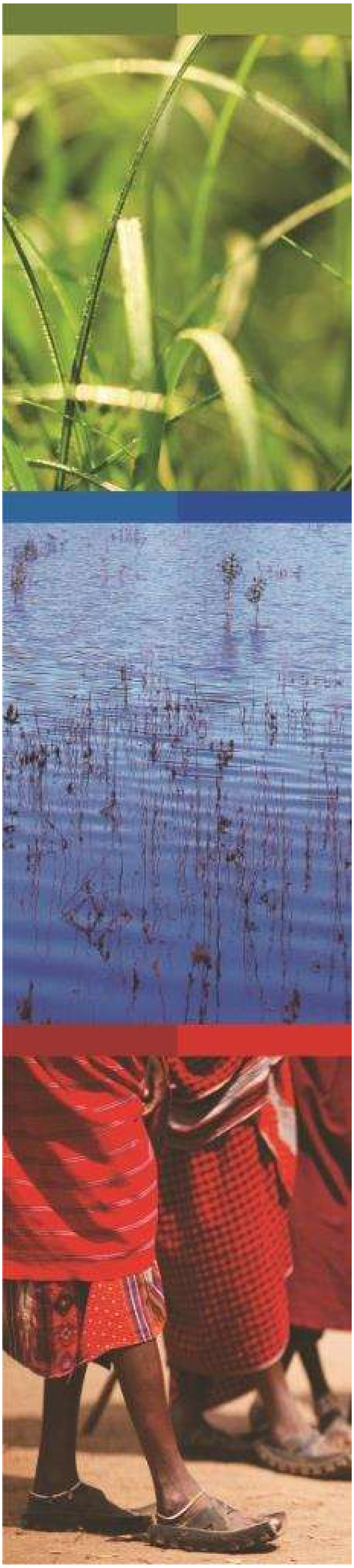

DIGBY WELLS ENVIRONMENTAL

Musina-Makhado Special Economic Zone Development, Vhembe District Municipality, Limpopo Province

Soils and Land Capability Assessment

Project Number:

LEA5525

Prepared for:

Limpopo Economic Development Agency

May 2019

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This document has been prepared by Digby Wells Environmental.

Report Type:	**Soils and Land Capability Assessment**
Project Name:	**Musina-Makhado Special Economic Zone Development, Vhembe District Municipality, Limpopo Province**
Project Code:	**LEA5525**

Name	**Responsibility**	**Signature**	**Date**
Arjan van 't Zelfde Pr.Sci.Nat	Report writer		May 2019
Leon Ellis	Reviewer		May 2019

DECLARATION OF INDEPENDENCE

I, **Jan Arie van 't Zelfde**, in my capacity as a specialist consultant, hereby declare that:

- I act as an independent specialist and I will comply with the Act, regulations and all other applicable legislation;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998);
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act 1998 (Act 107 of 1998);
- I undertake to disclose to the client 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;
- I undertake to have my work peer reviewed on regular basis by a competent specialist in the field of study for which I am registered;
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity; and
- Based on information provided to me by the project proponent and in addition to information obtained during this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

Title/ Position:	Soil Scientist
Qualification(s):	MSc in Soil Science
Experience (years):	15
Registration(s):	SACNASP (*Prof. Nat. Sci.: 115656*)
Signature:	

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zones
ARC	Agricultural Research Council
BRUs	Bioresource Groups and Units
CARA	The Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)
EIA	Environmental Impact Assessment
GPS	Global Positioning System
ISCW	Institute for Soil, Climate and Water
KM	Kilometres
MASL	Metre above sea level
NEMA	National Environmental Management Act, 1998 (Act No.107 of 1998)

1 Introduction

Digby Wells Environmental (hereafter Digby Wells) was requested by the Limpopo Economic Development Agency (LEDA) to carry out a soil and land capability assessment for the proposed Musina-Makhodo Special Economic Zone (SEZ) Development within the Vhembe District Municipality, Limpopo Province.

The proposed Musina-Makhado SEZ is located across the Musina and Makhado local municipalities which fall under the Vhembe District Municipality in the Limpopo Province. The nearest town of Makhado is located 31 km south and the town of Musina is located 36 km north of the SEZ site.

It is envisaged that The SEZ will be specifically designated to focus on energy and metallurgical processing, agro-processing, petrochemical and logistics and will initially comprise of a power plant, steel plant, stainless steel plant, coking plant, ferrochrome plant, ferromanganese plant, ferrosilicon plant, pig iron metallurgy plant and a lime plant amongst other things. The full list of the project components is listed in Table 1-1 below.

Table 1-1: Project Components

Project component	Area (ha)	Capacity (Mtpa)
Power Plant	300	3
Coke Plant	500	5
Ferrochromium Plant	500	3
Ferromanganese Plant	100	1
Pig Iron Plant	600	6
Carbon steel plant	200	2
Stainless steel plant	500	4
Lime plant	500	8
Silicon-manganese plant	100	0.5
Metal silicon plant	50	0.3
Calcium carbide plant	50	0.3
Infrastructure	2600	
Total	**6000**	

2 Project Locality

The Musina-Makhado SEZ development will be established across eight farms. The total farm size is approximately 8000 hectares (ha) of which 6000 ha will be used for the SEZ. The SEZ Development area is depicted in Figure 2-1. The proposed site comprises the following farm portions as shown in Table 2-1below.

Table 2-1: Farm Portions

Farm portion codes		
1/584	RE/580	1/586
RE/842	RE/565	564
RE/584	RE/611	617
RE/584	1/611	528
RE/1/567	RE/520	526
3/567	RE/522	585
RE/589	2/567	580
2/580	RE/525	RE/566
1/580	1/584	581

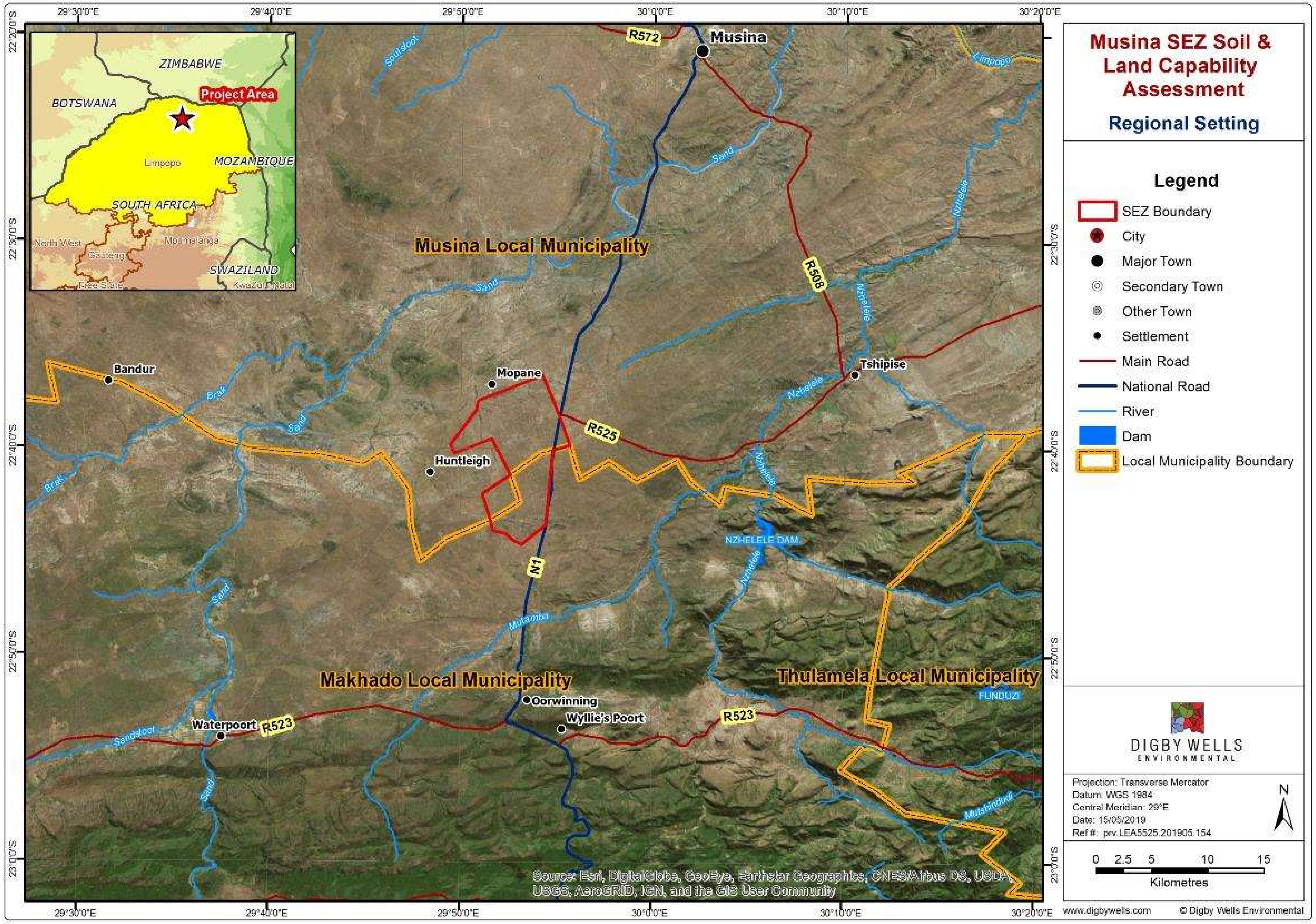

Figure 2-1: SEZ Development Project Locality

3 Scope and Purpose of this Report

The following tasks were undertaken as part of the soils and land capability scoping report:

- Review of all the existing information;
- Description and categorisation of land type data and expected soils in the area;
- Land use/cover: present land use/cover was mapped; and
- Identification of potential impacts on soils resulting from the project using the prescribed impact rating methodology.

4 Details of Specialist

Jan Arie (Arjan) van 't Zelfde is a Soil Scientist, completed his MSc in Soil Science at Wageningen University in The Netherlands and is a Professional Natural Scientist. Prior to his employment at Digby Wells Environmental, Arjan worked at GCS Water & Environmental Consultants (Pty) Ltd. as a Senior Hydrogeologist. He is the part of the Water Department at Digby Wells Environmental. His role involves conducting hydrogeological assessments; land capability assessments and land use environmental impact assessments; soil contamination assessments; interpreting results of soil samples; soil management plans and writing detailed scientific reports in accordance to local legislation and with the International Finance Corporation (IFC). Arjan has worked on projects in South Africa, Lesotho, DRC, Mozambique, Ireland and The Netherlands. A Curriculum Vitae of the specialist involved in this study can be found in Table 4-1 with details of the specialist shown in Table 4-1.

