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14 November 2013

SPECIALIST STUDY: SOIL CLASSIFICATION AND LAND CAPABILITY: Environmental Study for the Greater Soutpansberg Project: CHAPUDI
RFQ No: GSP-RFQ-004

Attached please find the final Soil and land capability report for the Chapudi Project.

Yours sincerely

....
Setenane Nkopane
For Gudani/Eco Soil Consortium

....
Francois Botha
for Gudani/Eco Soil Consortium

Final Soil Specialist Report on the Environmental Study for the Greater Soutpansberg Project: CHAPUDI

RFQ No: GSP-RFQ-004

Compiled

By

gudaniconsulting
ENVIRONMENTAL & SOCIAL SCIENTISTS

ECOsoil

Report by F. Botha and A. M. Hattingh

November 2013

STATEMENT OF INDEPENDANCE AND PROFESSIONAL AFFILIATION

We, the undersigned, hereby declare that we are not involved in any way with Coal of Africa Limited.

We conducted this survey in a scientific and impartial manner and declare that the findings of this report are free from influence or prejudice.

………………………………
Setenane Nkopane
For Gudani/Eco Soil Consortium

Field of expertise:

…………………………………………
Francois Botha
for Gudani/Eco Soil Consortium

Field of expertise: Soil classification and land capability studies

....

Astrid Hattingh
For Gudani/Eco Soil Consortium
Field of expertise: Soil Scientist and GIS Specialist

Date: 2013/11/14

EXECUTIVE SUMMARY

Coal of Africa Limited (CoAL) requested a detailed EIA study for the proposed opencast mining operations at the Greater Soutpansberg: CHAPUDI.

According to the parent material map the study area has Amphibolite, Serpentine, Granulite, Siliciclastic rocks, and Marble and calc-silicate rocks as parent material (Figure 1) which has an influence on soil properties of the area. According to the 1:250 000 land types map the seven specific ecotopes for the area under investigation are mainly red to yellow apedal soils, as well as shallow Glenrosa/Mispah soils and Rocky areas (Figure 2).

The topography of the area varies between level plains to a rolling landscape with slopes of 2-3% (largest parts of the area), open high hills or ridges, as well as high hills and ridges (small areas in the south western parts of the area).

The climate of the area is typified by warm to hot summers with low rainfall and high evaporation and dry warm winters. An assessment of the long-term rainfall records, indicate a mean annual rainfall of between 308-668mm within the study area.

- According to previous studies, combined with the present study the following land use areas were found for the total project area (surveyed and non-surveyed areas):
    - Commercial (or cleared) land: 2236ha. (537 ha irrigated and 1699ha dry land)
    - Degraded: Forest and woodland: 2816ha.
    - Thicket and Bushland: 13921 ha
    - Woodlands: 21158ha
    - Bare Rock and Soil (natural): 26ha
    - Wetlands: 403ha

- The soil investigation on the proposed area was done with a soil auger on a grid system (1observation/9ha for the footprint and 1observation/25ha for the mining right area). The soils were classified according to the SA Taxonomic system. Soils

were grouped into soil associations with the same physical characteristics e.g. colour, texture, and depth.

- Access was denied on all the farms west of the Sand River and some farms east of the Sand River and could therefore not be surveyed (Figure 1). Generalisations of the land capability and agricultural potential were derived from the 1:250 000 land-type study for areas not surveyed. This is presented in Figures 15 and 16 respectively.

- Only 16171ha of the total project area was surveyed. The majority of farms are on the eastern side (Chapudi and Wildebeesthoek) of the original project area (Figure 1). Different soil properties of the surveyed areas are illustrated in Figures 17 to 21. The land capability assessment of the surveyed are is presented in Figure 22.

- Table 15 presents the different categories and areas for the **surveyed farms** according to the Mining classification:
    - Arable land 9120 ha (56,4%)
    - Grazing areas 3751ha (23.2%)
    - Wilderness areas 3114ha (19.3%)
    - Wetland areas 186ha (1.1%).

- Table 16 presents the different categories and areas for the **surveyed footprint** area, according to the Mining classification:
    - Arable land 2594 ha (38.2%)
    - Grazing areas 2509ha (36.9%)
    - Wilderness areas 1576.7ha (23.2%)
    - Wetland areas 116.4ha (1.7%).

- There are significant differences between the information presented in Figure 16 and Figure 22 respectively. The differences are due to the small scale of survey that was used with the land type study compared to the more detailed soil survey for this specific project. From the differences between Figures 16 and 22 and it can be concluded that it is crucial to do a more detailed soil investigation on the farms not yet surveyed, in order to obtain a better and more accurate assessment of the land capability and agricultural potential.

- Additional factors like soil chemistry, topography, terrain, climatic factors and water quality were brought into account to determine the agricultural potential of the soils, which were classified according to Klingebiel and Montgomery (1961) (Table 4 and 5).
    - 9120ha is classified as arable soils according to the mining classification. Although there are areas of deep soils, these soils are marginal for dry-land crop production due to climatic and erosion restrictions. As a result of low rainfall, high temperatures (high evapotranspiration), susceptibility to soil compaction, water and wind erosion potential, the soils in the area study are not recommended for rain fed dry land crop production.
    - Approximately 2594 ha of the surveyed footprint area east of the Sand River (Chapudi and Wildebeesthoek) is deeper than 75cm and can be regarded as class III for crop production when rainfall permits or when high quality water for irrigation is available.

- Footprint areas west of the Sand River were not surveyed, but from Figure 15 it can be concluded that large areas of the proposed footprint have arable soils.

- At present (2236ha) in the project area are presently under cultivation (1699ha dry land and 537ha irrigated).
    - These areas generally have deep soils and are suitable for crop production especially under irrigation when sufficient amount of good quality irrigation water is available.
    - Rainfall is in general too low for rain-fed crop production, however areas near the hills have higher rainfall (even 400 to 550mm as indicated in Figures 11 and 12) and cultivated pastures may be an option for farmers.

- Shallow soils and surface rock are present in large areas to the south of the proposed project area. Areas classified for grazing have presently low basal grass cover and are dominated by Mopane shrub field and will be discussed in detail by the biodiversity report. Present land use of these shallow soils is cattle and game farming, but carrying capacity is questionable due to poor physical soil quality (erosion susceptibility, shallow soils, surface rock and poor climatic conditions).

- Almost the entire area has very low clay contents of between 3 and 10% which makes it susceptible for wind erosion. Profile available water capacities are high (above 125mm) in large areas. This confirms the suitability for irrigation.

- Overall soils of this area have a marginal dry land potential and any disturbance of such a magnitude will have a long term to permanent impact on the land capability and agricultural soil potential. Special measures must be implemented in the soil stripping and rehabilitation process to restore the soils to an arable and grazing potential (see Appendix). Specialist consultation is needed for the wind erosion potential of the area during stock piling and the soil stripping process.

- Twenty six water samples were taken across the study area by WSM Leshika. These samples are from boreholes only. No samples were taken from the Sand and Mutamba Rivers. The dataset was used to interpret water quality for irrigation purposes. Results are summarized in Table 14.
  - Eleven (11) of the 26 tested water sources are highly suited for irrigation purposes, with absolutely no restrictions to irrigation. These boreholes are situated near the hills in the southern parts of the project areas (Figure 21).
  - Some of the water samples only have minor suitability constraints and can be used for irrigation if it is well managed.
  - The quality of water of some of the boreholes further north of the hills, is less suitable for irrigation purposes with restrictions specifically to sensitive crops.
  - The quality of two boreholes (one each on the farms Chapudi and Kliprivier) are of very poor quality for irrigation purposes.

- Water samples were taken during the winter and it is recommended to make a continual assessment of water quality during the year, since it can change significantly during the year.

- If mining should be allowed in the area the following is recommended:
  - Specialist consultation is needed for the severe wind erosion potential and other possible impacts of the area during stock piling and the soil stripping process.
  - Limit impacts to footprint areas to keep physical impacts as small as possible.

- Specific control measures are needed to control erosion and water run-off to prevent excessive surface run-off from the site.
- Areas for road and site lay-out should be minimized.
- Dust generation and vehicle associated pollution must be minimized.

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GLOSSARY OF TERMINOLOGY

- **A-Horizon (30)**. The depth of the topsoil horizon.
- **B-Horizon (100)**. The bottom end of the sub-soil horizon.
- **G** – The percentage (G3 = 30%) of gravel soil (>2mm) in the total soil profile. This portion has a huge influence on the water holding capacity and water movement (permeability) in the soil.
- **R** – The percentage of rocks in the profile. This has an influence on land preparation as well as the water holding capacity of the soil.
- **Restriction layer:** It can be rock fragments, soil structure or hydromorphic soil conditions that can limit root development.
- **Profile available water capacity (PAWC)–** It is a calculation between the AWC multiplied with the effective rooting depth (ERD). TAM values are therefore the most important value to determine from an irrigation design and scheduling perspective. It is also mentioned as total available moisture (TAM)
- **Effective rooting depth (ERD)**. This is the average depth that roots will develop under irrigation or where they are limited by an impeding layer. The effective rooting depth is the most important from a management perspective, which includes irrigation design, water holding capacity, drainage and nutrition.
- **Topsoil**: Is defined as the A-Horizon and a portion of the red and yellow apedal A-Horizon where microbial activity takes place and the majority of the plants hair roots occur.
- **Soil Forms:** Soil Forms are identified according to the SA Taxonomic Soil Classification system
- **Kriging or kriged:** A group of geostatistical techniques to interpolate the value of a random attribute (e.g., depth or clay content, of the landscape as a function of the geographic location) at an unobserved location from observations of its value at nearby locations.

1. INTRODUCTION

A broad soil classification, chemical composition and agricultural potential were done on approximately 16171 (6690ha footprint area) to get baseline information regarding soil potential, land use and land capability. Due to accessibility problems only a few of the farms in the eastern parts could be surveyed. Profile pits could not be opened due to limitations with access and time constraints, as land owners are hosting surveyors in the peak hunting season.

The farms surveyed, not surveyed or partly surveyed during this study are illustrated in Map 1.

The following farms were fully surveyed on the recommended grid:

- Driehoek
- Pienaar
- Castle Koppies
- Mopanikop
- Sandstone Edge
- Mopani Ridge
- Malapchani
- Qualipan
- Mtamba Vlei
- Kalkbult
- Woodlands
- Bushy Rise
- Blackstone Edge
- Sandilands

The following farms were partly surveyed:

- Rochdale
- Coniston

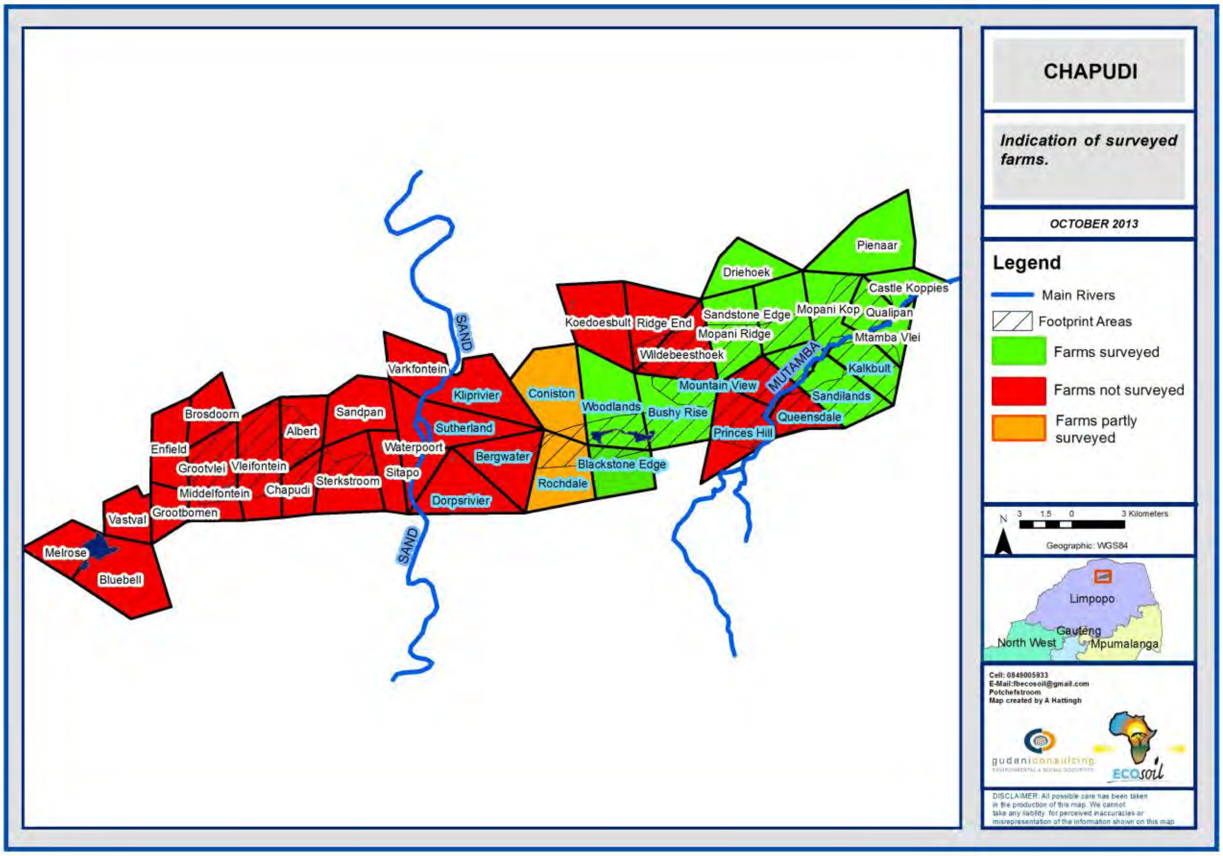
No soil surveys were done on the following farms due to the resistance of the farmers to enter the farms:

- Queensdale
- Mountain View
- Princess Hill
- Koedoesbult
- Ridge End
- Wildebeesthoek
- Kliprivier
- Sutherland
- Bergwater
- Dorpsrivier

As well as the entire Chapudi West which consist of the following farms:

- Albert
- Bluebell
- Brosdoorn
- Chapudi
- Enfield
- Grootbomen
- Grootvlei
- Melrose
- Middelfontein
- Sandpan
- Sitapo
- Sterkstroom
- Varkfontein
- Vastval
- Vierfontein
- Waterpoort

Figure 1: Map showing farms surveyed, partly surveyed or not surveyed



The soil investigation on the proposed area was done with a soil auger on a grid system. Applying these criteria where possible to soils that were mapped based on the limitations of the soils' chemical and physical characteristics and site constraints. A combination of these variables was then used to obtain the land capability and agricultural potential of the soils.

Soils were classified in terms of the Taxonomic System for South Africa. Land capability of the study area was classified into four classes (wetland, arable land, grazing land and wilderness) according to Coaltech 2020/ Chamber of Mines of SA 2007 and Chamber of Mines Guidelines (1991).

2. TERMS OF REFERENCE (ToR)

The ToR for the soil assessment is outlined as follows:

To perform the necessary soil impact assessment required to support the applications. It should include (as a minimum):

- Detail soil, land use and land capability mapping
- Potential impact and quantification thereof (as far as possible) on soils, land use and land capability
- Recommendations for mitigation measures to reduce the identified impacts
- Conceptual rehabilitation plan based on soil types - no soil utilisation plan required at this stage due to limited information on infrastructure and mining footprints

The following sampling intensity to be used:

- Larger MRA area - Broad Reconnaissance (500m grid, 1 observation per 25 ha)
- Resource footprint - Intensified Reconnaissance (300m grid, 1 observation per 9 ha).

3. PROBLEM STATEMENT AND STUDY OBJECTIVE

Soils occurring on the proposed development area will be disturbed during the mining operation. Any medium to long-term impacts after mining needs to be limited. The purpose of this study is to identify the present soil quality in terms of soil forms, as well as their physical and chemical characteristics and how they will react to any disturbance.

4. PROJECT TEAM

Complete Curriculum Vitae's are summarised in Appendix 2.

Table 1: List of the team members

SPECIALISTS	FUNCTION	QUALIFICATION
S. Nkopane	Project Management, Liaison and communication	M.Sc., Environmental Management
F Botha	Soils project leader	B.Sc. (Hon), Pedology
A.M. Hattingh	Pedologist, GIS Specialist	M.Sc. (Soil Science)
J.M. Hattingh	Pedologist, Soil Chemist	M.Sc. (Engineering geology)
J.L. Pauer	Pedologist	B.Sc. (Hon,) Pedology
JHA Thiart	Pedologist	Soil Pedology Technician
MJ Botha	Pedologist	Soil Pedology Technician

5. IDENTIFICATION OF RELEVANT LEGAL REQUIREMENTS AND GUIDELINES

A soil classification and agricultural potential study is required with every EIA where agricultural land is concerned.

6. INVESTIGATIVE METHODOLOGY AND TECHNIQUES

The investigation commenced conducting the following actions:

- The collation and evaluation of available information.
- A soil survey was conducted on a total area of approximately 16171ha during this study.
- The soil survey involved the traversing of the area on a grid base using a conventional bucket hand auger (1.5 m in length) to investigate and log the soil depths. More than 1088 points were logged (Figure 2) in the Eastern parts of the study area. Selected terrain information, topography and any other infield data of significance, and of relevance to the investigation, was used.
- The land capability of the study area was classified according to soil depth and PAWC, as well as the elevation of the area. Observation point data was transformed with a process called kriging to a 100 by 100meter grid (1ha). On this grid basis it was decided in which of the four represented land potential groups (arable land, grazing, wilderness or wetland) each hectare falls, as is outlined by guidelines from the Chamber of Mines (1991). Wetlands were first delineated and polygons for the

other groupings were then drawn from the kriged data. Detached areas smaller than one hectare was ignored.

- Profile Available Water Capacity (PAWC) was calculated by using soil form, soil depth and clay content.
- The data was recorded and stored in an electronic format (data base), and the information was then mapped with the ArcGIS program (See Figures 1 to Figure 22). Figures were created based on GPS information (Geographic: WGS 84). The field information was used to determine the Land capability.
- Twenty two top and sub soil samples (Table 9) were taken for chemical analysis. The positions of the samples are indicated in Figure 2.
- At each sampling point three soil samples were taken to a depth of 30cm. These three samples were then mixed thoroughly to get a composite representative sample for the area.
- Soil samples were sent to an accredited laboratory, namely NVirotek Laboratory at Brits (South Africa) for chemical analyses. pH (KCl), P (Bray 1), K, Ca, Mg Na and S (ammonium acetate) were determined. Ratios, CEC and percentages were calculated from the soil analyses.
- The chemical results were recorded in Table 9 and stored in an electronic format (data base).
- Twenty six water samples were taken across the study area by WSM Leshika. These samples include boreholes and samples from the Sand and Mutamba Rivers. The dataset was used to interpret water quality for irrigation purposes. Results are summarized in Table 14.

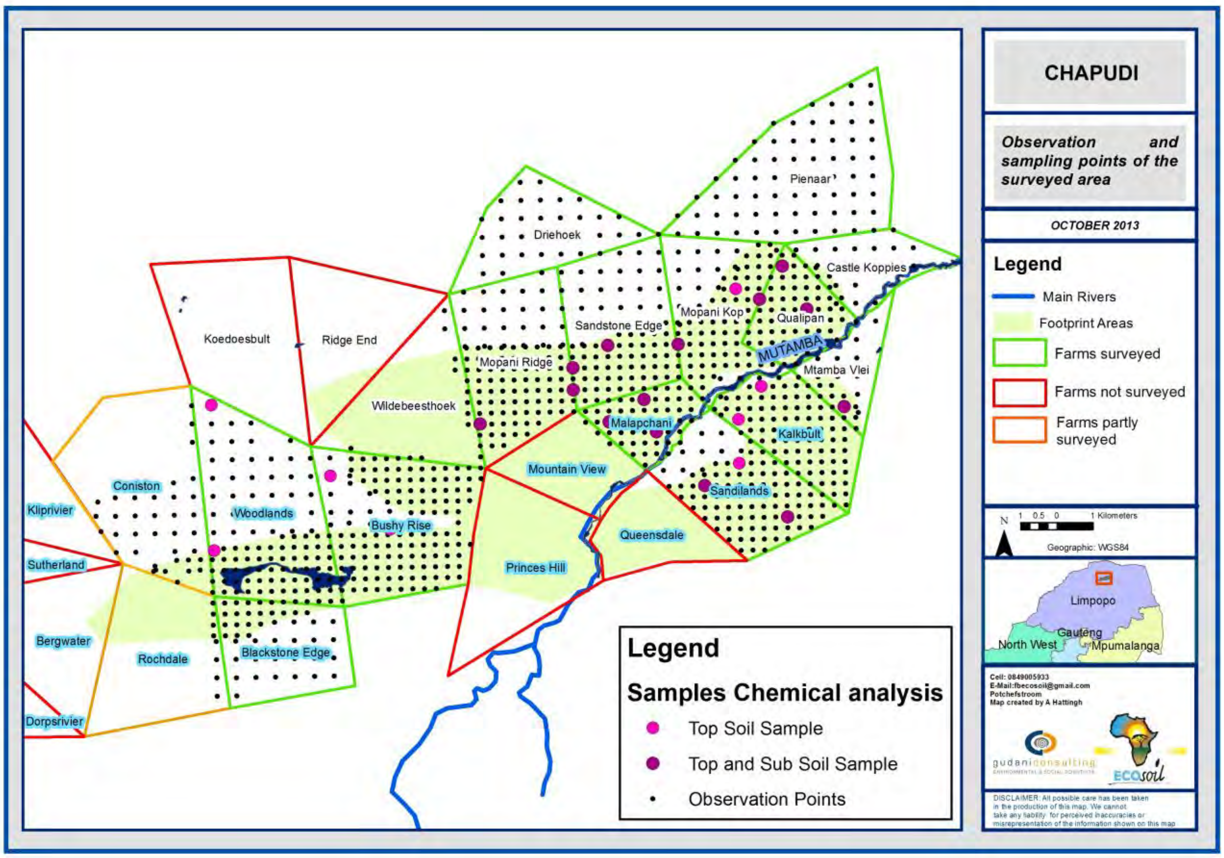
6.1 SOIL CLASSIFICATION

The investigation of the soils involved the traversing of the area on a grid base where possible, using a conventional bucket auger to investigate and log the soil characteristics. The following sampling intensity was used:

- Larger MRA area - Broad Reconnaissance (500m grid, 1 observation per 25 ha).
- Resource footprint - Intensified Reconnaissance (300m grid, 1 observation per 9 ha).

It was not possible to open profile pits due to restraints in terms of accessibility and time. Selected terrain information, topography and other infield data of significance, and of relevance to the soil investigation, was also recorded and stored in an electronic format (data base), and the information mapped on a recognised GIS system. Forty four top and sub soil samples were taken for chemical analysis (Positions where the samples were taken are indicated in Figure 2).

Figure 2: Observation and soil sampling points



Identification and classification of soil profiles was carried out using the TAXONOMIC SYSTEM FOR SOUTH AFRICA (*Soil Classification working group,* *1991*). Land capability of the study area was classified into four classes (wetland, arable land, grazing land and wilderness) according to Coaltech 2020/Chamber of Mines of SA (2007) and Chamber of Mines Guidelines (1991). In this way, standardised soil identification and communication is allowed by use of the names and numbers given to the soils classified. The procedure adopted when classifying soil profiles is as follows:

a. Demarcate master horizons
b. Identify applicable diagnostic horizons by visually noting physical characteristics such as:
    - Depth
    - Texture
    - Structure
    - Mottling
    - Visible pores
    - Concretions
c. Determine from a. and b. the appropriate Soil Form

6.2 INFORMATION SYSTEMS

The following sources of information were utilized:

- Initial maps supplied by Jacana
- Preliminary site layout plans
- ENPAT: Geology, Land use land capability, Land use, Land types
- Topo maps:
    - 2229CD Vetfontein,
    - 2229DC Waterpoort,
    - 2229DD Wylie's Poort
- Climate: Rasters University of Natal
- Remote sensing information:

- SRTM data
- *Google Earth*™ image; digital image - Background and cultivated fields

- Esri shape file information, ArcGIS.
- The Dept. of Agriculture's website (Agis) was used to determine land types.
- The Taxonomic system for South Africa was used to identify soil forms on the proposed site.
- Land Capability Classification Coaltech 2020/ Chamber of Mines of SA (2007) and Chamber of Mines Guidelines (1991).

7. GENERAL BACKGROUND INVESTIGATION

7.1 PARENT MATERIALS

The lithology of the area is:
Fine-grained felsic, siliciclastic sedimentary, as well as mafic and ultramafic volcanic rocks. It consists of arenite, gneiss, mudstone, sedimentary sands, shale and basalt.

