Reg No. 2019/317777/07
VAT Reg No. TBC
PO Box 751779
Gardenview
2047
Tel: 011 616 7893
Fax: 086 724 3132
Email: admin@sasenvgroup.co.za
www.sasenvironmental.co.za

HYDROPEDOLOGICAL ASSESSMENT AS PART OF THE SCOPING PHASE FOR THE PROPOSED DEVELOPMENT AT WONDERSTONE DRIEKUIL MINE, OTTOSDAL, NORTHWEST PROVINCE

Prepared for

QUALITATIVE REPORT (1/2)

February 2022

Prepared by: Zimpande Research Collaborative
Report author: B. Mzila
Report reviewer: T. Setsipane
S. van Staden (Pr.Sci.Nat)
Report Reference: ZRC 22-4001
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SAS Environmental Group of Companies

DOCUMENT GUIDE

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 overabstraction 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); 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).	Section 5
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)	Section 5

	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.	
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.	Section 4 and 5
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 4 and 5
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: Table 5.
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 6

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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

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

The Zimpande Research Collaborative (ZRC) was appointed to provide a Hydropedological assessment as part of the Environmental Impact assessment and authorisation process for the proposed development at Wonderstone Driekuil Mine, Ottosdal, Northwest Province. The project boundary where the proposed project is located will henceforth be referred to as the "study area" (refer to Figure 1 and 2).

Wonderstone is located on Portion 44 of the farm Gestoptefontein 349 IO which is approximately 300 kilometres west of Johannesburg and approximately 8.5km outside Ottosdal in the North-West Province, within the Tswaing Municipality (see Figure 1 below). The mine is located in quaternary catchment C31C in the Vaal Water management Area (WMA). The Driekuilspruit, which is a non-perennial (seasonal) stream, flows in a north-westerly direction through the project area and into the Klein-Harts River. The mine is accessed from the R505 road.

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.

1.1 Project Background

Up until recently the mine has been operating under the legal entitlement, Mining License: ML1-97, converted to Mining Right: NW 30/1/2/2/398 MR (Registered Right dated 23 December 2014). The issued mining right authorises the extraction of Pyrophyllite for a period of 30 years over the farm Gestoptefontein 349IO:

- Portion 44;
- Area measuring 135.916ha.

Mining takes place by means of open cast mining, comprising of hydraulic hammering and excavator loading with no drilling and blasting required.

In addition, Wonderstone Mine also holds an approved New Order Mining Right (NOMR) NW30/5/1/2/2/397MR (signed 20 March 2019) over various portions of the farms Gestoptefontein and Driekuil 280IP:

- Portion 5, 7, 9, 10, 11, 24 (portion of portion 5), remainder of portion 15 (a portion of portion 1), portion 20 and portion 40 (a portion of portion 41 now known as portion 44) of the farm Gestoptefontein 349IO;
- Portions 2, 4, remainder of portion 1, portion 7 (a portion of portion A) and the remainder of farm Driekuil 280IP.
- Area measuring: 4,595.4239ha

The mining rights combined cover an area of approximately140 ha of which just under 30ha has been disturbed by mining activities to date. A large portion of the northern section of the WST mining area on Gestoptefontein has been rehabilitated. WST aims to combine its existing mining rights into one, consolidated right, in an attempt to ease the administrative duties and compliance requirements associated with multiple mining authorisations associated with the mining complex.

At the same time, the operation would like to abandon some of the areas currently included and authorised as part of the approved NOMR area. After an extensive study, WST forecasts only using a select portion of the already approved NOMR area in its future mining endeavours. Abandonment of the remainder of the approved NOMR areas will ensure future mining in these areas and prevent the sterilisation of said areas for future mining.

During a pre-application meeting with the Department of Mineral Resources and Energy (DMRE) on 15 November 2021, the Department indicated that WST will be expected to submit a Section 102 Amendment Application. The application will include the areas of one approved mining right into the existing area of the other approved right.

WST decided to apply for the extension of the CMR (398MR) area by adding Portions of the approved NOMR (397) areas to the CMR area. At the same time the additional proposed areas of the NOMR, portions of the approved portions will be abandoned to allow for future mining.

New Project Activities

The mine will continue mining from the existing Wonderstone Opencast Pit and will include the additional five (5) mining blocks. The mineral to be mined is Pyrophyllite, an aluminium silicate of the phyllosilicate family, with the chemical formula Al_2 Si_4 O10 $(OH)_2$.

In areas where there is topsoil present, the topsoil, if any, will first be stripped to open the pyrophyllite, this topsoil will on completion of mining process be used during the rehabilitation process. Historically, there is little to no topsoil on Wonderstone deposits. The Pyrophyllite will be mined using an excavator equipped with a hydraulic hammer that will break the stone loose, an excavator with a shovel will load the usable stone on dump trucks that will transport the stone to the processing plant. Unusable stone will be transported to the low-grade stockpile (current Waste Rock Dump) for possible use in future. Mining will be done using the bench method with benches not higher than 5 meters.

It should however be noted, that two areas are demarcated for the temporary storage of overburden which will be used for backfilling of the opencast pits in the future.

Existing haul roads will be used but will have to be extended to the new mining area.

No electricity is required in new areas.

Dust control on haul roads will be done with the mine's own water bowser and water will be extracted from Driekuilspruit dam that is included in the mine's existing Water Use License. There are, however, existing boreholes that can be developed should the need arise.

The project will involve:

Mining activities

- Mining of existing area (Block 1N – about 15ha);
- five (5 mining blocks (2.5ha, 2.1ha, 2.1ha, 2ha, 2.9ha), which will be mined at different time intervals via opencast mining methods); and
- Area: Approx. 12ha (considering 14ha, for inclusion of the area between Block 5 and Block 5)

Stockpiles

- Two areas (3.4 and 3.2ha) have been identified for the temporary stockpiling of overburden – the mine will commit to ongoing rollover mining – but due to the time sequence, material will be stockpiled in these areas. For your studies, please look at these blocks and indicate whether there are any areas within these blocks which must be avoided. Important to note that the existing Waste Rock Dump will remain operational at 13.4ha;
- Provision in the two new areas must be for topsoil and overburden/waste rock (volumes is still to be supplied by the mine); and
- A new WRD of about 4ha is currently planned, which will likely comprise of a Pollution Control Dam (PCD).