Table 4-1: Details of the Specialist(s) who prepared this Report

Responsibility	Report compilation
Full Name of Specialist	Jan Arie (Arjan) van 't Zelfde
Highest Qualification	M.Sc.
Years of experience in specialist field	15

5 Environmental Law Applicable to Study

The South African Environmental Legislation needs to be considered with reference to the management of soil and land use which includes:

- Soils and land capability are protected under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). The NEMA requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimised and treated; and
- The Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) (CARA). The CARA requires that protection of land against soil erosion, the prevention of water logging and salinization of soils by means of suitable soil conservation works to be constructed and maintained.

6 Assumptions and Limitations

The following assumptions and limitations have been made:

- The information contained within this report is based on a desktop review and a site survey as previously carried out.

7 Methodology

This section provides the methodology used in the compilation of the soils report. To complete the proposed scope of work, there were several tasks which needed to be completed and these tasks are explained separately below.

7.1 Desktop Assessment

Aerial imagery was analysed to determine areas that are most likely to be suitable for agriculture. The aerial imagery analysis focused on lower lying areas where suitable soils are more likely to occur.

As part of the assessment, baseline soil information was obtained from the South African land type data published with maps at a scale of 1:250 000 by the Institute for Soil, Climate and Water (ISCW) of the Agricultural Research Council (ARC). These maps indicate delineated areas of relatively uniform terrain, soil pattern and climate (Land Type Survey Staff, 1972 - 2006). These maps and their accompanying reports provide a statistical estimate of the different soils that can be expected in the area.

7.2 Literature Review

Digby Wells conducted a desktop review of the baseline data and findings related to the soil surveys and other relevant existing documentation. The following sources of information were reviewed and utilised for the compilation of this report:

- Delta Built Environment Consultants (Pty) Ltd., 2019. Musina-Makhado Special Economic Zone Development – Scoping Report; and
- Digby Wells, 2019. Soils and Land Capability Impact Assessment for the proposed Musina-Makhado Special Economic Zone Development, Vhembe District Municipality, Limpopo Province - Inception Report.

7.3 Current Land Capability and Land Use

The current land use was identified using aerial imagery during the desktop assessment. Land capability was determined by assessing a combination of soil, terrain and climate features. Land capability is defined by the most suitable land use under rain-fed conditions. The approach by Schoeman *et al* (2000) was used to assess the land capability. The defined land capability shows the most intensive long-term use of land for rain-fed agriculture and at the same time indicates the permanent limitations associated with different land use classes. The classification system is made up of land capability classes and land capability groups.

Land capability mapping was based on identified soil forms at the site. As mentioned, the soil forms were derived according to the South African Soil Classification Taxonomic System (Soil Classification Working Group, 1991). The land capability mapping involved dividing land into one of eight (8) potential classes of soil capability, whereby Classes I-IV represent arable land and Classes V-VIII represent non-arable land according to the guidelines (refer toTable 7-1**)** (Schoeman et al., 2002).

Table 7-1: Land Capability Classes

Class	Increased Intensity of Use									Land Capability Groups		
I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable land	W -	Wildlife
II	W	F	LG	MG	IG	LC	MC	IC	-		F -	Forestry
III	W	F	LG	MG	IG	LC	MC	-	-		LG –	Light grazing
IV	W	F	LG	MG	IG	LC	-	-	-		MG –	Moderate grazing
V	W	-	LG	MG	-	-	-	-	-	Grazing land	IG -	Intensive grazing
VI	W	F	LG	MG	-	-	-	-	-		LC –	Light cultivation
VII	W	F	LG	-	-	-	-	-	-	Wildlife	MC –	Moderate cultivation
VIII	W	-	-	-	-	-	-	-	-		IC -	Intensive cultivation
											VIC –	Very intensive cultivation

Soil agricultural potential or suitability mapping was determined by considering the soil forms, land capability classes, soil chemistry results, the hydrology of the site and the current land use. The process involved allocating terrain factors (such as slope) and soil factors (such as depth, texture, internal drainage and mechanical limitations (which affect soil-water processes)) which define soil forms, to an area of land. The soil chemistry, which includes pH, cation and anion concentrations as well as nitrogen compositions, which are affected by the site hydrology, were considered in determining the final suitability of the soil. The suitability guidelines used in this study are presented in Table 7-2 (Schoeman et al., 2002).

Table 7-2: Land Classes - Descriptions and Suitability

Class	Definition	Conservation Need	Use-Suitability
I	• No or few limitations. • Very high arable potential. • Very low erosion hazard.	Good agronomic practice.	Annual cropping.
II	• Slight limitations. • High arable potential. • Low erosion hazard.	Adequate run-off control	Annual cropping with special tillage or ley (25 %).
III	• Moderate limitations. • Some erosion hazards.	Special conservation practice and tillage methods.	Rotation of crops and ley (50 %).
IV	• Severe limitations. • Low arable potential. • High erosion hazard.	Intensive conservation practice.	Long term leys (75 %).
V	• Watercourse and land with wetness limitations.	Protection and control of water table	Improved pastures or Wildlife
VI	• Limitations preclude cultivation. • Suitable for perennial vegetation.	Protection measures for establishment e.g. Sod-seeding	Veld and/or afforestation
VII	• Very severe limitations. • Suitable only for natural vegetation.	Adequate management for natural vegetation.	Natural veld grazing and afforestation.
VIII	• Extremely severe limitations. • Not suitable for grazing or afforestation.	Total protection from agriculture.	Wildlife.

8 Findings

Information related to the climate, topography, geology, vegetation, soils, land use and land capability associated with the project area is discussed in this Section.

8.1 Climate

The project area is situated in the north of the Limpopo Province between the towns of Musina to the north and Makhado to the south. The project area is situated on the Limpopo plain north of the Soutpansberg mountain range.

According to the Köppen Classification (Köppen, 1918), the project area is predominantly semi-arid, dry and hot (BSh). The temperature in the project area is influenced by the Soutpansberg mountain range that acts as a barrier between the Indian Ocean south-eastern maritime climate and the northern continental climate. The average rainfall is less than 500 mm with annual rainfall of approximately 300 to 400 mm, mostly falling during the summer months (October to March). Temperatures range between 33 – 20°C in November-February and between 28 and 7°C in May-August.

8.2 Topography

The topography of the SEZ Development Area as depicted in Figure 8-1 can be described as a relatively flat to slightly undulating landscape, with elevations ranging between approximately 670 and 770 metres above mean sea level (mamsl). An overall shallow gradient can be observed in an approximate south-north orientation. Higher elevations in the area are predominantly associated with rock outcrops that form ridges in approximate west-east orientations on the southern part of the site and west-southwest to east-northeast on the northern part of the area. Drainage in the vicinity of the site predominantly flows in a north-easterly direction with non-perennial drainage lines located to the east and west of the site. Slopes at the site are mainly less than 5%, with some ridges with slopes up to 14% along the northern and southern end of the site and a small section on the eastern side of the site (Figure 8-2).

8.3 Geology

The SEZ Development Area is situated in the area geologically indicated as the Limpopo Belt which is a broad zone of gneisses situated in between the granitoid-greenstone terranes of the Kaapvaal and Zimbabwe Cratons. The Limpopo Belt geology is observed on site as ridges where the Gumbu Group outcrops at surface. The Gumbu Group is the youngest group part of the Beit Bridge Complex, which consists of metasedimentary rocks and associated Leucogneisses (Johnson *et. al*., 2006). The Gumbu Group itself is characterised predominantly by marbles and calc-silicate rocks with minor greywacke. However, for most of the site the geology is covered by quaternary sediments in which mainly sandy soils have formed. The geology of the project area is shown in Figure 8-3.

8.4 Vegetation

The SEZ site falls within the Musina Mopane Bushveld as depicted in Figure 8-4. The Musina Mopane Bushveld is categorised as least threatened, with a target of 19%. Only 2% is statutorily conserved, mainly in the Mapungubwe National Park and the Nwanedi and Honnet Nature Reserves. It is the most diverse mopaneveld type in South Africa (Mucina *et. al*., 2006).

