GOLDER ASSOCIATES

REPORT ON:

VOLCLAY BATHLAKO MINING SOIL, LAND USE LAND CAPABILITY ASSESSMENT

REPORT: P274

Submitted to:

Golder Associates

PO Box 6001

Halfway House

1685

VILJOEN & ASSOCIATES

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EXECUTIVE SUMMARY

Golder Associates requested during May 2012 a proposal for a soil survey, land use land capability wetland assessment for Volclay Bathlako Mining.

The objectives of the investigation included a soil survey and mapping of study area, measurement of the effective depth of the soil(s), assessment of agriculture potential of soils, assessment of the erodibility and misuse of soils, mapping of land use & land capability, formulation of a soil stripping guide and plan, determination of chemical, mineralogical and physical properties of representative soil forms, assessment of suitability of soils for rehabilitation purposes and an impact assessment of topsoil stripping on soils with recommendations to mitigate negative impacts.

From the investigation it is conclusive the dominant soils according to the Taxonomical Soil Classification System of South Africa include Mispah, Avalon, Hutton, Clovelly, Witbank and Bainsvlei soils. The effective depth of the Avalon, Hutton, Clovelly and Bainsvlei soils exceed 300mm inclusive of the Orthic A – Horizons, Yellow and Red Apedalic B – Horizons.

The agricultural potential under dry land and irrigation conditions is available in **Table 3** (**p15**). The agricultural potential of the Avalon and Bainsvlei soils is considered low to medium under dryland (*650mm/y rainfall*) and irrigation conditions *(>10-15mm/week 33-1,500kPa plant available water*). The Hutton and Clovelly soils have a high agricultural potential (dryland & irrigation).

No evidence of soil erosion was observed on any of the soils during the investigation.

The current land use include natural veld (100%). Land capability includes 14% arable, 74% grazing and 12% wilderness of the total investigation area.

A soil stripping stockpiling strategy is given on **p20 (Table 6)**. An estimated total area of 415ha could potentially be covered 300mm thick @ BD 1,275kg.m^3 during rehabilitation taking into consideration a 10% loss of topsoil from the 1,383,000m^3 due to handling, compaction *etc*.

The Mispah, Avalon, Hutton, Clovelly, and Bainsvlei soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15mg/kg) and potassium (>50mg/kg) are readily available for plant uptake and sustainable plant growth. The Orthic A-Horizon is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10mm/h. The dominant clay mineral in the *Orthic A – Horizon, Yellow* & *Red Apedalic B – Horizon* is kaolinite (1:1 layer silicate), with a low buffer capacity due to the low cation exchange capacity

(<10cmol+/kg). This is a significant attribute to be considered during soil remediation and rehabilitation planning.

The soil horizons specified in **Section 4.4 p12** of the Avalon & Bainsvlei (*except Soft Plinthic B – Horizons*) and Hutton & Clovelly soil types are suitable for rehabilitation purposes.

The potential impacts and reasons/activities with proposed mitigation measures on the soil due to construction activities include:

- *Loss of topsoil*:

  This is due to stripping, handling and placement of the soil associated with the pre construction land clearing and rehabilitation and it is recommended to strip all usable soil irrespective of soil depth.

- *Change to soil's physical, chemical and biological properties*:
  There is a high probability that topsoil will be loss due to wind and water erosion, which will alter the soils properties. Stockpiling and subsequent mixing of soil layers during handling will ultimately have a negative effect on altering the basic soil properties. It is suggested to implement live management and placement of topsoil where possible, improve the organic content of the soils, and maintain fertility levels through fertilisation and to curb topsoil loss as much as possible.
- *Cumulative effect of the soil:*
  Alteration of the natural surface topography due to reprofiling during construction after stripping will have an accumulation effect on the soils and careful consideration should be given to minimise compaction and ensure free drainage preferential surface water pathways.

VOLCLAY BATHLAKO MINING SOIL, LAND USE & LAND CAPABILITY ASSESSMENT

1 TERMS OF REFERENCE

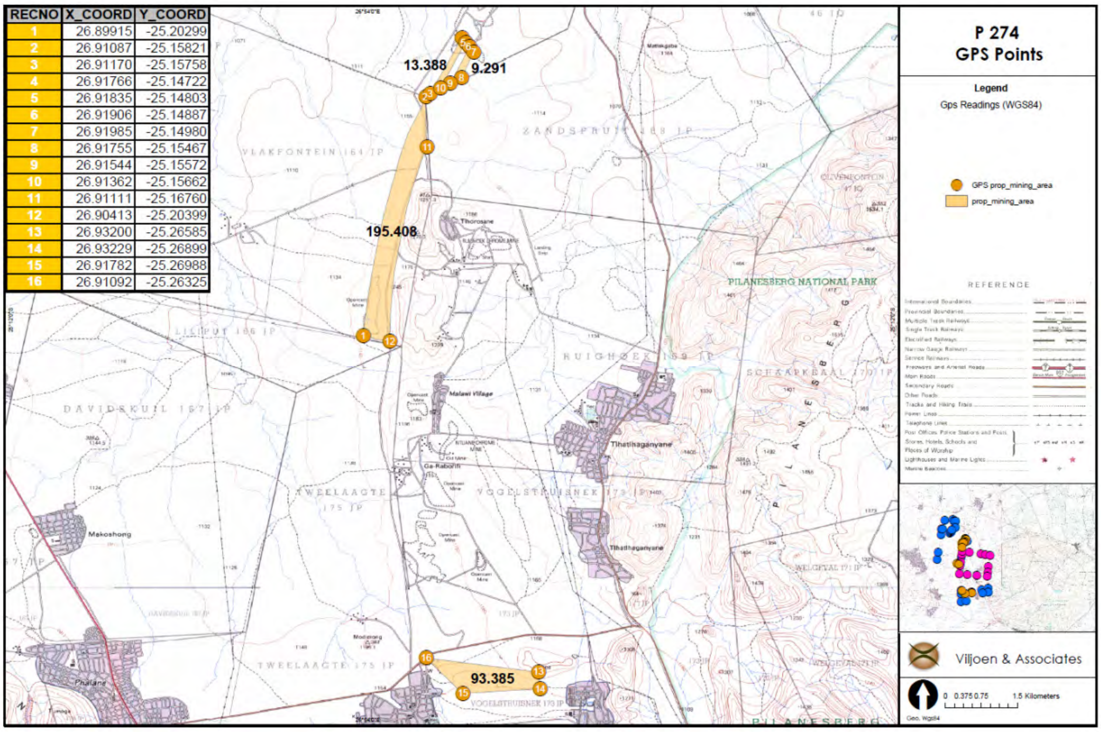

Figure 1. Investigation area.

During May 2012 Golder Associates requested a proposal for a baseline soil land use land capability wetland assessment at Volclay Bathlako Mining. The study area is approximately 350ha (**Figure 1**).

2 INVESTIGATION OBJECTIVES

The objectives of the investigation were interpreted as:

- **Objective 1:** *Soil survey and mapping of study area.*
- **Objective 2:** *Measurement of the effective depth of the soil(s).*
- **Objective 3:** *Assessment of agriculture potential of soils.*
- **Objective 4:** *Erodibility and misuse of soils.*
- **Objective 5:** *Land use & land capability.*
- **Objective 6:** *Soil stripping guide and plan*.

- **Objective 7:** *Determination of chemical, mineralogical and physical properties of representative soil forms.*

- **Objective 8:** *Assessment of suitability of soils for rehabilitation purposes*.

- **Objective 9:** *Impact assessment of topsoil stripping on soils with recommendations to mitigate negative impacts*.

3 METHOD OF INVESTIGATION

In order to meet the objectives of the investigation, the following scope of work was conducted:

- Collection of available information relevant to the study, *i.e.* GPS coordinates, map defining study area plotted on 1:50,000 tif image and aerial images.

- A soil survey according to standard soil survey techniques comprising of GPS referenced auger holes on a flexible grid 1,8m deep (or to auger refusal).

- Soil profile studies and classification according to the latest version of the *South African Taxonomical Soil Classification System of South Africa*.

- Representative sampling of soils.

- Analysis of the samples.

- Interpretation of analytical data and field observations.

- Compilation of draft report.

- Internal review and submission of final report.

3.1 Sampling Procedures

Soil sampling was carried out according to the following procedures:

- Auger holes drilled with a 75mm diameter 1,8m mechanical steel auger.

