SOIL ASSESSMENT FOR THE CLOSURE OF THE ST HELENA SHAFT, HARMONY

FREE STATE, SOUTH-AFRICA

June 2018

CLIENT

EIMS
ENVIRONMENTAL IMPACT MANAGEMENT SERVICES

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Report Name	**Soil assessment for the closure of the St Helena Shaft, Harmony**	
Submitted to	**EIMS**	
Survey/Report	**Ivan Baker**	
Report Review	**Wayne Jackson**	

EXECUTIVE SUMMARY

The Biodiversity Company was commissioned to conduct a soil assessment for the application of closure certificate for Harmony's St Helena 10 (FS96MR) shaft near Welkom. The project area was traversed, and samples were taken from the 30th until the 31st of May 2018 for the pre-mining land capability assessment and again on the 12th of September for the post-mining land capability assessment.

During the survey, five (5) dominant soil forms were identified, namely Avalon, Westleigh, Clovelly, Witbank, and Arcadia soil forms. The Avalon soil form covers grazing land use areas, the Arcadia soil form covers a small portion of the grazing land use area, whereas the Clovelly soil form covers the agricultural crops and grazing land use area. The Witbank soil form is characterised by disturbed soil, which is part of the disturbed area. The Westleigh soil form covers grazing and wetland land use areas.

Soil samples were analysed for standard fertility and textural tests. Results obtained from the lab analysis indicate possible deficiencies in the fertility of the soils in the area. These results would then be regarded as the reference conditions for soil in the vicinity. The textural classes determined during these analyses were that of sandy loam, which indicates high infiltration and a low water/nutrient holding capacity given that all crust and compaction issues are rectified.

The **climate capability** for this region was determined to be "C8" (Very Severe). This climate capability class indicates that the choice of crops is severely restricted due to heat and moisture stress, (Smith, 2006).

The Clovelly, Arcadia and Avalon soil forms have all been determined to have a **land capability class** of "III". The Westleigh "B" form has a land capability class of "IV" with the Westleigh "A" soil form having a land capability class of "V".

All of the soils except for the Westleigh "A" soil form has a **land potential** of "L6". The Westleigh "A" soil form has a land potential of "Vlei" due to the soil from being characterised by wetland conditions.

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Declaration

I, Ivan Baker declare that:

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

Ivan Baker

Soil Specialist

The Biodiversity Company

2 October 2018

1 Introduction

The Biodiversity Company was commissioned to conduct a soil assessment for the application of closure certificate for Harmony's St Helena 10 (FS30/5/1/2/2/86) shaft near Welkom. The project area was traversed, and samples were taken from the 30th until the 31st of May 2018 for the pre-mining land capability assessment and the 12th of September 2018 for the post-mining land capability assessment.

The conservation of South Africa's limited soil resources is essential. In the past misuse and poor management of the soil resource has led to the loss of these resources through erosion and destabilisation of the natural systems. In addition, loss of high potential agricultural land due to land use changes is a big concern presently in South Africa.

Soils can be seen as the foundation for ecological function as shown in Figure 1. Without a healthy soil system for microbes to thrive in, both flora and fauna would be negatively impacted, which in turn feeds the natural soil system with organics and nutrients.

Desktop data was compiled prior to the site-based assessment to support the findings from the survey as well as throughout the report. To identify soils accurately, it is necessary to undertake a soil survey. The aim is to provide an accurate record of the soil resources of the proposed project area and sample the top soil and subsoil for 4 sites. These samples were then sent away for relevant soil analyses.

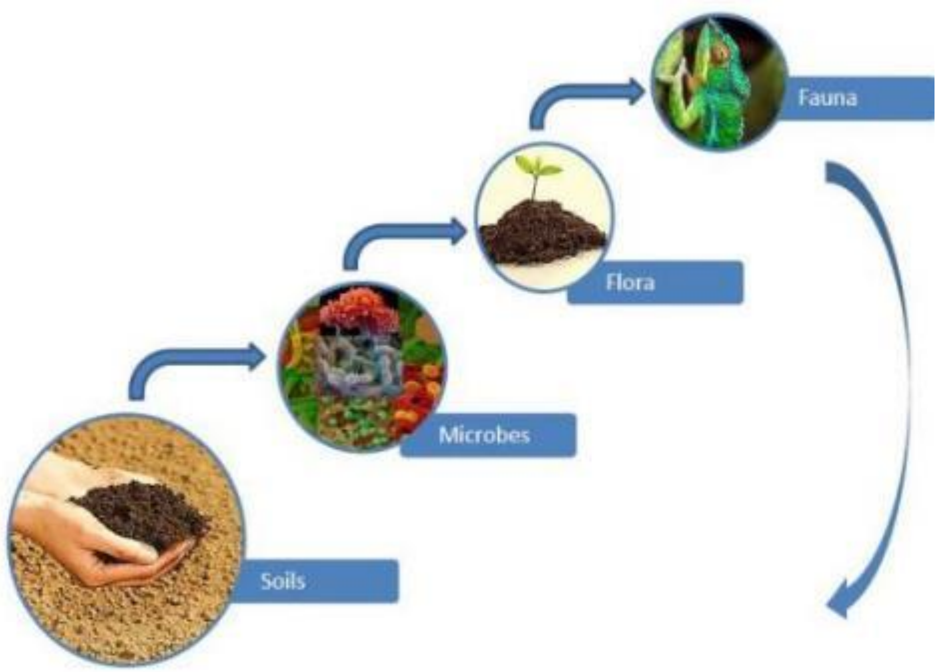


Figure 1: The relationship between soil and above-ground ecological succession

1.1 Objectives

It was requested that a soil assessment be conducted on the project area. This assessment has been done per the Chamber of Mines South Africa/Coaltech (2007) recommendations. This assessment includes assessing the disturbed/mining area in regard to land capability, potential and soil fertility as well as that of the surrounding areas to compare to one another. Recommendations will then be made regarding further rehabilitation (if necessary) to restore the disturbed/mining area to the surrounding land use.

1.2 Study Area

The St Helena 10 (FS30/5/1/2/2/86) shaft project area is located in the magisterial district of Matjhabeng within the Lejweleputswa District Council, Free State. The project area is approximately 10km south of Welkom and is surrounded by wetland, grazing, agricultural crops, and built-up land use areas. A Tailings Storage Facility (TSF) is located directly to the east of the project area, see Figure 2.

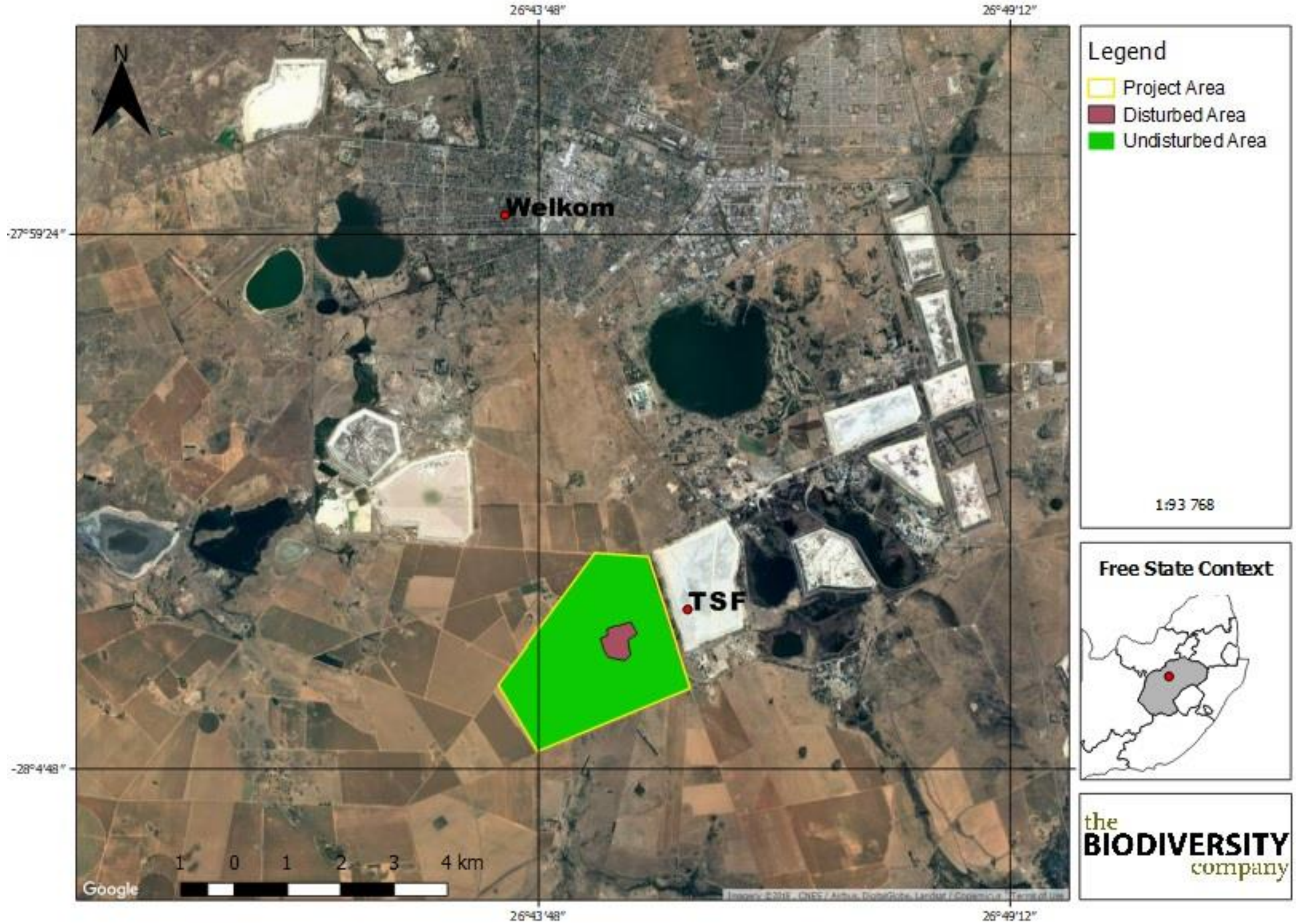


Figure 2: Map showing the project area

2 Scope of Work

The main purpose of the specialist study is to determine the land capability and land potential of the areas surrounding the currently disturbed/mining area and that of the disturbed area individually. The land capability and fertility of the disturbed area will then be compared to that of the surrounding areas to determine adequate measures in rectifying all shortcomings.

2.1 Soil Specific Scope

The soil specific scope required is as follows:

- Soil samples (eight samples total) of top soil and sub-soil needs to be collected from the surrounding land use areas and analysed (four samples from the top-soil and four from the sub-soil);
- Four soil samples from the disturbed area (two from the topsoil and two from the subsoil, if the subsoil is reachable);
- The topsoil analysis must include the following:
    - Phosphorus (Bray 1);
    - Exchangeable cations – Na, K, Ca, Mg (Ammonium Acetate); and
    - pH (water).
- The sub-soil needs to be analysed as follows:
    - Exchangeable cations – Na, K, Ca, Mg (Ammonium. Acetate); and
    - pH (water).
- Calculate the current land capability of the area after consideration of the information obtained during the field survey; and
- Compile a report including the description of soil characteristics and chemical composition as well as the land capability supported by the local soil conditions for the disturbed area and the surrounding land use areas.

3 Limitations and Knowledge Gaps

The following aspects were considered as limitations:

- The GPS used for the soil assessment is accurate to within five meters. Therefore, all delineations plotted digitally may be offset by at least five meters to either side; and
- Assumptions have been made that the entire disturbed area has been rehabilitated.

4 Methodology

4.1 Desktop Assessment

As part of the desktop assessment, baseline soil information was obtained using published South African Land Type Data. Land type data for the site was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC) (Land Type Survey Staff, 1972 - 2006). The land type data is presented at a scale of 1:250 000 and comprises of the division of land into land types. Additionally, vegetation maps by Mucina & Rutherford (2006) has been used to determine the vegetation type and the climatic conditions for the project area.

4.2 Field Survey

A study of the soils present within the project area was conducted during field visit in May 2018 and again in September. The site was traversed by vehicle and on foot. A soil auger was used to determine the soil form/family and depth. The soil was hand augured to the first restricting layer or 1.5 m after which a sample from four site's top soil and subsoil layers were taken in the surrounding land use areas and four top soil samples from the disturbed area. The soil from this area is extremely shallow due to severe compaction and the presence of waste material, i.e. waste rock and concrete. The subsoil could therefore in all four cases not be reached. Soil survey positions were recorded as waypoints using a handheld GPS. Soils were identified to the soil family level as per the "Soil Classification: A Taxonomic System for South Africa" (Soil Classification Working Group, 1991). Landscape features such as existing open trenches were also helpful in determining soil types and depth. The sampling locations are shown in Figure 3.