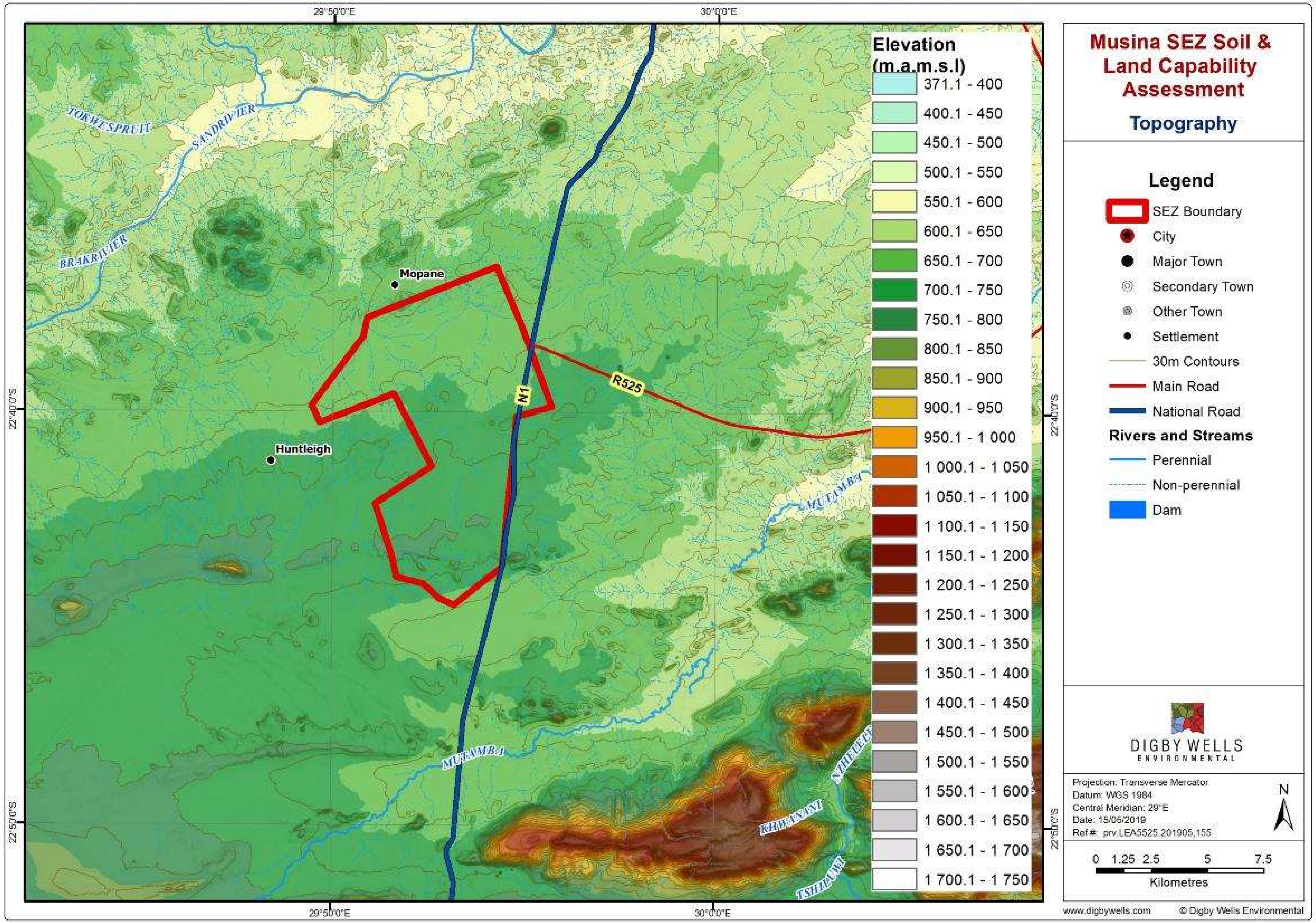

Figure 8-1: SEZ Development Area Topography

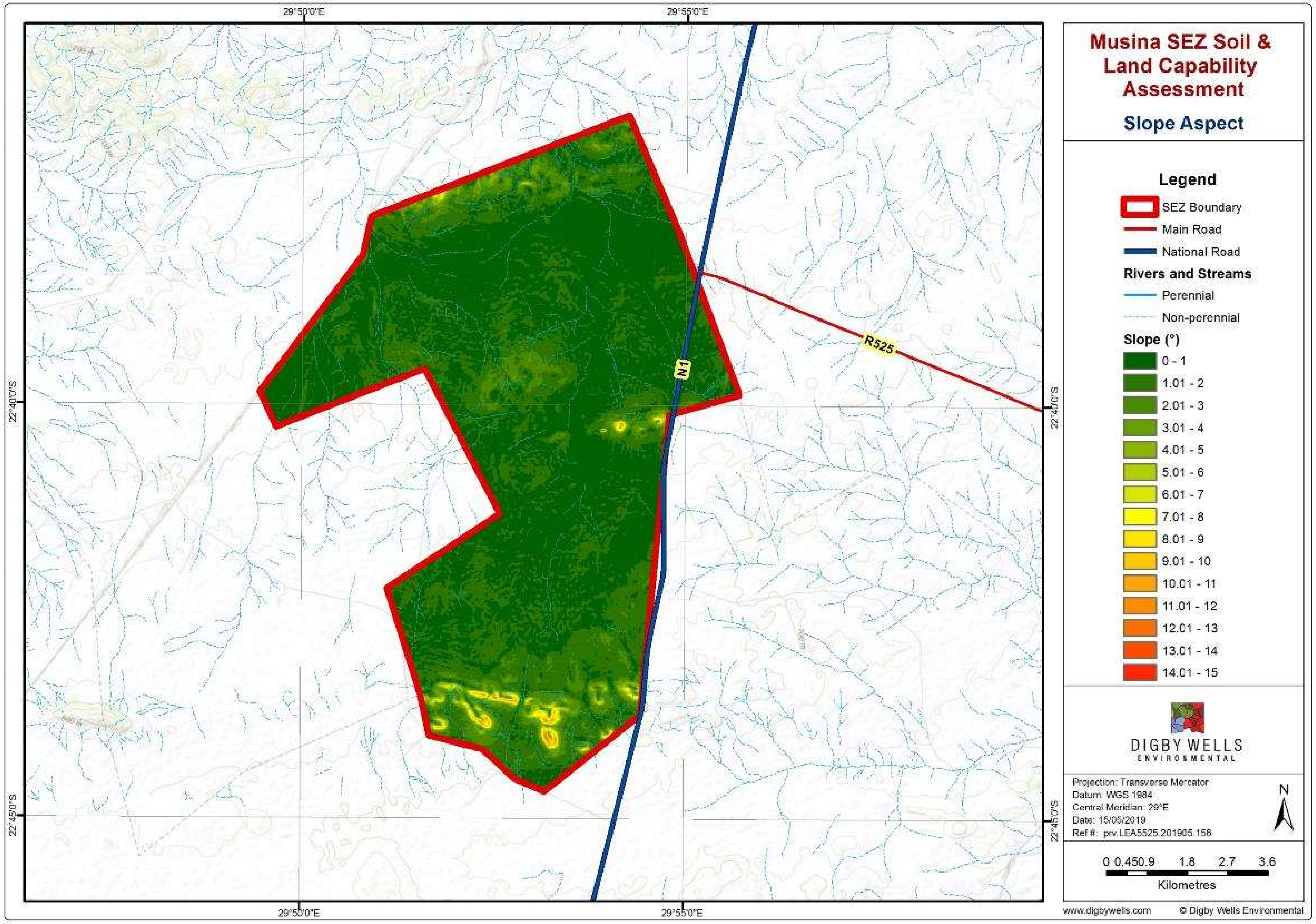

Figure 8-2: SEZ Development Area Slope Aspect

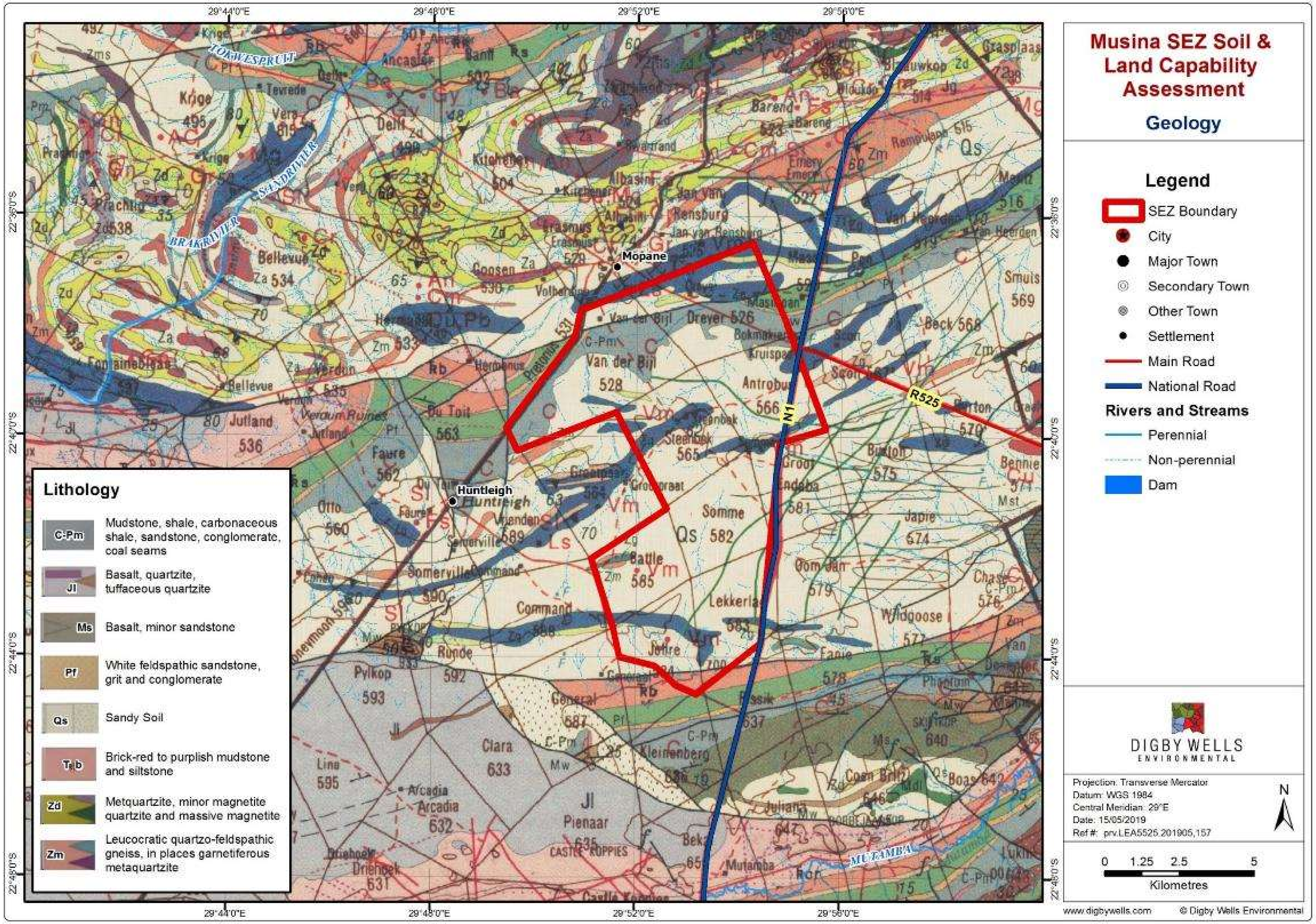

Figure 8-3: SEZ Development Area Regional Geology

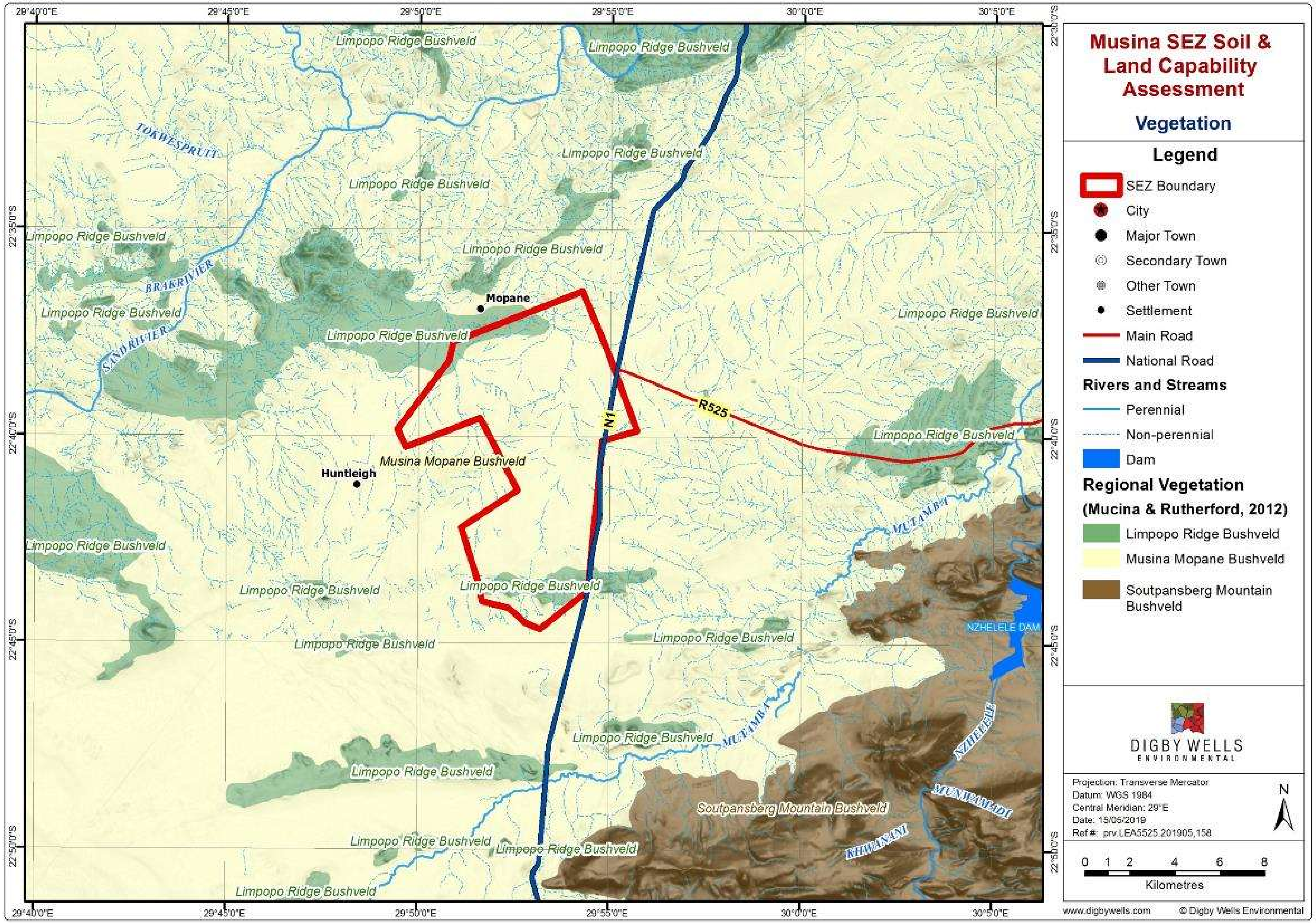

Figure 8-4: SEZ Development Area Vegetation Types

8.5 Land Type

The SEZ development areas is characterised by rock outcrops and generally shallow soils with moderate topography which makes the area to have a generally low potential for agricultural activities. The land type gathered suggested that the project area was dominated by land types Ah89, Fc483, Lb312 and Ae305 as depicted in Figure 8-5. Table 8-1 shows dominant land type and expected soil forms on the site. Site surveys will confirm details in this regard.

Table 8-1: Dominant land types

Land Type	Description
Ah89	Unit Ah89 is the most common landtype for the SEZ area and is characterised by shallow soils up to 300 mm deep, with occurrences of rock outcrops and some deeper soil forms up to 900-1000 mm deep. Freely drained, red and yellow, eutrophic, apedal soils develop in this unit and comprise >40% of the land type. The dominant soil form is Mispah, the Hutton soil form is common, and Clovelly and Oakleaf soil forms are present to a lesser extent.
Fc483	Unit Fc483 is a land type predominantly characterised by shallow soils up to 200 mm deep (more than 50%), some rock outcrops (18%) and deeper soil forms up to 1200 mm deep. The abundant soil form is Mispah with some lesser occurrences of Hutton, Clovelly and Oakleaf soil forms.
l312	Unit Lb312 is characterised predominantly by rock outcrops which comprise >60% of the land, the predominant soil form being Mispah with occurrences of the Hutton and Oakleaf soil forms.
Ae305	Unit Ae is characterised by freely drained, red, eutrophic, apedal soils comprising >40% of the land type, in the predominantly Hutton soil form which can be more than 1200 mm deep.

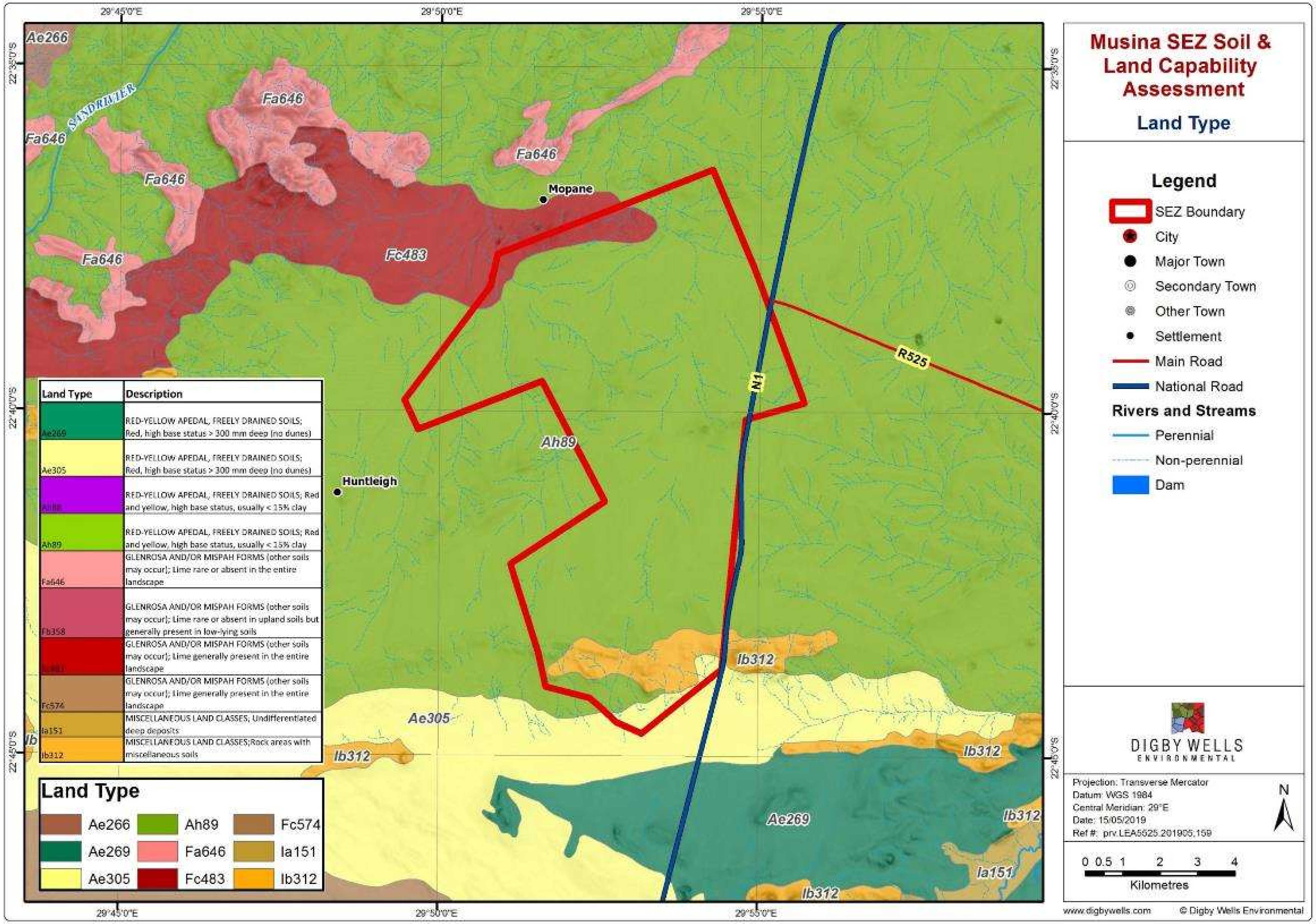

Figure 8-5: SEZ Development Area Land Type

