Appendix H-13

GEOTECHNICAL STUDY

Confidential

REPORT

Impumelelo Wind Energy Facility Geotechnical Desktop Assessment

Enertrag South Africa (Pty) Ltd

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Distribution List

1 x electronic copy to Enertrag South Africa (Pty) Ltd

1 x electronic copy to WSP SharePoint project site

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1.0 INTRODUCTION

WSP Group Africa (Pty) Ltd was appointed by Enertrag South Africa (Pty) Ltd to perform a geotechnical desktop assessment of the proposed Impumelelo Wind Energy Facility (WEF) and the associated grid infrastructure. The assessment was commissioned in an email by Enertrag and was undertaken in accordance with WSP's proposal entitled "*41104073_20220722_Enertrag Secunda WEF EIA Geotech Proposal_Final_V4*".

The main objective of the desktop assessment is to perform a general assessment of the impacts of the proposed WEF development on the geotechnical conditions on and around the site or vice versa. The geotechnical assessment will form part of the Environmental Impact Assessment (EIA).

This report presents the results of the geotechnical desktop assessment.

1.1 Project description

The Impumelelo WEF project will comprise the following:

Table 1: The key technical details of the Impumelelo WEF and the grid connection

Component	Description
Wind Energy Facility	
Capacity	Up to 200MW
Extent	2800 ha
Buildable area	Approximately 680ha, subject to finalization based on technical and environmental requirements
Number of turbines	Approximately 30 wind turbine generators
Turbine hub height:	Up to 200m
Rotor Diameter:	Up to 200m
Foundation	Approximately 25m^2 diameter x 3m deep. 500 m^3 – 650m^3 concrete. Excavation approximately 1000m^2, in sandy soils due to access requirements and safe slope stability requirements.
Operations and Maintenance (O&M) building footprint:	Located in close proximity to the substation. Septic tanks with portable toilets. Typical areas include Operations building – 20m x 10m = 200m^2, Workshop – 15m x 10m = 150m^2 & Stores - 15m x 10m = 150m^2
Construction camp laydown	Typical area 100m x 50m = 5000m^2. Sewage, septic tanks and portable toilets.
Temporary laydown or staging area:	Typical area 220m x 100m = 22 000m^2. Laydown area could increase to approximately 30 000m^2 to accommodate concrete towers, should they be required.
Batching plant (temporary):	Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo.
Internal Roads:	Width of internal road – 5m to 6m. Length of internal road is approximately 60km. Where required for turning circle/bypass areas, access or internal roads may be up to 20m to allow for larger component transport.
Cables:	The medium voltage collector system will comprise of cables up to and including 33kV that run underground, except where a technical assessment suggest that overhead lines are required, within the facility connecting the turbines to the onsite substation.

Component	Description
Independent Power Producer (IPP) site substation and battery energy storage system (BESS):	Total footprint will be up to 6.5ha in extent (5ha for the BESS and 1.5ha for the IPP portion of the substation). The substation will consist of a high voltage substation yard to allow for multiple (up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, and other substation components as required. The associated BESS storage capacity will be up to 200MW/800MWh with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology however the specific technology will only be determined following EPC procurement. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.
Site access	R547 and R23
Height of substation fencing	Up to 3 m high Galvanised steel
Grid connection	
Powerline corridor length	Approximately 34km (To be confirmed prior to construction)
Powerline assessment corridors width	500m (250m either side of centre line)
Powerline servitude	32m per 132kV powerline. Option 1 is ~33km and Option 2 is ~34km
Powerline pylons:	Monopole or Lattice pylons, or a combination of both where required
Powerline pylon height:	Maximum 40m height
Temporary laydown or staging area:	Typical area 220m x 100m = 22 000m². Laydown area could increase to 30 000m² for concrete towers, should they be required.
Site access	R547 and R23
Height of substation fencing	Up to 3 m high Galvanised steel

1.2 Scope of Work

The scope of work is limited to a desktop review and interpretive reporting on the findings. The desktop assessment included the following:

- Literature reviews of available published and unpublished information including, but not limited to, geological data, geological maps, topographical maps, aerial images and any existing geotechnical investigation reports of the study area
- Assessment of the relevant geotechnical and geological fatal flaws within the study area
- Assessment of the excavation conditions across the sites

1.3 Specialist Credentials

The geotechnical desktop assessment was undertaken by an experienced professionally registered engineering geologist and the work was overseen by a professionally registered senior geotechnical engineer.

Khuthadzo Bulala is an engineering geologist with a Bachelor of Science Honors Degree from the University of Limpopo. She is registered as a Professional Scientist (Pr.Sci.Nat 116482).

Khuthadzo has seven years of experience in engineering geology, geotechnical engineering, environmental geology, and soil surveys. She has extensive experience in conducting renewable energy geotechnical assessments and detailed geotechnical investigations.

The desktop assessment was reviewed and authorized by Heather Davis. Heather is a qualified Professional Engineer (Pr.Eng 960229) with 40 years of experience. She obtained a BSc Honours degree in Engineering Geology and Geotechnics from the University of Portsmouth (UK) in 1982. A post graduate diploma was obtained from the University of the Witwatersrand in 1993 which focused on geotechnical engineering and rock mechanics. She is currently the geotechnical team lead at WSP. Her responsibilities include providing geotechnical inputs to various projects, quality assurance on all geotechnical WSP work and provision of reports. She has accumulated extensive experience in Sub Saharan Africa which has included work on the Medupi and Kusile Power Plants and on renewable projects such as the Sere Wind Farm, for Eskom, in the Northern Cape.

The CV's for Khuthadzo Bulala and Heather Davis are included in APPENDIX A.

2.0 STUDY AREA INFORMATION

2.1 Site Description

The proposed WEF is located approximately 19km north-east of Greylingstad in the Dipaleseng Local Municipality and the Gert Sibande District Municipality, Mpumalanga Province. Figure 1.

The proposed WEF site is approximately 2 800ha with a buildable area of 680ha. The two proposed grid powerline options are approximately 33km and 34km.

The proposed WEF site will affect 9 property portions and the grid will traverse 49 properties as listed in Table 2:

Table 2: Affected Farm Portions

WEF Application site	Grid Infrastructure
Hartbeesfontein Farm 522 (Portions 6 & 25) Mahemsfontein Farm 544 (Portions 0, 7 & 8) Platkop Farm 543 (Portions 2, 4, 5 & 9)	De Bank of Vaalbank Farm 280 (Portions 1, 2, 4 & 6) Grootspruit Farm 279 Portion 0 Haartebeesfontein Farm 522 (Portions 6 & 25) Holgatsfontein Farm 535 (Portions 3, 4 & 14 to 20) Mahemsfontein Farm 544 (Portions 0, 7 & 8) Platkop Farm 543 (Portions 2, 4, 5 & 9) Roodebank Farm 323 Portion 20 Springbokdraai Farm 277 (Portions 2, 3 & 5) Wolvenfontein Farm 534 (Portions 1, 18, 19 & 20) Zandfontein Farm 130 (Portions 2, 3, 5, 8 & 9) Farm 529 Portion 0, Farm 277 Portion 5, Farm 545 Potion 0, Farm 130 Portion 3 & Farm 532 Portion 16

The site is mainly characterized by highveld grassland with the majority of the farms being utilized for agricultural farming and for cattle grazing.

2.2 Drainage and Topography

The site lies with the C12F Quaternary Catchment (Brits, 2015). The Greylingstad area receives on average annual rainfall of approximately 570mm, with the highest rainfall occurring between November and January. Evaporation data for the area is 1320mm.

Numerous non-perennial rivers drain in a westerly direction into the perennial Grootspruit River and in a easterly direction into the Ouhoutspruit River. Figure 2 illustrates the drainage features across the site.

The proposed WEF site lies at an elevation that ranges between approximately 1570m and 1650m. The lowest elevation values are in the drainage feature valleys. The WEF site is generally flat with slope degrees ranging between <1% and <3%.

Figure 2 and Figure 3 show the topography and slope across the site, respectively.

3.0 GEOLOGY

According to the published 1: 250 000 geological map (Sheet 2628 East Rand), the study area is underlain by rocks of the Vryheid Formation (Pv), Ecca Group of the Karoo Supergroup. This Vryheid Formation comprises sandstone, shale and coal beds.

The Vryheid Formation has been extensively intruded by Jurassic age dolerite (Jd). The dolerites occur both as sills and linear dyke structures that may extend over tens of kilometers.

Significant recent surficial deposits, alluvium, blanket the areas along the drainage features on the western side of the site.

An excerpt of the published geological map showing the project area is presented as Figure 4 and the lithostratigraphy is presented in Table 3.

Table 3: Lithostratigraphy of the Area

Supergroup	Group	Formation	Lithology	Map Symbol
			Alluvium	⌒⌒
			Dolerite	Jd
Karoo	Ecca	Vryheid	Sandstone, shale and coal beds	Pv

