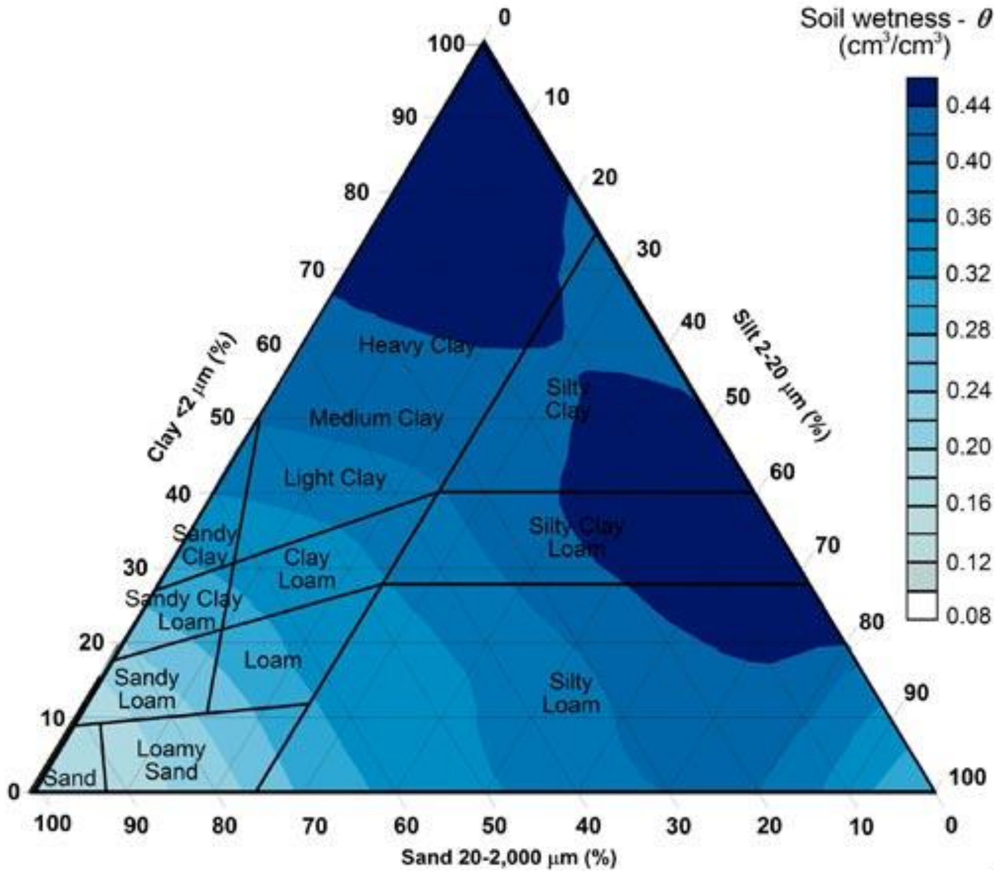

Figure 4: A diagram depicting soil wetness based on soil textural class.

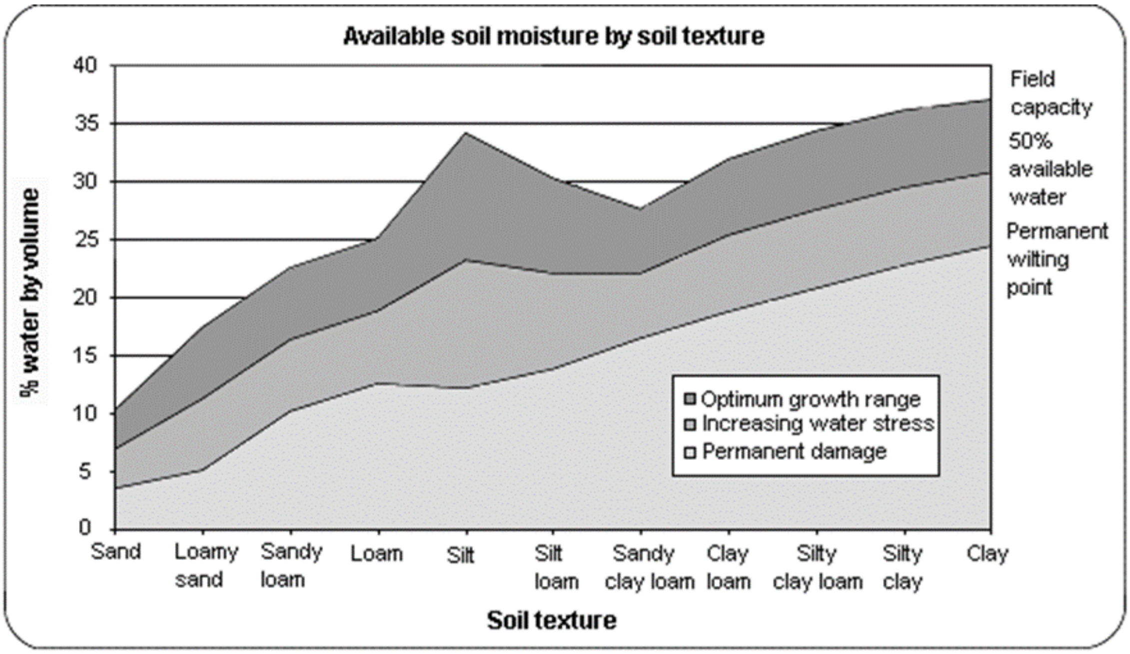

Figure 5: A diagram depicting the percentage volume of water in the soil by soil texture.

2.1 Wetland Impact Calculation Approach

To accurately calculate the percentage loss for each wetland system associated with the study area simple hydrological principles were applied. This approach considered various parameters such as:

- Rainfall;
- Hydropedological soil types;
- Catchment area for each wetland system;
- Mean Annual Runoff;
- Runoff coefficients (Mahmoud and Alazba, 2015) (Refer to Appendix B):
  - Slope percentage;
  - Soil texture; and
  - Land use.

For each wetland system, a catchment area was delineated. In catchments which extended upgradient beyond the area where hydropedological data was gathered, the inflow into the study areas was calculated using standard hydrological calculations of annual discharge. This value was used, where applicable, as an initial or catchment input volume to which the site specific hydropedological recharge values as well as other hydrological inputs were added. The contribution of the vadose zone or hydropedological input, taking into account its contribution to interflow and overland flow, was expressed as a percentage as well as estimated volumes of hydropedological recharge loss.

3 HYDROPEDOLOGICAL BEHAVIOUR OF SOIL TYPES

Hydropedological behaviour of different soils can vary significantly, depending on the soil drainage patterns. The discussion below is based on the concept presented in Figure 6 and Table 4 below.

High chroma red soils are typically deep, well drained soils, and vertical flow is the dominant hydrological pathway. These soils are referred to as recharge soils, as they are likely to recharge groundwater, or lower lying positions in the regolith, via the fractured bedrock. Therefore, these soils may be important in terms of recharge over significant distances (several kilometers) and over long periods (years to centuries). These soils are likely to contribute to surface freshwater systems three (3) stream orders down in the landscape. In this instance, groundwater may contribute to the recharge of river systems located in the surrounding areas.

On the contrary, lighter coloured soils or leached soils are usually associated with lateral movement of water which leaches soil minerals from the soil through the process of eluviation. Lateral flow occurs due to differences in the conductivity of soil horizons or due to the presence of an impermeable subsurface layer. These soils are termed interflow soils. Lateral flow occurs at the A/B horizon interface and/or bedrock interfaces due to the reduced permeability, which therefore prevents vertical movement. Fluctuating water tables in these areas leads to mottle formation (red, yellow and grey colours) at the level in the soil where the water level fluctuation occurs.

Grey colours in soils are mainly caused by prolonged saturation (hydroperiod), attributed to poor soil drainage due to high clay content or some other impediment. These soils drive freshwater resources on a more localised scale and the recharge path is generally completed over shorter periods (days to months depending on the transmissivity of the soils). Surface runoff occurs rapidly and leads to recharge of soils on a localised level after rainfall events. Figure 6 presents a conceptual diagram of the recharge mechanism of different soil types within the landscape and their influence on freshwater resources.