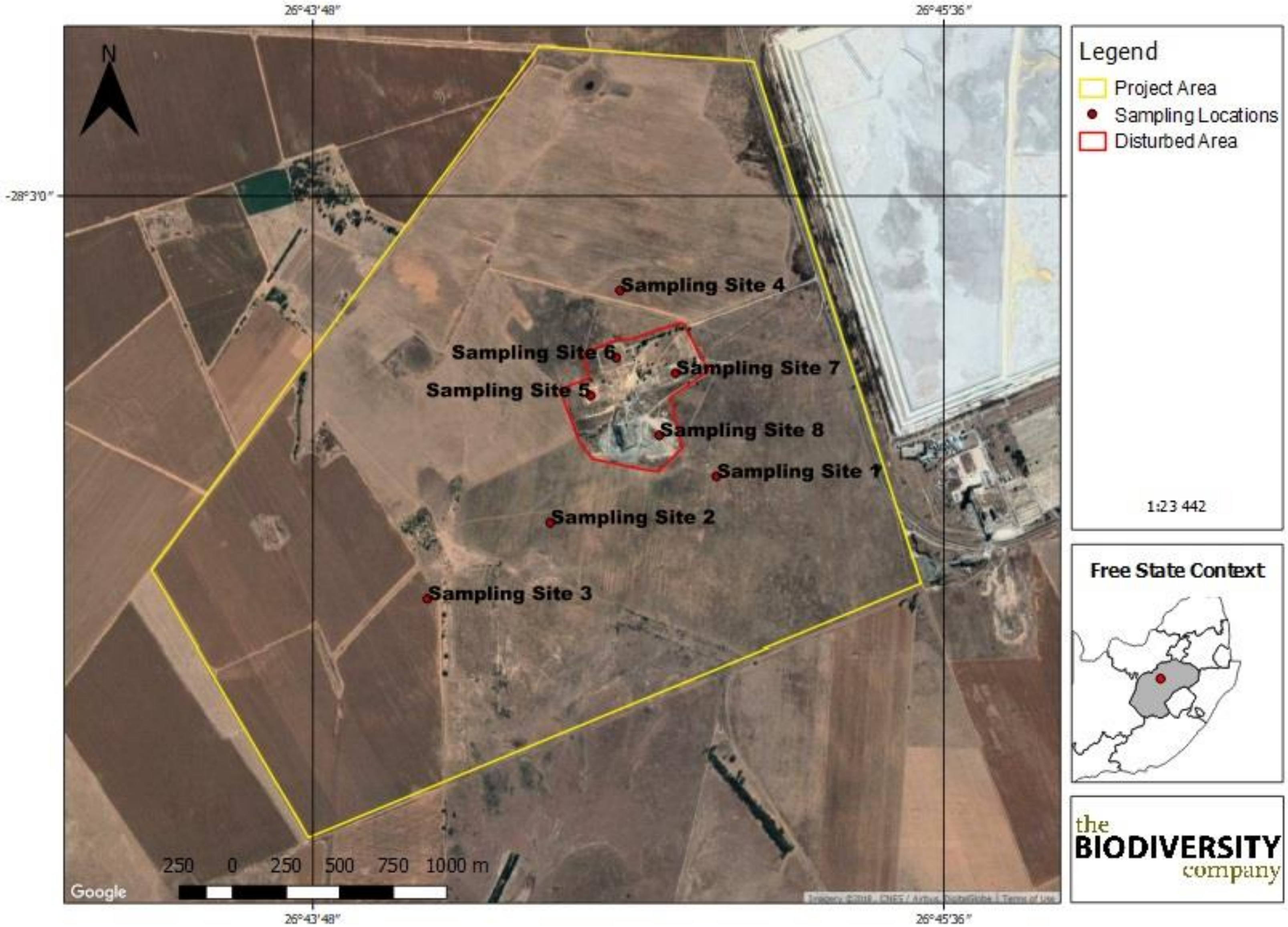


Figure 3: The sampling sites for the fertility assessment

4.3 Post Mining Land Capability

Soil quality deteriorates during stockpiling and replacement of soil material into soil profiles during rehabilitation cannot imitate pre-mining soil quality properties. Depth however can be imitated but the combined soil quality deterioration and resultant compaction by the machines used in rehabilitation leads to a net loss of land capability. A change in land capability then forces a change in land use.

The Chamber of Mines South Africa/Coaltech (2007) has defined the description of post-mining land capability into the following categories; grazing, arable, wilderness and wetland capabilities. The main criteria for these categories are soil depth and can be described as follow;

- **Arable**: For this category, the soil should not be sodic or saline and must exceed a depth of 0.6m. The value of the slope percentage multiplied by the erodibility factor should not exceed 2.0 in order for land capability to fall under this category.
- **Grazing**: The soil depth should be deeper than 0.25m in order for an area to be suitable for grazing.
- **Wilderness**: The soil depth should be between 0.15m and 0.25m for this category.
- **Wetland**: The criteria for wetland land capability is similar to that of "grazing" with the addition of wetland soils being present.

4.4 Agricultural Potential Assessment

Land capability and agricultural potential is determined by a combination of soil, terrain and climate features. Land capability is defined by the most intensive long-term sustainable use of land under rain-fed conditions. At the same time an indication is given about the permanent limitations associated with the different land use classes (Smith, 2006).

Land capability is divided into eight classes and these may be divided into three capability groups. Table 1 shows how the land classes and groups are arranged in order of decreasing capability and ranges of use. The risk of use increases from class I to class VIII (Smith, 2006).

Table 1: Land capability class and intensity of use (Smith, 2006)

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

The land potential classes are determined by combining the land capability results and the climate capability of a region as shown in Table 2. The final land potential results are then described in Table 3.

Table 2: The combination table for land potential classification

Land capability class	Climate capability class							
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
I	L1	L1	L2	L2	L3	L3	L4	L4
II	L1	L2	L2	L3	L3	L4	L4	L5
III	L2	L2	L3	L3	L4	L4	L5	L6
IV	L2	L3	L3	L4	L4	L5	L5	L6
V	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei
VI	L4	L4	L5	L5	L5	L6	L6	L7
VII	L5	L5	L6	L6	L7	L7	L7	L8
VIII	L6	L6	L7	L7	L8	L8	L8	L8

Table 3: The Land Potential Classes.

Land potential	Description of land potential class
L1	Very high potential: No limitations. Appropriate contour protection must be implemented and inspected.
L2	High potential: Very infrequent and/or minor limitations due to soil, slope, temperatures or rainfall. Appropriate contour protection must be implemented and inspected.
L3	Good potential: Infrequent and/or moderate limitations due to soil, slope, temperatures or rainfall. Appropriate contour protection must be implemented and inspected.
L4	Moderate potential: Moderately regular and/or severe to moderate limitations due to soil, slope, temperatures or rainfall. Appropriate permission is required before ploughing virgin land.
L5	Restricted potential: Regular and/or severe to moderate limitations due to soil, slope, temperatures or rainfall.
L6	Very restricted potential: Regular and/or severe limitations due to soil, slope, temperatures or rainfall. Non-arable
L7	Low potential: Severe limitations due to soil, slope, temperatures or rainfall. Non-arable
L8	Very low potential: Very severe limitations due to soil, slope, temperatures or rainfall. Non-arable

4.5 Current Land Use

Land use was identified using aerial imagery and then ground-truthed while out in the field. The possible land use categories are:

- Mining;
- Bare areas;
- Agriculture crops;
- Natural veld;
- Grazing lands;
- Forest;
- Plantation;
- Urban;
- Built-up;
- Waterbodies;
- Wetlands.

4.6 Impact Assessment

The impact assessment methodology was provided by EIMS and is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

5 Legislative & Policy Framework

Currently, various pieces of legislation and related policies exist that guide and direct the land user in terms of land use planning both on a national and provincial level. This legislation includes, but is not limited to:

- The Constitution of the Republic of South Africa (Act 108 of 1996);
- Sub-division of Agricultural Land Act (Act 70 of 1970);
- Municipal Structures Act (Act 117 of 1998);
- Municipal Systems Act (Act 32 of 2000); and

The above mentioned are supported by additional legislation that aims to manage the impact of development on the environment and the natural resource base of the country. Related legislation to this effect includes:

- Conservation of Agricultural Resources Act (Act 43 of 1983);
- Environment Conservation Act (Act 73 of 1989);
- National Environmental Management Act (Act 107 of 1998); and

- National Water Act (Act 36 of 1998).

6 Desktop Information

6.1 Vegetation

The project area falls within the Vaal-Vet Sandy Grassland (Gh10) vegetation type. This vegetation type is distributed throughout North-West and Free State and stretches from south of Lichtenburg to Klerksdorp, Bothaville, Leeudoringstad as well as Brandfort. The latitude suited for this vegetation type is between 1 260 meters above sea level to 1 360 meters above sea level, Mucina & Rutherford (2006).

This vegetation type features in areas dominated by plains with scattered and undulating hills. These areas mainly comprise of low-tussock grasslands with *Themeda triandra* being one of the most important features of this vegetation type. Overgrazing and erratic rainfall have however ensured that *Themeda triandra* is often replaced with *Elionurus muticus*, *Aristida congesta* and *Cymbopogon pospischilii*, Mucina & Rutherford (2006).

The conservation status of this vegetation type is endangered with only 0.3% of it being protected within the Bloemhof Dam, Sandveld, Schoonspruit, Wolwespruit, Soetdoring and Faan Meintjes nature reserves, Mucina & Rutherford (2006).

6.2 Climate

This region is characterised by a warm-temperate summer rainfall climate with the average annual precipitation being approximately 530mm, Mucina & Rutherford (2006), see Figure 4. High summer temperatures are common for this region with severe frost occurring throughout the winter (on average 37 days per year,).

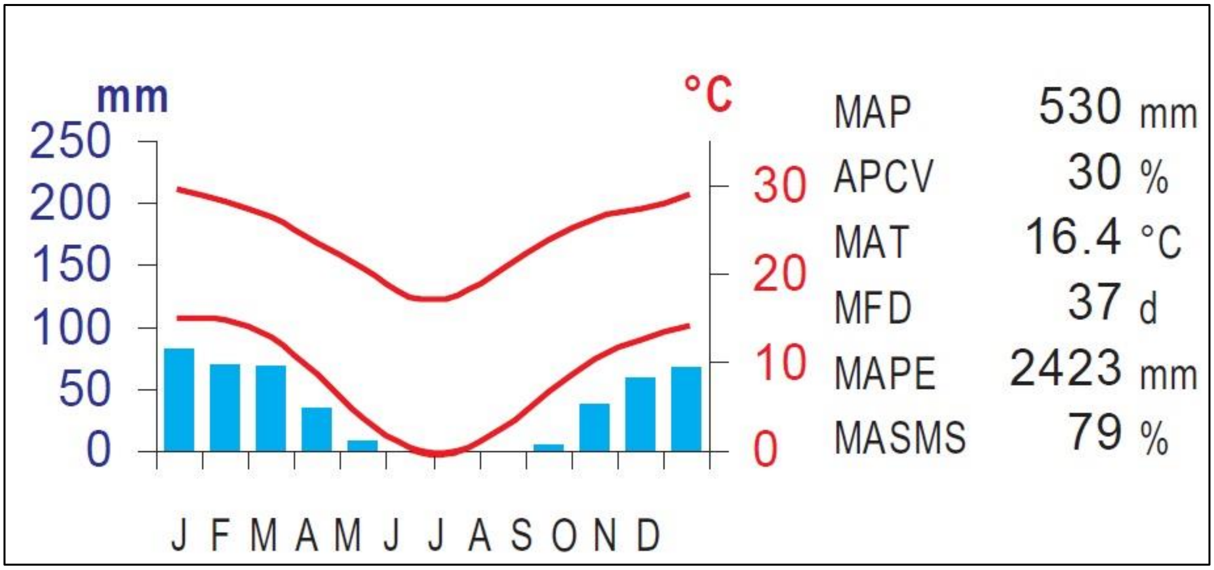


Figure 4: Climate for the Vaal-Vet Sandy Grassland (Gh10), Mucina & Rutherford (2006).

6.3 Terrain

A National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM) (V3.0, 1 arcsec resolution) Digital Elevation Model (DEM) was obtained from the United States Geological Survey (USGS) Earth Explorer website. Basic terrain analysis was performed on this DEM using the SAGA GIS software that encompassed a slope and channel network analyses in order to detect catchment areas and potential drainage lines respectively. The following processes have been considered for the desktop assessment:

- **The relief map (Figure 5):** The project area is flat throughout with an elevation range from approximately 1355 meter above sea level (masl) to 1455 masl.
- **The slope map (Figure 6):** The project area is flat with slopes between 0% and 3% without any major height changes within the project boundaries.
- **The aspect map (Figure 7):** The map shows that the western parts of the project area is west and south-west facing with the northern parts facing north to north-west.