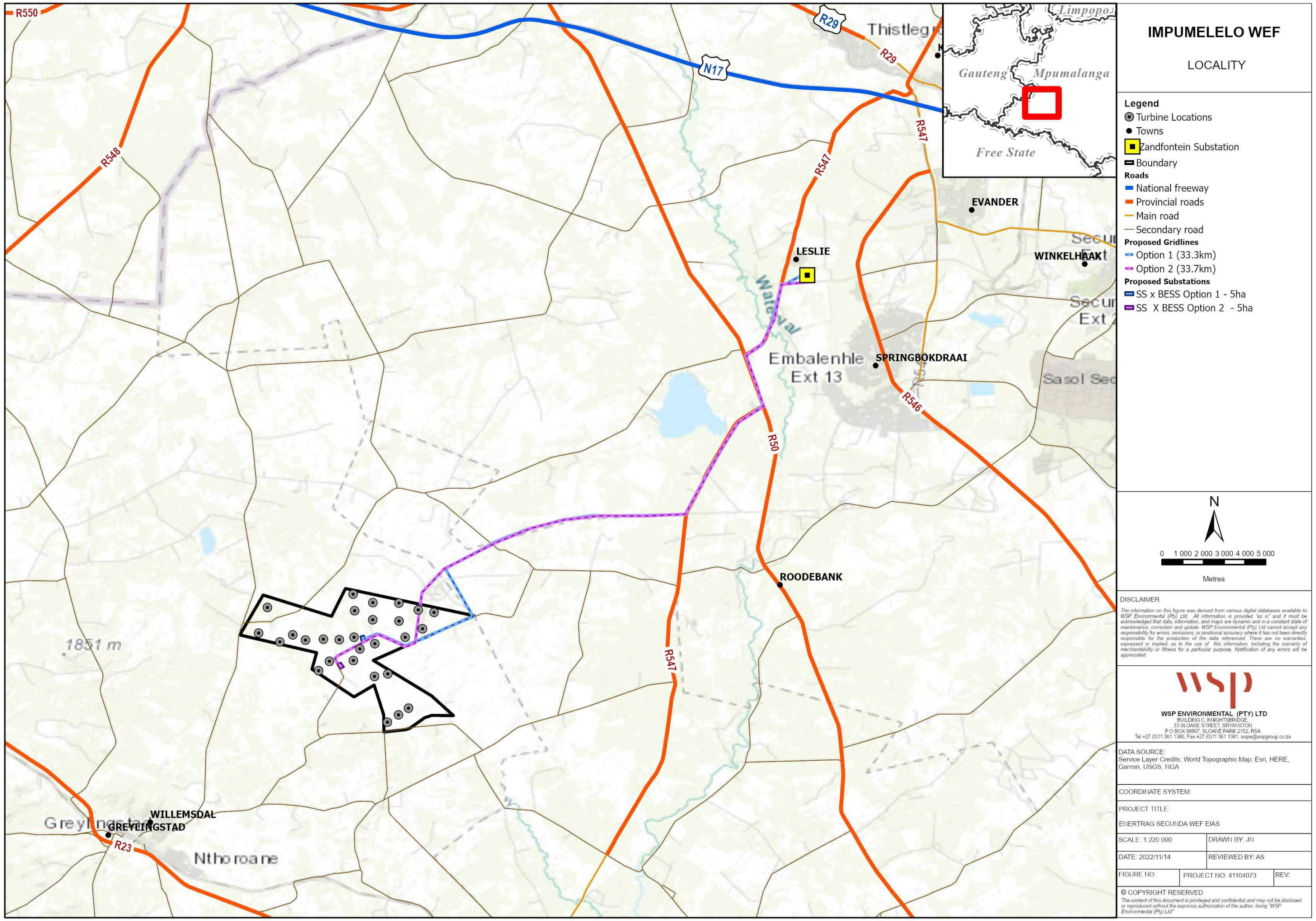

Figure 1: Location of the Impumelelo site

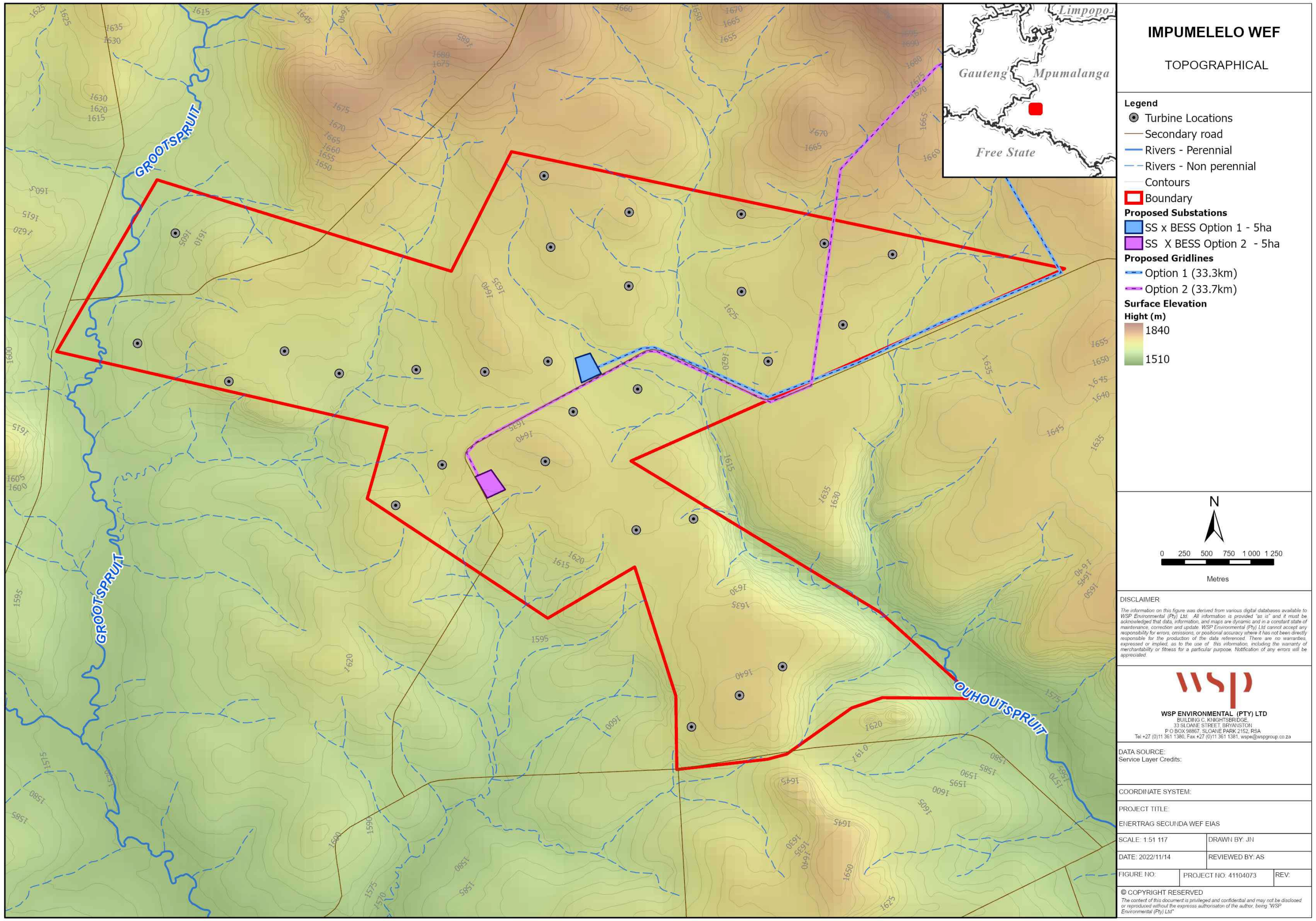

Figure 2: Topography across the site

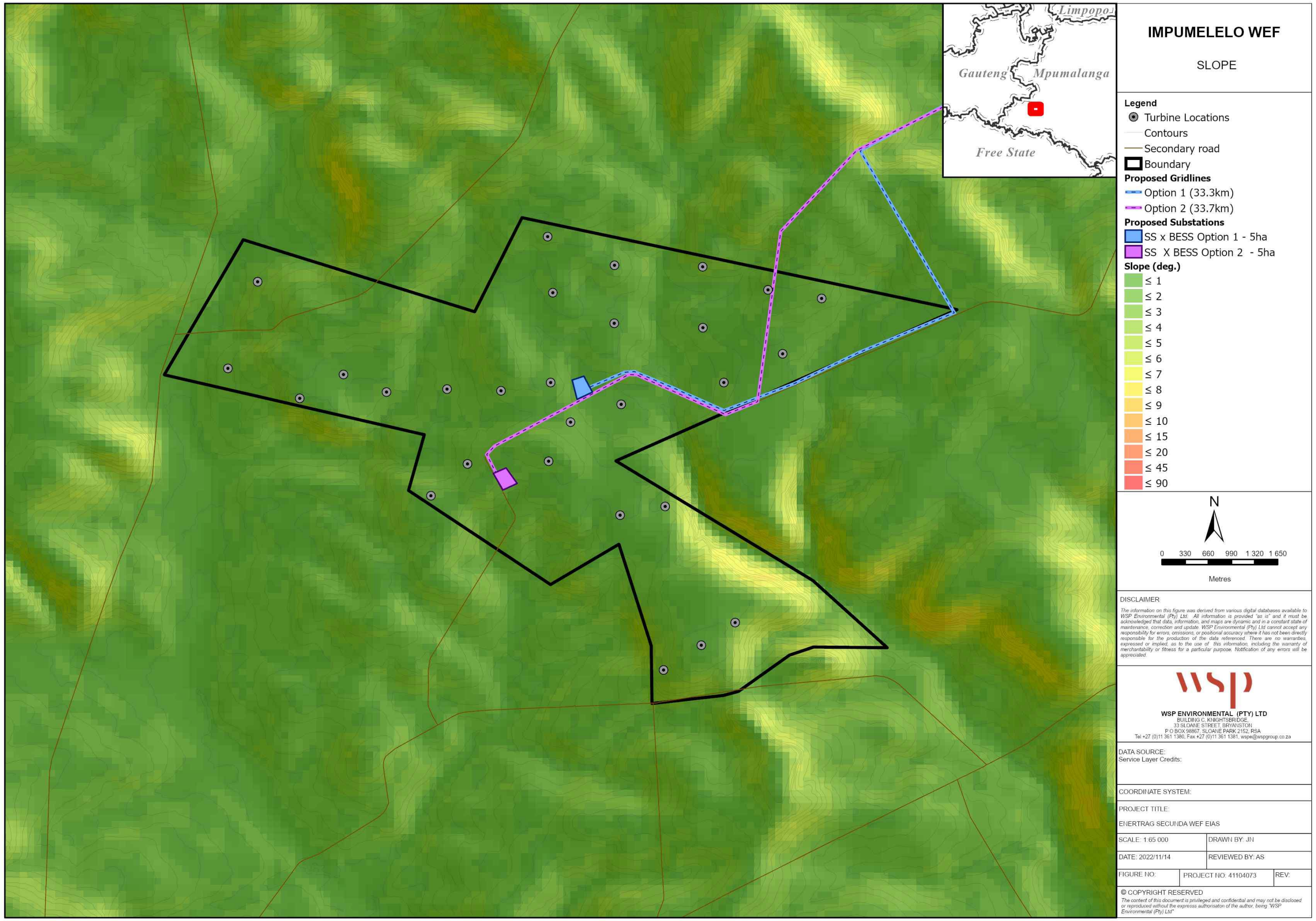

Figure 3: Slope across the site

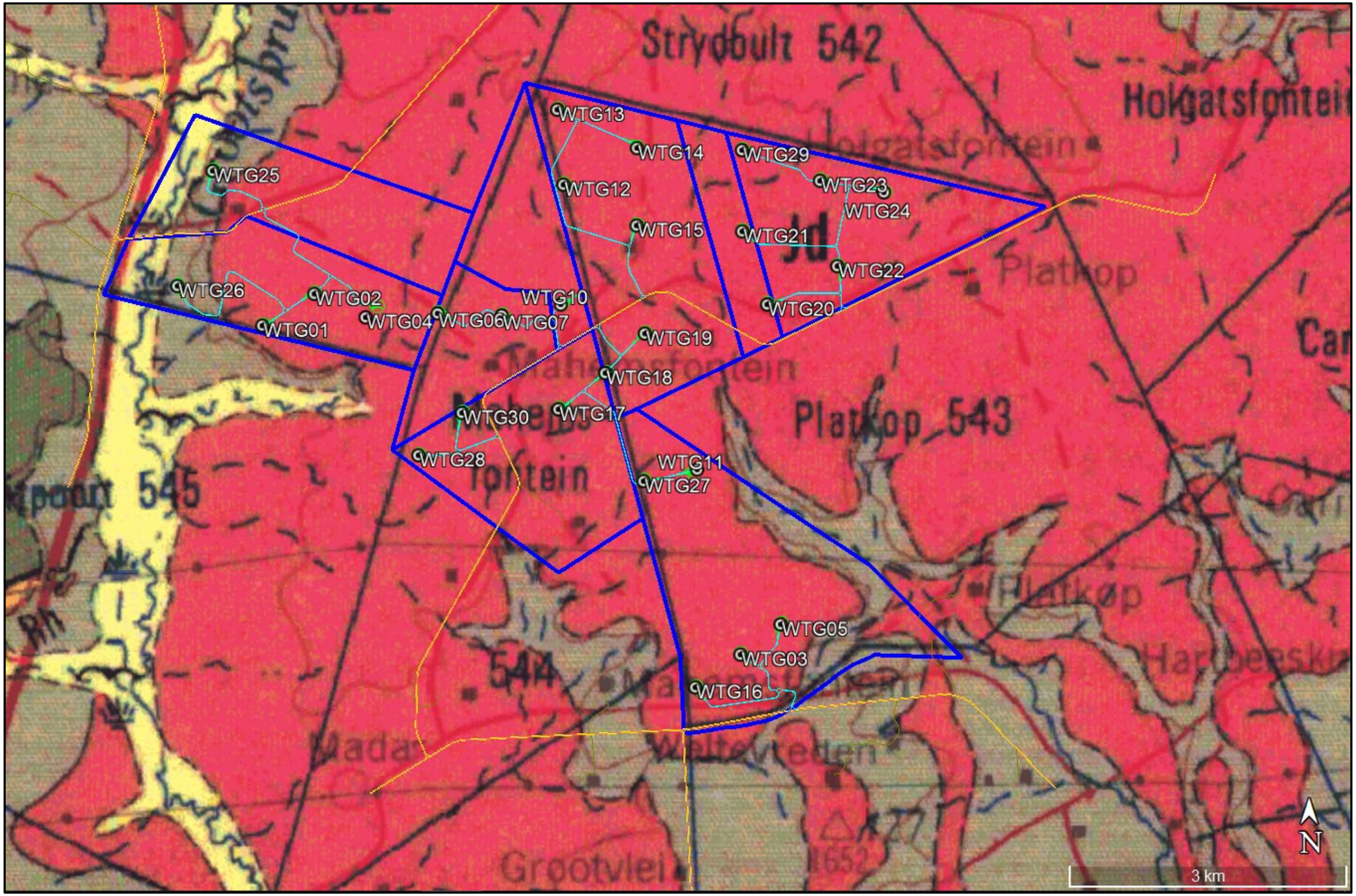

Figure 4: Geology map of the project area (Excerpt from the 1:250 000 Geological Map Sheet, 2628 East Rand)

4.0 RESULTS OF THE DESKTOP STUDY

Engineering geology relates to the engineering characteristics of the natural earths material for founding structures and suitability for use as construction materials.