Footprints are mainly on siliciclastic rocks and small areas on fine-grained felsic rocks, consisting of arenites and shale's.

The regional parent materials of the area are illustrated in Figure 3 and 4. The following parent materials are found in the area and may have an influence on the soil properties.

1. Alluvium, mudstone, sandstone, siltstone, shale and coal of the Clarens Formation and undifferentiated strata of the Karoo Sequence.
2. Alluvium, sand and calcrete of the Quaternary System. Basalt of the Letaba Formation and Lebombo Group. Shale, mudstone and sandstone of the Klopperfontein Formation. Both formations of the Karoo Sequence; also leucogneiss and amphibolite.

3. Basalt of the Letaba Formation in the Lebombo Group - Karoo Sequence. Leucogneiss, amphibolite, metapelite of the Malala Drift Group.
4. Sand of the Quaternary System.
5. Quartzite, conglomerate, sandstone and shale of the Stayt Formation, Soutpansberg Group; argillaceous sandstone of the Clarens Formation, Karoo Sequence.
6. Sandstone and conglomerate of the Wyllies Poort Formation and Soutpansberg Group.
7. Sandstone, shale, basalt and tuff of the Nzhelele Formation. Sandstone, conglomerate of the Wyllies Poort Formation. Both formations of the Soutpansberg Group. Also sandstone, shale and coal of the Karoo Sequence.
8. Shale, mudstone and sandstone of the Klopperfontein Formation. Basalt of the Letaba Formation, Lebombo Group, both from the Karoo Sequence. Leucogneiss, amphibolite and metapelite of the Malala Drift Group in the Beit Bridge Complex.
9. Shale, mudstone and sandstone of the Klopperfontein Formation. Basalt of the Letaba Formation, Lebombo Group, both from the Karoo Sequence. Leucogneiss, amphibolite and metapelite of the Malala Drift Group in the Beit Bridge Complex.
10. Shale, sandstone, siltstone, mudstone and conglomerate of the Karoo Sequence; also Sibasa-Basalt.

Figure 3: Parent materials of the western parts of the study area

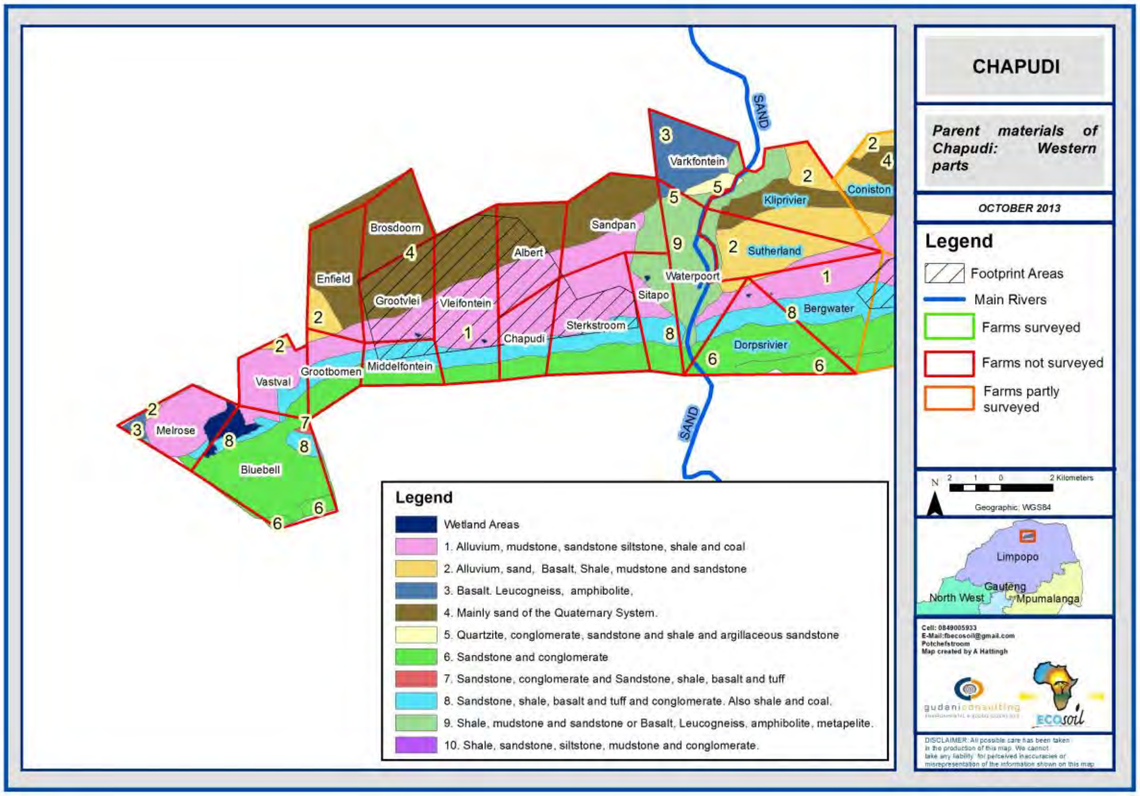
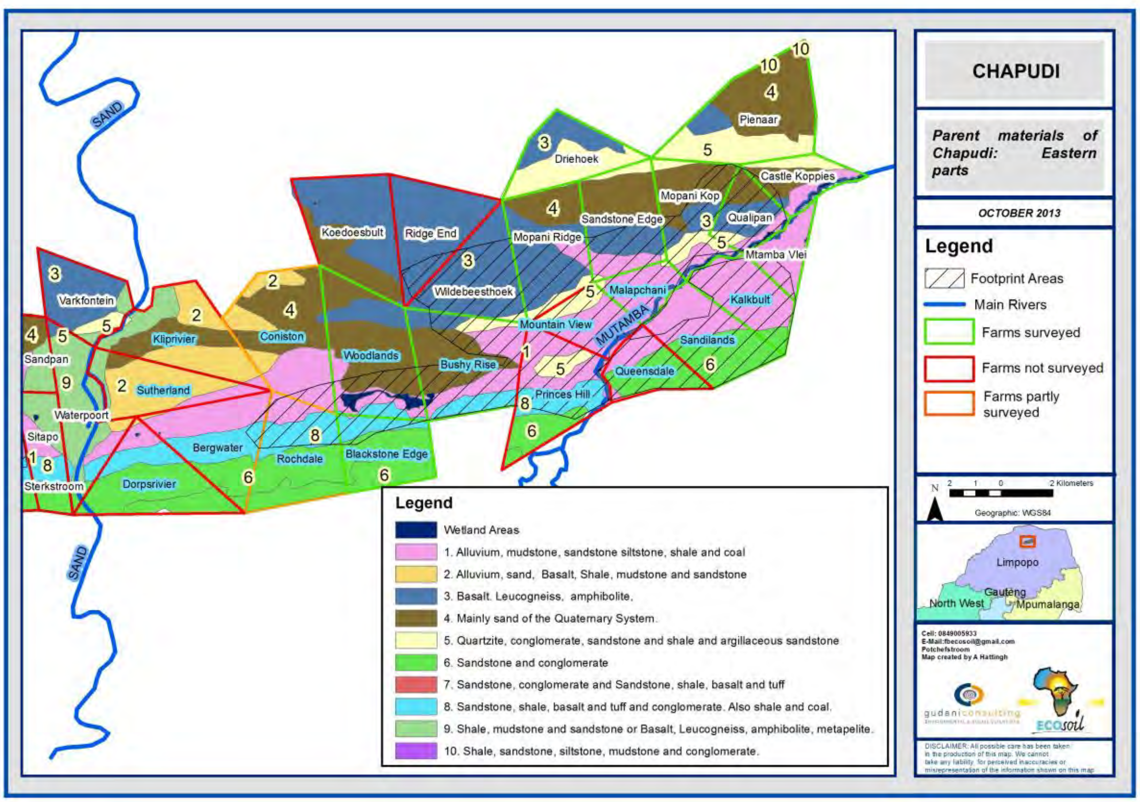


Figure 4: Parent materials of the eastern parts (Chapudi And Wildebeesthoek) of the study area



7.2 LANDTYPES

Twelve land types are found in the study area (Figure 5 and 6). Land types found in the study area, in the ranking order of area covered, are:

7.2.1 IA151: *MISCELLANEOUS LAND CLASSES.*

- Freely drained, structure less soils with favourable physical properties, but some areas may have restricted soil depth, excessive drainage, high erodibility, low natural fertility. Irrigation is possible in restricted areas within the land type.
- 8709ha.
- The parent material is alluvium, mudstone, sandstone siltstone, shale and coal.
- Water holding capacity 81 - 100 mm.

7.2.2 AE305: *RED-YELLOW APEDAL, FREELY DRAINED SOILS.*

- Red, high base status > 300 mm deep (no dunes). Freely drained, structure less soils. Favourable physical properties. May have restricted soil depth, excessive drainage, high erodibility, low natural fertility.
- 8191ha.
- Parent material is mainly sand of the Quaternary System.
- Soil depth is generally less than 750mm
- Plant available water content is between 41 - 60 mm, indicating low potential soils.

7.2.3 FC574: *GLENROSA AND/OR MISPAH FORMS (other soils may occur).*

- Lime generally present in the entire landscape. Freely drained, structure less soils with restricted soil depth, excessive drainage, high erodibility, low natural fertility, but with favourable physical properties.
- 5207ha.
- Parent material is basalt Leucogneiss and amphibolite.

- Soil depth less than 450mm.
- Plant available water content is between 21 - 40 mm, indicating very low potential soils.

7.2.4 FA641: *GLENROSA AND/OR MISPAH FORMS (But other soils may occur).*

- Lime rare or absent in the entire landscape. Undifferentiated shallow soils and land classes. Restricted land use options. Soil may receive water runoff from associated rock; water-intake areas.
- Parent material is sandstone and conglomerate.
- Plant available water content is between 21 - 40 mm, indicating very low potential soils.

7.2.5 AG174: *RED-YELLOW APEDAL, FREELY DRAINED SOILS.*

- Red, high base status <300 mm deep. The soils have favourable physical properties, but may have restricted soil depth, excessive drainage, high erodibility, low natural fertility.
- 2748ha.
- Parent material is sandstone, shale, basalt and tuff or either sandstone mixed with conglomerate. Shale and coal of the Karoo Sequence are also present.
- Soils are generally less than 450mm deep. Plant available water content is between 41 - 60 mm, indicating low potential soils.
- Freely drained, structure less soils.

7.2.6 IB312: *MISCELLANEOUS LAND CLASSES.*

- Restricted land use options. May have water-intake from other areas. Non soil land classes (rocky area).
- 1937ha.
- Parent material is quartzite, conglomerate, sandstone and shale as well as argillaceous sandstones.
- Soils are less than 450mm deep.

- Plant available water content is between 21 - 40 mm, indicating very low potential soils.

7.2.7 AE303: *RED-YELLOW APEDAL, FREELY DRAINED SOILS.*

- Red, high base status < 300 mm deep (no dunes). May have restricted soil depth, excessive drainage, high erodibility, low natural fertility. Freely drained, structure less soils.
- 1646ha.
- Parent material is alluvium, sand and calcrete and basalt, shale, mudstone and sandstone are also present.
- Soil depth is generally less than 450mm.
- Plant available water content is between 41 - 60 mm, indicating low potential soils.

7.2.8 IA152: *MISCELLANEOUS LAND CLASSES.*

- Undifferentiated deep deposits. Freely drained, structure less soils. Favourable physical properties, but some areas may have restricted soil depth, excessive drainage, high erodibility, low natural fertility. Irrigation is possible in restricted areas within the land type.
- 1387ha.
- Parent material is shale, mudstone and sandstone or basalt, leucogneiss, amphibolite and metapelite.
- Water holding capacity 61 - 80 mm.

7.2.9 IB394: *MISCELLANEOUS LAND CLASSES.*

- Rock areas with miscellaneous soils. Restricted land use options. May have water-intake from other areas. Non soil land classes (rocky area)
- 780ha.
- Parent material is sandstone and conglomerate.
- Plant available water content is between 21 - 40 mm, indicating very low potential soils.

7.2.10 IB362: *MISCELLANEOUS LAND CLASSES.*

- Rock areas with miscellaneous soils. Non soil land classes (rocky area). Restricted land use options. May have water-intake from other areas.
- 110ha.
- Parent material is sandstone and conglomerate.
- Shallow soils.
- Plant available water content is between 21 - 40 mm, indicating very low potential soils.

7.2.11 AE269: *RED-YELLOW APEDAL, FREELY DRAINED SOILS.*

- Red, high base status > 300 mm deep. Favourable physical properties. May have restricted soil depth, excessive drainage, high erodibility, low natural fertility.
- 16ha.
- Parent material is shale, sandstone, siltstone, mudstone and conglomerate.
- Soil depth is generally between 450mm - 750mm.
- Plant available water content is between 61 - 80 mm.

7.2.12 AE310: *RED-YELLOW APEDAL, FREELY DRAINED SOILS.*

- Red, high base status > 300 mm deep (no dunes). Freely drained, structure less soils. Favourable physical properties, but may have restricted soil depth, excessive drainage, high erodibility, low natural fertility.
- 14 ha.
- Parent material is sandstone and conglomerate or shale, basalt and tuff.
- Soils are generally between 450mm - 750mm deep.
- Plant available water content is between 41 - 60 mm, indicating low potential soils.

Figure 5: Land-types of the Western parts of the study area

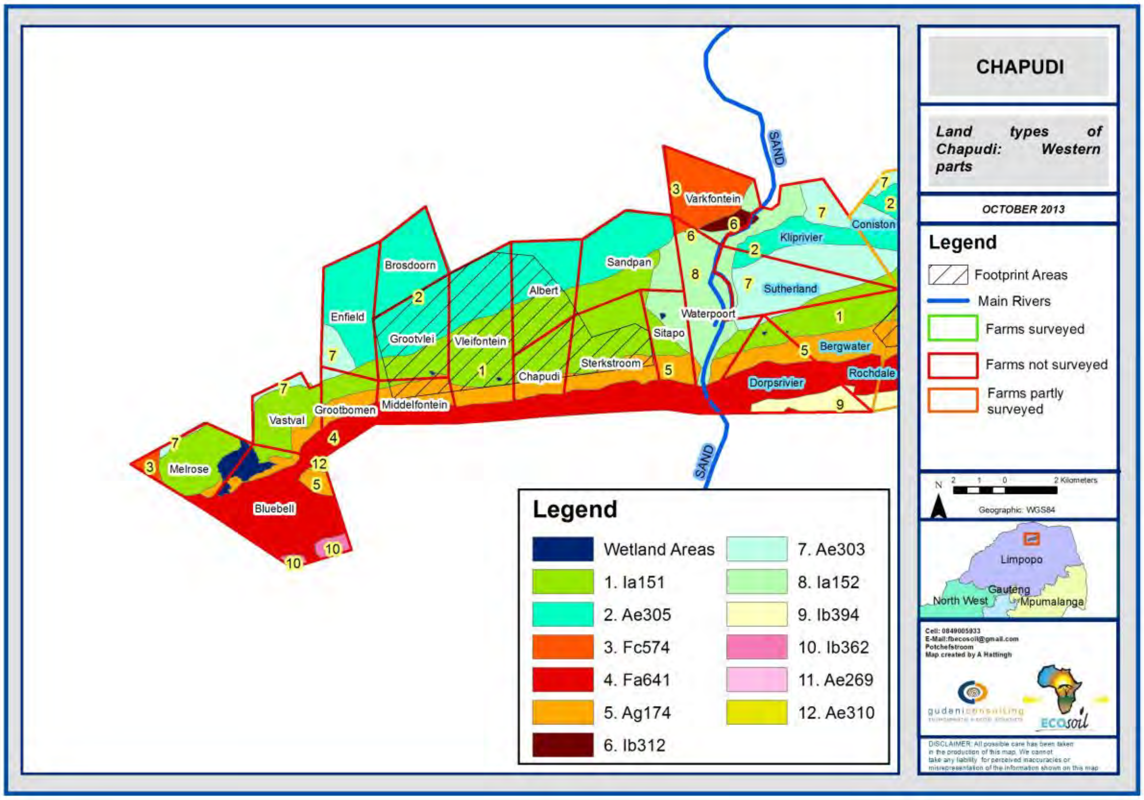
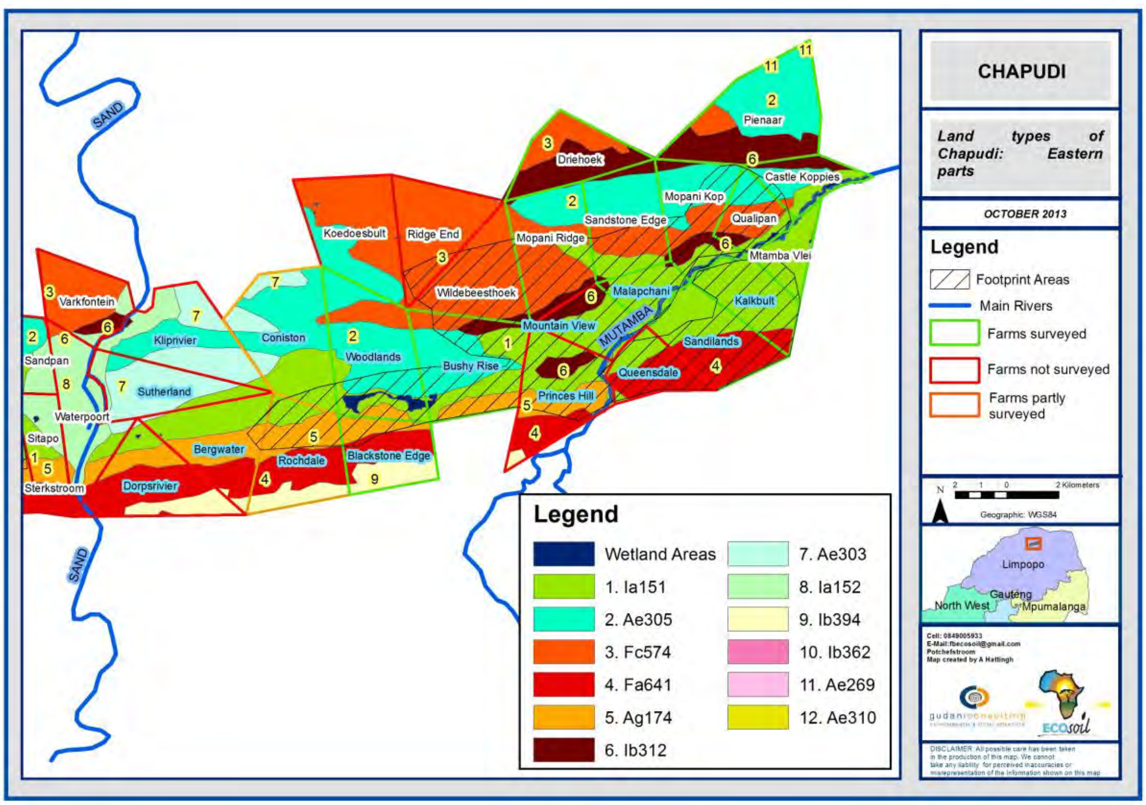


Figure 6: Land-types of the Eastern parts of the study area



7.3 TOPOGRAPHY

Topography of the area is illustrated in Figure 7 and 8. The southern parts of the project area is characterised by hills and ridges and forms part of the Soutpansberg.

Figure 7: Topography of the Western parts of the study area

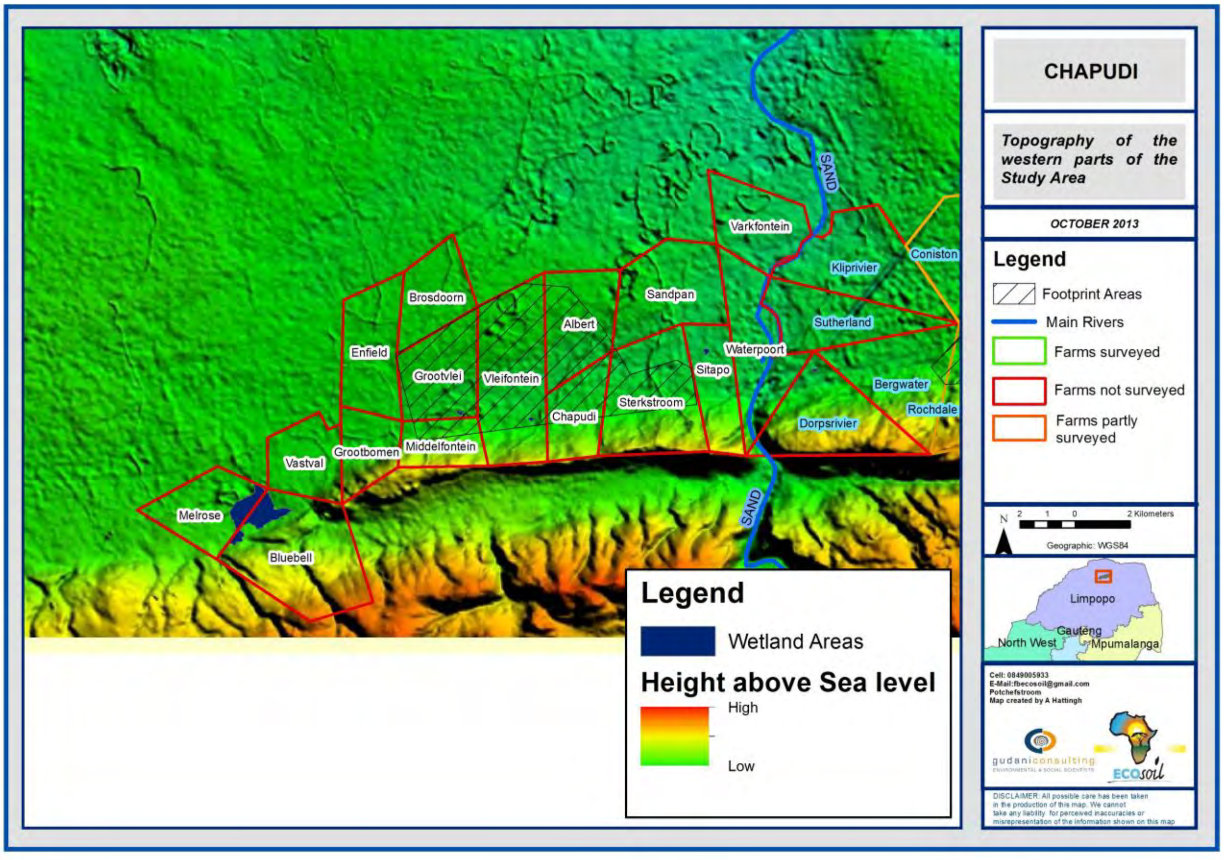
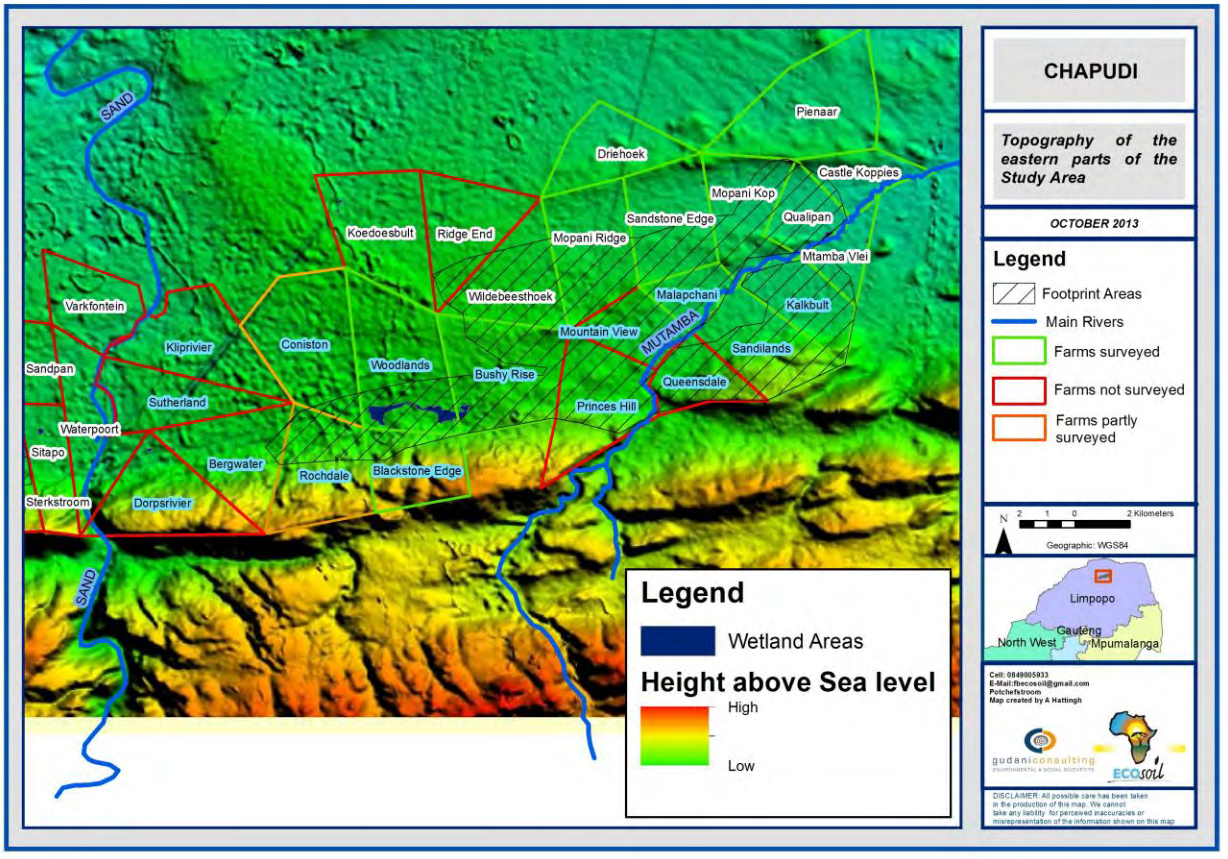


Figure 8: Topography of the Eastern parts of the study area



Terrain types

Terrain types are illustrated in Figure 9 and 10.