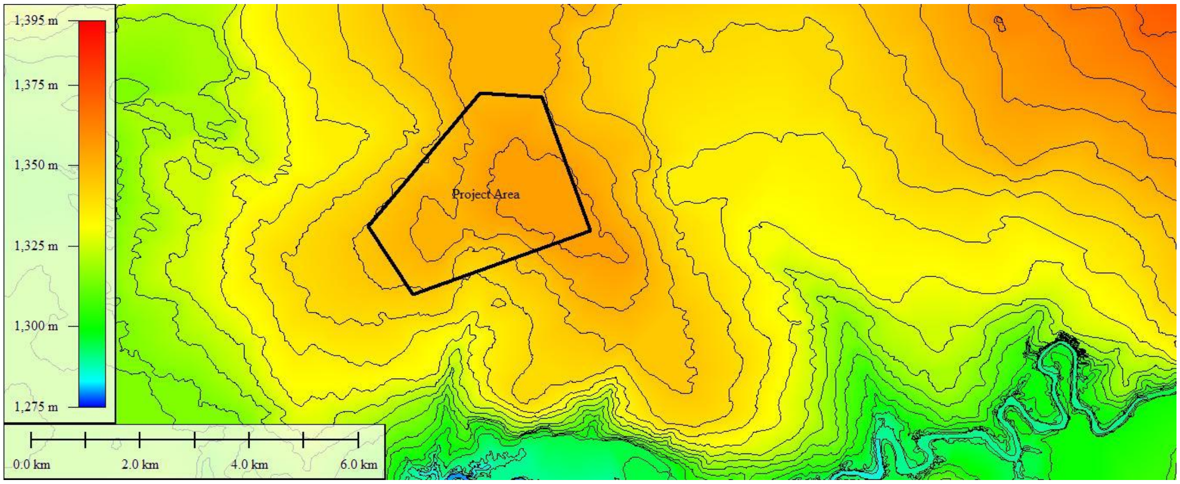


Figure 5: The relief map for the project area

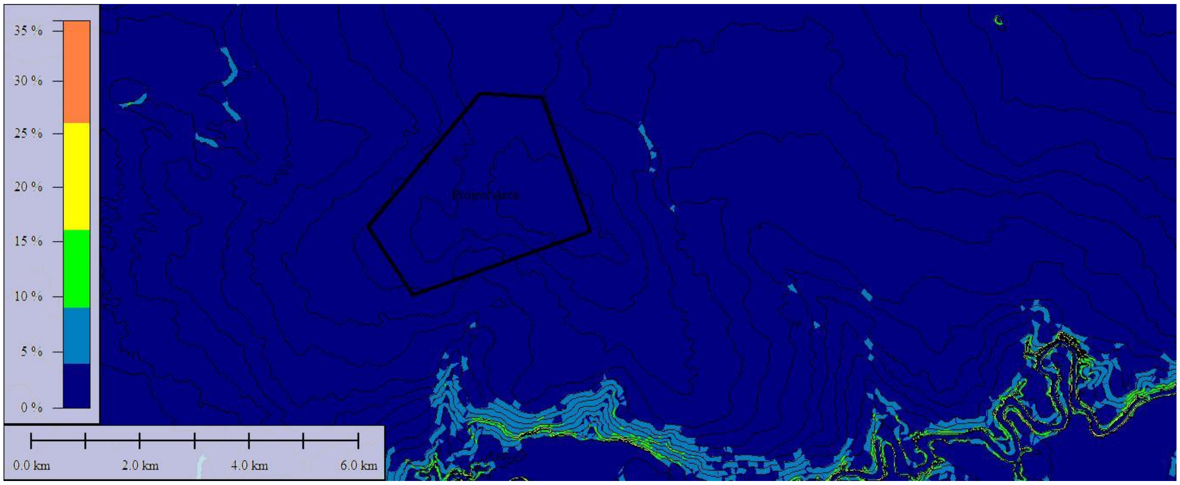


Figure 6: The Slope Percentage map for project area

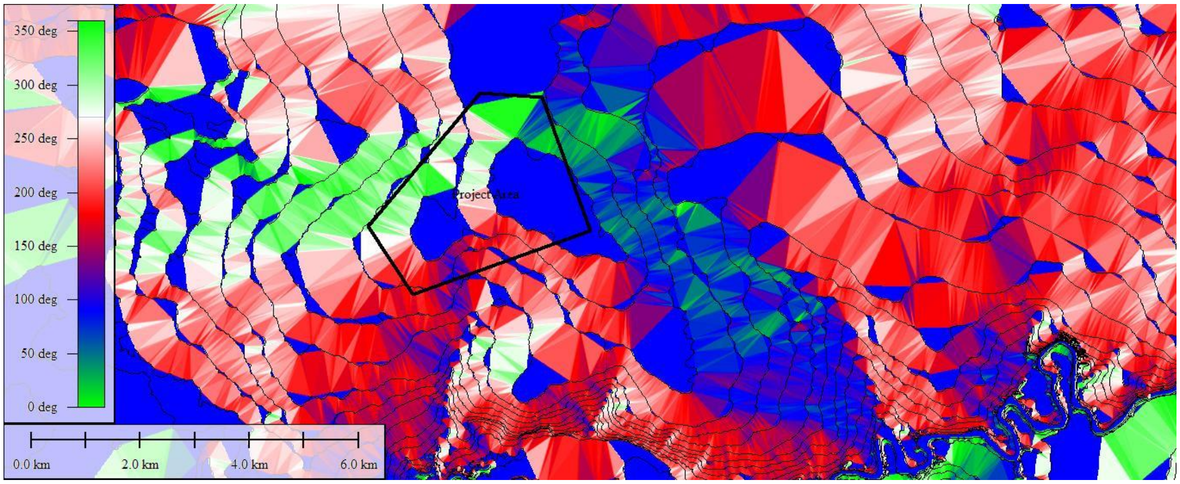


Figure 7: The Slope Aspect map for project area

6.4 Soils & Geology

According to the land type database (Land Type Survey Staff, 1972 - 2006) the project falls within the Bd20 land type. This land type consists of plinthic catena, upland duplex and margalitic soils which occur rare. Eutrophic, red soils are not widespread throughout the project area.

The geology of this area is characterised by aeolian and colluvial sand which overlies mudstone, sandstone and shale of the Karoo Supergroup. Older Ventersdorp Supergroup basement gneiss and andesite is located to the north, Mucina & Rutherford (2006).

7 Baseline Environment

7.1 Field Survey Findings

According to The Chamber of Mines South Africa/Coaltech (2007), the main property of soil that needs to be investigated is soil depth due to the importance thereof in determining agricultural potential and land capability.

Soil Summary

The project area is characterised by a gradual slope throughout the project area with the mining area being located close to the highest point in the project area. The soil delineation is shown in Figure 8.

A Westleigh soil form has been identified within the project area. This soil form is divided and delineated into two (2) different categories due to the difference in depth from the surface to the first signs of wetness. These differences ensure that all three (3) categories have different land capability classes. Additionally, an Arcadia, Avalon, Witbank (Disturbed Profile) and Clovelly soil form has been identified and delineated.

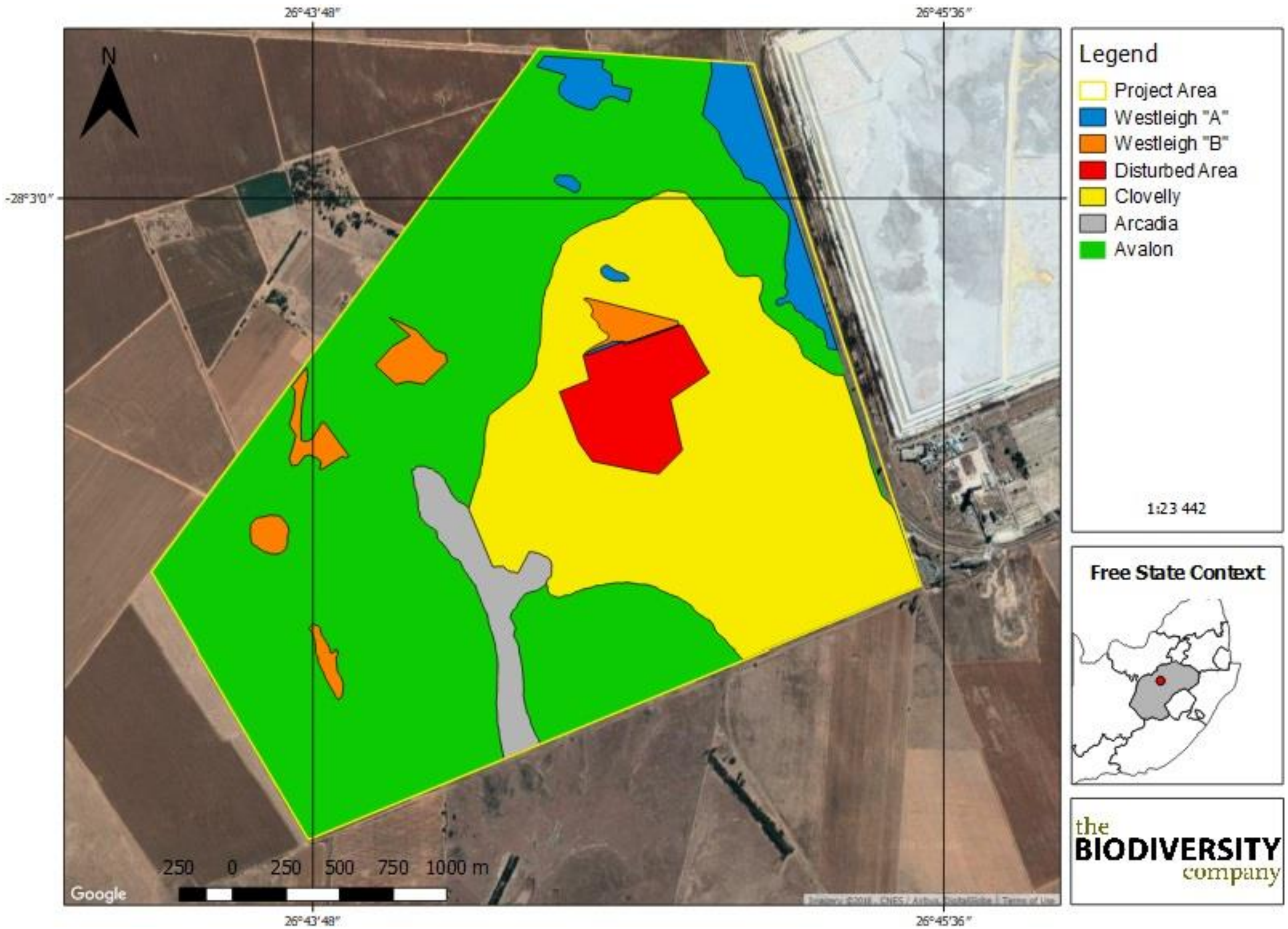


Figure 8: Soil map indicating the soil forms classified within the project site

Table 4: Witbank soils in the project area

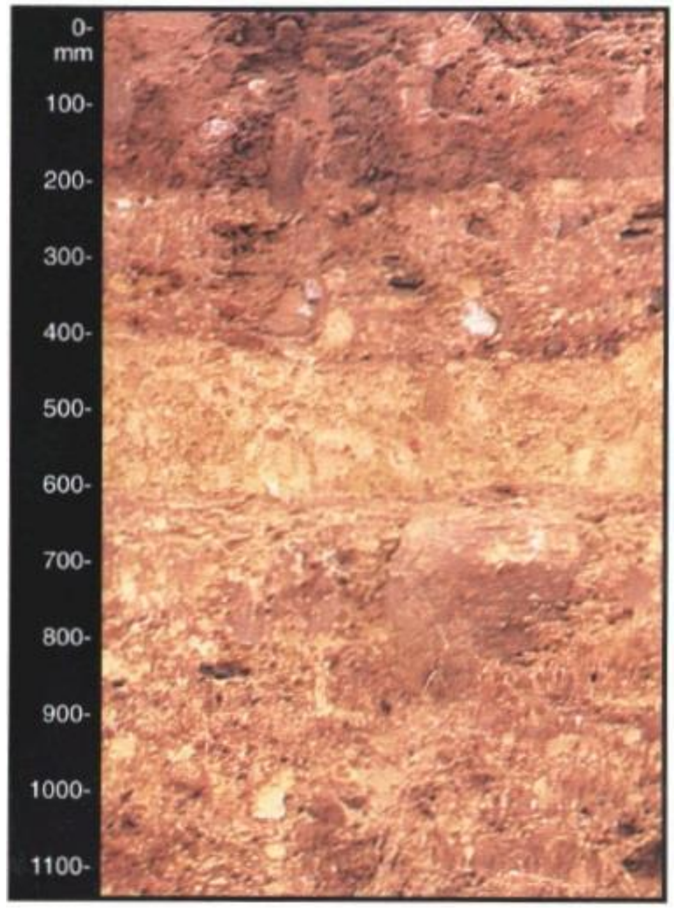
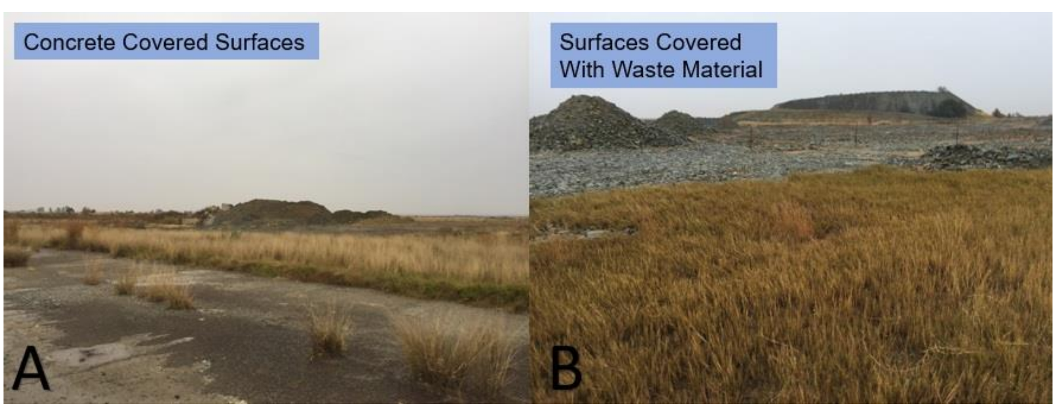
Witbank (Thornlea 1000)		
Horizons	A typical cross section of a Witbank soil (SASA, 1999).	
	Orthic A-horizon	
	Man-made soil deposit	
Description	The Witbank soil form consist of an Orthic A-horizon on top of a soil layer formed by human deposits which include sport fields, landfill areas, mined or rehabilitated areas, etc.	
Site photos (see Figure 8 for locations)		

Table 5: Avalon soils in the project area

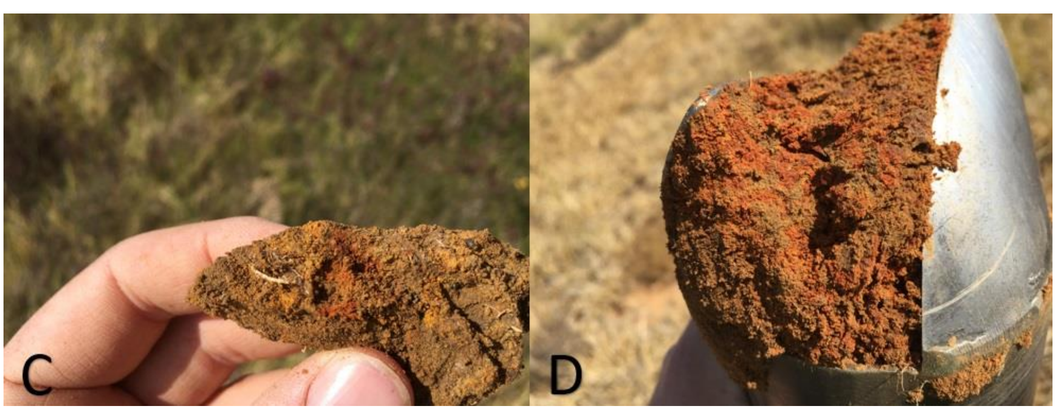
Avalon (Vryheid 2200)		
Horizons	A typical cross section of an Avalon soil (SASA, 1999).	
	Orthic A-horizon	
	Yellow-Brown Apedal B-horizon	
	Soft Plinthic B-horizon	
Description	The Avalon soil form consists of an Orthic A-horizon, on top of a Yellow-Brown Apedal B-horizon, which on turn is on top of a Soft Plinthite B-horizon.	
Site photos Of Soft Plinthic B-horizon (see Figure 8 for locations)		