- The ground surface at the position of the auger hole was carefully cleared of loose material. When present, surface vegetation was carefully removed and the soil clinging to any roots left behind collected with the surface soil sample.

- The sampling interval in the auger holes was 150mm and consolidated to one sample per auger hole.

- The auger was advanced to the required depth and then carefully removed from the hole. The hole was covered to prevent foreign material from entering.

- Approximately 1.5kg soil sample was taken from the hole raisings and soil material removed from the auger. The samples were quartered to produce a representative sample of suitable weight, *i.e.* 500g.

- Prior to the taking of each sample both the steel auger and stainless steel trowel used to collect the soil samples were wiped clean of soil, washed with tap water, rinsed in a phosphate free detergent and finally sprayed with de-ionised water to prevent cross contamination between sampling depths.

- The soil samples were placed directly in zip-lock freezer bags, clearly labelled in indelible ink with the name of the site, auger hole number and sampling date.

- The soil samples were stored in the shade prior to being transported to an air-conditioned environment awaiting transport to the analytical laboratory.

- Chain of custody forms accompanied the soil samples to the laboratory and the samples were verified and signed for by the laboratory chemist.

- All auger hole logs were geo-referenced (GPS: datum WGS1984, decimal degrees).

3.2 Inorganic Analyses

Table 1 shows the analytical soil parameters for analyses.

TABLE 1. SOIL ANALYTICAL PARAMETERS

ELEMENT	METHOD
CHEMICAL	
Sample Preparation	Standard
pH (H_2O)	Standard
CEC+K+Na	NH_4Ac-extraction
EC+NO_3	Saturated distilled water extract
P	Bray 1-extract
Lime Requirement	Double Buffer Titration
MINERALOGY	
Clay fraction (<0.002mm) identification	XRD-scan (6 treatments)
PHYSICAL	
Particle size distribution (3 fractions-sand+silt+clay)	Hydrometer

3.3 Quality Assurance Quality Control

The quality assurance/quality control procedure for the investigation entailed a combination of the following:

- Duplicate analyses on 5% of the samples submitted.
- Carry out additional checks using standard reference materials.
- Conduct multi linear regression techniques to ensure analytical equipment are properly calibrated.
- Double check calibrated equipment with spiked standards above highest standard and confirm with 10x dilution.

4 PROBLEM ANALYSES

Section 4.1 is a brief description of basic soil forming principles to set a framework for evaluation of the baseline soil assessment:

4.1 Basic Soil Forming Principles

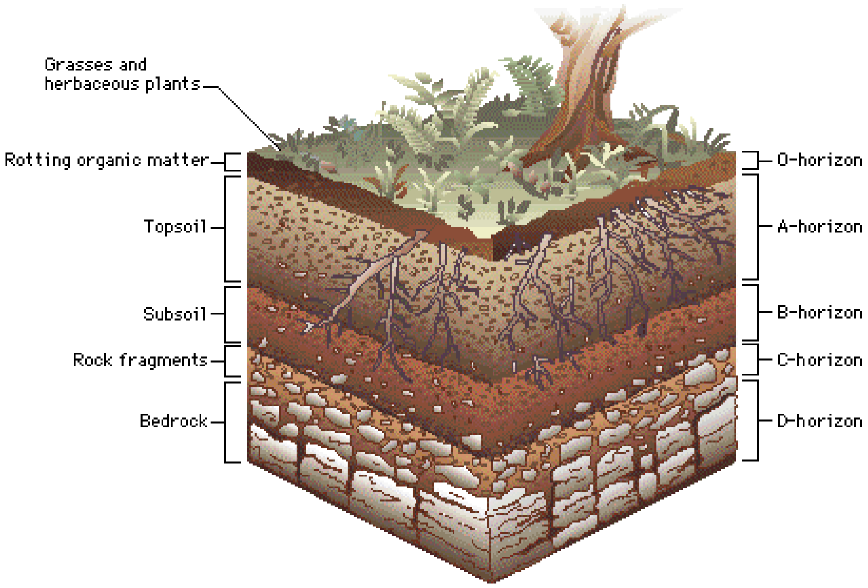

Figure 2. Typical soil profile.

According to A Glossary of Soil Science (1995), soil (**Figure 2**) can be defined as:

"the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for growth of plants, or, the unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including precipitation and temperature effects), macro- and micro-organisms and topography all acting over the period of time and producing a product – soil – that differs from the material, which is derived in many physical, chemical, biological and morphological properties and characteristics".

Soil is a thin surface covering the bedrock of most of the land area of the Earth. It is a resource that, along with water and air, provides the basis of human existence. Soil develops when rock is broken down by weathering and material is exchanged through interaction with the environment. Organic matter becomes incorporated into the soil as the result of the activity of living organisms. Soil also contains water, minerals, and gases. The soil system (**Figure 3**) is dynamic and it develops a distinct structure, often with recognizable layers or soil horizons arranged vertically through the soil profile.

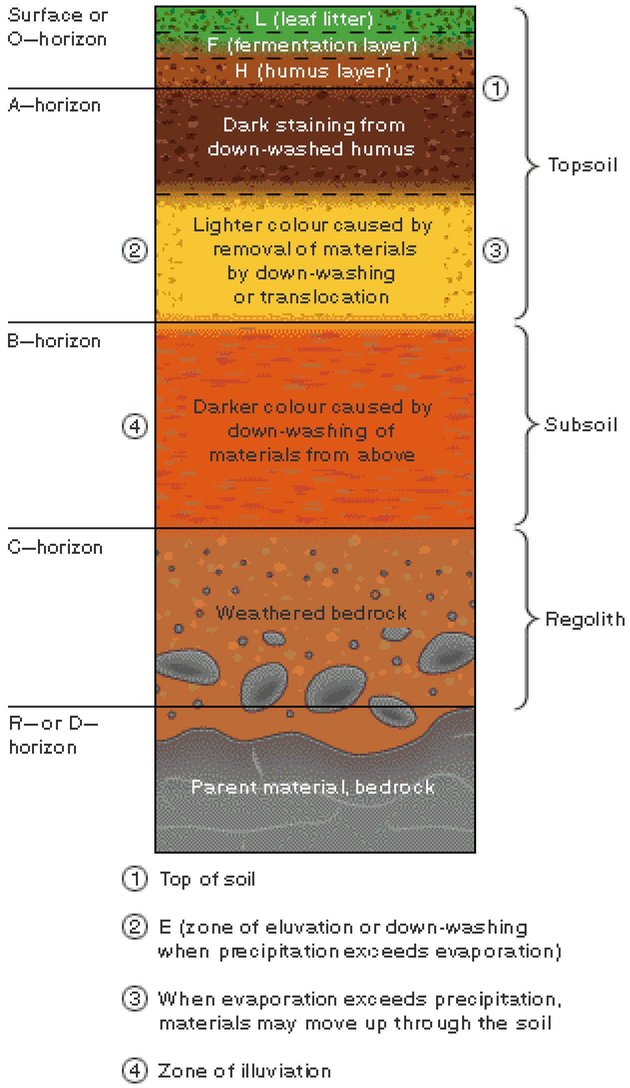

Figure 3. Soil system with different layers.

Soil is essential for the development of most plants, providing physical support and nutrients. Plants are anchored in the soil by their roots. Nutrients, dissolved in soil water, are necessary for the plants' growth. Soil contains various organic matter, including dead material from plants and animals as well as animals that choose to live in the soil. The soil is therefore a store of major nutrients such as carbon and nitrogen and plays an important role in global nutrient cycles and in regulating hydrological cycles and atmospheric systems.

Soils vary from place to place due to various conditions such as climate, rock type, topography, and the local soil-forming processes. Over time soils develop characteristics specific to their location, which relate closely to the climate and vegetation of the area. The major world biomes reflect a clear association between vegetation and soil that has developed in response to the prevailing climate. Each soil type has a distinct combination of soil horizons and associated soil properties.