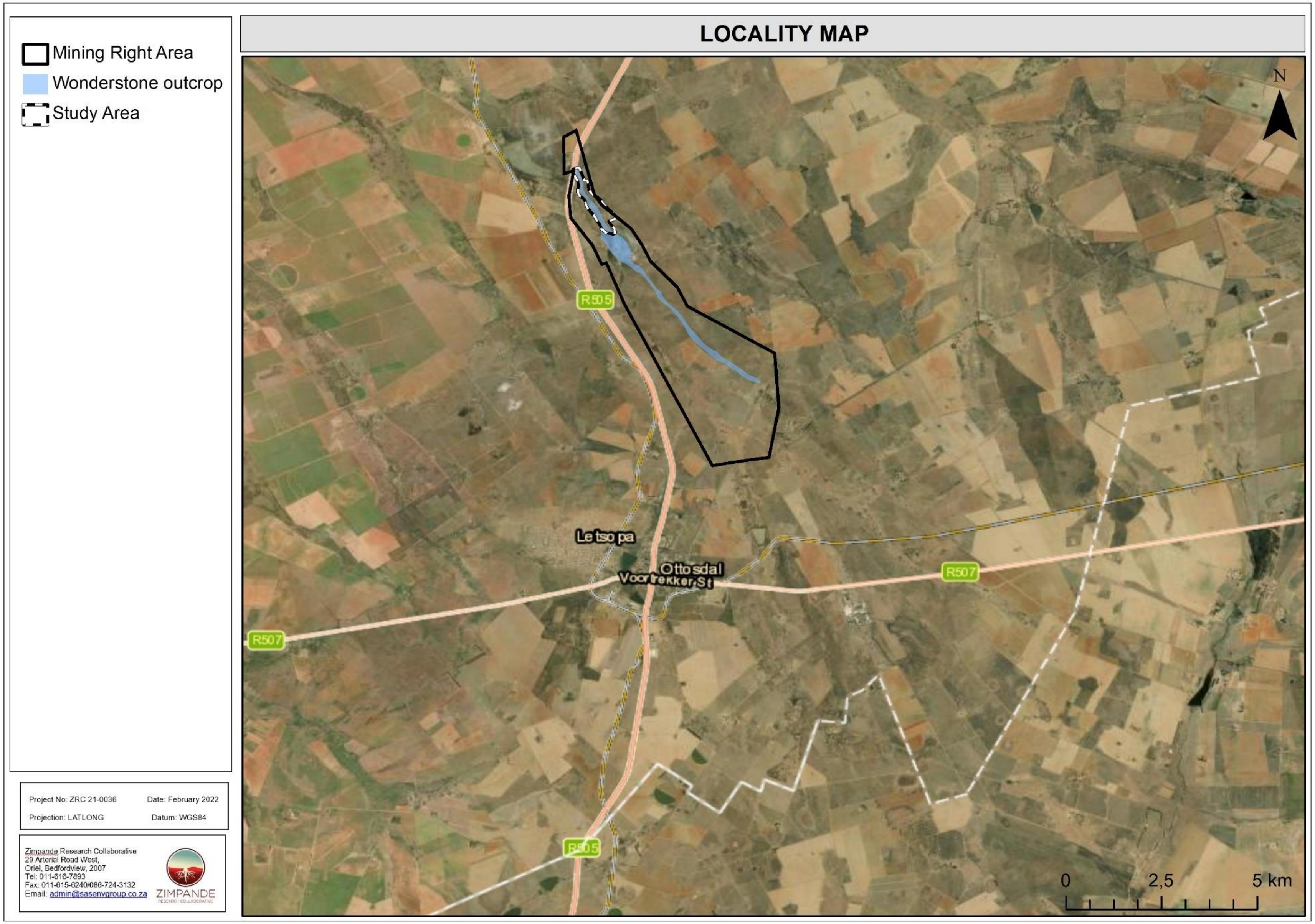

Figure 1: Locality map depicting the proposed diversion drain within the study area and surrounding areas

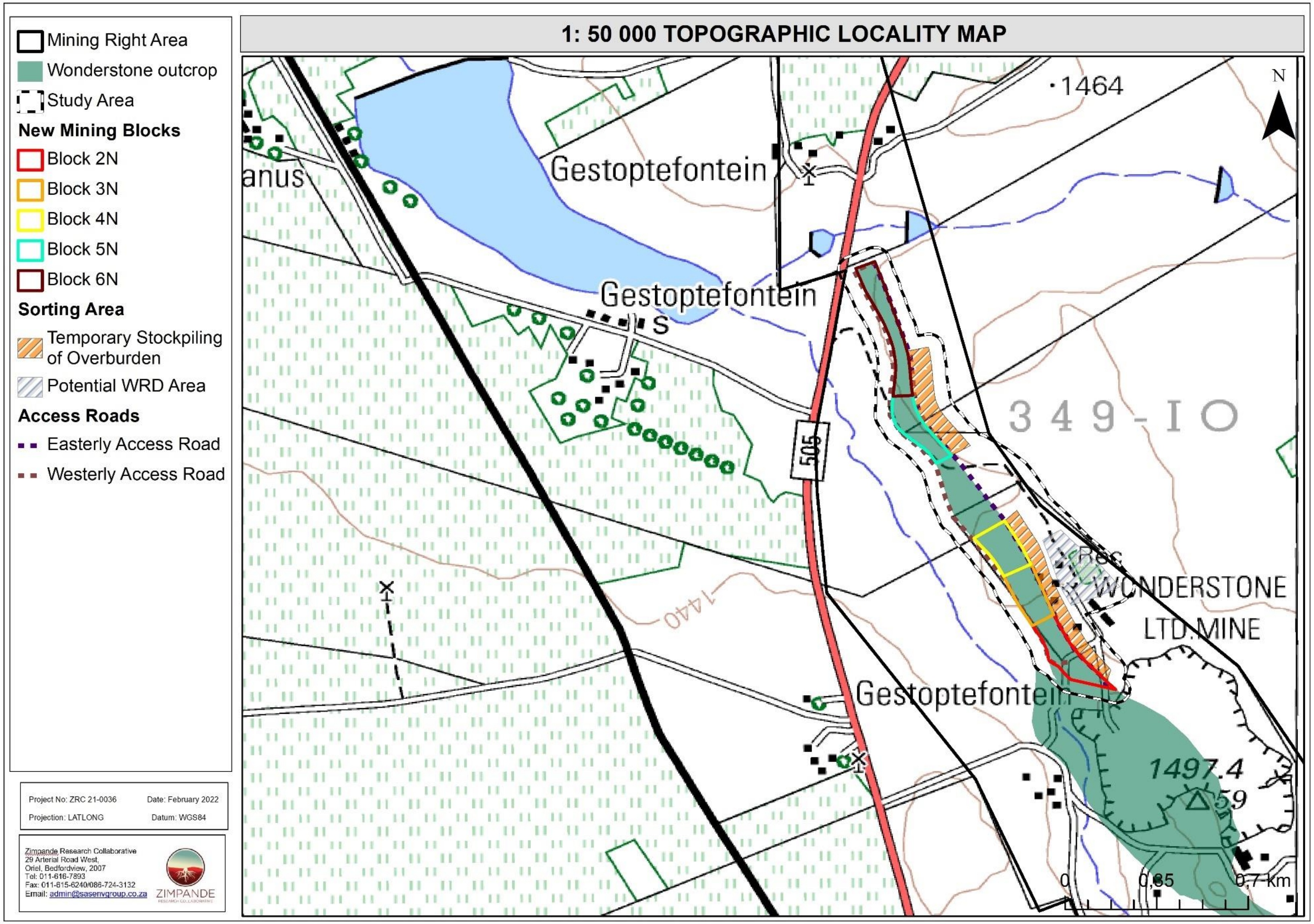

Figure 2: 1:50 000 topographic map depicting the proposed diversion drain within the study area and surrounding areas

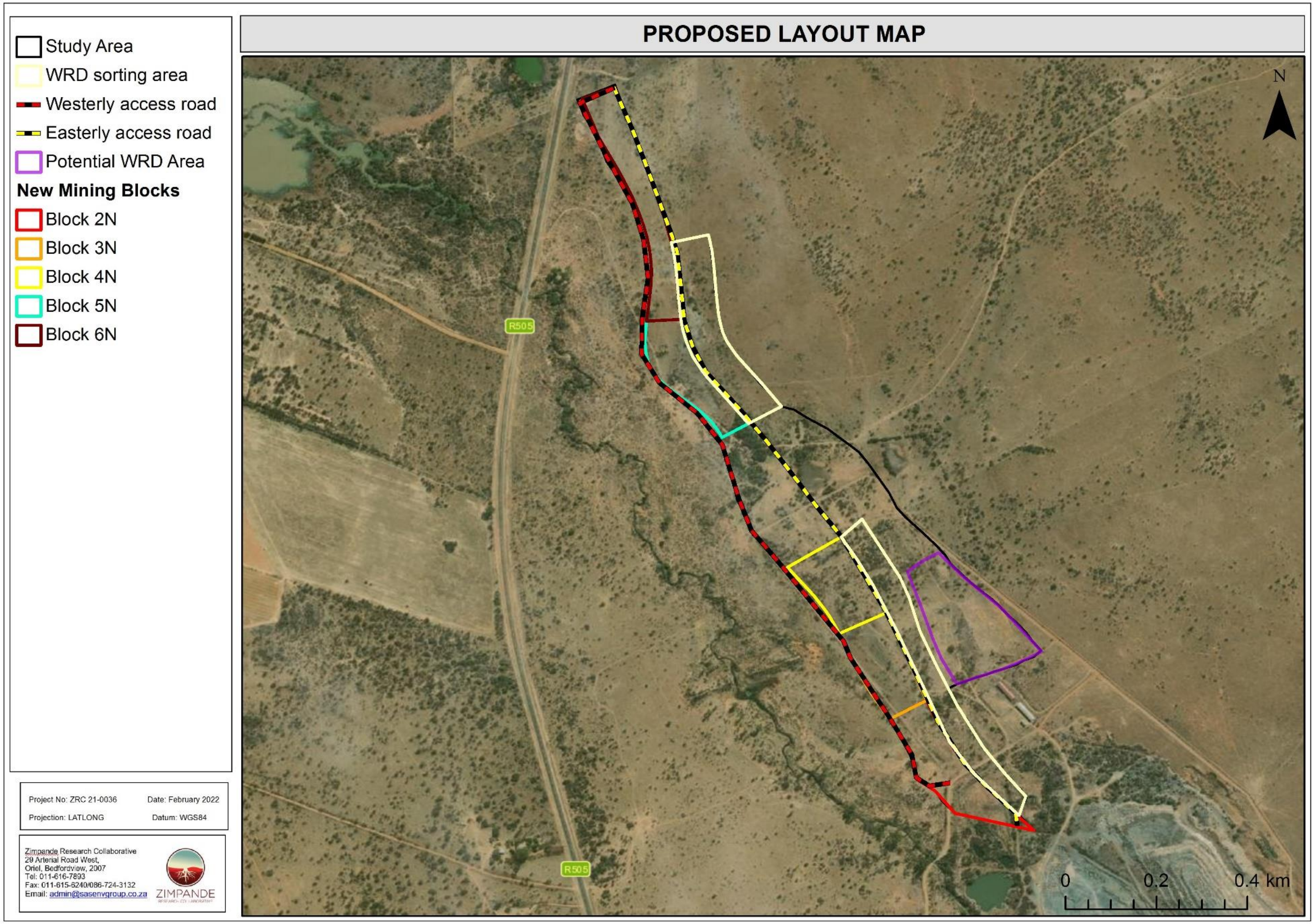

Figure 3: Proposed layout.