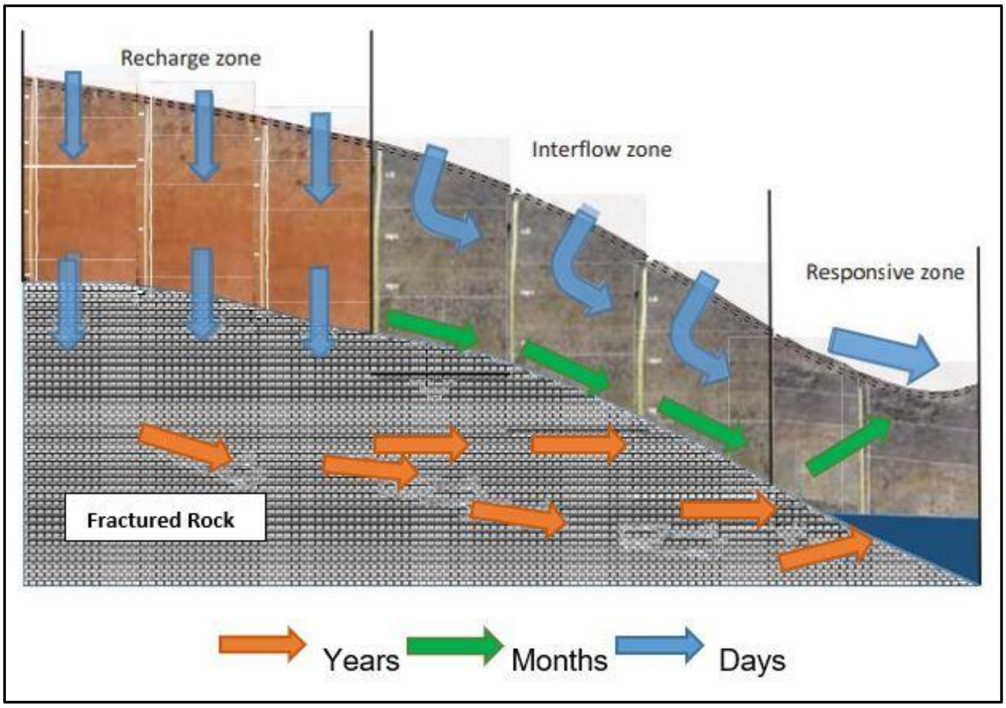

Figure 6: A typical conceptual presentation of hydrological flow paths on different hydropedological soil types- hillslope hydropedological behaviour.

Table 4: Hydrological soil types of the studied hillslopes (Le Roux, *et al.*, 2015).

Hydrological Soil Types	Description	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep, freely drained soils with significant contribution to ground water regime.	
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates accumulation of water in the topsoil. Duration of drainable water depends on the rate of evapotranspiration, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	
Interflow (Soil/Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build-up of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	
Responsive (Saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	

The flow paths from the crest of a slope to the valley bottom is assessed and classified. According to Le Roux, *et al.* (2015), the classification largely takes into account the flow drivers during a peak rainfall event and the associated flow paths of water through the soil. The hillslope classes are:

- Class 1 – Interflow (Soil/Bedrock Interface);
- Class 2 – Shallow responsive;
- Class 3 – Recharge to groundwater (not connected);
- Class 4 – Recharge to wetland;
- Class 5 – Recharge to midslope; and
- Class 6 – Quick interflow.

4 ECOLOGICAL SIGNIFICANCE

According to the risk assessment conducted by Limosella Consulting (2019), the study area comprises three wetland, two pans surrounded by a hillslope seep wetland. The results are summarised on the table below.

Table 5: Summary of the results of the assessments of the wetland systems occurring in the study area (Limosella, 2019)

Wetland (HGM types)	PES Status	EIS
Pans	D (Largely modified)	C/D
Hillslope Seep	E (Seriously Modified)	

Based on the PES/EIS results presented above, the wetland systems have been impacted to some degree, owing to ongoing mining as well as current and historical agricultural activities within the catchment, vegetation clearing, and road infrastructure (Limosella, 2019).

5 RESULTS AND DISCUSSION

5.1 Morphological and Hydraulic Properties of Wetland Soils within the Study Area

The catena of the wetlands within the study area resembled a plinthic topo sequence. Plinthic soils within the study area can be divided into soft and hard plinthic soil types, where in hard plinthic soils the Orthic A transitions to an Albic horizon and then grades into a plinthic horizon e.g. Wasbank (Ws). Additionally, hard plinthic soils can be moderately deep where the Orthic A horizon grades into a red or yellow-brown apedal horizon e.g. Glencoe (Gc), whereas in soft plinthic soils the Orthic A can grade into an Albic Horizon e.g. Longlands. Soft plinthic soils are generally wetter than the overlying horizon and have a high water storage capacity attributed to their clayey and less permeable nature, which results in prolonged wetness after rainfall events. These soils, amongst others, discourage vertical movement of water and promote lateral flow, thus are potentially important in terms of wetland functioning. Additionally, the presence of a possible G horizon on Katspruit (Ka) associated with the pans indicates greater susceptibility to wetness, and these soils are typically saturated with water, at least seasonally. Figure 7 depicts the locality of the delineated soils within the study area as well as the wetland features.