Table 6: Arcadia soils in the project area

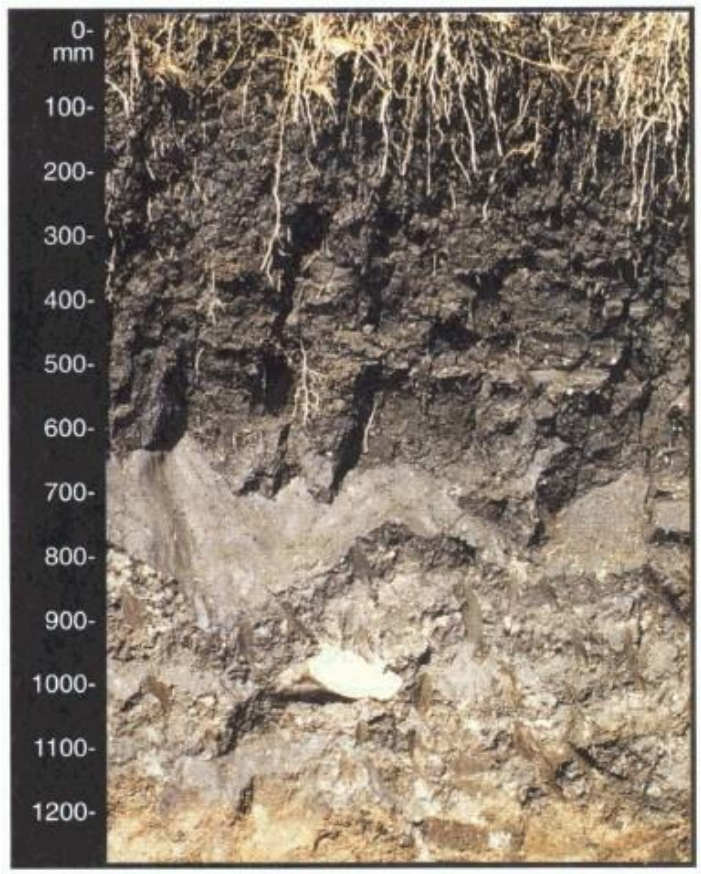
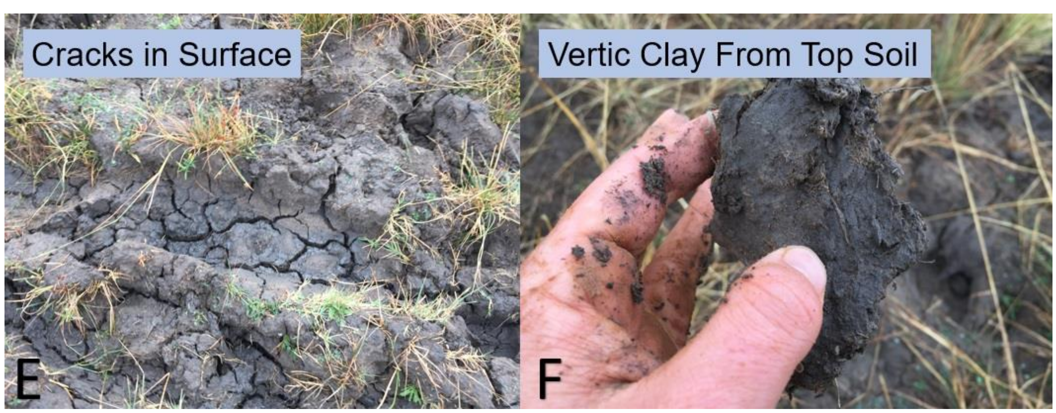
Arcadia (Lonehill 1100)		
Horizons	A typical cross section of an Arcadia soil (SASA, 1999).	
	Orthic A-horizon	
	Unspecified material	
Description	The Arcadia soil form consists of a Vertic A-horizon on top of an unspecified material. A typical feature of Vertic top soils are cracks in the surface after dry periods.	
Site photos (see Figure 8 for locations)		

Table 7: Westleigh soils in the project area

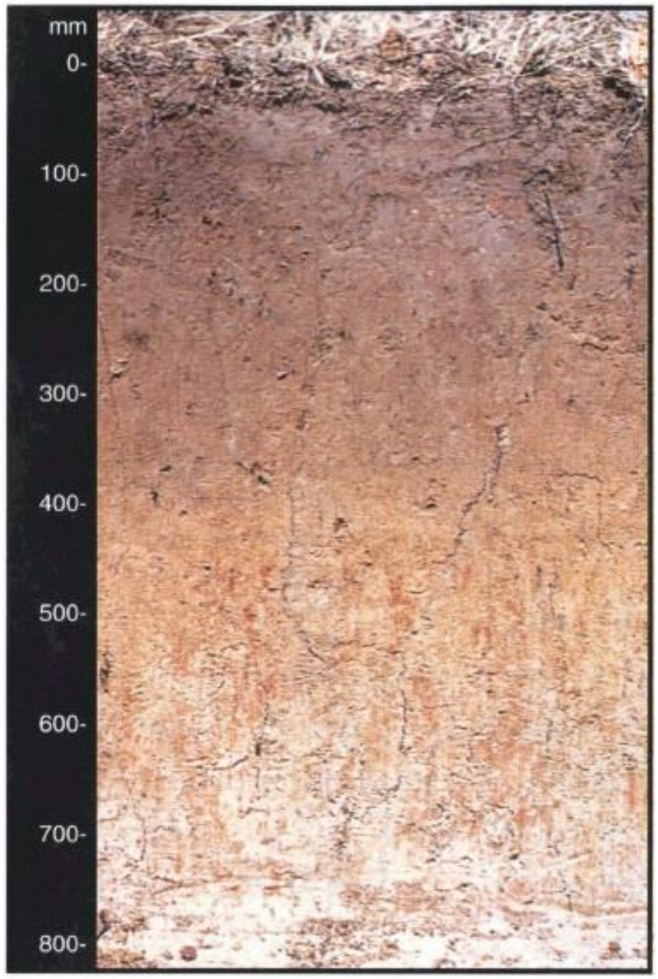
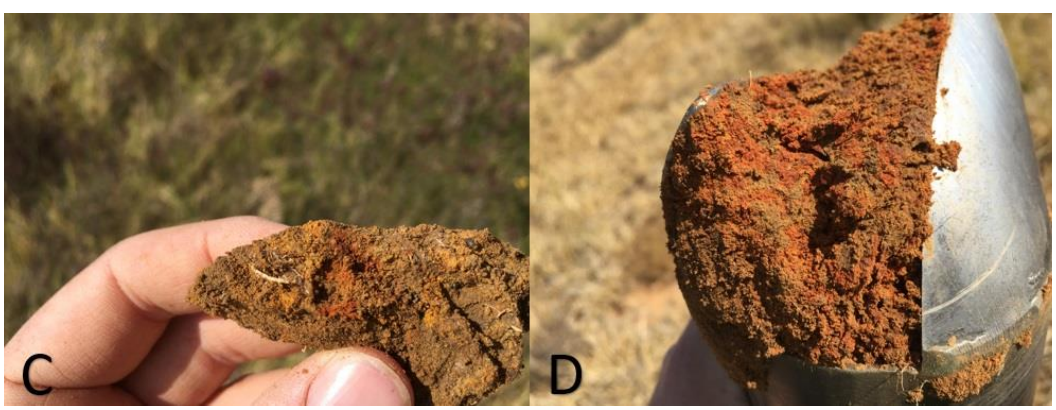
<table>
<tr><th colspan="3">Westleigh (Mareetsane 2200)</th></tr>
<tr><td rowspan="3">Horizons</td><td colspan="2">A typical cross section of a Westleigh soil (SASA, 1999).</td></tr>
<tr><td>Orthic A-horizon</td><td rowspan="2">
</td></tr>
<tr><td>Soft Plinthic B-horizon</td></tr>
<tr><td>Description</td><td colspan="2">The Westleigh soil form consists of an Orthic A-horizon on top of a Soft Plinthic B-horizon.</td></tr>
<tr><td>Site photos (see Figure 8 for locations)</td><td colspan="2">
</td></tr>
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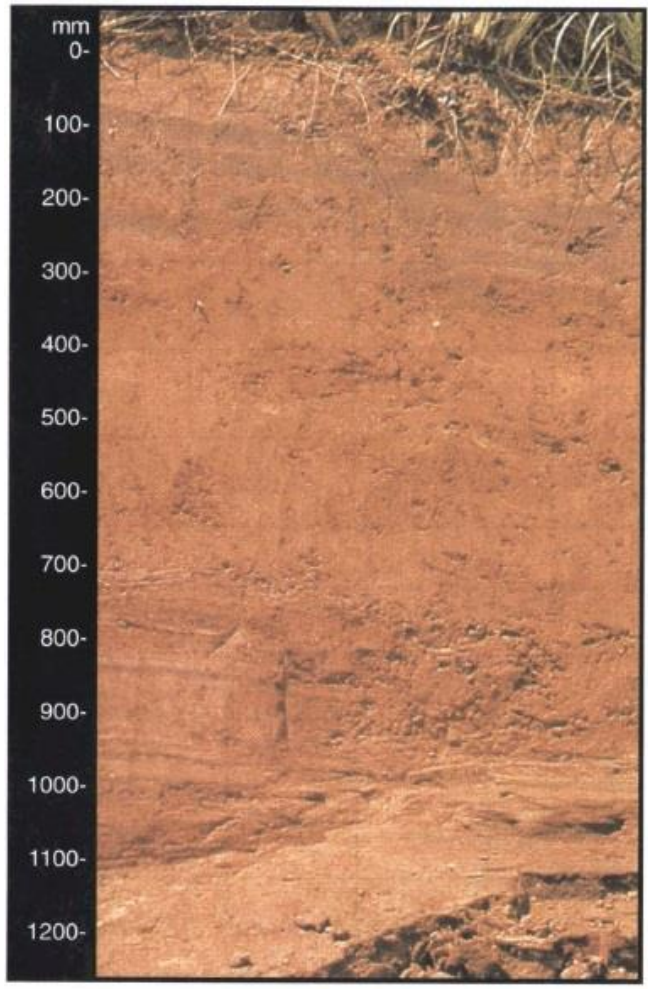
Table 8: Clovelly soils in the project area

<table>
<tr><th colspan="3">Clovelly (Leiden 2200)</th></tr>
<tr><td rowspan="3">Horizons</td><td colspan="2">A typical cross section of a Clovelly soil (SASA, 1999).</td></tr>
<tr><td>Orthic A-horizon</td><td rowspan="2">
</td></tr>
<tr><td>Yellow-Brown Apedal B-horizon</td></tr>
<tr><td>Description</td><td colspan="2">The Clovelly soil form consists of an Orthic A-horizon on top of a Yellow-Brown Apedal B-horizon.</td></tr>
<tr><td>Site photos (see Figure 8 for locations)</td><td colspan="2">


</td></tr>
</table>

Table 9: Shows the characteristics of the soil identified on site

Soil Forms	A-horizon					B-horizon (1st)			B-horizon (2nd)		
	Depth from surface (mm)	Clay (%)	Signs of wetness (mm)	Rock (%)	Surface crusting	Depth from surface (mm)	Signs of wetness (mm)	Rock (%)	Depth from surface (mm)	Signs of wetness (mm)	Rock (%)
Westleigh "A"	0-300	0-15	200	0	None	300->1000	Throughout	0	N/A		
Westleigh "B"	0-300	0-15	None	0	None	300->1000	450	0	N/A		
Avalon	0-300	0-15	None	0	Slight	300-1000	None	0	700->1000	None	0
Clovelly	0-300	0-15	None	0	N/A	300->1000	None	0	N/A		
Arcadia	0-200	>35	None	0	N/A	200->1000	None	0	N/A		
Witbank	100	0-15	None	>30	Unfavourable	Unknown			N/A		

7.2 Verified Agricultural Potential

The climate capability for this region was determined to be “C8” (Very Severe). This climate capability class indicates that the choice of crops is severely restricted due to heat and moisture stress, (Smith, 2006).

Pre-Mining Land Capability

The land capability was determined by using the guidelines described in *The Farming Handbook,* (Smith, 2006). A breakdown of the land capability classes is shown in Table 1. The Clovelly, Arcadia and Avalon soil forms has all been determined to have a land capability class of “III”. The Westleigh “B” soil form has a land capability class of “IV” with the Westleigh “A” soil form having a land capability class of “V”. It is worth noting that the “disturbed area’s” land capability will be assessed and discussed in section 0-“Post-Mining Land Capability”.

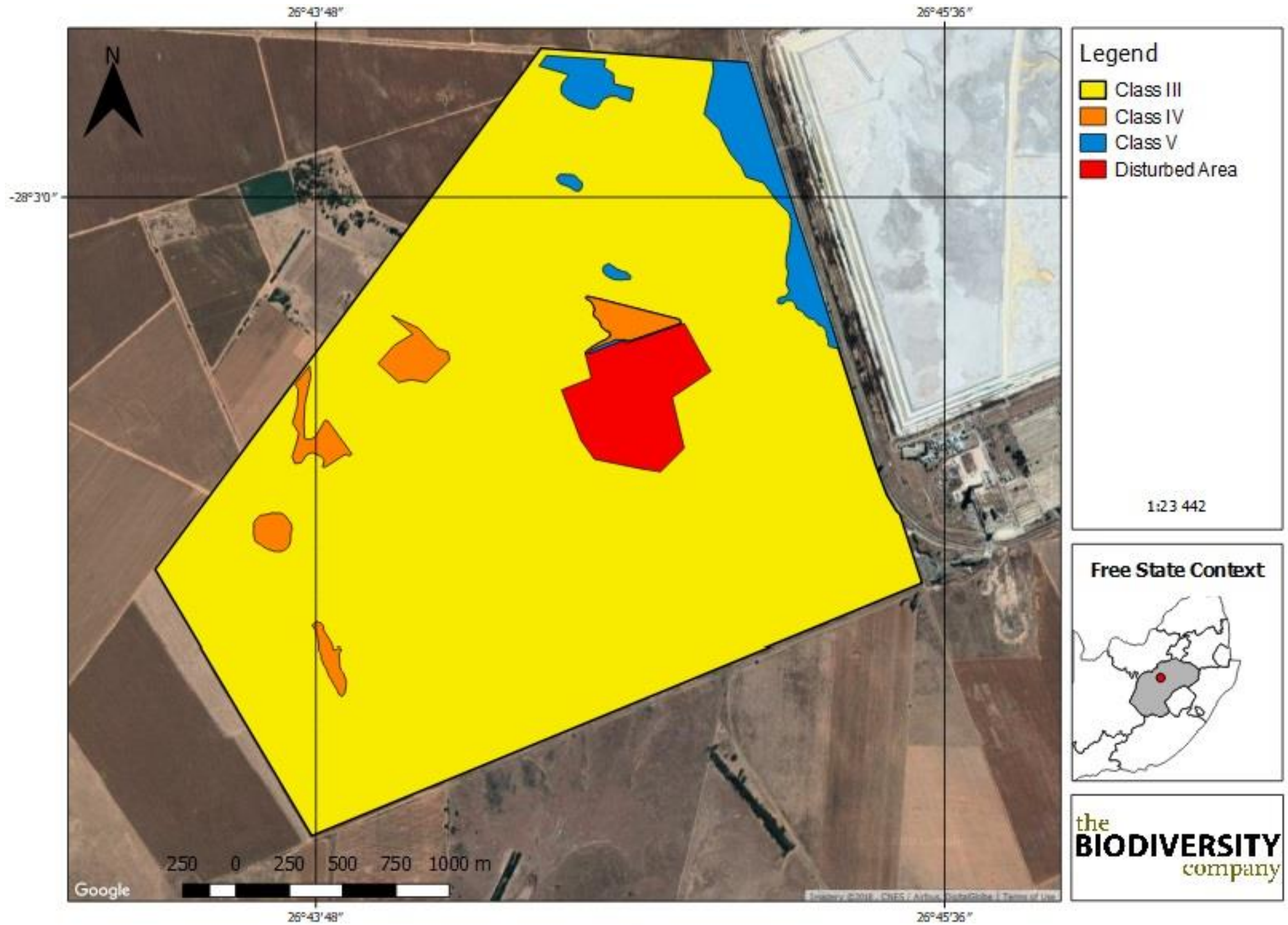


Figure 9: Pre-mining land capability of the proposed project area

Table 10: Land capability of the delineated soil forms

Soil Form	Land Capability Class	Definition of Class	Conservation Need	Use-Suitability	Land Capability Group
Clovelly	III	Moderate imitations. Some Erosion hazard	Special Conservation practice and tillage methods	Rotation of crops and ley (50%)	Arable land
Arcadia					
Avalon					
"Westleigh "B"	IV	Severe limitations. Low arable potential with high erosion hazard	Intensive conservation practice	Long-term leys (75%)	
Westleigh "A"	V	Water course and land with wetness limitations	Protection and control of water table	Improved pastures, suitable for wildlife	Grazing land

Land Potential of Surrounding Land Use Areas

The land potential of the delineated soils is described in Table 11 and illustrated in Figure 10. All of the soils except for the Westleigh "B" soil form has a land potential of "L6". The Westleigh "B" soil from has a land potential of "Vlei" due to the soil from being characterised by wetland conditions.