Figure 4: A general overview of the landscape of the study area.

1.2 Objectives

The proposed activities will include topsoil stripping as part of the site preparation for the development of the opencast and associated surface infrastructure within the study area. These activities may intercept the subsurface flows in the vadose zone feeding the watercourse as well as affect vadose zone recharge mechanisms. Thus, it was deemed necessary to investigate the recharge mechanism of the watercourse within and in close proximity to the study area to ensure that development planning takes cognisance of the hydropedologically important areas and hence enable informed decision making, construction design and support the principles of sustainable development. Recommendations considering mitigation were then considered and presented.

1.3 Assumptions and Limitations

- 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. These were very complex and thus some potentially important anomalies could have been missed. 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 focus of this study was on the dominant hillslope processes and therefore the transects focused on the dominant processes but some "micro-processes" may occur which we have not described.
- The effects 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 watercourse beyond the extent of the proposed development; and
- This assessment was confined to the study area as depicted in Figure 1, and does not include the neighbouring and adjacent properties, however the mapping of dominant soil forms was mapped up to the Driekuilspruit so as to indicate the destination and fate of water in the landscape.

2 ASSESSMENT METHODOLOGY

A hydropedological survey and sampling activities were conducted in August 2021 to assess the hydropedological characteristics of the landscape and associated soils within the study area. A soil sampling exercise was undertaken at selected representative points, considering the various soil types, to deduce the watercourse recharge mechanisms and identify the anticipated hydropedological impacts of the proposed development on the watercourses that will be affected by the proposed activity. Subsurface soil observations were made by means of a standard hand auger and investigation methods.

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.

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
- Soil 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 watercourse:

- Diagnostic soil horizon sequence;
- Landscape position in relation to the investigated watercourse (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

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

- Verify the spatial extent of the identified soil forms using a GIS software programme;
- Identify the potential impacts of the proposed development on the unsaturated flow processes, and implications to the functionality of the watercourse;
- Compile a brief report on the conceptual hydropedological regime of the assessed watercourse based on the soil types within the study area under current conditions; and
- Recommend suitable mitigation and management measures to alleviate the identified impacts on the watercourse 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	$3x10^{-2}$ – 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	$8x10^{-11}$ – $2x10^{-7}$

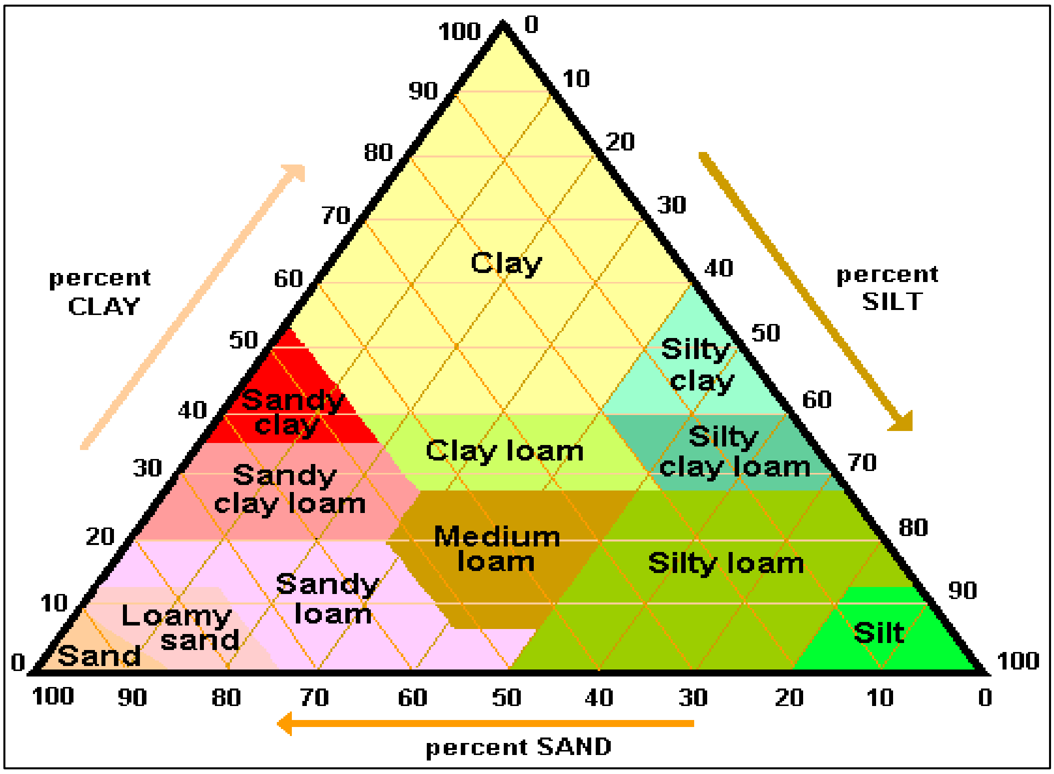

Figure 5: Soil texture classification chart (Food and Agriculture Organization (FAO), 1980.