The Chapudi West (Figure 9) exists mainly of six terrain types, namely:

- Level plains (central parts of the area); topography suitable for crop production.
- Level plains with some relief (northern parts of the area); topography generally well suited for crop production.
- Rolling or irregular plains with low hills or ridges; topography generally not suitable for crop production.
- Open high hills or ridges (southern parts of the area); topography not suitable for large scale crop production.

- Open low mountains (south-western parts of the area); topography not suitable for large scale crop production.
- High hills or ridges (mainly on the farm Varkfontein); topography generally not suitable for large scale crop production.

The Chapudi East and Wildebeesthoek (Figure 10) exist of five terrain types, namely:

- Level plains (central parts); topography suitable for crop production.
- Level plains with some relief (northern parts of the area); topography generally well suited for crop production.
- Rolling or irregular plains with low hills or ridges; topography generally not suitable crop production.
- Open high hills or ridges (southern parts of the area); topography generally not suitable for large scale crop production.
- High hills or ridges (mainly in the Wildebeesthoek area on the farms Pienaar and Driehoek); topography not suitable for large scale crop production.

Figure 9: Terrain types of the Western parts of the study area

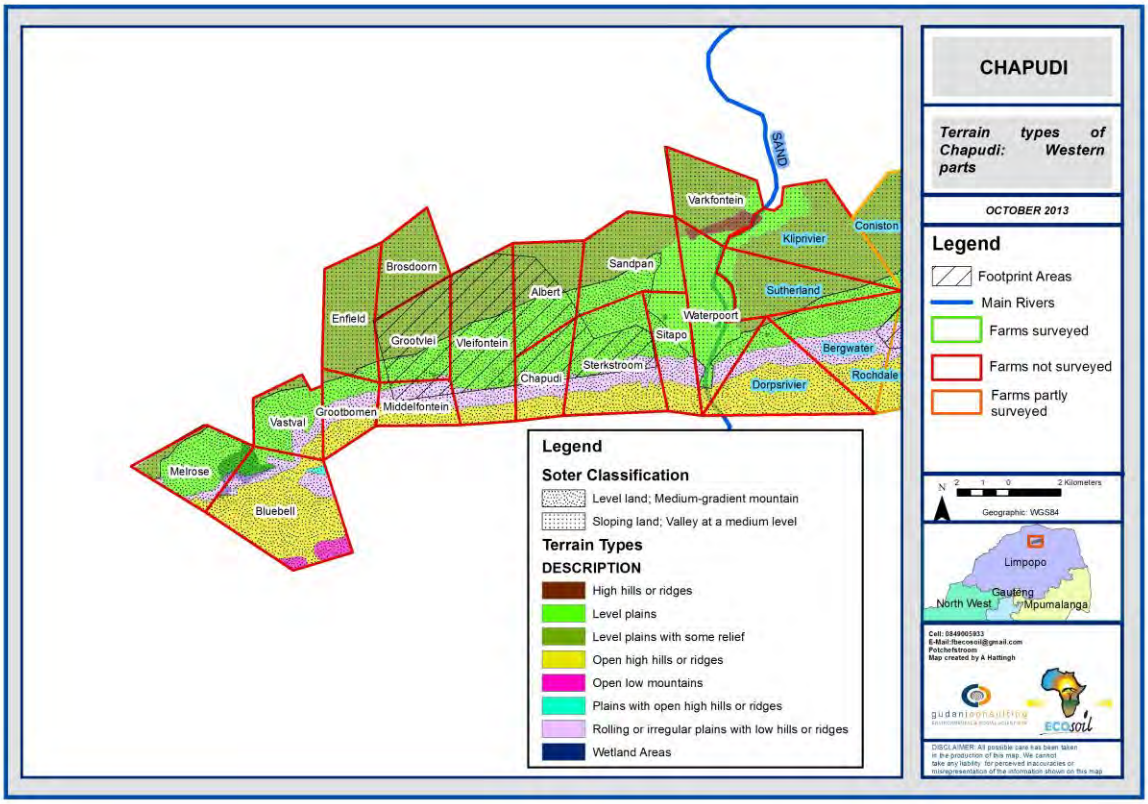
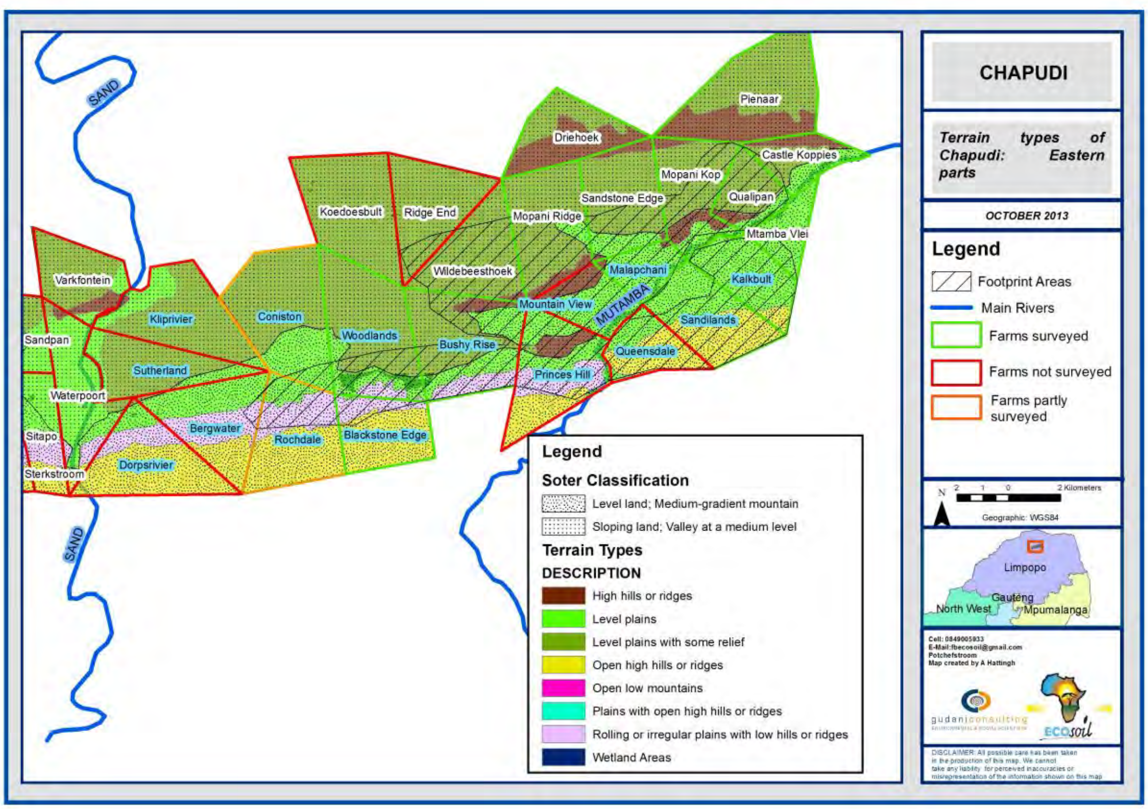


Figure 10: Terrain types of the Eastern parts of the study area



7.4 CLIMATE

The climate of the area is typified by warm to hot summers with low rainfall and high evaporation and dry warm winters. The area is generally frost free.

Precipitation is strongly seasonal with about 85% of the yearly rainfall falling in the summer months (October to March). Monthly variations in climate throughout the area are given in Table 2. The hills and ridges are predominantly orientated in an east-west direction. It has a very strong influence on the climatic pattern of the area. An assessment of the long-term rainfall records indicates a mean annual rainfall that varies between 308 to 624mm (Brosdoorn and Middelfontein respectively) within the Chapudi West area and 326 to 668mm (Sutherland and Blackstone Ridge respectively) in the eastern regions. Rainfall is generally higher in the southern parts next to the hills and is decreasing gradually to the northern parts further from the hills.

Highest temperatures are found during January in the area of Brosdoorn, Varkfontein and Pienaar in the northern parts of the study area. Coldest temperatures are found during July next to the hills from Sterkstroom to Blackstone Edge. Rainfall, as well as mean maximum and mean minimum temperatures of the Chapudi study area are summarised In Table 2. From the ranges found in Table 2 it can be seen that climate, especially rainfall during the summer, varies considerably throughout the area and also over relatively short distances. These variations have a very large influence on the agricultural potential of the area. The enormous diversity in possible crop and variety selection and climatic needs per crop, makes it difficult to characterize typical adaptive capacities and strategies for the area. All year round irrigated crop production is possible as the winters are frost free. However the suitability for arable crop production depends highly on quality of irrigation water, terrain- and soil properties. Areas with very low rainfall or either areas with high hills and difficult terrain is not suitable for dry land agriculture. Rainfall distribution patterns of the western and eastern areas are presented in Figures 11 and 12 respectively.

Table 2: Mean monthly rainfall, maximum and minimum temperatures

Month	Mean Rainfall mm	Mean Maximum Temperatures C°	Mean Minimum Temperatures C°
January	46-111	26.2-31.1	16.3-19.5
February	42-85	25.5-30.5	16.1-19.3
March	20-69	24.7-29.6	15.5-18.0
April	9-30	23.7-28.0	12.9-15.0
May	0-5	22.1-26.0	9.2-11.7
June	0-2	19.7-23.3	6.0-9.9
July	0-1	19.6-23.4	5.8-8.7
August	0	21.3-25.4	7.9-10.1
September	0-4	23.0-27.7	10.9-12.8
October	11-43	25.6-29.1	13.4-15.8
November	30-73	25.9-30.2	14.9-17.9
December	26-107	25.9-30.6	16.0-19
Total aver	308-668		

The Area falls mainly in two Quaternary Water Catchment areas. The western and central parts of the area are situated in Catchment A71J and eastern parts (farms east of Bushy Rise and Wildebeesthoek) are situated Catchment in A80F.

Figure 11: Mean annual rainfall of the Western parts of the study area

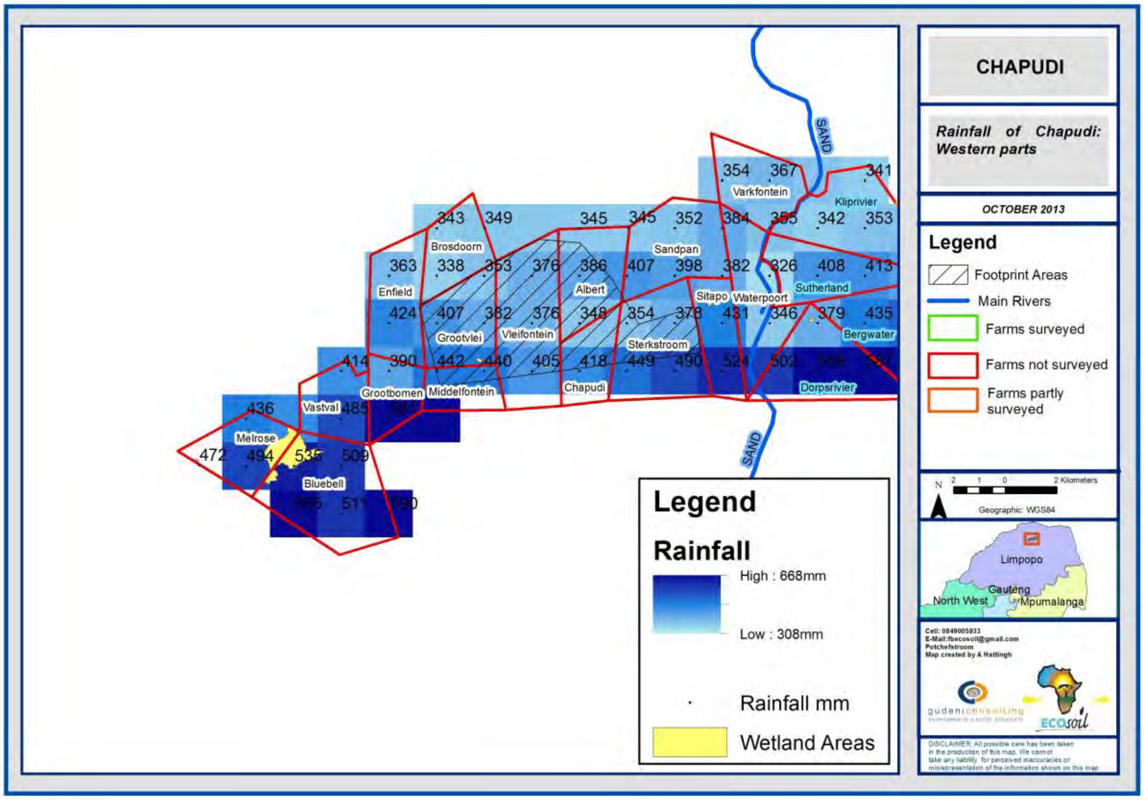
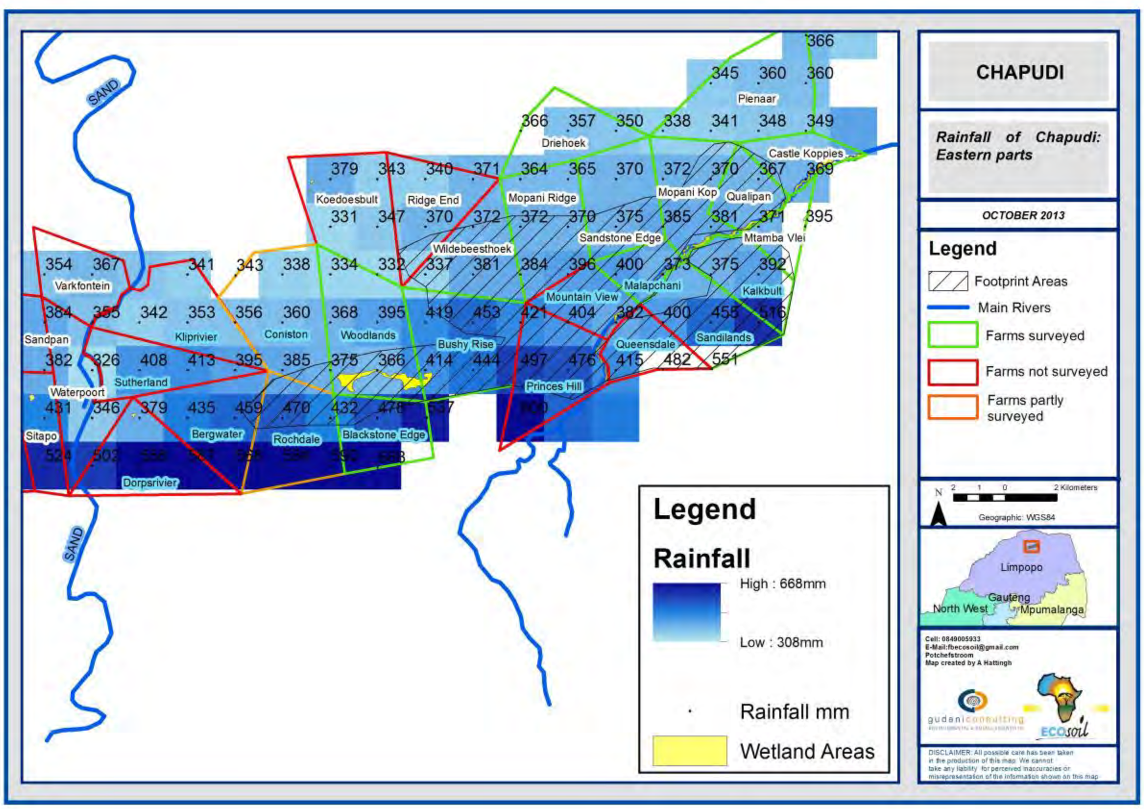


Figure 12: Mean annual rainfall of the Eastern parts of the study area



7.5 PRESENT LAND USE

Approximately 2236ha of the toal project area is cleared for crop production and 537ha is irrigated.

Chapudi west (Figure 13):

- Crop production (predominantly vegetables) is taking place on 938ha on the farms Waterpoort, Varkfontein, Sitapo and Sterkstroom (the floodplains of the Sandriver), as well as on Albert, Vleifontein and Enfield in the Chapudi west project area, as is indicated in yellow in Figure 13. All these farms, except Sterkstroom, also have some fields under irrigation (274ha).
- The majority of area is presently covered with low density woody species and used for grazing purposes for either cattle or game farming.
- The southern higher lying areas are largely covered with high density woody species, especially on the farms Bluebell, Grootbomen, Chapudi, Sterkstroom, Middelfontein, Waterpoort and Sitapo. The northern parts of the farms Varkfontein and Albert also have considerable areas of high density woody species. However, these high density woody species are present in smaller areas on almost all farms.
- Significant degraded areas with no or very scarce basal cover are present on the farms Sterkstroom, Sandpan and Grootvlei. Smaller areas of degraded land are also present on Vleifontein and Chapudi, Melrose, Albert, Enfield and Vastval. Due to the very low clay contents of the area degraded areas are highly susceptible to wind erosion. Water erosion may also occur.

Chapudi east and Wildebeesthoek (Figure 14):

- Crop production activities are present on 1298ha on the farms Mountain View, Princes Hill, Queensdale, Bergwater, Brosdoorn, Koedoesbult, Coniston, Grootvlei, Kliprivier, Rochdale, Sutherland, Wildebeesthoek and Bushy Rise as is indicated in Figure 14. Approximately 264ha of these soils are under irrigation.

- The majority of area is presently covered with low density woody species and used for grazing purposes for either cattle or game farming.
- Almost the entire Rochdale and Blackstone Edge, as well as the southern higher lying areas of the farms Dorpsrivier, Bergwater are covered with high density woody species, The northern parts of the farms Varkfontein and Albert also have considerable areas of high density woody species. However, these high density woody species are present in smaller areas on almost all farms.

According to previous studies, combined with the present study the following land use areas were found:

Commercial (or cleared) land: 2236ha. (537 ha irrigated and 1699ha dry land)

Degraded: Forest and woodland: 2816ha.

Thicket and Bushland: 13921ha

Woodlands: 21158ha

Bare Rock (natural): 26ha

Wetlands: 403ha

Figure 13: Present land cover of the Western parts of the study area

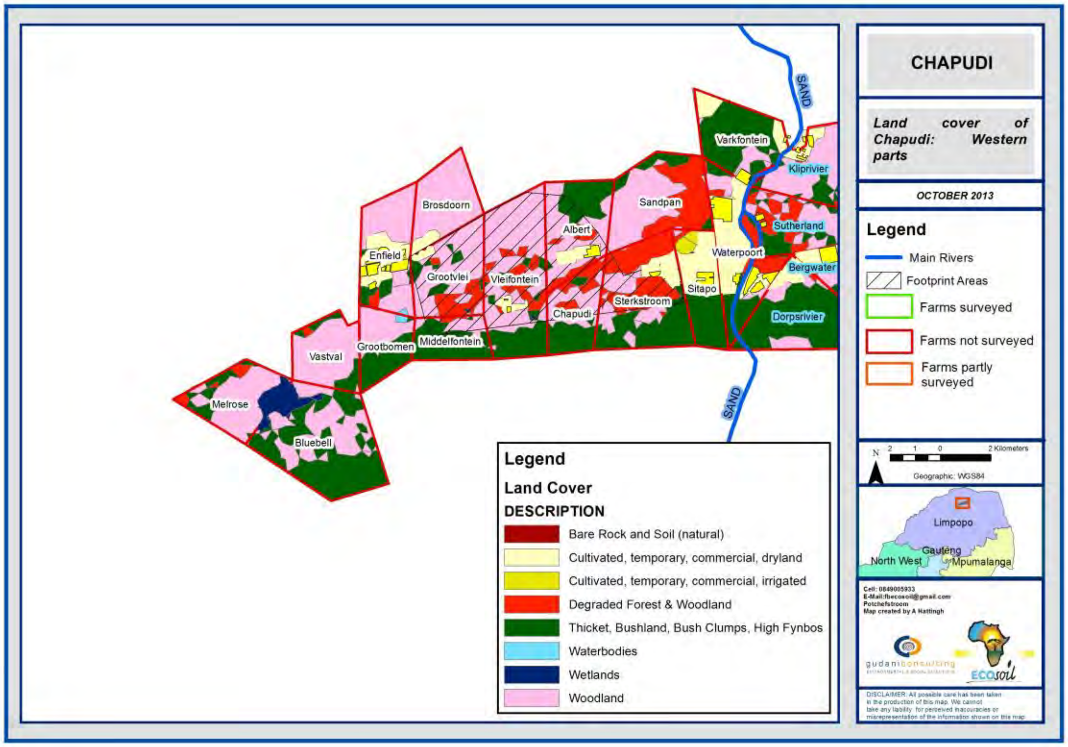
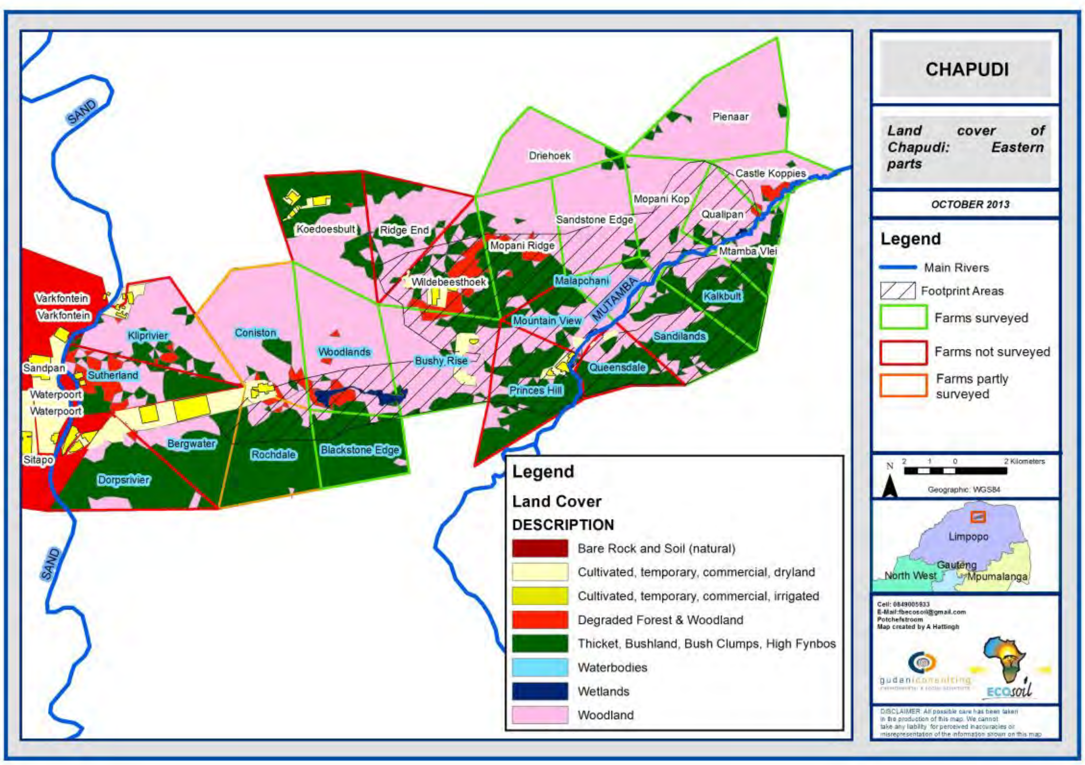


Figure 14: Present land cover of the Eastern parts of the study area



7.6 LAND CAPABILITY OF FARMS NOT SURVEYED DURING THIS STUDY

The entire Chapudi West area, as well as large areas of the Wildebeesthoek and Chapudi East were not surveyed during this study due to reasons as outlined in Point 1. Therefore existing historic land capability information was gathered to bridge the knowledge gap in the areas not surveyed. This information was derived the Dept. of Agriculture and Fisheries data (2013) and from the ENPAT data base.

