CHAPTER FIVE: SOIL SUITABILITY ASSESSMENT

5.1 INTRODUCTION

During August 2012 Mr F Ellis & JJN Lambrechts of the University of Stellenbosch were requested by Public Process Consultants, to do a reconnaissance soil survey on Miskruier Farm, Addo, on behalf of the owner Mr HHJ (Hermanus) Potgieter. In support of the application for a Basic Assessment a report in terms of the suitability of the soils in that part of the farm that will be used for future agricultural production purposes was required. If the soils are not suitable for agricultural production the Department of Economic Development, Environmental Affairs and Tourism will not necessarily approve the request for deforestation.

It is important to note that the survey undertaken for the site included the total area of the farm, approximately 223.5 ha. A copy of the detailed soil survey is included as Appendix F of this report. This Chapter of the report presents the findings of the soil survey and focuses on the cleared 20.2 ha portion of the site which forms part of the Section 24G assessment process.

5.2 TERMS OF REFERENCE

The initial terms of reference for the reconnaissance soil survey included the following:

- Test pits spread over the affected section of the farm that is considered for crop production.
- Soil analyses of soil samples from the test pits (following discussion with applicant this is not required at this stage of the soil survey).
    - A report and soil map with conclusions based on the analysis of *inter alia*:The suitability of the soils on the affected portions for the proposed crops.
    - Specific limitations that the soils may have on agriculture and crop production.
    - Specific precautionary measures required for the production of crops on the soils.

Following discussions with the applicant (owner) and Public Process Consultants the following terms of reference were finalized:

- A reconnaissance soil survey of the whole farm (approximately 223.4 ha) to determine the inherent properties, mainly physical and morphological, of the soils based on observations made in 40 randomly spaced soil pits. Approximately 41.8 ha were not included in the survey.
- Compilation of a soils map on a suitable scale (e.g. 1 : 10 000) to describe the natural distribution of the soils.
- Description of the soils in the different soil types in terms of their physical and morphological properties.
- To identify the more important soil physical and/or morphological limitations of the soil types. No chemical soil analyses will be required at this stage
- Evaluation of the relative suitability of the different soil types in terms of irrigated crops; especially citrus but also for watermelons and cabbage.

5.3 FIELD SOIL SURVEY AND THE RECONNAISSANCE SOIL MAP

Due to the fairly large area it was decided that a reconnaissance survey would be sufficient to identify the agricultural suitability of the soils for the use of citrus, watermelons and cabbage.

In consultation with the owner, Mr. Hermanus Potgieter, a total of 40 soil pits were mechanically excavated over the entire site to a depth of approximately 1 200 mm or down to any restricting subsoil limitation. The latitude and longitude of the excavated soils profile pits were determined by GPS during the field soil survey (see Annexure 3: Figure 1 in Appendix F).

A total of approximately 10 soil pits were excavated on the cleared portion of the site which forms part of this assessment process. Map 5.1 below indicates the location of the soil pits on the cleared 20.2 ha. The yellow dot and corresponding number indicates the soil pit and the map symbol, e.g. Ag1 indicates the soil type.

Map 5.1 Location of the soil pits on the cleared 20.2 ha. The yellow dot and corresponding number indicates the soil pit and the map symbol, e.g. Ag1 indicates the soil type

During the field soil survey the individual soil profiles were investigated and the important soil properties (e.g. texture, colour, mottling, structure, coarse fragments, hardpans, horizon depths, etc.) were described following standard procedures as prescribed by the Institute for Soil, Climate and Water, Pretoria. Based on recognizable, as well as inferred properties, the soils were classified according to the South African soil classification system (Soil Classification Working Group, 1991) into soil forms and soil families.

This system is based on the recognition of diagnostic soil horizons and materials. Soil forms are defined in terms of the type and vertical sequence of diagnostic horizons or materials. For communication, soil forms are given locality names, e.g. Augrabies, and abbreviated to a two-letter symbol, e.g. Ag. Soil forms are subdivided into soil families using properties that are not used in the definition of diagnostic horizons or materials. Reference to a soil family is by combining the soil form abbreviation and a four-digit symbol, e.g. Ag 1110 is family number 1110 of the Augrabies soil form. In **Table 5.1** all the soil forms and families described during the reconnaissance survey for the 20.2 ha cleared area are listed.