4.1 Weathering

The type and rate of rock weathering is determined by the climate of an area. Weinert (1980) developed an N-value system, which is used to derive the type of weathering likely to occur in an area based on macro-climatic conditions (evaporation and rainfall).

The study area falls within the temperate highland sub-tropical region of South Africa where the N value is between 2 and 5 as illustrated in Figure 5. This indicates that moderate climatic conditions occur on the site and that the rock and soil are, therefore, expected to be subject to, predominantly, chemical weathering.

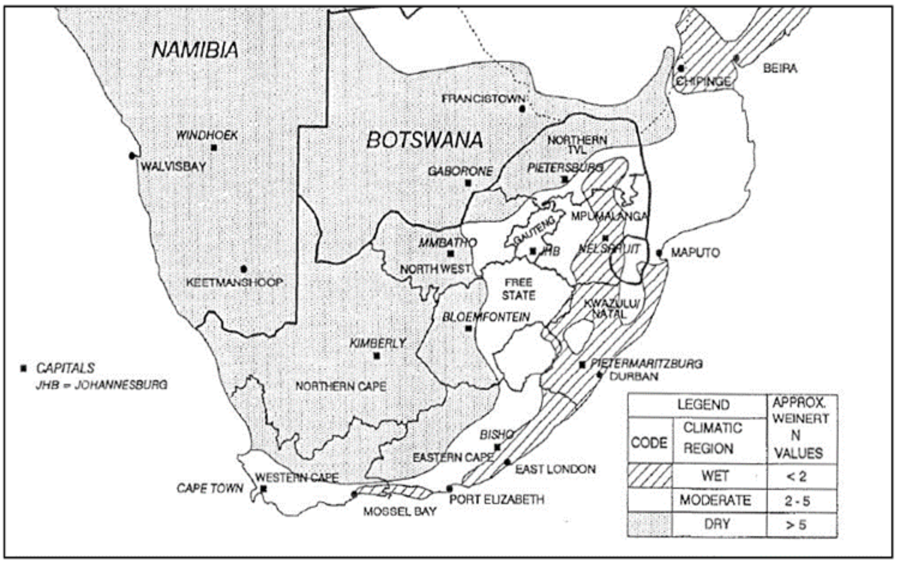

Figure 5: Macro-climatic regions of Southern Africa (Weinert, 1980) Engineering Geology

4.2 Ground Conditions

Figure 6 presents the site layout indicating the turbine positions. The turbine positions are underlain by either rocks of the Vryheid Formation or dolerite as indicated in Table 4. The underlying geology provides an indication of the soil conditions present across the site.

Table 4: Geological formations underlying the turbines and infrastructure

	Turbines	Grid and Associated Infrastructure
Dolerite	WTG01 to WTG24, WTG27 and WTG28	12.8km of Option 1 Powerline 13.5km of Option 2 Powerline SS x BESS Option 1 SS x BESS Option 2 Temporary Laydown Areas 1, 2 & 3 Construction Camp & Batching Plant 1, 2 & 3
Vryheid Formation	WTG25 and WTG26	18.5km of Option 1 Powerline 19km of Option 2 Powerline
Alluvium		1.7km of Option 1 Powerline 1.5km of Option 2 Powerline

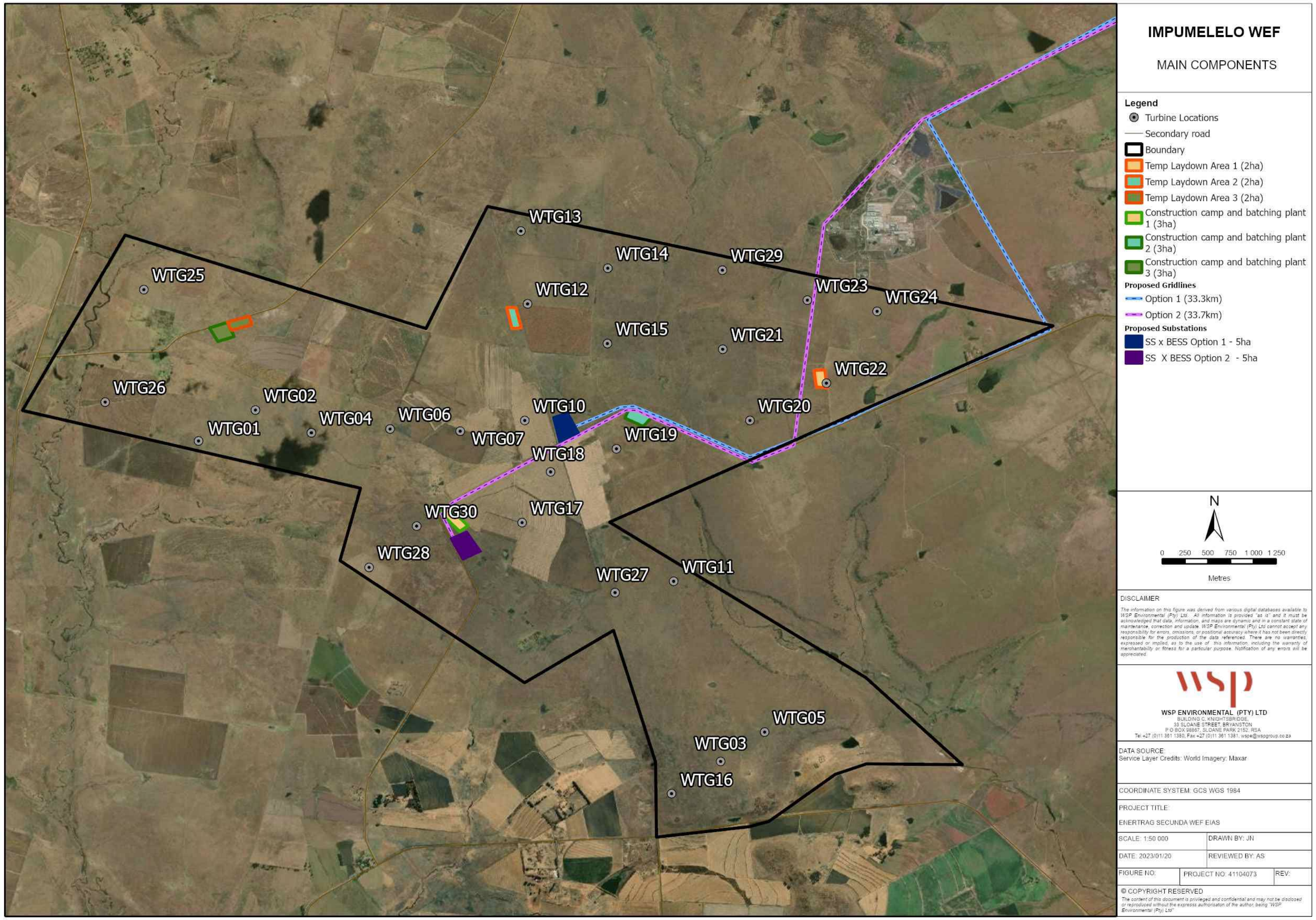

Figure 6: Layout of the facility

Alluvium

Alluvium is anticipated in the floodplains located along the two proposed powerline routes. Ponding of surface water is a common problem in such areas.

Alluvial deposits result from the transportation and deposition of sediment by rivers. The deposits vary in relation to the geology of the catchment area, the site of deposition and the strength of the river. Engineering problems related to alluvial deposits include:-

- Sandy materials being potentially collapsible
- Clayey and silty materials being compressible in the long tern
- Clay material being potentially expansive

Dolerite

The majority of the site is underlain by dolerite. Shallow rock and surface dolerite outcrops are present across the site as illustrated in Figure 7. Dolerite generally weathers into a profile becoming coarser with depth eventually grading into dolerite rock. Cobbles and boulders are often present above the rock grading upwards into gravel, sand and finally residual clay. Cobbles and boulders of dolerite, however, are often present throughout the residual profile.

Residual doleritic clay is generally compressible and potentially expansive in the “medium to high” range. Where any structure straddles residual dolerite and a different soil type, the structure should be moved to avoid differential settlement or designed accordingly.

Dolerite rock, cobbles, boulders, gravel and sand are generally durable and are suitable for a variety of purposes. The material is commonly quarried and used as a construction material for use as concrete aggregate and road construction materials.

Figure 7: Shallow and surface dolerite on site

Vryheid Formation

- Shale

Vryheid shale generally weathers to a clayey residual soil which is often compressible and potentially expansive. Expansive soils are those materials that exhibit volume change with a change in moisture content. These materials “shrink” when the moisture content decreases and “heave” or “expand” when the moisture content increases. Where the residual clay profile is thinly developed, it is recommended that the material should be stripped. Where thickly developed, the structural design needs to take cognizance of the potential expansiveness and compressibility of this material.

Shale rock and excavated shale, which presents as a gravel, often deteriorates on exposure. Although shale material can be considered for use in construction, the potential for deterioration needs to be pre-determined in the laboratory. If suitable, the gravel can be used in selected layers in road construction, but seldom as base course. Gravelly shales are occasionally used in the wearing course of gravel roads but not all types are suitable.

During construction Karoo shales and siltstones can usually be excavated by ripping, but blasting might occasionally be required.

Slope instability may occur when sliding occurs on bedding planes which are inclined sufficiently. Ingress of water into layers and the resulting high pore-water pressure plays a major role in sliding failures. This is considered highly unlikely as the strata are mostly horizontally disposed.

- Sandstone

Vryheid sandstone generally weathers into sandy residual soils. In some cases, the residual sand may develop a potentially collapsible grain structure. These collapsible materials exhibit additional settlement upon wetting up without any change in load. This can occur many years after construction and is usually due to an inundation of some kind such as a broken water pipe. If recognized at investigation stage, these collapsible materials can be easily dealt with during construction with limited remediation, only, being required.

Sands below the water table are likely to fail during the installation of augered piles and hence the pile system used should be carefully considered.

Residual sandstone does not weather uniformly, leading to dense layers of the horizon being underlain by less competent layers of the same soil.

Slope stability issues can arise in areas where closely intercalated sandstones and mudrock (shale and siltstone) exist. When shales and siltstones slake or disintegrate, the exposed sandstone layers are undercut. This can result in rockfalls. Intercalated siltstone layers are relatively impermeable, and impede the flow of water, which leads to pore pressure build up and sliding along the interface. This can only happen if the rock is dipping at an angle, towards the slope face, greater than the friction angle of the material.

Where material is required for the construction of roads and laydown areas, natural sandstone gravel or crushed sandstone bedrock can potentially provide a suitable source. Consideration must be given to the presence of excessive pyrite and muscovite which can cause distress where sandstone is used as basecourse. In addition, where chemical stabilization is required the clay matrix of sandstones make them suitable for stabilization with lime. The occurrence, nature, material quality and quantity of sandstone and other potential construction material will have to be assessed during the detailed geotechnical investigation.

Coals Beds

Coal seams are present within the Vryheid Formation with a thickness ranging from centimeters to 10m but are not generally encountered at surface. Impumelelo Mine, a coal mine, is located on the north-eastern side of the WEF site and will be discussed in Section 5.6.

5.0 GEOTECHNICAL EVALUATION

It is anticipated that areas of shallow dolerite rock will be present across much of the Impumelelo WEF, at the proposed BESS and construction sites and some areas along the powerline route. Relatively thickly developed residual shale will be present in some areas along the powerlines.

5.1 Surface Drainage (Flooding)

Flooding affects flat lying areas, areas confined to drained channels and flood plains. All the turbines, the BESS and construction areas are located on relatively flat areas where water ponding is a possibility during wet periods especially with shallow rock and clay being present. Stormwater management is recommended across all flat areas to facilitate water run-off and to alleviate the possibility of standing water at the foundation positions.