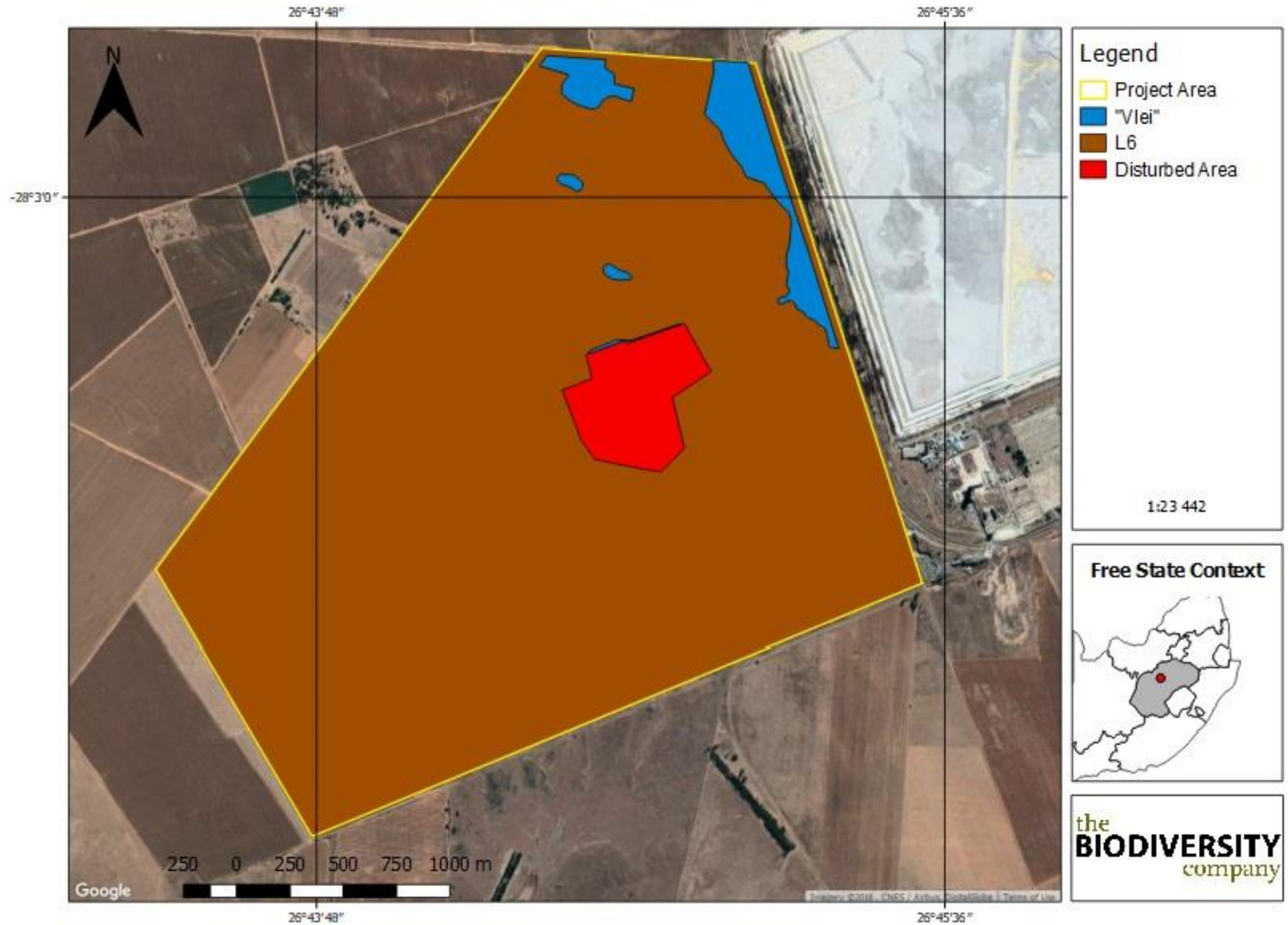


Figure 10: Land potential of the proposed project area

Table 11: Determined land potential of the project area

<table>
<tr><th>Soil Form</th><th>Land Capability Class</th><th>Land Potential Class</th><th>Description of Land Potential Class</th></tr>
<tr><td>Clovelly</td><td rowspan="3">III</td><td rowspan="4">L6</td><td rowspan="4">Very restricted potential. Regular and/or severe limitations due to soil, slope, temperatures and or/rainfall.</td></tr>
<tr><td>Arcadia</td></tr>
<tr><td>Avalon</td></tr>
<tr><td>Westleigh “B”</td><td>IV</td></tr>
<tr><td>Westleigh “A”</td><td>V</td><td>Vlei</td><td>Wetland areas. These areas are sensitive and has been deemed to be no-go areas.</td></tr>
<tr><td>Witbank (disturbed profile)</td><td colspan="3">Not Classifiable</td></tr>
</table>

Post-Mining Land Capability

During the site assessment, two different types of land capability have been determined, namely “Grazing” and “Wilderness”. The grazing land capability is characterised by soils with a depth deeper than 0.25m from the surface. It is assumed that these areas are characterised by saline conditions and are therefore, according to the Chamber of Mines South Africa/Coaltech (2007), cannot be classified as an arable land capability.

The wilderness land capability areas are characterised by soils with a depth between 0.15m and 0.25m below the surface, subsequently indicating extremely shallow soils.

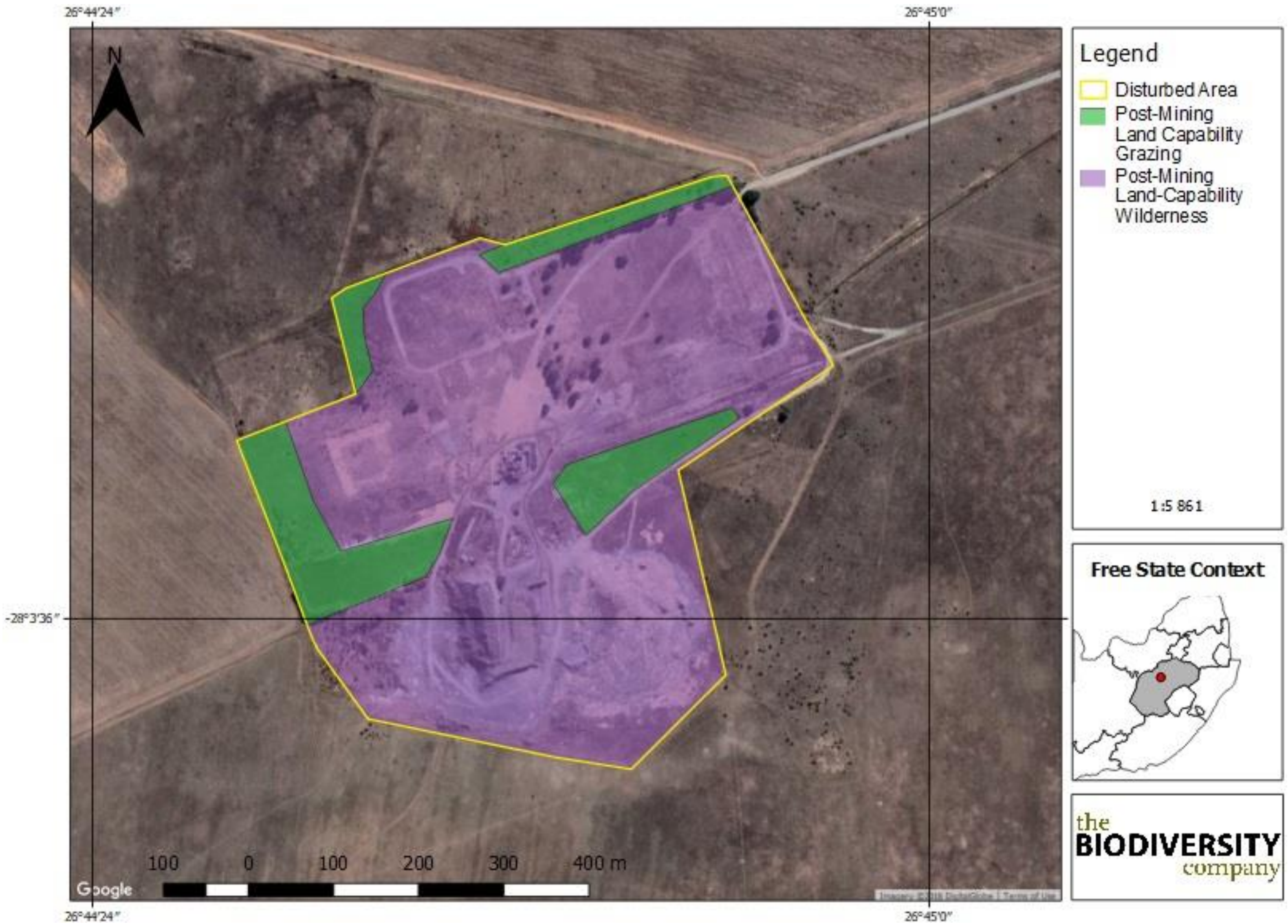


Figure 11: Post-mining land capability for the disturbed area

7.3 Current Land Use

The project area is approximately 800 ha in size with agriculture taking up approximately 21% of the area, built-up areas consisting of 0.25% of the project area, approximately 4% consisting of mining use, wetlands taking up 20% of the area and grazing land taking up approximately half of the area see Figure 12 to Figure 17.