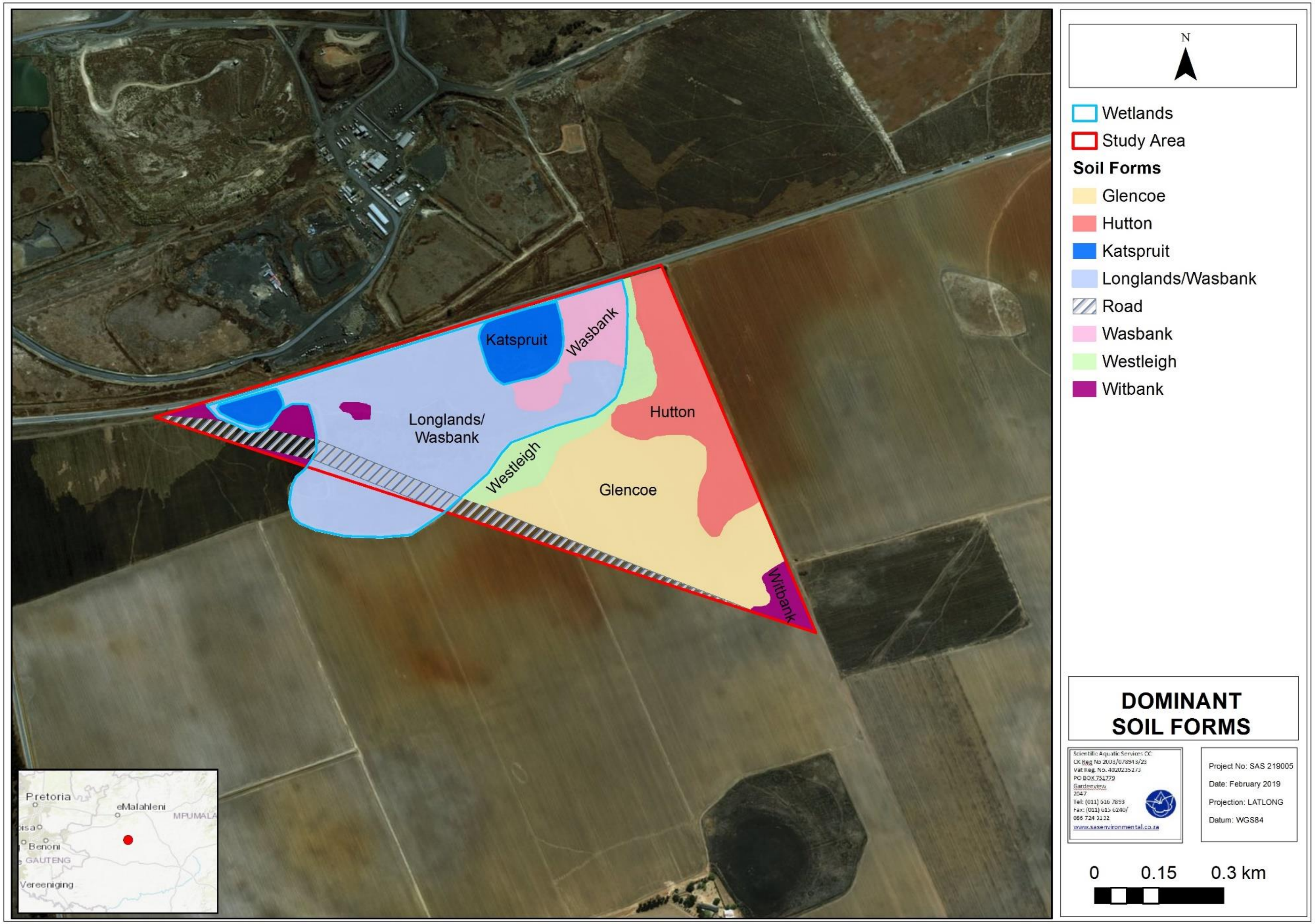

Figure 7: Map depicting spatial distribution of soils within the study area

5.1.1 Recharge Soils

Recharge soils are characterised by the absence of any morphological indication of saturation and are typically associated with deep, freely drained soils. The dominant hydrological pathway for these soils is vertical through and out the profile into the underlying bedrock. These soils are termed recharge soils, as they are likely to recharge groundwater, or lower lying positions in the regolith via fractured bedrock. The study area comprises both forms of recharge soils, with Hutton as recharge deep soil and Witbank (Anthrosols) soils as recharge shallow. Figure 8 illustrates the Hutton (Hu) soil form, a typical recharge soil identified within the study area.

Figure 8: Representative photographs of recharge soils with deep, well aerated and free draining characteristics.

5.1.2 Interflow (A/B) Soils

Interflow soils discharge in a predominantly lateral direction due to differences in the conductivity of horizons. The lateral flow occurs at the A/B horizon interface, due to the soft plinthic horizon restricting downward movement. The duration of the drainable water depends on rate of evapotranspiration (ET), position in the hillslope and slope. The interflow soils, as they contribute to the wetlands, are characterised by inherently poor internal drainage due to the slowly permeable underlying soft plinthite horizon. The lighter colour of the Albic horizon further supports that lateral flow dominates (Le Roux, *et al.,* 2015). The interflow (A/B) soils within the study area comprised Longlands, Wasbank and Westleigh soil forms, as illustrated in Figure 9 below. Spatial distribution of the soils within the study area is depicted in figure 7 above

Figure 9: Representative photographs of examples of the interflow soils in the A/B interface within the study area.

5.1.3 Interflow (Soil/Bedrock) soils

These soils are characterised by hydromorphic properties particularly mottling (red, yellow, and grey colours) which signify temporal accumulation of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction. The horizons are indicative that the underlying bedrock is slowly permeable and periodic saturation in the rainy season is likely, which may lead to lateral flow at the soil bedrock interface. Refer to Figure 10. The drainage may be restricted by a shallow impermeable rock layer (Le Roux, *et al.,* 2015).

Figure 10: An illustration of an interflow soil in the soil/bedrock interface within the study area.

5.1.4 Responsive (Saturated) Soils

Responsive soils include clayey Katspruit (Ka) soil form which display prominent signs of prolonged wetness (gleying) occurring within the permanent zone of the pan wetlands (refer to Table 4 and Figure 11). The morphological characteristics of the soils signify long periods of saturation (Le Roux, *et. al.,* 2015) and are essentially water receptors from the surrounding catchment, since they occur in the lowest points in the landscape setting. The high clay content of these soils prolongs the inundation (hydroperiod) of the wetlands by reducing the rate of lateral seepage while vertical movement of water in the soils does not occur. Spatial distribution of the soils within the study area is depicted in figure 7 above

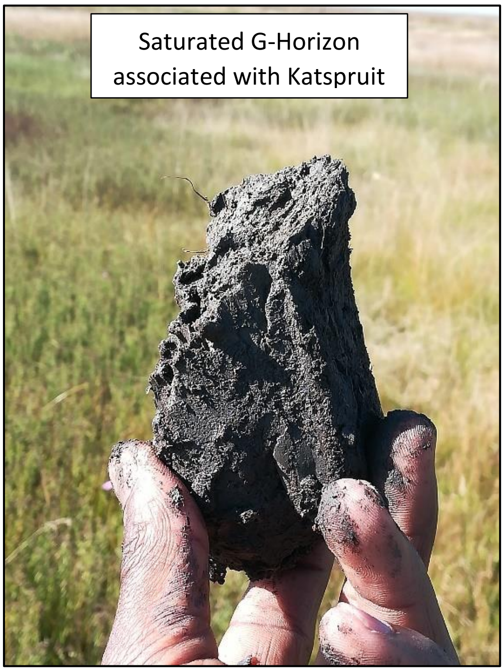

Figure 11: Representative photograph of the responsive saturated soils with impeded drainage characteristics.

5.2 Particle Size Distribution Analyses

Wetland hydrology is largely influenced by surrounding soil conditions as well as landscape position, amongst other factors. The ability of soils to recharge downstream wetlands and/or groundwater is mainly driven by the hydraulic conductivity, which is influenced by permeability according to particle size distribution (texture). The unsaturated flow potentially plays a pivotal role in the function of wetland systems, particularly if the wetlands are largely recharged by interflow.

The particle size distribution analyses indicate that the texture of the surrounding soils in the interflow zone are predominantly sandy clay loam with few soils classified as sandy loam and loamy sand and sand. Refer to Table 6 This suggests that permeability of the representative sampled soils in the interflow zone is moderately low, with a few soils comprising moderate and rapid permeability. Soils associated with the pan wetlands have a very low permeability due to the occurrence of high clay content soils. Even though these soils were not sampled, this is based on the knowledge and understanding of the soils obtained from similar studies which have been conducted by the hydropedologist on similar catenas. Permeability classes presented are according to the FAO (1980) and DWS (2011) permeability classification (refer to Table 2 and 3 under Section 2). For the purposes of this study, the DWS permeability classes were used, as these are considered more applicable and representative of South African soil transmissivity. The soil transmissivity classes are depicted in Figure 12 below.

Table 6: Textural classification of the dominant soil forms within the wetland catchment

<table>
<tr><th>Sampling point</th><th>Sampling Depth (cm)</th><th>Textural Class</th><th>Permeability Classes</th><th>FAO permeability (cm/day)</th><th>DWS permeability (cm/day)</th></tr>
<tr><td>1417</td><td>35 - 60</td><td rowspan="4">Sandy Clay Loam</td><td rowspan="4">Moderately Slow</td><td rowspan="4">31.104</td><td rowspan="4">31.104</td></tr>
<tr><td>1418</td><td>33 - 55</td></tr>
<tr><td>1423</td><td>30 - 48</td></tr>
<tr><td>1416</td><td>40 - 68</td></tr>
<tr><td>1421</td><td>38 – 90</td><td>Sandy Loam</td><td>Moderate</td><td>59.616</td><td>103.68</td></tr>
<tr><td>1428</td><td>0 - 32</td><td>Loamy Sand</td><td rowspan="2">Rapid</td><td rowspan="2">354.24</td><td rowspan="2">354.24</td></tr>
<tr><td>1412</td><td>0 - 100</td><td>Sand</td></tr>
</table>