Land capability for areas not surveyed during this study can be derived from Figure 15 and 16. The accuracy of these extrapolations is questionable considering the scale at which the data was generated and should only be used in areas not surveyed.

It will be necessary to do a proper soil survey of this area in order to determine the actual real land use potential of the entire area. According to the desk study the soils on the following farms are suited for arable crop production:

- Large areas on the footprints on especially Sterkstroom, Chapudi, Vleifontein, and Albert, as well as small areas on Grootvlei.
- The entire farm Waterpoort, as well as areas surrounding the footprint, on the farms Sitapo, Sandpan, Grootbomen, Vastval and Melrose.

From the rainfall maps (Figures 11 and 12) it can be deducted that rainfall becomes marginal for dry-land crop production, but with additional irrigation, these areas can be highly productive for most crops, especially for high value vegetable crop production when good quality irrigation water is used.

Figure 15: Land capability of the Western parts of the study area (information from previous studies)

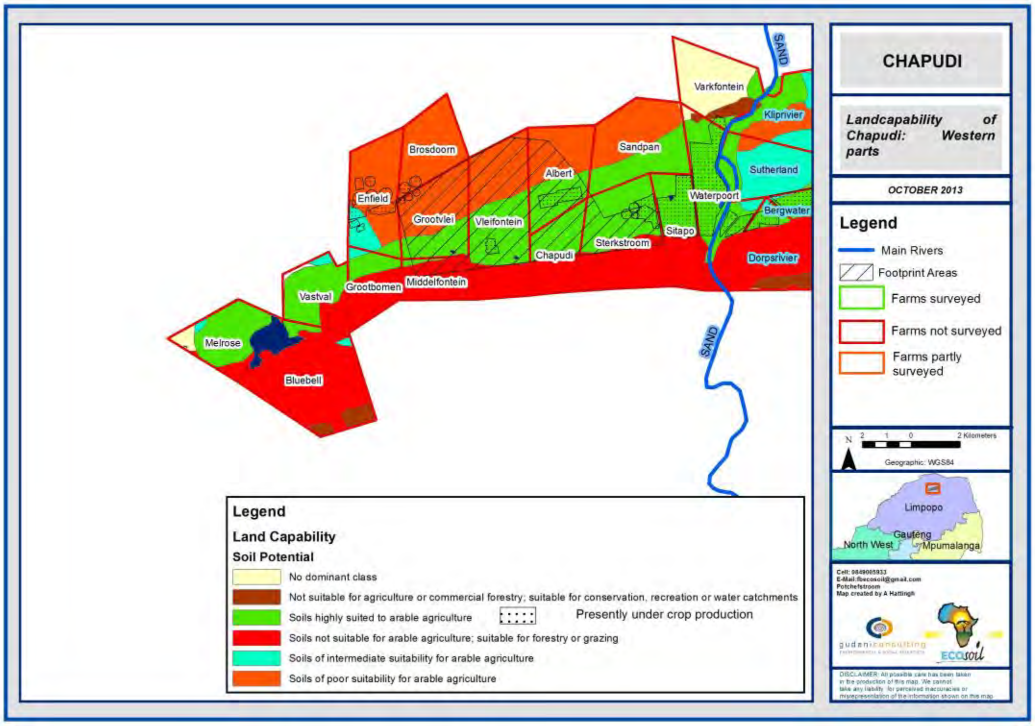
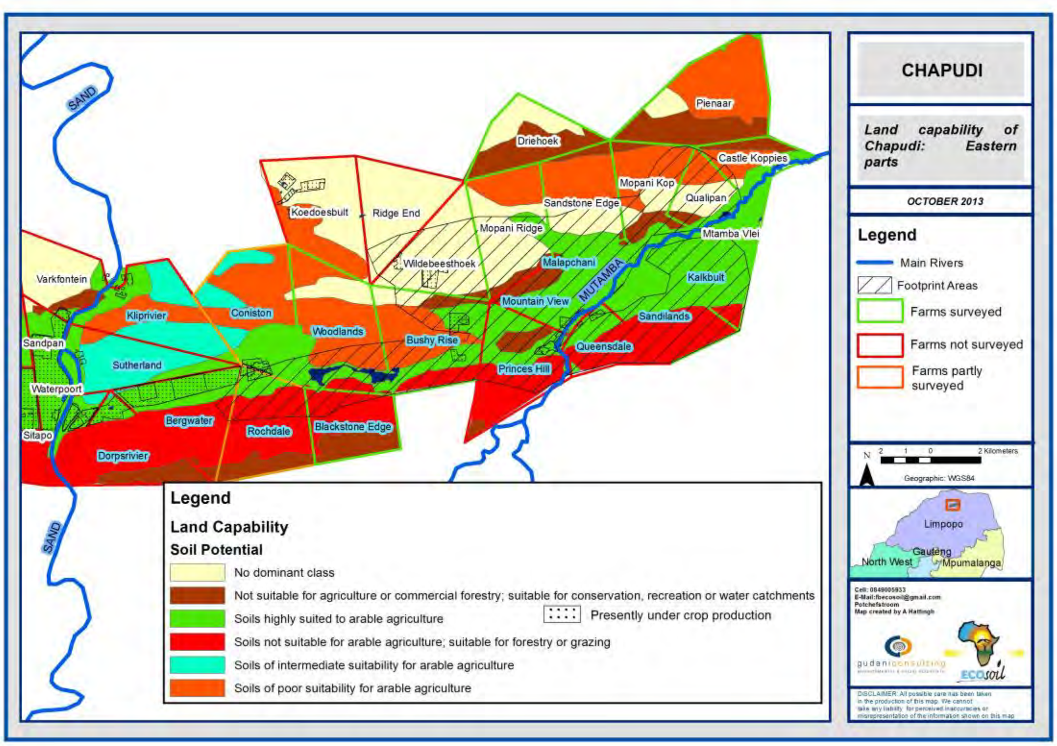


Figure 16: Land capability of the Eastern parts of the study area (information from previous studies)



Chapudi:

This portion is situated east of the Sand River and includes Chapudi and Wildebeesthoek. The Land capability according to the information obtained from the desk study (previous information) is illustrated in Figure 15 and 16. The area can be classed in six land capability classes, namely:

- Highly suited to arable agriculture where climate permits. The area highly suitable for agriculture is found in a west to east stretching strip in the centre of the area on almost all farms. The southern parts of the footprint of this area is also lying in the "highly suited to arable agriculture" area. Areas presently under cultivation are also shown on the maps. Most of the present cultivated lands are situated on areas highly suited to arable cultivation except for a continuous strip of fields on Enfield, Brosdoorn and Grootvlei.
- Soils not suitable for arable agriculture, but suitable for forestry or grazing are found in the northern parts. And is generally due to low rainfall. The northern parts of the footprint fall in this class.
- Soils of poor suitability for arable agriculture.
- Areas not suitable for agriculture or commercial forestry, but suitable for conservation, recreation or water catchment are found in the southern parts in the higher lying areas of the study area.
- Soils of intermediate suitability for arable agriculture.
- From the data of the desk study the farm Varkfontein is classified as "no dominant class". Huge variations in soil properties and potential are usually found this class and because of the lack of the soil survey, no clear indication of land capability can be given in this case.

7.7 LAND CAPABILITY AND AGRICULTURAL RATING

Land capability of the study area was classified into four classes (wetland, arable land, grazing land and wilderness) according to the Chamber of Mines Guidelines (1991). The criteria used for classification is summarized in Table 3.

Table 3: Criteria for Pre-Development Land Capability according to the Chamber of Mines Guidelines (1991)

Criteria for Wetland

- Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.

Criteria for Arable land

- Land, which does not qualify as a wetland.
- The soil is readily permeable to a depth of 750 mm.
- The soil has a pH value of between 4.0 and 8.4.
- The soil has a low salinity and SAR
- The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100 mm in the upper 750 mm.
- Has a slope (in %) and erodibility factor (K) such that their product is <2.0
- Occurs under a climate of crop yields that are at least equal to the current national average for these crops.

Criteria for Grazing land

- Land, which does not qualify as wetland or arable land.
- Has soil, or soil-like material, permeable to roots of native plants, that is more than 250 mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100 mm.
- Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.

Criteria for Wilderness land

- Land, which does not qualify as wetland, arable land or grazing land.

7.8 LAND USE AND AGRICULTURAL POTENTIAL FORMS

The original concepts (Klingebiel & Montgomery, 1961) are as follows:

Table 4: Land use classes suited for cultivation according to Klingebiel & Montgomery (1961)

Land suited for cultivation	
Class I	Land in Class I has few limitations that restrict its use.
	It may be used safely and profitably for cultivated crops.
	The soils are nearly level and deep.
	They hold water well and are generally well drained.
	They are easily worked, and are either fairly well supplied with plant nutrients or are highly responsive to inputs of fertilizer.
	When used for crops, the soils need ordinary management practices to maintain productivity.
	The climate is favourable for growing many of the common field crops.
Class II	Land in Class II have some limitations that reduce the choice of plants or require moderate conservation practices.
	It may be used for cultivated crops, but with less latitude in the choice of crops or management practices than Class I.
	The limitations are few and the practices are easy to apply.
	Limitations may include singly or in combination the effects of:
	*Gentle slopes.
	*Moderate susceptibility to wind and water erosion.
	*Less than ideal soil depth.
	*Somewhat unfavourable soil structure and workability.
	*Slight to moderate salinity or sodicity easily corrected but likely to recur.
	*Occasional damaging flooding.
	*Wetness correctable by drainage but existing permanently as a moderate limitation.
	*Slight climatic limitations on soil use and management.
	Limitations may cause special soil-conserving cropping systems, soil conservation practices, water-control devices or tillage methods to be required when used for cultivated crops.
	Note: "Slight to moderate salinity or sodicity, easily corrected, but likely to recur" is taken to imply that strong subsoil acidity, costly to correct and likely to recur, would disqualify land from Class II.
Class III	High susceptibility to water or wind erosion or severe adverse effects of past erosion.
	It may be used for cultivated crops, but has more restrictions than Class II. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain.
	Limitations restrict, singly or in combination, the amount of clean cultivation, time of planting, tillage, harvesting, choice of crops.
	Limitations may result from the effects of one or more of the following:
	The number of practical alternatives for average farmers is less than that for soils in Class II.
	*Moderately steep slopes.
	*Frequent flooding accompanied by some crop damage.
	*Very slow permeability of the subsoil.
	*Wetness or some continuing waterlogging after drainage.
	*Shallow soil depth to bedrock, hardpan, fragipan or claypan that limit the rooting zone and the water storage.
	*Low water-holding capacity.
	*Low fertility not easily corrected.
	*Moderate salinity or sodicity.
	*Moderate climatic limitations.
	Note: "Severe limitations" and "Low fertility not easily corrected" are taken to imply that land dominated by soils with severe subsoil acidity belongs in Class III.
Class IV	Land in Class IV has very severe limitations that restrict the choice of plants, require very careful management, or both.
	It may be used for cultivated crops, but more careful management is required than for Class III and conservation practices are more difficult to apply and maintain.
	Restrictions to land use are greater than those in Class III and the choice of plants is more limited.
	It may be well suited to only two or three of the common crops or the harvest produced may be low in relation to inputs over long period of time.
	In sub-humid and semi-arid areas, land in Class IV may produce good yields of adapted cultivated crops during years of above average rainfall and failures during years of below average rainfall.
	Use for cultivated crops is limited as a result of the effects of one or more permanent features such as:
	*Steep slopes.
	*Severe susceptibility to water or wind erosion or severe effects of past erosion.
	*Shallow soils.
	*Low water-holding capacity.
	*Frequent flooding accompanied by severe crop damage
	*Excessive wetness with continuing hazard of waterlogging after drainage.
	*Severe salinity or sodicity.
	*Moderately adverse climate.

Table 5: Land use classes not-suited for cultivation according to Klingebiel & Montgomery (1961)

Land with limited use - generally not suited to cultivation	
Class V	Land in Class V has little or no erosion hazard but have other limitations impractical to remove that limit its use largely to pasture, range, woodland or wildlife food and cover. These limitations restrict the kind of plants that can be grown and prevent normal tillage of cultivated crops. Pastures can be improved and benefits from proper management can be expected.
	It is nearly level. Some occurrences are wet or frequently flooded. Other are stony, have climatic limitations, or have some combination of these limitations.
	*Bottomlands subject to frequent flooding that prevents the normal production of cultivated crops.
	*Nearly level land with a growing season that prevents the normal production of cultivated crops.
	*Level or nearly level stony or rocky land.
	*Ponded areas where drainage for cultivated crops is not feasible but is suitable for grasses or trees.
Class VI	Land in Class VI has severe limitations that make it generally unsuited to cultivation and limit its use largely to pasture and range, woodland or wildlife.
	Land in Class VI has continuing limitations that cannot be corrected, such as:
	*Steep slope.
	*Severe erosion hazard.
	*Effects of past erosion.
	*Stoniness.
	*Shallow rooting zone.
	*Excessive wetness or flooding.
	*Low water-holding capacity.
	*Salinity or sodicity.
	*Severe climate.
	Physical conditions are such that it is practical to apply range or pasture improvements, if needed, such as seeding, liming and fertilizing.
	Some occurrences can be safely used for the common crops, provided unusually intensive management is used. Some occurrences are adapted to special crops.
	Depending on soil features and climate, land in Class VI may be well to poorly suited to woodlands.
Class VII	Land in Class VII has very severe limitations that makes it unsuited to cultivation and that restrict its use largely to grazing, woodland or wildlife.
	Restrictions are more severe than those for Class VI because of one or more continuing limitations that cannot be corrected, such as:
	*Very steep slopes.
	*Erosion.
	*Shallow soil.
	*Stones.
	*Wet soil.
	*Salts or sodicity.
	*Unfavourable climate.
	Physical conditions are such that it is impractical to apply such pasture or range improvements as seeding, liming and fertilizing.
	Depending on soil characteristics and climate, land in Class VII may be well or poorly suited to woodland.
	In unusual instances some occurrences may be used for special crops under unusual management practices.
Class VIII	Land in Class VIII have limitations that preclude its use for commercial plant production and restrict its use to recreation, wildlife, water supply or aesthetic purposes
	Limitations that cannot be corrected may result from the effects of one or more of:
	*Erosion or erosion hazard.
	*Severe climate.
	*Wet soil.
	*Stones.
	*Low water-holding capacity.
	*Salinity or sodicity.
	Land in Class VIII cannot be expected to return significant on-site benefits from management for crops, grasses or trees, although benefits from wildlife use, watershed protection or recreation may be possible.
	Badlands, rock outcrop, sandy beaches, river wash, mine tailings and other nearly barren lands are included in Class VIII.

Table 6: Land capability classes to establish land use

LAND CAPABILITY CLASS	LAND USE OPTIONS	LAND CAPABILITY GROUPS
Class I	W F LG MG IG LC MC IC VIC	Arable land
Class II	W F LG MG IG LC MC IC	Arable land
Class III	W F LG MG IG LC MC	Arable land
Class IV	W F LG MG IG LC	Arable land
Class V	W F LG MG	Grazing
Class VI	W F LG MG	Grazing
Class VII	W F LG MG	Grazing
Class VIII	W	Wildlife
W - Wildlife LC - Poorly adapted cultivation		
F - Forestry MC - Moderately well adapted cultivation		
LG - Light grazing IC - Intensive, well adapted cultivation		
MG - Moderate grazing VIC - Very intensive, well adapted cultivation		
IG - Intensive grazing		
IG - Intensive grazing		

8. FAO IRRIGATION WATER QUALITY GUIDELINES

Table 7: Water quality guidelines used in this study

Potential irrigation problems	Units	Degree of restriction on use		
		None	Slight to moderate	Severe
Salinity (affects crop water availibility)				
EC_w	dS m^{-1}	<0.7	0.7-3.0	>3.0
or TDS	mg l^{-1}	<450	450-2000	>2000
Infiltration (affects infiltration rate of water into the soil; evaluate using Ecw and SAR together)				
SAR 0-3 and ECw=		>0.7	0.7-0.2	<0.2
SAR 3-6 and ECw=		>1.2	1.2 -0.3	<0.3
SAR 6-12 and ECw=		>1.9	1.9-0.5	<0.5
SAR 12-20 and ECw=		>2.9	2.9-1.3	<1.3
SAR 20-40 and ECw=		>5.0	5.0-2.9	<2.9
Spesific ion toxicity (effects sensitive crops)				
Sodium (Na)				
Surface irrigation	SAR	<3	3-9	>9
Sprinkler irrigation	meq l^{-1}	<3	>3	
Chloride (Cl)				
Surface irrigation	meq l^{-1}	<4	4-10	>10
Sprinkler irrigation	meq l^{-1}	<3	>3	
Boron (B)	mg l^{-1}	<0.7	0.7-3.0	>3.0
Miscellaneous effects (on susceptible crops)				
Nitrate NO_3-N	mg l^{-1}	<5	5-30	>30
Bicarbonate HCO_3^- (overhead sprinkling only)	meq l^{-1}	<1.5	1.5-8.5	>8.5
pH			Normal range 6.5 -8.4	

9. OBSERVATIONS

9.1 SOIL FORMS

The soils vary significantly in physical and chemical composition over the different areas. They are strongly influenced by the underlying rocks (geology) from which they were derived, as well as by their position in the landscape and the origin of the parent material (*in-situ* versus colluvium/alluvium derived).

The major soil forms that generally have similar characteristics were grouped together in soil associations to simplify the data for interpretation purposes. Associations occurring on the proposed development and the number of soil form occurrences (in brackets), are as follow:

9.1.1 RED APEDAL SOILS

- **Hutton (Hu) [429]:** Has an Orthic A-Horizon over a Red Apedal A-Horizon over unspecified materials, like hard or weathered rock, stone or gravel.
- **Plooysburg (Py) [21]:** Has an Orthic A-Horizon over a Red Apedal A-Horizon over a hardpan horizon.
- **Griffin (Gf) [4]:** Has an Orthic A-Horizon over a Yellow Brown apedal A-Horizon on a Red Apedal Horizon.

The depth of the apedal red soils in this study area ranges between 40cm to deeper than 150cm (average 110cm). Clay content of the top soil ranges between 3 and 20% (average 6.7%), at 50cm the clay content ranges between 3 and 32% (average 8.7%), at 100cm the clay content ranges between 3 and 48% (mean 11.2%), at 150cm the clay content ranges between 3 and 43% (average 13.5%).

9.1.2 YELLOW-BROWN APEDAL SOILS

- **Clovelly (Cv) [88]**: Has an Orthic A-Horizon over a Yellow Brown Apedal A-Horizon over unspecified materials, like hard or weathered rock, or gravel.
- **Askham (Ak) [3]:** Has an Orthic A-Horizon over a Yellow Brown Apedal A-Horizon over hardpan carbonate.

The average depth of the apedal yellow soils in this study area range from 40-150cm with an average of 108cm. Clay content of the top soil ranges between 2 and 25% (average 6.7%), at 50cm the clay content ranges between 3 and 33% (average 9.7%), at 100cm the clay content ranges between 3 and 25% (average 9.7%), at 150cm the clay content ranges between 8 and 25% (average 11.5%).

9.1.3 NEOCUTANIC SOILS

- **Oakleaf (Oa) [94]:** Has an Orthic A-Horizon over a Neocutanic B-Horizon over unspecified materials, without signs of wetness in the subsoil.

- **Gamoep (Gm) [8]** and **Etosha (Et) [4]:** Have an Orthic A-Horizon over a Neocutanic B-Horizon over a hardpan- or soft carbonate horizon respectively.
- **Molopo (Mp) [3]:** Has an Orthic A-Horizon over a Yellow Brown Apedal A-Horizon on Soft Carbonate.
- **Villafontes (Vf) [1]:** Has an Orthic A-Horizon over an E horizon over a neocutanic A-Horizon.

In this study area the average depth of the neocutanic soils range from 40-150cm (average 106cm). Clay content in the top soil ranges between 3 and 27% (mean 10.2%), at 50cm the clay content ranges between 6 and 35% (average 18.2%), at 100cm the clay content ranges between 6 and 40% (mean 21.5%), at 150cm the clay content ranges between 15 and 25% (average 22.5%).

9.1.4 CARBONATE SOILS

- **Coega (Cg) [64] and Brandvlei Br [2]**: Have an Orthic A-Horizon over a hardpan- or soft carbonate horizon respectively.
- **Immerpan (Im) [1]:** Has a Melanic A-Horizon over a hardpan carbonate horizon.

The depth ranges from 10-60cm (mean 21cm). The clay content in the top soil ranges between 3 and 35% (mean 15%)

9.1.5 NEOCARBONATE SOILS

- **Augrabies (Ag) [20]:** Has an Orthic A-Horizon over a Neocarbonate B on unspecified materials.
- **Prieska (Pr) [13] and Addo (Ad) [2]:** Have an Orthic A-Horizon over a Neocutanic B on a hardpan- or soft carbonate horizon respectively.

In this study area the average depth of the neocarbonate soils range from 40-

150cm with an average of 87cm. Clay content in the top soil range between 9 and 45% (average 22.1%), at 50cm the clay content ranges between 8 and 35% (average 26.9%), at 100cm the clay content ranges between 10 and 40% (average 25.6%), at 150cm the clay content ranges between 22 and 28% (average 24.3%).

9.1.6 STRUCTURED SOILS

- **Bonheim (Bo) [2]:** It has a Melanic B-Horizon over a Pedocutanic B-Horizon without signs of wetness in the sub-soil.
- **Sepane (Se) [5]:** Has an Orthic A-Horizon over a Pedocutanic B-Horizon with signs of wetness.
- **Shortlands (Sd) [1]:** Has an Orthic A-Horizon over a Red Structured B-Horizon. Although this soil form does not have Pedocutanic properties it has soil structure in the sub soil and only occurs once in the entire area. It is therefore grouped in this class
- **Swartland (Sw) [4]:** Has an Orthic A-Horizon over a Pedocutanic B- horizon on Weathered rock (saprolite).
- **Valsrivier (Va) [5]:** Has an Orthic A-Horizon over a Pedocutanic B-Horizon without signs of wetness in the sub-soil.

In this study area the average depth of the structured soils range from 40-80cm with an average of 63cm. Clay content in the top soil ranges between 15 and 45% (average 28.4%), at 50cm the clay content varies between 24 and 60% (average 40%).

9.1.7 SHALLOW ROCKY SOILS

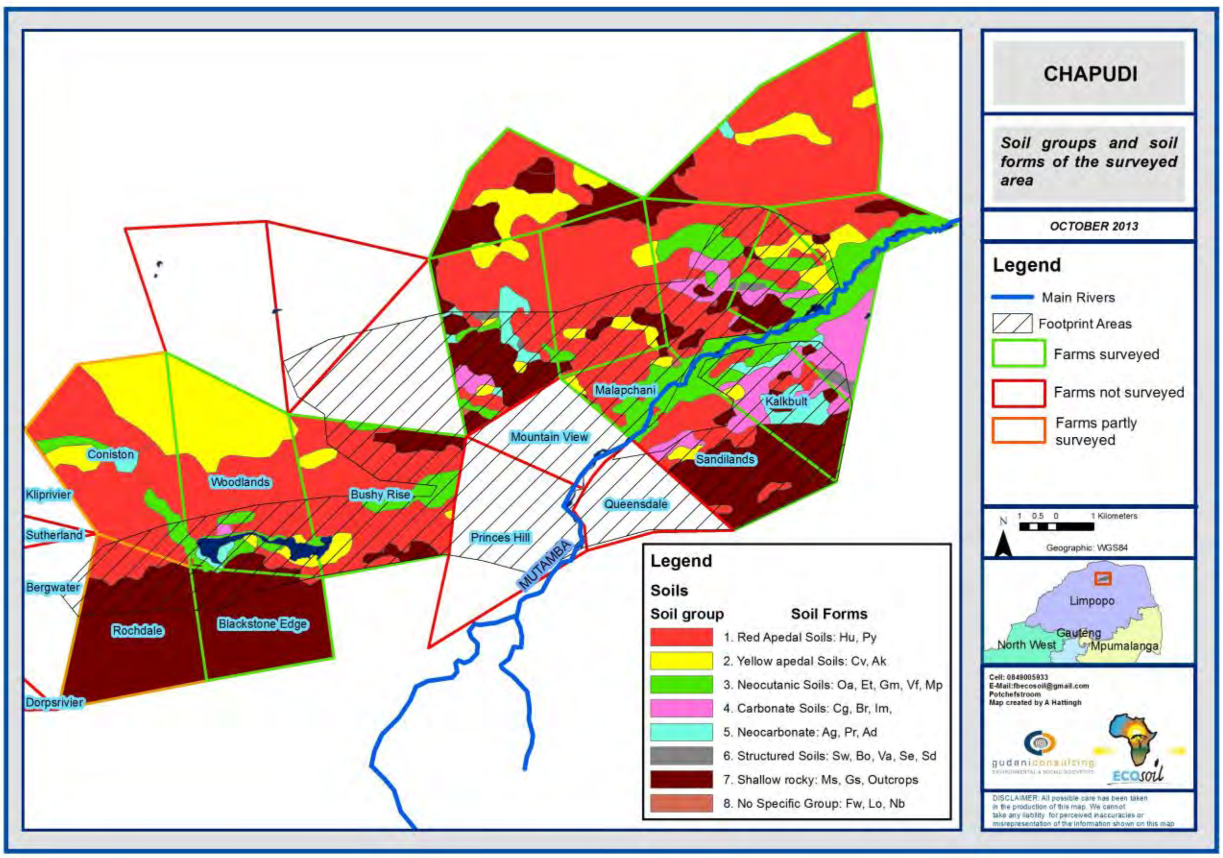
- **Mispah (Ms) [283]:** Has an Orthic A-Horizon over hard rock.
- **Glenrosa (Gs) [28]:** Has an Orthic A-Horizon on a Lithocutanic B-Horizon.
- **Outcrop (OC) [1]:** No soil present, only bare rock.

