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HYDROPEDOLOGICAL ASSESSMENT PROCESS FOR THE PROPOSED RIETKOL MINING OPERATIONS NEAR DELMAS WITHIN THE MPUMALANGA PROVINCE

Prepared for

Jacana Environmentals CC

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SAS Environmental Group of Companies

DOCUMENT GUIDE

The table below provides the specialist report requirements for the assessment and reporting of impacts on aquatic biodiversity in terms of Government Notice 648 as promulgated in Government Gazette 45421 of 2019 in line with the Department of Environmental Affairs screening tool requirements, as it relates to the National Environmental Management Act, 1998 (Act No. 107 of 1998).

No.	Requirements	Section in report
2.1	Assessment must be undertaken by a suitably qualified SACNASP registered specialist	Appendix A
2.2	Description of the preferred development site , including the following aspects-	Section 1.1
2.2.1	a. Aquatic ecosystem type b. Presence of aquatic species and composition of aquatic species communities, their habitat, distribution and movement patterns	Section 4
2.2.2	Threat status, according to the national web based environmental screening tool of the species and ecosystems, including listed ecosystems as well as locally important habitat types identified	Section 4
2.2.3	National and Provincial priority status of the aquatic ecosystem (i.e. is this a wetland or river Freshwater Ecosystem Priority Area (FEPA), a FEPA sub- catchment, a Strategic Water Source Area (SWSA), a priority estuary, whether or not they are free-flowing rivers, wetland clusters, etc., a CBA or an ESA; including for all a description of the criteria for their given status	Section 4
2.2.4	A description of the Ecological Importance and Sensitivity of the aquatic ecosystem including: a. The description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); b. The historic ecological condition (reference) as well as Present Ecological State (PES) of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel, flow regime (surface and groundwater)	Section 4
2.3	Identify any alternative development footprints within the preferred development site which would be of a "low" sensitivity as identified by the national web based environmental screening tool and verified through the Initial Site Sensitivity Verification	Section 5.3
2.4	Assessment of impacts - a detailed assessment of the potential impact(s) of the proposed development on the following very high sensitivity areas/ features:	Section 5.3
2.4.1	Is the development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Section 5.3
2.4.2	Is the development consistent with maintaining the Resource Quality Objectives for the aquatic ecosystems present?	Section 5 and 6
2.4.3	How will the development impact on fixed and dynamic ecological processes that operate within or across the site, including: a. Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); b. Change in the sediment regime (e.g. sand movement, meandering river mouth/estuary, changing flooding or sedimentation patterns) of the aquatic ecosystem and its sub-catchment; c. The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). d. Assessment of the risks associated with water use/s and related activities.	Section 5
2.4.4	How will the development impact on the functionality of the aquatic feature including: a. Base flows (e.g. too little/too much water in terms of characteristics and requirements of system); b. Quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over abstraction or instream or off-stream impoundment of a wetland or river); c. Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an Unchannelled valley-bottom wetland to a channelled valley-bottom wetland);	Section 6

	d. Quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); and e. Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).	
2.4.5	How will the development impact on the functionality of the aquatic feature including: a. water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river) b. Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an Unchannelled valley-bottom wetland to a channelled valley-bottom wetland). c. Quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); d. Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); e. The loss or degradation of all or part of any unique or important features (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.) associated with or within the aquatic ecosystem.	Section 6
2.4.6	How will the development impact on key ecosystem regulating and supporting services especially Flood attenuation; Streamflow regulation; Sediment trapping; Phosphate assimilation; Nitrate assimilation; Toxicant assimilation; Erosion control; and Carbon storage.	Section5 and 6
2.4.7	How will the development impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	Section 5 and 6
2.4.9	A motivation must be provided if there were development footprints identified as per paragraph 2.3 above that were identified as having a "low" biodiversity sensitivity and were not considered appropriate.	Section 5 and 6
3.	The report must contain as a minimum the following information:	
3.1	Contact details and curriculum vitae of the specialist including SACNASP registration number and field of expertise and their curriculum vitae;	Appendix A
3.2	A signed statement of independence by the specialist;	Appendix A
3.3	The duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 2
3.4	The methodology used to undertake the impact assessment and site inspection, including equipment and modelling used, where relevant;	Section 2
3.5	A description of the assumptions made and any uncertainties or gaps in knowledge or data as well as a statement of the timing and intensity of site inspection observations;	Section 1.3
3.6	Areas not suitable for development, to be avoided during construction and operation (where relevant);	Section 5.3
3.7	Additional environmental impacts expected from the proposed development based on those already evident on the site and a discussion on the cumulative impacts;	Section 5.3.3
3.8	A suitable construction and operational buffer for the aquatic ecosystem, using the accepted protocol;	Section 5.3.2
3.9	Impact management actions and impact management outcomes proposed by the specialist for inclusion in the EMPr;	Section 5.3.3
3.10	A motivation where the development footprint identified as per 2.3 were not considered stating reasons why these were not being not considered; and	None
3.11	A reasoned opinion, based on the finding of the specialist assessment, regarding the acceptability or not, of the development and if the development should receive approval, and any conditions to which the statement is subjected.	Section 6
3.12	A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.	Section 6
3.13	Proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr).	Section 7
3.14	A motivation must be provided if there were development footprints identified as per paragraph 2.3 for reporting in terms of Section 24(5)(a) and (h) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) that were identified as having a "low" aquatic biodiversity and sensitivity and that were not considered appropriate.	None.

3.15	A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not.	Section 6
3.16	Any conditions to which this statement is subjected.	Section 7

EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) cc was appointed by Jacana Environmentals CC to conduct a hydropedological assessment for the Rietkol, as part of the authorisation process for the proposed mining and related activities, where mining of silica through opencast methods will occur.

The proposed activities will entail deep excavation activities for the reclamation of the silica deposit, which may indirectly impact on some watercourses as well as potentially intercept the subsurface flows in the vadose zone feeding the watercourses. It was deemed necessary to investigate the recharge mechanisms of the watercourses and define the hydropedological responses of the various soils within the immediate catchments of the watercourse associated with the study area. This study is deemed necessary to ensure that development planning takes cognisance of the hydropedologically important areas and hence enable informed decision making, construction design and with the aim to guide the mine design in support of the principles of sustainable development and Integrated Environmental Management.

The objective of this study was to:

- Investigate the hydropedological drivers of the watercourse;
- Determine the risk of the proposed activities on the freshwater feature; and
- Define the developable areas from a hydropedological point of view taking into consideration the findings of other relevant studies.

It is deemed important to understand the status of the affected watercourses in terms of their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) to ensure that the necessary protection is afforded. According to the wetland assessment conducted by SAS (2018 updated in May 2021);

- The Mining Right Application (MRA) area is characterised by several wetlands systems including hillslope seeps and a depression pan wetland; and
- The overall Present Ecological State (PES) of these wetland systems ranges between moderately modified (C/D) and largely modified (D), refer to Table below.

Table A: Present Ecological Status of the wetland systems occurring in MRA area (SAS, 2018 Updated in May 2021)

Wetland (HGM types)	PES Status
Pan	Category: C (Moderately modified)
Hillslope Seep Wetlands	Category: D (Largely modified)

The wetlands are mainly recharged by surface water from seasonal rainfall as well as subsurface flow. According to the hydrocensus report, the ground water levels around the MRA area varies between ±10 and 100 mbs (Groundwater Complete, 2021). Therefore, the ground water is not anticipated to have a significant direct interaction with the surface and shallow sub-surface hydrogeological processes.

Following the quantification of percentage losses using the QSWAT+ model, it was concluded that the major losses at a finer scale [Hydropedological Response Unit (HRU)] are through evapotranspiration. At this scale the impact on the profile available water is decreased to -6%. From a hydropedological point of view, this will not lead to a change in the functionality and PES/EIS status of the affected wetlands once all mitigation measures recommended in this report have been put in place. Table B below presents the summary of the anticipated soil water profile losses at an HRU scale. Detailed results are presented in 6.4.

Table B: Summary of the soil profile water losses at a Hydropedological Response Unit Scale (HRU)

	Before	After	Change
Profile available water	32.1	30.2	-6.0
Topsoil available water	11.5	9.9	-14.0

From a hydropedological point of view, no significant impact is foreseen on the wetland systems due to proposed mining and related activities (during all phases) since the soil resources where the proposed project is to occur are not regarded as drivers of the wetland systems. Most of the opencast as well as surface infrastructure occur on shallow responsive and recharge deep soils which contribute to surface runoff and groundwater respectively.

Given the above findings, the proposed project is considered acceptable from a hydropedological impact perspective and will not lead to a significant impact on the receiving freshwater resources, both locally and regionally, provided that the outcome of this study, as well as mitigation measures outlined in this document, are used as a guideline to manage water in the landscape surrounding the proposed mine.

Keys, recommendations have been developed in the points below to minimise impact on hydropedological processes:

- Divert surface flow away from the pit areas;
- Water from the clean surfaces associated with the pits should be diverted and discharged back into the adjacent wetland systems in an attenuated manner;
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the wetlands adjacent to the proposed project;
- At closure, reinstate the soil to pre mining landscape (as far as practically possible) which is free draining to ensure that the surface runoff contributes to the adjacent wetlands that may be indirectly impacted during the construction and operational phase of the development;
- The pits should be rehabilitated progressively (if feasible) to limit the water losses to ensure that the PES category remains unchanged;
- Excavation activities and removal of topsoil out of the demarcated areas should be avoided as far as practically possible to limit the footprint area that will be impacted; and
- Following the completion of the construction phase, areas of disturbance should be monitored at least once after an erosive rainfall for erosion arising from the surface which leads to concentrated flow and changes to the pattern flow and timing of water in the landscape.

Based on the outcomes of the modelling and recharge loss quantification exercise the proposed mining development will have a limited impact at a local scale from a hydrological perspective. Edge effects which compromise the hydropedological function of adjacent soils such as the effects of roadways and bulk earthworks which alter vadose zone water movement must be appropriately managed in line with the mitigation hierarchy as defined by the DEA.

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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 flow 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.
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.
Pedology	The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.
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
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.
Swelling clay:	Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried.
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
Stream	A stream is a body of water with surface water flowing within the bed and banks of a channel. The flow of a stream is controlled by three inputs – surface water, subsurface water and groundwater.
Channel	Channel is a type of landform consisting of the outline of a path of relatively shallow and narrow body of fluid, most commonly the confine of a river, river delta or strait.

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

1.1 *Project Background*

Scientific Aquatic Services (SAS) cc was appointed by Jacana Environmentals CC to conduct a hydropedological assessment for the Rietkol Mining Operation (Rietkol Project), as part of the environmental assessment and authorisation process for the proposed mining operation, where mining of silica through opencast methods will occur. The Rietkol Project is located in Wards 8 and 9 of the Victor Khanye Local Municipality within the Nkangala District Municipality of Mpumalanga Province. Delmas Botleng are approximately 6 km east and Eloff 4 km south of the Mining Right Application (MRA) area. The Rietkol Project is located strategically close to major roads in the area, including the N12 (to the north-west), R50 (to the north-east) and R555 (to the south). The Springs/Durban Transnet Freight Rail (TFR) railway line is situated to the south, alongside the R555.

The Rietkol MRA area covers an area of 221 ha consisting of:

- 16 Modder East Agricultural Holdings on the farm Olifantsfontein 196 IR, each approximately 4.1 ha in extent;
- Portion 71 of the farm Rietkol 237 IR; and
- A portion of Remaining Extent (RE) of portion 31 of the farm Rietkol 237 IR.

1.2 *Project Description*

Silica is planned to be mined by means of conventional opencast methods to a depth of between 30 and 50 meters below surface (mbs). The estimated life of mine (LOM) for the proposed Rietkol Project is 20 years. Further exploration drilling will be conducted during the operational phase, which may increase the LOM and mining depth if the resource proves viable.

The proposed project includes the following mining and related infrastructure:

- Opencast pits;
- Processing plant (i.e. crushing, wash plant, screening, etc.);
- Product stockpiles;
- Administration office facilities (i.e. security building, administration and staff offices, reception area, ablution facilities, etc.);
- Access roads; and
- Clean and dirty water management infrastructure.

The objective of this study was to:

- Investigate the hydropedological drivers of the watercourse;
- Determine the risk of the proposed activities on the freshwater feature; and
- Define the developable areas from a hydropedological point of view taking into consideration the findings of other relevant studies.

A soil survey and sampling activities were conducted in April 2018 and May 2021 to assess the hydro-pedological characteristics of the landscape and associated soils within the MRA area. A soil classification assessment and soil sampling was conducted at selected representative points of the various soil types, in order to infer the wetland recharge potential and identify the anticipated hydropedological impacts of the proposed mine developments on the wetland resources that will be affected by the proposed developments. Wetland as well as soil and land capability studies were undertaken as part of the Rietkol Project.

1.3 *Site Sensitivity Verification Statement*

Nhlabathi applied for a Mining Right to mine silica in February 2018 and commenced with the Environmental Impact Assessment (EIA) process as contemplated in the National Environmental Management Act 107 of 1998 (NEMA) and Government Notice (GN) No. R. 982-986 of 4 December 2014: NEMA: Environmental Impact Assessment Regulations, as amended (2014 EIA Regulations), for the Rietkol Project.