5.2 Erosion

The slope on site, as well as the soil structure will influence the amount of erosion. The low site gradient makes the probability of erosion unlikely. The presence of vegetation (grassland) reduces the risk of erodibility problems. The possibility of erosion will be brought on by the disturbance of vegetation during construction. Erosion must be mitigated, at each structure position, by revegetation after construction.

5.3 Excavatability

The excavation characteristics of the soil horizons has been evaluated according to the South African Bureau of Standards standardized excavation classification for earthworks (SABS – sa1200D). The definition of the excavation classes is indicated in Table 5 and the assessment of the in-situ profile in Table 6.

The ease of excavation is a critical financial factor for any development. Shallow dolerite bedrock characterizes much of the site and it is also anticipated that shallow bedrock will be present in those areas underlain by sandstone.

Table 5: COLTO Excavation Classes

Class of Excavation	General Definition
Soft	Excavation in material which can be efficiently removed or loaded by any of the following plant without prior ripping: A bulldozer with a mass of at least 22 tons (which includes the mass of the ripper, if fitted) and an engine developing approximately 145kW at the flywheel. Or A tractor-scraper unit with a mass of at least 28 tons and an engine developing approximately 245kW at the flywheel, pushed during loading by a bulldozer as specified for intermediate excavation. Or A track type front end loader with a mass of at least 22 tons and an engine developing approximately 140kW at the flywheel
Intermediate	Excavation (excluding soft excavation) in material which can be efficiently ripped by a bulldozer with a mass of at least 35 tons when fitted with a single tine ripper and an engine developing approximately 220kW at the flywheel.

Class of Excavation	General Definition
Soft	Excavation (excluding boulder excavation) in material which cannot be efficiently ripped by a bulldozer with properties equivalent to those described for intermediate excavation. This type of excavation generally includes excavation in material such as formations of unweathered rock, which can be removed only after blasting.
Boulder Class A	■ Excavation in material containing in excess of 40% by volume of boulders between 0.03m3 and 20m3 in size, in a matrix of softer material or smaller boulders. ■ Excavation of fissured or fractured rock shall not be classed as boulder excavation but as hard or intermediate excavation according to the nature of the material.
Boulder Class B	Where material contains 40% or less by volume of boulders in a matrix or soft material or smaller boulders.

Table 6: Excavatability on Site

Alluvial material	Soft excavation
Dolerite	Soft excavation in residual clay, sand and gravel. Boulder Class A and Boulder Class B where boulders are encountered. Hard excavation in dolerite rock
Vryheid shale and residual shale	Soft excavation in residual shale and very soft to soft rock shale. Intermediate to hard excavation in medium hard and harder rock shale.
Vryheid sandstone and residual sandstone	Soft excavation in residual sandstone and very soft to soft rock sandstone. Intermediate to hard excavation in medium hard and harder rock sandstone.

5.4 Slope Stability

Development on site is unlikely to cause any slope instability as no significant cut slopes will be developed. Where excavations are required, up to a depth of 3m, excavations should be excavated at a batter of 1:1 in soil where no water or seepage is evident and to 1:2, or flatter, where water is encountered. Rock can be excavated at a batter of 1:0.5 or vertically in the temporary case up to a depth of 3m.

5.5 Seismic Hazard

According to the Seismic Hazard Map of South Africa (Kijko et al., 2003), the peak ground acceleration is 0.12g for the site. The peak ground acceleration may be described as the maximum acceleration of the ground shaking during an earthquake, which has a 10% probability of being exceeded in a 50-year period. Figure 8.

Mining induced seismicity is the failure of the earth's crust or rock mass as a result of mining induced changes in rock stress levels. Seismic events range in size from barely discernible ground motions to very large tremors. There are three types of mining induced seismicity namely:

- Failure at pre-existing geological weaknesses such as faults, dykes and joints which result in medium to
- large events often far away from workings
- Failure of the intact rock mass in the form of shear fractures that result in larger events close to workings
- Localized bursting or failure of brittle rock types often referred to as strain bursting or face bursting (small events at the working face)

The most economically exploitable coal seams in South Africa are encountered within the Vryheid Formation and the Impumelelo mine boarders the north-eastern side of the WEF site. Thus, the WEF could be influenced by mining induced seismic events due to the presence of the coal mine. All structures should be designed taking cognizance of this.

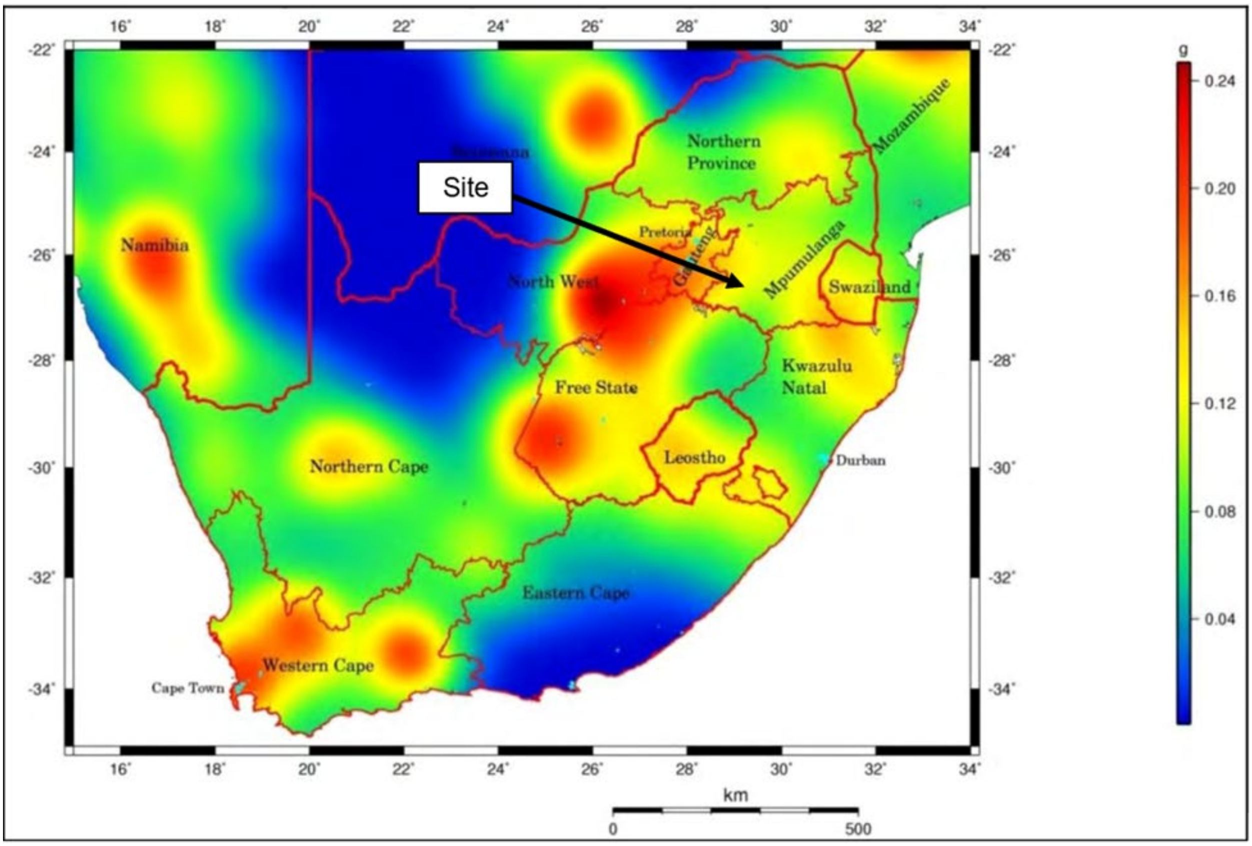

Figure 8: Probabilistic seismic hazard map of South Africa (Council for Geoscience)

5.6 Undermining

Subsidence at surface in undermined areas is caused by the collapse and failure of the underground mining voids relatively close to the surface (Heath and Engelbrecht, 2011). The extent of coal seams in South Africa as well as the location both historical and active opencast and underground mining activities are displayed in Figure 9.

Impumelelo Mine is an underground mine and could potentially pose problems for the proposed WEF site. The proposed site is underlain by mudrock (shale and siltstone) and possibly sandstone. Areas with roof strata composed of shale are more susceptible to gradual movements. Roof strata composed of competent sandstone are less susceptible to deformation. Gradual subsidence and sudden collapse are accompanied by surface deformation including fractures, crevices, faults, step folds and slides.

The extent of any undermining below the site should be assessed, in detail, prior to development.

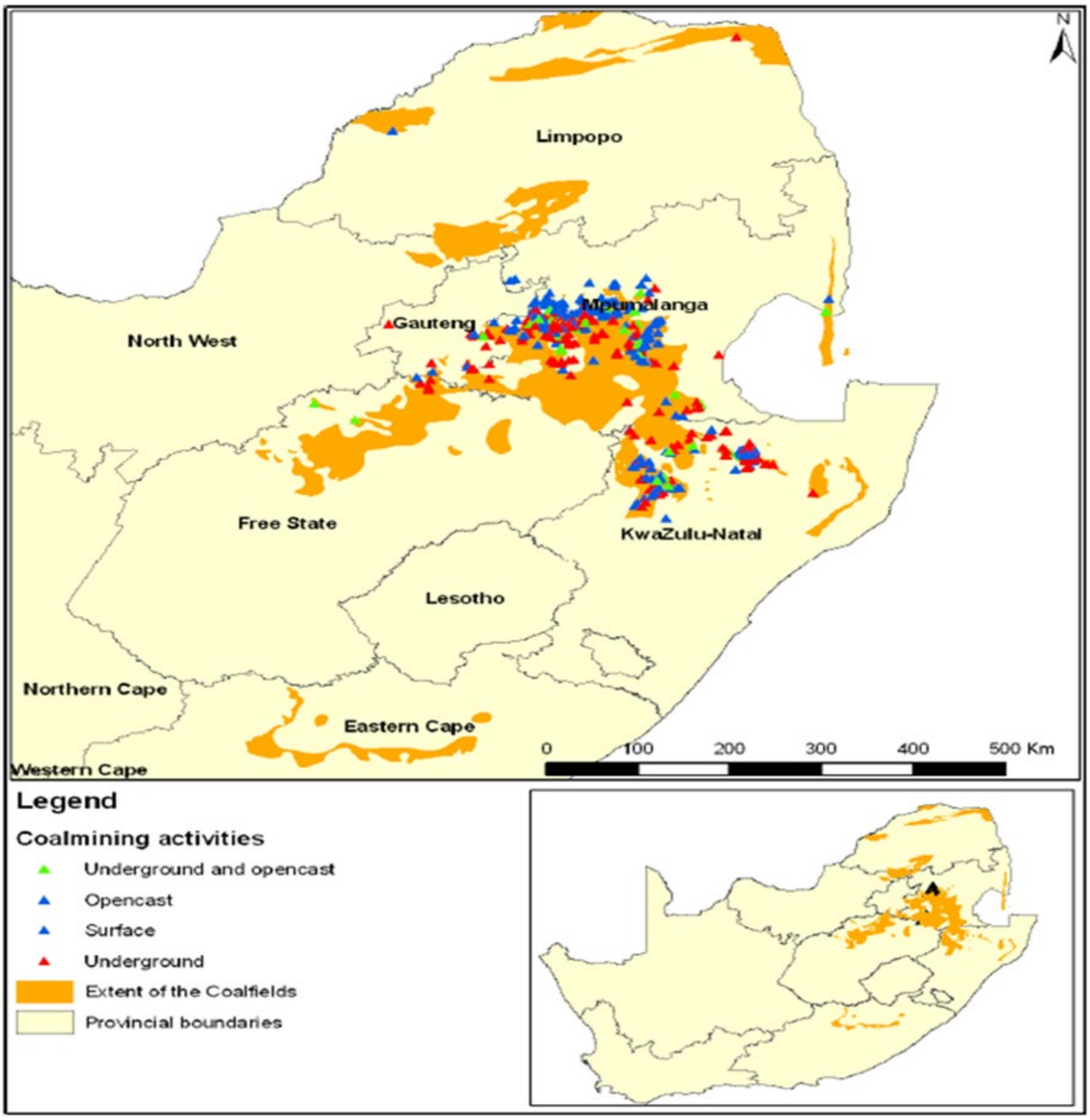

Figure 9: Coal seams in South Africa (Heath and Engelbrecht, 2011)

5.7 Turbine Foundations

The turbine structures exert a static load and significant loading due to the high wind shear A high strength material is required for founding to provide sufficient bearing capacity and strength.