The average depth of these soils varies from 0 to 50cm (average 16.7cm). The clay content in the top soil varies between 3 and 31% (average 10%).

9.1.8 NO SPECIFIC GROUP SOILS

- **Fernwood (Fw) [1]:** Has an Orthic A-Horizon over an E-Horizon on unspecified material.
- **Namib (Nb) [1]:** Has an Orthic A-Horizon over regic sand.
- **Longlands (Lo) [1]:** Has an Orthic A-Horizon over an E-Horizon on soft plinthite.

Figure 17: Soil groups (associations) and forms of the study area



Although soil forms can give a slight indication of soil capability, it cannot give an indication of agricultural potential. Soil forms give an indication of expected soil colour, properties and soil forming processes.

Large areas of the farms Coniston, Woodlands, Bushy Rise, Mopani Ridge, Sandstone Edge, Pienaar, Mopani Kop, Malapchani and even Sandilands and Caastle Koppies are covered with Hutton and Clovelly soil forms. These deep soils can be considered as medium to high potential, where climatic conditions are favourable. However this is not the case in the project area and the potential of these soils are degraded to Class III to IV (due to climatic constraints), as is summarised in Table 17.

Shallow rocky soils are dominant in the farms Rochdale, Sandstone Edge and Sandilands, and also occur on large areas on the farms Mopani Ridge, Driehoek and the southern parts of Kalkbult.

Neocutanic soils are mainly found in significant areas around the Matumba River on the farms Castle Koppies, Kalkbult, Malapchani and Sandilands, as well as on old riverbeds of the farms Coniston, Bushy Rise and Mopani Kop.

Carbonate soils are found in some areas on the farms Mtamba Vlei, Kalkbult, Mopani Kop, Sandilands and Qualipan.

Table 8: Summary of different soil physical properties of the soil groups

Properties	Soil Group 1	Soil Group 2	Soil Group 3	Soil Group 4	Soil Group 5	Soil Group 6	Soil Group 7
Soil association	Red Apedal	Yellow - brown Apedal	Neo-cutanic	Carbonate	Neo-carbonate	Structured Soils	Shallow, rocky
Soil forms	Hu, Py, Ky,	Cv, Ak	Oa, Gm, Et	Cg, Br	Ag, Pr, Ad	Bo, Sd Se, Sw, Va,	Ms, Gs
Dominant soil	Hutton	Clovelly	Oakleaf	Coega	Augrabies	Swartland	Mispah
Soil family	1200	1200	1120	1000	1120	1122	1100
Soil Depth cm	40-150	40-150	40-150	10-60	40-150	40-80	0-50
Average rooting depth cm	110	108	106	21	87	63	16.7
Infiltration rate	Fast 15-25mm/h	Fast 15-25mm/h	Moderate 10-15mm/h	Very Slow <5mm/h	Slow 5-10mm/h	Very Slow <5mm/h	Slow 5-10mm/h
Consistency	Loose	Loose	Friable	Soft	Soft	Hard	Loose
Structure	Apedal	Apedal	Weak blocky	Apedal	Weak blocky	Strong blocky	Apedal
Clay % A (aver)	3-20(6.7)	2-25(6.7)	3-27(10.2)	3-35(15)	9-45(22.1)	15-45(28.4)	5-55(53)
Clay % 50cm	3-32(8.7)	3-33(9.7)	6-35(18.2)	Soil not 50cm	8-35(26.9)	24-60(40)	Soil not 50cm
Clay% 100cm	3-48(11.2)	3-25(9.7)	6-40(21.5)	-	10-40(25.6)	-	
Clay% 150cm	3-43(13.5)	8-25(11.5)	15-25(22.5)	-	22-28(24.3)	-	
PAW mm/profile	13-185 (94.4)	30-183 (91.2)	18-198 (116.5)	6-74 (22.1)	50-188 (109.8)	57-136 (91.6)	0-54 (14.8)
Field capacity mm	49-340 (153)	45-334 (146)	31-378 (206.6)	9-137 (38.8)	90-383 (207)	120-396 (187.5)	0-105 (24.5)
Wilting point mm	12-156 (58.6)	16-152 (55.3)	14-180 (90.1)	3-66 (16.6)	41-165 (96.5)	63-224 (95.8)	0-51 (9.8)
Drainage	Fast	Fast	Moderate	Poor	Moderate	Poor	Moderate
Gravel/Rocks A-Horizon	-	-	-	R1	G3	-	R5
Gravel/rocks B1 Horizon	G1	G1	G3	R6	G3	-	R
Gravel/rocks B2 Horizon	G1	G1	G3	-	G3	G3	-
Wetness	0	0	0	0	0	W1	0
Compactability	High	High	High	Moderate	High	Moderate	Low

Erodibility	Very High	Very High	High	Very High	Very High	Very High	Very High
Potential Nematode Infestation	High	High	Moderate	Low	Low	Low	High
Irrigation classification	2	2	3	5	3	4	5

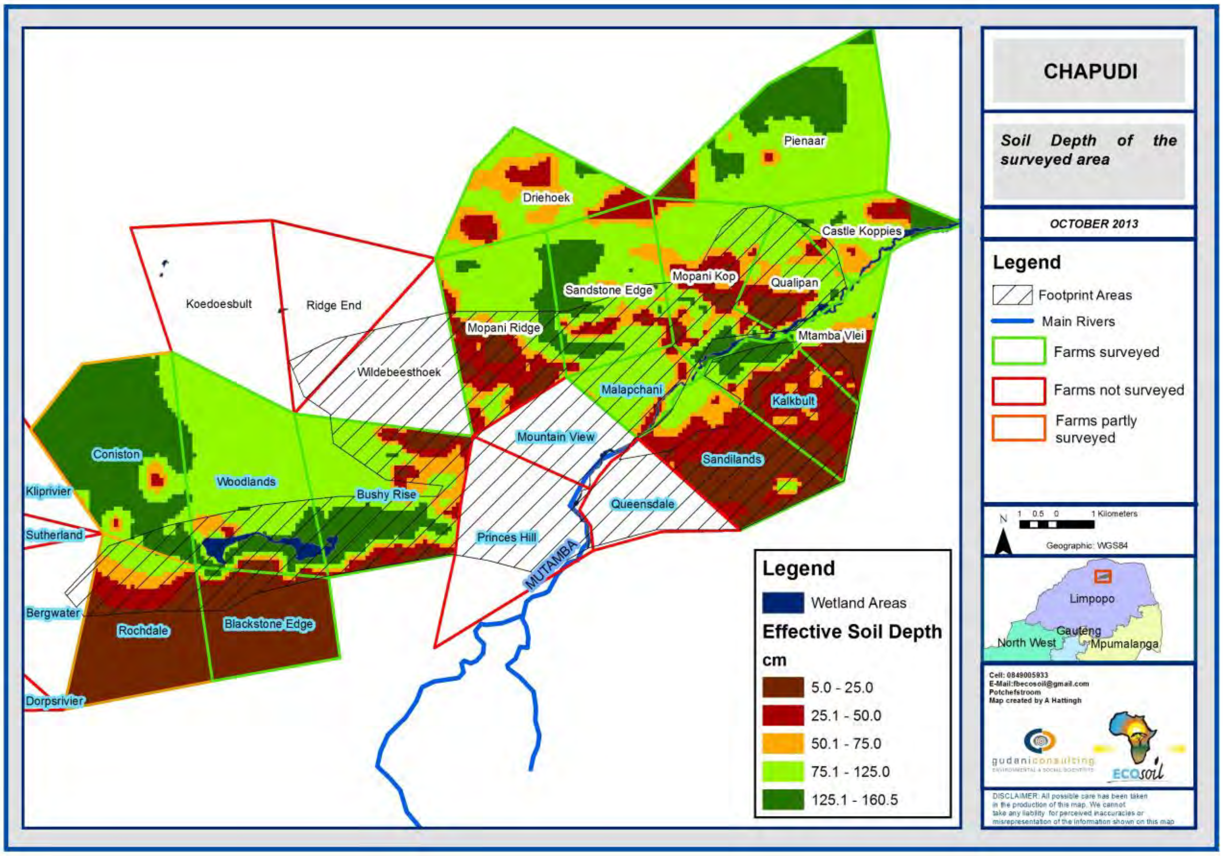
9.2 SOIL PHYSICAL PROPERTIES

Figures 18-20 shows the effective rooting depth, clay content of the A- Horizon and Profile Available Water capacity (PAWC) respectively.

- Large areas of deep soils (>125cm) are found on the farm Coniston. These deep soils are also found on the footprint on the farms Woodlands and Bushy Rise and are surrounding the Wetlands. Localised areas on the Farms Pienaar, Sandstone Edge, Mopani Ridge, Kalkbult and Mopani Kop also have deep soils deeper than 125cm and sometimes even deeper than 150cm. Soils between 75 and 125cm are generally found in large areas of the farms Woodlands and large areas of Bushy Rise, Sandstone Edge, Mopani Ridge, Malapchani, Pienaar and the northern parts of the farms Castle Koppies, Qualipan, Mopani Kop, Mtamba Vlei and Sandilands which also includes the footprint areas. According to the Chamber of Mines (1991) classification (Table 3) these deep soils can be regarded as arable. But according the agricultural classification (Klingebiel & Montgomery, 1961) these soils are classified as classes III to IV as is outlined in Table 4 and 5.

  Soils on Rochdale, Blackstone Edge, Sandilands, Kalkbult and the southern parts of Qualipan, Mtamba Vlei, Mopani Ridge and Mopani Kop are shallower than 50cm. Shallow soils also occur in isolated areas on the farms Driehoek, Pienaar, Castel Koppies and small areas of Sandstone Edge. The far southern and north-eastern parts of Bushy Rise also have very shallow soils.

Figure 18: Effective rooting depth of the study area

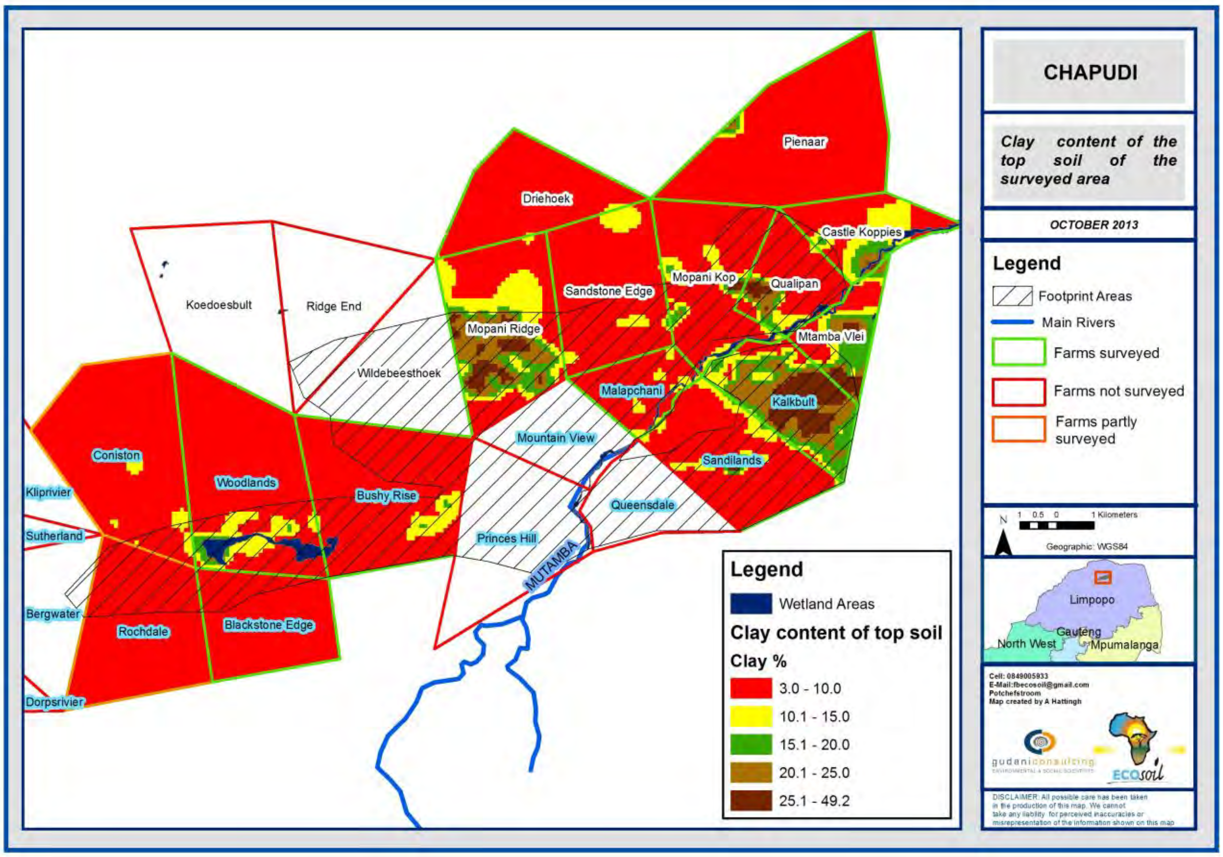


Clay contents of the top soils are illustrated in Figure 19. Clay content of the top soil gives an indication of the susceptibility to soil erosion. Clay contents of the top soils of almost the entire area are below 10%. These soils can be considered as prone to wind erosion. These soils should always be covered with vegetation to combat wind erosion. Almost the entire footprints of the surveyed area have such low clay contents, except on the farms Mopani Ridge Mtamba Vlei and Kalkbult.

It will be necessary to protect these low clay content areas from wind erosion and associated dust formation, if it is to be considered for moving soils during the mining process. Special attention is needed for this operation to combat wind erosion and specialist should be consulted.

High clay contents (>25%) can give rise to water erosion, especially during intensive rainstorms that occasionally may occur. Such areas are found on the farms Mopani Ridge and Kalkbult as well as on small areas on Mtamba Vlei and Qualipan. All the areas with clay contents higher than 25% are situated on the footprints of the surveyed area.

Figure 19: Clay content (%) of A-Horizons

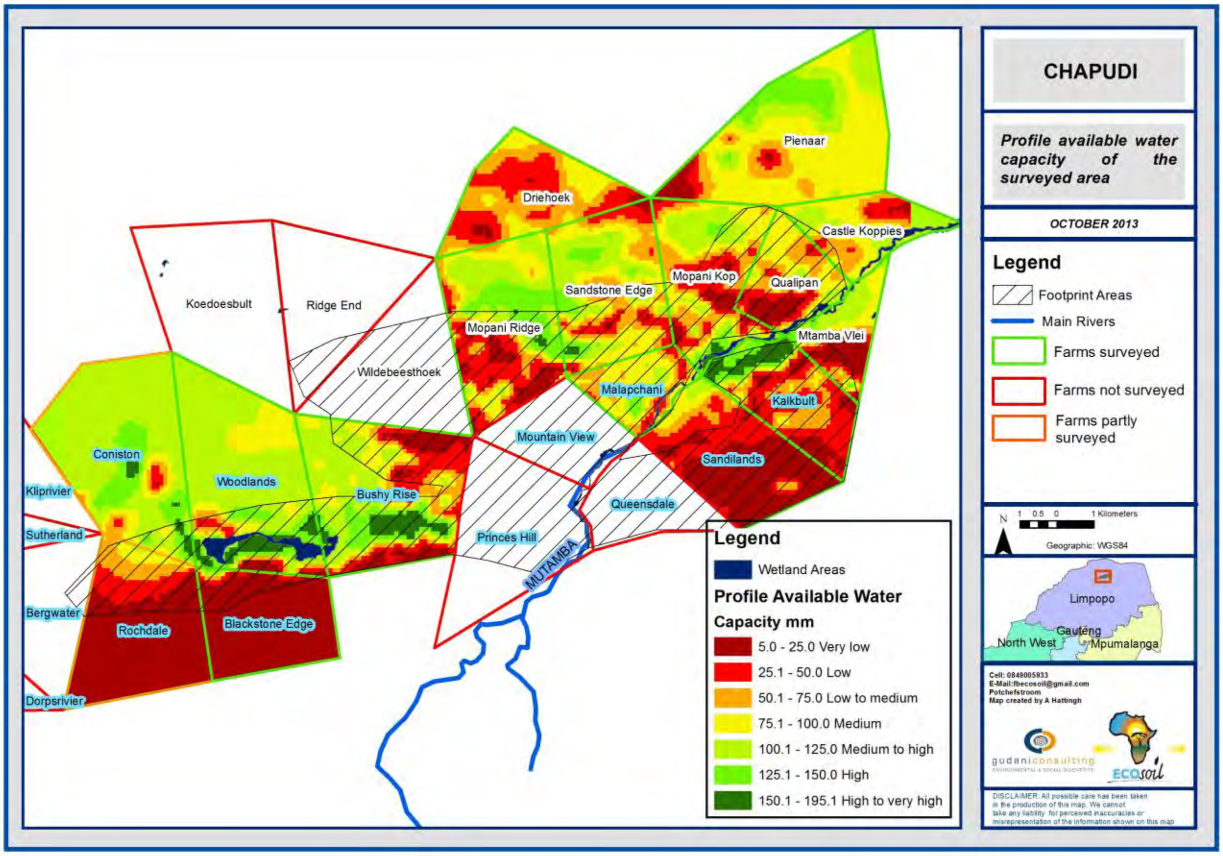


Profile available water capacity (PAWC) is illustrated in Figure 20. PAWC is the capacity of soil to keep a certain amount of water in the profile that can be used by a plant. The values are calculated from soil depth, soil texture (clay content) and soil forms. These combined factors give an indication of the potential of the soil for dry land crop production, as well as the amount of water that will be needed to fill the profile in the case of irrigation.

PAWC of the southern parts of the surveyed area is very low and ranges between 6 and 75mm (illustrated in brown, red and orange in Figure 20), which can be considered as sub-optimum for crop production purposes. Large areas with a low PAWC are mainly found on the farms Rochdale, Blackstone Ridge, Sandilands and Kalkbult. Some areas of the farms Driehoek, Qualipan and Mopani Kop, as well as the southern parts of Mtamba Vlei, and Mopani Ridge also have very profile available water capacities. The farm Bushy Rise has low profile available water capacities to the south and north, but has a very high capacity in the central areas. Only relatively small areas along the Mtamba River on the farm Kalkbult can be considered as having high water holding water capacities of more than 150mm (darkest green hue in Figure 20). However, the rainfall of the area is too low to regard these areas of high value for dry land crop production, unless irrigated with **good** quality water and that there will be sufficient water available.

On the footprint areas the farms Bushy Rise and Kalkbult have areas with a high profile available water capacity, which can be considered as of high potential value for irrigation purposes if good quality irrigation water is available.

Figure 20: Profile available water capacity of the study area



9.3 SOIL CHEMICAL PROPERTIES

Table 9 is a copy of the soil analysis and co-ordinates of sample sites.

- The pH of most soil samples are close to neutral. This is an indication of the influence of the free lime in the soil profile.
- The phosphate (P) levels are generally extremely low. This can be rectified with fertilisers where cop production is taking place.
- The cation exchange capacities are low. This is an indication of the low clay% of the soil and the resulting low nutrient fertility
- The majority of Potassium (K) and Magnesium (Mg) levels are low.
- Cation ratios are within acceptable ranges.
- There is no indication of any potential salinity or sodicity in any of the soil samples.

Table 9: Soil analysis Report

SOILANALYSIS REPORT

TEL: 088 303 2967 **FAX:** 086 683 7781

COMPANY: Eco Soil **NAME:** Ekland **DATE:** ########

ADRESS: 12 Olienhout Str **FARM:**

ADRESS: Mierderpark Potchefstroom **EMAIL:** fbecosoil@gmail.com

CODE: 2551 **FAX:**

TEL NO: 018 297 4826 **ORDER NO:**

Obs No.	Co-ordinates		pH (KCl)	PBray1	K	Na	Ca	Mg	EA_KCl	%Ca	%Mg	%K	%Na
	Long	Lat		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol(c)/kg	%	%	%	%
C316	29.7449565	-22.87500389	4.21	4	79	7	147	64	0.15	45.01	31.92	12.32	1.83
C327	29.7300792	-22.86172053	4.90	3	30	7	128	28	0.00	65.46	23.77	7.78	2.99
C873	29.8371658	-22.8394731	5.67	3	37	6	141	91	0.00	44.71	47.48	6.02	1.79
C887	29.8314934	-22.84769742	7.52	1	369	10	2474	233	0.00	81.00	12.53	6.18	0.29
C1011 A	29.8577209	-22.84452072	6.11	1	602	37	2664	636	0.00	65.83	25.77	7.61	0.80
C1011 B			6.60	2	248	59	3607	689	0.00	73.40	22.98	2.58	1.05
C1032 A	29.8111053	-22.85076679	6.16	1	103	7	643	151	0.00	67.68	26.11	5.54	0.67
C1032 B			5.70	13	116	8	513	154	0.00	61.74	30.35	7.11	0.81
C1039 A	29.8080179	-22.84269793	6.12	8	47	8	411	40	0.00	81.06	12.87	4.77	1.29
C1039 B			7.14	1	46	11	397	40	0.00	80.21	13.16	4.72	1.92
C1060 A	29.7993674	-22.84826598	5.84	2	30	6	78	23	0.00	57.02	27.82	11.36	3.80
C1060 B			4.48	1	69	9	98	47	0.06	42.87	33.29	15.36	3.24
C1104	29.8308209	-22.81521621	5.93	1	100	6	343	129	0.00	56.13	34.63	8.42	0.83
C1144 A	29.8165004	-22.82900906	6.43	4	307	8	348	101	0.00	51.43	24.35	23.20	1.02
C1144 B			5.67	1	137	9	481	96	0.00	67.17	22.00	9.75	1.07
C1241 A	29.7672403	-22.84882808	4.10	1	99	11	353	104	0.12	58.01	28.12	8.37	1.55
C1241 B			4.08	1	57	14	501	169	0.11	59.47	32.93	3.44	1.47
C1562 A	29.8484523	-22.82031731	6.14	1	185	12	685	124	0.00	68.95	20.51	9.51	1.04
C1562 B			6.52	1	341	11	883	168	0.00	65.81	20.49	13.01	0.69
C1577 A	29.8423877	-22.80959468	5.42	5	35	11	206	35	0.00	71.04	19.62	6.17	3.17
C1577 B			5.48	1	75	7	294	47	0.00	70.75	18.55	9.18	1.53
C1600 A	29.8367166	-22.81781906	5.75	7	172	9	469	116	0.00	62.19	25.17	11.64	0.99
C1600 B			5.39	1	157	8	409	174	0.00	52.41	36.42	10.28	0.89
C1836 A	29.8436825	-22.87184963	4.66	1	78	43	147	42	0.00	50.09	23.52	13.55	12.84
C1836 B			4.70	1	21	7	144	50	0.00	59.27	33.70	4.36	2.67
C1868	29.8317178	-22.85852445	5.88	1	268	7	893	166	0.00	68.25	20.80	10.49	0.46
C1995 A	29.8230675	-22.86409379	5.49	1	85	10	289	79	0.00	61.60	27.43	9.21	1.76
C1995 B			5.26	1	60	7	164	94	0.00	46.18	43.43	8.61	1.78
C2008 A	29.7989794	-22.8293181	6.12	1	74	7	314	66	0.00	67.51	23.09	8.12	1.28
C2008 B			5.98	1	69	7	275	71	0.00	63.53	26.95	8.11	1.41
C2022 A	29.7903293	-22.83488563	5.45	1	140	7	287	87	0.00	56.60	28.07	14.09	1.24
C2022 B			5.55	1	83	8	294	127	0.00	53.28	37.77	7.70	1.25
C2024 A	29.7904397	-22.84029935	5.92	1	167	10	596	239	0.00	55.07	36.23	7.87	0.84
C2024 B			5.57	1	295	11	750	340	0.00	51.09	37.98	10.27	0.66
C2506 A	29.7012254	-22.88026638	5.50	1	67	9	436	87	0.00	70.35	22.88	5.55	1.21
C2514	29.7005115	-22.8441723	5.69	1	29	5	189	27	0.00	74.69	17.66	5.82	1.83