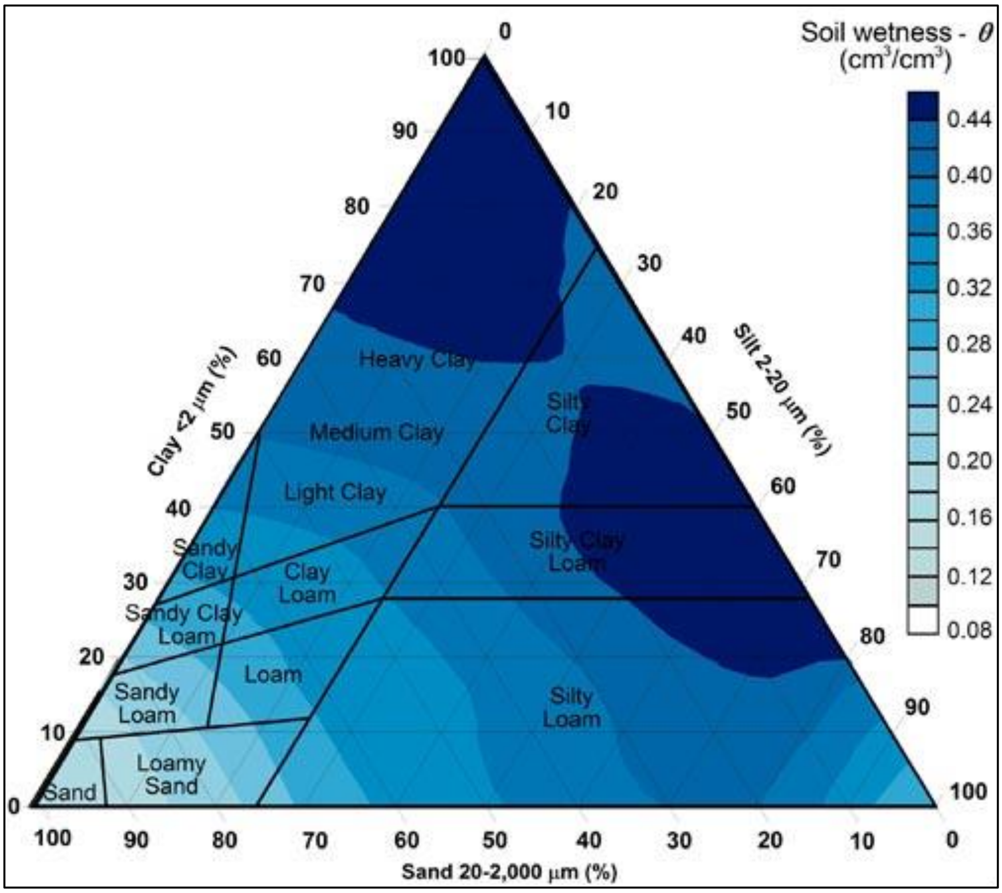

Figure 6: A diagram depicting soil wetness based on soil textural class

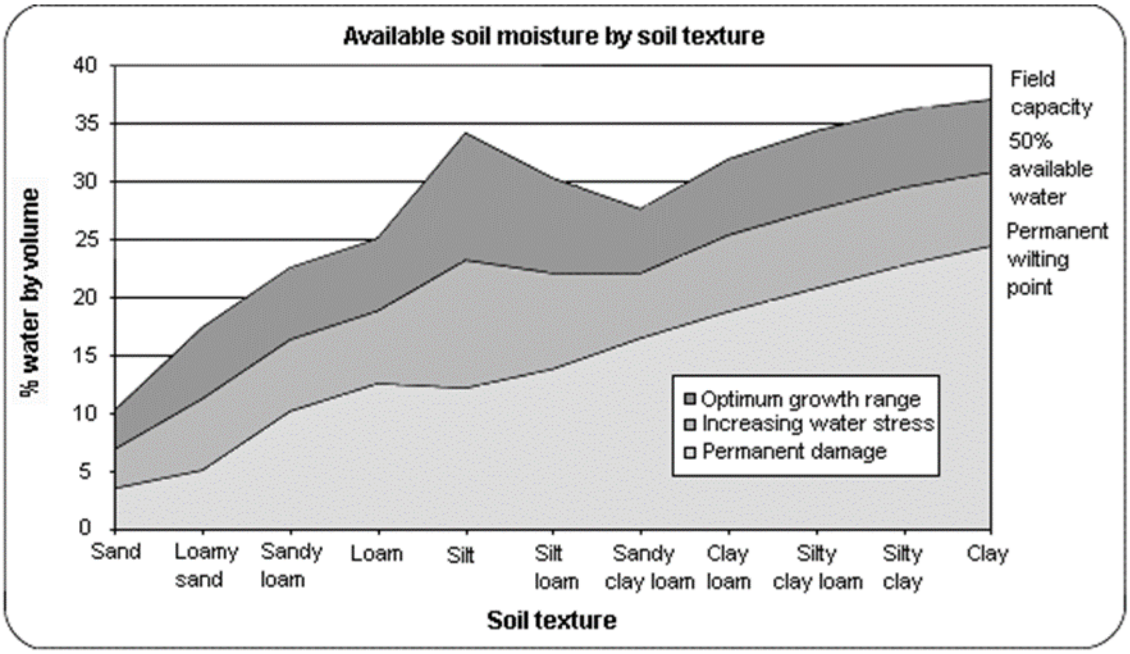

Figure 7: A diagram depicting the percentage volume of water in the soil using soil texture.

3 HYDROPEDOLOGICAL BEHAVIOUR OF SOIL TYPES

Hydropedological behaviour of different soils can vary significantly, depending on the soil drainage patterns. The discussion below is largely based on the concept presented in Figure 8 and Table 4 below.

Responsive shallow soils ‘respond’ quickly to rain events and typically generate overland flow. These soils can be shallow and overlie relatively impermeable bedrock, with limited storage capacity which is quickly exceeded following a rain event.

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).

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.

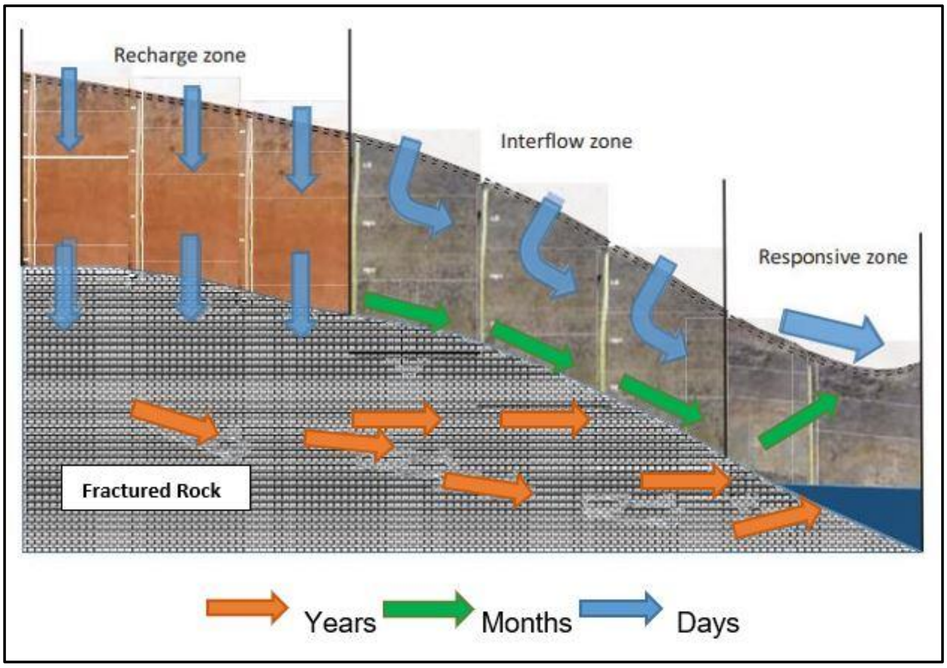

Figure 8: A typical conceptual presentation of hydrological flow paths on different hydropedological soil types- hillslope hydropedological behaviour.

3.1 Hydrological Soil Types

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 watercourse;
- Class 5 – Recharge to midslope; and
- Class 6 – Quick interflow.

4 ECOLOGICAL SIGNIFICANCE

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 freshwater report compiled by Scientific Aquatic Services SAS (2021), Five HGM units were identified within the study area: the Driekuilspruit (channelled valley bottom

[CVB1]), CVB2, hillslope seep (HS1), HS2 and an unchannelled valley bottom (UCVB). The systems were found to be in a moderately to largely modified ecological state, with moderate and low levels of ecological importance and sensitivity, and offering a range of moderately low to intermediate ecological services such as streamflow regulation, flood attenuation, nutrient and toxicant assimilation and erosion control.

The freshwater resources have been modified to a degree and the range of impact include:

- Potential impacts to water quality associated with the Wonderstone Waste Rock Dump, with special mention of acidification;
- Impacts related to edge effects as a result of encroachment from surface infrastructure and access roads;
- Impacts related to numerous impoundments and water abstraction on the Driekuilspruit; and
- The proliferation of woody species and alien and invasive vegetation species resulting in changes to the natural marginal and non-marginal vegetation structure.

The summary results of the freshwater study are presented in Table 5. Figure 9 depicts the locality of the delineated freshwater features as adapted from the freshwater study. (SAS, 2021). Although the watercourses associated with the proposed development have been impacted to a degree, protection of these watercourses where feasible is deemed important, in line with the National Water Act No. 36 of 1998 and National Environmental Management Act No. 107 of 1998. Further details pertaining to the conditions of the watercourses are within the freshwater study (SAS, 2022).

Figure 9: The location of the delineated watercourse associated with the study area.

Table 5: Summary of the wetland assessment (SAS, 2021).

Freshwater Ecosystem	Present Ecological State (PES) / Ecostatus	Ecoservices	Ecological Importance and Sensitivity (EIS)	Recommended Ecological Category / Recommended Management Objective / Best Attainable State
Driekuilspruit (CVB1)	D	Intermediate	Moderate	D / Maintain or Improve / C
CVB2	D	Moderately low	Moderate	D / Maintain or Improve / C
HS1	B	Moderately low	Low	B / Maintain / B
HS2	C	Moderately low	Low	C / Maintain / B
UCVB	C	Intermediate	Moderate	C / Maintain / C