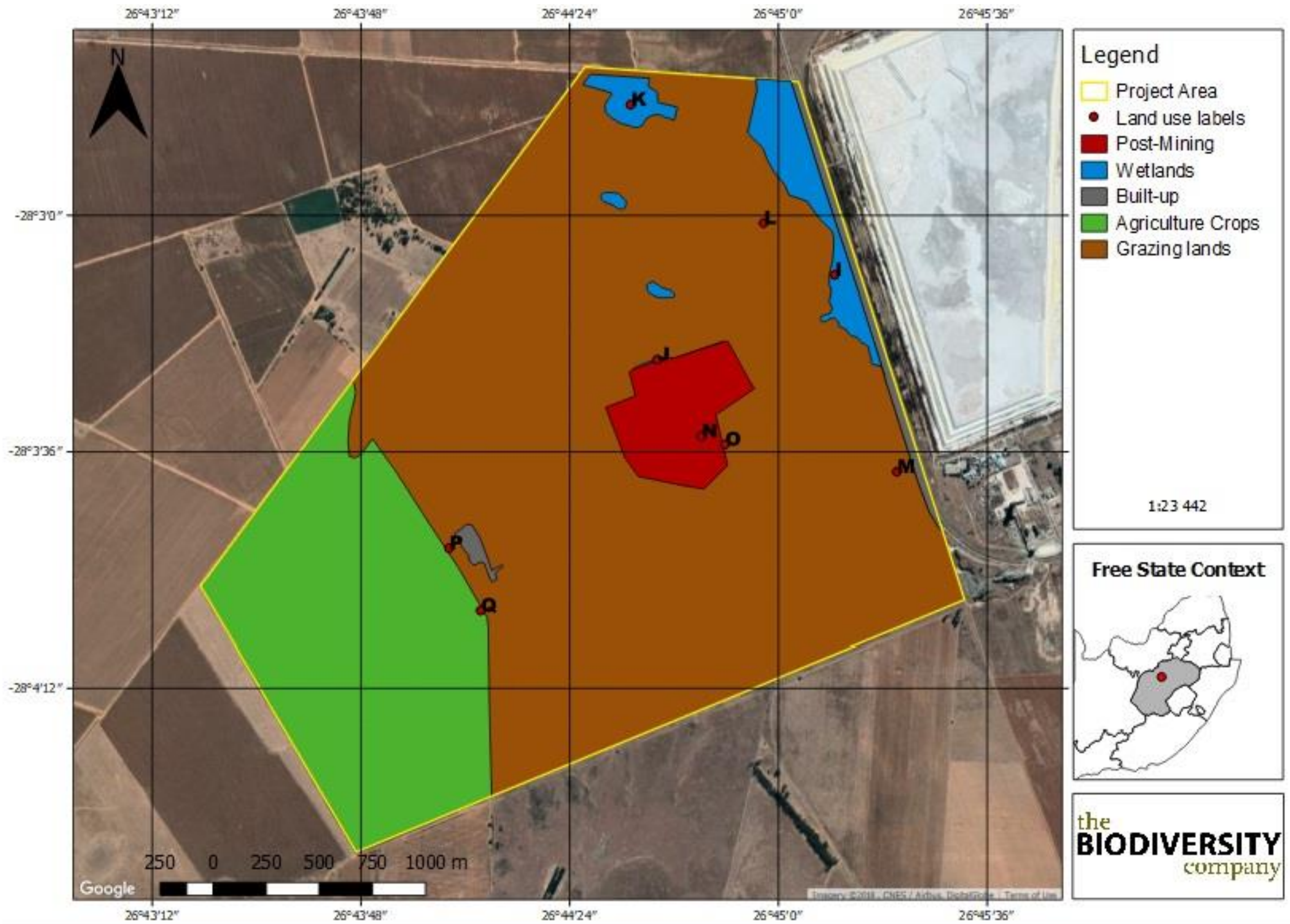


Figure 12: Land uses present within the project area

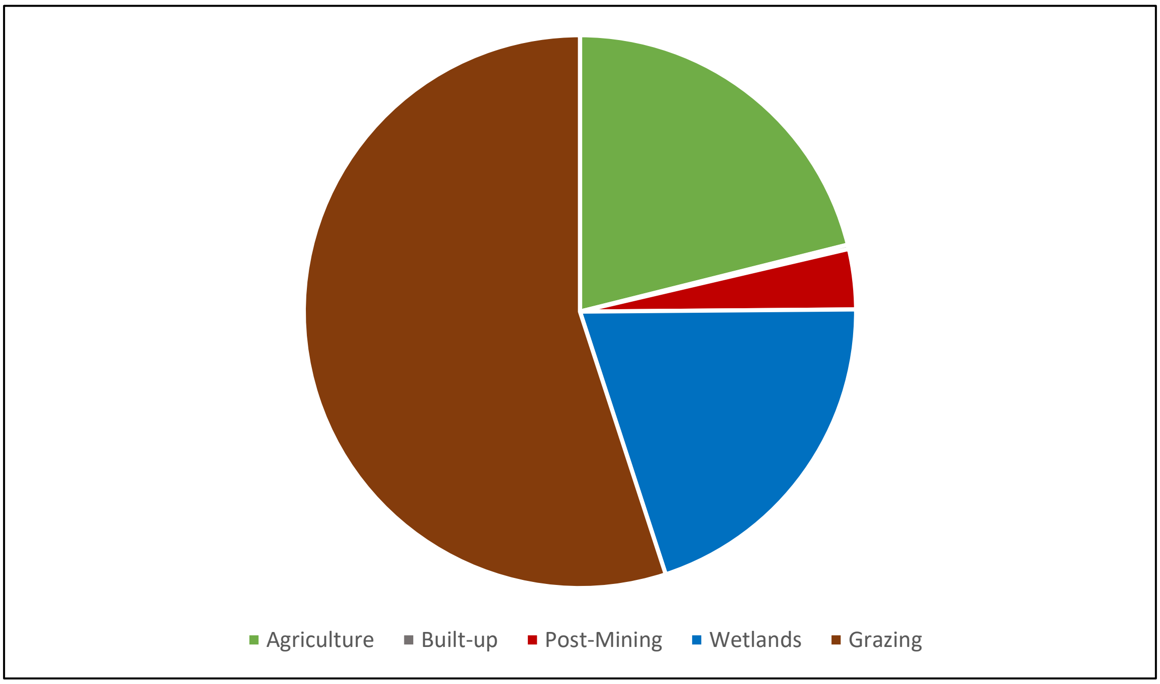


Figure 13: Illustration of the fractions taken up by different land uses within the project area

Figure 14: Wetland areas within project area

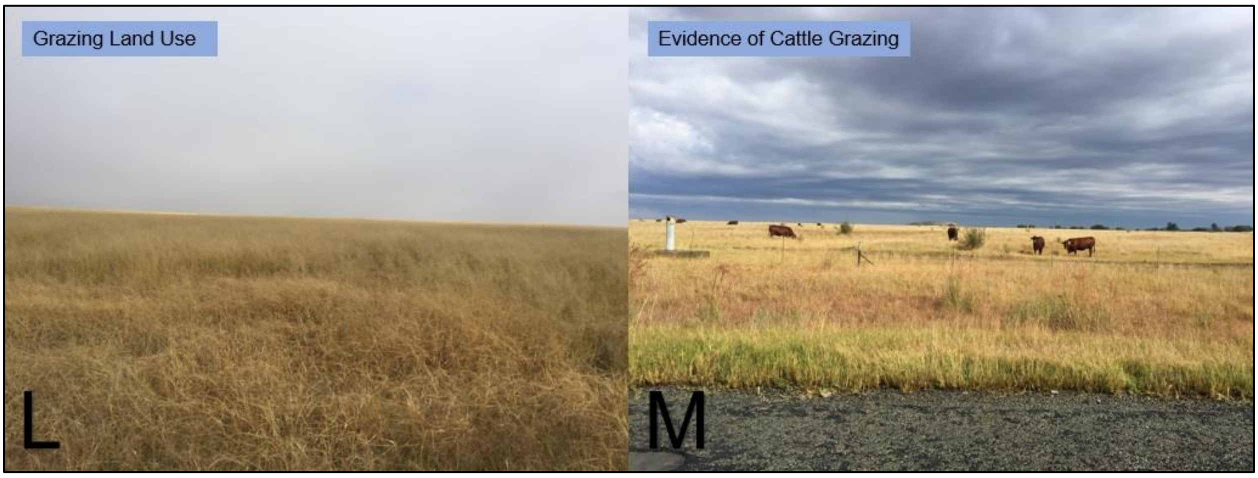


Figure 15: Grazing land use areas

Figure 16: Mining land use

Figure 17: Agricultural land use

7.4 Soil Physical and Chemical Properties

According to the Chamber of Mines South Africa/Coaltech (2007), one of the main objectives for rehabilitation is to restore the disturbed area back to the land capability conditions prior to mining activities. The land capability of the surrounding area has therefore been determined as the reference land capability. Additionally, samples were taken from the surrounding areas to be sent away for fertility tests. These results will also be used as reference for post-rehabilitation targets. These reference conditions will assist the responsible party in the rehabilitation process. The reference conditions should be achieved during rehabilitation to ensure that the conditions prior to development be restored.

7.4.1 Soil Physical Properties

Physical properties are defined by particle size distribution (soil textural classes) which refers to the percentage clay, silt and sand. All of the samples taken were sent for analysis. The average soil texture for all the soil samples are illustrated in Table 12.

Table 12: Results for physical properties for the surrounding land uses

Sample Site	Horizon	Clay %	Silt %	Sand %	Textural Class
1	Orthic A-horizon	16	23	61	Sandy Clay Loam
	Yellow-Brown Apedal B-horizon	6	23	71	Sandy Loam
2	Orthic A-horizon	14	22	64	Sandy Clay Loam
	Yellow-Brown Apedal B-horizon	12	21	67	Sandy Clay Loam
3	Orthic A-horizon	18	28	54	Sandy Clay Loam
	Yellow-Brown Apedal B-horizon	6	21	73	Sandy Loam
4	Orthic A-horizon	16	27	57	Sandy Clay Loam
	Yellow-Brown Apedal B-horizon	8	21	71	Sandy Loam

Table 13: Results for physical properties for the rehabilitated area

Sample Site	Horizon	Clay %	Silt %	Sand %	Textural Class
5	Orthic A-horizon	10	9,5	80,5	Sandy Loam
6	Orthic A-horizon	16	14,62	69,38	Sandy Clay Loam
7	Orthic A-horizon	34	19,64	46,36	Clay
8	Orthic A-horizon	8	4,12	87,88	Sandy Loam

The results from Table 12 indicates an average textural class of "Sandy Clay Loam" and "Sandy Loam", which subsequently represent the reference conditions for the rehabilitated area. Table 13 illustrates the results from the rehabilitated area. Sites "5", "6" and "8" have ideal textural conditions when comparing to the reference conditions whereas the clay percentage within the topsoil in site "7" is to high.

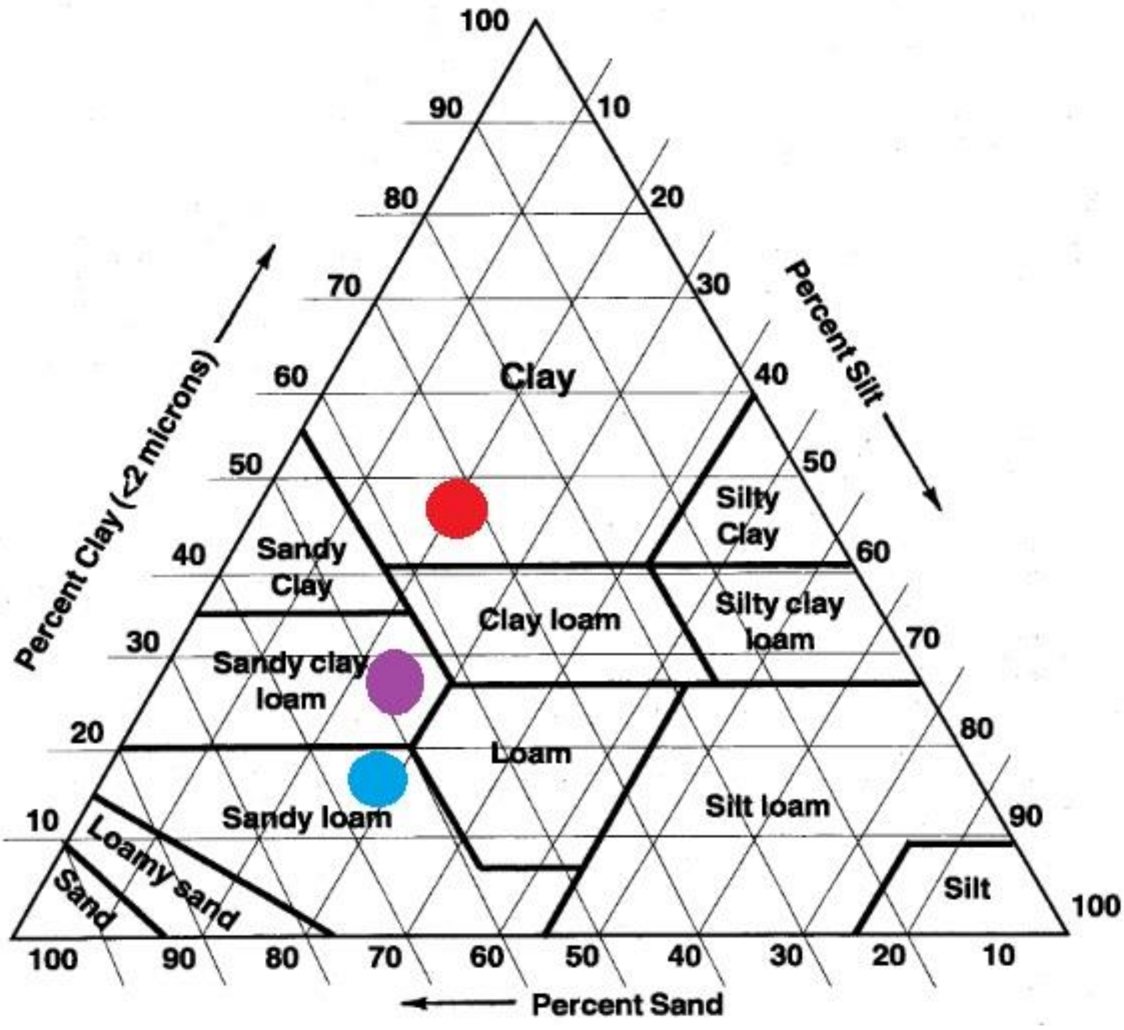


Figure 18: Soil texture pyramid

7.4.2 Soil Chemical Properties

Guidelines for relevant chemical properties are illustrated in Table 14, (Fertilizer Society of South Africa, 2007). The results from the chemical analysis are illustrated in Table 15. It is vital that the disturbed area be rehabilitated in such a way that not only the reference conditions be reached but that the recommended values described below be reached. This will ensure that vegetation be established with greater ease flourish.

Table 14: Guidelines for soil chemical properties

<table>
<tr><th colspan="6">Guidelines (mg/kg)</th></tr>
<tr><th colspan="3"></th><th>Low Values</th><th>Recommended Values</th><th>High Values</th></tr>
<tr><td colspan="3">Calcium (Ca)</td><td><200</td><td rowspan="5"></td><td>>3000</td></tr>
<tr><td colspan="3">Magnesium (Mg)</td><td><50</td><td>>300</td></tr>
<tr><td colspan="3">Potassium (K)</td><td><40</td><td>>250</td></tr>
<tr><td colspan="3">Phosphorus (Ph)</td><td><5</td><td>>35</td></tr>
<tr><td colspan="3">Sodium (Na)</td><td><50</td><td>>200</td></tr>
<tr><td colspan="6">pH (KCl)</td></tr>
<tr><td>Very Acidic</td><td>Acidic</td><td>Slightly Acidic</td><td>Neutral</td><td>Slightly Alkaline</td><td>Alkaline</td></tr>
<tr><td><4</td><td>4.0-5.9</td><td>6-6.7</td><td>6.8-7.2</td><td>7.3-8</td><td>>8</td></tr>
<tr><td colspan="6">Phosphate (P) Pbray 1 (mg/kg)</td></tr>
<tr><td>Very Low</td><td>Low</td><td>Moderate</td><td>High</td><td colspan="2">Very High</td></tr>
<tr><td><5</td><td>5-10</td><td>10-17</td><td>17-25</td><td colspan="2">>25</td></tr>
<tr><td colspan="6">Na:K ratio</td></tr>
<tr><td colspan="3">0.001-0.9</td><td colspan="3">>0.99</td></tr>
</table>

Table 15: Chemical property results from the surrounding land uses

Site	Horizon	Phosphorus (Bray 1) (mg/kg)	pH (KCl)	Exchangeable Cations				Na:K
				Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	
1	A	1	4,64	8	159	379	130	0,09
	B	8	4,48	10	154	332	107	0,11
2	A	2	4,30	61	147	147	26	0,70
	B	6	4,14	7	145	129	33	0,08
3	A	7	4,00	8	151	340	81	0,09
	B	56	3,77	7	202	92	36	0,06
4	A	7	4,00	5	137	115	29	0,06
	B	12	4,99	9	152	176	53	0,10

Table 16: Chemical property results from the rehabilitated area

Site	Horizon	Phosphorus (Bray 1) (mg/kg)	pH (KCl)	Exchangeable Cations				Na:K
				Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	
5	A	4,86	4,86	80	87	203	49	1,56
6	A	5,51	5,51	8	188	642	165	0,07
7	A	6,02	6,02	817	260	2061	430	5,35
8	A	3,82	3,82	54	8	1146	722	12,00

Phosphorus (Bray 1)

According to the Fertilizer Handbook (Fertilizer Society of South Africa, 2007), the recommended phosphorus value will be between 10 mg/kg and 17 mg/kg, which is classified as moderate. Anything higher or lower than that will be defined as low or high. The majority of sampling sites within the project area is characterised by very low (<5) phosphorus levels. Most samples tend to show "Low" phosphorus values with "Very Low" values being recorded for the A-horizons of sample site 1 and 2. A "Very High" value is perceived by the B-horizon of sample site 3. Even though the phosphorus concentrations for the rehabilitated areas are low, it perfectly correlates with those values recorded by the surrounding land use areas.