(Continues)

Obs No	Co-ordinates		ACID SAT	Ca:Mg	(Ca+Mg)/K	Mg:K	S-Value	Na:K	T	Density	S AmAc	EC	ESP	Clay	Silt	Sand
	Long	Lat	%	1.5-4.5	10.0-20.0	3.0-4.0	mol(+)/kg		cmol(c)/kg	g/cm3	mg/kg	µS/cm		%	%	%
C316	29.7449565	-22.87500389	8.92	1.41	6.24	2.59	1.49	0.15	1.64	1.62	1.80			15	1	84
C327	29.7300792	-22.86172053	0.00	2.75	11.47	3.06	0.98	0.38	0.98	1.71	1.32			9	1	90
C873	29.8371658	-22.8394731	0.00	0.94	15.32	7.89	1.57	0.30	1.57	1.71	0.60			9	1	90
C887	29.8314934	-22.84769742	0.00	6.47	15.14	2.03	15.27	0.05	15.27	1.48	1.93			23	7	70
C1011 A	29.8577209	-22.84452072	0.00	2.55	12.04	3.39	20.24	0.10	20.24	1.30	2.92			36	15	49
C1011 B			0.00	3.19	37.35	8.90	24.57	0.41	24.57	1.22	7.50	631.0	1.05	36	20	44
C1032 A	29.8111053	-22.85076679	0.00	2.59	16.92	4.71	4.75	0.12	4.75	1.66	0.45			15	1	84
C1032 B			0.00	2.03	12.95	4.27	4.16	0.11	4.16	1.68	0.69	53.0	0.81	15	2	83
C1039 A	29.8080179	-22.84269793	0.00	6.30	19.67	2.70	2.53	0.27	2.53	1.70	0.69			9	1	90
C1039 B			0.00	6.10	19.80	2.79	2.47	0.41	2.47	1.65	2.16	37.4	1.92	13	2	86
C1060 A	29.7993674	-22.84826598	0.00	2.05	7.47	2.45	0.68	0.33	0.68	1.72	1.19			7	1	92
C1060 B			5.23	1.29	4.96	2.17	1.09	0.21	1.15	1.70	1.26	26.2	3.24	12	2	86
C1104	29.8308209	-22.81521621	0.00	1.62	10.78	4.11	3.05	0.10	3.05	1.68	0.69			15	1	84
C1144 A	29.8165004	-22.82900906	0.00	2.11	3.27	1.05	3.39	0.04	3.39	1.63	2.39			12	1	87
C1144 B			0.00	3.05	9.14	2.26	3.58	0.11	3.58	1.53	1.54	92.4	1.07	16	1	83
C1241 A	29.7672403	-22.84882808	3.95	2.06	10.30	3.36	2.92	0.19	3.04	1.53	11.93			27	1	72
C1241 B			2.68	1.81	26.89	9.58	4.10	0.43	4.22	1.44	10.75	67.5	1.47	37	6	57
C1562 A	29.8484523	-22.82031731	0.00	3.36	9.41	2.16	4.97	0.11	4.97	1.57	2.48			17	1	82
C1562 B			0.00	3.21	6.63	1.57	6.70	0.05	6.70	1.43	2.42	177.6	0.68	21	1	78
C1577 A	29.8423877	-22.80959468	0.00	3.62	14.69	3.18	1.45	0.51	1.45	1.68	1.44			6	1	93
C1577 B			0.00	3.81	9.73	2.02	2.08	0.17	2.08	1.53	0.70	40.9	1.53	10	1	89
C1600 A	29.8367166	-22.81781906	0.00	2.47	7.50	2.16	3.77	0.09	3.77	1.64	0.45			14	2	84
C1600 B			0.00	1.44	8.64	3.54	3.91	0.09	3.91	1.47	0.28	52.0	0.89	16	3	81
C1836 A	29.8436825	-22.87184963	0.00	2.13	5.43	1.74	1.47	0.95	1.47	1.67	3.83			12	1	87
C1836 B			0.00	1.76	21.33	7.73	1.21	0.61	1.21	1.68	2.65	22	2.67	14	1	85
C1868	29.8317178	-22.85852445	0.00	3.28	8.49	1.98	6.54	0.04	6.54	1.67	1.07			17	2	82
C1995 A	29.8230675	-22.86409379	0.00	2.25	9.67	2.98	2.35	0.19	2.35	1.68	5.14			11	1	88
C1995 B			0.00	1.06	10.40	5.04	1.77	0.21	1.77	1.69	1.59	25.5	1.78	11	2	87
C2008 A	29.7989794	-22.8293181	0.00	2.92	11.16	2.84	2.33	0.16	2.33	1.68	0.70			11	1	88
C2008 B			0.00	2.36	11.15	3.32	2.17	0.17	2.17	1.69	0.91	39.9	1.41	11	1	88
C2022 A	29.7903293	-22.83488563	0.00	2.02	6.01	1.99	2.53	0.09	2.53	1.68	1.15			11	1	88
C2022 B			0.00	1.41	11.82	4.90	2.76	0.16	2.76	1.59	0.78	31.4	1.25	15	1	84
C2024 A	29.7904397	-22.84029935	0.00	1.52	11.60	4.60	5.41	0.11	5.41	1.53	1.38			15	1	84
C2024 B			0.00	1.35	8.67	3.70	7.34	0.06	7.34	1.39	1.00	73.4	0.66	25	1	74
C2506 A	29.7012254	-22.88026638	0.00	3.07	16.79	4.12	3.10	0.22	3.10	1.70	0.60			13	1	86
C2514	29.7005115	-22.8441723	0.00	4.23	15.87	3.04	1.26	0.31	1.26	1.81	1.45			9	2	89

9.4 WATER SAMPLE ANALYSIS FOR IRRIGATION PURPOSES

Twenty six water samples were taken by the WSM Leshika team for analysis throughout the area. The positions and indication of water quality of the samples are illustrated in Figure 21. Table 10 is a copy of the water analysis results, analysed for agricultural and irrigation purposes only.

There are various water quality parameters, but from an irrigation standpoint the chemical aspect (i.e., dissolved salts) is the most important. The following results are usually reported in testing irrigation water: electrical conductivity (EC), sodium adsorption ratio (SAR), pH, cations (Ca, Mg, K and Na), anions (CO_3, HCO_3, SO_4 and Cl), salinity hazard and boron. In addition NO_3, micronutrients (Zn, Cu, Fe and Mn) as well as Ni, Pb, Cd, and As may be reported. Soils will be maintained in a good condition (non-saline, non sodic) when good quality irrigation water and adequate leaching is used. The criteria of quality are low salinity, low ratio of Na^+ to (Ca^{2+} + Mg^{2+}) to prevent sodicity, and small concentrations of those ions which may have specific toxic effects. High salinity water has a direct effect on sensitive crops. At lower salinities, salts may accumulate leading to crop damage.

The chemical analyses of different water sources within the Chapudi Project are summarized in Table 10.

Table 10: Water analysis report (from WSM Leshika)

Species		pH	E.C	TDS	NO_3	F	SO_4	Cl	Ca	Mg	Na
Unit	date		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Bushy Rise BH5	22/12/08	7.7	33	205	2.6	0.5	8.5	46	5.8	6.5	37
Bushy Rise, BH4	22/12/08	6.9	281	2030	12	0.2	91	915	248	109	160
Chapudi, BH21	2/02/09	6.4	13	88	0.4	0.2	12	21	4.8	7.8	12
Chapudi, BH25	2/02/09	6.4	9.7	75	0.9	0.2	7	16	16	5.9	8.3
Chapudi, BH26	2/02/09	7.7	1820	11600	124	0.5	590	6220	223	461	3540
CON-4	15/02/13	7.0	38.7	251.6	<1.4	0.14	7.46	15.4	38.32	19.23	13.03
Coniston, BH9	22/12/08	7.7	43	270	4.5	0.2	18	24	40	23	
D. Rivier, BH12	22/12/08	6.1	11	56	2.7	0.1	4	12	5.5	5.2	6.7
K.rivier, BH10	22/12/08	7.5	191	1200	1	0.7	4.8	254	91	53	246
K.rivier, BH13	22/12/08	8.6	121	820	0.7	2.7	4.6	171	4.7	3.8	292
K.rivier, BH14	22/12/08	7.9	517	4000	32	0.8	925	1026	150	190	743
M.chani, BH2	22/12/08	8	123	740	1	0.7	26	258	26	12	213
M.View, BH1B	22/12/08	7.9	207	1400	5.2	0.4	157	390	107	109	154
MV-1	30/11/12	7.9	110	634	<0.2	1.10	20	191	23	13	199
MV-2	11/12/12	7.5	196	1266	3.50	0.60	130	313	87	112	151
Rdale, BH8A	22/12/08	7.6	44	292	3.5	0.2	20	30	38	21	14
S Edge, BH3	22/12/08	7.6	178	1090	0.3	1	102	346	115	76	181
S. land, BH17	22/12/08	8.1	299	1770	11	1.1	152	591	74	102	333
S.stroom, BH22	2/02/09	6	6.5	46	2.4	0.2	2.4	10	10	3.1	3.3
SAND-1	30/11/12	7.1	337	2056	0.70	0.80	233	721	98	182	329
SAND-2	30/11/12	7.9	95.6	540	<0.2	0.80	21	141	31	34	124
SAND-3	30/11/12	7.6	41.7	252	0.40	0.30	<5	53	18	18	47
V.fontein, BH20C	2/02/09	8.3	83	540	2.3	0.8	8.3	116	25	5.4	175
W.poort, BH11	22/12/08	6.4	163	980	11	0.1	62	455	64	71	147
Wlands, BH6C	22/12/08	7.9	120	760	7.7	0.5	60	197	45	36	161
WILD-1	30/11/12	6.7	49.9	286	<0.2	0.40	18	55	31	20	36

Table 11 discusses the actual measured components in relation to the suitability for irrigation of crops and not for drinking water or for animal health.

Table 11: Severity criteria for the different components of irrigation water

Species	Severity			Issue	Remarks
	No problem	Increasing problem	Severe problem		
pH	6.5– 8.0		<6 or >8	Influence availability of plant nutrients. Use as indicator that a problem can exist. Alkaline water can indicate water high in CO_3 and HCO_3 and or salinity. pH <5.5 or >8.5 can cause corrosion of pipes or equipment.	BH13 and BH20C Severe problem
EC (dS/m)	0.5–0.75	0.75 – 3.0	<0.5 or >3	Use EC as the initial identifying that a problem exists. Further evaluation is needed to determine if the problem is TDS, Na and or CO_3 and HCO_3.	BH26 (TDS, Na) BH14 (TDS, Na) SAND-1 (TDS, Na) Severe problem
TDS (mg/l)	< 500	500–2000	>2000	High salinity can result in salt accumulation in fine textured soils, making it hard for roots to adsorb water. Must determine if dominated by sodium.	BH26 (TDS, Na) BH14 (TDS, Na) SAND-1 (TDS, Na) Severe problem
NO_3 (mg/l)	<50	50 – 100	>100	High concentrations can cause succulent tissue that is not as resource efficient and more susceptible to some pests. Runoff can cause eutrophication in receiving	BH26 Severe problem

				waters.	
F (mg/l)	< 2.0	2.0 – 15.0	>15.0	The most serious effect of fluoride is usually not its effect on plant growth, but rather its effect on animals and humans that consume plants that have accumulated fluoride.	Not a problem
SO_4 (mg/l)	<100	100 - 200	>200	If calcium is present scale can form. As part of salinity, can reduce growth and or cause plant injury.	BH26, BH14 and SAND-1 Severe problem
Cl (mg/l)	< 70	70 - 300	>300	Mobile in the soil, Cl can be taken up by roots and accumulate in leaves causing toxicity.	BH4, BH26, BH14, BH1B, MV-2, BH3, BH17,SAND-1, BH11 Severe problem
Ca (mg/l) For soil and water ion hazard	< 25	25 – 250	>250	Binds with CO_3 and HCO_3 to form lime deposits, contributes to “hard water” and salinity.	No problem for soils. BH4, BH26, BH14, BH1B, BH3, Severe problem
For foliar injury	<60	60 - 100	>100		(foliar injury)
Mg (mg/l)	< 20	20 - 40	>40	Binds with CO_3 and HCO_3 to form lime deposits, contributes to “hard water” and salinity.	BH4, BH26, BH14, BH1B, MV-2, BH3, BH17, SAND-

					1, BH11 Severe problem
Na (mg/l) For soil and water ion hazard For foliar injury	<70 <70	70 - 200	> 200 >70	High concentration can speed up corrosion by other elements. Can also burn foliage. Can negatively influence soil structure. Must evaluate with SAR and EC.	Refer to SAR and EC in table 4. BH4, BH26, BH10, BH13, BH14, BH2, BH1B, MV-1, MV-2, BH3, SAND-1,SAND-2 BH20C, BH11 BH6C Severe problem Foliar injury

Infiltration can decrease under certain salinity and Na conditions. The EC (dS/m) and the SAR values should match up to Table 12 to determine if a problem may exits. Divalent cations such as Ca and Mg act as bridges to bind soil particles together forming soil aggregates. When there are few divalent cations, soil porosity is low with few aggregates and water infiltration is difficult (e.g. EC=0.3 dS/m and SAR is between 0 and 3). Sodium a monovalent cation does not form bridges between soil particles thus limiting aggregate formation. When Na dominates in irrigation water the soil particles disperse and water infiltration will become low. When Na is present in irrigation water but divalent cations dominate or the EC is high, the soil's ability to form aggregates and infiltration is high.

The SAR of the water samples with a high sodium content (> 200mg/l) were calculated and summarized in Table 12.

Table 12: The SAR and EC values of all water samples with sodium content higher than 200 mg/l

Sample	SAR	EC	Infiltration problem
BH26	31.1	18.2	Unlikely
BH10	5.1	1.9	Unlikely
BH13	24.3	1.2	Likely
BH14	9.5	5.2	Unlikely
BH2	8.7	1.2	Moderate
BH17	5.9	3.0	Unlikely
SAND-1	4.5	3.4	Unlikely

Table 13: Infiltration based on the SAR and EC of irrigation water

SAR of irrigation water	Infiltration problem unlikely when EC is more than	Infiltration problem likely when EC is less than
0 to 3	0.7	0.4
3 to 6	1.2	0.3
6 to 12	1.9	0.5
12 to 20	2.9	1.3
20 to 40	5.0	2.9

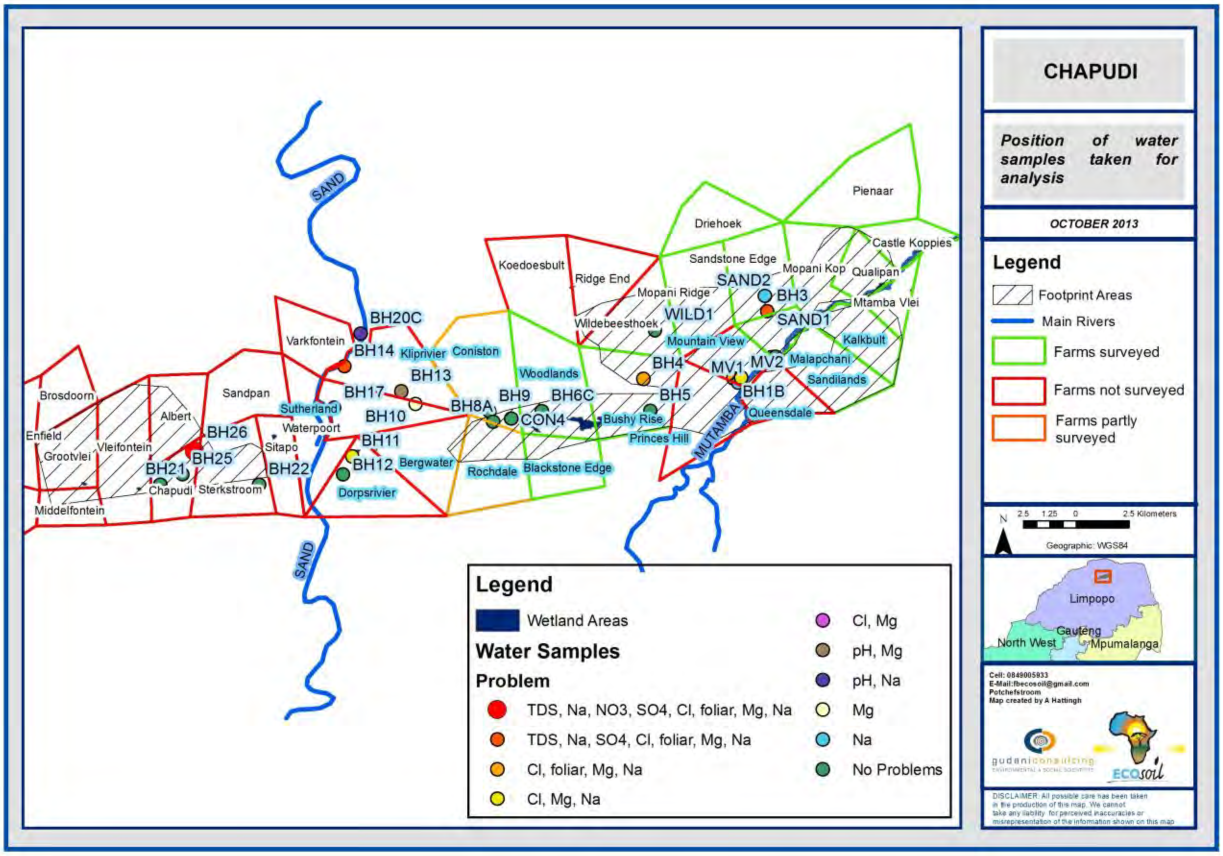
A summary of the water quality problems for irrigation purposes of each water sample is given in Table 14. Quality of borehole water is very good closer to the southern boundary, but generally deteriorates as one progresses north further away from the hills as can be seen from Figure 21. The quality of water of BH26 on the farm Chapudi is very poor and is situated on the footprint in Chapudi West, as can be seen in Figure 21. It cannot be used as a source for irrigation purposes without long-term problems occurring. Quality of water sources SAND1 (Sandstone Edge), BH14 (Kliprivier), BH4 (Bushy Rise and on footprint), BH1B (Mountain View and on footprint), MV2 (Mountain View and on footprint) and BH11 (Dorpsrivier) also have considerable quality problems and will pose a problem to crop production and soil quality in the long term.

Evaluation of water quality should also take the amounts and availability of water into consideration to determine the potential for irrigation purposes. This aspect is not covered in this report.

Table 14: Summary of the water quality problems of water samples analyzed

Sample Number	Problem
BH5	No
BH4	Cl, foliar, Mg, Na
BH21	No
BH25	No
BH26	TDS, Na, NO3, SO4, Cl, foliar, Mg, Na
CON4	No
BH9	No
BH12	No
BH10	Mg
BH13	pH, Mg
BH14	TDS, Na, SO4, Cl, foliar, Mg, Na
BH2	Na
BH1B	Cl, foliar, Mg, Na
MV1	Na
MV2	Cl, Mg, Na
BH8A	No
BH3	Cl, foliar, Mg, Na
BH17	Cl, Mg
BH22	No
SAND1	TDS, Na, SO4, Cl, foliar, Mg, Na
SAND2	Na
SAND3	No
BH20C	pH, Na
BH11	Cl, Mg, Na
BH6C	No
WILD1	No

Figure 21: Position and indication of water quality of water samples



9.4.1 LAND CAPABILITY ASSESSMENT

The land capability according to the Chamber of Mines 1991 classification of the surveyed area is presented in Figure 22 and is summarised per farm in Table 15.

- Wetlands are defined as: "Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined". In this study area the following criteria was used:
  - Riparian zones were not delineated, and only wetland soil parameters per definition were used.
  - Small farm dams and pans that fell between two observation points (based on the grid size in the ToR's) were not mapped.

- A large area of wetlands is found on the farm Woodlands. This wetland is situated on the proposed footprint area. According to law these areas should not be disturbed.
- Footprints on the surveyed areas are generally covered by soils classified with a mixture of arable, wilderness and grazing capability. The farms Woodlands, Bushy Rise and Malapchani have significant areas of arable soils on the proposed footprints and are well suited for irrigation purposes. Smaller areas of arable soils on the footprints, well suited for irrigation and if good quality water sources is available, are also found on the farms Mopani Ridge, Sandstone Edge, Kalkbult, Qualipan and Mopani Kop.

Figure 22: Land capability of the surveyed area

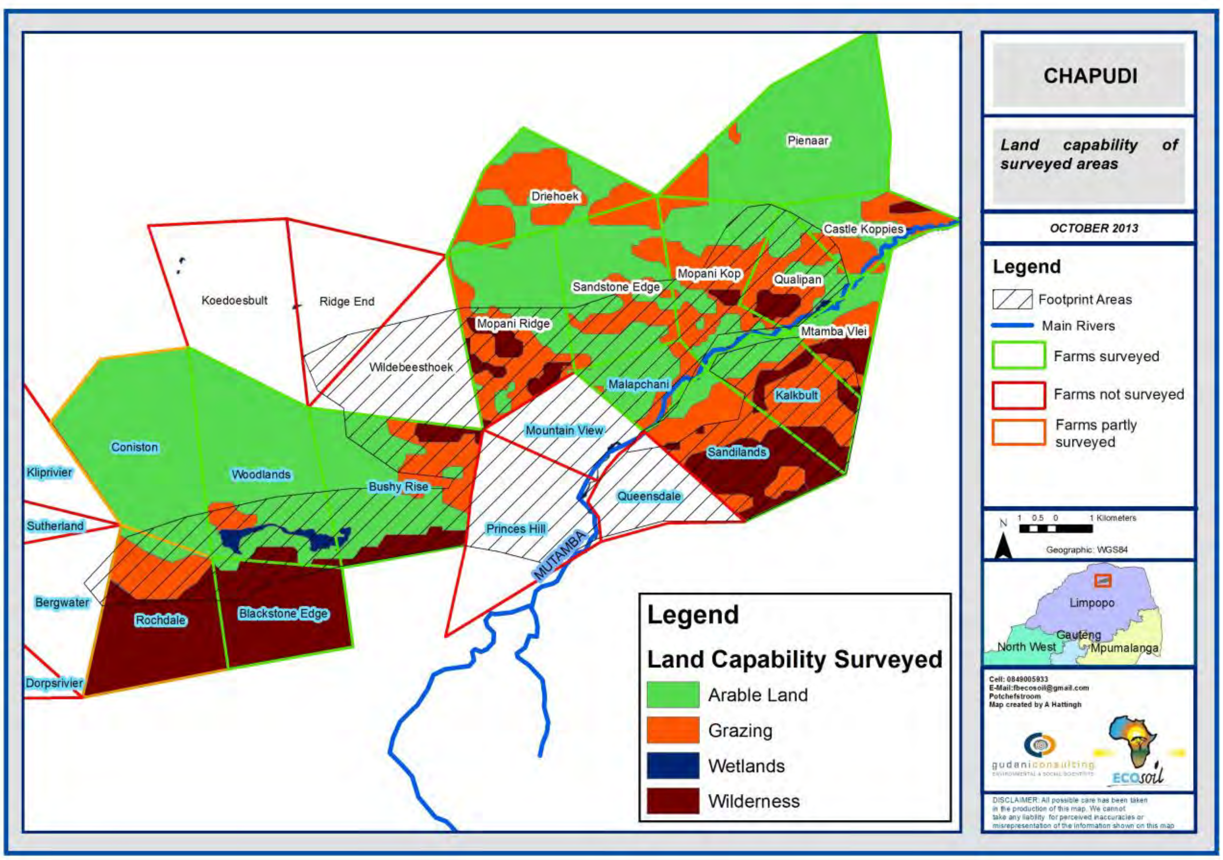


Table 15: Land capability classes and total hectares of each farm respectively for the surveyed area

Farm Name	Total Area (ha)	Arable	Grazing	Wetland	Wilderness
Blackstone Edge	858.7	20.9			837.8
Bushy Rise	1439.9	882.7	312.2	12.4	232.6
Castle Koppies	574.6	268.0	232.5	30.9	43.3
Coniston	1505.7	1505.7			
Driehoek	872.6	317.6	555.0		
Kalkbult	757.6	160.4	393.1	1.0	203.1
Malapchani	427.8	310.2	107.5	10.1	
Mopani Kop	980.5	487.5	442.9	20.4	29.7
Mopani Ridge	1202.7	633.3	402.3		167.1
Mtamba Vlei	421.8	146.7	150.7	10.5	113.9
Pienaar	1618.0	1512.2	105.8		
Qualipan	655.4	328.7	232.4	20.0	74.4
Rochdale	1187.5	82.1	266.5		838.8
Sandilands	1016.0	422.6	86.5	0.6	506.4
Sandstone Edge	1096.7	702.3	394.4		
Woodlands	1555.8	1339.1	69.5	80.0	67.2
Total	**16171.4**	**9120.0**	**3751.3**	**185.8**	**3114.3**
% of surveyed Area	**100.0**	56.4	23.2	1.1	19.3

Table 16: Land capability classes and total hectares of each farm respectively for the surveyed footprint area

Farm Name	Total Area (ha)	Arable	Grazing	Wetland	Wilderness
Blackstone Edge	189.2	20.9			168.3
Bushy Rise	1087.6	593.0	263.8	12.4	218.4
Castle Koppies	40.0	17.2	22.8		
Coniston	98.0	98.0			
Kalkbult	726.3	133.3	389.8		203.1
Malapchani	421.7	306.5	106.8	8.3	
Mopani Kop	592.4	244.1	317.7	1.0	29.7
Mopani Ridge	679.1	165.8	346.2		167.1
Mtamba Vlei	104.3	4.5	54.2	0.2	45.4
Qualipan	633.1	312.2	232.2	14.3	74.4
Rochdale	434.4	70.5	262.0		101.9
Sandilands	767.4	9.1	256.8	0.2	501.4
Sandstone Edge	480.3	277.0	203.3		
Woodlands	542.4	342.0	53.4	80.0	67.0
Total	**6796.1**	**2594.1**	**2508.9**	**116.4**	**1576.7**
% of surveyed footprint	**100.0**	38.2	36.9	1.7	23.2

9.4.2 AGRICULTURAL POTENTIAL ASSESMENT

For purposes of international and national technology transfer and simplicity, the methodology was aimed at reflecting the classic concepts of land capability, as established by Klingebiel and Montgomery (1961) as far as possible. These concepts were to be brought under parameters suited to South African conditions and the local availability of data.