Several specialist studies were conducted within the Mining Right Application (MRA) area in support of the EIA process, and a comprehensive Public Participation process was initiated. The Final Scoping Report was submitted on 3 April 2018 and accepted by the Department of Mineral Resources and Energy (DMRE) on 26 April 2018. However, the MRA was rejected by the DMRE Mpumalanga Mine Economics Directorate on the basis that the MRA formed part of another right granted in terms of the MPRDA. This decision resulted in a delay in the EIA process, ultimately causing the application for Environmental Authorisation to lapse.

Nhlabathi has recently re-initiated the MRA process and applied for a Mining Right over the same farm portions in early 2020. The MRA was accepted by the DMRE on 21 January 2021 and Nhlabathi has since re-initiated the EIA process with Jacana Environmentals cc (Jacana) appointed as the independent Environmental Assessment Practitioner (EAP).

Several additional requirements when applying for Environmental Authorisation (EA) have emerged since the 2018 EIA process, including but not limited to:

1. Notice was given in Government Notice No. 960 (GN 960) dated 5 July 2019 of the requirement to submit a report generated by the National Web Based Environmental Screening Tool in terms of section 24(5)(h) of the NEMA and regulation 16(1)(b)(v) of the 2014 EIA Regulations. Such a Screening Rreport became compulsory when applying for an EA 90 days from publication of GN 960 (5 October 2019). The purpose of the Screening Report is to identify the list of specialist assessments that needs to be conducted in support of the EA application, based on the selected classification, and the environmental sensitivities of the proposed development footprint.
2. Government Notice No. 320 (GN 320) dated 20 March 2020 prescribes general requirements for undertaking site sensitivity verification and for protocols for the assessment and minimum report content requirements of environmental impacts for environmental themes for activities requiring EA in terms of sections 24(5)(a), (h) and 44 of NEMA. These procedures and requirements came into effect 50 days after publication of GN 320 (15 May 2020). The purpose of the site sensitivity verification is to verify (confirm or dispute) the current use of the land and the environmental sensitivity of the site under consideration as identified in the Screening Report. This will determine the level of assessment required for each environmental theme, i.e. Specialist Assessment or Compliance Statement.

As indicated above, several specialist studies were commissioned for the Rietkol Project during 2016-2018 in support of the previous application, including:

- Soils, land use and capability, Hydropedology;
- Terrestrial / Aquatic Biodiversity;
- Groundwater;
- Air Quality;
- Ambient Noise;
- Blasting & Vibration;
- Traffic;
- Heritage and Cultural Resources;
- Palaeontology;
- Visual and Aesthetics;
- Social;
- Hazard Identification and Risk Assessment (HIRA); and
- Land Trade-off & Macro-Economic Analysis.

Comprehensive specialist assessments were conducted for all the environmental and social themes listed above, irrespective of the sensitivity identified by the specialist assessment (2018) or the Screening Report. Therefore, no site sensitivity verification has been done for this EA application as all themes have been considered to have a **high to very high sensitivity**, requiring a full Specialist Assessment.

The list of specialist assessments listed in the Screening Report and the extent to which it has been addressed in the re-application for EA for the Rietkol Project is indicated below. Where applicable, motivation is provided for the exclusion of certain specialist assessments.

GN 960 requirement	Extent to which it is included in the Plan of Study
Agricultural Impact Assessment	Soil and Land Capability Assessment by Scientific Aquatic Services.
Landscape/Visual Impact Assessment	Visual Impact Assessment by Scientific Aquatic Services.
Archaeological and Cultural Heritage Impact Assessment	Phase 1 Heritage Impact Assessment by R&R Cultural Resource Consultants.
Palaeontology Impact Assessment	Palaeontology Impact Assessment by ASG Geo Consultants (Pty) Ltd {Dr Gideon Groenewald}.
Terrestrial Biodiversity Impact Assessment	Faunal, Floral and Freshwater Assessment by Scientific Terrestrial Services.
Aquatic Biodiversity Impact Assessment	Faunal, Floral and Freshwater Assessment by Scientific Terrestrial Services.
Hydrology Assessment	Baseline Water Quality Assessment by Scientific Aquatic Services. Water Management Plan – Preliminary Design Report by Onno Fortuin Consulting.
Noise Impact Assessment	Environmental Noise Impact Assessment by Enviro Acoustic Research.
Radioactivity Impact Assessment	Waste Classification by Groundwater Complete. Analysis will include Uranium and Thorium to determine potential for radioactivity within the resource.
Traffic Impact Assessment	Traffic Impact Assessment by Avzcons Civil Engineering Consultant.
Geotechnical Assessment	A geotechnical assessment will be undertaken as part of the engineering package for the project, if required. This is not included in the application for EA.
Climate Impact Assessment	A greenhouse gas emissions statement is included in the Air Quality Impact Assessment by EBS Advisory.
Health Impact Assessment	Hazard Identification and Risk Assessment by AirCheck Occupational Health, Environmental & Training Services.
Socio-Economic Assessment	Socio-Economic Impact Assessment by Diphororo Development.
Ambient Air Quality Impact Assessment	Air Quality Impact Assessment by EBS Advisory.

GN 960 requirement	Extent to which it is included in the Plan of Study
Seismicity Assessment	A Blasting Impact Assessment is included and has been conducted by Blast Management Consulting. It deals extensively with the potential impact in respect of air blast and vibration from blasting operations.
Plant Species Assessment	Part of Terrestrial Biodiversity Impact Assessment.
Animal Species Assessment	Part of Terrestrial Biodiversity Impact Assessment.

Further studies that are not included in the GN 960 requirements, but were commissioned for the Rietkol Project, are:

- Hydropedological Assessment by Scientific Aquatic Services.
- Geohydrological Investigation by Groundwater Complete.
- Blasting Impact Assessment by Blast Management Consulting.
- Land Trade-off Study and Macro-Economic Impact Analysis by Mosaka Economic Consultants.
- Rehabilitation, Decommissioning and Closure Plan by Jacana Environmentals.

Where a specific environmental theme protocol has been prescribed by GN 320, the specialist assessment will adhere to such protocol. Where no protocol has been prescribed, the report will comply with Appendix 6 of the EIA Regulations

Figure 1: Locality map of the proposed mining and related activities

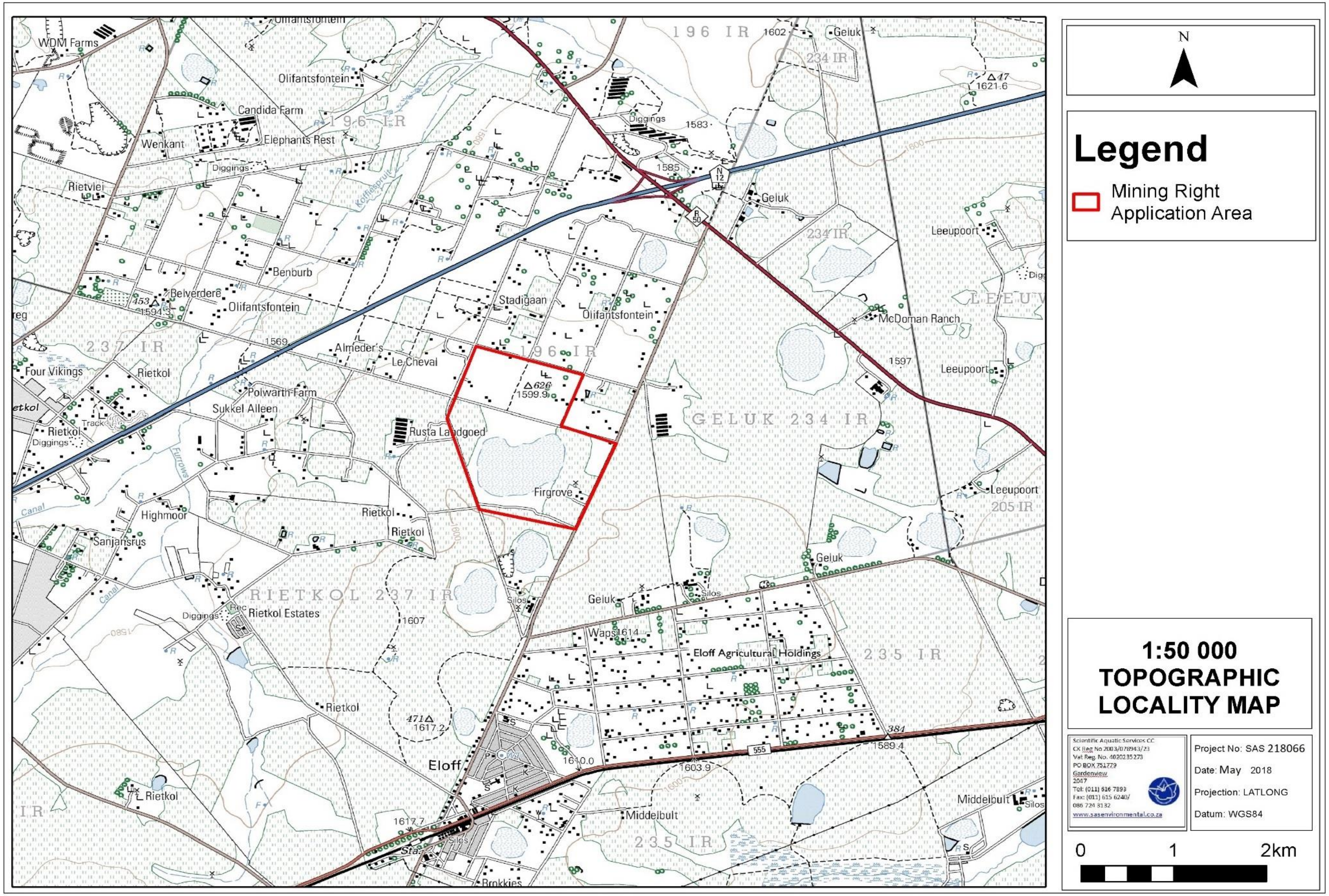

Figure 2: 1:50 000 Topographic map of the proposed mining and related activities

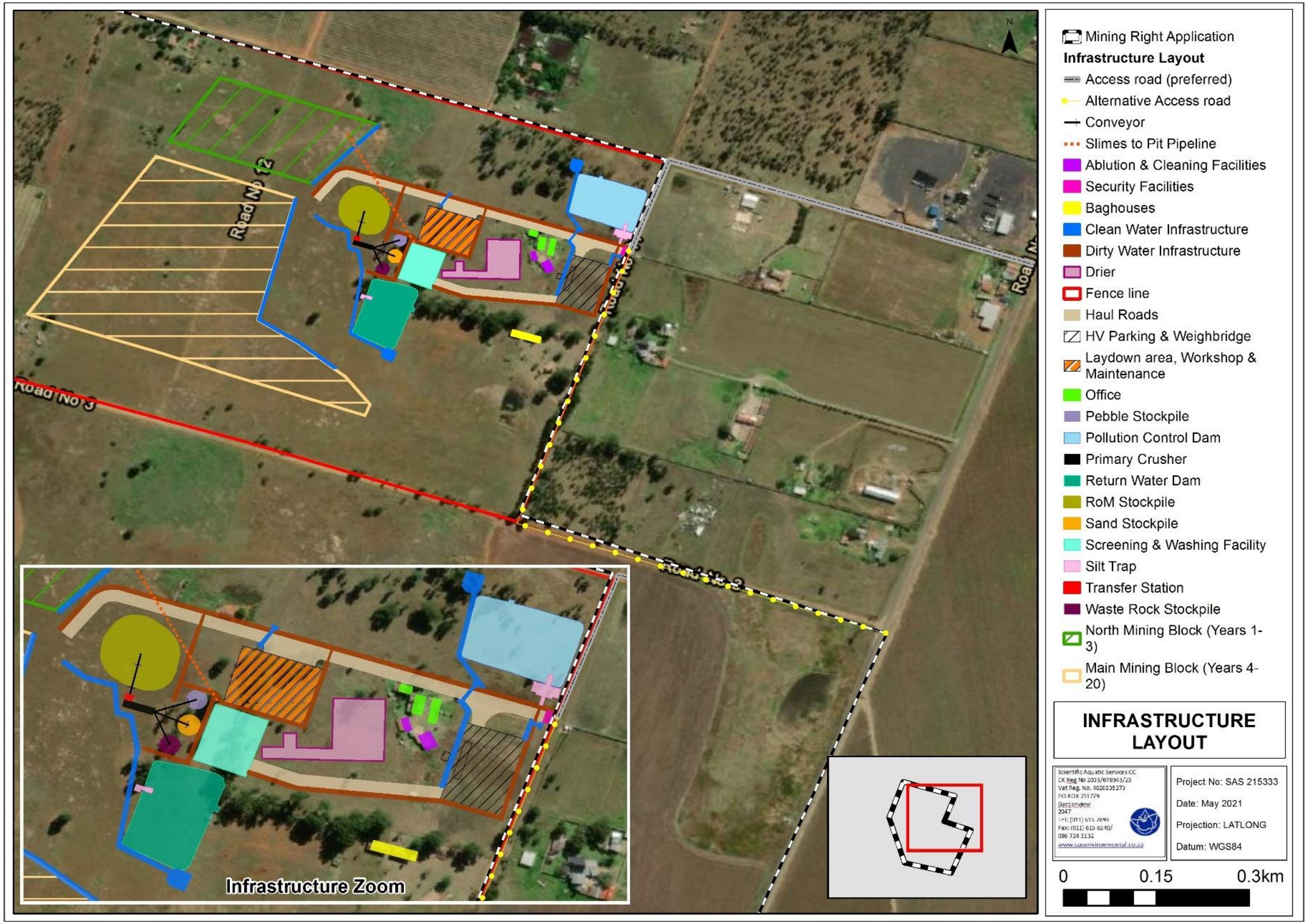

Figure 3: View of the proposed infrastructural and mining layout.