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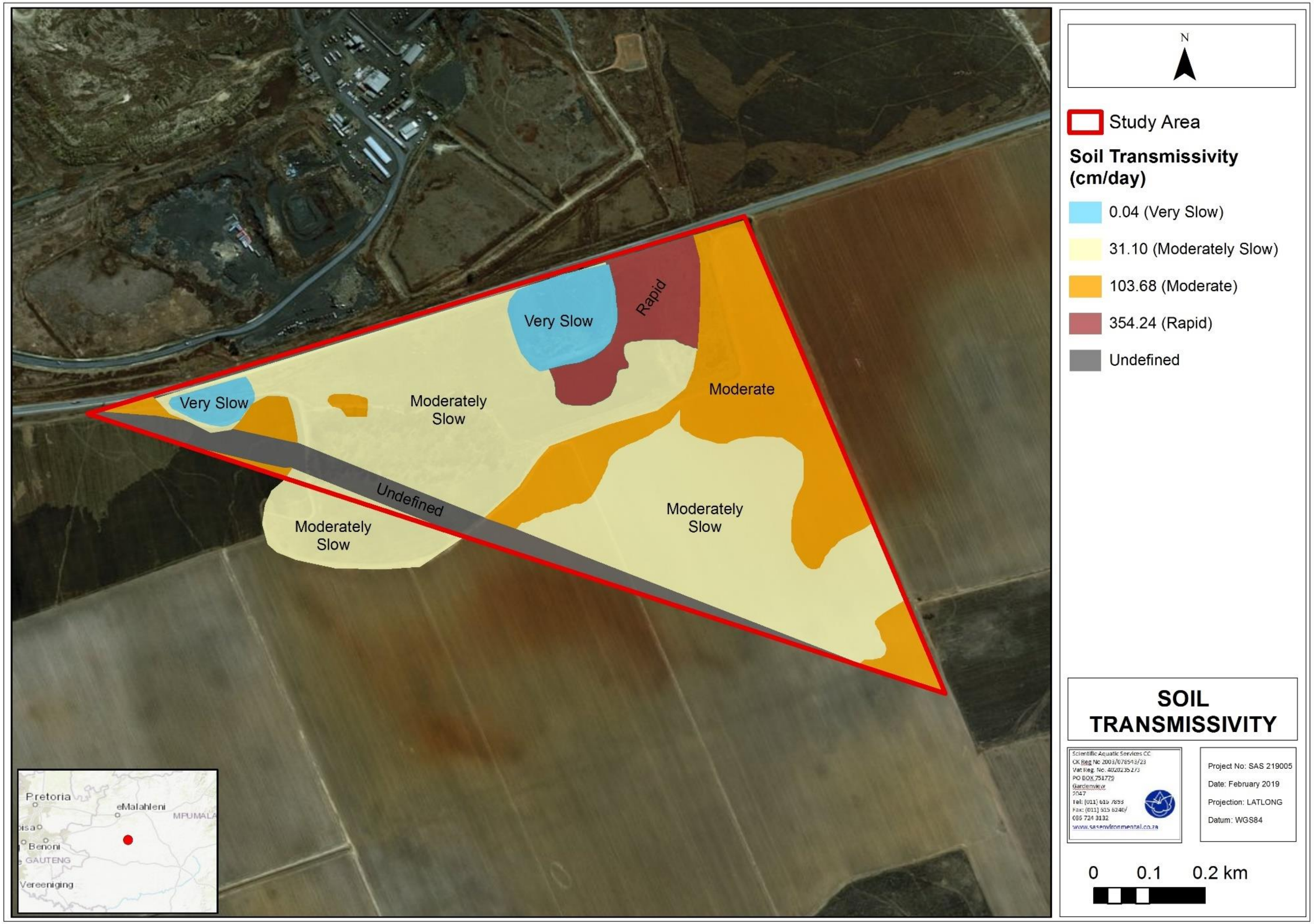

Figure 12: A map depicting soil transmissivity of the representative soil samples across the investigated wetland catchment (DWS, 2011).

5.3 Recharge of the Wetlands

The four primary wetland recharge mechanisms include precipitation (rainfall), surface flow (runoff), subsurface flow (interflow) through the vadose zone of the surrounding soils, and groundwater discharge.

The presence of a hillslope seep wetland on a plinthic catena indicates that the hillslope processes are significant for the recharge of these wetlands. It is also likely that the pans are fed by the hillslope seep as well the shallow aquifer to a degree, with hillslope processes being the dominant drivers of these wetlands. The contribution of overland flow and precipitation (rainfall) is considered significant during the rainy season. Table 7 presents the hydrological grouping of soils occurring within the study area according to Van Toll and Le Roux (2016). The conceptual wetland recharge based on the water flowpaths through the soil medium are presented in Table 8 below and Figure 13 depicts the hydrological soil types within the study area

Table 7: Hydrological grouping of soils occurring within the study area according to Van Toll and Le Roux (2016).

Recharge		Interflow		Responsive
Deep	**Shallow**	**A/B Horizon**	**Soil/Bedrock**	**Saturated**
Hutton	Witbank	Westleigh	Glencoe	Katspruit
		Longlands		
		Wasbank		

Table 8: List of soil forms within the study area and their relative contribution to wetland recharge.

Recharge Mechanism	Soil Forms	Diagnostic Horizons	Description
Recharge (Deep)	**Hutton (Hu)**	- A: Orthic - B1: Red Apedal - B2: Unspecified material	Relatively deep, loamy sand of poor structural stability, overlying red/light brown, and unspecified material. Vertical flow is dominant. These soils are referred to as recharge soils, as they are likely to recharge groundwater, or lower lying positions in the regolith, via the bedrock.
Recharge (Shallow))	**Witbank (Wb)**	Unspecified	Anthrosols which have been impacted to a degree that no diagnostic horizon can be identified.
Interflow (Soil/Bedrock)	**Glencoe (Gc)**	- A: Orthic - B1: Yellow Brown Apedal - Hard Plinthic	The horizons are indicative that the underlying bedrock is slowly permeable and periodic saturation in the rainy season is likely, which may lead to lateral flow at the soil bedrock interface. The drainage may be restricted by a shallow impermeable rock layer.

Recharge Mechanism	Soil Forms	Diagnostic Horizons	Description
Interflow (A/B)	**Longlands (Lo)**	- A: Orthic - B1: Albic - B2: Soft Plinthic	Characterised by a bleached E horizon indicating soil mineral exports by the process of eluviation, underlain by a relatively impermeable soft plinthic material. When the water level reaches the more permeable surface horizons lateral flow occurs at much faster rates at the A/B horizon interface.
	Wasbank (Wa)	- A: Orthic - B1: E Horizon - B2: Hard plinthic	Moderately shallow, sandy structured E horizon, overlying a relatively impermeable hard plinthic material.
Responsive (Saturated)	**Katspruit (Ka)**	- A: Orthic - G: Gleyed	Very poor recharge potential due to severe internal drainage constraints. These soils are saturated with water for most of the year such that poor drainage conditions have induced the development of the gleyed (G) horizon. The G-horizon is relatively impermeable, which impedes water movement (percolation) into the groundwater thereby retaining water in the wetlands.

Figure 13: Hydrological soil types within the study area.

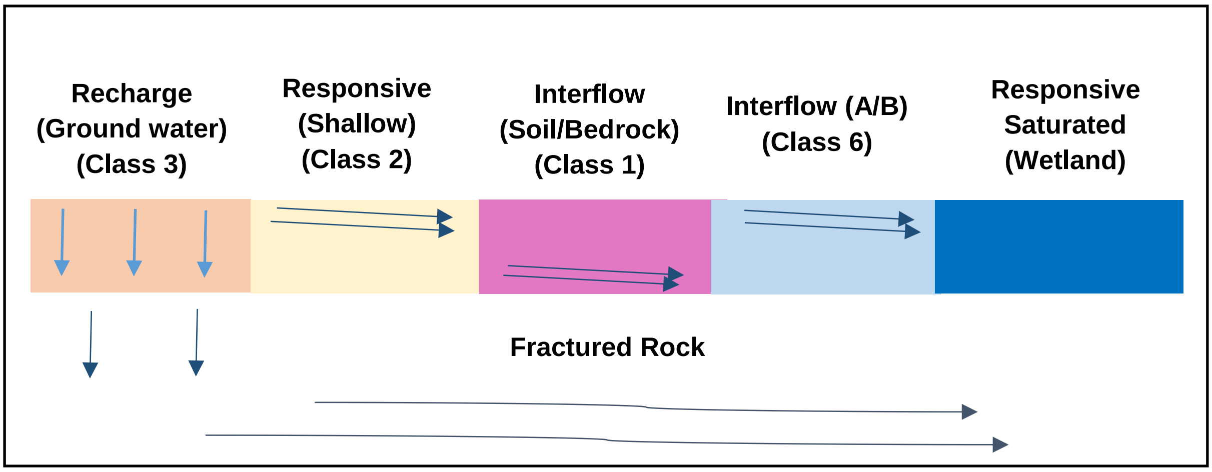

Figure 14: Hydrological responses in relation to the hydrological soil types within the study (Refer to Figure 13 above).