External factors like climate, topography, erosion factors, and surface rock and water quality parameters are brought in consideration to determine the present agricultural potential. Climatic conditions and availability of good quality irrigation water are general restraints within the region and has a direct impact on the agricultural potential of the different soil groups.

- The soils of Group 1-3 are classified as a class III potential. The biggest restraint being texture, percolation and soil fertility. These soils can be irrigated. Soil fertility problems can be overcome with chemical and biological fertilizers and management practices.
- The soils of Group 4 are classified as a class V-VI potential. The biggest restraint being shallow soils, erosion and surface rock.
- The soils of Group 5 are classified as a class IV potential. The biggest restraint being slow infiltration rates, erosion and surface rock.
- The soils of Group 6 are classified as a class V potential. The biggest restraint being slow infiltration rates, soil structure and poor drainage.
- The soils of Group 7 are classified as a class VII potential. The biggest restraint being surface rock, shallow soils.
- The soils of Group 8 are wetland areas and classified as a class VIII potential.

Table 17: Agricultural Potential Classification of land capability classes according to agricultural classification system

Soil Management Unit	Soil Group 1	Soil Group 2	Soil Group 3	Soil Group 4	Soil Group 5	Soil Group 6	Soil Group 7	Soil Group 8
Soil Types	Red Apedal	Yellow Apedal	Neo Cutanic	Carbonate	Neo Carbonate	Pedo cutanic	Shallow rocky	Wetland
Soil depths cm	40-150	40-150	40-150	10-60	40-150	40-80	0-50	-
Average soil depth cm	110	108	106	21	87	63	16.7	-
Limiting Factors	Texture, Percolation	Texture, Percolation	Erosion, Depth, Surface rock	Soil depth, Surface Rock, Erosion	Surface Rock, Erosion, Infiltration rate	Structure, Erosion, Wetness	Surface Rock, Depth	Water-logging
External Factors	Climate, Water Quality	Climate, Water Quality	Climate, Water Quality	Climate, Water Quality	Climate, Water Quality	Climate, Water Quality	Climate, Water Quality	Climate, Water Quality
Land capability	Arable, crop production	Arable crop production	Grazing	Grazing / Wilderness	Wilderness / Grazing	Grazing	Wilderness	Wetland
Agricultural potential	Low to medium	Low to medium	Low to medium	Marginal	Low	Low	Marginal	Marginal
Agricultural Classification	III	III	III	V-VI	IV	V	VII	VIII

10. SUMMARY OF THE IMPACT OF THE MINING DEVELOPMENT ON AGRICULTURAL POTENTIAL AND LAND CAPABILITY

Table 18: Summary of the impact of mining on agricultural potential and land capability

Impact	Loss of agricultural potential and land capability	
	Without mitigation	With mitigation
Extent	High	High
Duration	Permanent	Permanent
Magnitude	High	High
Probability	Highly probable	Highly probable
Significance	High	High
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources	No	No
Can impacts be mitigated	No	No
* The agricultural potential of the area is low, but the loss of agricultural land stretches far beyond the operational mining processes.		
* Due to low clay contents, wind erosion can become a problem if soils are not permanently covered with vegetation. Soil erosion is a strong possibility due to increased surface run-off and occasional high intensity rain occurrences in areas with higher clay contents. Erosion control and adequate management is needed.		
* Loss of agricultural land is a long term loss. There are no mitigation measures that can combat this type of loss.		

11. CONCLUSIONS OF SOILS ASSESSMENT

- Access was denied on all the farms west of the Sand River and some farms east of the Sand River. Generalisations of the land capability and agricultural potential were derived from the 1:250 000 land-type study for areas not surveyed. This is presented in Figures 15 and 16 respectively.
- Only 16171ha of the total project area was surveyed.
- Different soil properties of the surveyed areas are illustrated in Figures 17 to 22.
- There are significant differences between the information presented in Figure 16 and Figures 22 respectively. The differences are due to the different scale of survey that was used with the land type study and the more detailed soil survey for this specific project respectively. From the differences between Figures 16 and 22 and it can be concluded that it is crucial to do a more detailed soil

investigation on the farms not yet surveyed, in order to obtain a better and more accurate assessment of the land capability and agricultural potential.

- Approximately 2594 ha of the footprint area east of the Sand River (Chapudi and Wildebeesthoek) is deeper than 75cm and can be regarded as good for crop production under irrigation where high quality water for irrigation is available.
- Footprint areas west of the Sand River were not surveyed, but from Figure 15 it can be concluded that large areas of the proposed footprint have arable soils.
- At present (2236ha) in the project area are presently under cultivation (1699ha dry land and 537ha irrigated).
    - These areas generally have deep soils and are suitable for crop production especially under irrigation when sufficient amount of good quality irrigation water is available.
    - Rainfall is in general too low for rain-fed crop production, however areas near the hills have higher rainfall (even 400 to 550mm as indicated in Figures 11 and 12) and cultivated pastures may be an option for farmers.
    - As a result of low rainfall, high temperatures (high evapotranspiration), susceptibility to compaction, present erosion and potential erosion susceptibility of the soils in the area, the soils are not always optimal for rain fed crop production.
- Water quality for irrigation purposes varies across the project area.
    - Eleven (11) of the 26 tested water sources are highly suited for irrigation purposes, with absolutely no restrictions to irrigation. These boreholes are situated near the hills in the southern parts of the project area (Figure 21).
    - Some of the water samples only have minor suitability constraints and can be used for irrigation if it is well managed.
    - The quality of water of some of the boreholes further north in the study area, is less suitable for irrigation purposes with restrictions specifically to sensitive crops.
    - The quality of two boreholes (one each on the farms Chapudi and Kliprivier respectively) is of very poor quality for irrigation purposes.

  - Water samples were taken during the winter and it is recommended to make a continual assessment of water quality during the year, since it can change significantly during the year.
- Shallow soils and surface rock are dominant in large areas. Areas classified for grazing have presently low basal grass cover and are dominated by Mopane shrub field and will be discussed in detail by the biodiversity report.
- Present land use is cattle and game farming, but carrying capacity is questionable due to poor soil fertility (potential erosion susceptibility, shallow soils, and surface rock) and poor climatic conditions.
- Table 15 presents the different categories and areas for the **surveyed farms** according to the Mining classification:

  - Arable land 9120 ha (56,4%)
  - Grazing areas 3751ha (23.2%)
  - Wilderness areas 3114ha (19.3%)
  - Wetland areas 186ha (1.1%).
- Table 16 presents the different categories and areas for the **surveyed footprint** area, according to the Mining classification:

  - Arable land 2594 ha (38.2%)
  - Grazing areas 2509ha (36.9%)
  - Wilderness areas 1576.7ha (23.2%)
  - Wetland areas 116.4ha (1.7%).
- Soils classified as arable land fall into classes III to IV according to the agricultural classification system.
- Generally the soils are sandy and susceptible to erosion (water and wind) and should be permanently covered with vegetation to prevent erosion and top soil loss. Uncovered areas are also susceptible to water erosion in times of high intensity storms.
- Stripping and rehabilitation for the proposed mining operation will be discussed separately under point 15 and onwards.

12. RECOMMENDATIONS OF SOILS ASSESSMENT

Impacts on the environment must be minimized or limited on construction sites.

The following is recommended if the area will be used for mining purposes:

- The areas not yet surveyed should be surveyed and analysed in more detail to determine the areas for soil potential
- Water quality should be monitored as an on-going process with high priority. High quality irrigation is present especially in the area just north of the hills and should be kept in that state. If any changes are observed, the source of pollution should be determined and eliminated.
- If mining is considered in the area, specialists should be used to evaluate the erosion and other possible impacts during the entire mining process. The entire area should be vegetated throughout the entire duration of mining due to the possibility of wind erosion and relative dry conditions (low clay contents in the top soils).
- Specific control measures are needed to control water erosion and run-off to prevent excessive surface run-off from the site
- Limit impacts to the footprints to keep physical impacts as small as possible
- Areas for road and site lay-out should be minimized.
- Dust generation and vehicle associated pollution must be minimized.

13. METHODOLOGY USED FOR IMPACT RATING

The methodology includes the following:

- Descriptions of all methods, measures and instruments adopted during the undertaking of the applicable specialist study; and
- Impact rating method used, which is provided below.

13.1 NATURE OF IMPACT

The nature of the impact refers to whether an impact is positive or negative.

Table 19: Nature of impact

Status	Description	Rating
Positive	Benefit to the environment	+'ve'
Negative	Detriment to the environment	-'ve'

13.2 IMPACT TYPE

Each impact needs to be classified as a direct, indirect or cumulative impact. (Centre for Environmental Excellence, 2008) (Council on Environmental Quality, 2008).

Table 20: Impact type

Type	Description	Rating
Direct Impact	Is a reaction that is caused by the direct interaction of a planned action or activity on the receiving environment, e.g. the discharge of water into a water stream, the discharge of pollutions through a stack. Usually in close proximity to the action or activity.	Direct
Indirect Impact	Is a reasonably foreseeable reaction that is indirectly caused as a result of a planned action or activity, the effects/ impacts are usually later in time and farther removed from the action or activity, e.g. growth inducing effects, changes in patterns of land use, population density or growth rate and related effects on air, water, ground and ecosystems.	Indirect
Cumulative Impact	Is the impact on the environment, which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions, regardless of undertakings by other industries, mines, developments or persons? Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.	Cumulative

13.3 GROUPING OF IMPACT

The grouping of the impact refers to whether the impact will be a result of a planned project activities or unplanned project activities.

Table 21: Grouping of impact

Grouping	Description	Rating
Routine	Impact that occurs as a result of expected and planned project activities.	'R'
Non-Routine	Impact that occurs as a result of an unexpected and unplanned project activity. Usually occurs in emergency events.	'NR'

13.4 CERTAINTY (PROPABILITY) OF IMPACT

The certainty of the impact describes the likelihood of the impact occurring.

Table 22: Certainty of impact

Certainty	Description	Rating
Unlikely	Less than 40% sure that the impact or benefit will occur.	1
Possibility	Between 40% and 70% sure that the impact or benefit will occur.	2
Probable	Between 70% and 90% sure that the impact or benefit will occur.	3
Definite	Over 90% sure that the impact or benefit will occur.	4

13.5 SPATIAL EXTENT OF IMPACT

The extent of the impact refers to the spatial scale of the impact or benefit of the proposed project and the area over which it extends.

Table 23: Spatial extent of impact

Spatial Extent	Description	Rating
Site specific	Effects felt within the site boundary area.	1
Local	Effects are felt within 5 km radius from the site boundary area.	2
Regional	Effects are felt within a 50 km radius from the site boundary area.	3
National	Effects are felt beyond a 50 km radius from the site boundary area within South Africa.	4

13.6 DURATION OF IMPACT

The duration refers to the time scale of the impact or benefit in terms of the period of time that the surrounding environment will be affected or altered by the proposed project.

Table 24: Duration of impact

Duration	Description	Rating
Short term	Less than 5 years	1
Medium term	Between 5 and 20 years	2
Long term	Between 21 and 40 years	3
Permanent	Permanent impact	4

13.7 REVERSIBILITY OF IMPACT

Reversibility refers to the time it would take to reverse or undo the impact under discussion.

Table 25: Reversibility of impact

Reversibility	Description	Rating
Short term	Less than 5 years	1
Medium term	Between 5 and 20 years	2
Long term	Between 21 and 40 years	3
Permanent	Permanent impact, i.e. not reversible	4

13.8 SEVERITY (INTENSITY) OF IMPACT

The severity is the attempt to quantify the magnitude of the impact whether positive or negative, which is associated with the proposed project. The scale therefore accounts for the extent and magnitude but is subject to the value judgement.

Table 26: Severity of impact

Status of Impact	Severity	Description	Rating
Negative	Slight	• Minor deterioration; • Short to medium term duration; and • Mitigation is easy, cheap and quick.	1
	Moderately severe	• Moderate deterioration; • Medium to long term duration; and • Fairly easy to mitigate.	2

	Severe	• Marked deterioration; • Long term duration; • Serious and severe impact; and • Mitigation is very expensive, difficult or time consuming.	3
	Very severe	• Substantial deterioration; • Irreversible of permanent; and • Cannot be mitigated.	4
Positive	Slightly beneficial	• Minor improvement; and • Short to medium term duration.	1
	Moderately beneficial	• Moderate improvement; and • Medium to long term duration.	2
	Beneficial	• Large improvement; and • Long term duration.	3
	Very Beneficial	• Permanent improvement.	4

13.9 SIGNIFICANCE OF IMPACT

The significance of a positive or negative impact describes and evaluates the importance of that impact in accordance with the scope of the project. Impacts can be described and evaluated in terms of their type, extent, complexity, intensity and duration. This evaluation criterion provides a basis for comparison and the application of judgement (Department of Environmental Affairs and Tourism, 2002). The significance of an impact is calculated as follows:

(Severity + Reversibility + Duration + Spatial) x Certainty = Significance

Table 27: Significance of impact

Significance		Description	Rating
Very low(1)	Negative	• Constitutes as a short term effect, which is site specific; • Easily reversible by the application of easy, cheap or quick mitigation measures; • Mitigation might not even be required, and • Society and/or specialist view the change as negligible.	0-4
	Positive	• Slightly beneficial impact, which constitutes a minor improvement; • Short term duration; and • Enhancement measures to be implemented to increase the effect of the positive impact.	
Low (1 - 2)	Negative	• Marked deterioration; • Short to medium term; • Effects are not substantial. • Society and/or specialists view the change as unimportant; and • Mitigation is easy, cheap or quick.	5 - 15

Significance		Description	Rating
	Positive	• Marked improvement; • Short to medium term; and • Enhancement measures to be implemented to increase the effect of the positive impact.	
Moderate (2 - 3)	Negative	• Constitutes as medium to long term effect; • Effects are real but not substantial and ; • Society and/or specialist do not view the impact as substantial and very important; and • Mitigation is fairly easily possible.	16 - 35
	Positive	• Marked improvement; • Medium to long term; • Effects are real, but not substantial; and • Enhancement measures to be implemented to increase the effect of the positive impact.	
High (3-4)	Negative	• Long term effect; • Society and specialist view the change as very serious; • The reversibility of the impact is long term; and • Mitigation is very expensive, difficult and time consuming.	36-63
	Positive	• Long term effect; • Society and specialist view the change as very positive; and • Enhancement measures to be implemented to increase the effects of the positive impact.	
Very high (4)	Negative	• Constitutes as a permanent change to the environment; • Society and/or specialist view the change as very serious; • The impact cannot be reversed; and • The impact cannot be mitigated.	64
	Positive	• Constitutes as a permanent change to the environment; • Society and specialist view the change as very positive; and • Impacts cannot be reversed.	

14. IMPACT ASSESSMENT

Table 28: Predicted impact assessment of the proposed mining activity on the soils

Project phase	Nature	Certainty	Extent	Duration	Reversibility	Severity	Significance
Before Mitigation							
Construction	-	4	2	1	3	3	**36**
Operation	-	4	2	4	3	3	**48**
Decommissioning	-	2	2	2	3	3	**20**
After Mitigation							
Construction	-	4	1	1	3	2	**28**
Operation	-	4	2	4	3	3	**36**
Decommissioning	-	2	2	2	3	3	**20**

15. DUST GENERATION AND VEHICLE IMPACT ASSESSMENT

15.1 DUST GENERATION

During the operational time all vegetation will be removed and creates a potential for wind erosion and therefore dust generation.

- A soil with low clay contents is susceptible to wind erosion, but has a low dust generation potential.
- Soils with high clay contents have an inherent stability and have a low dust generation potential, except for Vehicle movement. Vehicles can cause powdering and breaking of the soil structure. It is recommended that all roads should be gravelled.
- Soils with clay contents between 5 and 25 percent have a high dust potential. Clay contents of the area are illustrated in Figure 19, and area susceptible to a high dust generation potential is illustrated in red.

Three potential areas of dust formation are identified:

- Open-pit areas: Dust control can be achieved by additives like molasses or watering on a regular base.
- Stockpiling areas: Rock armouring of the stock piles can reduce wind and water erosion.

- All roads: Use of gravelled roads.

15.2 ON SITE VEHICLE OPERATIONS

- Vehicle movement should be minimized and restricted to the construction site on gravelled roads, in order to reduce potential rill erosion and dust formation.
- Maintain vehicles and prevent and address spillages of lubricants and petroleum.

16. CONCLUSIONS OF IMPACT ASSESSMENT

- As mentioned previously, generally the soils are degraded through erosion and top soil loss. The majority of area has a poor basal cover, and it is prone to compaction and crust formation
- The soils are low to medium potential arable soils and have low soil fertility. This has the implication that rehabilitation will be complex and special measures need to be implemented to prevent soil loss through wind and water erosion (see Appendix)
- Majority of water samples tested for irrigation purposes have good quality. Special measures should be put in place to protect surface and sub-surface water sources from further contamination.

17. RECOMMENDATIONS

17.1 MITIGATION MEASURES REQUIRED

17.1.1 SOIL STRIPPING IN CONSTRUCTION PHASE

- The Red and Yellow Apedal soil groups are suitable as growing medium; effort should therefore be made to strip the topsoil separate from the underlying material (see Appendix) for later use.
- Soils in the wetland should be kept undisturbed.
- Average soil depths range from 40-150cm and are on average110cm deep. If soil stripping is necessary, it is recommended to strip only 40-60cm of the soil. These estimates take into consideration a possible 10% topsoil loss through compaction and allow the rehabilitated areas to be returned to the pre-mining land capability, i.e. arable cropping and grazing land.
- Any soil that might possibly be contaminated during the construction phase should be stripped and stockpiled in advance of construction activities.
- The stripped soils should be stockpiled upslope of areas of disturbance to prevent contamination of stockpiled soils by runoff or seepage.
- All stockpiles should also be protected by a bund wall to prevent erosion of stockpiled material and deflect water runoff.
- Stockpiles should be placed where possibly on the areas covered by stony or rocky soils (Mispah, Glenrosa and Coega).
- Care should be taken that stockpiles do not to block too many drainage lines as high intensity rainfall events can occur in this area (e.g. the rainfall in January 2013 exceeds the average annual rainfall).

17.1.2 OPERATIONAL PHASE

- 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 and to keep the soils biologically active.
- If used to screen operations, the surface of the stockpile should not be used as roadway as this will result in excessive soil compaction.

17.1.3 DECOMMISIONING AND REHABILITATION

Detailed recommendations concerning a sustainable approach to soil rehabilitation of opencast mining areas are given in the appendix. The following issues need to be taken into consideration before, during mining operations, with closure and rehabilitation:

- Loss of topsoil and usable soil
  - Strip all usable soil and stockpile.
  - Vegetate long-term soil stockpiles
- Contamination of topsoil and stockpiled soil
  - Prevent contamination of topsoil and stockpiled soil.
  - Site all soil stockpiles upslope from any mining / development activities
  - Position stockpiles upslope of mining areas, or as screens to restrict visibility of the mining operation provided that in doing so, the stockpile is not exposed to the risk of seepage or dirty water contamination.
- Erosion of stockpiled soil
  - Ensure that all stockpiles have a storm water diversion berm for protection against erosion and contamination by dirty water.
- Loss of soil biodiversity
  - Most soil stockpiles become sterile as soil microbiology dies off due to long-fallow syndrome. Compost, Kraal Manure and / or humic and microbial substances can be used to restore soil biology.

- Probability of compaction
  - The footprints of stockpiles on deep soils (not necessary for shallow soils) must be loosened after removal of the stockpiles, because of compaction during the stockpiling process.

17.1.4 MONITORING AND MEASUREMENT REQUIREMENTS

- Sampling sites need to be established down- stream on neighbouring farms.
- Regular water quality monitoring also need to take place in the Sand River to monitor any impact the proposed development might have on the regional surroundings.

18. MANAGEMENT RECOMMENDATIONS

The area can be converted to mining, but measures must be put in place to limit soil erosion and contamination of boreholes and surface water and the wetlands.

19. BIBLIOGRAPHY

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- Soil classification working group. 1991. Soil classification. A Taxonomic system for South Africa. Department of Agricultural Development. Pretoria.
- Coaltech 202/Chamber of mines of South Africa (2007). Chamber of Mines Guidelines for the rehabilitation of mined land (1991).

20. APPENDIX 1*:* REHABILITATION OF OPENCAST MINING SOILS

1. INTRODUCTION

Global agriculture is facing a trend in yield decline for most crops. This is specifically applicable to crops that are practised under a mono-cropping system. It is a well-known scientific fact that monoculture has a negative impact on soil fertility and potential.

With mono cropping and overuse of land, it has become necessary for farmers to resort to more drastic measures to maintain yields. One such practise is to increase N, P and K chemical fertilisers at ever increasing costs, because the perception is that the higher the fertiliser levels the higher the yield.

This same mind-set is prevalent with the rehabilitation of opencast mining areas. The impact of mining operations is just so much amplified as the whole soil profile with all the integrated soil physical, chemical and biological processes is destroyed. This is often the result of a lack of understanding that soil is a living eco-system and that there is a difference between soil fertility and plant nutrition. There is also a difference in understanding the term topsoil from a soil science and mining perspective.

A distinction must be made between restoring soils to previous inherent potential for crop production and sustainable rehabilitation. As previously mentioned soils form over a long period of time with various processes involved. The opencast mining operations totally disturb these process and soil forming factors.

It is not possible to restore the soil potential and initial characteristics to its original state but huge improvements can be made in the methodology of stripping and re-dressing of soil material to ensure sustainability of rehabilitation. Over time these soils can produce proper vegetation and grazing of cattle and arable crop production at lower yields then the initial soil potential.

To achieve this it is necessary to understand the soil forming factors and processes and the difference between soil fertility and plant nutrition.

2. DEFINITION OF SOIL

Soil is an open living ecosystem and can therefore be defined as a function of physical, chemical and biological processes.