Table 5.1 Soil forms and families listed alphabetically according to soil form abbreviation symbol

Abbre-viation	Soil form and vertical sequence of diagnostic horizons and/or materials

Ad ADDO FORM

Orthic A
Neocarbonate B
Soft carbonate horizon

SOIL FAMILIES

1000 A horizon not bleached
- 1100 Non-red B horizon
  - 1120 Luvic B1 horizon
    - 1121 No signs of wetness in carbonate horizon
- 1200 Red B horizon
  - 1220 Luvic B1 horizon
    - 1221 No sign of wetness in carbonate horizon

Ag AUGRABIES FORM

Orthic A
Neocarbonate B
Unspecified material

SOIL FAMILIES

1000 A horizon not bleached
- 1200 Red B horizon
  - 1210 Non-luvic B1 horizon
  - 1220 Luvic B1 horizon

2000 A horizon bleached
- 2200 Red B horizon

2220 Luvic B1 horizon

Br **BRANDVLEI FORM**

Orthic A
Soft carbonate horizon

SOIL FAMILIES

1000 No signs of wetness in carbonate horizon
2000 Signs of wetness in carbonate horizon

Km **KLAPMUTS FORM**

Orthic A
E horizon
Pedocutanic B

SOIL FAMILIES

1000 Colour of E horizon "grey" when moist
1100 Non-red B horizon
1120 Medium/coarse angular B horizon

In addition to the standard description the individual profiles were coded in detail according to a system used for detail soil survey in the fruit and wine industry in the Western Cape (Lambrechts *et al*. 1978; **Note**: In **Annexure 2 of the Soil Survey in Appendix F of this report** the symbols used during this survey are explained). The coded soil information was used to subdivide the soil families on an *ad hoc* basis into **soil types** using mainly subsoil properties. Soil types are identified by means of a symbol that consists of the abbreviation for the soil form followed by an Arabic number (e.g. Ag 1). The number suffix has no intrinsic meaning. It only serves as an identifier for different soil types that consist of soils belonging to the same soil form, but differ in one or more important soil properties. In **Table 5.2** the soil types that were defined in the 20.2 ha cleared area are briefly described in terms of soil form, diagnostic horizons, family criteria, additional features and effective depth before and after amelioration of physical limitations.

Table 5.2: Brief description of soil types on Miskruier Farm, Addo

Explanation of superscripts

[1)] Effective depth before mechanical amelioration of physical limitations
[2)] Effective depth after mechanical amelioration of physical limitations

Addo form soils: *Soils with an orthic A on a neocarbonate B horizon on a soft carbonate horizon*

Soil type symbol:	**Ad 1**	**Ad 2**
Soil family	Ad 1121	Ad 1221 & 11/221
Family criteria:		
Bleaching of A horizon	Non-bleached	Non-bleached
Colour of B horizon	Non-red	Red (locally marginally red)
Clay increase from A to B	Luvic	Luvic
Signs of wetness in the soft carbonate horizon	No signs of wetness	No signs of wetness
Additional features:		
Free lime in topsoil	Non-calcareous	Non-calcareous
Clay content topsoil	10-20 %	10-20 %
Depth to soft carbonate horizon	40-60 cm	≈ 50 cm
Coarse fragments in B horizon	Non-gravelly	Non-gravelly
Effective depth: (cm)	40-60[1)]; 75+[2)]	≈ 50[1)]; 75+[2)]

Augrabies form soils: *Soils with an orthic A on a neocarbonate B horizon on unspecified material*

Soil type symbol:	**Ag 1**	**Ag 2**
Soil family	Ag 1220, 121/20 & 1/220	Ag 2220
Family criteria:		
Bleaching of A horizon	Non-bleached to marginally bleached	Bleached
Colour of B horizon	Red (locally marginally red)	Red
Clay increase from A to B	Luvic	Luvic
Additional features:		
Free lime in topsoil	Usually non-calcareous	Usually non-calcareous
Clay content topsoil	10-20 %	10-17 %
Coarse fragments in B horizon	Non-gravelly	Non-gravelly
Depth to and type of unspecified material	Usually deeper 50-65 cm; variety of material that varies from red, blocky clay to weathered bedrock	Deeper than 70 cm; red, blocky clay
Effective depth: (cm)	50-65[1)]; 75+[2)]	>70[1)]; 75+[2)]

Brandvlei form soils: *Soils with an orthic A horizon on a soft carbonate horizon on unspecified material*

Soil type symbol:	**Br 1**	**Br 2**
Soil family:	Br 1000	Br 2000
Family criteria:		
Signs of wetness in soft carbonate horizon	No signs of wetness	With signs of wetness
Additional features:		
Depth of soft carbonate horizon	20-30 cm	10-20 cm
Clay content topsoil	10-20 %	10-17 %
Coarse fragments in topsoil	Non-gravelly	Non-gravelly
Effective depth: (cm)	20-30[1)]; 75[2)]	10-20[1)]; 75[2)]