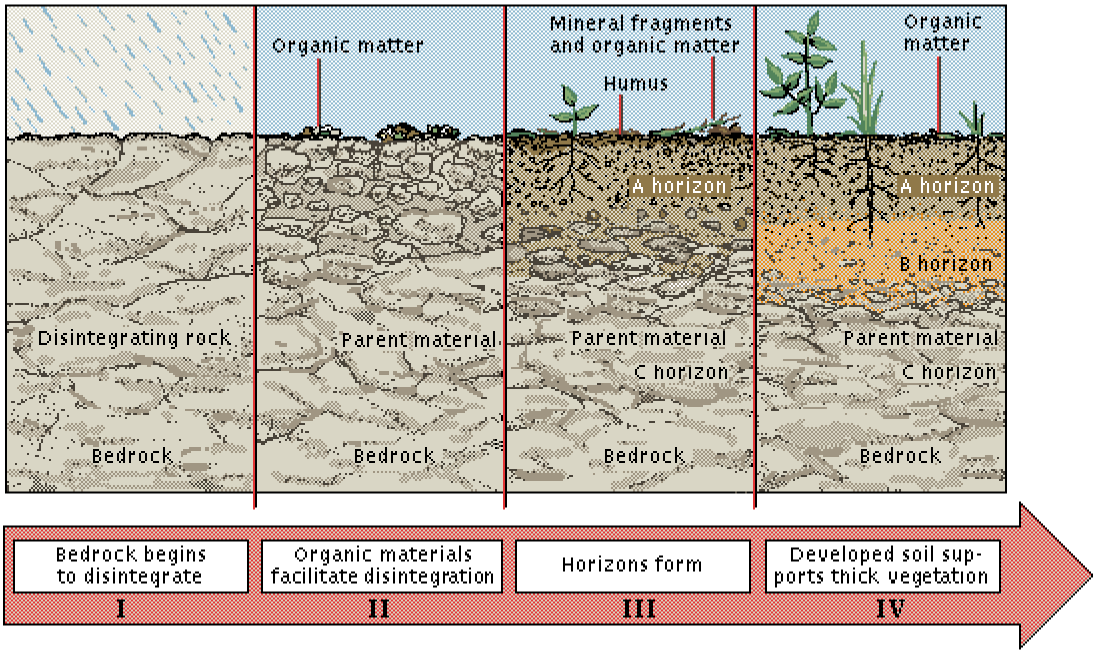

Figure 4. Different stages of soil formation.

People depend on the soil for agriculture, and as such it is a valuable natural resource. Soils form continuously as the result of natural processes (**Figure 4**), and can therefore be regarded as a renewable resource. However, the soil-forming processes operate very slowly and the misuse or mismanagement of the soil may lead to damage or erosion, (**Figure 5**) or can disrupt the processes by which the soil forms.

Figure 5. Example of soil erosion (*not taken on site*).

If this happens the resource can be degraded or even lost and this is what should be prevented during topsoil stripping, stockpiling, replacement and rehabilitation. Many human activities cause damage to soils. These include bad farming techniques, overgrazing, deforestation, urbanization, construction, soil stripping, wars, contamination, pollution, and fires. The most critical result of these is soil erosion (**Figure 5**). With growing populations, the need for productive soils is increasing. Soil loss in many developing countries is a major cause for concern and will become a major issue in the future. The process of soil loss can have a detrimental effect on other systems as it produces sediment that can cause siltation of river systems and reservoirs, set off flooding downstream, and contribute to pollution and damage to estuaries, wetlands, and coral reefs. Soils need to be managed carefully in order to remain in good condition.

4.2 Abbreviated Legal Register for Rehabilitation

The following ***Acts*** focused on human rights, protection of the environment, accountability and financial provision should be considered with projects in South Africa:

- *Section 12 of the Minerals Act 50 of 1991.*
- *Sections 41, 42 and 43 of the Mineral & Petroleum Resources Development Act 28 of 2002, the M&PRD Regulations R527.*
- *Constitution of South Africa Act 108 of 1996.*
- *National Environmental Management Act 107 of 1998, and Ammendments.*
- *National Water Act 36 of 1998 (Section 36), and Amendments, with specific reference to the NWA Regulations GN704 of 1999 and use of Water for Mining and Related Activities aimed at the Protection of Water Resources.*
- *The Water Services Act 108 of 1997.*
- *The Conservation of Agricultural Resources Act No. 43 of 1983 & Amendments (Govt. Gazette Vol. 429 No. 22166 of March 2001).*
- *National Forest Act 84 of 1998.*
- *Physical Planning Act of 1991.*
- *National Environmental Management Biodiversity Act of 2003.*
- *National Environmental Management Protected Areas Act of 2003.*
- *National Veld and Forest Fire Act 101 of 1998.*

- *Environmental Conservation Act 73 of 1089.*
- *Environmental Conservation Amendment Act 50 of 2003.*
- *Atmospheric Pollution Prevention Act 45 of 1965.*
- *National Heritage Resources Act 25 of 1999.*
- *National Development Facilitation Act 67 of 1999.*
- *National Development Facilitation Act 67 of 1995.*
- *Promotion of Access to Information Act 2 of 2000.*
- *National Monuments Act 28 of 1969.*
- *Nuclear Energy Act 46 of 1999.*
- *National Nuclear Regulator Act 47 of 1999.*
- *Health Act 63 of 1997.*
- *Plant Improvement Act 53 of 1976.*
- *Occupational Health and Safety Act 85 of 1993.*
- *Agricultural Pests Act 36 of 1983.*
- *Fertilisers, Farm Feeds, Agricultural remedies and Stock Remedies Act 36 of 1947.*
- *Mine Health and Safety Act 29 of 1996.*
- *Hazardous Substances Act 15 of 1973.*
- *Land Survey Act 8 of 1997.*
- *SABS 0286: 1998 Code of Practice for Mine Residue.*
- *SABS: Water Quality.*
- *Chamber of Mines of SA Guidelines for Environmental Protection: Engineering Design, Operation & Closure of Metalliferous, Diamond & Coal residue deposits.*

- *Department of Mining & Energy Aide Memoir Guideline for the Peparation of EMPR'S.*

- *Department of Mining & Energy Mineral Policy in terms of Section 12 of the Minerals Act 1995.*

- *Department of Mining & Energy Policy on Financial Provision 1994.*

- *Guideline on the Compilation of a Mandatory Code of Practice on Mine Residue Deposits.*

- *Department of Water Affairs & Forestry Guideline on water & salt balances for TSF's.*

- *Chamber of Mines Guidelines for Vegetation of Mine Residue Deposits.*

- *Department of Water Affairs Policy and Guidelines for dealing with pollution from TFS's, and the containment and rehabilitation of abandoned TFS's, and prosecutions.*

- *Convention of Wetlands of International Importance especially as Waterfowl Habitat RAMSAR (in force in SA from 12 Dec 1975).*

- *International Cyanide Code.*

4.3 South African Environmental Soil Legislation

The following section outlines a summary of *South African Environmental Legislation* that needs to be considered for the proposed project with reference to management of soil:

- *The law on Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal.*

- *The Bill of Rights states that environmental rights exist primarily to ensure good health and well being, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources.*

- *The Environmental right is furthered in the National Environmental Management Act (No. 107 of 1998), which prescribes three principles, namely the precautionary principle, the "polluter pays" principle and the preventive principle.*

- *It is stated in the above-mentioned Act that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source.*

- *Soils and land capability are protected under the National Environmental Management Act 107 of 1998, the Environmental Conservation Act 73 of 1989, the Minerals Act 50 of 1991 and the Conservation of Agricultural Resources Act 43 of 1983.*

- *The National Veld and Forest Fire Bill of 10 July 1998 and the Fertiliser, Farm Feeds, Agricultural Remedies and Stock Remedies Act 36 of 1947 can also be applicable in some cases.*

- *The National Environmental Management Act 107 of 1998 requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimized and remedied.*

- *The Minerals Act of 1991, MPRDA requires an EMPR, in which the soils and land capability be described.*

- *The Conservation of Agriculture Resources Act 43 of 1983 requires the protection of land against soil erosion and the prevention of water logging and salinisation of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and water courses are also addressed.*

Sections 4.4 to 4.11 address the investigation objectives (*Section 2, p1*) for the project.