Where turbines are underlain by dolerite and Vryheid sandstone, rock is expected at a depth of, generally, less than 3m. Therefore, founding in rock should be possible. Test pits should be excavated at each turbine position during the geotechnical site investigation to determine the depth to rock and the strength characteristics thereof.

Where turbines are underlain by shale, the residual profile may be more thickly developed with rock expected at a depth of, generally, more than 3m.

Test pits should be excavated at each turbine position during the geotechnical site investigation to determine the depth to rock and the strength characteristics thereof.

Pits excavated with an excavator will be required in some areas as an excavator, being more powerful than a Tractor Loader Backhoe (TLB) would be able to penetrate the doleritic boulders and excavate to a depth where rock would be encountered.

Some rotary cored boreholes would be required to determine the rock strength with depth in, particularly, the shales.

Consideration should be given to shallow foundations that are anchored to the rock. This will require a detailed study of the rock mass and residuum properties at the wind turbine locations.

5.8 Cable Trenches

Depending on the embedment depth, soft to intermediate excavation may be required for the cable trenches in areas underlain by shallow dolerite rock. Soft excavation conditions are expected in the areas underlain by Vryheid sandstone and shale.

Selected sandy fill is required for laying buried cables. The overburden is expected to range from silty clay to silty/gravelly sand. Some excavated material may be suitable for bedding and backfill. However, the majority of the excavated material is not expected to be suitable for bedding or backfill and as such, materials may have to be imported. This and the thermal conductivity of materials should be investigated.

5.9 Access Roads

The use of local weathered dolerite obtained during construction excavations, as a suitable gravel wearing course should be possible. The access road development will disturb the ground cover and erosion may occur.

6.0 GEOTECHNICAL IMPACT ASSESSMENT

The geotechnical impact assessment of the proposed Impumelelo WEF and associated grid infrastructure development was performed according to the methodology provided and included in APPENDIX B.

Geotechnical impacts need to be taken into account as part of the WEF development. The identified risks can typically be mitigated by the implementation of an appropriate and effective plan. Mitigation measures must be implemented to avoid or reduce negative impacts during the construction, operation and decommissioning phases.

The assessment considers the entire development but the three main parts of the development, namely large structures (turbines), cable trenches and access roads are the primary consideration. Based on the impact assessment matrix undertaken for this project, from a geotechnical perspective the impact of the Impumelelo WEF was found to be "*Negative moderate to low impact* - The anticipated impact will have negative effects and will require mitigation." With mitigation measures the impact will be "*Negative very low*". The assessment impact assessment matrix is presented in APPENDIX B.

The two grid servitude options do not have differing geotechnical conditions and as such the one assessment applies to both options. This also results in there being no preferred options between Option 1 and Option 2 with respect to the geotechnical impact assessment. Both alternatives are favorable.

The WEF application site is considered suitable for the proposed development provided that the recommendations presented in this report are adhered too and which need to be verified by more detailed geotechnical investigations during detailed design.

7.0 FURTHER GEOTECHNICAL RECOMMENDATIONS

A detailed intrusive site investigation is recommended to further characterize site conditions, to better understand the key geotechnical risks characteristics in order to refine the development of the WEF. Based on the current lack of previous geotechnical investigation data, the primary objectives of the proposed intrusive investigation must include:

- Determination of the founding conditions for all structures. The scope of the intrusive investigation should comprise test pitting, the drilling of a representative number of boreholes and laboratory testing
- Investigation of subgrade conditions for service roads
- Investigation for materials to be used during construction
- Non-intrusive investigation techniques, such as geophysical (seismic refraction) surveys, thermal and electrical resistivity for ground earthing requirement

8.0 CONCLUSIONS

The completed desktop assessment of the geotechnical conditions at the proposed development site and grid servitude of the Impumelelo WEF has shown the site to be generally suitable for the proposed development.

A "*negative low to moderate*" impact was assessed, from a geotechnical perspective, for the pre-mitigation situation. Post-mitigation, the assessed impact decreases significantly to "*negative very low*".

A geotechnical site investigation must be undertaken to provide detailed geotechnical information for the design of the proposed structures and roads.

The proposed development should, from a geotechnical impact perspective, be authorized. There is no preferred grid servitude option with respect to the geotechnical impact assessment. The most significant geotechnical condition that will affect the development is the expected hard excavation conditions where shallow rock is present.

Minimal slope stability issues are expected as slope areas are minimal. Access roads can be developed as gravel road with suitable wearing-course to protect the subgrade likely being obtained from local weathered dolerite rock deposits.

9.0 ASSUMPTIONS AND LIMITATIONS

The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimize the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by WSP, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

10.0 REFERENCES

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Signature Page

WSP GROUP AFRICA (PTY) LTD

Khuthadzo Bulala
Engineering Geologist (Pr.Sci.Nat)

Heather Davis
Geotechnical Team Lead (Pr.Eng)

KB/HD/mfb

APPENDIX A

Specialist CVs

Heather Davis

Mine Waste, Geotechnical & Material Services, Senior Geotechnical Engineer

CAREER SUMMARY

Forty years of experience within the fields of geotechnical engineering and engineering geology. Most of the work has been gained in Sub Saharan Africa including South Africa, Swaziland, Botswana, Malawi, and Angola. A wide range of projects have been handled ranging from investigations for large projects such as coal fired power stations, hydroelectric power schemes, mine processing plants, major freeways and major pipelines to smaller scale projects for commercial developments and residential buildings. Forensic investigations have, also, been completed for failed tailings facilities, structures and slopes.

Responsibility has been taken for all facets of the geotechnical investigation including the site investigation planning, procurement, drilling supervision, fieldwork, in situ testing, analysis, reporting and supervision during construction. Contract documentation and administration for geotechnical investigations has, also, been handled.

Extensive experience in dolomitic terrain and was involved in the re-drafting of SANS 1936 Parts 1 and 2 and subsequent revisions to the standard. Also, involved in the ECSA feasibility study to have a specified category of registration for D4 level dolomite geo-professionals. Dolomite assessments for large facilities such as the Telkom site in Centurion, the Mispah tailings facility as well as for residential complexes and individual units have been carried out. Linear dolomitic assessments for roads and pipelines have been completed.

Heather is a registered professional engineer, a fellow of the South African Institution of Civil Engineers and served as Treasurer of the Geotechnical Division from 2006 to 2020.

4 months with WSP

40 years of experience

Area of expertise

Site Investigations.

Forensic Assessments.

Dolomitic Terrain Assessments.

Problem Soil Assessments

Language

English - Fluent

EDUCATION

Graduate Diploma in Civil Engineering in the field of Geotechnical Engineering, University of the Witwatersrand SA	1993
BSc (Honours) Engineering Geology and Geotechnics, Portsmouth University, England	1982

PROFESSIONAL MEMBERSHIPS

Professionally registered Engineer with the Engineering Council of South Africa (PrEng 960229)	1996
Fellow of the South African Institution of Civil Engineering.	1998

Heather Davis

Mine Waste, Geotechnical & Material Services, Senior Geotechnical Engineer

PROFESSIONAL HISTORY

WSP Group Africa (Pty) Ltd	April 2022 – present
Jones & Wagener (Pty) Ltd (following the merger with Verdi Consulting)	January 2018 – March 2022
Verdi Consulting Engineers (Pty) Ltd	March 2014 – December 2017
AECOM SA (Pty) Ltd (formerly BKS (Pty) Ltd.	February 2007 – February 2014
ARQ (Pty) Ltd	January 2003 – January 2007
Knight Hall Hendry (Pty) Ltd	January 2001 – December 2003
VKE Engineers (Pty) Ltd	November 1987 – December 2000
National Building Research Institute of the CSIR	November 1985 – October 1987
Geological Survey of South Africa	November 1982 – October 1985

PROFESSIONAL EXPERIENCE

SANRAL, N1 Sections 20 and 21 Geotechnical Investigation, Brakfontein, South Africa
2008 to 2012
Lead Geotechnical Engineer
Upgrade, extensions and additions to the N1 Ben Schoeman Freeway, Sections 20 and 21, between the Brakfontein and Allandale Interchanges as part of the Gauteng Freeway Improvement Project (GFIP) carried out for South African National Roads Agency SOC Ltd (SANRAL). Contract documentation for the subsurface investigation was drafted and all components of the project management of the SANRAL contract were handled. The site investigation included extensive rotary core drilling, percussion drilling and test pitting. Work included the analysis, assessment and provision of founding recommendations for the 22km of dual carriageway. Design components included culverts, retaining walls, cut slopes, embankments and bridges founded on ancient granite, sedimentary rocks of the Pretoria Group along with dolomite and dolomitic residuum. Both conventional and piled foundations were used for the various bridge structures and elements.

SANRAL, N11 Section 9, Hendrina, South Africa
2015 to 2016
Lead Geotechnical Engineer
Upgrade of National route N11 Section 9 between Hendrina and Hendrina Power Station. Planning and supervision of the linear investigation, by means of rotary drilling and test pitting, of 18.56km of roadway including two river bridges, cuts, fills and culverts. Full report complied including recommendations for all facets of the project. All work carried out as per the current SANRAL requirements and all contract administration for the drilling investigation handled.

SANRAL, National Route N5, between Harrismith and Kestell, Harrismith and Kestell, Orange Free State, South Africa
2011 to 2013
Lead Geotechnical Engineer
Carried out for SANRAL, which included drafting the contract documentation for the subsurface investigation which included extensive rotary core drilling and test pitting. The project includes the rehabilitation of the National Route 5 involving extending existing bridges, design and construction of new bridges and design of significant culvert structures. The bridge structures included river bridges, road over rail and road over road structures. Work carried out included supervision of the site investigation, analysis and provision of founding recommendations for all structures, contract administration and arbitration of claims.

Heather Davis

Mine Waste, Geotechnical & Material Services, Senior Geotechnical Engineer

Anglo Platinum. Mogalakwena Platinum Mine, New Northern Concentrator, Limpopo, South Africa.
2020 to 2021
Lead Geotechnical Engineer
Pre-feasibility and feasibility level investigations for the New Northern Concentrator. Supervision of all field work and provision of recommendations for all the structural elements. Additional design level investigation carried out for the M3C BOS Low Grade Stockpile.

NMPP/ Transnet, Multi Products Pipeline, Geotechnical Investigation, Johannesburg. South Africa
2008 to 2009
Section Lead Geotechnical Engineer
Geotechnical input for pipeline section running from Kendal to Waltloo and Jameson Park to Langlaagte in Johannesburg. Investigations have included test pitting; in situ testing and borehole have included test pitting, in situ testing and borehole drilling. The assessment of the route underlain by dolomite and dolomitic residuum was, also undertaken.

TCTA, Vaal River Eastern Sub-System Augmentation (VRESAP),Vaal, South Africa
2006 to 2008
Lead Geotechnical Investigation
Geotechnical investigation for TCTA for a pipeline to carry water from the Vaal Dam to Secunda for use by SASOL and ESKOM. Planning and preparation of contract documentation for drilling, trenching programmes, laboratory and in situ testing. Extensive field work was completed, and recommendations provided for trench sidewall stability, excavatability, construction through problem areas and recommendations for design and construction of the surge tanks, pipe bridges, abstraction works, de-silting works and access roads.