Klapmuts form soils: *Soils with an orthic A on an E on a pedocutanic B horizon*

Soil type symbol:	**Km 1**
Soil family	Km 1120
Family criteria:	
Colour of E horizon in moist state	Grey
Colour of B horizon	Non-red
Structure of pedocutanic B horizon	Medium/coarse angular blocky
Additional features:	
Clay content topsoil	≈10 %
Coarse fragments in A/E horizon	Non-gravelly
Depth to pedocutanic B horizon	≈ 40 cm
Depth and nature of underlying material	≈ 60 cm; calcareous wet clay
Effective depth: (cm)	≈ 30[1)]; ≈ 60+[2)] depending on stability clay

In **Annexure 1: Table 2 of Appendix F** the soil types are listed alphanumerical according to the soil type symbol together with all the profiles and codes in the different soil types.

Certain properties (e.g. diagnostic horizons or materials) of the soil types are specified **Table 5.2**. Additional properties can be abstracted from the:

i) properties of diagnostic horizons and materials (Soil Classification Working Group, 1991),

ii) differentiating family criteria (Soil Classification Working Group, 1991), and

iii) additional information specified in the soil code (Lambrechts *et al*. 1978; refer to **Annexure 2**.

A reconnaissance soil map of the farm was compiled using the soil types as listed in **Table 5.2** (see **Annexure 3: Figure 1**). A Google Earth image of the survey area was used as background map. In addition to the soil type symbols and boundaries, the positions of the soil pits are also indicated on the map together with a line scale. See Map 5.1 above

In addition to the soil type properties the characteristics of individual soil pits in a soil type unit

were used for interpretation of the suitability of the soils as indicated on the maps and the attached tables in Appendix F.

5.4 SUITABILITY OF SOIL TYPES FOR CROP PRODUCTION

The most common limitations of the soils on Miskruier Farm, Addo, are high topsoil clay content, dense subsoil clay layers, dense subsoil hardpan carbonate layers, presence of free lime at various depths through the profile and localised wetness.

During the field soil survey the individual soil pits were evaluated by the soil surveyor in terms of its general suitability as well as the suitability for the commercial production of annual crops. Annual crops included irrigated watermelons and cabbage. Because citrus is adapted to the climatic conditions in the Addo region, the suitability of the soils was also evaluated during the writing of the report. The suitability rating ranges from 1 to 10, with 1 the lowest and 10 equal to the highest or best suitability. For both annual and perennial crops the suitability rating refers to vigour and potential production potential without considering product quality. Although fairly subjective, suitability ratings by an experienced soil scientist with many years of field experience are a handy tool to group soil types into production potential classes and for land use recommendations. The ratings can be interpreted according to the guidelines in **Table 5.3**.

Table 5.3 Interpretation of suitability ratings

Rating	General suitability	
≤2	Very low	Not recommended (NR)
>2 - ≤3	Low	
>3 - ≤4	Low-medium	Marginally recommended (MR)
>4 - ≤5	Medium	Conditionally recommended (CR)
>5 - ≤6	Medium-high	Recommended (RE)
>6 - ≤8	High	Highly recommended (HR)
>8	Very high	

For annual crops the variation in the suitability rating of different soil profiles and soil types were fairly small. The main reason for this small variation is the relatively shallow effective soil depth (*viz*. 30 - 40 cm) required by these crops for optimum production under irrigated conditions. Most of the soils were rated as moderately (medium) suitable for these crops. Only in localised areas the ratings were lower and only marginally suitable for crop production.

The suitability ratings for irrigated citrus largely depend on limiting soil properties/features such as free lime in the subsoil (and locally in the topsoil) and high clay content in upper subsoil.

In **Table 5.4** the recommendation for watermelons (annual crops) and citrus are given. The average suitability rating for soil types was calculated from the individual profile ratings. It is important to note that the table below represents the suitability rating of a soil type for the **entire** site and not just the 20.2 ha cleared area.