4.4 Objectives 1 and 2: Soil Classification and effective soil depth

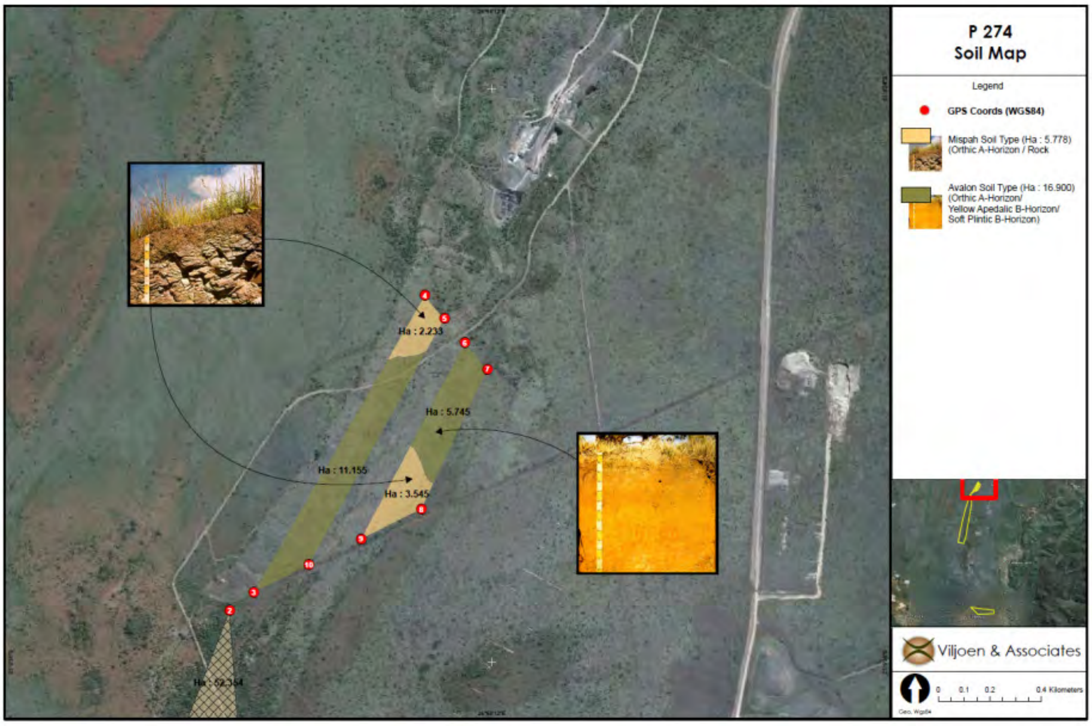

Figure 6. Soil types.

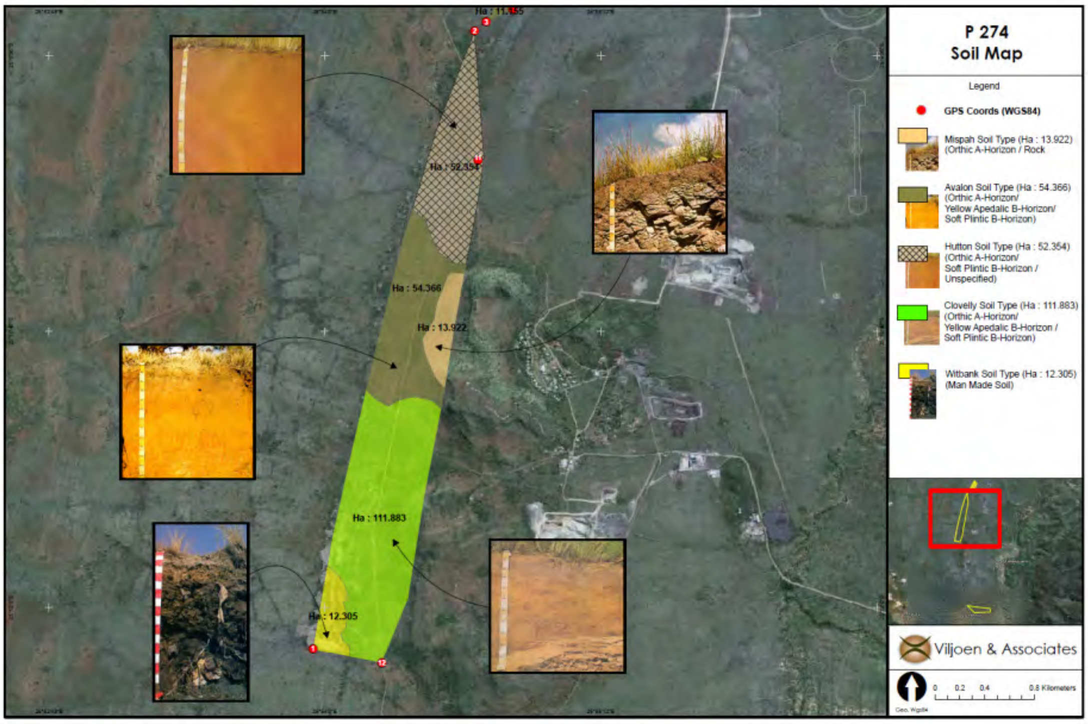

Figure 7. Soil types.

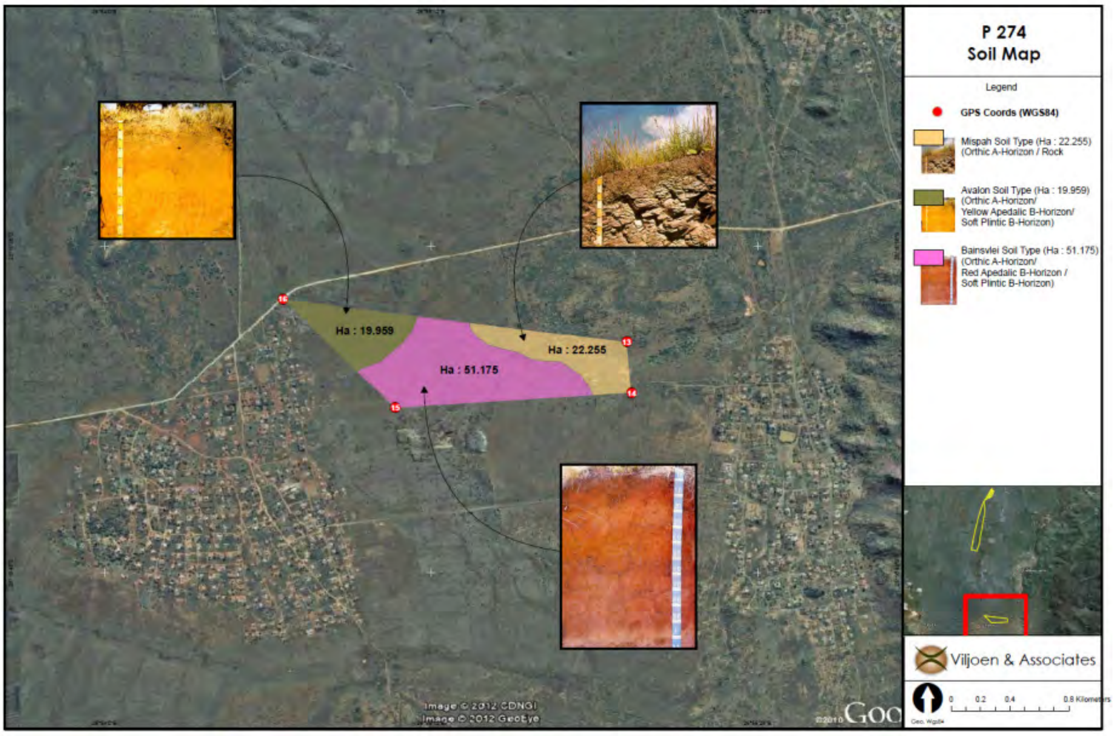

Figure 8. Soil types.

Figures 6-8 show the distribution of soil types classified on the study area according to the latest version of the *South African Taxonomical Soil Classification System*.

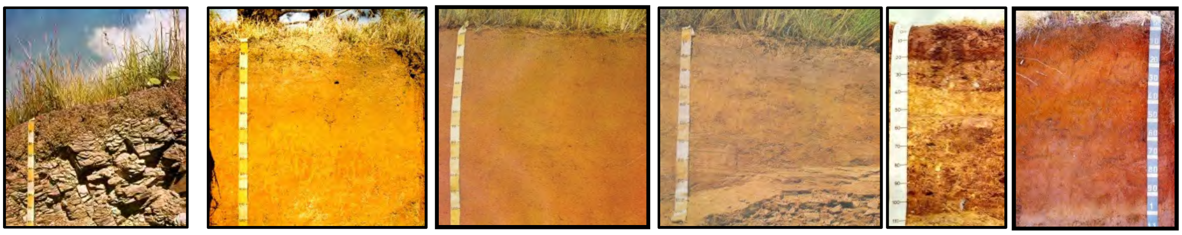

Figure 9. Soil types: Mispah, Avalon, Hutton, Clovelly, Witbank and Bainsvlei soils (*left to right*).