5.4 Hydro-pedological Implications

The wetlands which will be directly impacted upon by the proposed mining activities (i.e. mined out) will be destroyed as a result of the proposed activities, however the remaining portion of the hillslope seep located outside of the study area will likely remain functional and be sustained by water input, including hydropedological input from catchment areas to the south of the study area. Although the remaining portion of the hillslope seep will remain functional, mitigation measures are imperative, particularly reinstating the soil back to its original sequence and backfilling to a free draining scenario post mining to try and restore the natural hillslope processes.

The depth of the open cast mining may result in the formation of a cone of depression, pulling groundwater towards the open pit area over time. This may to lead to further alteration of the ecological integrity of the remaining wetland (i.e. the remaining portion of the hillslope seep). Figure 15 presents an example of interflow in a mining scenario within a soil profile which will lead to a cone of depression impact in the landscape.

Figure 15: An example of interflow in the subsoil indicated by the red circle

5.4.1 Buffer Determination Using Hydropedological Principles

Following the quantification of the anticipated hydropedological loss due to the proposed mining activities it was determined that there would be a significant impact on the adjacent wetlands which will be directly impacted by the proposed mining activities. In line with the latest thinking of the DWS it was deemed important to determine a suitable buffer to ensure that appropriate consideration is given to the proposed mining activities, the perceived impacts thereof on the affected wetlands and the associated hydropedological drivers in the study area, in support of the principles of Integrated Environmental Management (IEM) and sustainable development. Refer to Figure 17. The buffer was developed in such a way that no significant change in the PES of wetlands is likely to occur although limited impacts are nevertheless anticipated even if this buffer was strictly implemented. Additionally, residual impacts on the wetland will be limited from a hydropedological perspective should this buffer be implemented.

Table 9 presents the impact categories for describing the impact significance of the proposed mining activities on the wetlands and associated hydropedological drivers based on the hydrological principles used to calculate the anticipated percentage loss.

Table 9: Impact categories for describing the impact significance of the proposed mining activities on the wetlands and associated hydropedological drivers.

Severity	Soil Saturation Index Reduction	Change Class	Description
No Impact	0 – 2.5 %	No change	Hydropedological process are predicted to be unmodified and the functionality of the wetland will remain unchanged
Low	2.5 – 5 %	No Significant change	Small effect on the hydropedological process are predicted, however the functionality of the wetland remains unchanged and no change in resource class is expected.
Low to Moderate	5 – 10 %	Limited change with a change in PES category possible	A slight change in hydropedological processes is predicted and a small change in the in the wetland may have taken place but is change to the PES, EIS or wetland functionality and ecoservice provision is limited with no more than one PES class predicted.
Moderate	10 – 15 %	Significant change with a change in PES Category definite and possibly a change of more than one category	A moderate change in the hydropedological processes is predicted to occur, The change in PES may exceed one category but no change in EIS takes place. No loss of important ecoservices is predicted to occur
High	15 – 22.5 %	Very significant change with a change in PES of more than two categories	Modifications have reached a very significant level and the hydropedological processes are predicted to be largely modified with a large change in the PES, EIS of the wetland feature as well as a significant loss in ecoservice provision.
Very High	22.5 -60%	Serious to Critical change with a change in PES of more than three categories or a permanent complete loss of wetland resource	Modifications have reached a serious level and the hydropedological processes have been seriously modified with an almost complete loss of wetland integrity, functionality and service provision.

Figure 16: Rated wetland impact for wetland systems associated with the study area.

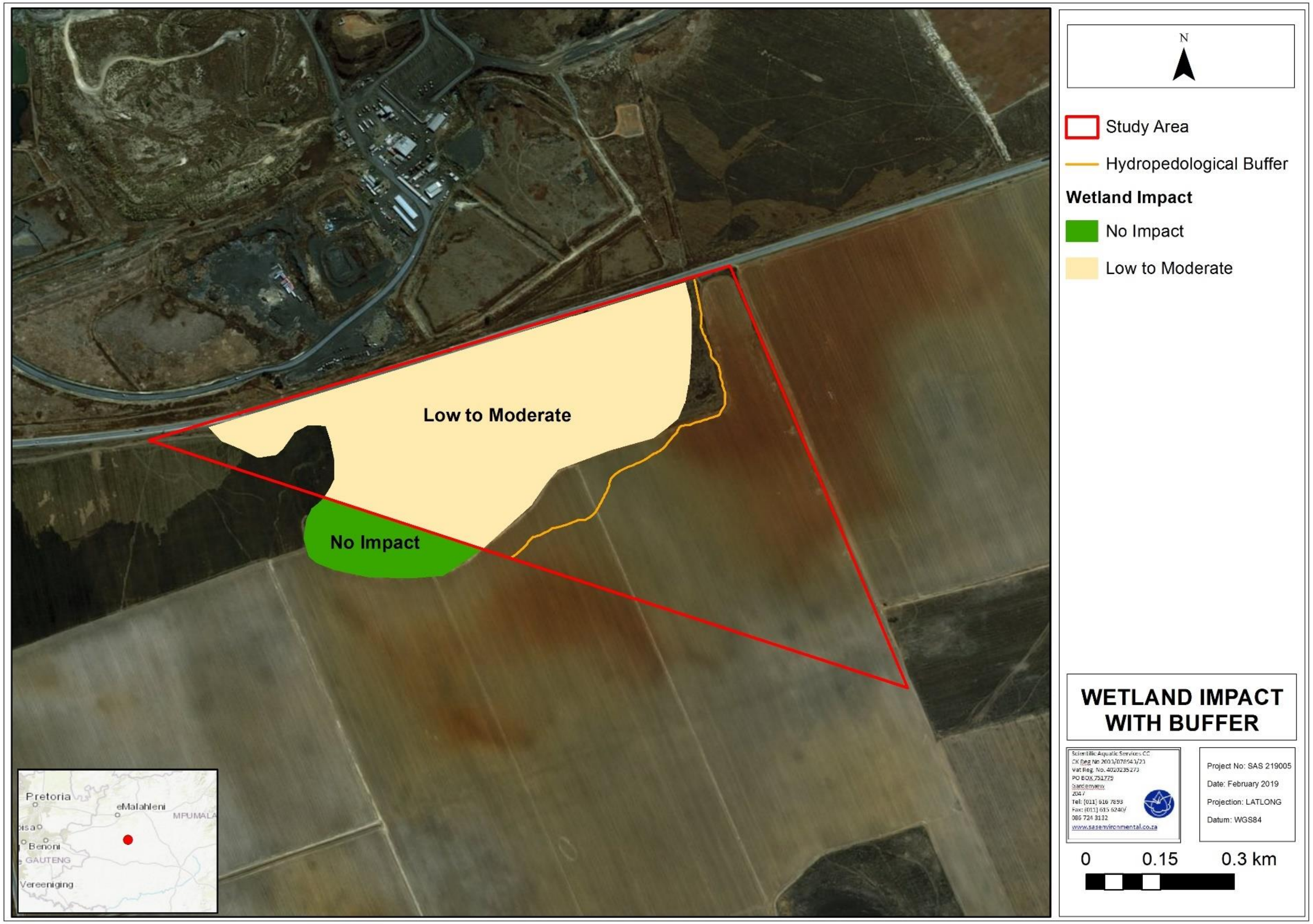

Figure 17: Rated wetland impact for wetland systems associated with the study area with a hydropedological buffer.

6 RISK ASSESSMENT

Following the calculation of the impact significance using hydrological principles, a DWS risk assessment approach was also applied. This section presents the significance of potential impacts on the affected wetlands within the study area and their associated hydropedological drivers. In addition, it indicates the required mitigatory measures required to minimise the perceived impacts of the proposed activities and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures and assuming that they are fully implemented.

The risk assessment was based on the information as provided by the proponent, which includes the following:

- The proposed opencast mining activities would entail the complete removal (i.e. mining out) of two (2) pan wetlands; and
- The proposed opencast mining activities would also entail the complete removal of a large portion of the hillslope seep wetland associated with the pan wetlands.

A summary of the risk assessment is provided in the table below.

Table 10: DWS Risk Assessment and mitigation measures applicable to the affected wetlands within the study area.