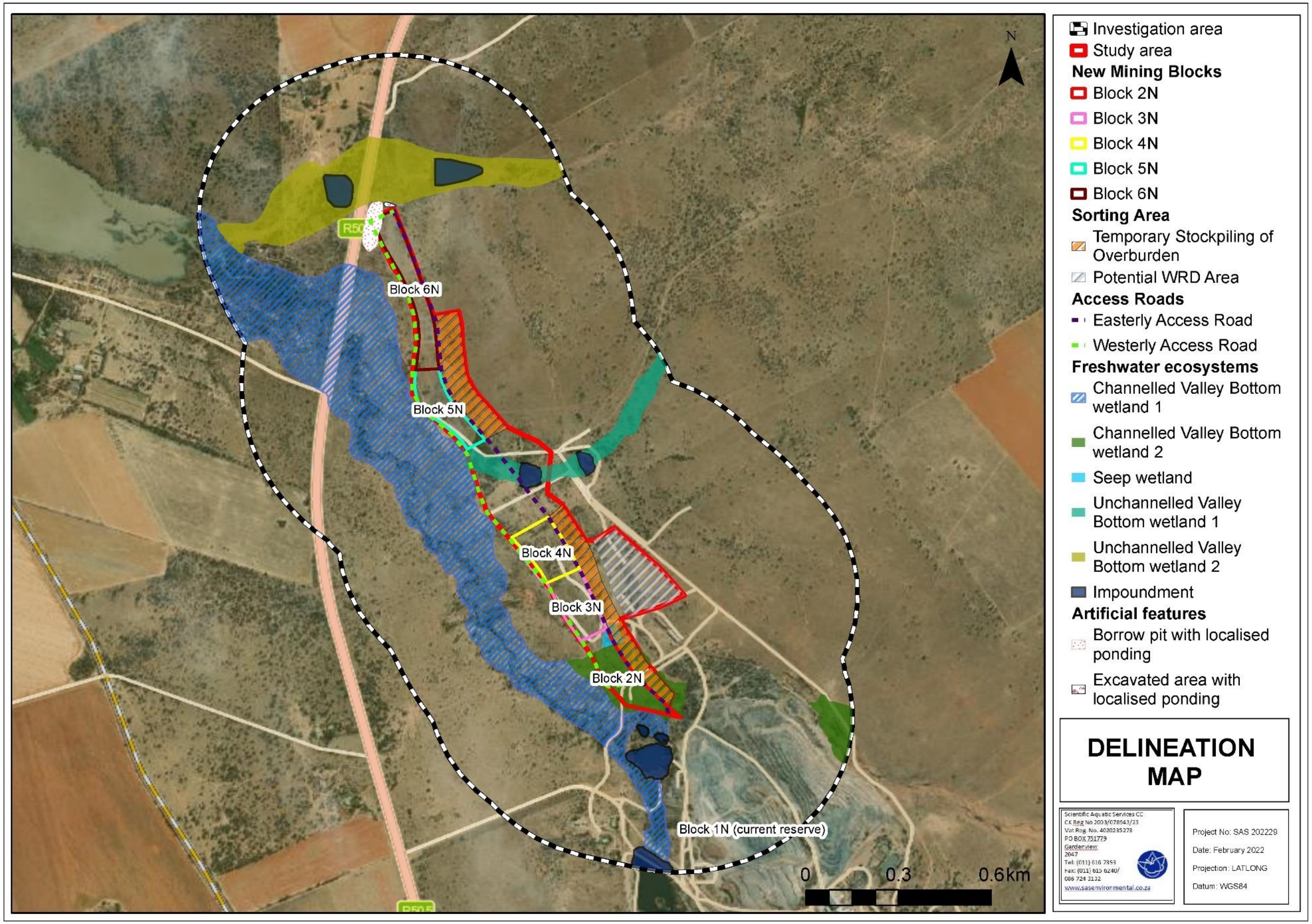

Figure 10: The location of the delineated watercourse associated with the study area

5 RESULTS AND DISCUSSION

5.1 Recharge of the Watercourse

Typically, there are four primary watercourse recharge mechanisms which include precipitation (rainfall), surface flow (runoff), subsurface flow (interflow) through the vadose zone of the surrounding soils, and groundwater discharge. Identified soils with the study area have been grouped into hydropedological soil types and are discussed below to understand their contribution to watercourse recharge.

5.2 Morphological and Hydraulic Properties of Watercourse and Hydropedologically Important Soils Associated with the Study Area:

The catena of the watercourses resembled a lithic topo sequence. These soils are generally shallow (less than 20cm) and have a low-water storage capacity attributed to their shallow nature. These soils are shallow and comprised of loamy sand of poor structure overlying relatively impermeable hard rock/lithic horizon. Limited storage capacity results in the generation of overland flow after rain events with limited infiltration. The slope position of the soils is typically the crest and scarp. It must be noted that these are not wetland soils, however they are important for recharge of watercourses during rainfall events by means of overland flow. Thus, these soils only support freshwater resources during rainy seasons and particularly directly after rainfall events.

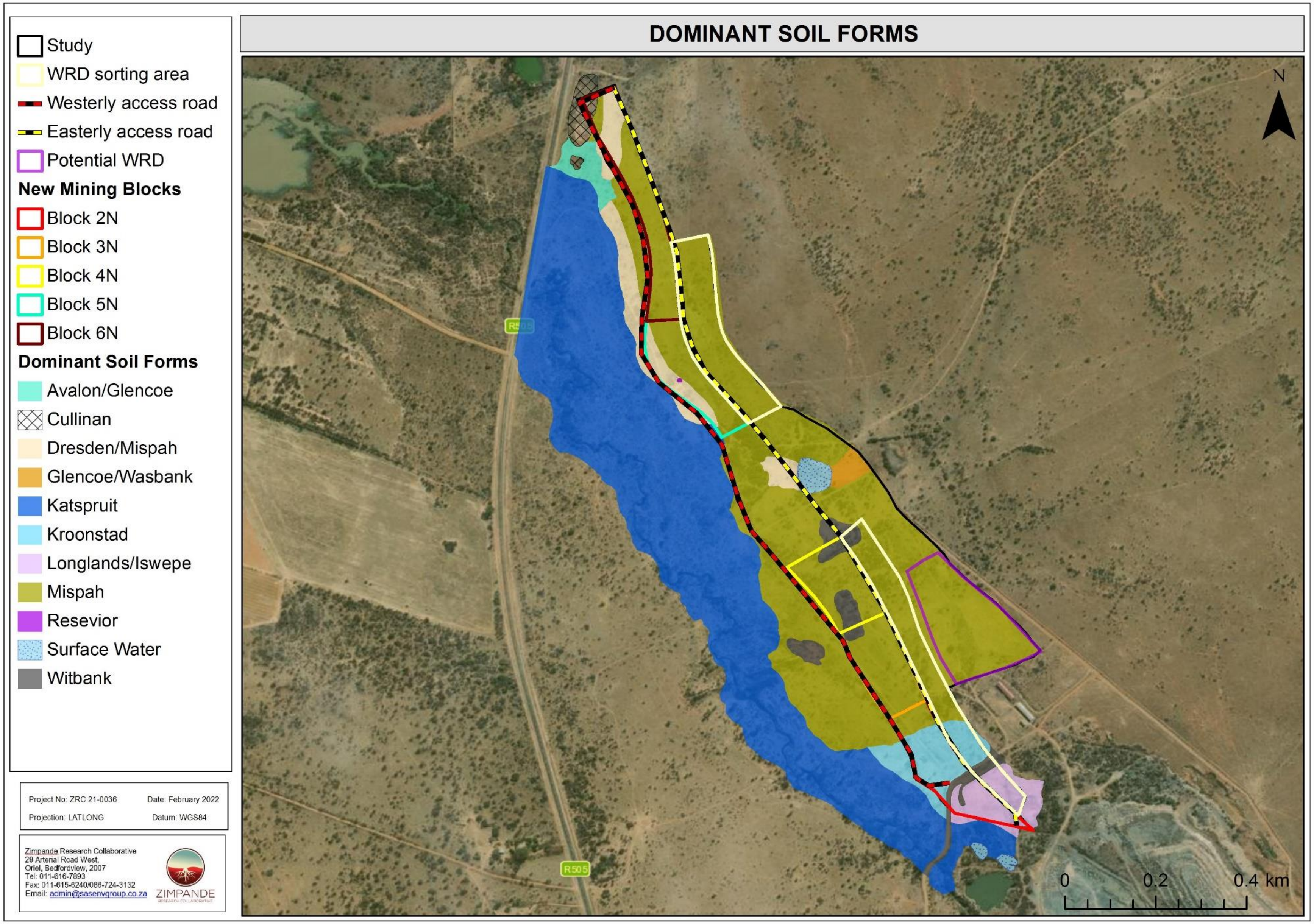

Figure 11: Map depicting spatial distribution of soils within the study area.

5.2.1 Responsive (Shallow) Soils

These soils are shallow, loamy sand of weak structure overlying relatively impermeable dark rock horizon. Limited storage capacity results in the generation of overland flow after rain events. These soils lead to a rapid runoff response time during intense rainfall events attributed to their shallow nature which inhibits infiltration. Figure 12 depicts Glenrosa soil form, a typical responsive shallow soil identified within the study area.

Figure 12: A depiction of responsive shallow soils

5.2.2 Recharge (Deep)Soils

Recharge soils are characterised by 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 bedrock. Figure 11 depicts Witbank soil form, a typical recharge soil identified within the study area.