Aquarius Mining. Marikana, Mine Processing Plant, Rustenburg, South Africa
2001 to 2002
Geotechnical Engineer – Plant side
Several candidate sites and the detailed Geotechnical investigation of the final site for the processing plant for new platinum mine. Foundation recommendations for all plant elements were provided including those for silos, mills, crushers and conveyor trestles. Foundation design for large vibratory plant elements. Ongoing foundation inspections and providing geotechnical advice and recommendations to the client throughout construction.

Eskom, Medupi and Kusile Power Stations, Investigations and Foundation Assessments, Limpopo, South Africa
2008 to 2014
Lead Geotechnical engineer for AECOM
Assessment carried out for Hitachi/Eskom of existing information regarding the founding conditions. Provision of structure specific foundation recommendations which included settlement analysis, assessment of bearing capacity and determination of parameters for dynamic design. Site inspections and assessment of ground conditions during construction for both Kusile and Medupi. Also, project manager for an additional geotechnical investigation carried out at Medupi Power Station due to unforeseen ground conditions. Investigation included percussion drilling with the Jean Lutz computerised system along with triple tube rotary drilling. Analysis of data allowing optimisation of the power station design.

Harmony Goldfields. Mispah, Tailings Storage Facility, Far West Rand
2017 to 2018
Geotechnical Team Lead
Failure of a section of the Mispah Tailings Storage Facility (TSF) which is underlain by dolomite, dolomitic residuum and rocks of the Karoo Supergroup. The initial assessment lead to the entire facility being re-assessed and candidate sites for new facilities being investigated. Of specific note was the liaison with several other geotechnical/engineering geological consulting firms regarding the failure.

Heather Davis

Mine Waste, Geotechnical & Material Services, Senior Geotechnical Engineer

Eskom. Medupi, Flue Gas De-sulphurisation Project, Limpopo
2017 to 2018
Lead Geotechnical Engineer
Construction of Units 1 to 6. The investigation comprises test pitting, geophysical surveys and drilling. Foundation recommendations for all facets of the project were provided.

Irene Village, Mall Extensions, Centurion, South Africa
2015 to 2018
Dolomite Specialist.
In depth assessment of existing information applicable to the Irene Village Mall retail development in Irene. Dolomite stability assessments for extensions to the existing shopping mall including the addition of a multi-level parkade and additional retail space. Provision of founding recommendations for all facets of the development including earthworks, roadways and foundations.

Gautrans. Gautrain Project, Centurion, South Africa
2007 to 2014
Geotechnical Engineer
Input and comment on aspects of the route underlain by dolomite including the Centurion Gautrain Station were provided. Assessment of the efficacy of the remedial measures utilised at the station including an extensive programme of grouting. Also, investigation of dolomite related subsidence and a sinkhole adjacent to the Gautrain route and below a raised section of the train line in the Centurion area. Subsequent design of the remedial measures for the sinkhole, drainage measures and long-term monitoring of the area.

Africa Kingdom Holdings. Serengeti Golf and Wildlife Estate, Estate Developments, Kempton Park, South Africa
2016 to 2022
Dolomite Specialist
Dolomite stability assessments, coupled with near surface investigations, of parcels of land throughout the Serengeti Golf and Wildlife Estate. Developments have included single, double and triple storey residential units, Hotel, Club House and artificial lake. All reports have been submitted to the Council for Geoscience (CGS) and have included IHC to IHC7 conditions with Dolomite Area Designations of D2 to D4 being represented. NHBRC applications have been made for all the residential developments.

Aerosud, Manufacturing Facility, Pierre van Ryneveld Park, Centurion . South Africa
2016 to 2018
Dolomite Specialist
Various dolomite stability investigations and reviews have been undertaken for warehouses, ablution blocks, workshops, parking areas and other infrastructure elements across the Aerosud manufacturing facility. All work has, and is, being carried out according to SANS 1936 Parts 1 to 4 of 2012. A Dolomite Risk Management Plan was drafted for the Aerosud Facility and is updated on a regular basis. The site manly classifies as IHC4 to IHC7 with Dolomite Area Designation D2 and D3 being applicable to most of the site.

Atterbury Properties. Erasmuspark/ Castlegate, Multi Use Development, Erasmuspark, South Africa
2016 to 2020
Geotechnical Engineer and Dolomite Specialist
Existing information in line with SANS 1936 on a site underlain by dolomite and dolomitic residuum and non-dolomitic formations. Programme of drilling and near surface investigation, to feasibility level, to de-lineate those areas underlain by dolomite and provision of recommendations for a mixed-use development which will include retail and residential components. Subsequent design level investigations have been completed for various large structures across the site and further de-lineation of developable and non-developable areas.

Khuthadzo Bulala

Mine Waste, Geotechnical & Engineering Services

CAREER SUMMARY

Khuthadzo Bulala is an Engineering Geologist with 6.5 years' experience in geotechnical investigations. Her experience and technical skills include:

- Compilation of geotechnical investigation reports
- Geotechnical core logging
- Core orientation for inclines boreholes
- Planning, managing, and executing in-situ testing (test-pitting, geotechnical drilling operations, DCP testing and piezometer installations) for geotechnical investigations
- Laboratory testing selection and liaison with laboratories
- Analysis and interpretation of laboratory and in-situ test data
- Geological mapping and sourcing of construction materials and aggregates
- Sourcing, testing and specification of construction materials and aggregates
- Health and safety documentation for fieldwork projects
- Project management including resource management and client liaison

1 year with WSP

6.5 years of experience

Area of expertise

Geotechnical Investigations

Geotechnical Core Logging

Geotechnical Report Writing

Laboratory Sampling Selection

Geological Mapping

H & S Documentation

Project Management

Language

English – Fluent

Tshivenda - Fluent

EDUCATION

BSc. (Honours) in Geological Sciences, University of Limpopo South Africa	2013
BSc. Degree in Geological Sciences, University of Johannesburg (Auckland Park Campus)	2011

ADDITIONAL TRAINING

Civil Engineering and Renewable Energy, Geopile Africa	2020
ArcGIS1, Introduction to Geographic Information System, JG Africa	2018
Geotubes and Dewatering, Kaytech,	2019

Site Monitoring Workshop, JG Afrika, 2019

PROFESSIONAL MEMBERSHIPS

South African Council for Natural Professions – Pr. Sci Nat Member No. 115482 2021

PROFESSIONAL HISTOR

WSP Group Africa (Pty) Ltd July 2021 - present

JG Afrika (Pty) Ltd September 2016 – September 2021

Lesotho Highlands Development Agency (LHDA) March 2016 – August 2016

PROFESSIONAL EXPERIENCE

Geotechnical Investigations

Enertrag South Africa (Pty) Ltd, Vhuvhili Solar Energy Facility Geotechnical Desktop Study, Secunda, Mpumalanga, South Africa
June – August 2022
Project Management and Client Liaison
Geotechnical desktop study for the Vhuvhili Solar Energy Facility and the associated structures to supplement a project Environmental Impact Assessment.

Enertrag South Africa (Pty) Ltd, Vhuvhili Solar Energy Facility Detailed Geotechnical Investigation, Secunda, Mpumalanga, South Africa
October 2020 to July 2021
Field Engineering Geologist
Field investigation including test pitting, DCP and sampling. Report writing and foundation recommendation.

Enertrag SA (Pty) Ltd, Dalmanutha Wind Energy Facility, Belfast, Mpumalanga, South Africa
December 2021 – May 2022
Project Manager and Client Liaison
Geotechnical desktop study for three wind energy facilities and their associated structures to supplement a project Environmental Impact Assessment.

Scaw South Africa (Pty) Ltd, Union Junction Hill Borrow Pit Geotechnical Investigation, Johannesburg, South Africa
February 2022 – May 2022
Project Management and Client Liaison
Geotechnical investigation for clay lining material that is needed for the development of the landfill site for their operations and.

ArcelorMittal Mine Extensions, Geotechnical Investigation, Tokadeh, Liberia
January 2022 -
Geotechnical Report Writing
For the ArcelorMittal facilities; Tokadeh pit, Tokadeh infrastructure, Gangra Pit, Water Storage Dam, Tailings Management Facility, and Bucanan Port.

Debswana Diamond Company, Debswana Mine Facilities, Central District, Botswana
November 2021 -
Geotechnical Desktop Study

Gap analysis and additional investigation executions plans for Damtshaa, Orapa and Letlhakane mine facilities.

Lesotho Highlands Development Agency (LHDA), Polihali Dam, the Diversion Tunnel and the Transfer Tunnel, Tlokeng, Lesotho
March 2016 – December 2017
Site Supervision
Drilling, water pressure tests, installation of piezometers, rotary core logging for the dam site, the saddle dam, the coffer dam, the diversion tunnel, the Katse Dam transfer tunnel and the proposed borrow pits.

Calvus Properties (Pty) Ltd, Rietfontein Dam, Eastern Cape, South Africa
May 2019 to September 2021
Project Manager
Trial pitting for the dam foundation, spillway construction and the construction material at the site. Evaluation of engineering properties of subsurface material. Geotechnical reporting for dam design purposes. Geotechnical investigation and reporting for construction material borrow pits.

Umgeni Water, Darvil Dam, Pietermaritzburg, Kwa-Zulu Natal, South Africa
August 2018 to December 2018
In-Situ Investigation
Including test pitting for geotechnical soil profiles of the proposed dam site to determine the dam foundation depth. Project management and selection of laboratory tests for study objectives subsequent to the fieldwork. Compilation of a geotechnical report for the dam design and fr the construction material.

Sivest SA (Pty) Ltd, Gluckstadt Water Supply Scheme, Tugela Ferry, Kwa-Zulu Natal, South Africa
November 2019 to March 2020
Field Geologist
Evaluation along the proposed water supply pipeline, at the proposed borehole structures and at the proposed reservoir. Assessment of geotechnical properties of potential bedding material for construction. Ntabamhlophe Tank –Responsible for the field investigation and the report writing for the proposed tank.

JG Afrika Water Division, Ntabamhlophe Tank, Wembezi, Kwa-Zulu Natal, South Africa
January – April 2021
Project Manager and Client Liaison
Field investigation including test pitting and sampling. Report writing and foundation recommendation. Foundation assessment during construction.

Scatec Solar South Africa, Kenhardt Solar Farm, Kenhardt, Northern Cape, South Africa
October 2020 to July 2021
Project and Subcontract Management
Drilling supervision, in-situ investigation for site characterization. Management and selection of laboratory tests for study objectives. Client liaison and geotechnical report for pylon foundations, substation foundation and access road construction.

G7 Renwable Energies (Pty) Ltd, Oya and Yemaya Solar and Wind Energy Facility, Maitjiesfontein, Western Cape, South Africa
August 2019 – July 2020
Geotechnical Desktop Study Reports
For the two sites for the two solar sites. Test pitting and sample selection for required tests for the Oya site. Analysing and interpreting fieldwork data and laboratory results.

Sivest SA (Pty) Ltd, Client, Koup 1 and Koup 2 Wind Energy Facility, Leeu Gamka, Western Cape, South Africa
February 201 – July 2021
Project Manager and Client Liaison

Geotechnical desktop study for two wind energy facilities and their associated structures to supplement a project Environmental Impact Assessment.

WSP Africa, Client, Three Wind Energy Facilities, Northern and Western Cape, South Africa
May – September 2021
Project Manager and Client Liaison
Project management and client liaison. Geotechnical desktop studies for the proposed Brandvalley, Karreebosch and Rietkloof wind farm energy facilities and three 33kV powerlines and their associated structures.

WSP Africa Group, Uvuvuselela Railway Line Extensions, South Africa
October 201 – December 2021
Project Manager and Client Liaison
Geotechnical desktop studies for the proposed Transnet Railway Loop extensions, Port Elizabeth Port extensions and loading yards in Gauteng.

South African National Road Agency Limited, N2 Pongola to Kangela, Kwa-Zulu Natal, South Africa
2017 - 2021
Field Geologist
Responsible for trial pitting, logging, and sample collection for laboratory analysis for the N2 construction borrow pits. Collation of field data and laboratory data.