Figure 9 shows the diagnostic horizons of the Mispah, Avalon, Hutton, Clovelly, Witbank and Bainsvlei soils classified according to the *South African Taxonomical Soil Classification System* summarised in **Table 2**:

TABLE 2. SOIL TYPES

SOIL TYPE	DIAGNOSTIC HORIZONS	EFFECTIVE DEPTH (MM)
Mispah	Orthic A – Horizon/Rock	<300
Avalon	Orthic A – Horizon/Yellow Brown Apedalic B – Horizon/Soft Plinthic B – Horizon	>300
Hutton	Orthic A – Horizon/Red Apedalic B – Horizon/Unspecified	>300
Clovelly	Orthic A – Horizon/Yellow Brown Apedalic B – Horizon/Unspecified	>300
Witbank	Human Made Soil – disturbed	<300
Bainsvlei	Orthic A – Horizon/Red Apedalic B – Horizon/Soft Plinthic B – Horizon	>300

4.5 Objective 3: Agricultural potential

The agricultural potential was assessed using the following formula as a function of various variables:

$$YIELD\ (kg\ ha^{-1}) = R/B \times ED/A \times C \times X$$

Where:

R **–** Rainfall (mm)

B - Species growth characteristics factor.

ED - Effective depth of the soil.

A - Soil wetness factor for textural classes of soil above effective depth.

C - Correction factor for aeration of soil.

X - Fixed coefficient for species.

The main variables determining the soil's agricultural potential (**Table 3**) include the **effective depth** (>300mm), **clay content** (15%) and **rainfall** (650mm).

TABLE 3. AGRICULTURAL POTENTIAL OF SOILS.

SOIL TYPE	AGRICULTURAL POTENTIAL	
	DRY LAND	IRRIGATION
Mispah	Low	Low
Avalon	Low	Medium
Hutton	High	High
Clovelly	High	High
Witbank	Low	Low
Bainsvlei	Low	Medium

4.6 Objective 4: Assessment of erodibility of soils and evidence of misuse

The exchangeable sodium percentage of the soils is below 15% of the cation exchange capacity, rendering the soils free of dispersion anomalies caused by the hydration of sodium and consequent soil erosion.

4.7 Objective 5: Land Use & Land Capability

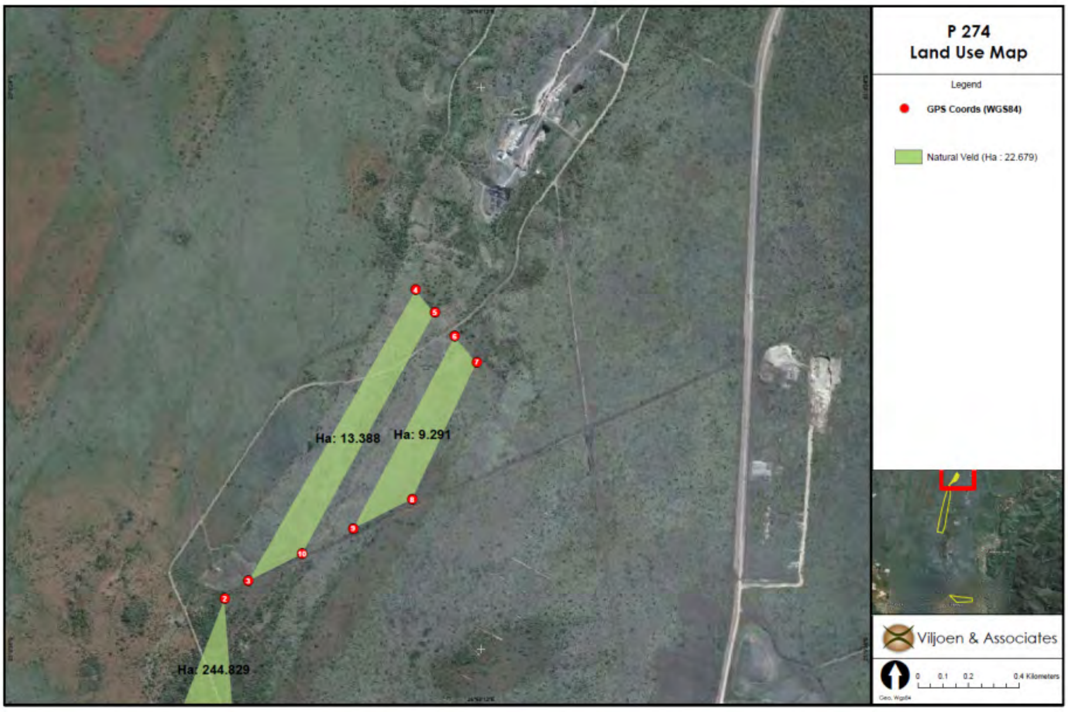

Figure 10. Land use.

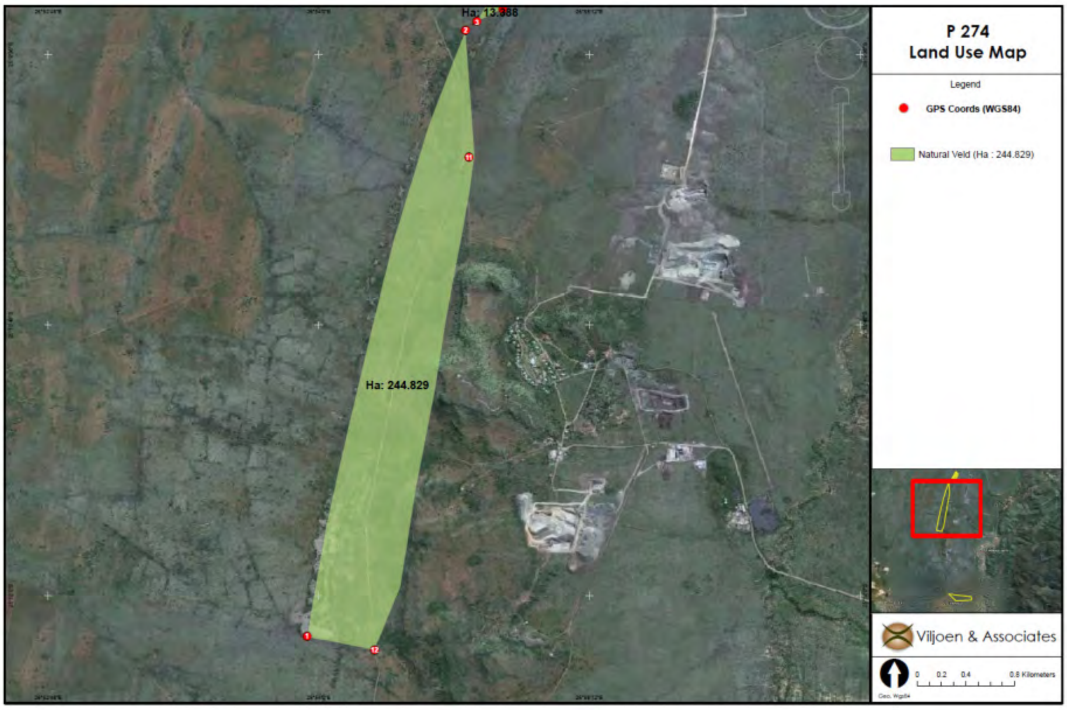

Figure 11. Land use.

Figure 12. Land use.