Therefore, increasing the phosphorus concentrations will improve revegetation but is not necessary to achieve the reference conditions. Phosphorus is very immobile and only available for plant uptake within the immediate vicinity of plant roots. The natural level of phosphates is low in South African soils. The recommended values for phosphorus are only necessary for crop production.

Plants use phosphorus as a source of energy used to assist the process of photosynthesis as well as respiration, (Hazelton & Murphy, 2007.) therefore, by increasing the phosphate levels by means of ameliorants and/or fertiliser, an increase in plant growth could be expected which will add significance to the rehabilitation process.

pH (KCl)

The recommended pH level will be between 6.8 and 7.2, (Fertilizer Society of South Africa, 2007). Reaching this value will be very difficult and, in some cases, impractical, therefore, it is recommended that a pH of at least 5.5 be reached seeing that this level of pH will decrease most of the risks involved with an acidic soil. Figure 19 indicates the pH level where nutrients become available. All of the sites fall under the “Acidic” level with the exception of site 3’s sub-soil being “Very Acidic”. For the rehabilitated area, sites “5” and “6” falls within the reference conditions whereas that of site “7” exceeds that of the reference conditions. The pH of site “8” is however to low and must be rectified.

Acidic soils are characterised by nutrient deficiency and lacks organic matter which is vital to healthy soil, (Fertilizer Society of South Africa, 2007). The pH of the project site could and should be increased by applying relevant amounts of dolomitic lime to aim for a neutral level. A soil pH lower than 5 potentially could cause aluminium and manganese toxicity as well as calcium deficiency.

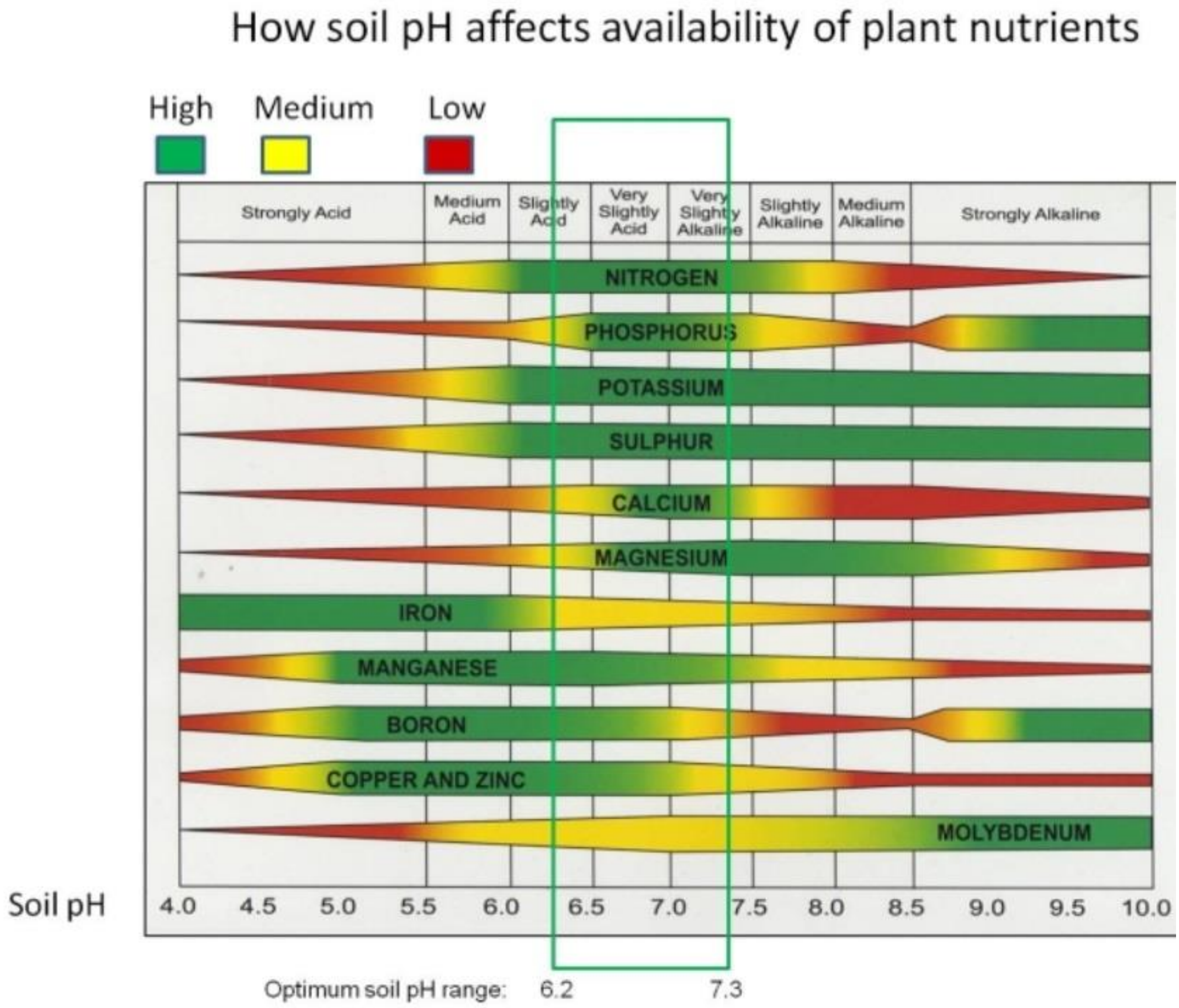


Figure 19: Indication of the nutrient availability at certain pH levels

Sodium (Na)

All of the sample sites show low sodium concentrations except for that of the top-soil of sample site 2, which has an ideal sodium concentration. The recommended sodium concentration lies between 50 mg/kg and 200 mg/kg. It is however important to notice that the Na:K relationships for all of the sites result in good relationships (0-0.9). The only rehabilitation site that does not meet the reference conditions is that of site “7”. The sodium concentration is extremely high and exceeds the recommended maximum value by four times.

The sodium concentrations within soil should always be lower than potassium. If sodium levels exceed that of potassium, the sodium cations will replace that of potassium on a Cation Exchange Capacity point of view seeing that plants require large amounts of potassium compared to other elements, (Fertilizer Society of South Africa, 2007).

Potassium (K)

The recommended potassium levels are between 40 mg/kg and 250 mg/kg, (Fertilizer Society of South Africa, 2007). All of the samples taken on site is characterised by “Ideal” levels of potassium. For the rehabilitated area, site “7” has slightly high potassium concentrations whereas that of site “8” is characterised by a potassium deficiency. Site “7” only exceeds the maximum recommended value with 20mg/kg which is expected to be leached out in the future to such an extent that the potassium concentrations fall within the “Ideal value”. As for site “8” however, it is recommended that ameliorants be applied to rectify the deficiency of potassium for the area.

Potassium is vital for healthy plant growth due to the integral role this element plays in the size, shape, strength and colour of plants, (Fertilizer Society of South Africa, 2007).

Calcium (Ca)

According to (Fertilizer Society of South Africa, 2007) the recommended calcium levels range between 200 mg/kg and 3000 mg/kg. Half of the samples have calcium deficiencies, whereas the other half has ideal calcium values. For the rehabilitated area, all sites are characterised by “Ideal” conditions regarding calcium concentrations. In general, dolomitic lime can be applied to the project area to boost the magnesium and calcium balance and ultimately increase the pH value.

Calcium plays an integral part in rectifying acidity and is vital for plants as a basic need. Calcium should be present within the root zone for easy abstraction by roots and pods, (Fertilizer Society of South Africa, 2007).

Magnesium (Mg)

According to (Fertilizer Society of South Africa, 2007), the recommended magnesium concentrations range between 50 mg/kg and 300 mg/kg. Half of the samples (similar to those proving to have calcium deficiencies) have potassium deficiencies with the rest having “Ideal” values. As for the rehabilitated area, sites “7” and “8” do not meet the reference conditions. These sites are characterised by high magnesium concentrations which might be because of over liming of dolomitic lime.

8 Impact Assessment

From an agricultural perspective, the loss of high value farm land and / or food security production, as a result of the proposed activities, is the primary concern of this assessment. In South Africa there is a scarcity of high potential agricultural land, with less than 14% of the total area being suitable for dry land crop production (Smith, 2006).

The impact section will assess the impacts on soils and land capability for all the relevant impacts shown in Table 17 which are described below along with their respective impact ratings.

Table 17: Impacts relevant to the proposed activity

Phase	Aspect	Impact
Decommissioning	Removal of all infrastructure rubble	• Degradation of soil; • Decrease in land capability; • Decrease in land potential; • Compaction; • Increased erosion; and • Loss of vegetation.
	Backfilling of the shaft voids	
Rehabilitation	Application of lime, fertilizer and other ameliorants	
	Reseeding	
	Ripping compacted areas	

Decommissioning phase (Table 18 and Table 19): During this phase, all of the infrastructure components constructed during the construction phase and used during the operational phase is decommissioned and removed from site by means of heavy vehicles. Explosives are often used to decommission the latter mentioned infrastructure components. Those foundations that are not of use to future land users will be either removed or covered in at least 300mm of top soil of similar nature to that of the surrounding soil types.

For the impact "Removing concrete slabs/foundations, waste material and all associated infrastructure components," low-negative significance ratings are expected before and after mitigation. It is however imperative that all recommended mitigation measures still be applied to minimise soil degradation during decommissioning. For the impact "Backfilling of the shaft," a medium-negative significance rating has been calculated prior to mitigation. This score is however expected to be decreased in significance (to low-negative) given that the responsible party tend to all recommendations and apply all relevant mitigation measures.

Table 18: Loss of land capability assessed for the relevant impact during the decommissioning phase

Removal of all infrastructure rubble	
Impact Name	**Removal of all infrastructure rubble**
Alternative	**-**
Phase	**Decommissioning**
Environmental Risk	

Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	2	2	Reversibility of Impact	4	3
Duration of Impact	3	3	Probability	3	3
Environmental Risk (Pre-mitigation)					-9.00
Mitigation Measures					
• Only the designated access routes are to be used to reduce any unnecessary compaction; • If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; • Use lighter vehicles (i.e. double cab vehicles) where possible; • Use manual labour instead of heavy machinery where possible; • Use as small as possible explosives for decommissioning; • Rip all dirt roads after final use thereof and reseed; • Liaise with future land users to find innovative ways to re-use current foundations instead of decommissioning; • Apply sufficient amounts of top soil on historic foundations; • Apply sufficient amounts of top soil where significant erosion has occurred; • Ensure that a specialist inspects all waste material to identify whether or not the relevant material is safe to backfill; and • All waste material deemed unsafe to backfill must be removed from site in an environmentally friendly manner.					
Environmental Risk (Post-mitigation)					-7.5
Degree of confidence in impact prediction:					High
Impact Prioritisation					
Public Response					1
Low: Issue not raised in public responses					
Cumulative Impacts					1
Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
<30% certain of impact prediction					
Prioritisation Factor					1.00
Final Significance					-7.5

Table 19: Loss of land capability assessed for the relevant impact during the decommissioning phase

Backfilling of the shaft					
Impact Name	**Backfilling of the shaft**				
Alternative	**-**				
Phase	**Decommissioning**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	3	2	Reversibility of Impact	4	3

Duration of Impact	4	4	Probability	3	3
Environmental Risk (Pre-mitigation)					-10.5
Mitigation Measures					
• Only the designated access routes are to be used to reduce any unnecessary compaction; • If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; • Apply sufficient amounts of top soil where significant erosion has occurred; • Ensure that a specialist inspects all waste material to identify whether or not the relevant material is safe to backfill; and • All waste material deemed unsafe to backfill must be removed from site in an environmentally friendly manner.					
Environmental Risk (Post-mitigation)					-9.0
Degree of confidence in impact prediction:					High
Impact Prioritisation					
Public Response					1
Low: Issue not raised in public responses					
Cumulative Impacts					1
Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
<30% certain of impact prediction					
Prioritisation Factor					1.00
Final Significance					-9.0

Rehabilitation and closure phase (Table 20 to Table 22): During this phase, the entire footprint area is rehabilitated in the sense that amelioration is applied to degraded areas, reseeding takes place in bare areas and compacted areas are ripped. Tending to these aspects in a wrongful manner could result in further degradation instead of a positive rehabilitated outcome. By tending to all recommendations and mitigation measures, a positive outcome can be expected.

All three potential impacts associated with rehabilitation and closure is expected to have a low-negative significance prior to the application of mitigation measures. This negative score has been calculated for a worst-case scenario, i.e. over application of lime, reseeding with invasive seeds etc. By applying relevant mitigation measures and respecting all recommendations, the post-mitigation significance rating is expected to be low-positive for all three "impacts". These scores have positive significance due to the nature of rehabilitation. By rehabilitating the area, a positive and beneficial outcome is expected for the soil resources.