No.	Phases	Activity	Aspect	Impact	Severity	Spatial scale	Duration	Consequence	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
1	Construction	Site preparation prior to commencement of open cast mining, including placement of contractor laydown areas and storage facilities	*Vehicular movement and access to the site; *Removal and associated disturbances to wetland recharge soils and the wetlands; and *Possible unplanned and uncontrolled movement of construction equipment through the wetland recharge soils.	*Alteration to hydropedological flow paths, leading to degradation of wetlands and associated wetland recharge soils; *Exposure of soils, leading to increased runoff from cleared areas and erosion of the wetlands, and thus increased the potential for sedimentation of the wetlands; *Impacts on the hydropedological processes supporting the wetlands; and *Soil compaction.	5	2	2	9	10	90	M	80	*All development footprint areas to remain as small as possible and vegetation clearing to be limited to what is absolutely essential; *Retain as much indigenous vegetation as possible; *Exposed soils to be protected by means of a suitable covering; *It should be feasible to utilise existing roads to gain access to site, and crossing the wetlands in areas where no existing crossing is apparent should be unnecessary, but if it is essential crossings should be made at right angles.
2		Removal of topsoil material within wetlands and associated wetland recharge soils	*Excavation activities as part of open cast pit preparation	*Removal of wetland recharge soils and *Compaction of soil, leading to increased runoff rate and reduced infiltration.	5	1	5	11	16	176	H	80	*If possible vegetation clearing should be done in a phased manner to limit bare/exposed soils which are prone to erosion. *Exposed soils to be protected by suitable covering.

No.	Phases	Activity	Aspect	Impact	Severity	Spatial scale	Duration	Consequence	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
3		Operation of opencast mining activities.	Blasting and ore extraction from the open cast mining block area	*Complete loss of the wetlands located within the proposed opencast mining footprint; namely, two (2) pans and a large portion of the associated hillslope seep	**5**	**5**	**5**	**15**	**17**	**255**	**H**	**80**	Mining within the wetlands and associated wetland recharge soils should be strongly reconsidered
4	**Closure and Rehabilitation**	Rehabilitation of mining footprint areas (with specific focus on the open cast pit areas).	*Backfilling of the opencast pit area by using overburden from overburden stockpiles	Compacted soils, latent impacts of vegetation losses, causing: *Increased runoff volumes and formation of preferential surface flow paths as a result of compacted soils, leading to alteration of hydropedological flow paths, increased sedimentation and erosion.	**1**	**1**	**5**	**7**	**6**	**42**	**L**	**81**	*Should the proposed activities be authorised, concurrent rehabilitation is strongly recommended to ensure that the duration that any pit or extent thereof is left unrehabilitated is minimised; *Restrict the amount of mechanical handling of soils, as each excision increases the compaction level; *A very well designed, managed and executed topsoil (separate from soft overburden) management program is highly recommended where separate stripping, stockpiling and replacing of soil horizons [A (0-30 cm) and B (30-60 cm)] in the original natural sequence to combat hardsetting and compaction is ensured; *Separate stockpiling of different soils such that soils which are regarded as important for wetland recharge (i.e. Longlands, Wasbank and Glencoe) are separated from ground water recharge soils (i.e. Hutton); *Stockpile height should be restricted to that which can deposited without additional traversing by machinery. A maximum height of 2-3 m is therefore proposed, and the stockpile should be treated with temporary soil stabilisation methods.

7 CONCLUSIONS AND RECOMMENDATIONS

Scientific Aquatic Services (SAS) was appointed to conduct a hydropedological assessment as part of the Water Use Authorisation (WUA) process for the proposed expansion of the existing opencast mine at Exxaro Leeuwpan Coal Mine near Delmas, Mpumalanga Province.

The proposed mine expansion includes open cast mining through some wetlands. Thus, it was deemed necessary to investigate the recharge mechanism of the wetland systems within and in close proximity to the proposed mining activity areas to ensure informed mine design and planning as well as to support the decision-making process in line with the principles of sustainable development and Integrated Environmental Management.

According to the risk assessment conducted by Limosella Consulting (2018), the study area comprises three wetlands systems, two pan wetlands surrounded by a hillslope seep wetland. The results are summarised on the table below.

Table 11: Summary of the results of the assessments of the wetland systems occurring in study area (Limosella, 2018)

Wetland (HGM types)	PES Status	EIS
Pans	D (Largely modified)	C/D
Hillslope Seep	E (Seriously Modified)	

Based on the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) results presented above, the wetland systems have been impacted to some degree, owing to ongoing mining as well as current and historical agricultural activities within the catchment, vegetation clearing, and road infrastructure.

The presence of a hillslope seep surrounding the pan wetlands and the dominance of interflow soils may be indicative that hillslope processes are significant drivers of the wetlands within the study area. Furthermore, several geohydrological studies have reported on the presence of aquifers in the Mpumalanga coalfields, therefore it is highly likely that the wetlands are largely driven both by hillslope processes and shallow fractured aquifer/s which have a direct interaction with the wetlands, with specific mention of the pan wetlands. It should be noted that the presence of aquifers was not confirmed as part of this investigation, however, based on previous studies which have been conducted in a similar regional geological setting. The contribution of overland flow and precipitation (rainfall) is considered significant during rainy seasons due to limited rainfall days to generate adequate runoff to sustain the wetlands.

The hydropedological contribution to the wetland systems was calculated using simple hydrological principles in an effort to quantify the hydropedological percentage loss due to the proposed project both on a local and catchment scale. The impacts are summarised as follows:

- The wetlands located within the proposed open cast footprint will be completely destroyed since coal deposits underlie these wetlands as well as their associated flow drivers;
- The remaining portion of the hillslope seep located outside and upgradient of the study area will likely remain functional and be sustained by water input, including hydropedological input from catchment areas to the south of the study area, assuming that water input into this system is not intercepted for some unrelated reason;
- Although the remaining portion of hillslope seep will remain functional, mitigation measures are imperative, particularly reinstating the soil back to its original sequence and backfilling to a free draining scenario post mining to restore recharge to these drainage features and reduce the duration of impact;
- If the hydropedological processes in the landscape are considered, a scientifically derived buffer can be determined. The results of this determination are presented in Figure 17. The key principles of the plan are to avoid the Westleigh while the Glencoe is sacrificed along with the deep recharge Hutton soils. If the proposed mine plan was adapted to avoid this defined buffer, the loss of hydropedological contribution to the affected wetlands is calculated to be approximately 5.7% which will have a low to moderate impact on the wetlands which are then left unmined.

Key mitigation measures include:

- It is strongly recommended that concurrent rehabilitation be undertaken to ensure that the duration that any pit or extent thereof is left unrehabilitated is minimised;
- Restrict the amount of mechanical handling of soils, as each excision increases the compaction level;
- Separate stockpiling of different soils such that soils which are regarded as important for wetland recharge (i.e. Longlands, Wasbank, Westleigh, Glencoe) are separated from ground water recharge soils (i.e. Hutton);
- A very well designed, managed and executed topsoil (separate from soft overburden) management program is highly recommended where separate stripping, stockpiling and replacing of soil horizons in the original sequence to combat hard setting is ensured;

- The A (0-30cm) and B (30-60cm) horizons of topsoil should be stripped separately and replaced in the same sequence on top of the backfilled areas to ensure that the hydropedological functioning of wetland recharge soils is reinstated post mining;
- Stockpile height should be restricted to that which can deposited without additional traversing by machinery. A maximum height of 2-3 m is therefore proposed, and the stockpile should be treated with temporary soil stabilisation methods such are Geotextile; and
- At rehabilitation replace soil to appropriate soil depths in the correct order, and cover areas to achieve an appropriate topographic aspect and elevation profile so as to achieve a free draining landscape that is as close as possible the pre-mining conditions. Should this not be feasible, recommendations in the wetland report compiled by Limosella Consulting should be considered (Limosella, 2019).
-

Based on the findings of this study, the proposed project will lead to a high impact on the wetlands within the study area, particularly during the operational phase, since the wetlands will be mined. It should be noted however that from a hydropedological point of view, the proposed project is not anticipated to impact on surrounding wetlands located outside of the study area since they are not hydropedologically linked to wetlands associated with the proposed mine expansion.