Table 5.4 Average suitability rating of soil types for the production of irrigated citrus and watermelons (see **Table 3** for abbreviations)

Soil type	Area (ha)	Average soil type field suitability rating	Recommendation of map units for after amelioration	
			Watermelon	Citrus
Addo soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on a soft carbonate horizon*				
Ad 2	19.34	4.2	RE	CR
Augrabies soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on unspecified material*				
Ag 1	41.83	4.8	RE	CR
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*				
Br 2	5.93	2.8	NR	NR
Klapmuts soil form: *Soils with an orthic A horizon on an E horizon on a pedocutanic B horizon*				
Km 1	2.00	3.8	MR	MR

Total area surveyed	179.99
Not surveyed	44.30
Total area farm	223.45

Based on the average suitability rating most of the soil types on the cleared area under assessment (20.2 ha) (Ad 2 and Ag 1) can be conditionally recommended for irrigated crop production that may include watermelon, cabbage and perennial citrus. Due to the more severe soil limitations soil type Km 1 can only be marginally recommended while Br 2 cannot be recommended for these crops.

5.5 SOIL LIMITATIONS

All the profiles investigated during the field survey have one or more soil physical and/or morphological properties that will negatively effect root development, plant growth and production potential. In **Table 5.5** the most important limitations in the 20.2 ha cleared area are listed per soil type.

Table 5.5 Limitations of soil types

Notes:

i) The following classes and abbreviations are used to qualify the physical soil limitations of the map units:

Limitation class	Abbreviation
None	(no symbol)
Low	Low
Moderate	Mod
Severe	Sev
Variable	Var

ii) Low clay content refers to a topsoil clay content of < 5 %.

iii) The depth to subsoil limitations is specified in centimetres (cm) following the limitation class.

Soil type	High clay content in topsoil	High alkalinity due to free lime		Dense subsoil clay layer	Hardpan carbonate horizon
		In topsoil	In upper subsoil		
Addo soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on a soft carbonate horizon*					
Ad 2	Low-Mod	Low-Mod	Mod		
Augrabies soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on unspecified material*					
Ag 1	Low-Mod	Low-Mod	Mod	Low-Mod 70+	
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*					
Br 2	Low	Mod	Sev		
Klapmuts soil form: *Soils with an orthic A horizon on an E horizon on a pedocutanic B horizon*					
Km 1	Low			Mod-Sev ≈40	

In the following paragraphs the individual limitations are discussed. It is important to note that this section of the report refers to the limitations of the soils over the entire site.

5.5.1 High clay content in topsoil

Except for soil types Km 1, Oa 1 and Pr 1 with less than 15 % clay in the topsoil, all the other soil types have 10 – 20 % clay in the topsoil. Crops with a weak root system might be negatively

affected when the clay content is more than 15 %.

Depending on chemical nature in terms of magnesium and sodium saturation, some of these soils might tend to set hard on drying and could develop a surface crust. These negative aspects could be ameliorated by judicious application of gypsum and mulching.

5.5.2 High alkalinity

Free lime in the subsoil associated with neocarbonate B, soft carbonate and hardpan carbonate horizons may pose a problem for crops sensitive to alkaline pH conditions especially if the lime is powdery form as in the neocarbonate B and soft carbonate B horizon. The more powdery the lime, the higher the solubility in water.

Nutritional problems such as low phosphorous availability and trace element deficiencies (especially iron, zinc, manganese and copper) may occur if the calcareous material is moved to the surface during deep physical cultivation (e.g. deep ploughing or during ridging).

High pH sensitive crops might experience these nutritional problems especially when the topsoil is calcareous.

5.5.3 Dense subsoil clay layers and hardpan carbonate layers

Both these layers are impenetrable for roots and therefore restrict the effective depth that plants roots can penetrate the soil.

Hardpan carbonate horizons (soil types Pr 1 and Pr 2) can be broken up during deep soil preparation with a tine implement to improve effective rooting depth.

A dense clay layer (soil types Km 1, Va 1, Va 2 and Va 3) can be loosened during soil preparation but, depending on the chemical composition in terms of exchangeable magnesium and/or sodium, the loosening effect is not long term and tends to re-compact over time.

In the case of the Km 1 soil type the clay layer is so dense that a water table periodically develops above the clay layer resulting in a bleached E horizon. These soils should be drained to prevent the development of a water table above the clay layer.

5.5.4 Wetness

This refers to the presence of free water at varying depths in a soil profile. The Km 1 and Br 2 soil types have signs of wetness in the E horizon and below the soft carbonate horizon respectively. If they should be used drainage is recommended on these soil types.

5.5.5 Other limitations

Other soil properties that might be considered as a limitation for crop production could be hard-setting and crusting in the topsoil. Soil types with a bleached topsoil, e.g. Ag 2 and Va 2 are more severely affected than soil types with a non-bleached topsoil. Mulching is therefore a

practice that is strongly recommended to prevent hard-setting and crusting.