Table 4 summarises the *land use* (**Figures 10, 11 and 12**) of the area investigated:

TABLE 4. LAND USE

Area	Land Use	Surface Area (ha)	% of Total
Volclay Bathlako Mining	Natural Veld	360	100
	Total	**100**	**100**

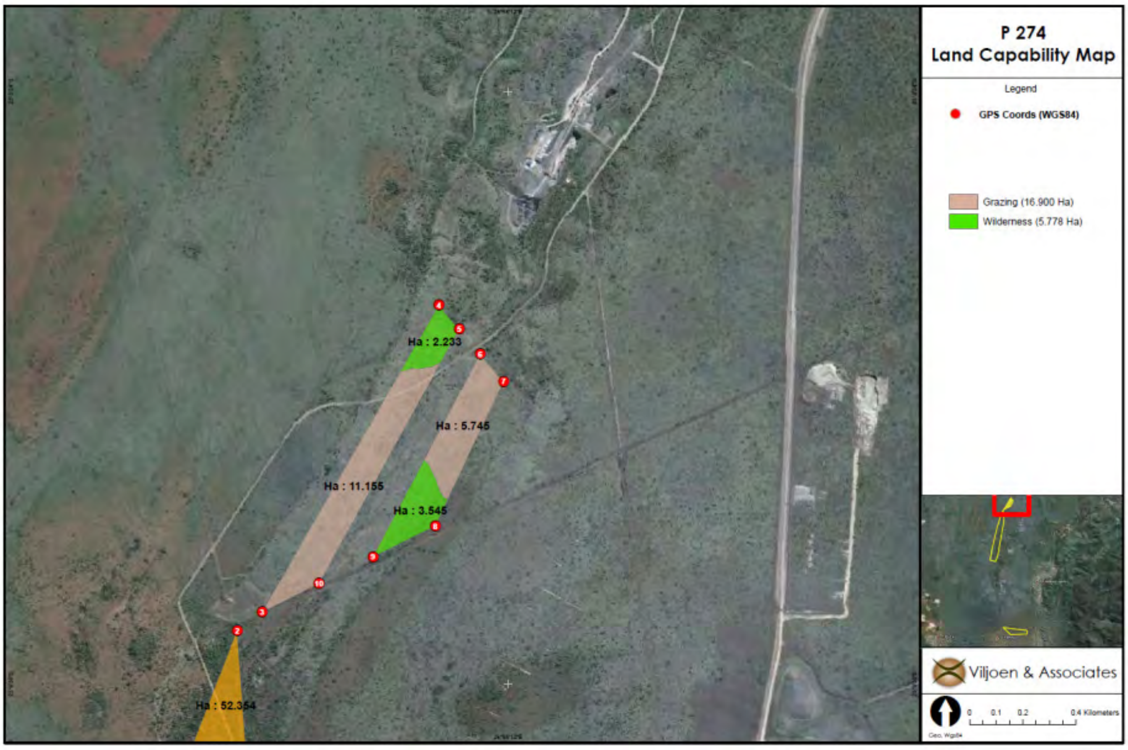

Figure 13. Land capability.

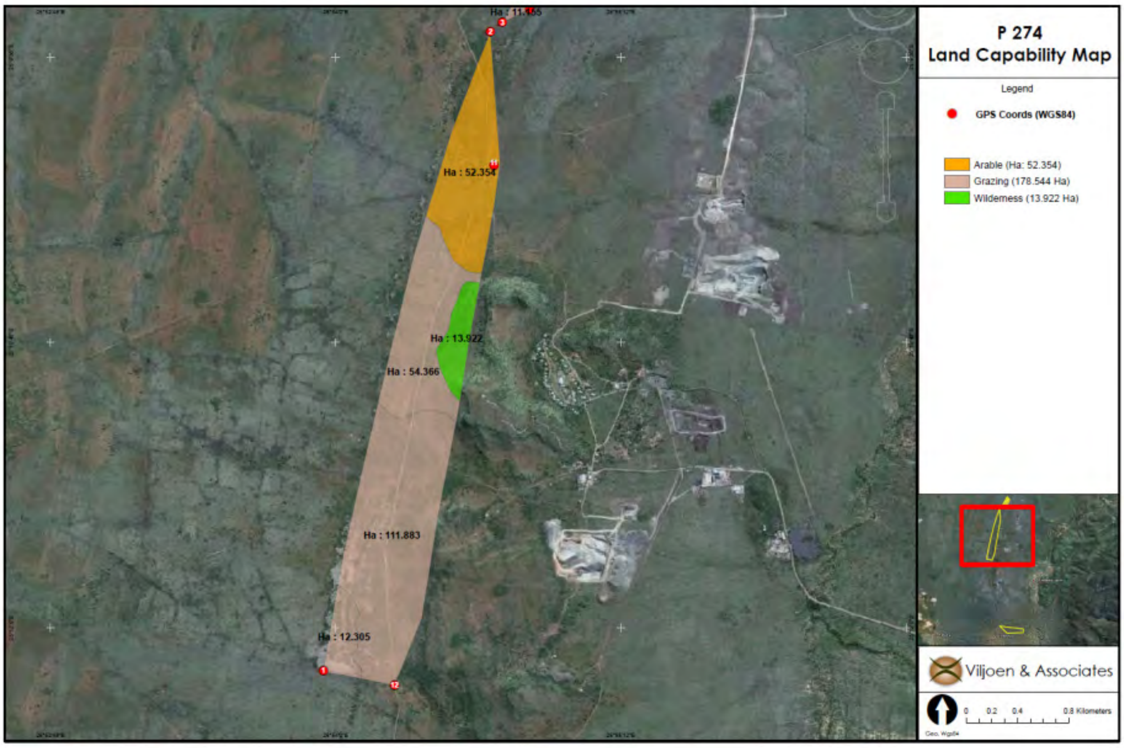

Figure 14. Land capability.

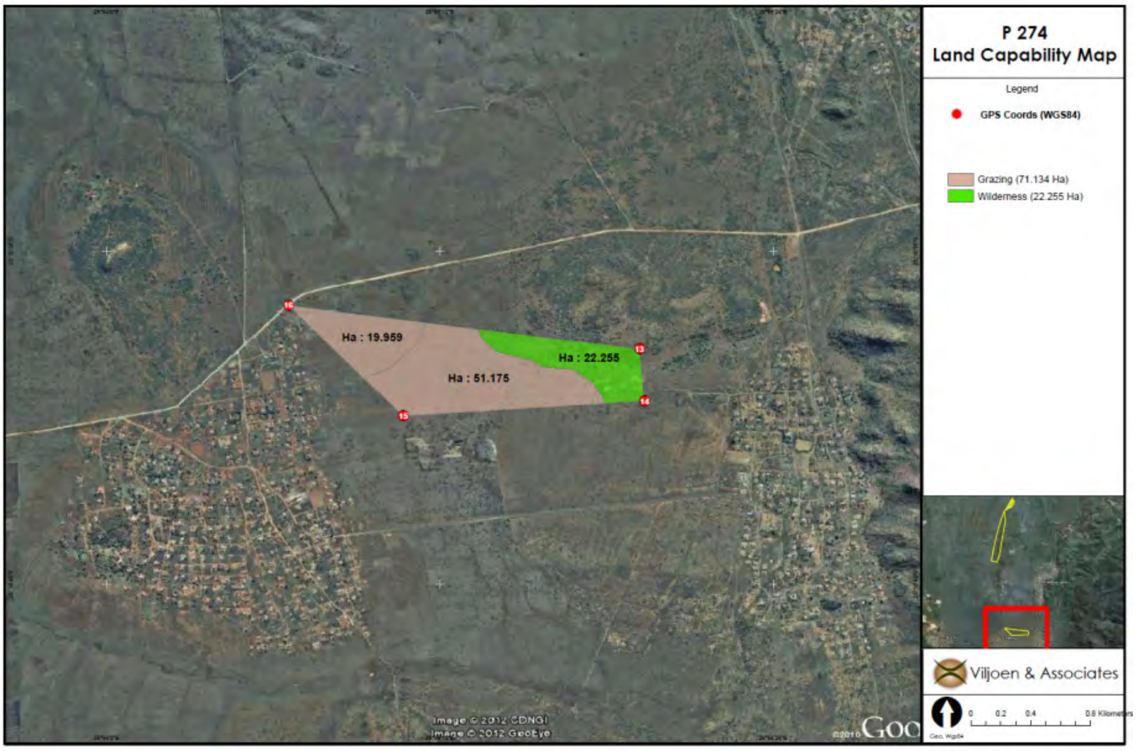

Figure 15. Land capability.