1.4 *Objectives*

The primary objective of this assessment is to assess the hydropedological properties of the soils in the areas most likely to recharge the wetlands in the local area, in order to define the potential recharge mechanisms of the surrounding soils that may be affected by the proposed project. Based on this information, it was then an objective to assess the impact of the proposed mining and related activities on the wetlands in terms of the hydropedological drivers. Recommendations on mitigation were then considered and presented. The outcome of this study was utilised as part of the freshwater assessment conducted by SAS (2018 updated in May 2021).

1.5 *Assumptions and Limitations*

- The SWAT model mainly models surface processes and does not entail processes relating to ground water recharge. Impacts on groundwater need to be considered on the broader landscape and drainage regime by a suitably qualified geohydrologist.
- The main limitation of the model is the spatial representation of the Hydrological Response Units (HRUs) within each subcatchment. This approach ignores flow and pollutants routing between the HRUs. Thus, the results presented at HRU scale may have inaccuracies however, they are considered sufficient to guide the decision-making process.
- It should be noted that the "streams and channels" presented from Figure 5 to 7 were generated based on the Digital Elevation Model (DEM) for modelling purposes and do not represent freshwater systems that truly occur in the field as defined in the freshwater report compiled by SAS (2021). The generated lines should therefore only be considered as indicative of the position of preferential flow paths in the landscape.
- Weather generator data (Obtained from the online sources) in the absence of measured weather data is not 100% accurate especially with respect to precipitation data thus inaccuracies can be expected.
- 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 sufficient 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 climate change dynamics were not considered as part this assessment; however, it is acknowledged that this might exacerbate the anticipated impacts associated with a reduction in water inputs and the resultant hydrological function of the remaining wetlands beyond the extent of the proposed development.

2 ASSESSMENT METHODOLOGY

A hydropedological survey and sampling activities were conducted in November 2020 and May 2021 to assess the hydropedological characteristics of the landscape and associated soils within the project area. This date was deemed acceptable since seasonality has no bearing on the hydropedological characteristics. A soil sampling exercise was undertaken at selected representative points, considering the various soil types, in order to deduce the wetland recharge mechanisms and identify the anticipated hydropedological impacts of the proposed development on the wetland resources that will be affected by the proposed development. Subsurface soil observations were made by means of a standard hand auger and investigation methods.

Step 1. Identification of the representative hillslope/s

Prior to the site visit a desk-based exercise was undertaken which included the following:

- Identification of land types (Land Type Survey Staff, 1972 – 2006) within the study area; and
- Identification of dominant hillslopes (from crest to stream) of the study area using terrain analysis.

Step 2: Conceptualize hillslope hydropedological responses

- Transect soil survey was conducted on each of the identified hillslope (Le Roux et al., 2011);
- Soil observations were made at regular intervals, not exceeding 100 m, on the transect;
- Analysis of soil was made by means of a hand augur as well as analysis of exposed profile areas which depict the diagnostic horizon sequence; and
- soils observations were made until the layer of refusal.

Field assessment data included 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 GPS); and
- Depth to saturation (water table), if encountered;

Conceptual hillslope hydropedological response

The occurrence, sequence, and coverage of the different hydropedological groups on a transect was used to describe the hydrological behaviour of the hillslope (van Tol *et al*., 2013).

This includes a graphical representation of the dominant and sub-dominant flowpaths at hillslope scale prior to development (as presented in Section 5.3). This will include:

- Overland flow;
- Subsurface lateral flow;
- Bedrock flow;
- Return flow; and
- Storage mechanisms.

Step 3: Quantification of hydraulic properties and flowrates

- Identify the representative soil forms and horizons from the transect survey.
- Collect selected verification samples for textural analysis, bulk density and conductivity at a SANAS accredited analytical laboratory.
- Relate the measurements to the conceptualised hydropedological response model to provide a quantitative description of flowrates and storage.

Step 4: Quantification of hydropedological fluxes

- Quantify the hydropedological fluxes using SWAT+ Model (Bieger et al., 2017; van Tol et al., 2020a).
- Identify the potential impacts of the proposed mining development on the unsaturated flow processes and wetlands.
- Recommend suitable mitigation and management measures to alleviate the identified impacts on the wetland hydropedological drivers.
- Based on the outcome of the hydropedological assessment and taking into consideration the results of the geohydrological assessment, a scientifically determined buffer will be generated around the affected wetlands.
- Compile a specialist report on the conceptual hydropedological regime of the investigated wetlands based on the identified soil types under current 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	$3x10^{-2}$ – 3
Coarse Sand	$9x10^{-5}$ – $6x10^{-1}$
Medium Sand	$9x10^{-5}$ – $5x10^{-2}$
Fine Sand	$2x10^{-5}$ – $2x10^{-2}$
Loamy Sand	$4.1x10^{-3}$
Sandy Loam	$1.2x10^{-3}$
Loam	$2.9x10^{-4}$
Silt, Loess	$1x10^{-7}$ – $2x10^{-3}$
Silt Loam	$1.2x10^{-4}$
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	$8x10^{-11}$ – $2x10^{-7}$

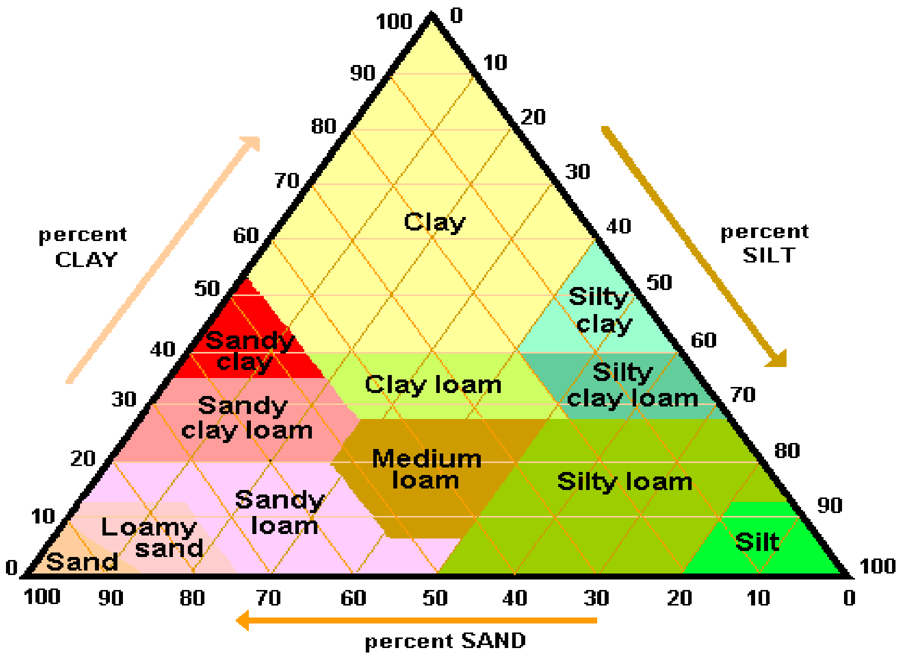

Figure 4: Soil texture classification chart (Food and Agriculture Organization (FAO), 1980).

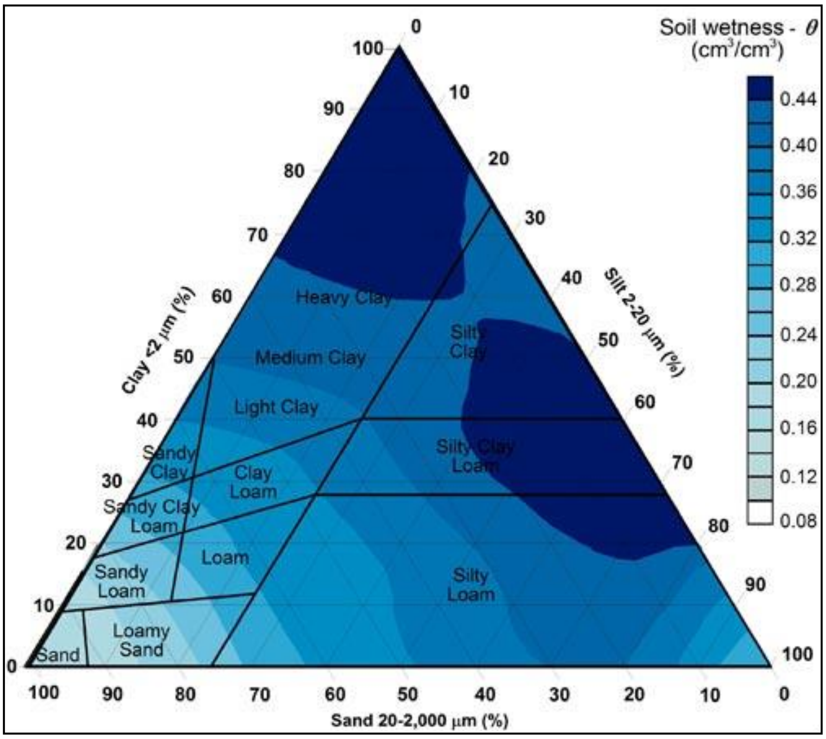

Figure 5: A diagram depicting soil wetness based on soil textural class

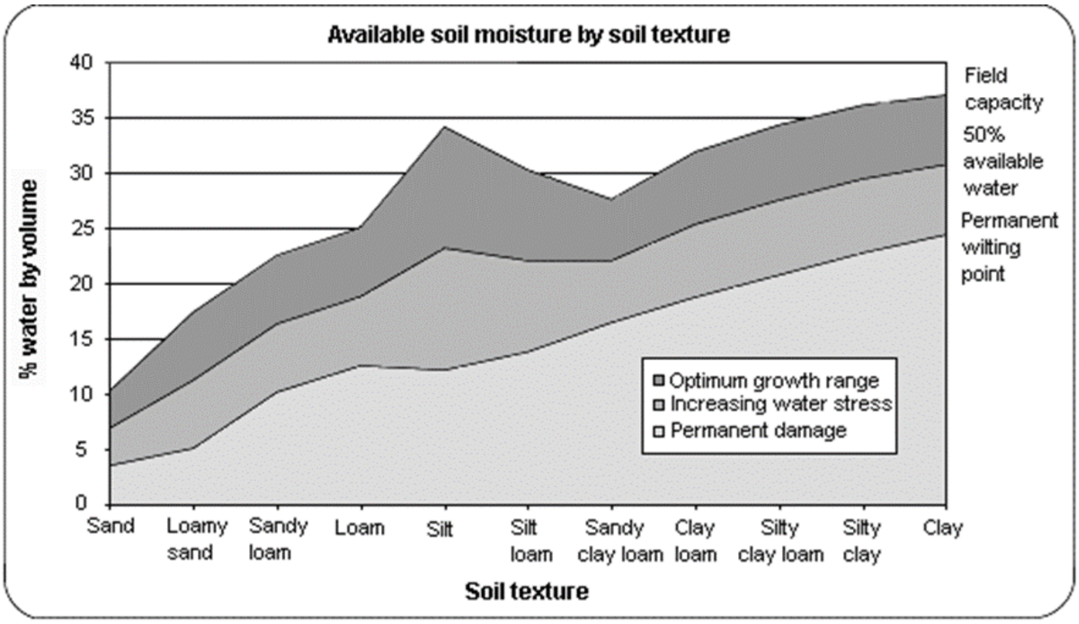

Figure 6: A diagram depicting the percentage volume of water in the soil by soil texture

Table 4 presents impact categories for describing the impact significance of the proposed development on the wetlands and associated hydropedological drivers.

Table 4: Impact categories for describing the impact significance of the proposed development on the wetlands and associated hydropedological drivers

Severity	SSI 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.

3 MODELLING APPROACH

The hydrological model SWAT+ (v 1.2.3) was used for the modelling process with QSWAT+ (v. 1.2.2) to set up the watershed. SWAT+ is a revised version of the well-known Soil and Water Assessment Tool (SWAT; Arnold *et al*., 1998). SWAT is a widely used small watershed to river basin-scale model. It is typically used to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change.

The aim of the hydrological modelling was to quantify the dominant hydrological processes as well as the impact of the proposed development on these processes and the wetlands [at a Hydeo- Geomorphic Unit (HGM unit) level] associated with the project. Although modelling and reporting was undertaken on simulated percolation volumes, the impact of the open cast pit on resources is beyond the scope of this study.

