CHAPTER SEVEN: SOIL SUITABILITY ASSESSMENT

7.1 INTRODUCTION

This chapter presents the findings of the Reconnaissance Soil Survey conducted by the soil specialist Dr Freddie Ellis. The study was commissioned as part of the Environmental Impact Assessment (EIA) process in order to determine the suitability of the soils on the site for the commercial production of citrus; and to refine the project layout by identifying areas most suitable for cultivation.

The applicant does not require a detailed analysis of the total production area of the farm. The only requirement is the determination of whether the soils in the surveyed section are generally suitable for the production of the intended crops (citrus and annual crops). If necessary, the owner will in future be responsible for more detailed soil studies. The soil suitability assessment was prepared as a supplementary report to the one undertaken and prepared for the Environmental Assessment Process undertaken for the development of the adjacent properties, namely, portions 16 and 17 of Farm 203 Logan Braes.

7.2 TERMS OF REFERENCE

The terms of reference for the reconnaissance soil survey requested by Public Process Consultants, on behalf of the applicant for the application for clearing of the natural vegetation for agricultural purposes included the following:

- *"A reconnaissance soil survey of the farm to determine the inherent properties, mainly physical and morphological, of the soils based on observations made in randomly spaced soil pits.*
- *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.*
- *Evaluation of the relative suitability of the different soil types in terms of citrus cultivation*
- *Specific precautionary measures required for the production of crops on the soils."*

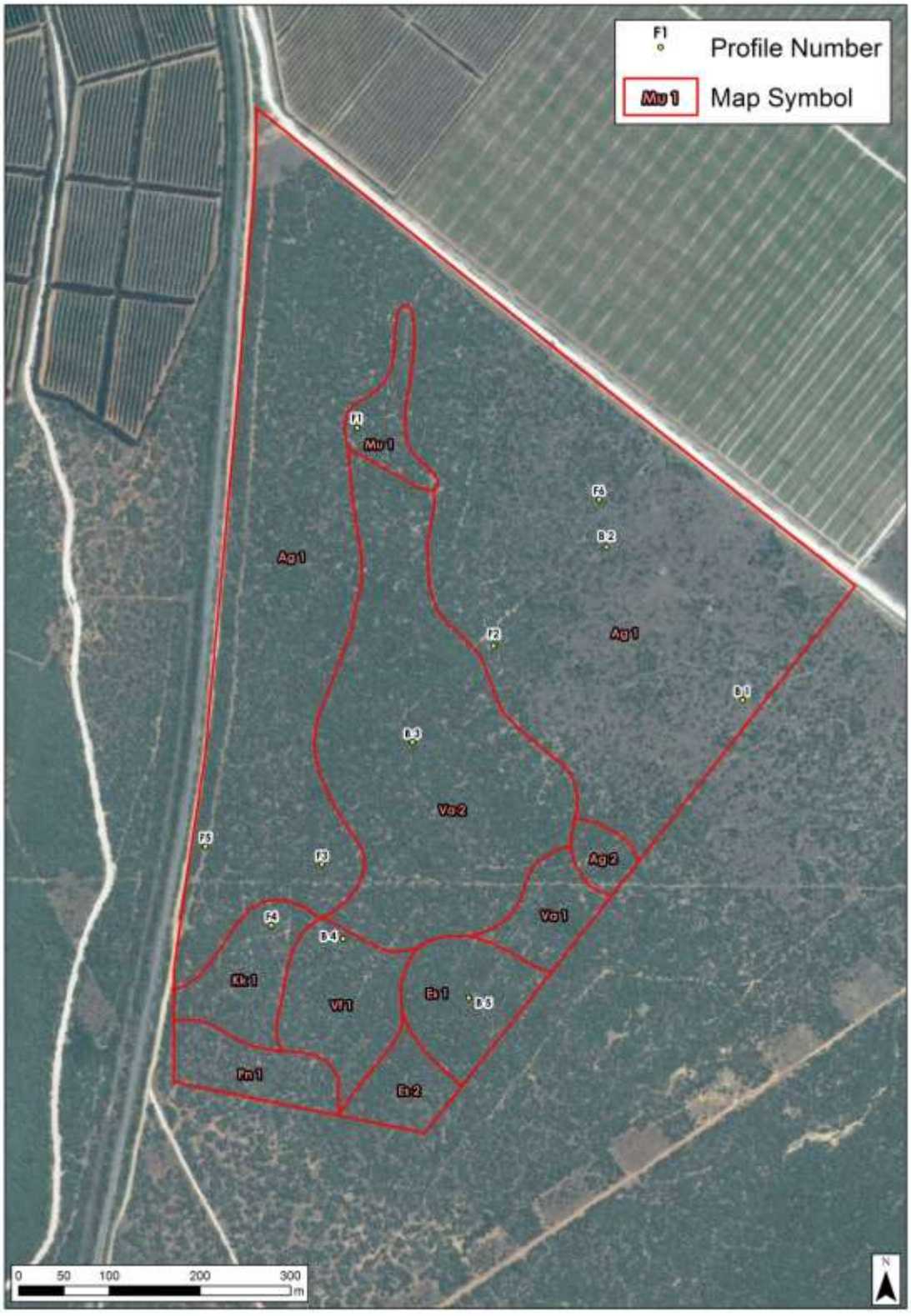
Following discussions with the applicant (owner) and Public Process Consultants the following terms of reference were finalized:

- A reconnaissance soil survey of the whole farm (47 ha) to determine the inherent properties, mainly physical and morphological, of the soils based on observations made in 11 randomly spaced soil pits.
- 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 watermelons and cabbage.

7.3 FIELD SOIL SURVEY AND THE RECONNAISACE SOIL MAP

Due to the nature of the proposed development a detail soil survey at this stage was not considered to be necessary. It was therefore decided that a reconnaissance survey would be sufficient to identify the agricultural suitability of the soils for cultivation of citrus and annual crops such as watermelons and cabbage.

In consultation with the owner, Mr. Hannes Joubert, a total of 11 soil pit positions were marked on a Google Earth map of the selected area (see Map 7.1). The soil pits were mechanically excavated 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.



Map 7.1 Reconnaissance soil map of the survey portion with positions of the soil pits and soil map symbols and boundaries.

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 7.1 all the soil forms and families described during the reconnaissance survey are listed.

Table 7.1 Soil forms and families listed alphabetically according to soil form abbreviation symbol.

Abbreviation	**Soil form and vertical sequence of diagnostic horizons and/or materials**
Ag	**AUGRABIES FORM**
	Orthic A
	Neocarbonate B
	Unspecified material

SOIL FAMILIES

1000 A horizon not bleached
1100 Non-red B horizon
1110 Non-luvic B1 horizon

Es	**ESTCOURT FORM**
	Orthic A
	E horizon
	Prismacutanic B

SOIL FAMILIES

2100 B horizon lacks continuous black cutans on vertical ped faces

Kk	**KINKELBOS FORM**
	Orthic A
	E horizon
	Neocarbonate B

SOIL FAMILIES

1000 Colour of E horizon “grey” when moist
1100 Non-red B horizon
1120 Luvic B1 horizon

Pn	**PINEDENE FORM**
	Orthic A
	Yellow-brown apedal B
	Unspecified material with signs of wetnesss

SOIL FAMILIES

3000 Eutrohic B1 horizon
3100 Non-luvic B1 horizon

Mu **MONTAGU FORM**

Orthic A
Neocarbonate B
Unspecified material with signs of wetness

1000 A horizon not bleached
1100 Non-red B horizon
1110 Non-luvic B1 horizon

Va **VALSRIVIER FORM**

Orthic A
Pedocutanic B
Unconsolidated material without signs of wetness

SOIL FAMILIES

1000 A horizon not bleached
1100 Non-Red B horizon
1120 Medium/coarse angular B horizon
1112 Calcareous B or upper C horizon

Vf **VILAFONTES FORM**

Orthic A
E horizon
Neocutanic B

SOIL FAMILIES

2000 Colour of E horizon “yellow” when moist
2100 Non-red B horizon
2120 Luvic B1 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 Appendix 1 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 7.2 the soil types that were defined 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 7.2: Brief description of soil types on Portion 15 of Farm 203.

Explanation of superscripts

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

Augrabies form soils: *Soils with an Orthic A- on a Neocarbonate B horizon on Unspecified material.*

Soil type symbol:	**Ag 1**
Soil family	Ag 1110
Family criteria:	
Bleaching of A horizon	Non-bleached
Colour of B horizon	Non-red; grey to dark grey
Clay increase from A to B	Non-luvic
Additional features:	
Free lime in topsoil	Calcareous
Clay content topsoil	≈20 %
Coarse fragments in B horizon	Non-gravelly
Depth to and type of unspecified material	100+ cm; weakly stratified calcareous loamy material
Effective depth (cm):	≈20[1)]; 75+[2)]

Estcourt form soils: *Soils with an orthic A horizon on an E horizon on a prismacutanic B horizon.*

Soil map symbol:	**Es 1**	**Es 2**
Soil families	Es 2100	Es 2100
Family criteria:		
Moist colour of E horizon	Yellow	Yellow
Colour of cutans in prismacutanic horizon	Non-dark	Non-dark
Additional features:		
Clay content A horizon	≈10 %	≈5 %
Depth to prismacutanic horizon	≈30 cm	≈50 cm
Coarse fragments in top- and upper subsoil	Non-gravelly	Non-gravelly
Effective depth (cm):	≈20[1)]; ≈30[2)]	≈30[1)]; ≈50[2)]