8.5.1 Expected Soil Forms

8.5.1.1 Mispah

The Mispah soil form consists of an Orthic A horizon overlying a hard rock or silcrete, as depicted in Figure 8-6. Mispah soils are too shallow and are generally on too steep topography to allow any form of agricultural activities.

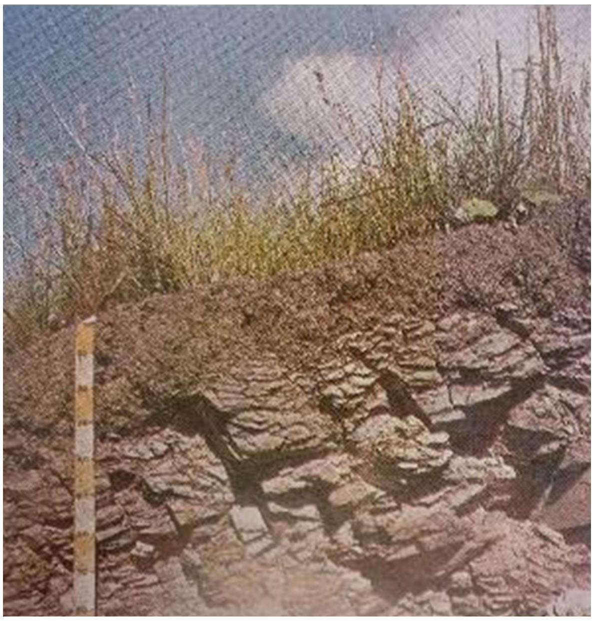	
	Orthic A
	Hard rock

Figure 8-6: A typical cross section of the Mispah soil form

8.5.1.2 Oakleaf

The Oakleaf soil form are deep (>1.2 m) soils that consist of an Orthic A horizon, overlying a Neocutanic B, overlying a subsoil with no signs of wetness due to A and B horizons having good internal drainage properties, as depicted in Figure 8-9. They generally have moderate clay percentages (15 – 25% and 25 – 40% clay in A and B horizons). Oakleaf soils are moderately suitable for crop production but irrigation is limited by availability of water and climate.

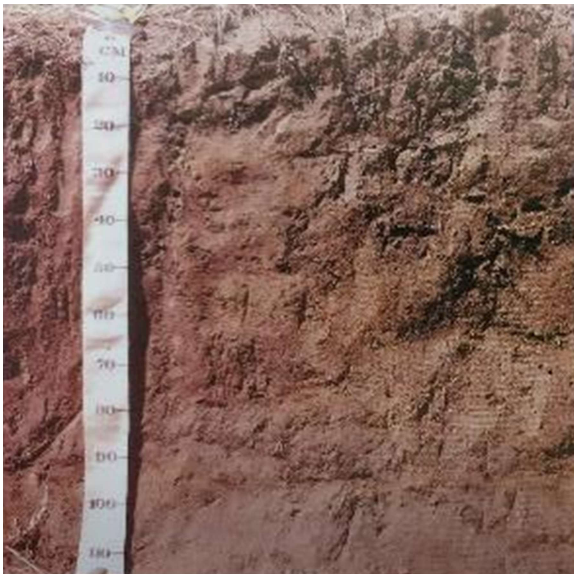	Orthic A
	Neocutanic B

Figure 8-7: Oakleaf soil form

8.5.1.3 Clovelly

The Clovely soil form are deep (>1.2 m) soils that consist of an orthic A and yellow-brown apedal B over unspecified material. Like those of the Hutton form these soils are well drained, slightly acidic and have low Cation Exchange Capacity (CEC). They have similarly favourable physical properties for use in rehabilitation. The yellow-brown colour (due to goethite) is commonly indicative of a moister soil climate than that of adjacent Hutton soils (red colour due to hematite) in the same landscape.

	
	Orthic A
	Yellow-brown Apedal B

Figure 8-8: Clovelly soil form

8.5.1.4 Hutton

The Hutton soil form are deep (>1.2 m) soils that consist of an orthic A and red apedal B over unspecified material. These soils are well drained, usually slightly acidic, and have a low CEC due mainly to clay mineral composition (kaolinite, iron oxides) and sometimes low clay content. This soil form was identified in relatively flat landscape positions and has high arable potential and high value for use as topsoil, having favourable structure (weak blocky to apedal) and consistence (slightly firm to friable).