Table 5 summarises the *land capability* (**Figures 13, 14 and 15**) of the area investigated:

TABLE 5. LAND CAPABILITY

Area	**Land Capability**	**Surface Area (ha)**	**% of Total**
Volclay Bathlako Mining	Arable	52	14
	Grazing	266	74
	Wilderness	42	12
	Total	**360**	**100**

4.8 Objective 6: Soil stripping utilisation guide and plan

It is recommended that all usable soil be stripped and stockpiled in advance of activities that might contaminate the soil.

The stripped soil should be stockpiled upslope of areas of disturbance or development to prevent contamination of stockpiled soils by dirty runoff or seepage. All stockpiles should also be protected by a bund wall to prevent erosion of stockpiled material and deflect surface water runoff.

Stockpiles can be used as a barrier to screen operational activities. If stockpiles are used as screens, the same preventative measures described above should be implemented to prevent loss or contamination of soil. The stockpiles should not exceed a maximum height of 6m and it is recommended that the side slopes and surface areas be vegetated in order to prevent water and wind erosion. If used to screen construction operations, the surface of the stockpile should not be used as a roadway as this will result in excessive soil compaction.

A conservative estimate of available topsoil to be stripped is summarised in **Table 6**.

TABLE 6. AVAILABLE TOPSOIL FOR REHABILITATION PURPOSES.

Soil Type & Average Effective Depth (mm)	**Size (ha)**	**Available Volume (m^3)**
Avalon (300)	91	273,000
Hutton (1,200)	52	624,000
Clovelly (300)	111	333,000
Bainsvlei (300)	51	153,000
	TOTAL	**1,383,000 @ BD: 1,275kg/m^3**

A total area of 415ha could potentially be covered 300mm thick @ bulk density 1,275kg.m^3 during rehabilitation taking into consideration a 10% loss of topsoil from the 1,383,000m^3 due to handling, compaction *etc*.

4.9 Objective 7: Overview of basic soil chemical, physical and mineralogical properties of soils

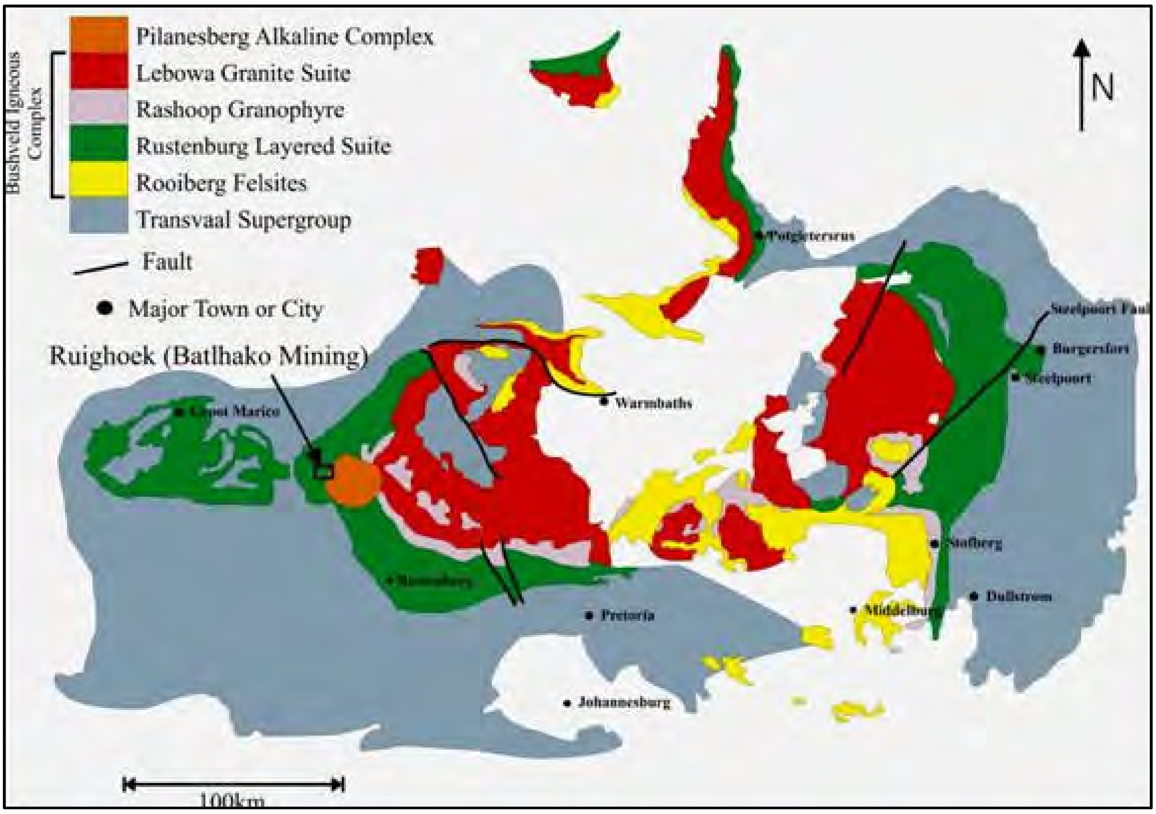

Figure 16. Geology of study area.

The main geological feature within which the farms Groenfontein, Vlakfontein, Ruighoek and Vogelstruisnek are located is the Bushveld Complex, a saucer-shaped volcanic intrusion about 375km wide (east to west) and 300km north to south. It is approximately 2 billion years old. Mineralization at the proposed mining areas is associated with the *Lower Critical Zone* and *Lower Zone* of the *Rustenburg Layered Suite*, which comprises a layered sequence of pyroxenites, bronzitites, harzburgite, and dunites inter-layered with chromitites. Weathering of the geology would yield low clay content light textured well drained soils. The chemical, physical and mechanical properties of these soils would be dictated by 1:1 layer silicates (*colloidal fraction <0,002mm*) weathered from the mineralogy of the geology.

The Mispah, Avalon, Hutton, Clovelly, and Bainsvlei soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15mg/kg) and potassium (>50mg/kg) are readily available for plant uptake and sustainable plant growth.

The Orthic A-Horizon is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10mm/h.

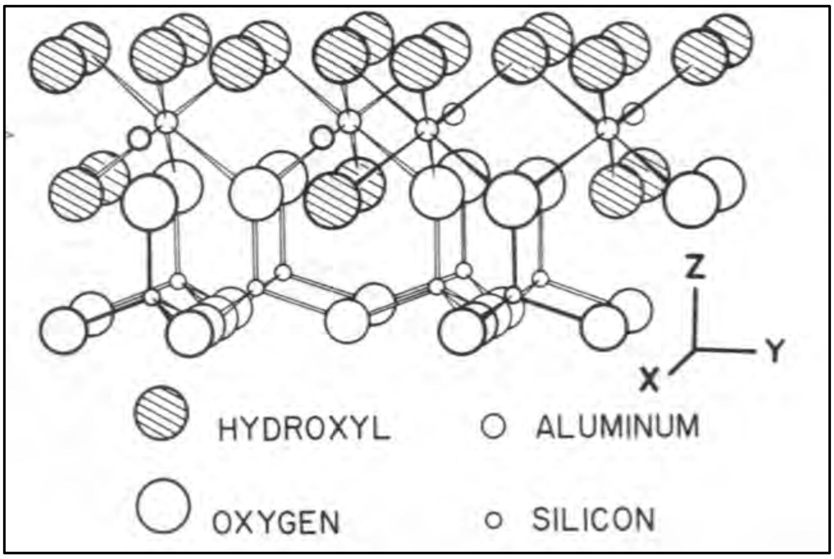

Figure 17. 1:1 Clay mineral (*left*) 2:1 clay mineral (*right*).

The dominant clay mineral in the *Orthic A – Horizon, Yellow* & *Red Apedalic B – Horizon* is kaolinite (1:1 layer silicate) (**Figure 17**), with a low buffer capacity due to the low cation exchange capacity (<10cmol+/kg). This is a significant attribute to be considered during soil remediation and rehabilitation planning.

4.10 Objective 8: Assessment of suitability of soils for rehabilitation purposes.

The soil horizons specified in *Section 4.4 p13* of the soil types are suitable for rehabilitation purposes.

When uncontaminated stockpiled soils have been replaced during rehabilitation, the soil fertility should be assessed to determine the level of fertilisation required to sustain normal plant growth. The fertility remediation requirements need to be verified at time of rehabilitation. The topsoil should be uniformly spread onto the rehabilitated areas and care should be taken to minimise compaction that would result in soil loss and poor root penetration.