Kinkelbos form soils: *Soils with an orthic A horizon on an E horizon on a neocarbonate B horizon.*

Soil map symbol:	**Km 1**
Soil families:	Kk 1120
Family criteria:	
Moist colour of E horizon	Grey
Colour of B horizon	Yellowish
Clay increase from A to B	Luvic
Additional features:	
Clay content A horizon	3 - 6%
Depth to B horizon	≈60 cm
Coarse fragments in A/E horizon	Non-gravelly
Effective depth (cm):	20[1)]; 60[2)]

Pinedene form: *Soils with an Orthic A- on a Yellow-brown apedal on Unspecified material with signs of wetness.*

Soil map symbol:	**Pn 1**
Soil families	Pn 3100
Family criteria:	
Degree of leaching of upper B horizon	Poorly leached (eutrophic)
Clay increase from A to B	Non-luvic
Additional features:	
Clay content A horizon	≈5 %
Depth to soft plinthic B horizon	≈80 cm
Depth to and nature of underlying material	120+ cm; calcareous apedal material
Coarse fragments in top- and upper subsoil	Non-gravelly
Effective depth (cm):	80[1)]; 80[2)]

Valsrivier form soils: *Soils with an Orthic A- on a Pedocutanic B horizon on Unconsolidated material without signs of wetness.*

Soil type symbol:	**Va 1**	**Va 2**
Soil family:	Va 1212	Va 2112
Family criteria:		
Bleaching of A horizon	Non-bleached	Bleached
Colour of B horizon	Red	Non-red
Structure of B horizon	Subangular to fine angular blocky	Subangular to fine angular blocky
Presence of free lime in B or upper C horizon	Calcareous	Calcareous
Additional features:		
Free lime in topsoil	Non-calcareous	Non calcareous
Clay content topsoil	15 - 20 %	≈20 %
Depth to B horizon	≈20 cm	≈20 cm
Coarse fragments in topsoil	Non-gravelly	Non-gravelly
Depth to and nature of unconsolidated material	100 -120 cm; neocarbonate to soft carbonate material	150+ cm; neocarbonate material with signs of wetness
Effective depth (cm):	≈20[1)]; 75+[2)] depending on effectiveness of loosening	≈20[1)]; 75+[2)] depending on effectiveness of loosening

Vilafontes form soils: *Soils with an orthic A horizon on an E horizon on a neocutanic B horizon*.

Soil map symbol:	**Vf 1**
Soil families:	Vf 2120
Family criteria:	
Moist colour of E horizon	Yellow
Colour of B horizon	Yellowish
Clay increase from A to B	Luvic
Additional features:	
Clay content A horizon	3 - 6%
Depth to B horizon	≈60 cm
Coarse fragments in A/E horizon	Non-gravelly
Effective depth (cm):	20[1)]; 60[2)]

Montagu form soils: *Soils with an orthic A horizon on a neocarbonate B horizon on Unspecified material with signs of wetness*

Soil map symbol:	**Mu 1**
Soil families:	Mu 1110
Family criteria:	
Colour of B horizon	Yellowish
Clay increase from A to B	Non-Luvic
Additional features:	
Clay content A horizon	10 - 16%
Depth to B horizon	≈60 cm
Depth to and nature of underlying material	70 + cm Calcareous blocky structured material
Effective depth (cm):	20[1)]; 60[2)]

In Appendix 2 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. 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 Appendix 1.

A reconnaissance soil map of the farm was compiled using the soil types as listed above (see Map 7.2). 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. 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.

7.4 SUITABILITY OF SOIL TYPES FOR CROP PRODUCTION

The most common morphological limitations of the soils types on Barklybrug, Addo are low topsoil clay content, wetness. dense subsoil clay layers and the presence of free lime at various depths through the profile.

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 (e.g. watermelons and cabbage). Because citrus is adapted to the climatic conditions in the Addo/Kirkwood region, the suitability of the soils was also evaluated during the writing of this 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 7.3.

Table 7.3: 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 to highly suitable for these crops. In localized areas soils with a small effective depth (≤20 cm) the ratings were low and rated as only marginally suitable for watermelons.

The suitability ratings for irrigated citrus largely depend on limiting soil properties/features such as dense subsoil clay layers, free lime in the subsoil, and high clay content in upper subsoil. These limitations will be discussed in the following section.

The general suitability ratings on a profile basis are listed in Appendix 2 and the average rating for each soil type in Table 7.4. In Table 7.4 the recommendation for watermelons (annual crops) and citrus are also given. The average general suitability rating for soil types was calculated from the individual profile ratings.