HHO Consulting Engineers, N3 Borrow Pits, Kwa-Zulu Natal, South Africa
November 2018 to April 2019
Field Engineering Geologist
Rotary core logging and percussion chips logging for the proposed borrow pits located between Durban and Pietermaritzburg for the N3 construction.

ZVK Holdings (Pty) LtdMfulamuni Access Road and Aggregates, Pomeroy, Kwa-Zulu Natal, South Africa
January – June 20221
Project Manager andClient Liaison
Fieldwork for the realignment and the re-gravelling of the Mfulamuni access road. Ensuring adequate laboratory testing for the road and the potential borrow pits. Report compilation for the road and the material investigation.

Naidu Consulting, P77 Culverts, Dududu, Kwa-Zulu Natal, South Africa
January – July 2020
Project Manager and Client Liaison

Responsible for trial pitting, logging and DPL testing to determine the subsurface characteristics for the proposed seven culverts. Compilation of an interpretive geotechnical report highlighting the foundation depths for each culvert and the geotechnical constraints thereof.

Royal HaskoningDHV, Kikwood to Addo Borrow Pit and Retaining Walls, Kirkwood, Eastern Cape, South Africa
April – December 2019
Project Manager and Client Liaison
Soil profiling and interpretation of the field profiles and laboratory results for the borrow pit and retaining walls. Material volume calculations for the borrow pits. Dynamic cone penetration and interpretation for the competent foundations for the retaining walls. Data assimilation and assessment for report writing.

High End Construction, Eastwood Pedestrian Bridge, Pietermaritzburg, Kwa-Zulu Natal, South Africa
February – May 2019
Project Manager and Client Liaison

Construction of a pedestrian bridge. Fieldwork including test pitting and DPL testing. Analysing and interpreting the field data to recommend foundation levels.

Eskom, Refurbishment of 9 Eskom Towers, Eastern Cape, South Africa
August 2019 to September 2019
Engineering Geologist
Test pitting for geotechnical ground profiles of each site. Management and selection of laboratory tests for study objectives. Foundation recommendations for each site. Geotechnical report for design purposes.

KZN Department of Public Works, Nkweletsheni Primary School, Richmond, Kwa-Zulu Natal, South Africa
January – March 2020
Project Manager and Client Liaison
School refurbishment. Test pitting, percolation testing and DPL testing for geotechnical ground profiles of the site. Management and selection of laboratory tests for study objectives. Geotechnical report for foundations, recommendations for the soak-away and for the multipurpose sports ground.

JG Afrika (Pty) Ltd Water Department, Zwelisha Moyeni Water Treatment Works, Bergville, Kwa-Zulu Natal, South Africa
January – March 2021
Project Manager and Client Liaison
Test pitting and DPL testing for geotechnical ground profiles of the site. Management and selection of laboratory tests for study objectives. Geotechnical report for foundations of treatment works structure founded at depth of 4-5m below NGL.

JG Afrika (Pty) Ltd Water Department, Hammersdale Waste-Water Treatment Works, Hammersdale, Kwa-Zulu Natal, South Africa
May 2020 – March 2021
Engineering Geologist
Subsurface profiling and DPL testing for the extensions to the existing Hammersdale WWTW. Analysis of the profiles and selection of laboratory tests for study objectives. Data analysis and report compilation for structure foundations.

Sultex Holdings (Pty) Ltd, Proposed Giba Industrial Development, Pinetown, Kwa-Zulu Natal, South Africa
May 2019 – July 2019
Engineering Geologist
Test pitting for soil profiling, disturbed and undisturbed sampling, delineation of groundwater seepage areas. Management and selection of laboratory tests. Analysing and interpretation of laboratory test results. Compilation of geotechnical report for foundations and groundwater management recommendations.

Smec, Cornubia Fills, Cornubia, Kwa-Zulu Natal, South Africa
March 2020 – January 2021
Project Manager and Client Liaison
In-situ testing for geotechnical soil profiles of the site and general site characterization for fills for the proposed housing development. Engineering geological report for the study for the fills. Reviewing the rotary drilling report for the client.

Mariswe (Pty) Ltd, Ward 7 Community Hall, Taylors Halt, Kwa-Zulu Natal, South Africa
January 2020 – March 2020
Project Manager and Client Liaison
Conducting the geotechnical investigation that included trial pitting, laboratory testing and percolation testing. Fieldwork and laboratory data processing for geotechnical report compilation.

Dartingo Consulting Engineers (Pty) Ltd, Mandalathi Community Hall, Kwa-Zulu Natal, South Africa
2020

Project Manager and Client Liaison
Conducting the geotechnical investigation that included trial pitting, laboratory testing and percolation testing. Fieldwork and laboratory data processing for geotechnical report compilation.

Ethekwini Municipality: Human Settlements and Infrastructure, Austerville Sites, Durban, Kwa-Zulu Natal, South Africa
February 2021 – June 2021
Project Manager and Client Liaison
In situ soil profiling and interpretation of the profiles. Consistency tests (DPL) and interpretation of the results evaluate the EASPB. Data compilation and report writing to determine the site's suitability for temporary housing development and recommending relevant foundation measures.

JG Afrika (Pty) Ltd Agricultural Engineering Division, Five ADA Rabbitry Sites, Kwa-Zulu Natal, South Africa
August 2019 – October 2019
Project Manager and Client Liaison
In situ soil profiling and interpretation of the profiles. Consistency tests (DPL) and interpretation of the results evaluate the EASPB and sample collection for laboratory analysis. Report compilation with foundation recommendations.

Private Developers, Several Intaba Ridge Estate Houses Pietermaritzburg, Kwa-Zulu Natal, South Africa
2017 - 2020
Project Manager and Client Liaison with Property Developers
In situ soil profiling, conducting in-situ consistency tests (DPL) and sampling for laboratory analysis. Report writing to determine the site's suitability for the house developments and recommending foundation depths and types as per NHBRC guidelines.

Private Developer, Student Accommodation, Pietermaritzburg, Kwa-Zulu Natal, South Africa
April 2019 – July 2019
Project Manager and Client Liaison
For the proposed three storey student accommodation development. In situ soil profiling, conducting in-situ consistency tests (DPL) and sampling for laboratory analysis. Report writing to determine the site's suitability for the housing development and recommending foundation depths and type as per NHBRC guidelines.

Green Door Environmental, 220 Murray Road Development, Pietermaritzburg, Kwa-Zulu Natal, South Africa
June 2019 – August 2019
Project Manager and Client Liaison
Report writing and field data analysis for the infill geotechnical investigation report for a multi-story development in Hayfields. The development includes a school, a shopping complex, a drive through, a petrol filling station and a residential area.

Marang Environmental and Associates (Pty) Ltd, Heidelberg Cemetery Extension, Heidelberg, Gauteng, South Africa
June 2020 – December 2020
Project Manager and Client Liaison
For the extension of the existing Heidelberg cemetery. Subsurface profiling and interpretation of the profiles. Field sampling for laboratory analysis. Geotechnical report writing and evaluating the site as per the South African Council for Geoscience Guidelines for Cemeteries.

Ziphelele Planning and Environmental Consultancy, Three Proposed Umhlathuze Cemeteries, Empangeni, Kwa-Zulu Natal, South Africa
May 2018 – February 2019
Project Manager and Client Liaison

For the development of three cemetery sites. Subsurface profiling, percolation testing and field sampling for laboratory analysis. Geotechnical report writing, evaluating and rating the sites as per the South African Council for Geoscience Guidelines for Cemetery Development.

Ziphele Planning and Environmental Consultancy, Alfred Duma Cemeteries, Ladysmith, Kwa-Zulu Natal, South Africa
June 2019 – October 2019
Project Manager and Client Liaison
For the development of cemetery sites in the municipality. Geotechnical desktop studies to evaluate and rate the proposed sites in Colenso, Ladysmith and Ezakheni. The desktop study reports were written as per the South African Council for Geoscience Guidelines for Cemeteries.

Alfred Duma Municipality, Closure of Acaciavale Landfill Site, Ladysmith, Kwa-Zulu Natal, South Africa
2018-2020
Engineering Geologist
Fieldwork including test pit profiling and interpretation from test pitting and sampling for study objectives. Data analysis and report compilation for the closure of the landfill site and recommendations on closure material.

Alfred Duma Municipality, Danskraal Landfill Site, Ladysmith, Kwa-Zulu Natal, South Africa
2020
Project Manager and Client Liaison

Including GIS work to identify and shortlist potential landfill sites. Fieldwork including test pit profiling and interpretation from test pitting for landfill site development investigation. Data analysis and report compilation.

Department of Rural Development and Land Reform, UMgungundlovu Landfill Site, Pietermaritzburg, Kwa-Zulu Natal, South Africa
March 2020
Site Supervision
For the percussion drilling contract for the proposed new landfill site. Subcontractor management and client liaison. Percussion chip logging. Borehole water level and yield measurements. Hydrocensus and sampling existing boreholes in a 1km radius.

Department of Rural Development and Land Reform, Agricultural Potential Assessment for the Ground Truthing: New Irrigation Schemes Survey in Harry Gwala District, Umzimkhulu, Kwa-Zulu Natal, South Africa
July 2017 to August 2019
Project Manager and Client Liaison
Agricultural soil survey and sampling. Data analysis and report compilation for the agricultural potential and the irrigation potential of 7500ha land in the district municipality. Presentation of the final findings to the client.

APPENDIX B

Impact Assessment Methodology

IMPACT ASSESSMENT METHODOLOGY

EIA PHASE

REPORTING REQUIREMENTS

- Project Description
- Legislative Context (as applicable)
- Assumptions and limitations
- Description of methodology (as required)
- Update and/or confirmation of Baseline Environment – including update and / or confirmation of sensitivity mapping
- Identification and description of Impacts
- Full impact assessment (including Cumulative)
- Mitigation measures
- Impact Statement

ASSESSMENT OF IMPACTS AND MITIGATION

The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

The key objectives of the risk assessment methodology are to identify any additional potential environmental issues and associated impacts likely to arise from the proposed project, and to propose a significance ranking. Issues / aspects will be reviewed and ranked against a series of significance criteria to identify and record interactions between activities and aspects, and resources and receptors to provide a detailed discussion of impacts. The assessment considers direct[1], indirect[2], secondary[3] as well as cumulative[4] impacts.

A standard risk assessment methodology is used for the ranking of the identified environmental impacts pre-and post-mitigation (i.e. residual impact). The significance of environmental aspects is determined and ranked by considering the criteria[5] presented in **Table 0-1**.

[1] Impacts that arise directly from activities that form an integral part of the Project.
[2] Impacts that arise indirectly from activities not explicitly forming part of the Project.
[3] Secondary or induced impacts caused by a change in the Project environment.
[4] Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.
[5] The definitions given are for guidance only, and not all the definitions will apply to all the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

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Table 0-1: Impact Assessment Criteria and Scoring System

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries
Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite
Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
IMPACT SIGNIFICANCE RATING					
Total Score	**4 to 15**	**16 to 30**	**31 to 60**	**61 to 80**	**81 to 100**
Environmental Significance Rating (Negative (-))	**Very low**	**Low**	**Moderate**	**High**	**Very High**
Environmental Significance Rating (Positive (+))	**Very low**	**Low**	**Moderate**	**High**	**Very High**

IMPACT MITIGATION

The impact significance without mitigation measures will be assessed with the design controls in place. Impacts without mitigation measures in place are not representative of the proposed development's actual extent of impact and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the application of mitigation and management measures and is thus the final level of impact associated with the development. Residual impacts also serve as the focus of management and monitoring activities during Project implementation to verify that actual impacts are the same as those predicted in this report.

The mitigation measures chosen are based on the mitigation sequence/hierarchy which allows for consideration of five (5) different levels, which include avoid/prevent, minimise, rehabilitate/restore, offset and no-go in that order. The idea is that when project impacts are considered, the first option should be to avoid or prevent the impacts from occurring in the first place if possible, however, this is not always feasible. If this is not attainable, the impacts can be allowed, however they must be minimised as far as possible by considering reducing the footprint of the development for example so that little damage is encountered. If impacts are unavoidable, the next goal is to rehabilitate or restore the areas impacted back to their original form after project completion. Offsets are then considered if all the other measures described above fail to remedy high/significant residual negative impacts. If no offsets can be achieved on a potential impact, which results in full destruction of any ecosystem for example, the no-go option is considered so that another activity or location is considered in place of the original plan.