Table 20: Loss of land capability assessed for the relevant impact during the rehabilitation and closure phase

Application of lime, fertilizer and other ameliorants	
Impact Name	**Application of lime, fertilizer and other ameliorants**
Alternative	**-**
Phase	**Rehabilitation and closure**
Environmental Risk	

Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature of Impact	-1	1	Magnitude of Impact	2	3
Extent of Impact	2	2	Reversibility of Impact	2	1
Duration of Impact	4	4	Probability	2	3
Environmental Risk (Pre-mitigation)					-5.5
Mitigation Measures					
• Only the designated access routes are to be used to reduce any unnecessary compaction; • The lime requirement for the degraded area must be calculated once decommissioning and backfilling of all material (or the removal thereof) has been done. This will include testing the pH post-decommissioning and pre-rehabilitation; • The application of fertiliser, lime and other ameliorants must take place a few weeks before reseeding; • By applying the wrong type of lime or excessive amounts of lime will further degrade the soil resources; • Testing of inorganic parameters must be completed with the latter mentioned tests to identify possible land contamination; • Relevant ameliorants must be applied to contaminated areas to rectify these imbalances; and • All ameliorants, lime and fertiliser applied to the footprint area must be done according to the reference site conditions.					
Environmental Risk (Post-mitigation)					+7.5
Degree of confidence in impact prediction:					High
Impact Prioritisation					
Public Response					1
Low: Issue not raised in public responses					
Cumulative Impacts					1
Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
<30% certain of impact prediction					
Prioritisation Factor					1
Final Significance					+7.5

Table 21: Loss of land capability assessed for the relevant impact during the rehabilitation and closure phase

Reseeding					
Impact Name	**Reseeding**				
Alternative	**-**				
Phase	**Rehabilitation and closure**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	1	Magnitude of Impact	1	4
Extent of Impact	3	2	Reversibility of Impact	2	1
Duration of Impact	2	2	Probability	1	3
Environmental Risk (Pre-mitigation)					-2.0
Mitigation Measures					

• Reseeding should take place a few weeks before the anticipated dry season to ensure a successful germination; • Rock armour should be applied to the degraded/eroded areas (especially those characterised by a slope) to support successful reseeding and minimize the risk of seeds washing away via overland flow; • Ripping should be carried out on all compacted areas a few days before reseeding; • Only indigenous grass species should be reseeded; and • Reseeding must take place a few weeks after the application of fertilizer, lime and other ameliorants.	
Environmental Risk (Post-mitigation)	+6.75
Degree of confidence in impact prediction:	High
Impact Prioritisation	
Public Response	1
Low: Issue not raised in public responses	
Cumulative Impacts	1
Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	
Degree of potential irreplaceable loss of resources	1
<30% certain of impact prediction	
Prioritisation Factor	1
Final Significance	+6.75

Table 22: Loss of land capability assessed for the relevant impact during the rehabilitation and closure phase

Ripping of compacted areas					
Impact Name	**Ripping of compacted areas**				
Alternative	**-**				
Phase	**Rehabilitation and closure**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	1	Magnitude of Impact	1	3
Extent of Impact	1	2	Reversibility of Impact	1	1
Duration of Impact	1	2	Probability	1	3
Environmental Risk (Pre-mitigation)					-1.0
Mitigation Measures					
• Ripping of compacted areas must be done by means of manual labour instead of heavy machinery as much as possible; and • Reseeding must take place a few days after ripping.					
Environmental Risk (Post-mitigation)					+6.0
Degree of confidence in impact prediction:					High
Impact Prioritisation					
Public Response					1
Low: Issue not raised in public responses					
Cumulative Impacts					1
Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1

<30% certain of impact prediction	
Prioritisation Factor	1
Final Significance	+6.0

9 Recommendations

9.1 Achieving Surrounding Land Use Conditions

The post-mining area has various shortcomings when comparing land capability and fertility to the surrounding land use areas. Figure 20 indicates the portions that resemble conditions described for each of the rehabilitated sampling sites. These delineations are not a direct indication of conditions due to the fact that only four samples have been taken within the rehabilitated area.

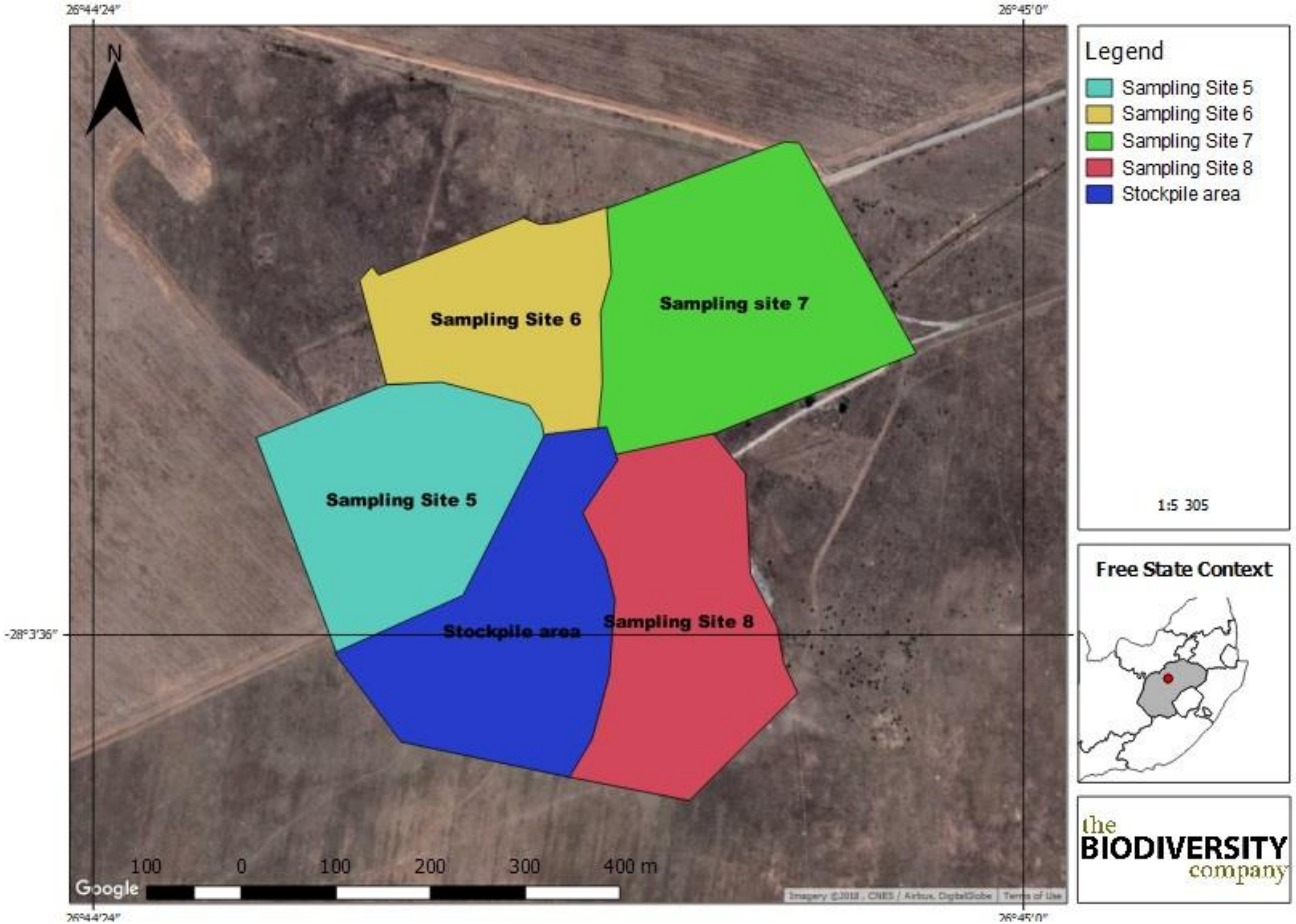


Figure 20: Sampling site areas

As for the soil chemical parameters, the following recommendations have been made to ensure that reference conditions be met;

- No remediation measures pertaining to phosphor application is necessary given the fact that reference conditions already are met. An application of phosphorus would however be beneficial to successful revegetation;
- Site "8" is characterised by very acidic conditions. 4 ton/ha calcitic lime must be applied to this area to increase the pH instead of dolomitic lime due to the high concentrations of magnesium. Sampling site "8" is 6.2ha in size and would therefore require 24.8 ton calcitic lime. Alternatively, additionally soils samples can be taken and tested in sampling site "8" to determine the refined boundaries characterised by acidic conditions to determine whether or not smaller areas requires lime;
- The sodium concentration for sampling site "7" is extremely high. The only way to rectify this issue is by ensuring that the soil profile leaches out the excess sodium. It is recommended that samples be taken in the same location as sampling site "7" before and after the wet season to determine the concentrations before and after the soil profile is leached. The sampling of this site must be undertaken until the sodium concentrations reach the reference condition sodium concentration. Continues ripping must take place to ensure a high infiltration. If the sodium concentrations do not decrease to such a degree that the reference conditions are reached after three years, another soil assessment must be undertaken on this area to determine the physical parameters of the soil profile. This assessment will determine whether irrigation is needed or other rehabilitation strategies to improve the leaching ability of the soil profile;
- Site "8" is characterised by potassium deficiencies, it is recommended that potassium rich fertiliser be applied to this area;
- The magnesium concentrations for sites "7" and "8" is too high and must be rectified by leaching. Therefore, the same strategy must be implemented for the area surrounding sampling site "8" as that described for sampling site "7".

The following recommendations are applicable to the general remediation of the project area, to ultimately ensure successful rehabilitation and decrease the possibility of soil degradation;

- All rubble and building material must be removed from site, see Figure 21;
- Any potential hazardous material within the waste rock should be assessed by a specialist to ensure that suitable recommendations are made for the safe removal thereof, this include waste material (Figure 22);
- The reference land capability should be achieved and similar soil physical and chemical properties to the reference conditions should be achieved during the rehabilitation plan. The land capability of the surrounding environment has been determined to be "Arable." However, given the land potential level (L6), severe limitations for arable land exist due to climate restrictions. Therefore, it is the specialist's opinion that "Grazing" land capability rather be favoured. According to the Chamber of Mines South Africa/Coaltech (2007), a post-mining land capability of "grazing land" can be reached by ensuring the rehabilitated area has a soil profile exceeding a depth of 250mm. The rehabilitated area is extremely compacted at a depth of 100mm. Therefore, the entire rehabilitated area must be ripped to at least 250mm to achieve a grazing post-mining land capability.

- The current stockpile area must be removed, and the shaft must be backfilled and rehabilitated;
- After the rehabilitation of this area, samples must be taken to ensure that this area be rehabilitated to the reference conditions.

Figure 21: Building material

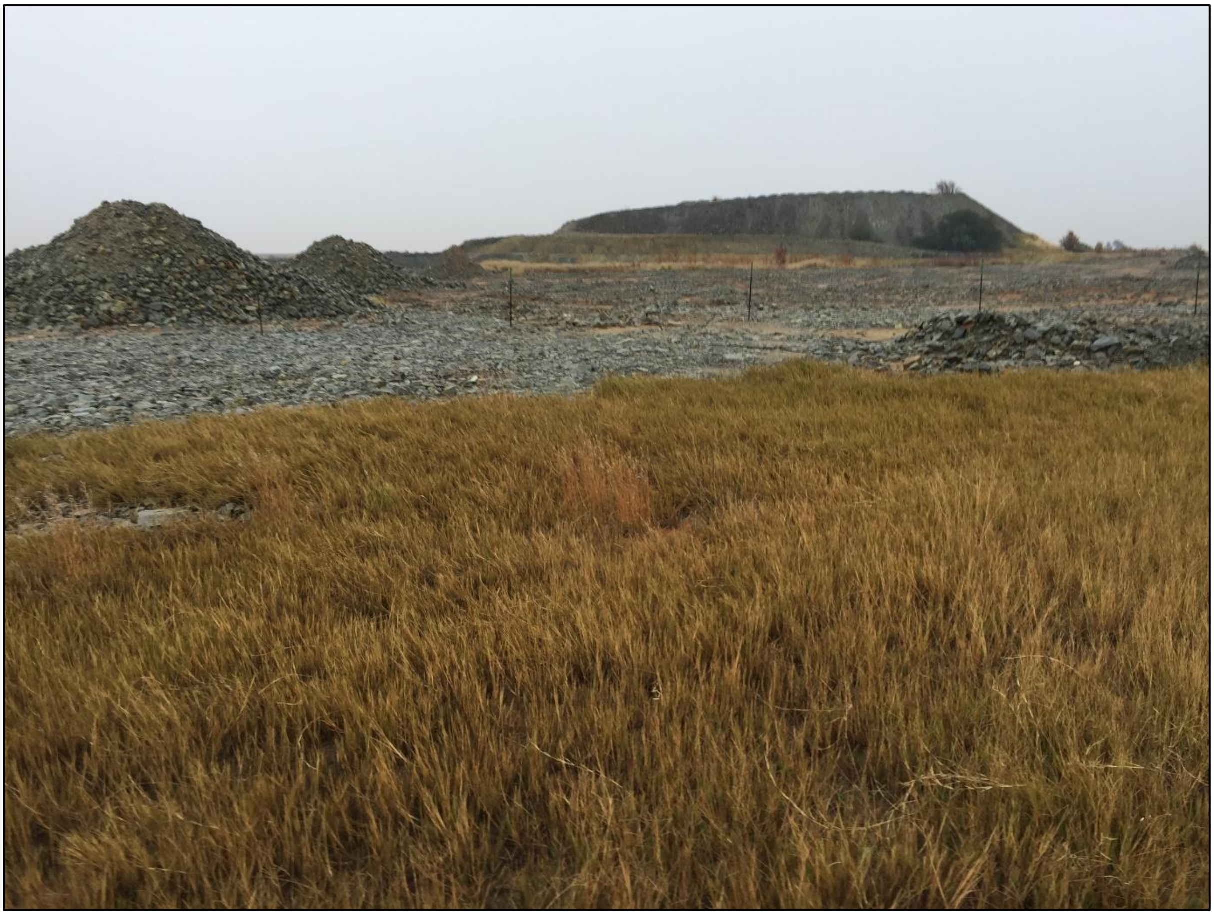


Figure 22: Waste material covering the mining area

10 Conclusion

During the survey, five dominant soil forms were identified, namely an Avalon, Westleigh, Clovelly, Witbank, and Arcadia soil form. The Avalon soil form covers grazing land use areas, the Arcadia soil form covers a small portion of the grazing land use area, whereas the Clovelly soil form covers the agricultural crops and grazing land use area. The Witbank soil form is characterised by disturbed soil, which in this case is characterised by the mining land use area. The Westleigh soil form covers grazing and wetland land use areas.

Soil samples were analysed for standard fertility and textural tests. Results obtained from the lab analysis indicate possible deficiencies in the fertility of the soils in the area. These results would then be regarded as the reference conditions for soil in the vicinity. The textural classes determined during these analyses were that of sandy loam, which indicates high infiltration and a low water/nutrient holding capacity given that all crust and compaction issues are been rectified.

The **climate capability** for this region was determined to be “C8” (Very Severe). This climate capability class indicates that the choice of crops is severely restricted due to heat and moisture stress, (Smith, 2006).

The Clovelly, Arcadia and Avalon soil forms have all been determined to have a **land capability class** of “III”. The Westleigh “B” form has a land capability class of “IV” with the Westleigh “A” soil form having a land capability class of “V”.

All of the soils except for the Westleigh "A" soil form has a **land potential** of "L6". The Westleigh "A" soil form has a land potential of "Vlei" due to the soil from being characterised by wetland conditions.

Various mitigation measures, including amelioration and revegetation have been recommended to ensure that the rehabilitated area meet all requirements of the surrounding land use areas. Some areas of the rehabilitated area's texture, chemical parameters (except for calcium) and the land capability do not meet the surrounding land use reference conditions and needs to be rectified before a closure certificate can be awarded.

Additionally, the stockpile area and shaft need to be rehabilitated where after the process involved in this report must be carried out again.

11 References

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