Table 7.4: Average suitability rating of map units and soil types for the production of irrigated citrus.

Soil type	Area (ha)	Average soil type field suitability rating	Recommendation of soil types after amelioration	
			Vegetables	Citrus
Augrabies form: *Soils with an Orthic A- on a Neocarbonate B horizon on Unspecified material*				
Ag 1	29.56	6.00	HR	RE
Ag 2	0.41	6.75	RE	HR
Estcourt form soils: *Soils with an orthic A horizon on an E horizon on a prismacutanic B horizon*				
Es 1	1.65	4.25	MR	CR
Es 2	0.83	4.50	CR	CR
Pinedene form: *Soils with an Orthic A- on a Yellow-brown apedal on Unspecified material with signs of wetness*				
Pn 1	1.13	4.75	HR	CR
Montagu form soils: *Soils with an orthic A horizon on a neocutanic B horizon on Unspecified material with signs of wetness*				
Mu 1	0.80	4.75	RE	CR
Kinkelbos form soils: *Soils with an orthic A horizon on an E horizon on a neocarbonate B horizon*				
Kk 1	1.38	4.00	MR	CR
Vilafontes form soils: *Soils with an orthic A horizon on an E horizon on a neocutanic B horizon*				
Vf 1	1.89	5.0	RE	RE
Valsrivier form soils: *Soils with an orthic A horizon on a pedocutanic B horizon on unconsolidated material without signs of wetness*				
Va 1	0.96	5.50	MR	RE
Va 2	8.64	4.75	RE	CR

Based on the average suitability rating (see Table 7.4) the Augrabies soils can be recommended and highly recommended for irrigated crop production that may include watermelon, cabbage and perennial citrus. All the other soils can be either marginally of conditionally recommended for the above crops but due to expected saline condition (e.g. Mu 1, Es and Va soils), although ratings given seem to be high, this may change if soil analyses indicate that salinity is a problem. The owner is now taking soil samples to find out about the probable salinity hazard.

The morphological limitations in most soil types, however, are low enough that it can be successfully ameliorated developed for citrus and annual crops. Map 7.2 (citrus) and 7.3 (annual crops) below depicts the suitability rating of soils as indicated in table 7.4 above.

Map 7.2 Recommendation for the production of citrus on Portion 15.

Map 7.3 Recommendation for the production of annual crops (vegetables and melons) on Portion 15.

7.5 SOIL LIMITATIONS

All the profiles investigated during the field survey have one or more soil physical, morphological and/or chemical propertie(s) that will negatively effect root development, plant growth and production potential. In Table 7.5 the most important limitations are listed per soil type.

Table 7.5: Soil limitations of map units.

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) Coarse fragments refer to material larger than 2.0 mm in top- and upper subsoil.
iii) The depth to subsoil limitations is specified in centimetres (cm) following the limitation class.

Soil type	Clay content in topsoils		Wetness	High alkalinity due to free lime		Dense subsoil clay layer
	Low	High		In topsoil	In upper subsoil	
Augrabies form: *Soils with an Orthic A- on a Neocarbonate B horizon on Unspecified material*						
Ag 1		Low-Mod			Mod	
Ag 2	Low-Mod			Low	Mod	Low 80+
Estcourt form soils: *Soils with an orthic A horizon on an E horizon on a prismacutanic B horizon*						
Es 1	Low		Low-Mod 20-30			Sev ≈30
Es 2	Low-Mod		Low-Mod 30-50			Sev ≈50
Kinkelbos form soils: *Soils with an orthic A horizon on an E horizon on a neocarbonate B horizon*						
Kk 1	Low		Low 20-50			Low ≈50
Montagu form soils: *Soils with an orthic A horizon on a neocutanic B horizon on Unspecified material with signs of wetness*						
Mu 1	Low		Low≈80	Low	Low – High?	
Pinedene form: *Soils with an Orthic A- on a Yellow-brown apedal on Unspecified material with signs of wetness*						
Pn 1	Low-Mod		Low 80			
Valsrivier form soils: *Soils with an orthic A horizon on a pedocutanic B horizon on unconsolidated material without signs of wetness*						
Va 1		Low-Mod				Mod-Sev ≈20
Va 2		Low-Mod				Mod-Sev ≈20
Vilafontes form soils: *Soils with an orthic A horizon on an E horizon on a neocutanic B horizon*						
Vf 1	Low		Low 20-50			Low ≈50

The individual limitations will be discussed in the following paragraphs.

7.5.1 Dense subsoil clay layers (pans)

Dense subsoil clay layers are a moderate to severe depth limitation in the Estcourt, and Valsrivier soil forms. In the Escourt form the clay layer qualify as a prismacutanic B, while in the Valsrivier it qualifies as a pedocutanic B.