The catchment area was determined from a 30m DEM and subdivided into 7 sub-basins, with 59 Landscape Units (LSUs) and 470 Hydrological Response Units (HRUs). The extent of the proposed open-cast pits and the infrastructure (focus area) is limited to LSUs 160, 270, 450, 520 and 570. These LSUs were consequently the focus of this modelling (See Figure 8 below). The current land use was obtained from the South African National Land-Cover Database (2013 – 2014) with predefined parameters for each of the uses. To simulate the impact of the development, the area under the open-cast footprint was assigned a “mining barren” class, with associated properties assigned a “mine buildings” class in the post mining modelling scenario.

The soils identified from the soil survey were reclassified and regrouped into hydropedological classes namely according to (Van Tol & Le Roux, 2019; Interflow (deep), Interflow (shallow), Recharge (deep) and Responsive (wet). The soils were further extrapolated to cover the areas outside the study area using the Land Type soil information and thus enabling the modelling to take place at a lager catchment scale (Basin scale). Soil physical parameters such as bulk density, particle size distribution affecting the water content and the hydraulic conductivity were determined under laboratory conditions.

A 10-year simulation period was selected (1st January 2000 – 31st December 2009). Climatic data for this period was obtained from the Climate Forecast System Reanalysis (CFSR, 1979 – 2014) project done by the National Centers for Environmental Prediction (NCEP) (Saha *et al*., 2010). WeatherGen in SWAT+ Editor used daily precipitation, temperature (minimum and maximum, wind speed, solar radiation and relative humidity from selected stations to generate daily climatic variables for the simulations. The daily precipitation was adjusted so that the annual rainfall was comparable with the measured rainfall for the site. Only years with full data ranges were selected, leaving a 10-year evaluation period. Results are reported only as yearly averages for the affected HRUS, LSUs and the basin, before, and after the proposed development.

3.1 *Hydraulic Properties*

The hydraulic properties of the dominant horizons used as inputs into the SWAT+ model are presented in Table 5.

Table 5: Selected hydraulic properties of representative horizons

Soil form	Hydroped class	Horizon	Depths	Db	Ks	Clay	Silt	Sand	DUL	LL	AWC
Mispah	RESS	ot	15	1.23	1263.16	24.80	16.80	58.41	0.25	0.16	0.09
		lc/ro	30	-	-	-	-	-	-	-	-
Westleigh / Pinedene	INTD	ot	18	1.17	857.14	18.01	11.81	70.77	0.22	0.12	0.09
		yb/gh	35	1.60	150.94	17.01	10.01	73.76	0.17	0.10	0.07
Hutton	RECD	ot	15	1.23	1263.16	24.80	16.80	58.41	0.25	0.16	0.09
		hu	90	1.31	289.16	19.59	12.00	68.49	0.20	0.13	0.08
Katspruit	RESW	ot	30	1.17	857.14	18.01	11.81	70.77	0.22	0.12	0.09
		gh	60	1.54	263.74	20.24	15.83	64.39	0.32	0.13	0.19
Ba3	RECD	Topsoil	30	1.10	120.00	17.00	24.00	57.00	0.25	0.16	0.09
Bb3	RECD	Topsoil	30	1.30	100.00	17.00	24.00	57.00	0.25	0.15	0.10

Db – bulk density; C – carbon (estimated); AWC – available water content; Ks – saturated hydraulic conductivity.

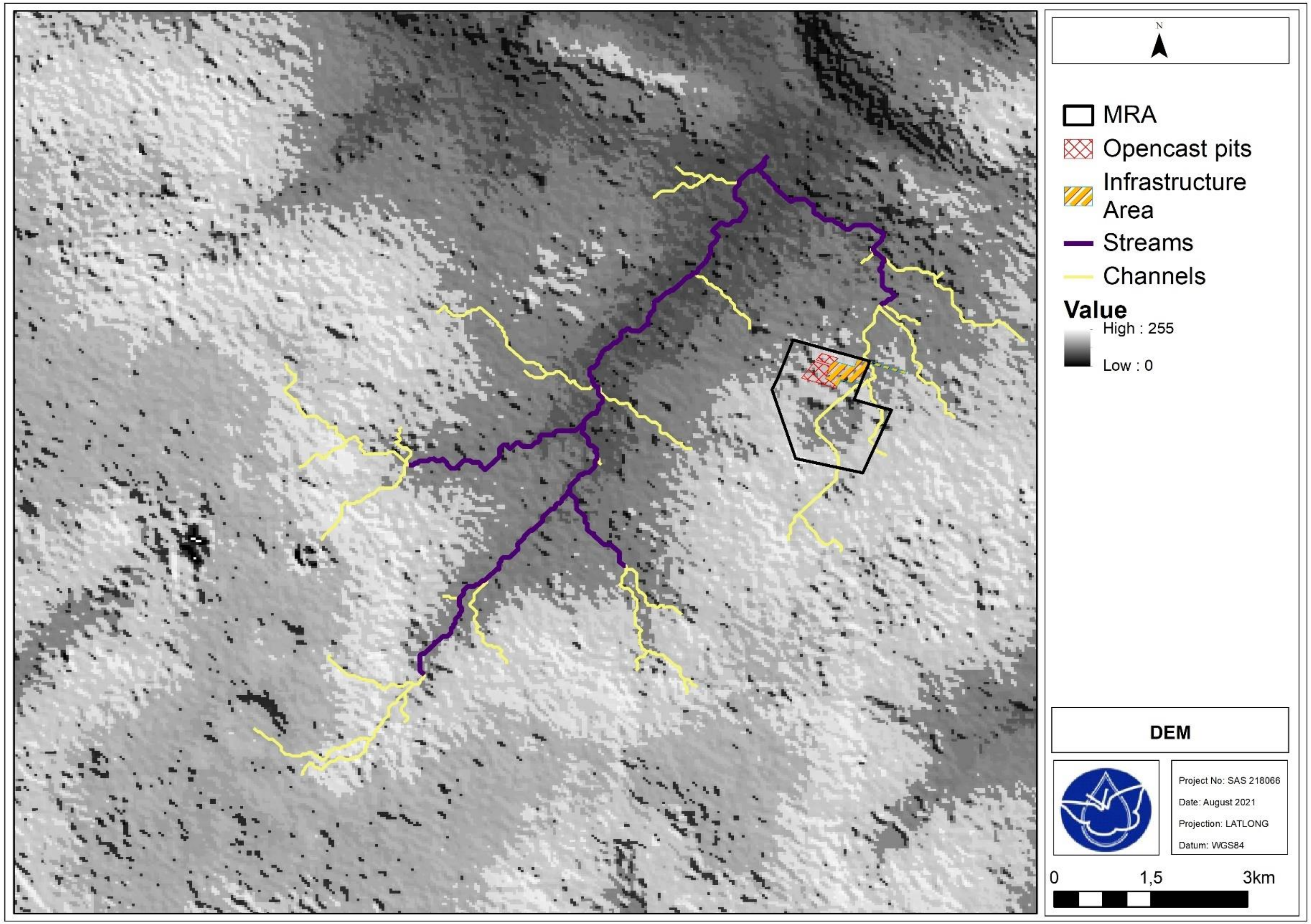

Figure 7: Digital elevation model (DEM) associated with the catchment area indicating areas of low elevation where water is most likely to flow.

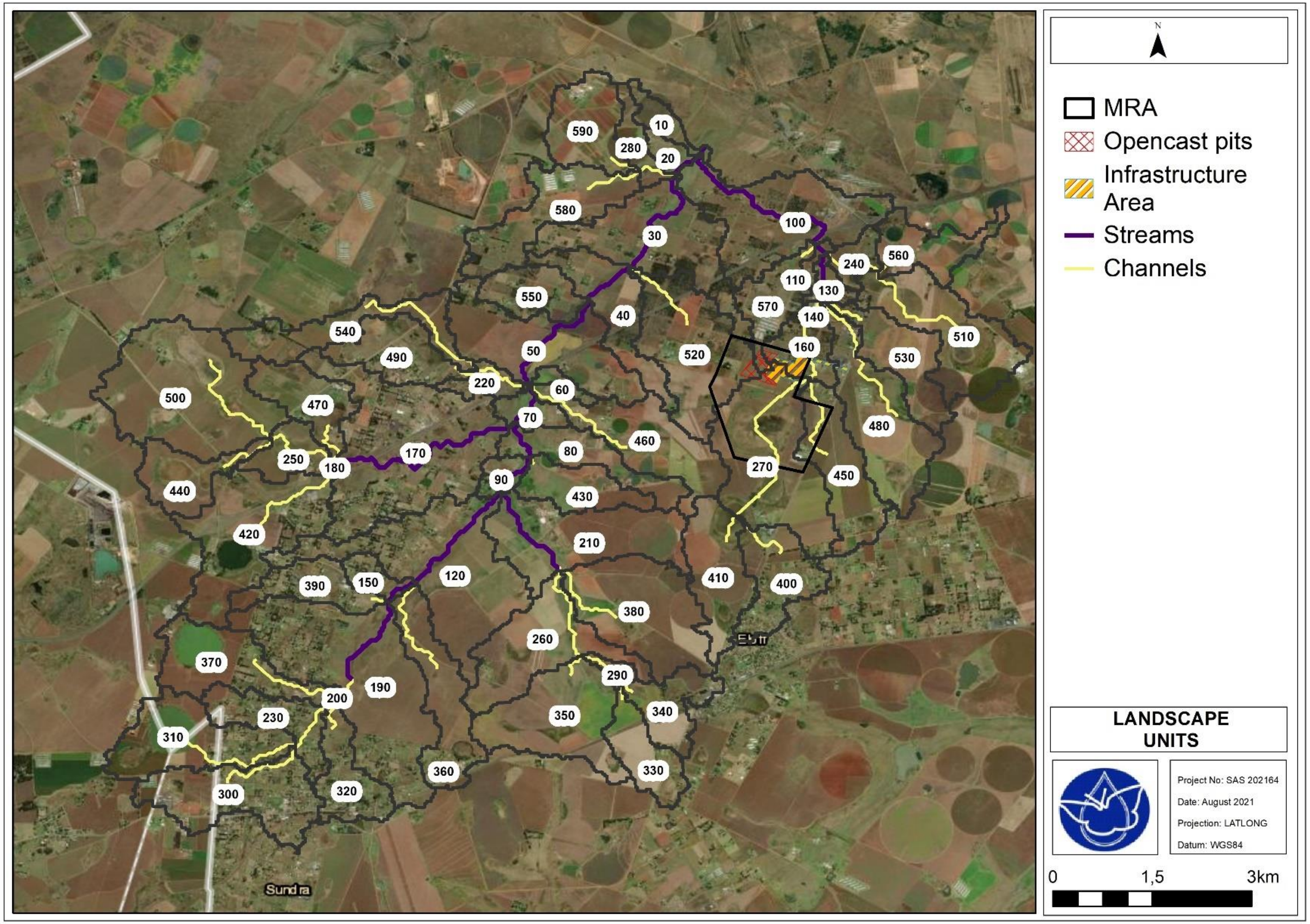

Figure 8: Landscape units (LSU's) associated with the catchment area.