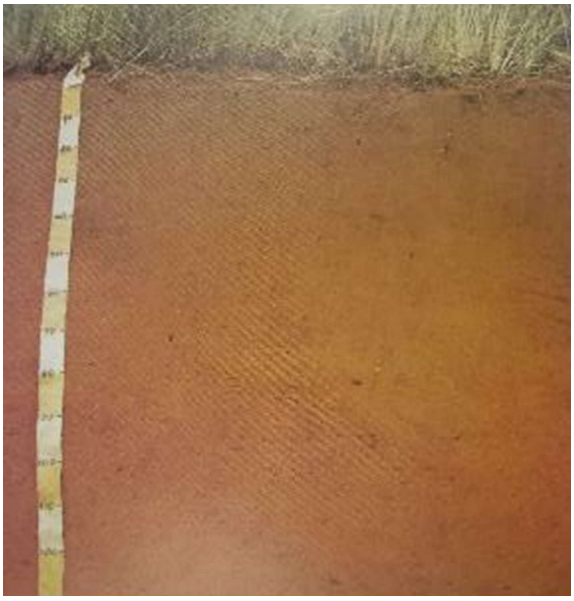	Orthic A Red Apedal B

Figure 8-9: Hutton soil form

Figure 8-10 illustrates typical site conditions observed on the Property.

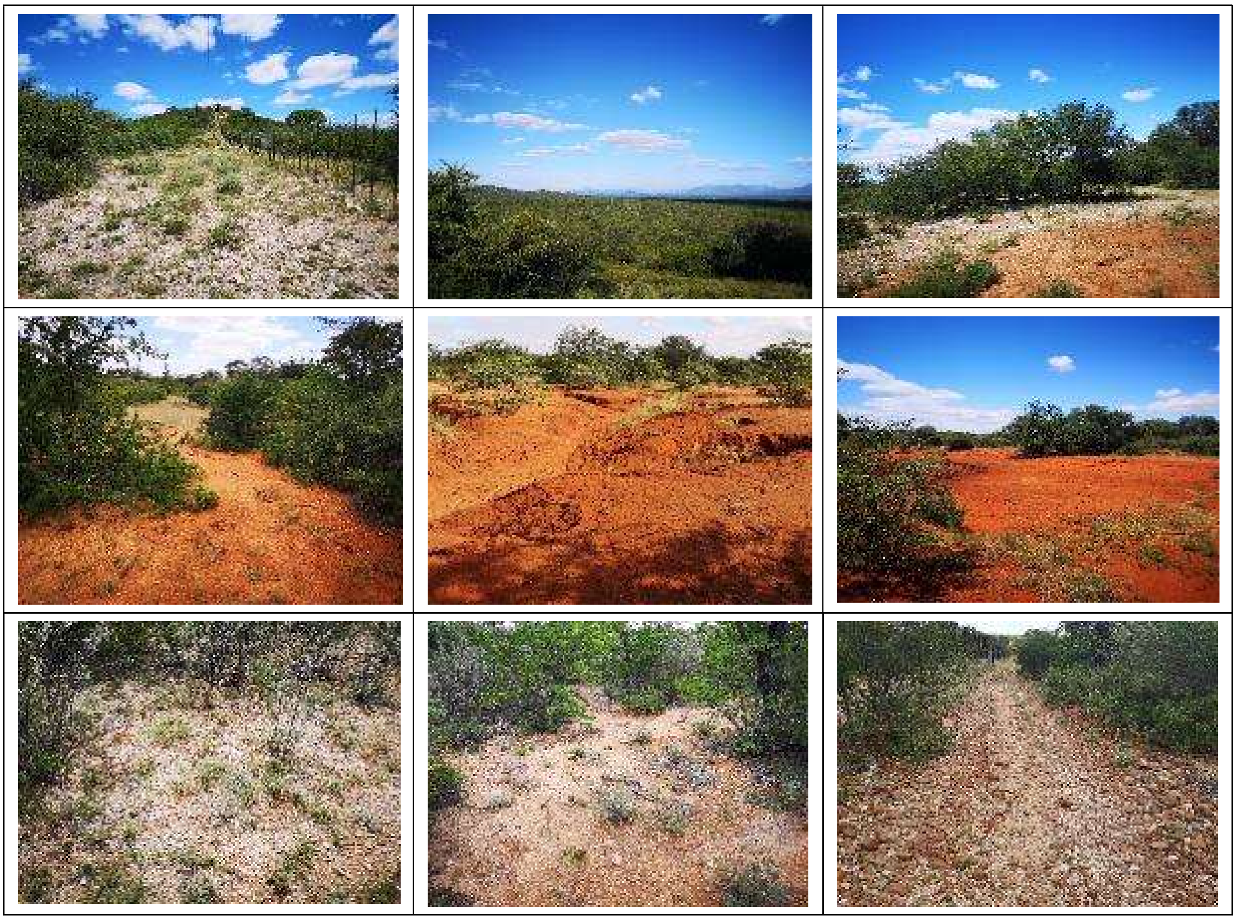

Figure 8-10: On-site conditions

8.6 Land Use

The SEZ Development area is covered by natural bushveld vegetation consisting mainly of grassland with some areas with shrubland and thicket and woodlands and/or open bush. This is at current mainly used for extensive agricultural purposes as shown by a few farmsteads present within the area. Smaller areas show signs of shallow digging/mining, and there is a toll plaza present along the N1 highway near the eastern boundary (Figure 8-11).

8.7 Land Capability

The approach used for the land capability assessment is used in agriculture and is recommended by Schoeman *et al* (2000) who defined land capability in terms of the combined effects of soil, terrain and climatic features. The defined land capability shows the most intensive long-term use of land for rain-fed agriculture and at the same time indicates the permanent limitations associated with different land use classes. Land capability was determined by assessing a combination of soil, terrain and climate features. According to the land type data (Land Type Survey Staff, 1972 – 2006); the current land capability identified within the proposed development area was mostly Class VI (wildlife, forestry, light grazing), with smaller areas of Class VIII (wildlife) as depicted in Figure 8-12.

8.7.1 Class VI

Land in Class VI has limitations that makes it unsuited for cultivation and restrict its use to light to moderate grazing, woodland or wildlife. Physical conditions are such that it is impractical to apply such pasture or range improvements as seeding, liming and fertilizing. In unusual instances some occurrences may be used for special crops but only under unusual management practices.

8.7.2 Class VIII

Land in Class VIII has very severe limitations that makes it unsuited to cultivation and that restrict its use largely to woodland or wildlife. Physical conditions, such as limited soil depth, are such that it is restricting root penetration and impractical to apply such pasture or range improvements as seeding, liming and fertilizing. Depending on soil characteristics and climate, land in Class VIII may be well or poorly suited to woodland.