The limitation on root development due to a slight increase in clay content from the top- to the subsoil in Augrabies soil types with a non-luvic B horizon was rated as low.

In the Es1, Es 2 soil types the clear transition between the topsoil and the clay rich prismacutanic with significantly higher clay content, stronger structure and higher consistence, may result in the accumulation of free water in the overlying, slightly lighter textured horizon during the rainy season or as a result of over-irrigation. Under conditions of water saturation, reduction and loss of iron can lead to the development of pale coloured E horizon the dry state. E horizons tend to set hard in the dry state and the overlying topsoil that is usually bleached tends to crust in the dry state.

In addition to the physical limitation of the clay pan on root development, the clay itself is usually be physically unstable (disperse in non-saline water) when the concentration of exchangeable magnesium and sodium are high relative to calcium. This type of clay is less suitable for mechanical loosening and will re-compact over time as a result of the dispersive nature of the clay particles.

7.5.2 Low clay content in topsoils

The topsoil clay content and upper subsoil in Pn 1 soil type is approximately 5 % and the organic carbon content of these soils is also low. In the case of the Estcourt soil types the clay content is approximately 5 – 10 % clay in the topsoil.

The ability of soils to store water and plant nutrients for use by plants is determined mainly by the clay content, particularly when the soils has a low organic matter content (<1 % organic carbon). At a clay content of less than 8 10 % the water storage capacity is already so low that it can be considered a limitation for crop production; the lower the clay content, the greater the limitation.

A low clay content is regarded as a limitation because such soils become very warm and dry out quickly. It is therefore difficult to maintain plant available water at an optimal level during warm summer months and when trees are young with a small leaf canopy. Dry land crops on such soils experience one or more dry stress periods during their growth cycle.

Sandy soils are normally permeable with a very rapid hydraulic conductivity and they are leached very quickly. It is therefore difficult to maintain the concentration of soluble plant nutrients (particularly nitrogen and potassium) at an acceptable level for optimal growth and development.

Another limitation of sandy topsoils with low organic matter content is their susceptibility for water and wind erosion; the latter especially when the surface is bare during warm, dry periods. Wind transported sand grains can also cause serious mechanical damage to young plants.

It is important that irrigation systems on such soils are well designed and must be able to supplement water loss during periods with exceptionally high evapotranspiration. With regular soil water monitoring, above average irrigation management and other measures such as organic mulches, these limitations can largely be overcome. The same comments are applicable to fertilization.

Another problem of sandy topsoils is that topsoil structures, e.g. ridges are extremely unstable and need regular maintenance. Sandy ridges dry our very quickly and become extremely warm.

7.5.3 High clay content in topsoils

All the Augrabies and Valsrivier profiles investigated have a clay content in the topsoil that range from a low of around 5 - 10 % to as high as 20 %. Crops with a weak root system might be negatively affected. Emergence of annual seedlings may also be negatively affected.

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.

7.5.4 Wetness

In the Estcourt and to a lesser extent in the Kinkelbos soil types wetness may occur seasonally (or due to over-irrigation) in the E horizon overlying the underlying clayey prismacutanic or neocutanoc B horizon. The shallower the more clayey horizon the greater the risk of wetness.

Wetness during active root respiration results in a lowered oxygen concentration and an increased carbon dioxide concentration. It also causes reduction and loss of iron oxides/hydroxides. As the iron content decreases, soil structure disintegrate, soil density increases and very large soil strengths can develop when the soil dries out.

Other adverse effects of wetness are:

- Toxic concentrations iron (Fe^{2+}), manganese (Mn^{2+}), sulfides, nitrites, ethylene and volatile organic acids can develop. For certain fruit trees and rootstocks, a moderate level of wetness has a negative influence on growth, but trees/plants do not die. Sensitive trees, however, can die-back.
- Various diseases can become epidemic under wet conditions.
- As a result of limited volumes of non-wet soil that is available for root growth, plants have a limited root system during the wet season. Crops with a high-water requirement can have drought stress during warm and/or dry spells if water contents become very low.
- Wet soils become severely compacted by implements or cultivation.
- More nitrogen fertilizers must be applied to wet soils to get the same result as on a well-drained soil. The reason is the slow tempo of nitrogen mineralization.
- Under warm, dry conditions, hydromorphic soils with a shallow water table can become saline because of capillary movement of salts from the shallow water table to the soil surface.

7.5.5 High alkalinity

Free lime in the subsoil associated with neocarbonate B horizons or deep subsoil horizons that tend to soft carbonate material may pose a problem for crops sensitive to alkaline pH conditions. 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 physical (deep ploughing) cultivation.

High pH sensitive crops might experience these nutritional problems especially soil type Ag 2 with free lime in the topsoil and on the Mu 1 soil type.