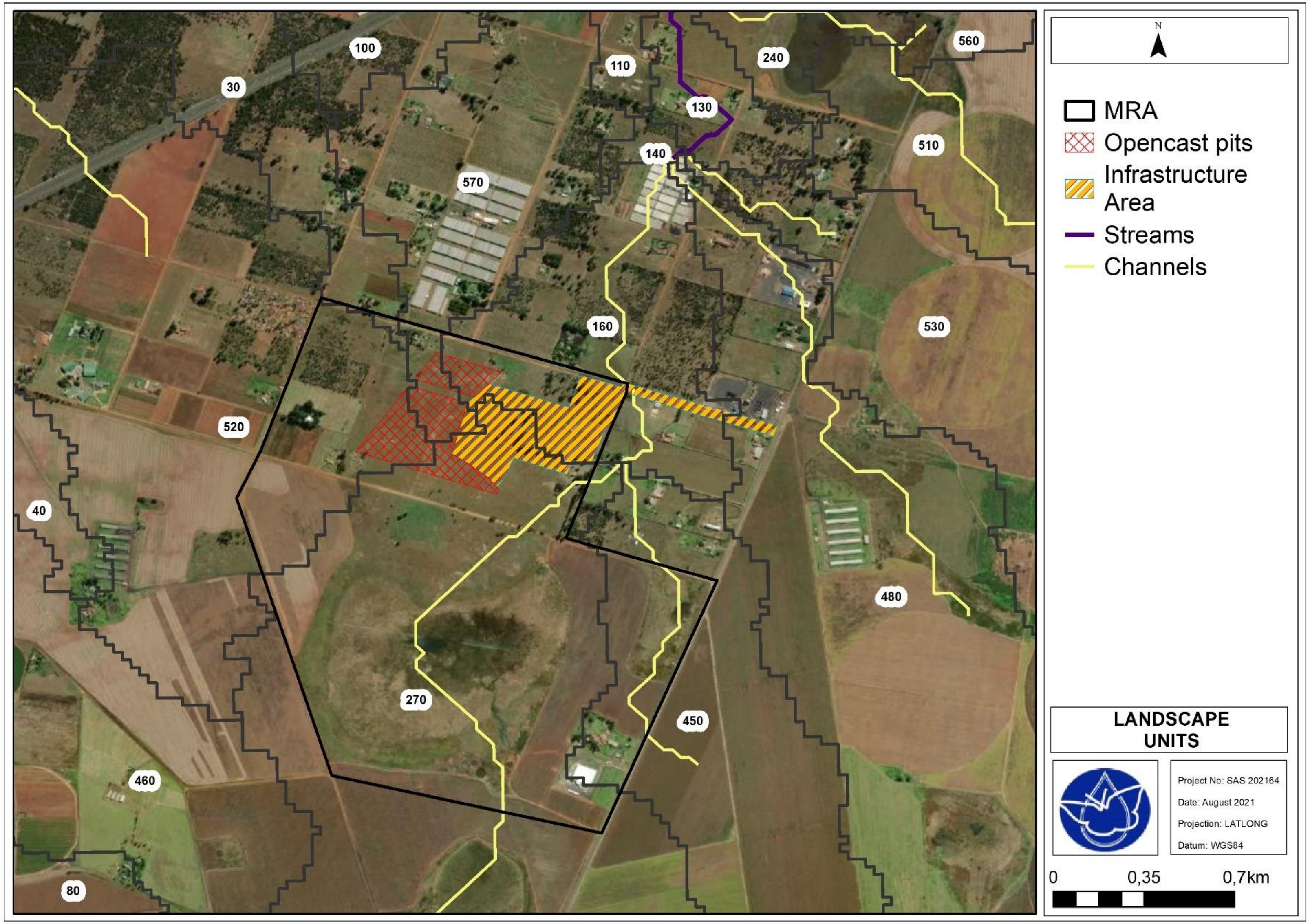

Figure 9: Landscape units (LSU's) associated with the MRA.

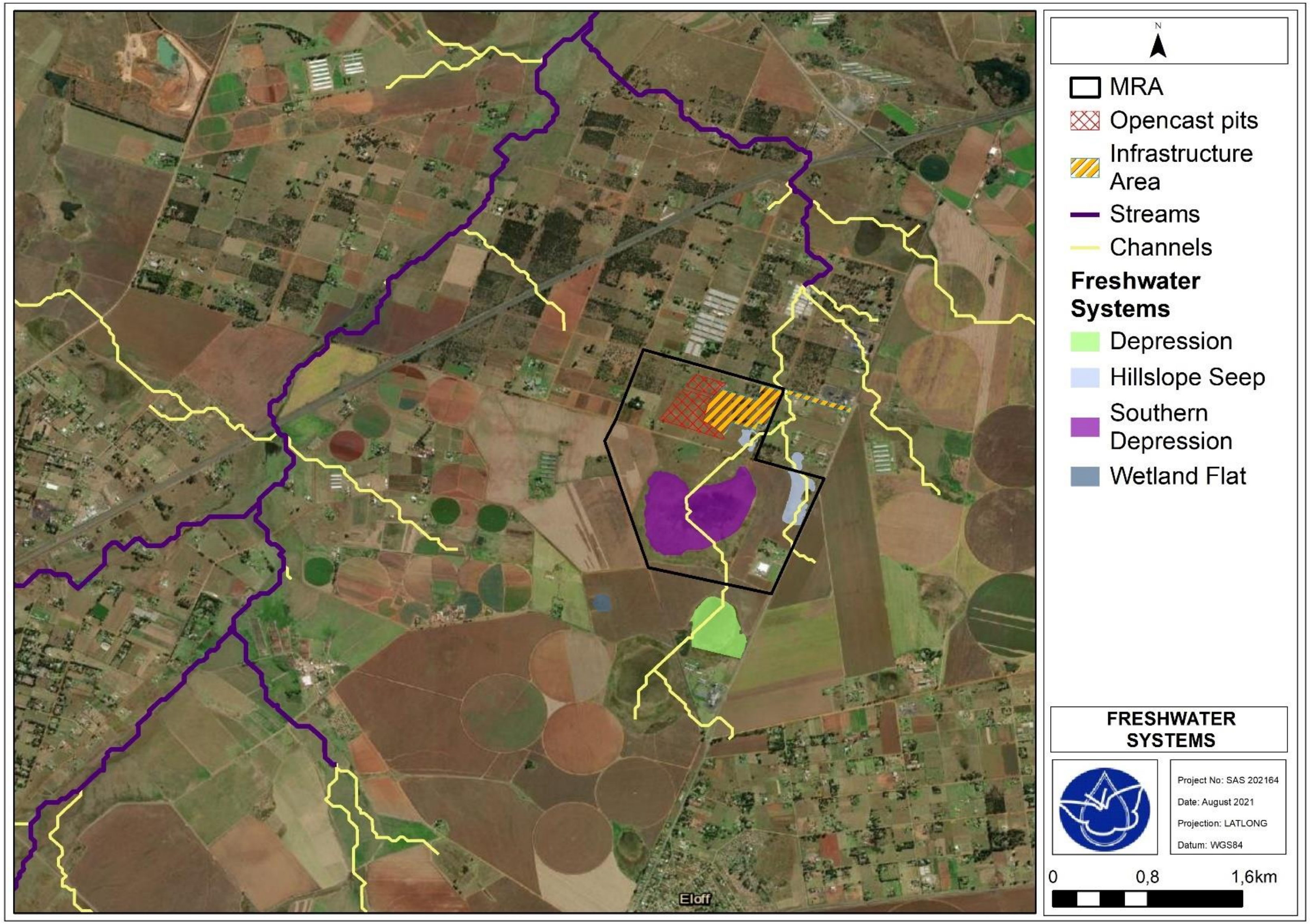

Figure 10: Freshwater systems associated with the MRA

4 HYDROPEDOLOGICAL BEHAVIOUR OF SOIL TYPES

Hydropedological behavior of different soils can vary significantly, depending on the soil drainage patterns. The discussion below is largely based on the concept presented in Figure 11 and Table 3 below. High chroma red soils are usually well drained, 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 bedrock. Thus, these systems may be important in terms of recharge over significant distances (several kilometers) and over long periods (years to centuries).

The lighter colour in soils or where colour has been leached from the soils by processes of eluviation, is usually associated with lateral flow. Lateral flow occurs due to differences in the conductivity of soil horizons or due to the presence of an impermeable bedrock layer. These soils are termed interflow soils. Lateral flow occurs at the A/B horizon interface as well as on high clay content soils (i.e. G horizon) and bedrock interfaces due to the reduced permeability. Fluctuating water table leads to mottle formation (red, yellow and grey colours) at the level in the soil where the water level fluctuation occurs. The grey colours in soils are largely caused by prolonged saturation (hydroperiod) which can be attributed to poor permeability of the soil due to high clay content or some other impediment. These interflow soils drive wetlands 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. The figure below depicts a conceptual diagram of the recharge mechanism of different soil types within the landscape and their influence on wetlands.

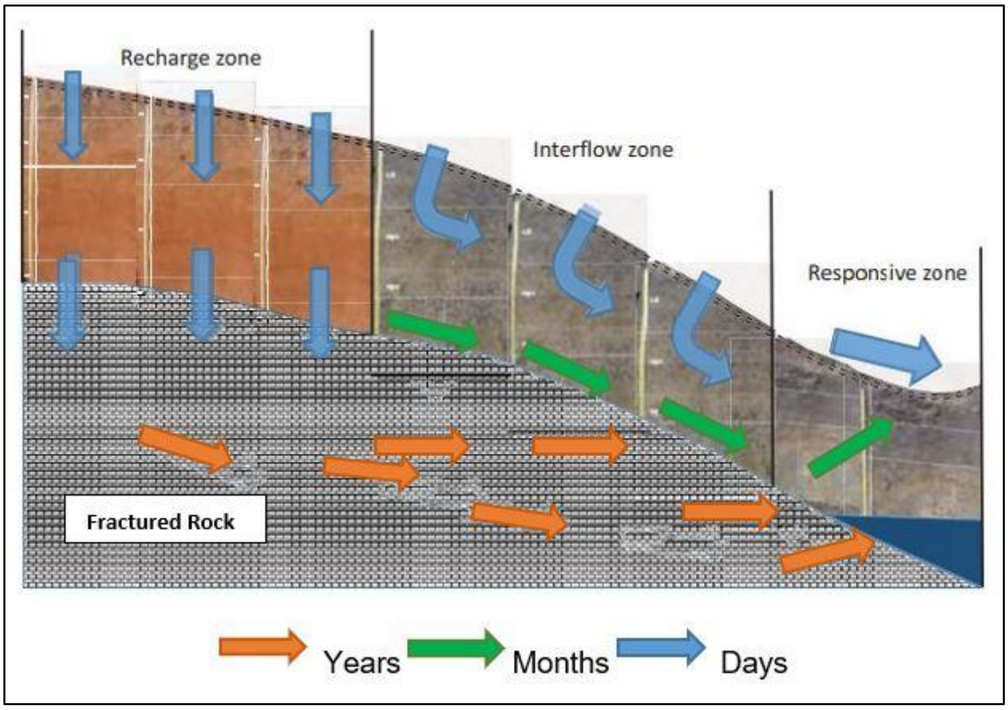

Figure 11: A typical presentation of hydrological flowpaths on different hydropedological soil types- hillslope hydropedological behaviour.

4.1 *Hydrological Soil Types*

Table 6: 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 evapotranspiration.	
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates build up of water in the topsoil. Duration of drainable water depends on rate of ET, 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 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.	

4.2 *Hydrological Hillslope Classes*

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.

5 ECOLOGICAL SIGNIFICANCE

According to the wetland assessment conducted by Scientific Aquatic Services (2018 Updated in May 2021), the MRA area is characterised by several wetlands systems including a pan, as well as hillslope seeps. According to SAS (2018 updated in May 2021), the wetland systems within the MRA area have been impacted upon, owing to artificial impoundments as well other impacting factors resulting from trampling and grazing by livestock. The Present Ecological State (PES) of these wetland systems ranges between moderately modified (C) and Largely modified (D), as presented in Table 7. Although this may be the case, it is imperative that the current state of these wetland systems is not further deteriorated, and wetland flow drivers are not impacted upon.

Table 7: Present Ecological Status of the wetland systems occurring in MRA area (SAS, 2018 Updated in May 2021)

Wetland (HGM types)	PES Status
Pan	Category: C (Moderately modified)
Hillslope Seep Wetlands	Category: D (Largely modified)

Figure 12: Map depicting delineated wetland features within the MRA and Investigation area

6 RESULTS AND DISCUSSION

6.1 *Morphological and Hydraulic Properties of Wetland Soils within the MRA area*

The catena of the wetland systems within the MRA area is characterised by a plinthic and hydromorphic topo sequence. Plinthic and hydromorphic soils are characterised susceptibility to prolonged seasonal wetness due to a fluctuating water table, which creates reducing redox conditions that are expressed as mottles and sometimes Iron (Fe) and Manganese (Mn) concretions. Plinthic soils in which the Orthic A grades directly into a plinthic horizon e.g. Westleigh (We) are generally wetter than soils in which the Orthic A grades indirectly through to an apedal B or E horizon. These soils have a high-water storage capacity attributed to their clayey and slowly impermeable nature, which result in prolonged wetness after rainfall events and are thus important in terms of the wetland functioning. Furthermore, the presence of a G horizon e.g. Katspruit (Ka) soils indicates greater susceptibility to wetness, and these soils are typically saturated with water at least seasonally. Refer to Figure 13.