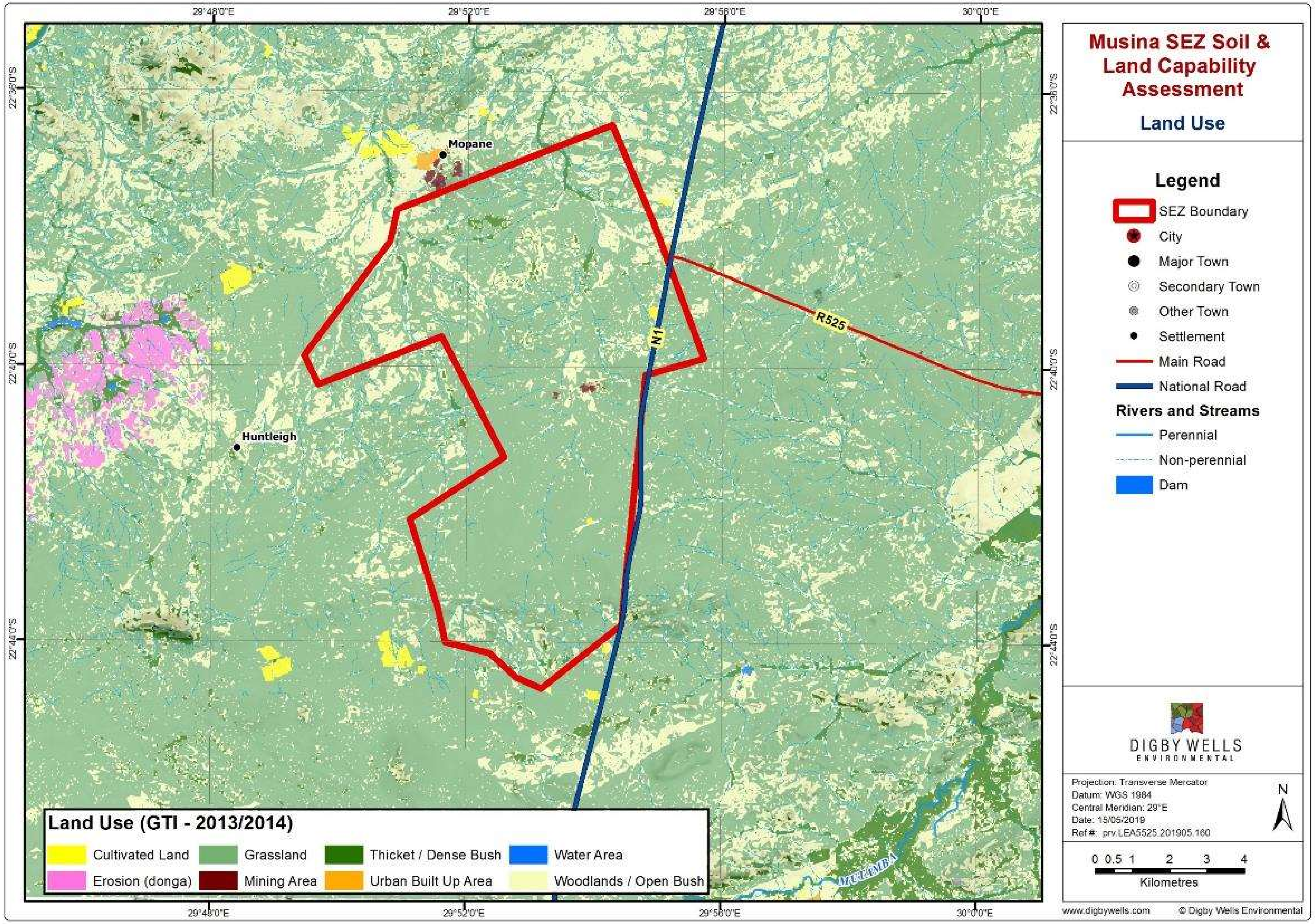

Figure 8-11: SEZ Development Area Land Use

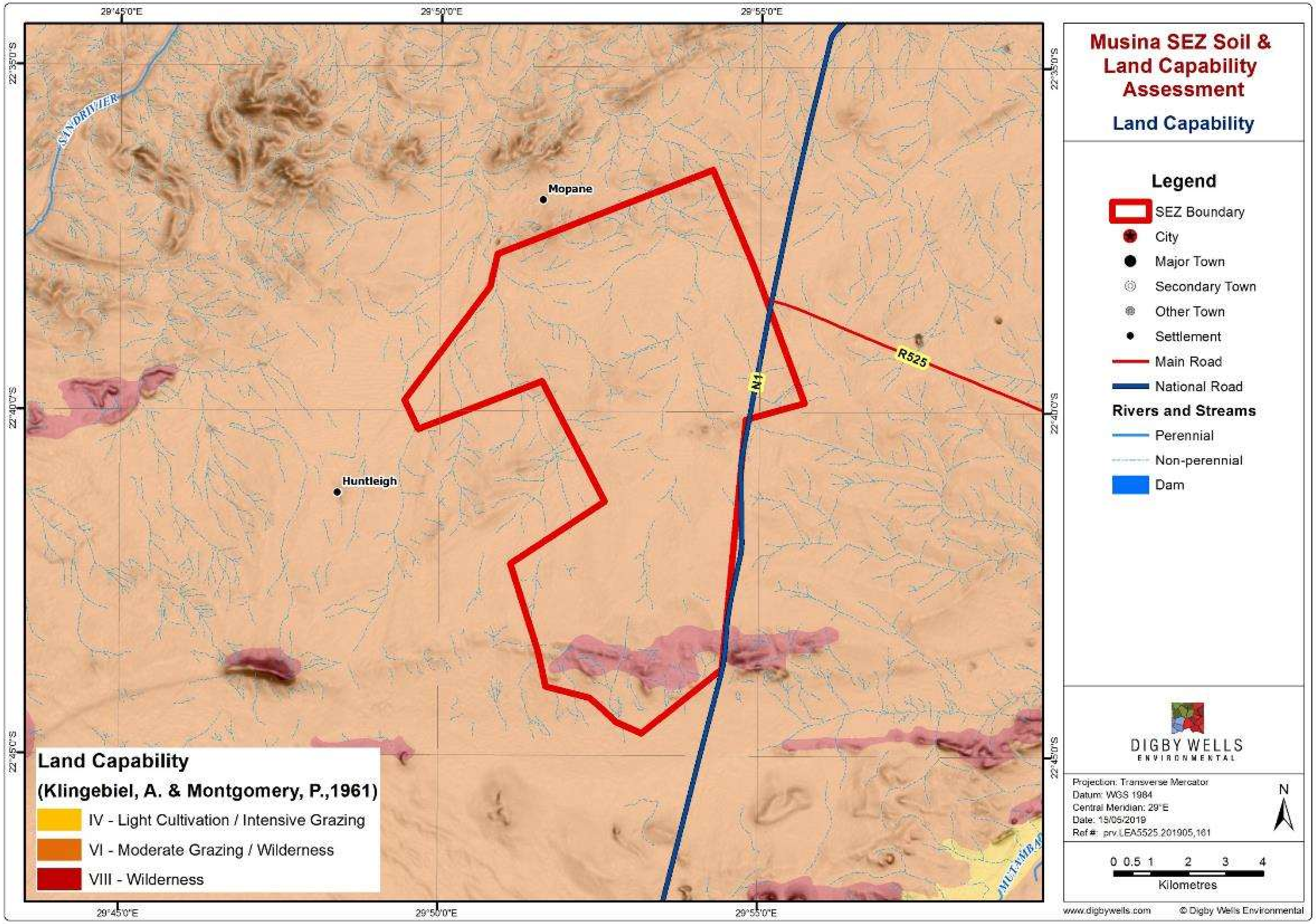

Figure 8-12: SEZ Development Area Land Capability – Regional Data

8.8 Soil Classification

Three different soil forms were identified within the surveyed area, and these are the Mispah, Clovelly and Hutton soil forms. The distribution of the identified soil forms at the SEZ Development area is presented in Table 8-2 and Figure 8-12. This distribution is based on a combination of information from the field survey, the soil classification and the regional land type and capability data and site imagery.

The most dominant soil form on the project site is the Hutton (66%) which mainly covers the lower lying areas. The Mispah (31%) soil form follows in dominance and this form is mainly found surrounding topographical highs where bedrock outcrops or is close to surface. Clovelly soil cover the remainder of the lower lying areas.

Table 8-2: Identified soil forms within the SEZ Development Area

Soil Forms	Area Surveyed (km^2)	% Surveyed Area
Hutton	54.9	66
Mispah	25.6	31
Clovelly	2.5	3

Based on the indicated soil distribution on the site, the Land Capability map was updated, and capability classes redefined based on the site-specific information collated during this study. The updated map (Figure 8-14) shows a larger part of the site would have a land capability class VIII than based on the regional data, based on the shallow soil depth and the low suitability of the soils for cultivation.