7.5.6 Other limitations

Other soil properties that might be considered as a limitation for crop production could be hard-setting and crusting in the topsoil. Due to the generally non-bleached nature of most of the topsoils (Augrabies, Pinedene and Valsrivier soil types) investigated, these limitations are limited to small, restricted areas on these soil types. It might, however, be a limitation of the Estcourt soil types.

7.6 AMELIORATION MEASURES

For annual crops no specific physical soil amelioration measures are required except 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. Although the applicant does not intend to plant perennial crops, e.g. citrus, the following amelioration measures could be used to improve the soils for deep rooted crops:

- **Ridging**
- **Cut-off drainage**
- **Deep soil tillage:** Shift ploughing and/or Ripping

The recommended physical soil amelioration measures for deep rooted crops are listed per soil type in Table 7.6 below.

Table 7.6 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	Ridging	Deep soil tillage		Cut-off drains
		Shift plough (depth)	Ripping (depth)	
Augrabies form: *Soils with an Orthic A- on a Neocarbonate B horizon on Unspecified material*				
Ag 1			Essen DE	
Ag 2			Essen DE	
Estcourt form soils: *Soils with an orthic A horizon on an E horizon on a prismacutanic B horizon*				
Es 1	Essen		Recom DE	Essen
Es 2	Essen	Recom MD	Recom DE	Essen
Kinkelbos form soils: *Soils with an orthic A horizon on an E horizon on a neocarbonate B horizon*				
Kk 1	Recom	Recom MD	Recom DE	Essen
Montagu form soils: *Soils with an orthic A horizon on a neocutanic B horizon on Unspecified material with signs of wetness*				
Mu 1	Recom	Recom MD	Recom DE	Essen
Pinedene form: *Soils with an Orthic A- on a Yellow-brown apedal on Unspecified material with signs of wetness*				
Pn 1		Essen DE	Low 80	
Valsrivier form soils: *Soils with an orthic A horizon on a pedocutanic B horizon on unconsolidated material without signs of wetness*				
Va 1	Recom		Recom DE	
Va 2	Recom		Recom DE	
Vilafontes form soils: *Soils with an orthic A horizon on an E horizon on a neocutanic B horizon*				
Vf 1	Recom	Recom MD	Recom DE	Essen

7.7 RECOMMENDATIONS

According to the reconnaissance survey, all the soil types (100% of the farm) are suitable (marginally recommended and higher) for annual vegetable (watermelon and cabbage) production under irrigation or for citrus under irrigation.

Provided that there is sufficient irrigation water available the whole area surveyed can be deforested for the production of citrus and vegetables.

7.8 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.

APPENDIX 7.1: STRUCTURE OF SOIL CODE AND EXPLANATION OF SYMBOLS

1. Structure of soil code

The code consists of two series of letter-number symbols, separated by a horizontal line, arranged in the following order:

Position to horizontal line	For description refer to section
Above the line	
Depth of horizons and/or materials Soil form Soil family Subsoil limitations or properties	2.1 2.2 2.3 2.4
Below the line	
Texture of topsoil horizon Additional qualifiers	3.1 3.2

In a Microsoft Word or Excel table the letter-number symbols can be written in a single line with the "above the line" letter-number symbols followed by the "below the line" letter-number symbols.
In uncultivated soils the term topsoil horizon refers to the natural A horizon, while for cultivated soils it refers to the upper 150 - 300 mm of the soil profile affected by tillage.

2. Classes and symbols for properties above the line

2.1 Horizon and/or effective depths

The depths of all the diagnostic as well as non-diagnostic horizons and/or materials encountered in a profile are coded with a number symbol in front of the soil form symbol. Depth classes and symbols used are:

Depth class (mm)			Symbol	Depth class (mm)			Symbol
0	-	150	1	750	-	950	7
150	-	250	2	950	-	1 150	8
250	-	350	3	1 150	-	1 350	9
350	-	450	4	1 350	-	1 550	0
450	-	550	5	>1 550			no symbol
550	-	750	6				

Depth symbols for diagnostic horizons or materials specified in a particular soil form are arranged from shallow (topsoil transition) to deep (deepest subsoil transition) before the form symbol (e.g. 3 5 Es 1100, where 3 refers to the A/E transition and 5 to the E/B transition). Depth symbols for subsoil limitations or properties (arranged from shallow to deep) appear between the depth symbols for diagnostic horizon transitions and the form symbol (e.g. 3 5 3 Es 1100; the second 3 indicates the depth of a subsoil limitation or property.)

2.2 Soil Form

Soil forms and abbreviations used in the soil code are explained by the Soil Classification Working Group (1991). For example Tu is the abbreviation for a Tukulu form soil.