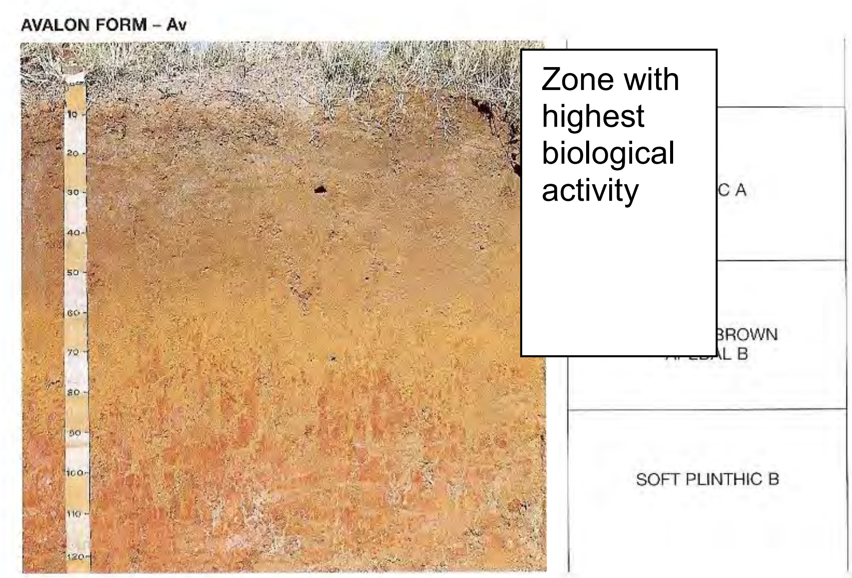
3. SOIL FORMING PROCESSES

The following factors are involved in soil formation:

- Parent Material (geology, e.g. sedimentary rock (sandstone), acid igneous (granite) or basic rock dolerite) etc.)
- Topography (slope of landscape)
- Climate (wind, water, temperature etc.)
- Microbial Activity and microbial diversity
- Time (soil formation occurs over a long time period, e.g. 1cm of topsoil is formed over 100yrs)

These factors with different physical, chemical and biological processes combine under specific conditions to form specific soil diagnostic horizons with a unique character and inherent soil fertility.

Photo 1: Avalon soil showing different horizons (Soil classification working group, (1991)



4. FERTILITY / PLANT NUTRITION

Fertility refers to the inherent capacity of a soil to supply nutrients to plants in adequate amounts and in suitable proportions as well as oxygen and moisture to maintain a healthy soil bio-diversity (active micro-biology, immune system). The focus here is soil health.

Plant nutrition refers to the soils ability to supply nutrients to the plant so it can complete its reproductive cycle. The nutrient status of the soil can be manipulated by adding organic and inorganic fertilisers according to the crop's need. The focus here is on the crop's needs.

It can now be summarised that different soils have different levels of soil fertility according to the combination of the soil forming factors and soil processes involved under specific conditions. All these factors and processes are interlinked and no single soil type has all these factors in the ideal combination, therefore the yield potential and use of soils varies.

Unfortunately soil fertility and nutrition was relegated to a simple recipe of four elements provided through chemical fertilisers e.g. Nitrogen (N), Phosphorous (P), Potassium (K) and Zinc (Zn) to meet only the crop needs at the expense of soil fertility. Very little attention was given to the important role of bio-diversity and active microbiology in plant nutrition. It is only in the last couple of years that there is a serious interest on this matter.

5. THE ROLE OF BIODIVERSITY

Active and healthy soil microbiology is able to:

- Mineralise nitrogen, phosphorous and sulphur
- Suppress nematodes, bacterial and fungal diseases
- Actively decompose organic material
- Improve root development with the result of better nutrient and water uptake
- Recycle and keep nutrients available for plants, especially micro-nutrients
- Improve soil physical and chemical conditions by increasing the humus content
- Improve water holding capacity of soil
- Less KWa power needed for soil tillage

6. MINING PRACTISES THAT CONTRIBUTE TO THE DESTRUCTION OF SOIL FERTILITY AND LOSS OF BIO-DIVERSITY

- Incorrect stripping of topsoil. Various soil horizons with different properties are stripped together and stockpiled.
- Stockpiling of proper topsoil with sterile or acidic subsoil (plinthic or grey clay material)
- Long periods of stockpiling creates anaerobic conditions, resulting in a decline in microbial activity and/ or changes in bio diversity.
- Soils are nutritionally stripped and have low microbial activity

- Long fallow periods are as detrimental to soil health as no fallowing.
- Incorrect soil placement with rehabilitation (plinthic and grey clay material on the soil surface), causes slaking, increasing crust formation, and compaction resulting in poor infiltration, aeration and increased run-off and erosion. These plinthic and grey clay materials are also basically sterile in terms of microbial activity
- Poor irrigation practises. Over irrigation causes leaching of nutrients.
- Decline in water quality in major river systems is causing a gradual build-up of salinity and sodicity.

In most cases poor seed germination or die-back of seeded grass occur because of a combination of these factors mentioned.

The following can be done to improve soil bio-diversity and therefore sustainable rehabilitation:

- Crop rotation
- Fallowing and green-manuring
- If there is not sufficient time to introduce proper fallowing or green-manuring practises compost can be applied to the soil

7. RECOMMENDATIONS FOR PROPER REHABILITATION OF SOILS DISTURBED BY OPENCAST MINING OPERATIONS

7.1. STRIPPING

- Sequential stripping of soil horizons. In some cases the A and A-Horizons can be stripped together. This has a huge practical, logistics and cost implication, but until such time that it is implemented, no improvement in sustainability of rehabilitation will occur
- Smaller stockpiles and seeding of stockpiles with grass

7.2. LANDSCAPING AND REPLACEMENT OF SOILS

- It is imperative to reshape the landscape as close as possible to its original topographic features (e.g. slope and drainage lines, wetlands). Various surveying and GIS software can be used to achieve this goal
- Where possible use the "freshest" stripped soils for redressing, as this will alleviate the soils becoming sterile or lose microbial activity
- Place the plinthic and grey clay material in the sub-soils and the original A and A-Horizon material on top. Create an environment where the topsoil is at least 40-60cm deep for proper aeration, water-holding capacity and drainage, resulting in proper root development

7.3. SEEDING WITH GRASS SPECIES AND LEGUME CROPS

- A three stage approach can be implemented where pioneer species are planted to create a soil environment for sub-climax species. After some time climax species can be introduced. There are many case studies where reseeding is necessary because the sub-climax and climax grass species die back after the first or second season
- Legume crops like soya, cow peas, Dolichos, or Lucerne can be introduced to improve the soils microbial activity and soil structure.
- Compost and other organic humic substances can be used to speed up the process of restoring soil biodiversity

8. THE ROLE OF COMPOST AND OTHER HUMIC SUBSTANCES IN RESTORING BIODIVERSITY IN DISTURBED SOILS

Many books have been written about the role of compost in improving soil bio-diversity as well as the making of compost. It never became a standard practise in commercial agriculture for the following reasons:

- It is bulky and transport costs did not make it viable
- Practical problems with application

- The value was always measured in terms of N, P and K content and in monetary terms.

Times have changed however and recent research across the world has shown that soil bio-diversity has great value in commercial agriculture and rehabilitation both from fertility as well as a plant nutrition perspective. Compost is a great and fairly quick way in restoring soil fertility although it must be made clear that it is a long term approach that is necessary. Organic and humic products can overcome to some degree the practical and logistical problems posed of importing large volumes of organic matter.

9. SUMMARY

- There is no quick fix solution to the seriously negative impact of opencast mining on high potential soils
- Proper stripping and replacement of soils is imperative for any proper redressing and seeding with grass species to take place
- A holistic long term, staged approach is necessary to restore physical, chemical and biological processes in the growth medium
- Long term monitoring and relevant adjustments must be made to restore the soils to some sort of arable crop production potential to ensure future food security problems that might loom.

21. APPENDIX 2: CURRICULUM VITAES

21.1 CURRICULUM VITAE OF S. NKOPANE

21.1.1 PERSONAL DETAILS

- **Name :** Nkopane S.L
- **Date of Birth :** 11th January 1972
- **ID Number :** 720111 5172 089
- **Marital Status :** Married
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21.1.2 FORMAL QUALIFICATIONS

- BSc – Physical Geography and Biology: University of Lesotho, 1994
- BSc (Hon) – Environmental Sciences: University of Cape Town, 1995
- MSc – Environmental Impact Assessment: University of Cape Town, 1997

21.1.3 PROFESSIONAL AFFILIATIONS

- SACNASP – 400022/13
- International Association of Impact Assessments – South Africa (IAIA-SA).
- IAIA-SA – Limpopo Regional Chairperson 2012/13.

21.1.4 EMPLOYMENT HISTORY

- March 1997 – November 1997, Environment Officer, Department of Environmental Affairs, Gauteng Province.
- November 1997 – February 2006. Deputy Director: Mine Rehabilitation, Department of Minerals and Energy, Limpopo Province

- April 2006 – February 2008, Regional Environmental Manager – Venetia Mine and The Oaks Mine – both DBCM mines.
- March 2008-Current , Managing Director, Gudani Consulting

21.1.5 WORK EXPERIENCE AND PROJECTS

- EMP Amendment – Modikwa Platinum Mine – 2009
- Prospecting Right Application (including EMP) – Fine Asset Investments – 2009
- IWULA – Bus Rapid Transit (BRT) Project – Mabopane to Pretoria – 2009
- EMP for proposed Sefateng Chrome Mine – Corridor Mining Resources – 2010
- Environmental Impact Assessment – Bulk Water Supply Pipeline – Lephalale Local Municipality – 2010
- Environmental Impact Assessment – Giyani Bulk Water Supply Pipeline – Department of Water Affairs - 2010
- Environmental Impact Assessment – Upgrading of R35 Main Road – Amersfoort to Morgenzon – SANRAL – 2010
- Waste Rock Dump Plan and Rehabilitation Strategy – Modikwa Mine – 2010/11
- Stakeholder Empowerment & Capacity Building – Mogalakwena sub-Catchment, Limpopo – Department of Water Affairs – 2010/11.
- EMP Performance Assessment and Closure Costing – Modikwa Mine - 2011
- ISO 18001/14001 Internal Audit – Thabazimbi Iron Ore Mine – 2011.
- Strategic Environmental Assessment – Agricultural Development – Lephalale Municipality – 2011.
- Institutional Assessment and Re-Engineering of NCWSTI into University of Limpopo – The Mvula Trust – 2011
- Feasibility Study on Small Scale Mining Potential within Sekhukhune District Municipality – Sekhukhune Development Agency – 2011
- EMP Amendment and Closure Costing– Silicon Smelters, Polokwane – 2011

- Stakeholder Engagement – Limpopo Catchment Area – Department of Water Affairs – 2012
- Atmospheric Emissions License – Silicon Smelters – 2012
- Environmental Impact Assessment – Bulk Water Supply and Sewage Pipeline – Lephalale Local Municipality/COGHTA – 2012
- Environmental Impact Assessment for Commercial Site Development - Ratsoma Properties, 2012
- Public Participation Process – Harriet's Wish Mining Project – Hacra Mining and Exploration (Pty) Ltd – 2012
- Environmental Screening Process – Relocation Project De Hoop Dam: ORWRDP – Phase 2 – Department of Water Affairs, 2012
- Public Participation Process – Jaglust and Lwala Mining Projects – Samancor Eastern Chrome Mine – 2012/13
- EMP Amendment – Doornbosch Triangle Project - Modikwa Platinum Mine – 2012/13

21.2 CURRICULUM VITAE OF F. BOTHA

21.2.1 PERSONAL DETAILS

- **Name :** Botha, F
- **Date of Birth :** 9 June 1959
- **ID Number :** 59 06095074087
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21.2.2 FORMAL QUALIFICATIONS

- B.Sc (Pedology) from PU for CHE, 1984
- B.Sc (Hon) Pedology) from PU for CHE, 1988
- B. Comm. (Economics and Business Economics) from UNISA, 2001.

21.2.3 PROFFESIONAL AFFILIATIONS

- Soil Science Society of South Africa
- South African Soil Surveyors association
- Land Rehabilitation Association of SA (formation in process)
- SA Irrigation Institute

21.2.4 EMPLOYMENT HISTORY

- 1984-1988, Trans-Agric, College of Agriculture, Senior Lecturer in Soil Science.
- 1988-1991, ICI-Kynoch Agrochemicals, Training Co-coordinator
- 1991-1996, Lowveld College of Agriculture, Senior Lecturer in Soil Science.
- 1997-2004, SA Sugar Association, Senior Extension Officer, Malelane region.

- 2004-2007, Advanced Nutrients SA, Technical Director.
- 2007-Present, Private Consultancy and Director of Eco Soil.

21.2.5 WORK EXPERIENCE AND PROJECTS

- 8 years' experience as an extension officer, with the focus on sugarcane production under irrigation in the Malelane region.
- Initiated and Assisted SASRI research Dept with various trials related to sugarcane production.
- Involvement in pedological and geological surveys for Forestek (35 000ha's), ARC and private individuals for forestry, game ranching, farming enterprises and new agricultural developments (150 000ha).
- Functioned as project leader on a number of large scale soil survey projects, e.g. Donkerhoek Agricultural project, Mpmalanga
- Pedological specialist studies for environmental impact assessments (EIA's) as well as a number of economic and agronomic feasibility studies for new agricultural developments.
- 13 Years lecturing experience in soil science at agricultural colleges.
- Consultation on biological and soil health principles on various agricultural projects
- At present consulting on the following Precision farming sampling and mapping in the maize sugar and industry
    - Feasibility studies on new sugarcane and agricultural projects under irrigation in Southern Africa
    - Environmental Impact Assessments for mining and new projects
    - Rehabilitation of opencast mining soils

21.3 CURRICULUM VITAE OF A. HATTINGH

21.3.1 PERSONAL DETAILS

- **Name :** Hattingh, A. M.
- **Date of Birth :** 9 December 1956
- **ID Number :** 5612090077089
- **Marital Status :** Married
- **Cell:** 0828536228
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21.3.2 FORMAL QUALIFICATIONS

- BSc Pedology, PU for CHE, 1977
- BSc (Hon) Pedology, PU for CHE, 1978
- MSc Pedology, PU for CHE, 1983

21.3.3 MEMBERSHIP

- Soil Science Society of South Africa.
- International Soil Science Society.

21.3.4 EMPLOYMENT HISTORY

- 1979 –1993 Dept. of Agriculture (Highveld Region) as Researcher.
- 1993-1996 Assistant Director Soil Science.
- 1997-1998 Part time lecturer at PU for CHE in clay mineralogy, soil physics, irrigation, drainage, soil chemistry.
- 1997 Part time at REHAB. Soil consultant
- 1998-2002 Own business: Handrid Flora: Seedlings and vegetable production.
- 2002- 2003 Own Business in participation with Africa Plus Projects and Geoquip. Irrigation scheduling and soil consultant.

- 2004 Consultant Techniland. Precision farming.
- 2006 GCI- ARC. Researcher
- 2007 –2008 Africa Geo Environmental Services (AGES) GIS specialist, Soil Scientist
- 2009-2010 Part time Lecturer at Potchefstroom University and Agricultural College Potchefstroom. Private consultation.
- 2011-present. Precision Farming Own Business. Africa and mine Projects with GIS interpretation of soil and land capability studies.

21.3.5 WORK EXPERIENCE AND PROJECTS

- Reports and GIS work for Africa (Tanzania, Mozambique) Projects: Basanza/Lugufu, Kigoma, Kilombero, Kasulu, Mopeia, Rufiji.
- Management Plan for Vredefort World Heritage Site: GIS and agriculture
- Geotechnical reports and GIS work.
- Planning and research of various projects
    - Research: Water holding capacity – Influence of clay content and mineralogy
    - Determination of field capacity and wilting point.
    - Water conservation practices
    - Stubble mulching
    - Evaluation of cultivation practices
    - Recompaction rate of soils with different clay contents.
    - Cone penetrometer studies.
    - Water consumption of maize at different plant densities.
    - Calibration of neutron water meters and gamma density meters.
    - “Basin cultivation”
    - Handling of research plots: plant, herbicides and pesticides, cultivation, harvesting, soil water and compaction monitoring etc.
    - Nitrogen transfer
    - Organic growing of vegetables

    - Fertilisation of vegetables
    - Water conservation and irrigation for small-scale vegetable farming.
    - Soil acidity
    - Fertilisation of pasture
    - Phosphorus studies.
- Head of soil analysis laboratory:
    - Soil, plant, water, lime, in vitro analysis --- supervisor
    - Interpretation and approval of results
    - Fertiliser recommendations- grain, pasture and vegetables.

21.3.6 POSITIONS HELD AND COMMITTEE PARTICIPATION

- Assistant Director Soil Science. Dept. Of Agriculture Northwest Province (Administration, supervision of junior researchers, technicians and head of laboratory).
- WRC steering committee projects.
- 1994 Secretary of SSSSA Congress organising committee.
- Member of research steering committee Highveld Region.
- Soil interest group of Western Transvaal: Founder member and Secretary and Chairlady-several times.
- Combined Soil, Crop Science, Crop protection Congress: Organizing committee 1996 and 2012
- Organizing convenor: Precision Farming Congress for 2013

21.4 CURRICULUM VITAE OF J. HATTINGH

21.4.1 PERSONAL DETAILS

- **Name :** Hattingh, J. M.
- **Date of Birth :** 17 October 1950
- **ID Number :** 501017 5010 085
- **Marital Status :** Married
- **Cell:** 0798936537
- **Email address:** soilhats@safricom.co.za

21.4.2 FORMAL QUALIFICATIONS

- BSc (Pedology) University: PU for CHE
- BSc (Hon) (Pedology) University: PU for CHE
- MSc (Engineering Geology) University: Purdue (Indiana USA)

21.4.3 PROFESSIONAL AFFILIATION

- International Society for Terrain Vehicle Interaction
- Soil Science Society of South Africa

21.4.4 EMPLOYMENT HISTORY

- 1982 - 1998: Lecturer in Soil Science at the PU for CHE.
- 1998 - 2003: Own business (Handrid Flora) and technical consultant for Envirogreen (Pty) Ltd.
- 2003 - 2005: Research and development in precision farming for Techniland (Pty) Ltd
- 2005 - 2007: Specialist agronomist in precision agriculture for Cal Tech (Pty) Ltd

- 2007-present: Own business in precision agriculture & consultant OmniPreciseTM

21.4.5 WORK EXPERIENCE AND PROJECTS

- Planning and implementing research projects
    - Trafficability of vehicles (53 Reports)
    - Terrain evaluation
    - Dispersion of soils
    - Phosphate adsorption.
    - Soil Compaction (Forestry)
    - Cone penetrometer and Bevameter
    - Backfill material
    - Erosion
    - Rehabilitation of Gold tailings dams
- Lecturing at PU for CHE
    - Soil Chemistry (4 years)
    - Clay mineralogy (5 years)
    - Soil Mechanics (17 years)
    - Soil Physics (6 years)
    - Irrigation (6 years)
    - Drainage (6 years)
    - Erosion (6 years)
    - Soil classification (7 years)
    - Land use planning and sustainability (5 years)
- Post graduate leader
    - Leader of five M.Sc dissertations
    - Examiner of various M.Sc dissertations.
- Research projects
    - Reconnaissance soil investigations (soil mapping) (Venda and Gazankulu)

- Soil investigation for irrigation purposes (Taung and Klein Letaba)
- Soil investigation for township development (Potchefstroom, Klerksdorp, Krugersdorp, Fochville and Nylstroom)
- Soil investigation for precision farming (more than 40 000ha) (Schweizer Reneke, Hoopstad, Hertzogville, Klerksdorp, Viljoenskroon, Bothaville, Lichtenburg)
- Rehabilitation of slimes dams (FS N 6, ST Helena and Beatrix slimes dams)

21.4.6 POSITIONS HELD AND COMMITTEE PARTICIPATION

- Acting head of Department of Soil Science. PU for CHE
- Administration, management, training, research and projects
- Acting director of Institute for Soil Science Research. PU for CHE
- Member of the Faculty Board: Natural Science. PU for CHE
- Executive member of the Environmental Earth Science Group (4 years)
- Member of various ARMSCOR panels
- Member of various WRC panels

21.5 CURRICULUM VITAE OF JL PAUER

21.5.1 PERSONAL DETAILS

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- **Date of Birth :** 13 June 1957
- **ID Number :** 5706135034087
- **Marital Status :** Married
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21.5.2 FORMAL QUALIFICATIONS

- BSc Pedology PU for CHE, 1981
- BSc Hon Pedology, PU for CHE, 1990

21.5.3 ROFFESIONAL AFFILIATIONS

- Soil Science Society of South Africa.
- SA Mapping Society

21.5.4 EMPLOYMENT HISTORY

- 1982-1995 Institute for Pedological Research, PU for CHE.
- 1995-1998 Private consultancies in Soil Surveys for Mondi forests.
- 1999-2003 Private consultancies to commercial farmers.
- 2003-2004 Part time consultancies to Techniland a division of Afgri.
- 2005-2012 Partnership with Pedo –Kode, Soil surveys in Mpumalanga and Gauteng
- 2012 – Present Soil Surveys for Correck BDY in Tanzania and Mozambique for rice and sugar projects.

21.6 CURRICULUM VITAE OF MJ BOTHA

21.6.1 PERSONAL DETAILS

- **Name :** Botha, M. J
- **Date of Birth :** 22 May 1957
- **ID Number :** 5705225161081
- **Marital Status :** Married

21.6.2 FORMAL QUALIFICATIONS

- National Diploma in Soil Science at Pretoria Technicon,1978
- 2 Year Military training (1979-1981) spec. Photogrammetry and Cartography

21.6.3 EMPLOYMENT HISTORY

- June 1977 - Sept. 1995 : Institute for Soil , Climate and Water (ARC - Agriculture Research Council)
- Oct. 1995 - Feb. 1999 : Subcontractor to BLP Soil Surveys
- April 2002 - August 2003 : Subcontractor to AfriGIS Environmental Solutions
- Aug 2003 - May 2005 : Soil Consultant to Afgri (Technilands) – Pretoria
- Jun 2006 – Jun 2007 : Soil Consultant to Unie-Tech and McCains
- Jul 2007 – present, private soils consultant for various projects.

21.6.4 WORK EXPERIENCE

- Soil Surveyor (June 1977 - September 1995). 20 Detail Soil surveys (1:5000 - 1:10000 scale) - 169 349ha
- Detail SOIL SURVEYS (SIRI. Report No. GB/A/86/27) 1:5 500 2333ha
- Detail soil surveys (SIRI. Report No. GB/A/86/28) 1:5 000 en 1:6 000 > 10 000ha

- Black farmers development: Detail soil survey of Doornkop 239IQ and Kaalfontein 529IQ, Westonaria 1:10000, 75mgrid (ISCW Report No. GW/A/94/80)
- Detail soil survey Kakamas area, 1:10000, 11 652ha, (ISCW Report No. GB/A/87/26)
- Detail soil survey Rietrivier area (ISCW Report Nr. GB/A/88/4)
- Semi detail soil surveys (1:25000 scale) - 393 900ha
- 2 Recon and Landtype surveys (1:50000 scale) - 3 120 625ha
- Madikwe – game reserve. Soil survey 1: 50 000, 70 000ha, ISCW (Report No. GW/A/94/58)
- Reconnaissance surveys on soils adjacent to the Palala-river north of the Waterberg, 42 000ha (ISCW Report No. GB/A/87/28)

21.7 CURRICULUM VITAE OF JHA THIART

21.7.1 PERSONAL DETAILS

- **Name :** Thiart, Johannes Hendrik Albertus
- **Date of Birth :** 22 May 1957
- **ID Number :** 4910105045088
- **Marital Status :** Married
- **Cell:** 0823758909
- **Email:** johan@hispeople.co.za

21.7.2 FORMAL QUALIFICATIONS

- National Diploma (Agric), Technical College Pretoria
- Agricultural Resource Identification and Planning (Passed with distinction)

21.7.3 EMPLOYMENT HISTORY

- January 1969 – October 1999 (29 years), Employed by Department of Agriculture, Highveld region, Agricultural and Resource Conservation Technician.
- 1999-2001, Private consultancy, Soil classification and resource Planning
- 2001-2008, Senwes Co-op, Precision Farming devision, soil surveys and resource planning
- 2008-Present, Subcontract to Eco Soil, Soil classification and land-use planning for EIA's and feasibility studies for new agricultural projects.

21.7.4 WORK EXPERIENCE

- Experience in Soil Classification on various projects for Dept of Agriculture in the Free State and the previously known Highveld region

- Lectured and assisted in the presentation of the National Resource and Classification Course presented in Potchefstroom
- Lectured for 10 years at the Trans-Agric College of Agriculture, Agronomy and Farm Planning.
- Have experience in Commercial and Emerging farmer extension services.
- Have 8 years' experience in precision farming classification and Mapping.