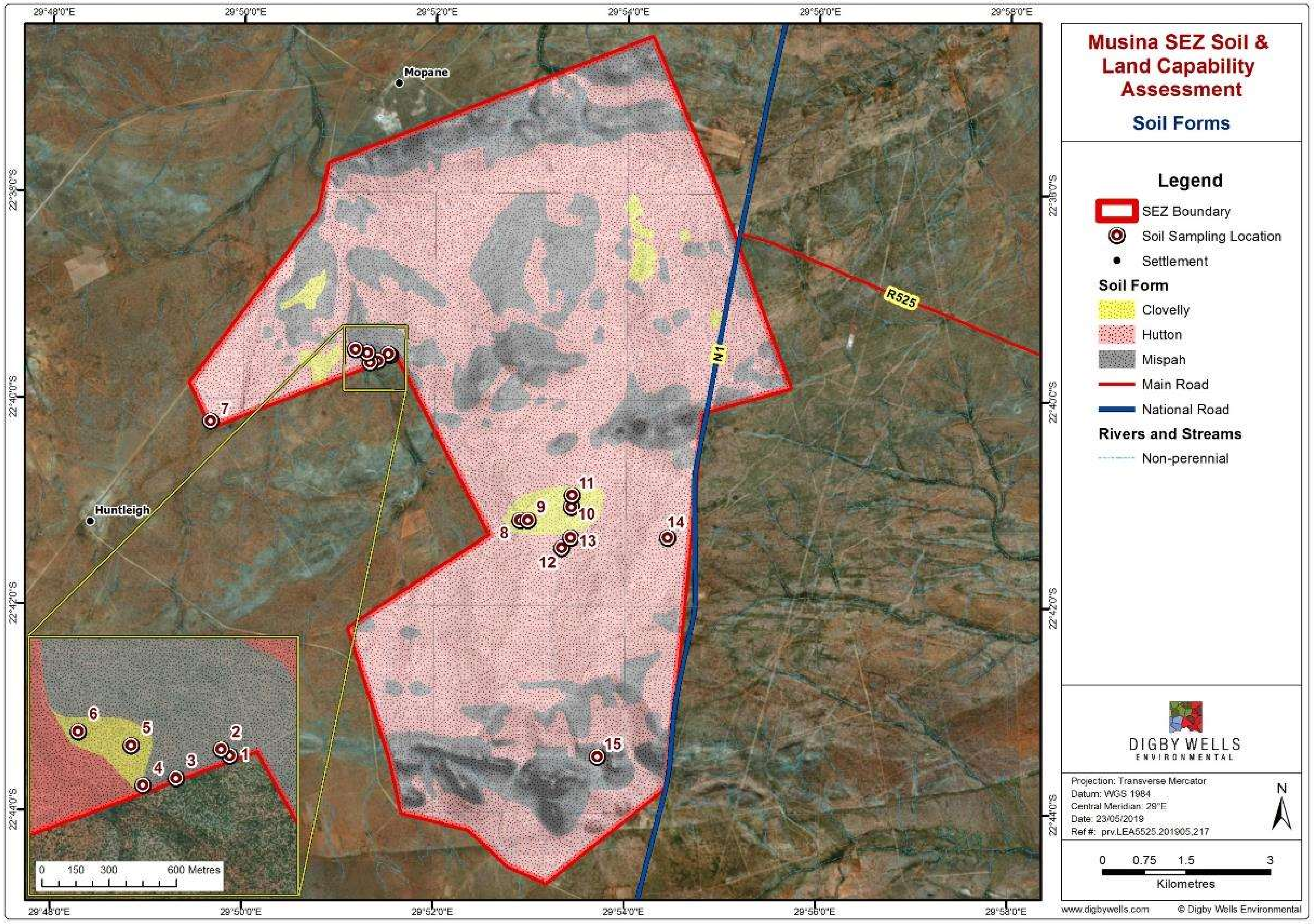

Figure 8-13: SEZ Development Area Soil Forms

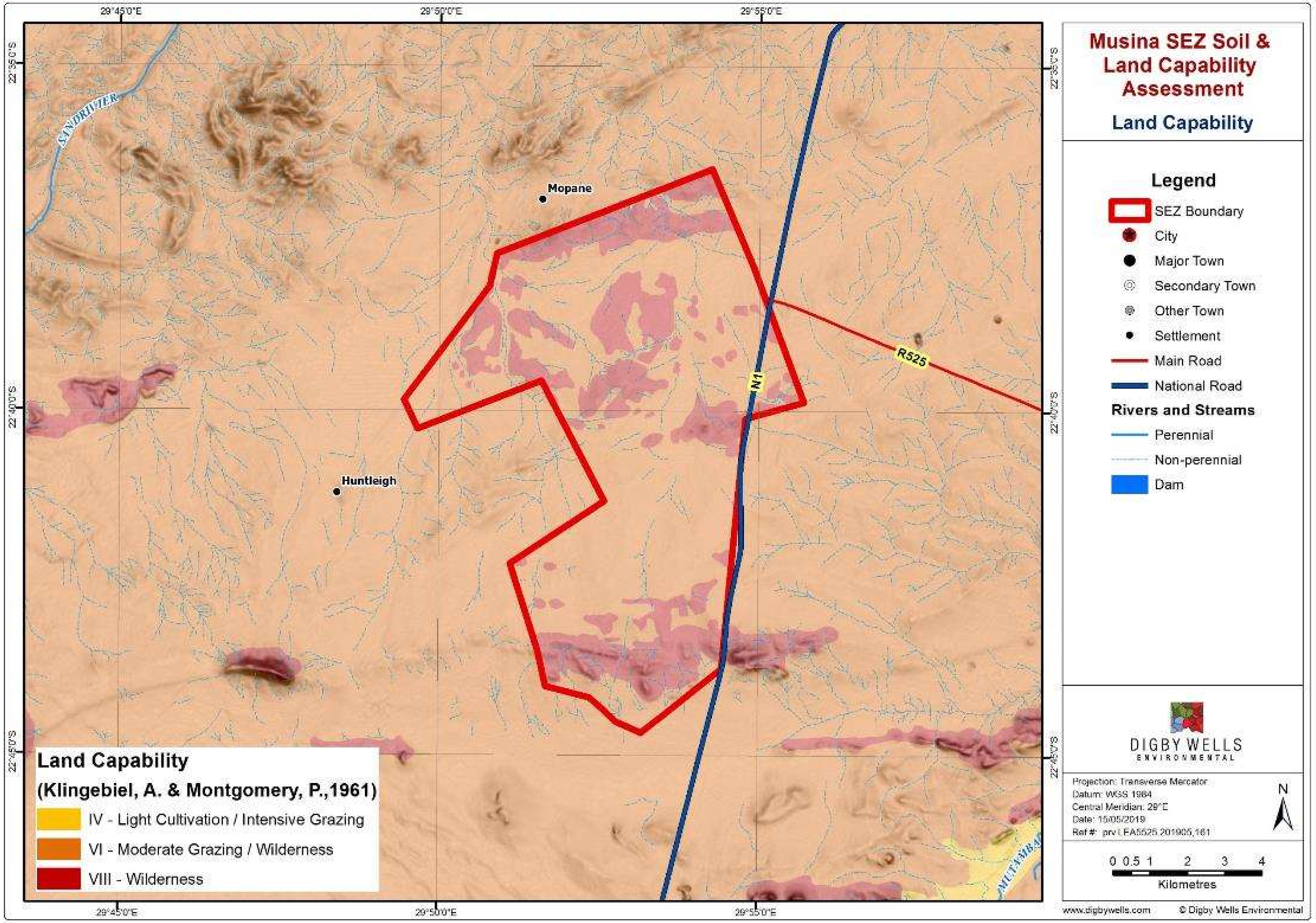

Figure 8-14: SEZ Development Area Soil Forms

8.9 Soil Characteristics

8.9.1 Soil Texture

The sand, silt and clay content of the soil samples were determined using laboratory results and the soil texture triangle as shown in Figure 8.15. In Figure 8.15 each fraction is expressed as a percentage proportional to the sum of the three fractions. The value resulting from this is termed the texture of a soil and the textural class can be obtained from plotting the three fractions on the textural triangle.

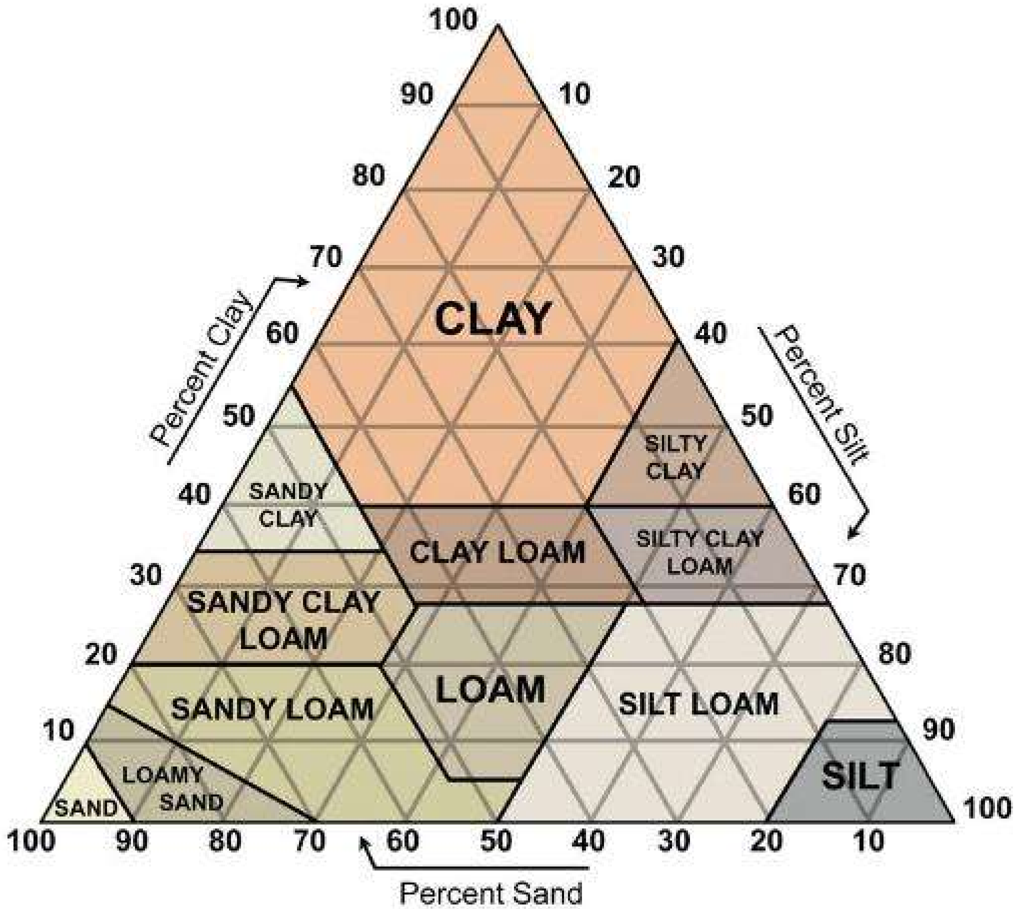

Figure 8.15 Soil texture triangle

The interpreted results indicated that the soil identified on site all fall in one texture class, namely sandy loam. All samples have a clay content lower than 20%. Topsoils that range between loamy sand and sandy clay loam textures allow for good to fair infiltration of water, and as such it is not expected the loamy sand texture as observed will significantly reduce infiltration into the soils found on the site.

8.9.2 Soil pH

The soil pH is determined in the supernatant liquid of an aqueous suspension of soil after having allowed the sand fraction to settle out of suspension. The soil pH has a direct influence on plant growth through the following:

- Direct effect of the hydrogen ion concentration on nutrient uptake;
- Mobilisation of toxic ions such as aluminium and manganese, which restrict plant growth; and
- Indirectly through the effect on trace nutrient availability.

The soil pH ranged from 4.3 to 5.9. These soils are considered acidic according to the guidelines (Table 8-3) and the soil pH values of below 7 is likely due to the acidic nature of the parent material from which the soils were derived and/or subsequent leaching processes. In case of agricultural use addition of agricultural lime would be required to counteract the acidity.

Table 8-3: Soil Fertility Guidelines

<table>
<tr><th colspan="6">Guidelines (mg per kg)</th></tr>
<tr><th colspan="3">Macro Nutrient</th><th colspan="2">Low</th><th>High</th></tr>
<tr><td colspan="3">Phosphorus (P)</td><td colspan="2"><5</td><td>>35</td></tr>
<tr><td colspan="3">Potassium (K)</td><td colspan="2"><40</td><td>>250</td></tr>
<tr><td colspan="3">Sodium (Na)</td><td colspan="2"><50</td><td>>200</td></tr>
<tr><td colspan="3">Calcium (Ca)</td><td colspan="2"><200</td><td>>3000</td></tr>
<tr><td colspan="3">Magnesium (Mg)</td><td colspan="2"><50</td><td>>300</td></tr>
<tr><th colspan="6">pH (KCl)</th></tr>
<tr><th>Very Acidic</th><th>Acidic</th><th>Slightly Acidic</th><th>Neutral</th><th>Slightly Alkaline</th><th>Alkaline</th></tr>
<tr><td><4</td><td>4.1-5.9</td><td>6-6.7</td><td>6.8-7.2</td><td>7.3-8</td><td>>8</td></tr>
</table>

8.9.3 Exchangeable Cations

The levels of the basic cations Ca, Mg, K and Na are determined in soil samples for agronomic purposes through extraction with an ammonium acetate solution. In general, the amounts of exchangeable cations normally follow the same trend as outlined for soil pH and texture. For most soils, cations follow the typical trend Ca>Mg>K>Na.

The CEC of the soil samples range between 3.8 and 17.7 $cmol_c$/kg, with the general trend being a higher CEC for the soils with higher clay and silt contents, as expected. The CEC values indicate a general low to moderate CEC.

Table 8-4: Soil Chemical and Physical Properties

Sample ID	pH (KCl)	P (Bray1)	K	Na	Ca	Mg	Cu	Fe	Mn	Zn	Organic C	Clay	Sand	Silt	Texture
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%	%	%	
4	4.88	2	130	29	992	291	1.06	5.47	8.11	0.4	0.4	11	81	8	Sandy Loam
7	5.76	3	299	42	1184	285	0.91	8.23	9.51	0.63	0.6	19	65	16	Sandy Loam
8	4.9	3	122	30	1185	325	0.8	3.06	12	0.38	0.4	11	76	13	Sandy Loam
9	4.99	4	143	22	648	166	0.94	4.96	14.4	0.44	0.5	11	78	11	Sandy Loam
10	4.32	3	149	24	380	180	0.96	3.34	9.56	0.41	0.3	11	81	8	Sandy Loam
11	5.91	2	373	27	1047	198	1.05	1.18	9.47	0.51	0.3	19	68	13	Sandy Loam
12	4.53	1	174	23	354	176	1.18	7.93	19.1	0.47	0.6	15	76	9	Sandy Loam
13	4.78	1	237	24	409	155	1.55	1.85	10.8	0.52	0.4	11	79	10	Sandy Loam
14	5.81	3	165	52	2555	521	2.05	2.72	14.24	0.49	0.5	19	63	18	Sandy Loam

Soil samples collected on the SEZ Development Area show the profile of Ca>Mg>K>Na concentrations as expected with exception of samples 7, 11 and 13 (K higher than Mg). The measured concentrations of Ca, Mg and Na show that calcium and magnesium are within the range for optimal plant growth, sodium concentrations are low and potassium concentrations are considered high for samples 7 and 11. Based on the soil exchangeable cations there would be no need for addition of fertilisers for agricultural purposes.

8.9.4 Phosphorus

The soil phosphorus levels at the SEZ Development Area are very low (1-4 mg/kg) which may be due to phosphorus fixation and the acidic nature of the soil. Phosphorus fertilisation would be required in case of any planned agricultural use and an application of phosphorus would lead to long-term improvement in soil fertility.

8.9.5 Main findings

The soils on the site have a sandy loam texture, with a low clay content (less than 20%) and a low soil organic carbon content (between 0.3 and 0.6 mg/kg). As a result, the soil CEC is low to moderate. Exchangeable cation concentrations indicate a low sodium content with good calcium, magnesium and potassium concentrations for crop growth.

The soils are acidic and as a result, phosphorus concentrations are very low due to a high adsorption rate related to a low pH. Zinc and copper concentrations are also considered to be low for common crops and likely related to the sandy nature of the soils as observed, with a low CEC and low organic carbon content. Based on the chemical characteristics the soils have limited potential for crop growth without additional management practises such liming or fertilisation.

9 Potential Impacts

The major impacts will be associated with potential contamination of soils due to the planned activities and the construction of the plants and associated infrastructure, which will cover approximately 75% of the area. This will likely entail topsoil removal, soil compaction and disturbances of the natural occurring soil profiles. The potential impacts associated with the development on soils are detailed below:

- Potential negative impacts:
  - The proposed activities, including metallurgical plants and movement of vehicles, could cause small-scale contamination of soils if these activities are not properly managed;
  - Soil compaction may deteriorate the land capability:
    - in areas where base preparation for the construction of plants/infrastructure is planned, and
    - in areas where movement of construction vehicles will occur.