Figure 13: View of the disturbed soils characterised by a lithic underlying material, draining in a vertical direction.

5.2.3 Interflow (A/B) Soils

Interflow soils discharge in a predominately 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 ET (evapotranspiration), extent of soils with interflow properties, position in the hillslope and slope. The interflow soils are characterised by inherently poor internal drainage due to the slowly permeable underlying soft plinthite horizon leading to lateral movement in the soil profile which allows recharge of wetlands via the vadose zone. The lighter color of the Albic horizon further supports that lateral flow dominates (Le Roux, *et al.,* 2015).

Figure 14: A depiction of an interflow soil in the A/B interface.

5.2.4 Interflow (Soil/Bedrock) soils

These soils are characterised by hydromorphic properties particularly mottling (red, yellow, and grey colors) which signify temporal build 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. The drainage may be restricted by an impermeable rock layer (Le Roux, *et al.,* 2015).

Figure 15: A depiction of an interflow soil in the soil/bedrock interface

5.2.5 Responsive (Saturated) Soils

Responsive soils include clayey Katspruit (Ka) soil form which depict prominent signs of prolonged wetness (Gleying) occurring within the permanent zone of the valley bottom wetlands (refer to Table 4) 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 largely 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.

Figure 16: A depiction of responsive (saturated) soils associated with the pan and valley bottom.

Table 6 presents the hydrological grouping of soils occurring within the study area according to Van Tol and Le Roux (2019) while Table 7 presents their respective diagnostic horizon and textural characteristics. The conceptual watercourse recharge based on the water flow paths through the soil medium are presented in Figure 17 below.

Table 6: Hydrological grouping of soils occurring within the study area according to Van Tol and Le Roux (2016).

Recharge (Deep)	Responsive (Shallow)	Interflow (A/B)	Interflow (Soil/Bedrock)	Responsive Wet
Witbank	Glenrosa	Wasbank	Avalon	Katspruit
	Mispah		Glencoe	

Table 7: List of soil forms within the study area and their contribution to watercourse recharge.

Recharge Mechanism	Soil Forms	Diagnostic Horizons	Description
Interflow (A/B)	**Wasbank (Wb)**	-A- Orthic -B- Albic -B2-Hard Plinthic	Characterised by a bleached Albic horizon indicating soil mineral exports by the process of eluviation underlined by a semi-impermeable plinthic material.
Interflow (Soil/Bedrock)	**Avalon (Av)**	- A: Orthic - B1: Yellow-Brown - B2: Lithic	Characterised by a bleached Albic horizon indicating soil mineral exports by the process of eluviation, underlain by a relatively impermeable lithic underlying material. When the water level reaches the more permeable surface horizons lateral flow occurs at much faster rates at the A/B horizon interface.
Responsive (Saturated)	**Katspruit (Ka)**	-A: Orthic -B: Gleyed	Characterised by prominent signs of prolonged wetness (Gleying) occurring within the permanent zone of the valley bottom wetlands. The soil morphological characteristics of the soils signify long periods of saturation.
Responsive (shallow)	**Glenrosa**	- A -Orthic -B - Lithic	The combination of relatively impermeable bedrock and shallow soil depth implies that these soils have a low storage capacity. They will saturate quickly following a rain event and contribute mostly to overland flow.
	Mispah (Ms)	- A: Orthic - B – hard rock	
Recharge (Vertical flow)	**Witbank (Wb)**	Unspecified	These soils are disturbed such that the diagnostic horizon could not be identified. 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.

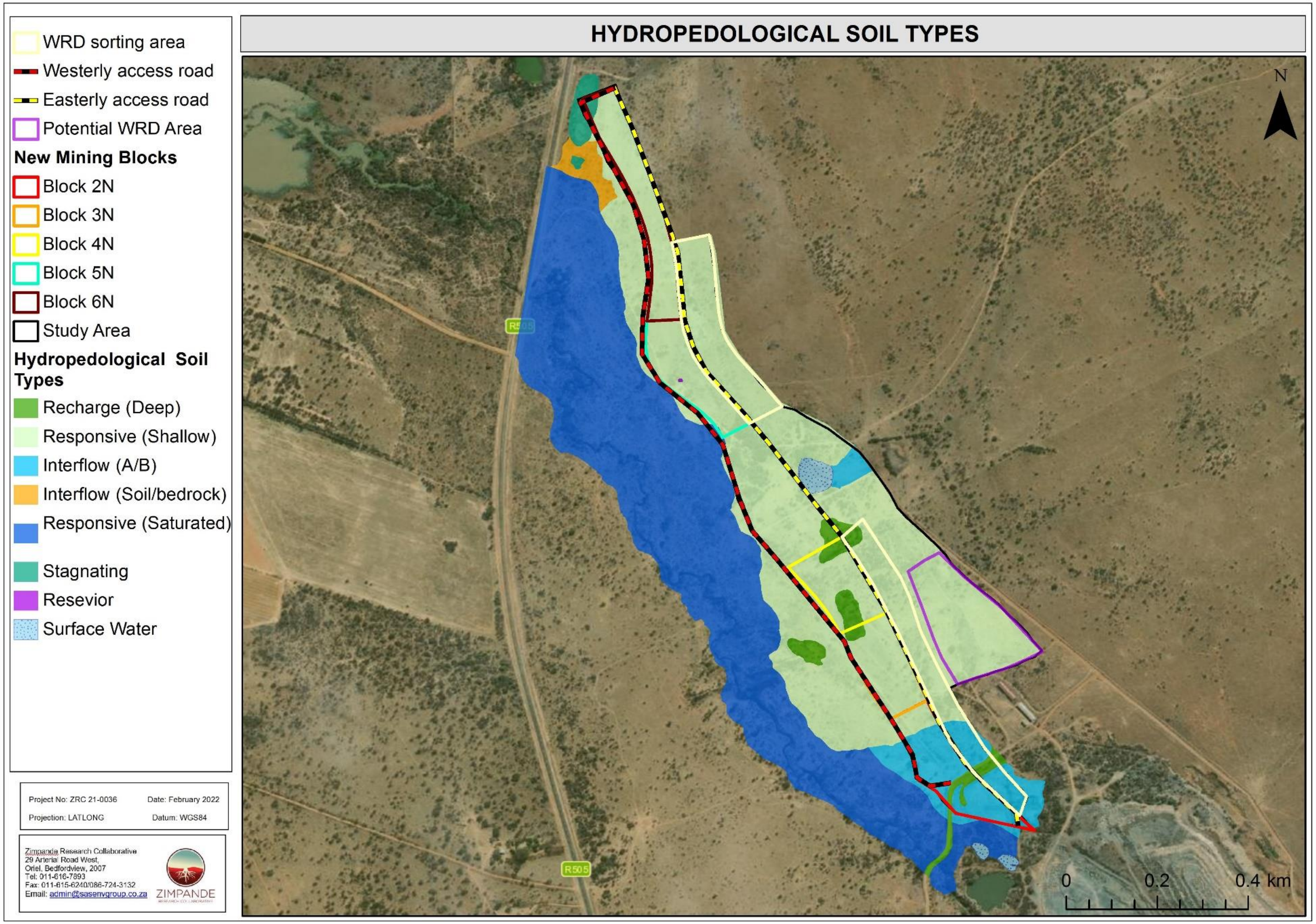

Figure 17: Map depicting hydrological soil types and delineated watercourses associated with the study area.

5.3 Hydro-pedological Implications

Most of the proposed development area comprises shallows soils which do not depict signs of wetness or an indicator of lateral flows in the vadose zone. These soils include Mispah and Glenrosa soils forms. The best suited hydropedological recharge mechanism definition for these areas is responsive shallow.

The hydropedological processes are deemed to have a limited contribution (if any) to the wetlands identified within the study area due to the occurrence of shallow soils (less than 20cm at most) which contribute to surface overflow flow during the rainy season. The anticipated dominant recharge mechanism of these wetlands is anticipated to be the shallow aquifer which manifests as springs.

The Driekuilspruit is likely driven by surface runoff with contribution from groundwater processes (as reported in the hydrology report). Although soils associated with interflow processes were identified within some portions of the study area which potentially feed the Driekuilspruit their contribution is limited and thus the impact of the proposed development is likely to be low to negligible. However, this will further be confirmed once the modelling processes have been completed.