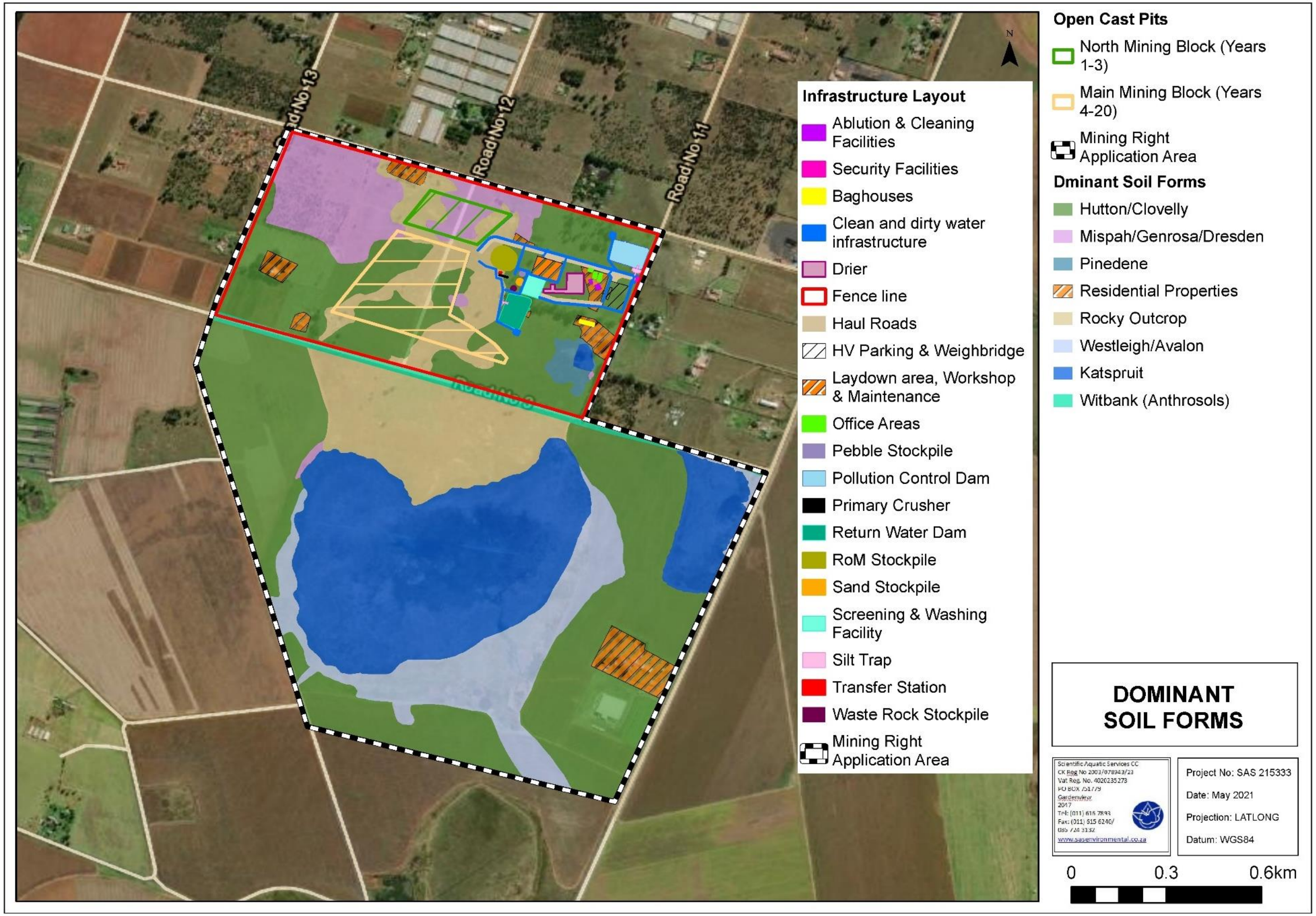

Figure 13: Map depicting spatial distribution of the identified soil forms within the MRA area

6.1.1 Responsive (Shallow) soils

These soils are shallow (including rocky outcrops), loamy sand of poor structure overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events. These soils have a quick response time during intense rainfall events attributed to their shallow nature. The slope position of the soils is typically the crest and scarp. The locality of these soils is depicted in Figure 20.

Figure 14: Example of responsive shallow soils which are characterised by quick response time during rainfall events

6.1.2 Interflow (A/B) Soils

Interflow soils comprise of Westleigh (We), Pinedene (Pn) and Avalon (Av) soil forms identified mainly on gently sloping hillslopes associated with the hillslope seep and pan wetlands within the MRA area. The interflow soils, as they contribute to the wetlands, are characterised by inherently poor internal drainage due to the slowly permeable underlying soft plinthite. The locality of these soils is depicted in Figure 20.

Figure 15: View of the interflow soils within the MRA area

6.1.3 Responsive (Saturated) Soils

These soils comprise of clayey Katspruit (Ka) soil form with prominent signs of prolonged wetness (Gleying) identified within the permanent zone of the investigated wetlands (refer to Table 4 and Figure 16). These soils are comprised of strongly clayey upper horizon underlined by a G horizon. The G horizon occurs in the subsoil, and it is characterised by high clay content with impeded drainage just below it, creating a perched water table scenario. These soils are essentially water receptors from the surrounding catchment. 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, often creating a perched water table. The slow permeability of these clayey textured soil therefore suggests that evaporation and surface (overland) flow of water are largely the water output mechanism. The locality of these soils is depicted in Figure 20.

Figure 16: View of the identified Katspruit soil forms with impeded drainage characteristics

6.2 *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 location of the representative soil samples is depicted on the sampling locality map in Figure 17. The particle size distribution analyses indicate that the hillslope seep located north in the MRA area is characterised by a sandy loam texture, with a moderate permeability whilst the hillslope seep located northeast, and the pan are comprised of clay soils, with very low permeability attributed to the high clay content. Refer to Figure 18 for transmissivity of soils within the MRA area.

Table 8: Textural classification of the dominant soil forms within the wetland catchment

Sampling point	Sampling Depth (cm)	Textural Class	Permeability Classes	FAO permeability (cm/day)	DWS permeability (cm/day)
1069	40-70	Clay	Very Slow	1.2096	8.6x10-5 - 0.041
1071	38 - 65	Clay		1.2096	8.6x10-5 - 0.041
1073	38 - 69	Sandy Clay Loam	Moderately slow	31.104	31.10
1074	41 - 73	Sandy Clay Loam		31.104	31.10
1075	30 - 50	Sandy Loam	Moderate	59.616	103.68
1076	0 - 35	Sandy Loam		59.616	103.68

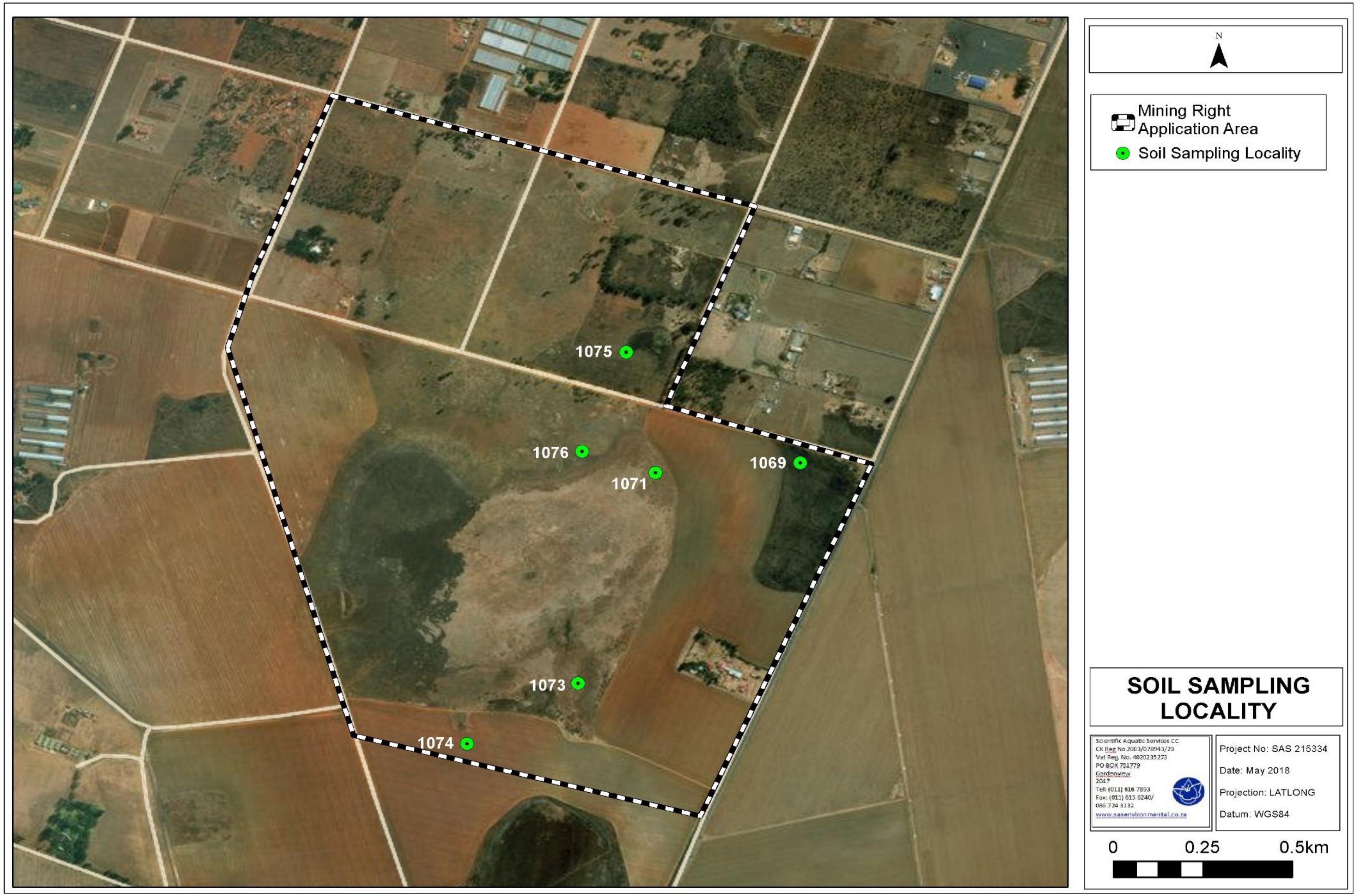

Figure 17: Soil sampling points map depicting the locality of the representative soil samples across the investigated wetland catchment.

Figure 18: A map depicting soil transmissivity of the representative soil samples across the investigated wetland catchment.

6.3 *Recharge of the Wetlands*

Typically, wetland recharge mechanisms include precipitation (rainfall), surface flow (runoff), subsurface flow (interflow) through the vadose zone of the surrounding soils, and groundwater discharge. Figure 19 presents an example of interflow within a soil profile which will lead to a cone of depression impact in the landscape. Hydrological soil types and soil responses are depicted in Figure 20 and 21 respectively.

Figure 19: An example of interflow in the subsoil indicated by the red circle

This groundwater recharge of wetland mechanism is anticipated to be limited for the wetlands within the project footprint. The interactions between the surface wetlands and ground water within the MRA area is strongly limited by the underlying plinthite and clay material which is slowly permeable. Furthermore, the water level is greater than 10 m below the wetland system and therefore separated from the surface wetland system. The conceptual wetland recharge based on the water flowpaths through the soil medium are presented in Table 6 below.

Table 9: List of soil forms within the MRA area and their relative contribution to wetland recharge

Recharge Mechanism	Soil Forms	Diagnostic Horizons	Description
Recharge (Vertical flow)	**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.
	Clovelly (Cv)	- A: Orthic - B1: Yellow Brown Apedal - B2: Unspecified material	
	Pinedene	- A: - Orthic - B1: Yellow Brown Apedal - B2: Unspecified material with signs of wetness	
	Westleigh	- A: - Orthic - B: - Soft Plinthic	Relatively deep, loamy sand of poor structural stability, overlying light brown, considerably gleyed soft plinthite. Subsurface and groundwater recharge potential is impeded by the clayey, slowly permeable soft plinthite. Lateral water discharge “interflow” may occur through topsoil and the apedal B1 horizon during wet periods.
	Avalon	- A: Orthic - B1: Yellow Brown Apedal - B2: Soft Plinthic	
Responsive (Shallow)	**Rocky Outcrop/ Mispah/ Glenrosa**	- A: Orthic - Hard Rock/Lithocutanic	Shallow, loamy sand of poor structure underlined by a hard rock. These soils have a quick response time during intense rainfall events attributed to their shallow nature.
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.
Unknown	**Witbank**	Human Transformed soils with altered properties	For the purpose of this assessment, roads and other surface infrastructure (i.e. residential properties) within the MRA area were classified as Witbank soils, as the hydropedological properties could not investigated.