2.3 Soil family

Soil families are identified by a locality name or coded by means of a four-digit symbol (Soil Classification Working Group, 1991). For example 1110 is the four-digit symbol for the Hefnaar soil family of the Augrabies soil form. In the code the four-digit symbol is used directly after the soil form abbreviation symbol; e.g. Ag 1110.

2.4 Subsoil limitations and properties

The depth of soil utilized by plant roots is determined by a variety of soil materials and factors. For example, in the Valsrivier soil form the maximum effective root depth is determined by the pedocutanic B.
In those forms where the limiting horizon is part of the defined sequence of horizons that is diagnostic of the soil form, the symbol for the limiting material or horizon do not have to be coded. It is, however, recommended that symbols for all diagnostic horizons are included in the code. If the limiting horizon or material is not included in the sequence of diagnostic horizons, the symbol for the specific horizon or material must be specified after the family number in the code. The depth symbol for such horizons is written between the depth symbol for diagnostic horizons and the soil form symbol.

The more important materials that may affect root penetration and water infiltration to a greater or lesser extent are one or more of the following:

- **Moderate to strongly structured, unconsolidated material without signs of wetness**
  - **vp** - Blocky clay: a non-gleyed soil material with a non-uniform non-red colour and a moderate or stronger structure when moist. It largely meets the requirements of a pedocutanic B horizon
  - **vr** - Blocky clay: a non-gleyed soil material with a uniform red colour and a moderate or stronger structure when moist. It largely meets the requirements of a red structured B horizon
- **Weaker than moderately structured, unconsolidated material without signs of wetness**
  - **nc** - Calcareous unconsolidated material with signs of soil development, e.g. aggregation, clay illuviation and/or disappearance of original stratification. It largely meets the requirements of a neocarbonate B horizon. Red as well as non-red variants occur.
  - **re** - Red, non-calcareous soil material with a structure weaker than moderate blocky or prismatic. It largely meets the requirements of a red apedal B horizon.
  - **sk** - Calcareous material which largely meets the requirements of a soft carbonate horizon.
  - **ye** - Brown or yellow-brown, non-calcareous soil material with a structure weaker than moderate blocky or prismatic. It largely meets the requirements of a yellow-brown apedal B horizon.
  - **Note:** The colour of certain of these horizons/materials (e.g. **nc**) might be important for land use interpretation and soil suitability evaluation. In such cases the dominant colour should be coded by using the following colour abbreviation symbols: **dkgr** = dark grey; **gr =** grey; **grye** = grayish yellow; **re =** red; **ye =** yellow and **yere** = yellowish red.
    For example the combined symbol **nc/yere** (horizon/material symbol linked to the colour symbol with forward slash) refers to a yellowish red neocarbonate horizon/material.
- **Textural stratification in diagnostic and non-diagnostic unconsolidated material**
  Depending on the mode of transport (water or wind) and deposition, some unconsolidated materials are texturally stratified. However, with time soil development may result in the disappearance of the stratification. However, in certain young soils stratification can still be detected. Since textural stratification is an important characteristic in land use, it has to be indicated in the code in the following way:

Description	Symbol
Textural stratification non-prominent or absent	
Predominantly loamy or porous silt	U6

3. Classes and symbols for properties below the line

3.1 Texture of topsoil and directly underlying E or apedal B1 horizon

The texture is coded in terms of the:

- sand grade for soils with less than 20% clay and
- clay content (percentage).

Classes and abbreviations for sand grade clay content are the following:

Sand grade	Symbol
fine	fi

Clay content	Symbol
15 – 20	4
20 – 35	5

Examples:

- A topsoil developed from parent material with 18 % clay and fine sand grade is coded by the symbol **fi 4**.
- In cases where the clay content is on or near the boundary between two classes, e.g. 23 %, it should be coded as **fi 4/5**.

3.2 Additional qualifiers

- **Tge** Other (general) topsoil related features
- **Tge-nca - Non-calcareous A horizon:** Having a non-calcareous topsoil horizon (associated with soils where the subsoil is calcareous by definition e.g. neocarbonate, soft carbonate or within certain families, e.g. pedocutanic B)
- **Tge-cal - Calcareous A horizon:** Having a calcareous upper or whole part of the topsoil that is calcareous lying on a subsoil that is non-calcareous. Calcareous nature due to natural factors such as dust blown in. It is optional to use this symbol also for a soil having a calcareous topsoil in soils where the subsoil is also calcareous by definition e.g. neocarbonate, soft carbonate or within families, e.g. pedocutanic B

4. Examples of a fully coded description

Although the sequential position of the symbols for certain components used in the soil code is fixed, the sequence of non-diagnostic subsoil limitations and their respective depth symbols can be coded in more than one way. The detail that soil surveyors want to include in the code may also differ. For this reason, a few examples will discussed as guidelines for individuals that is not familiar with the code.