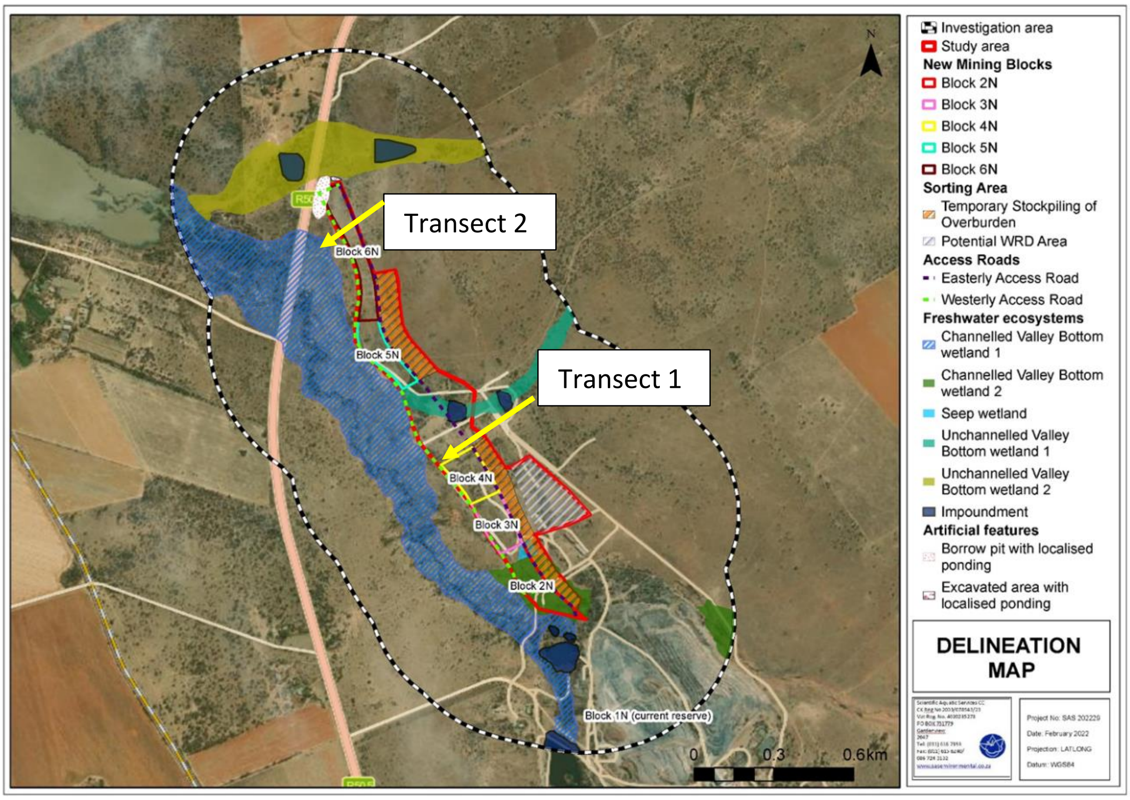

Figure 18: Localities of the investigated transects.

Transect 1: The proposed development area depicts strong characteristic of shallow lithic soils which have limited storage with no signatures of wetness in the subsoil within the catchment of the CVB wetland system. The post mining scenario will alter the surface runoff in the greater landscape. This means that quantity as well as the pattern, timing, and duration of the hydrograph would change and little to no mitigatory options are available. The post mining scenario will have no impact on ground water recharging the Driekuilspruit CVB since the proposed mining approach will not exceed 17 metres.

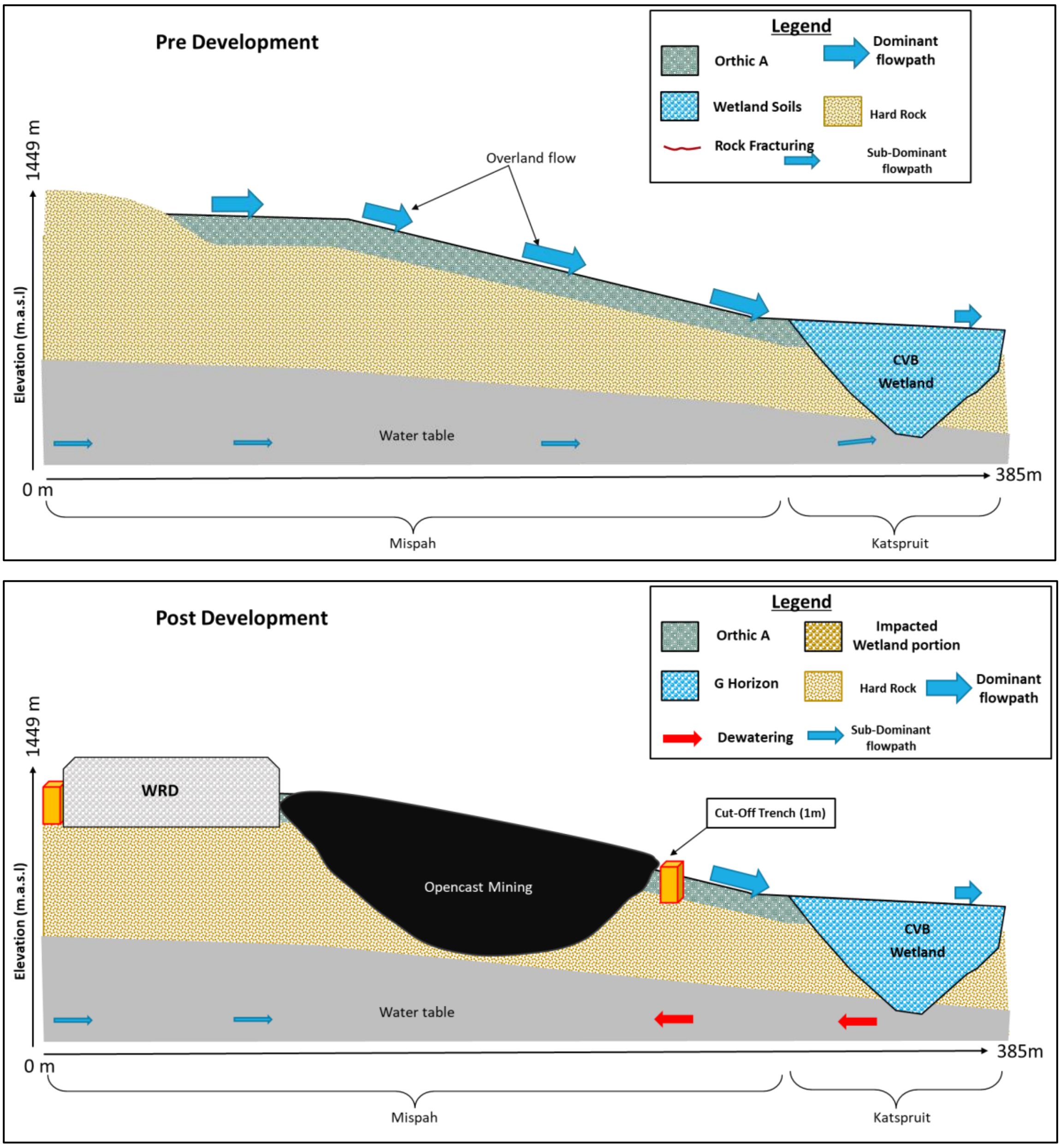

Figure 19: Conceptual hydropedological flow paths for cross section for pre- and post-development scenarios for transect 1.

Transect 2: This transects has an occurrence of interflow soils in the lower lying areas towards the Driekuilspruit system. The post mining scenario will alter the surface runoff which feeds these soils and subsequently impacting the functionality of these soils, however the contribution of the interflow soils on the overall functionality of the systems is limited.