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APPENDIX A: Legislation

LEGISLATIVE REQUIREMENTS

National Environmental Management Act (NEMA) (Act No. 107 of 1998)	The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations as amended in 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. Provincial regulations must also be considered.
National Water Act (NWA) (Act No. 36 of 1998)	The National Water Act (NWA) (Act 36 of 1998) recognises that the entire ecosystem and not just the water itself in 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 Department of Water and Sanitation (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) & (i).
General Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the NWA (Act 36 of 1998)	In accordance with Regulation GN509 of 2016, a regulated area of a watercourse for section 21c and 21i of the NWA, 1998 is defined as: a) 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; b) 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 c) A 500 m radius from the delineated boundary (extent) of any wetland or pan. This notice **replaces GN1199** and may be exercised as follows: i) Exercise the water use activities in terms of Section 21(c) and (i) of the Act as set out in the table below, subject to the conditions of this authorisation; ii) Use water in terms of section 21(c) or (i) of the Act if it has a low risk class as determines through the Risk Matrix; iii) Do maintenance with their existing lawful water use in terms of section 21(c) or (i) of the Act that has a LOW risk class as determined through the Risk Matrix; iv) Conduct river and stormwater management activities as contained in a river management plan; v) Conduct rehabilitation of wetlands or rivers where such rehabilitation activities has a LOW risk class as determined through the Risk Matrix; and vi) Conduct emergency work arising from an emergency situation or incident associated with the persons' existing lawful water use, provided that all work is executed and reported in the manner prescribed in the Emergency protocol. A General Authorisation (GA) issued as per this notice will require the proponent to adhere with specific conditions, rehabilitation criteria and monitoring and reporting programme. Furthermore, the water user must ensure that there is a sufficient budget to complete, rehabilitate and maintain the water use as set out in this GA. Upon completion of the registration, the responsible authority will provide a certificate of registration to the water user within 30 working days of the submission. On written receipt of a registration certificate from the Department, the person will be regarded as a registered water user and can commence within the water use as contemplated in the GA.
GN 704: Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999	These Regulations, forming part of the NWA, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining. It is recommended that the proposed project complies with Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that: *No person in control of a mine or activity may:* *(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or*

	within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become waterlogged, undermined, unstable or cracked; According to the above, the activity footprint must fall outside of the 1:100 year floodline of the aquatic resource or 100m from the edge of the resource, whichever distance is the greatest.
Mineral and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002)	The obtaining of a New Order Mining Right (NOMR) is governed by the MPRDA. The MPRDA requires the applicant to apply to the DMR for a NOMR which triggers a process of compliance with the various applicable sections of the MPRDA. The NOMR process requires environmental authorisation in terms of the MPRDA Regulations and specifically requires the preparation of a Scoping Report, an Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP), and a Public Participation Process (PPP).

APPENDIX B: Particle Size Analysis Results

WATERLAB

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CERTIFICATE OF ANALYSES
PARTICLE SIZE DISTRIBUTION [s]

Date received: 2019-01-11
Project number: 244
Report number: 79965
Date completed: 2019-01-23
Order number: Nsovo Mining

Client name: Scientific Aquatic Services
Address: 347 Highland Road, Kensington, 2094
Telephone: 011 616 7893
Fax: 086 724 3132
Contact person: Braveman Mzila
Email: brave@sasenvgroup.co.za
Cell: 078 152 6993

Analyses	Sample Identification
	1421
Sample Number	51890
Material Description	Quartzite & Ferricrete - Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	100
0.425 mm	92
0.075 mm	47
Hydrometer analysis (% Passing)	
59 µm	35
35 µm	31
14 µm	25
6 µm	23
2 µm	20
% Clay	23
% Silt	12
% Sand	65
% Gravel	0

Analyses	Sample Identification
	1428
Sample Number	51891
Material Description	Quartzite & Ferricrete – Silty Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	100
0.425 mm	89
0.075 mm	31
Hydrometer analysis (% Passing)	
57 µm	21
33 µm	15
13 µm	12
6 µm	10
2 µm	8
% Clay	10
% Silt	11
% Sand	79
% Gravel	0

Analyses	Sample Identification
	1418
Sample Number	51893
Material Description	Ferricrete – Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	95
2.00 mm	92
0.425 mm	86
0.075 mm	50
Hydrometer analysis (% Passing)	
60 µm	36
35 µm	32
14 µm	24
6 µm	20
2 µm	18
% Clay	20
% Silt	16
% Sand	56
% Gravel	8

Analyses	Sample Identification
	1417
Sample Number	51892
Material Description	Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	100
0.425 mm	94
0.075 mm	59
Hydrometer analysis (% Passing)	
54 µm	47
32 µm	43
13 µm	28
6 µm	24
2 µm	20
% Clay	24
% Silt	23
% Sand	53
% Gravel	0

Analyses	Sample Identification
	1423
Sample Number	51894
Material Description	Ferricrete – Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	99
5.0 mm	90
2.00 mm	89
0.425 mm	81
0.075 mm	37
Hydrometer analysis (% Passing)	
55 µm	24
32 µm	21
13 µm	17
6 µm	16
2 µm	14
% Clay	16
% Silt	8
% Sand	65
% Gravel	11

Analyses	Sample Identification
	1412
Sample Number	51896
Material Description	Ferricrete – Sandy Gravel
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	59
2.00 mm	40
0.425 mm	35
0.075 mm	22
Hydrometer analysis (% Passing)	
59 µm	18
35 µm	17
14 µm	13
6 µm	11
2 µm	9
% Clay	11
% Silt	7
% Sand	22
% Gravel	60

Analyses	Sample Identification
	1416
Sample Number	51895
Material Description	Silty Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	100
0.425 mm	95
0.075 mm	57
Hydrometer analysis (% Passing)	
59 µm	49
34 µm	43
14 µm	28
6 µm	24
2 µm	22
% Clay	24
% Silt	25
% Sand	51
% Gravel	0

Analyses	Sample Identification
	1420
Sample Number	**51897**
Material Description	Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	99
0.425 mm	94
0.075 mm	54
Hydrometer analysis (% Passing)	
57 µm	41
33 µm	39
13 µm	31
6 µm	28
2 µm	26
% Clay	28
% Silt	13
% Sand	58
% Gravel	1

APPENDIX C: Soil Moisture Content

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
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Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

Date received: 2019-01-11
Project number: 244
Report number: 79965
Date completed: 2019-01-23
Order number: Nsovo Mining

Client name: Scientific Aquatic Services
Address: 347 Highland Road, Kensington, 2094
Telephone: 011 616 7893
Fax: 086 724 3132
Contact person: Braveman Mzila
Email: brave@sasenvgroup.co.za
Cell: 078 152 6993

Analyses	Sample Identification	
	1421	1428
Sample number	51890	51891
Moisture %	10.2	7.6
Particle size distribution [s]	See attached report 79965 PSD	

Analyses	Sample Identification	
	1417	1418
Sample number	51892	51893
Moisture %	10.1	10.6
Particle size distribution [s]	See attached report 79965 PSD	

WATERLAB (PTY) LTD

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Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
PARTICLE SIZE DISTRIBUTION [s]

Date received: 2019-01-11
Project number: 244
Report number: 79965
Date completed: 2019-01-23
Order number: Nsovo Mining

Client name: Scientific Aquatic Services
Address: 347 Highland Road, Kensington, 2094
Telephone: 011 616 7893
Fax: 086 724 3132
Contact person: Braveman Mzila
Email: brave@sasenvgroup.co.za
Cell: 078 152 6993

Analyses	Sample Identification	
	1417	**1418**
Sample number	**51892**	**51893**
Moisture %	10.1	10.6
Particle size distribution [s]	See attached report 79965 PSD	

Analyses	Sample Identification	
	1423	**1416**
Sample number	**51894**	**51895**
Moisture %	9.0	13.2
Particle size distribution [s]	See attached report 79965 PSD	

Analyses	Sample Identification	
	1412	**1420**
Sample number	**51896**	**51897**
Moisture %	9.2	10.8
Particle size distribution [s]	See attached report 79965 PSD	

[s] = Subcontracted

APPENDIX D: Risk Assessment Methodology

In order for the EAP to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.

The first stage of the risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that is possessed by an organisation.
- An **environmental aspect** is an 'element of an organizations activities, products and services which can interact with the environment'[1]. The interaction of an aspect with the environment may result in an impact.
- **Environmental risks/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or wellbeing, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as freshwater features, flora and riverine systems.
- **Resources** include components of the biophysical environment.
- **Frequency of activity** refers to how often the proposed activity will take place.
- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor.
- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- **Spatial extent** refers to the geographical scale of the impact.
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria (refer to the table below). The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity, impact, legal issues and the detection of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 20. The values for likelihood and consequence of the impact are then read off a significance rating matrix and are used to determine whether mitigation is necessary[2].