Example:

Dystrophic, luvic Hutton form soil with an A/B transition at 300 mm, extremely hard ferricrete (hard plinthite) at 850 mm and stoneline at 500 mm. The topsoil contains 15 % coarse gravel and 35 % stones, 15 – 20 % clay, and has a coarse sand grade. The clay content of the B is constant with depth. The code for this soil may be written in one of the following ways:

Field code 1 3 7 5 Hu1200 re hp2 sl
2g+4k co4

Field code 2 3 5 7 Hu1200 sl hp2
2g+4k co4

Word/Excel format 1 3 7 5 Hu1200 re hp2 sl
followed in same line by a double forward slash and then
2g+4k co4

Word/Excel format 2 3 7 5 Hu1200 hp2 sl
followed in same line by a double forward slash and then
2g+4k co4

Note: Field code 1 and Word/Excel format 1 is the preferred way of coding.
It is recommended that when the code is captured in a Word or Excel format table, the separate items of the code should each constitute a separate column. The following can be used as an example of a Word format table:

Profile number	Depth codes	Soil form and family	Subsoil limitations/properties				Topsoil			Wetness class	Changed properties or condition
			Upper subsoil	Middle subsoil	Lower subsoil	Coarse fragments	Coarse fragments	Sand grade	Clay class		
1	2 4 6 2	Tu 2110	ne/ye	gs+4g	vp	3f+2g	2f	co	3	3	md 7
2	3 6 8 3	Es 1100	pr	sw		6f	4f	fi	2/3	6	dr

The subsoil limitations/properties are sequentially linked to the depth codes from right to left. For example:

Profile 1

Depth codes	2	4	6	2
	↓	↓	↓	↓
Subsoil limitations/properties	ne/ye	gs+4g	vp	3f + 2g
Upper and lower depth of subsoil limitation/property	20 - 40 cm	40 - 60 cm	60 cm and deeper	20 – 40 cm

Profile 2

Depth codes	3	6	8	3
	↓	↓	↓	↓
Subsoil limitations/properties		pr	sw	6f
Upper and lower depth of subsoil limitation/property	30 - 60 cm	60 - 85 cm	85 cm and deeper	30 – 60 cm

The first 3 in the depth code refer to the boundary between the orthic A and the E horizon.

APPENDIX 7.2: Soil types with a complete list of described soil profiles and codes - Barklybrug, Addo

Soil type symbol	Profile number	Depth codes	Form & Family	Subsoil limitations/properties			Topsoil		Wetness class	Changes	Transitional form	Suitability rating
				Upper	Middle	Lower	Sand grade	Clay class				
Augrabies form: *Soils with an Orthic A- on a Neocarbonate B horizon on Unspecified material*												
Ag 1	B1	2/3 7	Ag 1110	ne/nc(ye)	nc		fi	2				6,0
Ag 1	B2	2	Ag 1110	nc			fi	2				6,0
Ag 1	F2	2 6	Ag 1110	nc(dk)	vp(fi)+ca		fi	3				4.5 - 5
Ag 1	F3	2 7	Ag 1110	ne/nc(ye)	nc		fi	2				5,0
Ag 1	F5	1 6	Ag 1110	nc/vp(ye)	nc(ye)		fi	3				4,5
Ag 1	F6	2	Ag 1110	nc(dk)			fi	2/3				5.5 - 6
Ag 2	No profiles described in supplement part, see 2014 report for description											
Estcourt form soils: *Soils with an orthic A horizon on an E horizon on a prismacutanic B horizon*												
Es 1	B5	1 6	Es 2100	pr	gc		fi	1	3/6			3,0
Es 2	No profiles described in supplement part, see 2014 report for description											
Pinedene form: *Soils with an Orthic A- on a Yellow-brown apedal on Unspecified material with signs of wetness*												
Pn 1	No profiles described in supplement part, see 2014 report for description											
Valsrivier form soils: *Soils with an orthic A horizon on a pedocutanic B horizon on unconsolidated material without signs of wetness*												
Va 1	No profiles described in supplement part, see 2014 report for description											
Va 2	B3	2 5	Va 1112	vp	nc		fi	2				4,0
Kinkelbos form soils: *Soils with an orthic A horizon on an E horizonon a neocarbonate B horizon*												
Kk 1	F4	2 6	Kk 1120	gs	nc(ye)		fi	1				4,0
Montagu form soils: *Soils with an orthic A horizon on a neocarbonate B horizon on unspecified material with signs of wetness*												
Mu 1	F1	2 5	Mu 1110	nc(dk)	nc/vp		fi	3			Ag	4.5 - 5
ilafontes form soils: *Soils with an orthic A horizon on an E horizonon a neocutanic B horizon*												
Vf 1	B4	2 6	Vf 2120	ne			fi/me	1				5,0