When returning soil to the rehabilitation site care should be taken to place soil in a manner that will allow for levelling of soil to take place in a single pass. The soil profile should not be built up using a repeated tipping and levelling action to increase the soil depth.

Proper water control measures should be implemented to ensure a free draining rehabilitated landscape.

4.11 Objective 9: Impact assessment

The potential significance of environmental impacts identified during topsoil stripping was determined by using a ranking scale, based on the following (the terminology is from the DEAT guideline document on EIA Regulations, April 1998):

Occurrence

Probability of occurrence (how likely is it that the impact may occur?), and duration of occurrence (how long may it last?)

Severity

Magnitude (severity) of impact (will the impact be of high, moderate or low severity?), and scale/extent of impact (will the impact affect the national, regional or local environment, or only that of the site?).

In order to assess each of these factors for each impact, the following ranking scales **(Table 7**) were used:

TABLE 7. RANKING SCALES FOR IMPACT ASSESSMENT.

Probability:	Duration:
5 – Definite/don't know	5 – Permanent
4 – Highly probable	4 - Long-term (ceases with the operational life)
3 – Medium probability	3 - Medium-term (5-15 years)
2 – Low probability	2 - Short-term (0-5 years)
1 – Improbable	1 – Immediate
0 – None	
Scale:	**Magnitude**:
5 – International	10 - Very high/don't know
4 – National	8 – High
3 – Regional	6 – Moderate
2 – Local	4 – Low
1 – Site only	2 – Minor
0 – None	

Once the above factors had been ranked for each impact, the environmental significance of each was assessed using the following formula:

SP = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). Environmental effects were rated as either of high, moderate or low significance on the following basis:

- More than 60 significance points indicated high environmental significance.
- Between 30 and 60 significance points indicated moderate environmental significance.
- Less than 30 significance points indicated low environmental significance.

TABLE 8. IMPACTS ON SOIL

Environmental component	Potential impact	Activity/Reason	Environmental significance score						Criteria for magnitude	Mitigation measures
			P	D	S	M	Total	Rating		
Soil	• Loss of topsoil	• Stripping, handling and placement of soil associated with pre construction land clearing and rehabilitation	4 2	2 3	1 1	8 4	56 24	SBM SAM L	**High:** Loss of finite resource due to poor stripping **Low:** Recovery of as much usable soil material as possible	• *Strip all usable soil, irrespective of soil depth*
	• Change to soil's physical, chemical and biological properties	• Loss of topsoil through erosion. • Stockpiling of soils • Mixing of deep and surface soils during handling, stockpiling and subsequent placement	4 3	3 3	1 1	8 4	64 28	SBM SAM L	**High:** Soil properties are changed to such an extent that the associated agricultural potential cannot be maintained and/or realised. **Low:** Change to soil properties do not adversely affect land capability.	• *Implement live placement of soil where possible* • *Improve organic status of soils* • *Maintain fertility levels* • *Curb topsoil loss*
	• Cumulative effect on soil	• Change in natural surface topography due to reprofiling of surface after stripping	4	3	1	4	32	SBM L	**High:** Agricultural potential is compromised. **Low:** Pre-mining agricultural potential is maintained.	• *No specific measures are required. Stipulated remedial measures must be implemented*

4.11.1 Construction phase

<u>Loss of topsoil and usable soil</u>

Land transformation will lead to some losses of topsoil during construction and soil stripping.

<u>Contamination of topsoil and stockpiled soil</u>

Topsoil may be contaminated during the construction. Soil contamination is the result of surface runoff and seepage.

Contamination of stockpiled soil may occur due to seepage or contact with dirty surface water.

<u>Soil erosion</u>

Soil stockpiles may be exposed to erosion by surface water and wind. The aspect that would cause erosion is runoff.

4.11.2 Operational phase

<u>Loss of topsoil and usable soil</u>

During the construction usable soil may be lost due to inefficient stripping practices.

<u>Contamination of soil</u>

Seepage from contamination sources may contaminate stockpiled soil or *in situ* soil that has not yet been stripped.

Depending on the chemical composition of dust pollution, soil adjacent to the mining areas may be contaminated.

Leakages or spillages from conveyor may contaminate adjacent soils.

<u>Soil erosion</u>

Surface runoff leads to soil erosion. Soil stockpiles will be exposed to erosion activities during operation of the tailings dam, return water dam and concentrator areas.

4.11.3 Decommissioning and Closure phase

Loss of topsoil and replaced soil

Soil that has been used for rehabilitation purposes may be lost due to erosion caused by surface water runoff.

Soil erosion

The consumption of potable water during rehabilitation may lead to soil erosion if not done efficiently.

Contamination of soil

Depending on the content of the dust pollution, soil adjacent to construction areas may be contaminated.

The generation of hazardous and non-hazardous waste may pose a risk of soil contamination through seepage.

Potential incidents such as failure may cause contamination of topsoil if spills take place.

Visual impact

The use of stockpiled topsoil for rehabilitation purposes will have a positive visual impact.

4.11.4 Post-closure phase

Soil erosion

Soil erosion may occur due to surface water runoff across the rehabilitated construction sites.

Contamination of soil

Seepage from all construction and mining areas may contaminate surrounding soil.

5 CONCLUSIONS

- The dominant soils according to the Taxonomical Soil Classification System of South Africa are Mispah, Avalon, Hutton, Clovelly, Witbank and Bainsvlei soils.

- The effective depth of the Avalon, Hutton, Clovelly and Bainsvlei soils exceed 300mm inclusive of the Orthic A – Horizons, Yellow and Red Apedalic B – Horizons.

- The agricultural potential under dry land and irrigation conditions is available in **Table 3** (**p15**). The agricultural potential of the Avalon and Bainsvlei soils is considered low to medium under dryland (*650mm/y rainfall*) and irrigation conditions (*>10-15mm/week 33-1,500kPa plant available water*). The Hutton and Clovelly soils have a high agricultural potential (dryland & irrigation).

- No evidence of soil erosion was observed on any of the soils during the investigation.

- The current land use include natural veld (100%). Land capability includes 14% arable, 74% grazing and 12% wilderness of the total investigation area.

- A soil stripping stockpiling strategy is given on **p20 (Table 6)**. An estimated total area of 415ha could potentially be covered 300mm thick @ BD 1,275kg.m^3 during rehabilitation taking into consideration a 10% loss of topsoil from the 1,383,000m^3 due to handling, compaction *etc*. The soil horizons specified in **Section 4.4 p12** of the Avalon & Bainsvlei (*except Soft Plinthic B – Horizons*) and Hutton & Clovelly soil types are suitable for rehabilitation purposes.

- The Mispah, Avalon, Hutton, Clovelly, and Bainsvlei soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15mg/kg) and potassium (>50mg/kg) are readily available for plant uptake and sustainable plant growth. The Orthic A-Horizon is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10mm/h. The dominant clay mineral in the *Orthic A – Horizon, Yellow* & *Red Apedalic B – Horizon* is kaolinite (1:1 layer silicate), with a low buffer capacity due to the low cation exchange capacity (<10cmol+/kg). This is a significant attribute to be considered during soil remediation and rehabilitation planning.

- The potential impacts and reasons/activities with proposed mitigation measures on the soil due to construction activities include:

- *Loss of topsoil*:

  This is due to stripping, handling and placement of the soil associated with the pre construction land clearing and rehabilitation and it is recommended to strip all usable soil irrespective of soil depth.

- *Change to soil's physical, chemical and biological properties*:
  There is a high probability that topsoil will be loss due to wind and water erosion, which will alter the soils properties. Stockpiling and subsequent mixing of soil layers during handling will ultimately have a negative effect on altering the basic soil properties. It is suggested to implement live management and placement of topsoil where possible, improve the organic content of the soils, and maintain fertility levels through fertilisation and to curb topsoil loss as much as possible.
- *Cumulative effect of the soil:*
  Alteration of the natural surface topography due to reprofiling during construction after stripping will have an accumulation effect on the soils and careful consideration should be given to minimise compaction and ensure free drainage preferential surface water pathways.

6 REFERENCES

VAN DER WATT H. AND VAN ROOYEN, T.H. 1990. A Glossary for Soil Science. V&R Printing Works (Pty) Ltd.

This investigation was done on available information and subsequent interpretation of data to reveal the properties on site with the techniques described.

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