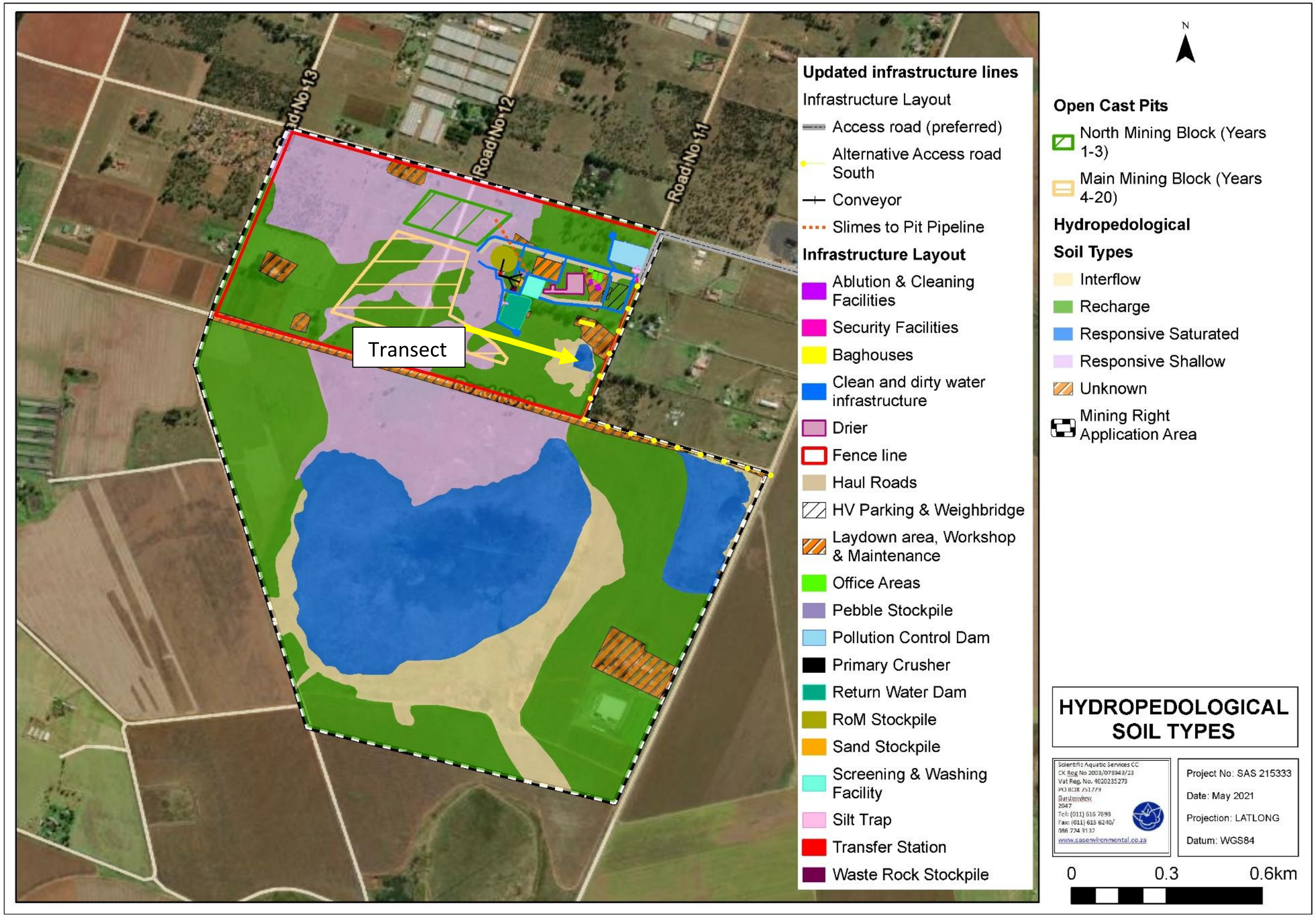

Figure 20: Hydrological soil types within the MRA area.

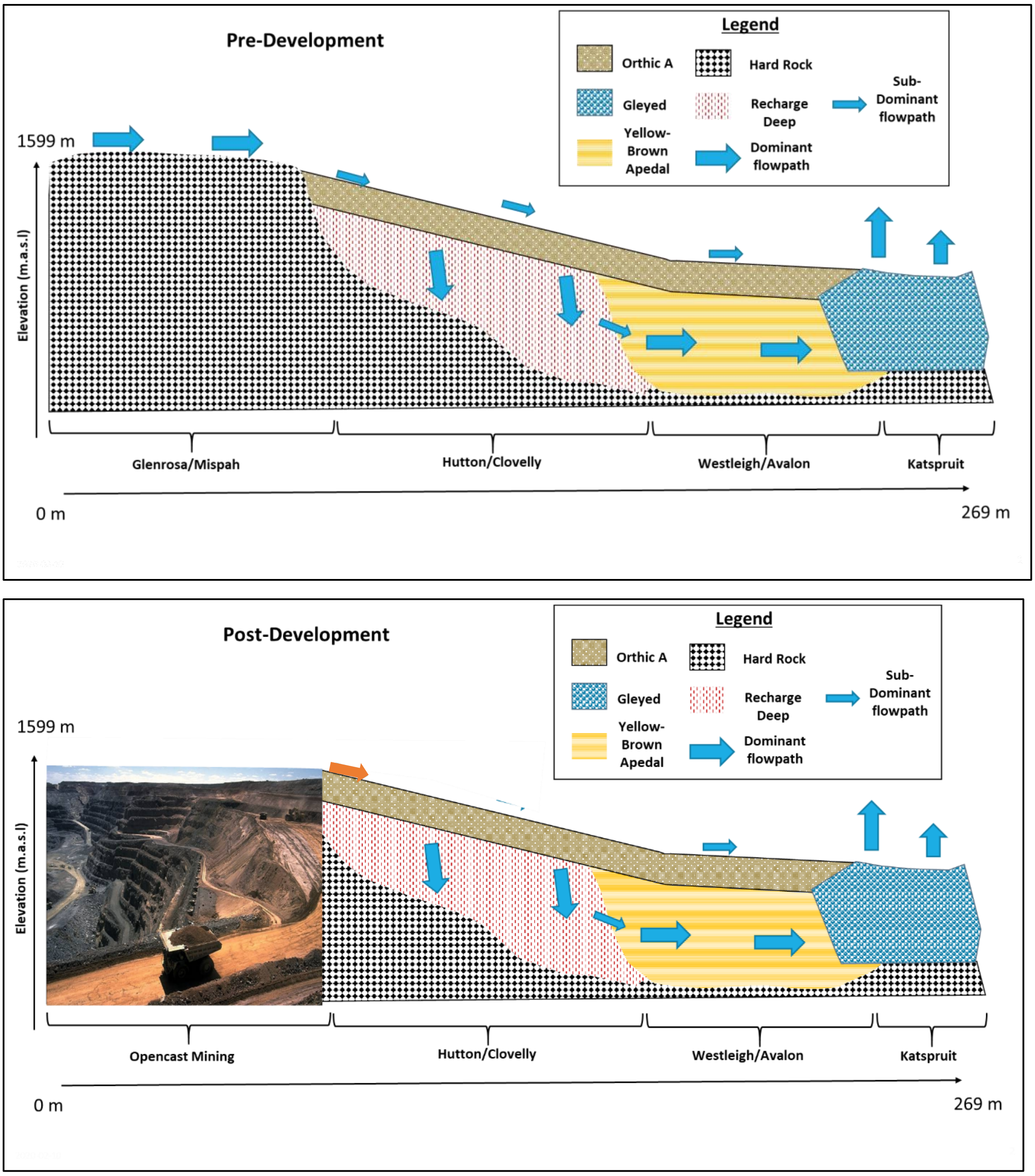

Figure 21: Conceptual models depicting he pre and post development scenarios

The proposed development is located within responsive shallow and recharge deep soils which contribute to runoff and groundwater respectively. These soils are not deemed important from a hydropedological point of view. The post mining scenario is anticipated to have limited impact on the hillslope process, the surface runoff component will be impacted mostly in the unmitigated scenario.

6.4 *Quantification of Hydropedological losses*

Impacted Basins, Landscapes and HRU's

Basin Scale

At the Basin scale the impacts of the proposed open cast and infrastructure development can be considered limited. This is due to the observed increase in streamflow. The increase in streamflow is attributed to the increase in surface runoff. The increase in surface runoff is likely due to the removal of vegetation and the implementation of surface infrastructure to divert clean water around the mining landscape leading to concentrated flow in the landscape which reduces infiltration opportunity. The increase in lateral flow can be attributed to the runoff water reaching the non-affected hydropedologically important soils in proximity to the MRA and thus reaching the streams through subsurface flows. The proposed development is situated on areas dominated by shallow outcropping rocks and the surrounding soils are of a recharge nature and thus water overflowing from the proposed development areas will reach the recharge soils of the Hutton and Clovelly. Significant losses of water will occur through evapotranspiration on exposed water bodies.

Table 10: Change in water balance at basin scale

	Before	% of WB	After	% of WB	% Change
Rainfall	559.4		559.4		
Streamflow	96.0	17.2	132.6	23.7	38.1
Surface runoff	47.3	8.5	53.7	9.6	13.6
Lateral flow	48.7	8.7	78.9	14.1	62.0
Percolation	11.5	2.1	21.9	3.9	90.0
ET	449.9	80.4	357.5	63.9	-20.5
Transpiration	98.6	17.6	63.5	11.3	-35.6
Evaporation	351.3	62.8	294.0	52.6	-16.3
ET0	1724.2		1724.2		

	Before	After	% Change
Profile available water	30.0	29.4	-2.1
Topsoil available water	11.4	9.8	-13.9

Land segment unit scale

The impacts at this scale are slightly higher in comparison to the basin scale scenario. This can be attributed to the fact that these are the immediately adjacent areas which are important for recharging the wetlands. At this scale, the soil is being removed at various phases of development as part of the establishment of the opencast mining operations and the surface infrastructure. Streamflow is expected to increase by 39.9% which is likely affected by the increase in surface runoff, lateral flow and percolation even though they account for a small percentage on the water balance. The major loss of water at this scale is still through evapotranspiration.

Table 11: Summary of the soil profile water losses

	Before	% of WB	After	% of WB	Change
Rainfall	559.4		559.4		
Streamflow	93.3	16.7	130.6	23.3	39.9
Surface runoff	42.3	7.6	49.8	8.9	17.6
Lateral flow	51.0	9.1	80.7	14.4	58.4
Percolation	11.9	2.1	22.4	4.0	87.3
ET	451.9	80.8	358.3	64.0	-20.7
Transpiration	88.0	15.7	55.8	10.0	-36.7
Evaporation	363.9	65.0	302.5	54.1	-16.9
ET0	1724.2		1724.2		

	Before	After	Change
Profile available water	31.7	30.6	-3.3
Topsoil available water	11.7	10.0	-14.7

HRU scale

At the HRU scale there is still an increase in streamflow. However, compared to the Basin and the LSU scale there is an increase in surface runoff and a decrease in lateral flow contribution to the streamflow. At this scale the impacts of the open cast pits and the hardened surfaces associated with the surface infrastructure can be observed. At this scale the impact on the profile available water is decreased to -6%. The most significant losses at this scale are through evapotranspiration.

	Before	% of WB	After	% of WB	Change
Rainfall	559.3		559.3		
Streamflow	89.3	16.0	130.6	23.3	46.3
Surface runoff	35.7	6.4	49.8	8.9	39.4
Lateral flow	53.5	9.6	80.7	14.4	50.8
Percolation	10.6	1.9	22.4	4.0	111.7
ET	457.3	81.8	358.3	64.1	-21.7
Transpiration	110.6	19.8	55.8	10.0	-49.6
Evaporation	346.8	62.0	302.5	54.1	-12.8
ET0	1724.2		1724.2		

Table 12: Summary of the soil profile water losses

	Before	After	Change
Profile available water	32.1	30.2	-6.0
Topsoil available water	11.5	9.9	-14.0

The simulated hydropedological processes in the catchment are dominated by evapotranspiration (64%) and lateral flows (14.1%). Although at fine scales the contributions of the lateral flows decrease, they are still the most significant drivers of the catchment processes. The proposed open cast pits and surface infrastructure are located on shallow soils of Mispah formations and rock outcropping. Some of the soils outside the impact area are hydropedologically important soils in terms of wetland recharge. Water which runs off from the impact areas will potentially report to these soils and thus maintain the functionality of the systems.

From a hydropedological point of view, no significant impact is foreseen on the wetland systems due to proposed mining and related activities (during all phases) since the soil resources where the proposed project is to occur are not regarded as drivers of the wetland systems. No impacts are foreseen, provided that the mitigation measures presented in this report are adhered to, on the hillslope seeps during all phases of mining, since the project footprint is located on soil resources which report to the groundwater regime and less to the interflow soils driving the hillslope seeps.

6.5 *Hydro-pedological Implications*

The wetlands are recharged by surface water from seasonal rainfall as well as subsurface flow. According to the hydrocensus report, the ground water levels around the MRA area varies between ±10 and 100 mbs. Therefore, the ground water is not anticipated to have a direct significant interaction with the surface and shallow sub-surface hydrogeological processes.

The proposed mining and related activities are not anticipated to hinder water infiltration or distribution across the wetland system (during all phases) due to the proposed project being located on soil resources not considered flow drivers of the wetlands except for their contribution to overland flow. It must be noted that the surface runoff from the responsive (shallow) soils located north of the road does not contribute to either the pan or hillslope seep to the north of the road. This is due to the catchment as well as hydropedological disconnect created by the road as well as the landscape setting which slope towards the east of the MRA area. The surface runoff from these soils rather flows towards the recharge soils (i.e., Hutton/Clovelly) which then infiltrates (if the soil is not under full saturation) and contributes to ground water regime of the local area. Therefore, the project is not anticipated to impact on the wetland flow drivers. Loss of surface runoff is unavoidable, however, the hydropedological flow paths will not be significantly altered, particularly if mitigation measures are carefully implemented, particularly during all phases.

6.6 *Buffer Determination Using Hydropedological Principles*

A scientifically derived buffer was developed to ensure that appropriate consideration of the hydropedological drivers in the study area is given in support of the principles of Integrated Environmental Management (IEM) and sustainable development. Refer to Figure 25. The buffer was developed to minimise impact in line with the mitigation hierarchy, although no significant impact would occur if slight encroachment on the buffer was to occur.