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances, where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

"RISK ASSESSMENT KEY" (Based on DWS 2015 publication: Section 21 c and i water use Risk Assessment Protocol)

[1] The definition has been aligned with that used in the ISO 14001 Standard.

[2] Some risks/impacts that have low significance will however still require mitigation

Table D1 Severity (How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, habitat)

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.	

Table D2 Spatial Scale (How big is the area that the aspect is impacting on)

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighbouring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

Table D3: Duration (How long does the aspect impact on the resource quality)

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5
PES and EIS (sensitivity) must be considered.	

Table D4: Frequency of the activity (How often do you do the specific activity)

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

Table D5: The frequency of the incident or impact (How often does the activity impact on the resource quality)

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

Table D6: Legal issues (How is the activity governed by legislation)

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5
Located within the regulated areas	

Table D7: Detection (How quickly or easily can the impacts/risks of the activity be observed on the resource quality, people and resource)

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

Table D8: Rating Classes

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

A low risk class must be obtained for all activities to be considered for a GA

TableD9: Calculations

Consequence = Severity + Spatial Scale + Duration
Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection
Significance\Risk = Consequence X Likelihood

The following points were considered when undertaking the assessment:

- Risks and impacts were analysed in the context of the *project's area of influence* encompassing:
  - Primary project site and related facilities that the client and its contractors develops or controls;
  - Areas potentially impacted by cumulative impacts for further planned development of the project, any existing project or condition and other project-related developments; and
  - Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.
- Risks/Impacts were assessed for construction phase and operational phase; and
- Individuals or groups who may be differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status were assessed.

Control Measure Development

The following points presents the key concepts considered in the development of mitigation measures for the proposed construction:

- Mitigation and performance improvement measures and actions that address the risks and impacts[3] are identified and described in as much detail as possible. Mitigating measures are investigated according to the impact minimisation hierarchy as follows:
  - Avoidance or prevention of impact;
  - Minimisation of impact;
  - Rehabilitation; and
  - Offsetting.
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation; and
- Desired outcomes are defined, and have been developed in such a way as to be measurable events with performance indicators, targets and acceptable criteria that can be tracked over defined periods, wherever possible.

Recommendations

Recommendations were developed to address and mitigate potential impacts on the freshwater ecology of the resources in traversed by or in close proximity of the proposed infrastructure.

[3] Mitigation measures should address both positive and negative impacts

APPENDIX E: Specialist Information

1. (a) (i) Details of the specialist who prepared the report

Stephen van Staden MSc (Environmental Management) (University of Johannesburg)

Braveman Mzila BSc (Hons) Hydrology University of KwaZulu-Natal

1. (a). (ii) The expertise of that specialist to compile a specialist report including a curriculum vitae

Company of Specialist:	Scientific Aquatic Services		
Name / Contact person:	Stephen van Staden		
Postal address:	29 Arterial Road West, Oriel, Bedfordview		
Postal code:	2007	Cell:	083 415 2356
Telephone:	011 616 7893	Fax:	011 615 6240/ 086 724 3132
E-mail:	stephen@sasenvgroup.co.za		
Qualifications	MSc (Environmental Management) (University of Johannesburg) BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)		
Registration / Associations	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP) Accredited River Health practitioner by the South African River Health Program (RHP) Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum		

1. (b) a declaration that the specialist is independent in a form as may be specified by the competent authority

I, Stephen van Staden, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

----

Signature of the Specialist

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION
CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Managing member, Ecologist with focus on Freshwater Ecology
Date of Birth	13 July 1979
Nationality	South African
Languages	English, Afrikaans
Joined SAS	2003 (year of establishment)
Other Business	Trustee of the Serenity Property Trust and emerald Management Trust

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP);
Accredited River Health practitioner by the South African River Health Program (RHP);
Member of the South African Soil Surveyors Association (SASSO);
Member of the Gauteng Wetland Forum;
Member of International Association of Impact Assessors (IAIA) South Africa;
Member pf the Land Rehabilitation Society of South Africa (LaRSSA)

EDUCATION

Qualifications

MSc (Environmental Management) (University of Johannesburg)	2003
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2001
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	2000
Tools for wetland Assessment short course Rhodes University	2016

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces
Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe Zambia
Eastern Africa – Tanzania Mauritius
West Africa – Ghana, Liberia, Angola, Guinea Bissau, Nigeria, Sierra Leone
Central Africa – Democratic Republic of the Congo

PROJECT EXPERIENCE (Over 2500 projects executed with varying degrees of involvement)

1 Mining Coal, Chrome, PGM's, Mineral Sands, Gold, Phosphate, river sand, clay, fluorspar
2 Linear developments
3 Energy Transmission, telecommunication, pipelines, roads
4 Minerals beneficiation
5 Renewable energy (wind and solar)
6 Commercial development
7 Residential development
8 Agriculture
9 Industrial/chemical

REFERENCES

- Terry Calmeyer (Former Chairperson of IAIA SA)
  Director: ILISO Consulting Environmental Management (Pty) Ltd
  Tel: +27 (0) 11 465 2163
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- Alex Pheiffer
  African Environmental Management Operations Manager
  SLR Consulting
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- Marietjie Eksteen
  Managing Director: Jacana Environmental
  Tel: 015 291 4015

Yours faithfully

Staden

STEPHEN VAN STADEN

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF BRAVEMAN MZILA

PERSONAL DETAILS

Position in Company	Wetland Ecologist and Soil Scientist
Date of Birth	03 January 1991
Nationality	South African
Languages	IsiZulu, English
Joined SAS	2017

EDUCATION

Qualifications

BSc (Hons) Environmental Hydrology (University of KwaZulu-Natal)	2013
BSc Hydrology and Soil Science (University of KwaZulu-Natal))	2012

COUNTRIES OF WORK EXPERIENCE

South Africa – Gauteng, KwaZulu-Natal, Eastern Cape

SELECTED PROJECT EXAMPLES

Freshwater Ecological Assessments

- Freshwater ecological assessment as part of the water use authorisation relating to stormwater damage of a tributary of the Sandspruit, Norwood, Gauteng province.
- Wetland verification as part of the environmental assessment and authorization process for the proposed development in Crowthorne extension 67, Gauteng province.
- Freshwater assessment as part of the section 24g rectification process for unauthorised construction related activities that took place on erf 411, Ruimsig extension 9, Gauteng province
- Baseline aquatic and freshwater assessment as part of the environmental assessment and authorisation process for the N11 Ring Road, Mokopane, Limpopo Province
- Wetland Resource Scoping Assessment as Part of The Environmental Assessment and Authorisation Process for The Kitwe TSF Reclamation Project, Kitwe, Zambia
- Wetland delineation as part of the environmental assessment and authorization process for the proposed development in Boden Road, Benoni, Ekurhuleni Metropolitan Municipality, Gauteng Province.

Soil, Land Use and Land Capability Assessments

- Soil, Land Use and Land Capability Assessment as part of the environmental assessment and authorisation process for the proposed Witfontein Railway Siding Project Near Bethal, Mpumalanga Province
- Soil, Land Use and Land Capability Assessment as part of the environmental assessment and authorisation process for the proposed Hueningkranz Mine, Postmasburg, Northern Cape Province

Hydropedological Wetland Impact Assessments

- Hydropedological Assessment as Part of The Environmental Assessment and Authorisation Process for the proposed Vandyksdrift Central Dewatering Project
- Hydropedological Assessment for the Proposed Evander Gold Elikhulu Tailings Storage Facility (TSF) Expansion, Mpumalanga Province

- Hydropedological Assessment as part of the environmental assessment and authorisation process for the proposed Palmietkuilen Mine, Springs, Gauteng Province
- Hydropedological Assessment as part of the environmental assessment and authorisation process for the proposed Uitkomst Colliery Mine expansion, Newcastle, KwaZulu-Natal Province

Soil Rehabilitation Assessments

- Soil rehabilitation plan, a water resource assessment and develop a management plan in support of the water use licence for the Driefontein operations, Carletonville, Gauteng