- The compaction and removal of soils for construction purposes can negatively impact on the land capability, however, the land capability at current is already limited to mainly wildlife or light/moderate grazing;
- The removal of vegetation may lead to soil erosion caused by wind and water movement over the soil surface;

- Potential positive impacts:
  - The land use will promote agricultural activities and contribute to gross domestic product (GDP).

10 Conclusions

The project area is predominantly semi-arid, dry and hot (BSh), influenced by the Soutpansberg mountain range that acts as a barrier between the Indian Ocean south-eastern maritime climate and the northern continental climate. The topography can be described as a relatively flat to slightly undulating landscape, with an overall shallow gradient in an approximate south-north orientation. Higher elevations in the area are predominantly associated with rock outcrops that form ridges in approximate west-east and west-southwest to east-northeast orientations. The predominant vegetation type found at the site is that of the Musina Mopane Bushveld.

The land type gathered suggested that the project area was dominated by land types Ah89, Fc483, Ib312 and Ae305. Soil forms identified during the site survey include Mispah, Hutton and Clovelly. The soils on the site have a sandy loam texture with low clay and soil organic carbon contents. As a result, the soil CEC is low to moderate, with exchangeable cation concentrations indicate a low sodium content with good calcium, magnesium and potassium concentrations for crop growth.

However, the soils are acidic and phosphorus concentrations are very low. Zinc and copper concentrations are also considered to be low for common crops. Based on the chemical characteristics the soils have limited potential for crop growth without additional management practises such liming or fertilisation.

The current land capabilities identified within the proposed development area were Class VI and VIII, mainly due to the soil chemical characteristics and the shallow depth to bedrock for large parts of the site. This limits the land capability potential to mainly wildlife or moderate grazing.

The high-level impact assessment indicated the main impacts will be potential soil contamination due to the proposed activities and soil compaction and removal due to base preparation for construction and movement of construction vehicles. However, the current land capability is limited to mainly wildlife or light/moderate grazing and if risk of contamination is minimised land capability will not be severely impacted upon.

11 References

Delta Built Environment Consultants (Pty) Ltd., 2019. Musina-Makhado Special Economic Zone Development – Scoping Report

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Land Type Survey Staff. 1972 – 2006. Land Types of South Africa: Digital Map (1:250 000) and soil inventory databases. Agricultural Research Council – Institute for Soil, Climate and Water, Pretoria.

Mucina, L., & Rutherford, M.C., 2006. The Vegetation of South Africa, Lesotho and Swaziland, Strelitzia 19, South Africa.

Soil Classification of Working Group. 1991. Soil Classification A Taxonomic System for South Africa. Pretoria: The Department of Agricultural Development.

Appendix A: CV

Mr Arjan (J.A.) van 't Zelfde

Soil Scientist / Hydrogeologist

Water Services

Digby Wells Environmental

Education

- 1997 – 2003: BSc/MSc programme Soil, Water & Atmosphere, specialisation in Soil Science – Wageningen University, The Netherlands.

Employment

- April 2019 – Present: Digby Wells Environmental – Senior Hydrogeologist.
- August 2014 – April 2019: VGCS Water & Environmental Consultants (Pty) Ltd. – Senior Hydrogeologist.
- Mar 2009 – July 2014: Royal HaskoningDHV, The Netherlands - Hydrogeological consultant.
- Jan 2005–Dec 2008: Hydrogeological consultant, O'Neill Ground Water Engineering Ltd. Ireland

Experience

Jan Arie (Arjan) van 't Zelfde is a Soil Scientist and completed his MSc in Soil Science at Wageningen University, The Netherlands in June 2003. His soil science degree was approved by Saqa in 2014 (Saqa no. 726549). Arjan is a Pr.Sci.Nat registered with SACNASP under no. 115656 in the field of Earth Science. Prior to his employment at Digby Wells, Arjan worked as a Senior Hydrogeologist at GCS Water & Environmental Consultants (Pty) Ltd. And as hydrogeologist at Royal HaskoningDHV in The Netherlands and O'Neill Groundwater Engineering in Ireland. He joined Digby Wells in April 2019 and is part of the Water Department. His role involves conducting soil surveys and soil contamination assessments, hydrogeological assessments and modelling, environmental impact assessments and writing detailed scientific reports.

Project Experience

- Soil study for an Environmental Authorisation Application for Proposed Mukulu mine, near Hotazel– Northern Cape, Hatch Goba – Soil Scientist.
- Soil Study for an Environmental Impact for an Environmental Authorisation Application for Proposed Rietkuil mine, near Kriel, Mpumalanga, Total Coal – Soil Scientist.
- Feasibility Study Comide mine, Kolzwezi: Water section and complex numerical model for a multi open-pit copper cobalt mine operation in the DRC – Hydrogeologist.
- Hydrogeological numerical model for the Moatize mine, Tete: complex numerical model for a multi-opencast coal mine in Mozambique – Hydrogeologist.

- Impact assessment and numerical model for a Manganese mine near Hotazel, Northern Cape – Hydrogeologist.
- Impact assessments and numerical modelling for numerous coal mines for Exxaro – Hydrogeologist.
- Hydrogeological investigation Letseng Mine, Lesotho: Update of an existing numerical model using time series data of groundwater levels and hydrochemistry data – Hydrogeologist.
- Hydrogeological investigation Styldrift mine: numerical modelling of potential groundwater inflows into a proposed expansion of an existing platinum mine near Pilanesberg – Hydrogeologist.

Research

- Asten, P.J.A. van; Zelfde, J.A. van 't; Zee, S.E.A.T.M. van der; Hammecker, C.. The effect of irrigated rice cropping on the alkalinity of two alkaline rice soils in the Sahel. Geoderma 119(3-4):233-247, April 2004.
- Zelfde, J.A. van 't; Bredenkamp, B.J.; Levay, E.; Marais, A.W.C.. Estimation Of Groundwater Inflow And Pore Pressure Distribution For A Coal Mine Using A Numerical Flow Model With Accurate Grid Refinement – GWD 2017 Conference, Cape Town - Conference paper

Short Courses

IGI	BS5930:1999 Soil description for engineering projects
IGI	Groundwater recharge
WISA	Short Course on Acid Mine Drainage
DHV	ArcGIS introductory course
ESBI	Mapinfo introductory course
Scoil Mhuire	AutoCAD introductory course

Professional Affiliations

Water Institute of South Africa (WISA).

Professional Registration

- 2016: Registered as a Professional Natural Scientist with The South African Council for Natural Scientific Professions. Registration number: 115656.

Appendix B: Laboratory Certificates

AGRICULTURAL SERVICES

SOIL ANALYSIS REPORT

intertek
Total Quality. Assured.

Farm Elandsfontein
District Bapsfontein
Gauteng, South Africa

Certificate Number : AGRI 03_19-0218-0
Report date : 2019/03/30

CERTIFICATE OF ANALYSIS

Customer : Digby Wells

CN : AGRI 03_19-0218-0				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	Cmol H+/Kg Soil	%	%	%	%	Calculation	Calculation	Calculation	Calculation	Calculation (Ca+ Mg+K+Na)	Calculation	Calculation (Ca+ Mg+K+Na+H)	g/ml	mg/kg	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	%	Digby Wells	
			S 003	S 007	S 009	S 009	S 009	S 009	*	*	*	*	*	*	*	*	*	*	*	*	S 003	*	*	*	*	*	*	*	*	*		
Batch Seq Number	Land Reference	Stikker No	pH (KCl)	PBray1	K	Na	Ca	Mg	Exchngeable acid	%Ca	%Mg	%K	%Na	Acid Saturation %	Ca:Mg	(Ca+Mg)/K	Mg:K	S-Value	Na:K	CEC	Digtheid	S	Clay	Sand	Silt	Cu (DTPA)	Fe (DTPA)	Mn (DTPA)	Zn (DTPA)	C	Date Received	Date Reported
AGRI 03_19-0218-1		004	4.88	2	130	29	992	291	0.00	63.5	30.6	4.2	1.6	0.0	2.1	22.2	7.2	7.8	0.4	7.8	1.501	13.24	11	81	8	0.96	3.34	9.56	0.41	0.34	2019/03/26	2019/03/30
AGRI 03_19-0218-2		007	5.76	3	299	42	1184	285	0.00	64.3	25.4	8.3	2.0	0.0	2.5	10.8	3.1	9.2	0.2	9.2	1.340	19.22	19	65	16	1.55	1.85	10.80	0.52	0.40	2019/03/26	2019/03/30
AGRI 03_19-0218-3		008	4.90	3	122	30	1185	325	0.00	65.6	29.5	3.4	1.5	0.0	2.2	27.6	8.6	9.0	0.4	9.0	1.410	11.96	11	76	13	1.18	7.93	19.10	0.47	0.57	2019/03/26	2019/03/30
AGRI 03_19-0218-4		009	4.99	4	143	22	648	166	0.00	64.0	26.9	7.2	1.9	0.0	2.4	12.6	3.7	5.1	0.3	5.1	1.480	5.28	11	78	11	0.94	4.96	14.40	0.44	0.48	2019/03/26	2019/03/30
AGRI 03_19-0218-5		010	4.32	3	149	24	380	180	0.17	47.1	36.7	9.4	2.5	4.2	1.3	8.9	3.9	3.9	0.3	4.0	1.452	1.80	11	81	8	0.91	8.23	9.51	0.63	0.62	2019/03/26	2019/03/30
AGRI 03_19-0218-6		011	5.91	2	373	27	1047	198	0.00	66.1	20.4	12.0	1.5	0.0	3.2	7.2	1.7	7.9	0.1	7.9	1.342	7.63	19	68	13	1.05	1.18	9.47	0.51	0.31	2019/03/26	2019/03/30
AGRI 03_19-0218-7		012	4.53	1	174	23	354	176	0.00	47.2	38.4	11.8	2.6	0.0	1.2	7.2	3.2	3.8	0.2	3.8	1.491	2.01	15	76	9	1.06	5.47	8.11	0.40	0.40	2019/03/26	2019/03/30
AGRI 03_19-0218-8		013	4.78	1	237	24	409	155	0.00	50.8	31.6	15.1	2.6	0.0	1.6	5.5	2.1	4.0	0.2	4.0	1.446	4.95	11	79	10	0.80	3.06	12.00	0.38	0.40	2019/03/26	2019/03/30
AGRI 03_19-0218-9		014	5.81	3	165	52	2555	521	0.00	72.2	24.1	2.4	1.3	0.0	3.0	40.3	10.1	17.7	0.5	17.7	1.255	31.86	19	63	18	2.05	2.72	14.24	0.49	0.54	2019/03/26	2019/03/30

T0627

Results marked as not SANAS accredited (*) in this report are not included in the SANAS Schedule of Accreditation for this laboratory. Measurement of uncertainty values are available upon request.

Frederick Mafethe
Laboratory Analyst