All the important hydropedological aspects were considered, including considering the ecology of the area where hydropedological drivers were considered less significant, and the following criteria was used to determine the buffer:

- The pan wetland was protected at a catchment level so as to ensure that the all the runoff reports to the pan wetland. Where the catchment boundary was less than 100m; the 100m zone of regulation took precedence as a minimum to avoid edge effects as well as dust (to a degree). Thus a 100m buffer was deemed sufficient to allow for overland flow to feed the pan wetland feature; and
- The remaining seep wetlands were afforded the minimum buffer size of 100m to avoid edge effects as well as dust (to a degree) on wetland plants due to their small catchment size as well as absence of hydropedologically important soils.

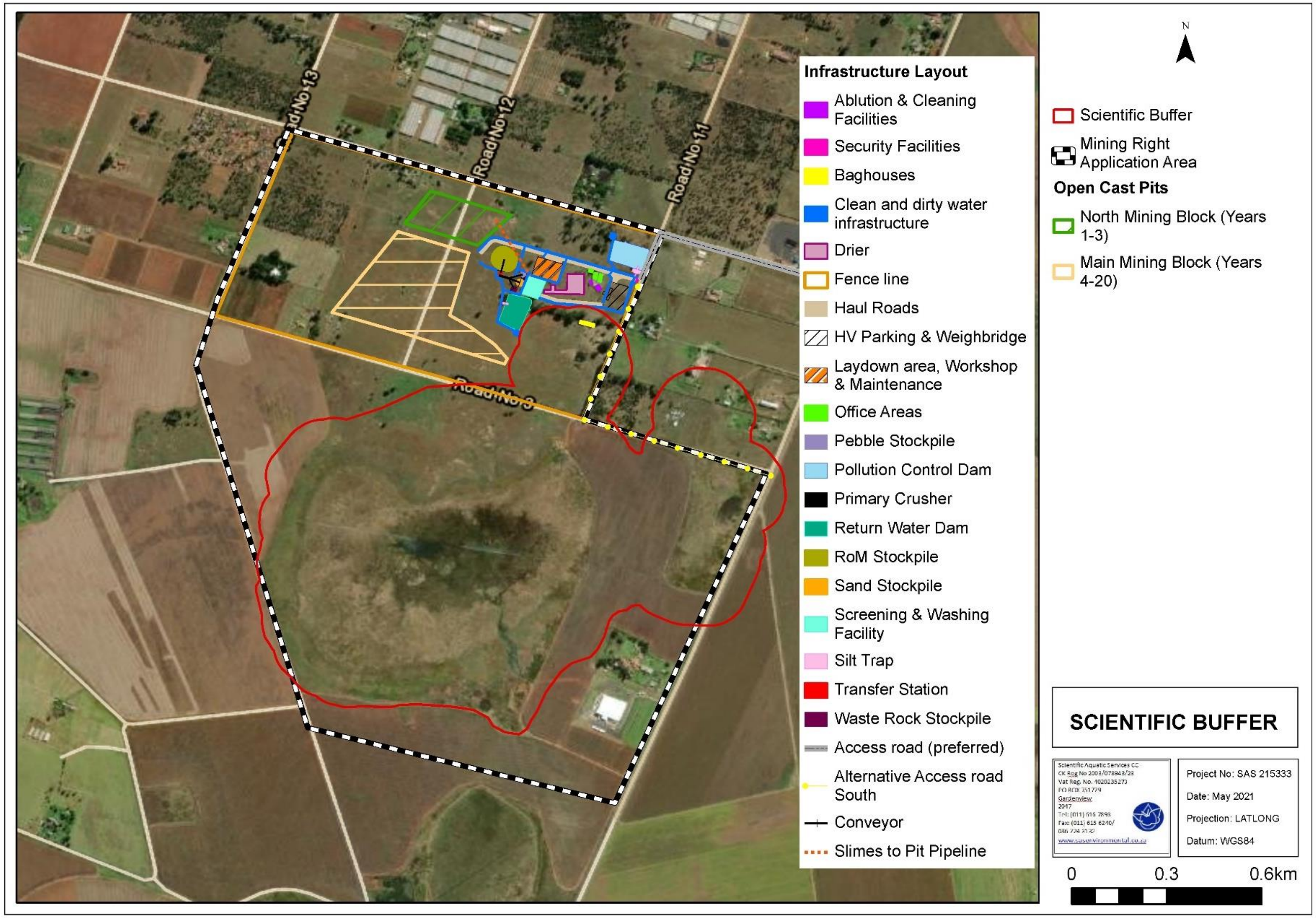

Figure 22: Scientifically derived buffer

7 CONCLUSIONS AND RECOMMENDATIONS

Scientific Aquatic Services (SAS) cc was appointed by Jacana Environmentals CC to conduct a hydropedological assessment for the Rietkol mining, as part of the authorisation process for the proposed mining and related activities, where mining of silica through opencast methods will occur.

The proposed activities will entail deep excavation activities for the reclamation of the silica deposit, which will directly impact on some watercourses as well as potentially intercept the subsurface flows in the vadose zone feeding the watercourses. It was deemed necessary to investigate the recharge mechanisms of the watercourses and define the hydropedological responses of the various soils within the immediate catchments of the watercourse associated with the study area. This study is deemed necessary to ensure that development planning takes cognisance of the hydropedologically important areas and hence enable informed decision making, construction design and with the aim to guide the mine design in support of the principles of sustainable development and Integrated Environmental Management.

The objective of this study was to:

- Investigate the hydropedological drivers of the watercourse;
- Determine the risk of the proposed activities on the freshwater feature; and
- Define the developable areas from a hydropedological point of view taking into consideration the findings of other relevant studies.

The wetlands are mainly recharged by surface water from seasonal rainfall as well as subsurface flow. According to the hydrocensus report, the ground water levels around the MRA area varies between ±10 and 100 mbs (Groundwater Complete, 2021). Therefore, the ground water is not anticipated to have a significant direct interaction with the surface and shallow sub-surface hydrogeological processes.

Following the quantification of percentage losses using the QSWAT+ model, it was concluded that the major losses at a finer scale [Hydropedological Response Unit (HRU)] are through evapotranspiration. At this scale the impact on the profile available water is decreased to -6%. From a hydropedological point of view, this will not lead to a change in the functionality and PES/EIS status of the affected wetlands once all mitigation measures recommended in this report have been put in place. Table B below presents the summary of the anticipated soil water profile losses at an HRU scale. Detailed results are presented in 6.4.

Table B: Summary of the soil profile water losses at a Hydropedological Response Unit Scale (HRU)

	Before	After	Change
Profile available water	32.1	30.2	-6.0
Topsoil available water	11.5	9.9	-14.0

From a hydropedological point of view, no significant impact is foreseen on the wetland systems due to proposed mining and related activities (during all phases) since the soil resources where the proposed project is to occur are not regarded as drivers of the wetland systems. Most of the opencast as well as surface infrastructure occur on shallow responsive and recharge deep soils which contribute to surface runoff and groundwater respectively.

Given the above findings, the proposed project is considered acceptable from a hydropedological impact perspective and will not lead to a significant impact on the receiving freshwater resources, both locally and regionally, provided that the outcome of this study, as well as mitigation measures outlined in this document, are used as a guideline to manage water in the landscape surrounding the proposed mine.

Keys, recommendations have been developed in the points below to minimise impact on hydropedological processes:

- Divert surface flow away from the pit areas;
- Water from the clean surfaces associated with the pits should be diverted and discharged back into the adjacent wetland systems in an attenuated manner;
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the wetlands adjacent to the proposed project;
- At closure, reinstate the soil the pre mining landscape which is free draining to ensure that the surface runoff contributes to the adjacent wetlands that may be indirectly impacted during the construction and operational phase of the development;
- The pits should be rehabilitated progressively (if feasible) to limit the water losses to ensure that the PES category remains unchanged;
- Excavation activities and removal of topsoil out of the demarcated areas should be avoided as far as practically possible to limit the footprint area that will be impacted; and
- Following the completion of the construction phase, areas of disturbance should be monitored at least once after an erosive rainfall for erosion arising from the surface which leads to concentrated flow and changes to the pattern flow and timing of water in the landscape.

Based on the outcomes of the modelling and recharge loss quantification exercise the proposed mining development will have a limited impact at a local scale from a hydrological perspective. Edge effects which compromise the hydropedological function of adjacent soils such as the effects of roadways and bulk earthworks which alter vadose zone water movement must be appropriately managed in line with the mitigation hierarchy as defined by the DEA.

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APPENDIX A:

DETAILS, EXPERTISE AND CURRICULUM VITAE OF SPECIALISTS

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

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

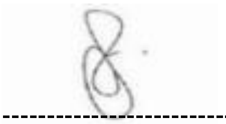
----

Signature of the Specialist

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

I, Braveman Mzila, 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

SAS ENVIRONMENTAL GROUP OF COMPANIES – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Group CEO, Water Resource discipline lead, Managing member, Ecologist, Aquatic Ecologist
Joined SAS Environmental Group of Companies	2003 (year of establishment)

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 the Gauteng Wetland Forum;
Member of International Association of Impact Assessors (IAIA) South Africa;
Member of 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
Legal liability training course (Legricon Pty Ltd)	2018
Hazard identification and risk assessment training course (Legricon Pty Ltd)	2013

Short Courses

Certificate – Department of Environmental Science in Legal context of Environmental Management, Compliance and Enforcement (UNISA)	2009
Introduction to Project Management - Online course by the University of Adelaide	2016
Integrated Water Resource Management, the National Water Act, and Water Use Authorisations, focusing on WULAs and IWWMPs	2017

AREAS 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 Leona
Central Africa – Democratic Republic of the Congo

KEY SPECIALIST DISCIPLINES

Biodiversity Assessments
- Floral Assessments
- Biodiversity Actions Plan (BAP)
- Biodiversity Management Plan (BMP)
- Alien and Invasive Control Plan (AICP)
- Ecological Scan
- Terrestrial Monitoring
- Protected Tree and Floral Marking and Reporting
- Biodiversity Offset Plan

Freshwater Assessments
- Desktop Freshwater Delineation
- Freshwater Verification Assessment
- Freshwater (wetland / riparian) Delineation and Assessment
- Freshwater Eco Service and Status Determination
- Rehabilitation Assessment / Planning
- Maintenance and Management Plans
- Plant species and Landscape Plan
- Freshwater Offset Plan
- Hydropedological Assessment
- Pit Closure Analysis

Aquatic Ecological Assessment and Water Quality Studies
- Habitat Assessment Indices (IHAS, HRC, IHIA & RHAM)
- Aquatic Macro-Invertebrates (SASS5 & MIRAI)
- Fish Assemblage Integrity Index (FRAI)
- Fish Health Assessments
- Riparian Vegetation Integrity (VEGRAI)
- Toxicological Analysis
- Water quality Monitoring
- Screening Test
- Riverine Rehabilitation Plans

Soil and Land Capability Assessment
- Soil and Land Capability Assessment
- Soil Monitoring
- Soil Mapping

Visual Impact Assessment
- Visual Baseline and Impact Assessments
- Visual Impact Peer Review Assessments
- View Shed Analyses
- Visual Modelling

Legislative Requirements, Processes and Assessments
- Water Use Applications (Water Use Licence Applications / General Authorisations)
- Environmental and Water Use Audits
- Freshwater Resource Management and Monitoring as part of EMPR and WUL conditions

SAS ENVIRONMENTAL GROUP OF COMPANIES (SEGC) –
SPECIALIST CONSULTANT INFORMATION
CURRICULUM VITAE OF TSHIAMO SETSIPANE

PERSONAL DETAILS

Position in Company	Soil Scientist/ Hydropedologist
Joined SAS Environmental Group of Companies	2020

MEMBERSHIP IN PROFESSIONAL SOCIETIES

South African Council for Natural Scientist Professions (SACNASP)

EDUCATION

Qualifications

M.Sc. (Agric) Soil Science (*Cum Laude*)	(University of the Free State)	2019
B.Sc. (Agric) Honours Soil Science	(University of the Free State)	2014
B.Sc. (Agric) Soil Science & Agrometeorology	(University of the Free State)	2013

COUNTRIES OF WORK EXPERIENCE

South Africa – Kwa-Zulu Natal, Mpumalanga and Free State

KEY SPECIALIST DISCIPLINES

Hydropedological Assessments:

- Soil Survey
- Soil Delineation
- Hydrological hillslope classification
- Hydropedological loss Quantification
- Hydropedological impact assessment
- Scientific buffer determination

Soil, Land use, Land Capability and Agricultural Potential Studies

- Soil Desktop assessment
- Soil classification
- Agricultural potential
- Agricultural Impact Assessments

SAS ENVIRONMENTAL GROUP OF COMPANIES – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF BRAVEMAN MZILA

PERSONAL DETAILS

Position in Company	Wetland Ecologist and Soil Scientist
Joined SAS Environmental Group of Companies	2017

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Member of the South African Soil Science Society (SASSO)

Member of the Gauteng Wetland Forum (GWF)

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, Mpumalanga, Free State, North West, Limpopo, Northern Cape, Eastern Cape, KwaZulu-Natal

KEY SPECIALIST DISCIPLINES

Hydropedological Assessments:

- Soil Survey
- Soil Delineation
- Hydrological hillslope classification
- Hydropedological loss Quantification
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- Soil Desktop assessment
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- Agricultural potential
- Agricultural Impact Assessments