The mitigation sequence/hierarchy is shown in **Figure 1** below.

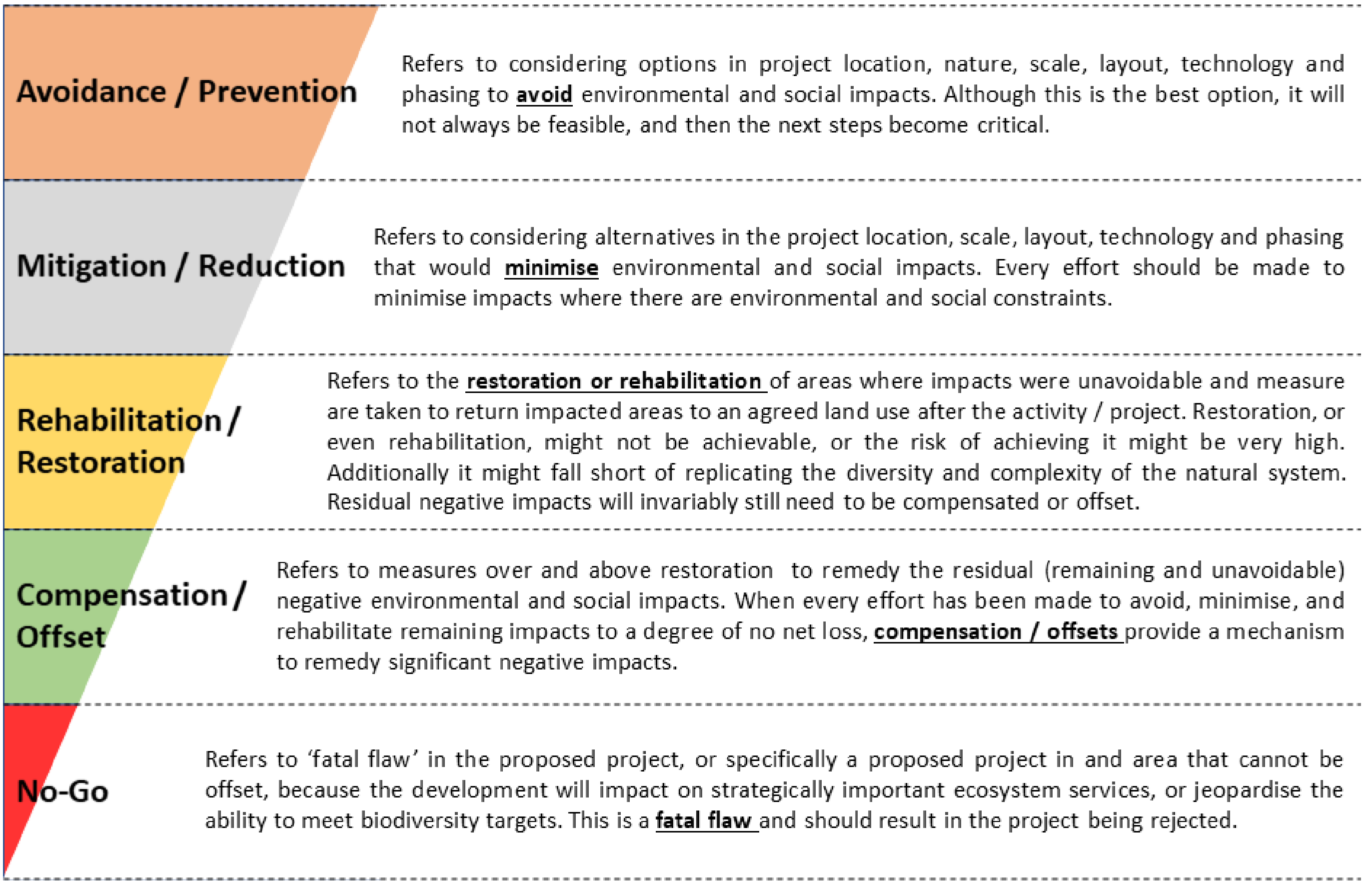

Figure 1: Mitigation Sequence/Hierarchy

Project Name	41104073 - Impumelelo Wind Energy Facility Geotechnical Impact Assessment																			
Impact Assessment																				
CONSTRUCTION																				
Impact number	**Aspect**	**Description**	**Stage**	**Character**	**Ease of Mitigation**	**Pre-Mitigation**							**Post-Mitigation**							**Mitigation Measures**
						(M+	**E+**	**R+**	**D)x**	**P=**	**S**	**Rating**	**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**	**Rating**	
Impact 1:	Soil Erosion	• Increased stormwater velocity. • Increase in soil and wind erosion due to clearing of vegetation. • Creation of drainage paths along access tracks. • Sedimentation of non-perennial features and excessive dust.	Construction	Negative		3	3	3	3	4	**48**	**N3**	2	1	1	2	2	**12**	**N1**	• Rehabilitation of affected areas (such as revegetation). • Construction of temporary berms and drainage channels to divert surface water. • Minimize earthworks and fills. • Use existing road network and access tracks. • Correct engineering design and construction of gravel roads and water crossings. • Control stormwater flow.
					Significance	**N3 - Moderate**							**N1 - Very Low**							
Impact 2:	Oil Spillages	Contamination of ground and surface water resources from heavy plant leading to quality deterioration of the water resources.	Construction	Negative		3	3	3	3	4	**48**	**N3**	2	2	1	1	2	**12**	**N1**	• Vehicle and construction machinery repairs to be undertaken in designated areas with proper soil protection. • Frequent checks and conditional monitoring
					Significance	**N3 - Moderate**							**N1 - Very Low**							
Impact 3:	Disturbance of fauna and flora	The displacement of natural earth material and overlying vegetation leading to erosion.	Construction	Negative		3	1	3	3	3	**30**	**N2**	2	1	1	2	2	**12**	**N1**	Limit and control excavations
					Significance	**N2 - Low**							**N1 - Very Low**							
Impact 4:	Slope stability	Slope instability around structures.	Construction	Negative		2	1	3	3	2	**18**	**N2**	1	1	3	2	2	**14**	**N1**	• Avoid steep slope areas. • Design cut slopes according to detailed geotechnical analysis.
					Significance	**N2 - Low**							**N1 - Very Low**							
Impact 8:	Seismic activity	Damage of proposed development.	Construction	Negative		4	1	3	4	1	**12**	**N1**	2	1	3	3	1	**9**	**N1**	Design according to expected peak ground acceleration.
					Significance	**N1 - Very Low**							**N1 - Very Low**							
OPERATIONAL																				
Impact number	**Receptor**	**Description**	**Stage**	**Character**	**Ease of Mitigation**	**Pre-Mitigation**							**Post-Mitigation**							
						(M+	**E+**	**R+**	**D)x**	**P=**	**S**		**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**		
Impact 1:	Soil Erosion	• Increase in soil and wind erosion due to clearance of structures. • Displacement of soil and damage to vegetation by vehicles	Operational	Negative		2	1	3	2	2	**16**	**N2**	1	1	1	1	1	**4**	**N1**	• Use existing road network and access tracks. • Use of temporary berms and drainage channels to divert surface water. • Minimize earthworks and demolish footprints. • Rehabilitation of affected areas (such as revegetation). • Reinstate channelized drainage features. • Strip, stockpile and re-spread topsoil.
					Significance	**N2 - Low**							**N1 - Very Low**							
Impact 2:	Potential Oil Spillages	Potential oil spillages from service vehicles and heavy plant.	Operational	Negative		3	2	5	5	3	**45**	**N3**	2	1	3	1	1	**7**	**N1**	• Vehicle repairs to be undertaken in designated areas.
					Significance	**N3 - Moderate**							**N1 - Very Low**							
DECOMISSIONING																				
Impact number	**Receptor**	**Description**	**Stage**	**Character**	**Ease of Mitigation**	**Pre-Mitigation**							**Post-Mitigation**							
						(M+	**E+**	**R+**	**D)x**	**P=**	**S**		**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**		
Impact 1:	Soil Erosion	• Increase in soil and wind erosion due to clearance of structures. • Displacement of soil and damage to vegetation by vehicles	Decommissioning	Negative		4	2	3	3	4	**48**	**N3**	2	1	1	2	2	**12**	**N1**	• Use existing road network and access tracks. • Use of temporary berms and drainage channels to divert surface water. • Minimize earthworks and demolish footprints. • Rehabilitation of affected areas (such as revegetation). • Reinstate channelized drainage features. • Strip, stockpile and re-spread topsoil.
					Significance	**N3 - Moderate**							**N1 - Very Low**							
Impact 2:	Potential oil spillages	• Potential oil spillages due to clearance of structures.	Decommissioning	Negative		3	3	3	3	4	**48**	**N3**	2	1	3	1	2	**14**	**N1**	• Vehicle and construction machinery repairs to be undertaken in designated areas with proper soil protection. • Frequent checks and conditional monitoring
					Significance	**N3 - Moderate**							**N1 - Very Low**							
Impact 3:	Disturbance of fauna and flora	The displacement of natural earth material and overlying vegetation leading to erosion.	Decommissioning	Negative		3	1	3	3	3	**30**	**N2**	2	1	1	2	2	**12**	**N1**	Limit excavation
					Significance	**N2 - Low**							**N1 - Very Low**							
Impact 4:	Slope stability	Slope instability around structures.	Decommissioning	Negative		2	1	3	3	2	**18**	**N2**	1	1	3	2	2	**14**	**N1**	• Avoid steep slopes areas. • Design cut slopes according to detailed geotechnical analysis.
					Significance	**N2 - Low**							**N1 - Very Low**							
CUMULATIVE																				

Impact number	Receptor	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation							
						(M+	E+	R+	D)x	P=	S		(M+	E+	R+	D)x	P=	S		
Impact 1:	Erosion	The displacement of natural earth material and overlying vegetation leading to: • Exposure of upper soil layer. • Increase in stormwater velocity. • Soil washed downslope into drainage channels leading to sedimentation. •The erosion of these slopes will be exacerbated during periods of heavy rainfall.	Cumulative	Negative		3	2	3	3	4	**44**	**N3**	2	1	1	2	2	**12**	**N1**	• Use existing road network and access tracks. • Use of temporary berms and drainage channels to divert surface water. • Minimize earthworks and demolish footprints. • Rehabilitation of affected areas (such as revegetation). • Develop a chemical spill response plan. • Reinstate channelized drainage features.
					Significance	**N3 - Moderate**							**N1 - Very Low**							
Impact 2:	Potential Oil Spillages	Contamination of ground and surface water resources from heavy plant leading to quality deterioration of the water resources.	Cumulative	Negative		3	3	3	3	4	**48**	**N3**	2	1	3	1	2	**14**	**N1**	• Vehicle and construction machinery repairs to be undertaken in designated areas with proper soil protection. • Frequent checks and conditional monitoring
					Significance	**N3 - Moderate**							**N1 - Very Low**							
Impact 3:	Disturbance of fauna and flora	The displacement of natural earth material and overlying vegetation leading to erosion.	Cumulative	Negative		3	1	3	3	3	**30**	**N2**	2	1	1	2	2	**12**	**N1**	Limited excavations
					Significance	**N2 - Low**							**N1 - Very Low**							
Impact 4:	Slope stability	Slope instability around structures.	Cumulative	Negative		2	1	3	3	2	**18**	**N2**	1	1	3	2	2	**14**	**N1**	• Avoid steep slopes areas. • Design cut slopes according to detailed geotechnical analysis.
					Significance	**N2 - Low**							**N1 - Very Low**							
Impact 5:	Seismic activity	Damage of proposed development.	Cumulative	Negative		4	1	3	4	1	**12**	**N1**	2	1	3	3	1	**9**	**N1**	Design according to expected peak ground acceleration.
					Significance	**N1 - Very Low**							**N1 - Very Low**							

wsp GOLDER