5.6 AMELIORATION MEASURES

For annual crops no specific physical soil amelioration measures are required accept ridging in the case of soils with shallow subsoil clay layers and levelling and landscaping the site to provide runoff control and to facilitate the planting of crops, *inter alia* melons and cabbage.

For the production of perennial crops, e.g. citrus, the following amelioration measures could be used to improve the soils for deep rooted crops:

- **Drainage**
- **Ridging**
- **Deep soil tillage:** Shift ploughing and/or
  Ripping

In **Table 5.6** the recommended physical soil amelioration measures for deep rooted crops are listed per soil type as they are relevant to the 20.2 ha cleared area.

Table 5.6 Recommended physical soil amelioration measures for deep rooted crops

Notes:

i) The following classes are used to qualify the necessity for a particular amelioration measure:

Necessity	Symbol
Not necessary	(No symbol)
Recommended	Recom
Essential	Essen

ii) The following depth classes are used with the recommendations for shift ploughing or ripping:

Depth class	Symbol
Shallow	SH
Moderately deep	MD
Deep	DE
Very deep	VD

Soil type	Amelioration measures			
	Drainage	Ridging	Deep soil tillage	
			Shift plough (depth)	Ripping (depth)
Addo soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on a soft carbonate horizo*n				

Ad 2				Recom DE
Augrabies soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on unspecified material*				
Ag 1				Recom DE
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*				
Br 2	Recom	Essen		Recom DE
Klapmuts soil form: *Soils with an orthic A horizon on an E horizon on a pedocutanic B horizon*				
Km 1	Essen	Essen	Essen MD	Recom DE

5.7 RECOMMENDATION

According to the reconnaissance survey, the Ad 1, Ad 2, Ag 1, Ag 2, Pr 1, Va 1 and Va 2 soil types with a total area of 97.52 ha are conditionally recommended for annual watermelon, cabbage and citrus production under irrigation, while Oa 1 (1.38 ha) is recommended. Soil types which are conditionally recommended for annual watermelon, cabbage and citrus production and occur on the 20.2 ha cleared area are Ag 1 and Ad 2. Map 5.2 below indicates these soil types in light green.

Br 1 and Km 1 (total area 72.73 ha) soil types can only be marginally recommended while Br 2 and Va 3 (total area 7.52 ha) soil types cannot be recommended for these crops. Soil types which are marginally and cannot be recommended for production and which occur on the southern portion of the cleared 20,2 ha are Km 1 (yellow on map 5.2 below) and Br 2 respectively (orange on map 5.2 below).

Provided that there is sufficient irrigation water available, approximately 100 ha is conditionally recommended and recommended soil types could be deforested for the production of citrus, watermelons or cabbage. The majority of the area that has already been cleared for citrus production falls into the category of soil types which are conditionally recommended for citrus production. An additional 73 ha which is marginally recommended can also be developed provided that the specified amelioration measures are followed and high pH resistant citrus rootstocks are selected. A small portion of the area under assessment, in the central northern border of the cleared area, includes soil types which are marginally recommended.

The specific area where the best and most appropriate area of suitable soils that occur adjacent to each other can be developed to suit the applicant's requirements is shown on **Annexure 3: Figure 3 of Appendix F of this report**. In **Table 5.7** the soil type symbols and areas that are associated with the recommended section for development is listed. All the soil types in the recommended section are conditionally recommended for citrus. This table indicates soil types for the entire site. Highlighted in grey are the soil types which fall into the 20.2 ha cleared area, however it is important to note that the number in hectares indicates the soil type for the entire site and not just the 20.2 ha cleared area.

Map 5.2 Green area indicating soil types (Ag 1 and Ad 2) which are conditionally recommended and those marginally recommended (yellow) and not recommended (orange).

Table 5.7 Soil type symbols and areas associated with the recommended section for development

Soil type	Area (ha)
Ad 1	1.79
Ad 2	19.06
Ag 1	41.74

Ag 2	9.76
Oa 1	1.38
Pr 1	2.69
Va 1	15.60
Va 2	1.28
Total	**93.30**

5.8 REFERENCES

Lambrechts, JJN; Van Zyl, J; Ellis, F and Schloms, BHA. 1978. Grondkode en kaartsimbool vir detailkartering in die Winterreënstreek. Technical Communication No. 165, Dept. Agric. Tech. Services, Pretoria.

Soil Classification Working Group. 1991. Soil Classification: A Taxonomic System for South Africa. Mem. Natural Agric. Resources for S.A. No. 15.