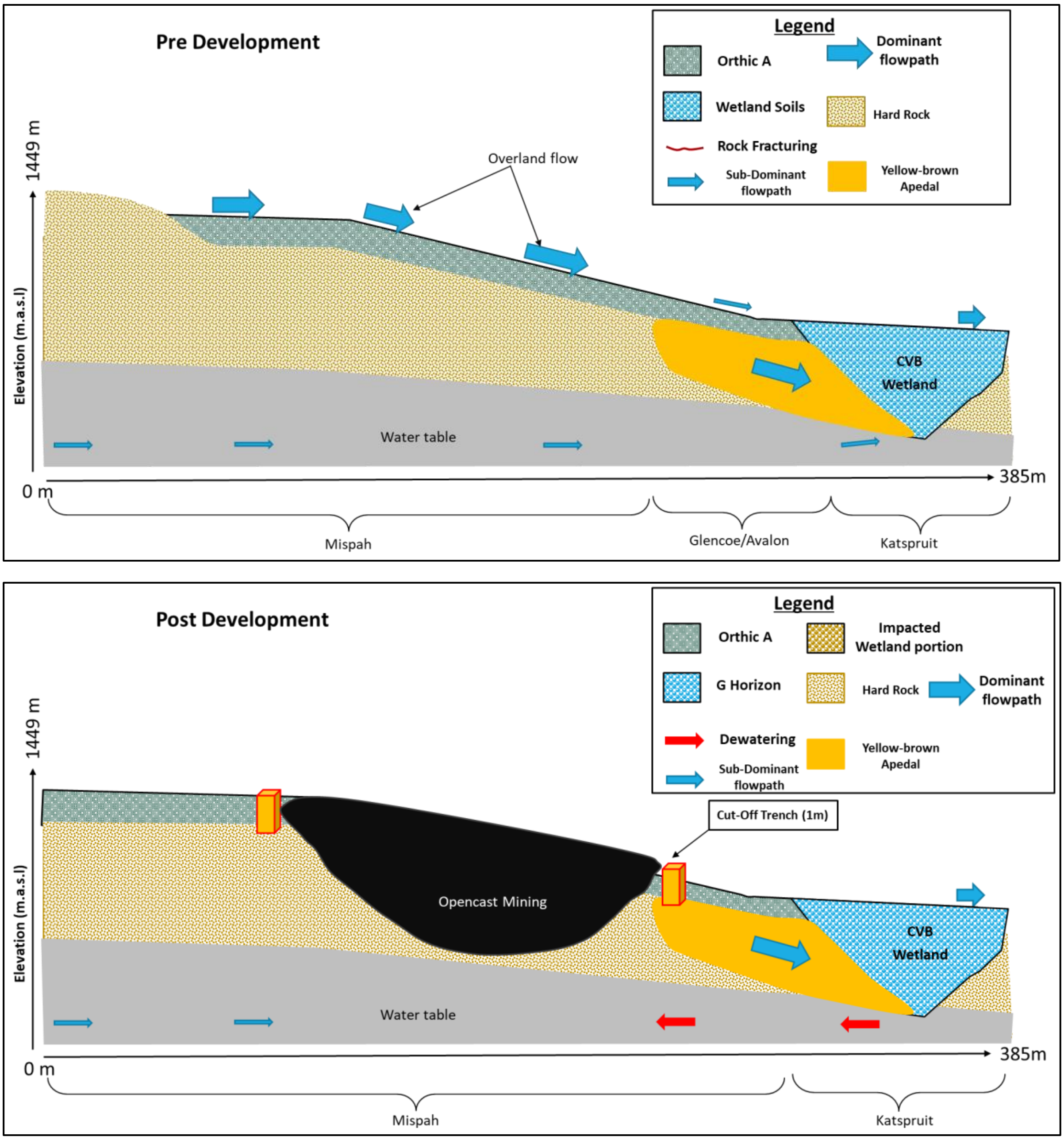

Figure 20: Conceptual hydropedological flow paths for cross section for pre- and post-development scenarios for transect 2.

5.4 Groundwater Consideration

The groundwater levels vary from 17.2 metres below ground level (mbgl) towards the south-east of the project area, to 0.4 mbgl near the Driekuilspruit directly north of the Driekuilspruit Dam. The general groundwater flow direction is from south-east to north-west (Digby Wells Environmental, 2020).

The general groundwater flow direction is from south-east to north-west (Digby Wells Environmental, 2020). Following the recent proposed mining approach, the mine will aim to avoid mining to the groundwater table, thus the opencast mining blocks are therefore not anticipated to have any interaction with the groundwater regime. Figure 22 depicts a conceptual landscape cross section as well as the location of the proposed opencast blocks. From this figure, it is apparent that the wetland systems might have a direct interaction with the ground water. The mine should ensure that the mining depth does not exceed 17 meters to ensure that no cone of depression occurs.

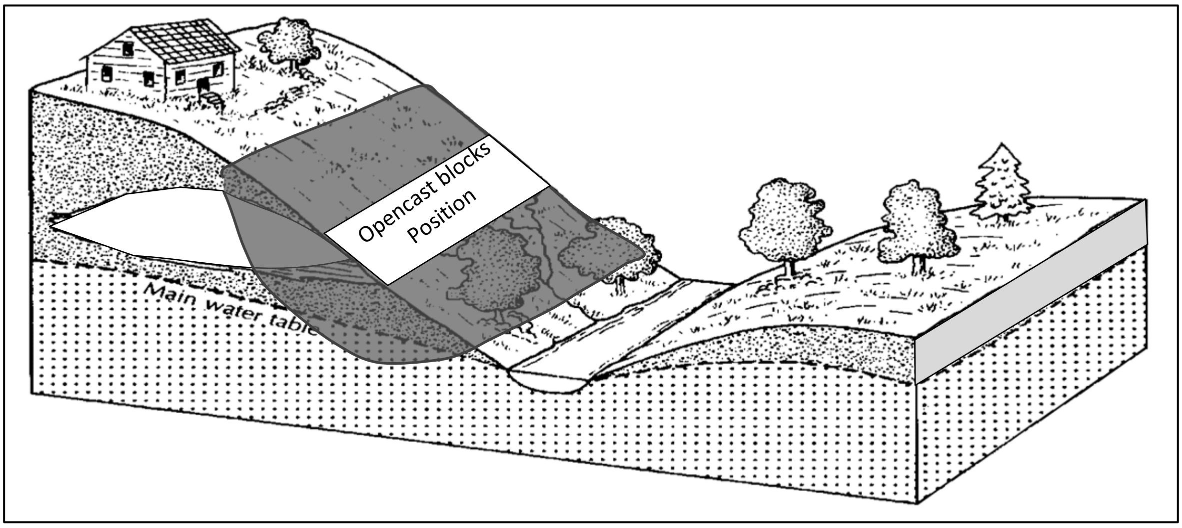

Figure 21: Conceptual imagery depicting a landscape cross section as well as the position of the proposed new Wonderstone mining development.

The surface infrastructure associated with the mining activities will hinder water distribution across the landscape. This is anticipated to reduce the recharge yield to the Driekuilspruit system, which may further reduce its ecological state. In addition, the proposed surface infrastructure will create a physical barrier resulting in landscape discontinuity, which will impede overland water flow from the upgradient areas.

5.4.1 Buffer Determination Using Hydropedological Principles

A scientifically derived buffer will be developed once the quantification of hydrological losses exercise has been undertaken. However, for planning purposes and to avoid edge effects recommendation of the freshwater report should be strongly considered.

6 PRELIMIARY CONCLUSION & RECOMMENDATIONS

Most of the proposed development area comprises shallow soils which do not depict signs of wetness or an indicator of lateral flows in the vadose zone. These soils include Mispah and Glenrosa soil forms. The best suited hydropedological recharge mechanism definition for these areas is responsive shallow. The hydropedological processes are deemed to have a limited contribution (if any) to the wetlands identified in the north-eastern portion of the study area due to the occurrence of shallow soils (less than 30cm at most) which contribute to surface overflow flow during the rainy season. The anticipated dominant recharge mechanism of these wetlands is anticipated to be the shallow aquifer which manifest as springs at specific geological inflection points.

The Driekuilspruit is mainly driven by surface runoff with contribution from groundwater processes (as reported in the hydrology report). Some portions of the smaller wetlands that feed the Driekuilspruit will be mined through while other systems will largely remain unimpacted from a hydropedological point of view. Although soils associated with interflow processes were identified within some portions of the study area which potentially feed the Driekuilspruit their contribution is limited and thus the impact of the proposed development on hydropedological processes supporting the Driekuilspruit is likely to be low to negligible. However, this will further be confirmed once the modelling processes have been completed.

The post mining scenario will likely alter the surface runoff in the greater landscape and ultimately impact on the overall water balance of the catchment. This means that quantity as well as the pattern, timing, and duration of the hydrograph would change and little to no mitigatory options are available. However, no cone of depression is foreseen since the opencast pits will not have any interaction with the groundwater.
Additional mitigation measures and recommendations include:

- All surface development footprint areas should remain within demarcated areas as far as possible and disturbance of soil profiles to be limited to what is essential;
- Water from clean water structures should be discharged back into the watercourse in an attenuated manner; and
- Implementation of strict erosion control measures to limit loss of soil and sedimentation of the watercourse within the proposed project.

If the above mitigatory measures are implemented, with careful construction practices, the significance of the impact can be reduced to a low significance.

7 REFERENCES

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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) Environmental 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:	Zimpande Research Collaborative		
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

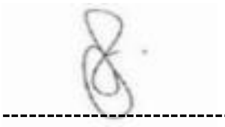
----

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

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

I, Tshiamo Setsipane, 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
- 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