Appendix H: Soil Suitability Assessment

RECONNAISSANCE SOIL SURVEY OF THE MISKRUIER FARM, ADDO

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DRAFT REPORT

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1 INTRODUCTION

During August 2012 the authors of this report were requested by Dr Paul-Pierre Steyn (PhD), Environmental Scientist, Public Process Consultants, Adcockvale, Port Elizabeth, to do a reconnaissance soil survey on Miskruier Farm, Addo, on behalf of the owner Mr. HHJ (Hermanus) Potgieter.

The Applicant is proposing the agricultural development of Miskruier Farm, Addo, as an extension of his existing farming activities in the Addo district. The total area of the farm is approximately 223.5 ha. The land proposed for development represents an area of about 180. The property is located adjacent to the present development on the existing Miskruier Farm, and can readily be tied into the access and irrigation infrastructure of the current farming operation. The site is located about 40 km from Port Elizabeth, and falls within the Sundays River Municipality.

In terms of the NEMA EIA Regulations: GN R543, 544 and 546 promulgated under Chapter 5 of the National Environmental Act (Act 107 of 1998) ("NEMA"), a Basic Assessment is required for this project. The applicant has appointed Public Process Consultants as the independent Environmental Assessment Practitioner to undertake the Basic Assessment.

At present Public Process Consultants are busy with an environmental impact study for deforestation of approximately 100 ha of the farm. The cleared land will be used for the production of *citrus* for export purposes and other crops.

In support of the application Public Process Consultants require 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. If the soils are not suitable for agricultural production the Department of Environmental Affairs will not necessarily approve the request for deforestation.

Public Process Consultants do not require a detailed analysis of the total production area. The only requirement is the determination whether the soils are generally suitable for the production of the intended crops. If necessary the owner will in future be responsible for more detailed soil studies.

The proposed development will entail the following activities on the site:

- Clearing of vegetation from portions of the site proposed for development.
- Levelling and landscaping the site to provide runoff control and to facilitate the planting of crops.
- Establishment of internal roads to provide access to cultivated lands.
- Installation of an appropriate irrigation system.

Once the necessary infrastructure has been established, the lands will be used for citrus planting. The applicant proposes to use existing nearby infrastructure as offices and service buildings, thus negating the need for any associated infrastructure such as water, electricity and sanitation, other than the water required for the irrigation of the crops.

2 TERMS OF REFERENCE

The initial 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:

- 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.

3 FIELD SOIL SURVEY AND THE RECONNAISACE SOIL MAP

Due to the fairly large area of the proposed development a detail soil survey at this stage was considered as an “over-kill”. It was therefore 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 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)**.

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

Table 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

Oa **OAKLEAF FORM**

Orthic A
Neocutanic B
Unspecified material

SOIL FAMILIES

1000 A horizon not bleached
- 1100 Non-red B horizon
  - 1120 Luvic B1 horizon

Pr **PRIESKA FORM**

Orthic A
Neocarbonate B
Hardpan carbonate horizon

SOIL FAMILIES

1000 A horizon not bleached
- 1200 Red B horizon
  - 1210 Non-luvic B1 horizon
  - 1220 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
    - 1122 Calcareous B or upper C horizon
- 1200 Red B horizon
  - 1210 Subangular/fine angular B horizon
    - 1212 Calcareous B or upper C horizon
  - 1220 Medium/coarse angular B horizon
    - 1222 Calcareous B or upper C horizon

2000 A horizon bleached
- 2200 Red B horizon
  - 2210 Subangular/fine angular B horizon
    - 2212 Calcareous B or upper C horizon
  - 3220 Medium/coarse angular B horizon

2222 Calcareous B or upper C 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** 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 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 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

Oakleaf form soils: *Soils with an orthic A on a neocutanic B horizon on unspecified material*

Soil type symbol:	**Oa 1**
Soil family	Oa 1120
Family criteria:	
Bleaching of A horizon	Non-bleached
Colour of B horizon	Non-red
Clay increase from A to B	Luvic
Additional features:	
Clay content topsoil	10-15 %
Coarse fragments in B horizon	Non-gravelly
Depth to and type of unspecified material	Blocky material
Effective depth: (cm)	≈30[1)]; 75+[2)]

Prieska form soils: *Soils with an orthic A on a neocarbonate B horizon on a hardpan carbonate horizon*

Soil type symbol:	**Pr 1**
Soil family	Pr 121/20
Family criteria:	
Bleaching of A horizon	Non-bleached
Colour of B horizon	Red
Clay increase from A to B	Marginally luvic
Additional features:	
Clay content topsoil	10-20 %
Depth to hardpan carbonate horizon	≈ 50 cm
Coarse fragments in A/B horizon	Non-gravelly
Effective depth: (cm)	≈ 50[1)]; 75+[2)] depending on hardness of hardpan

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**	**Va 3**
Soil family	Va 1212 & 1222	Va 2222	Va 1122
Family criteria:			
Bleaching of A horizon	Non-bleached	Bleached	Non-bleached
Colour of B horizon	Non-red and red	Red	Non-red
Structure of pedocutanic B horizon	Usually medium/coarse angular blocky	Medium/coarse angular blocky	Medium/coarse angular blocky
Presence of free lime in B/C horizon	Calcareous	Calcareous	Calcareous
Additional features:			
Clay content topsoil	10-20 %	10-17 %	15-20 %
Depth to pedocutanic B horizon	10-20 cm	10-20 cm	≈10 cm
Coarse fragments in A horizon	Non-gravelly	Non-gravelly	Non-gravelly
Effective depth: (cm)	10-20[1)]; 75+[2)] depending on stability clay	10-20[1)]; 75+[2)] depending on stability clay	≈10[1)]; 75+[2)] depending on stability clay

In **Annexure 1: Table 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 **Table 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 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.

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.

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 3**.

Table 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. These limitations will be discussed in the following chapter.

The general suitability ratings on a profile basis are listed in **Annexure 1: Table 2** and the average rating for each soil type in **Table 4**. In **Table 4** the recommendation for watermelons (annual crops) and citrus are also given. The average suitability rating for soil types was calculated from the individual profile ratings.

Table 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 1	2.52	4.3	RE	CR
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
Ag 2	9.76	4.9	RE	CR
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*				
Br 1	70.74	3.3	MR	MR
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
Oakleaf soil form: *Soils with an orthic A horizon on a neocutanic B horizon on unspecified material*				
Oa 1	1.38	6.0	HR	RE
Prieska soil form: *Soils with an orthic A on a neocarbonate B horizon on a hardpan carbonate horizon*				
Pr 1	2.69	4.3	RE	CR
Valsrivier soil form: *Soils with an orthic A- on a pedocutanic B horizon on unconsolidated material without signs of wetness*				
Va 1	15.60	4.7	CR	CR
Va 2	5.78	4.3	CR	CR
Va 3	1.59	3.0	NR	NR

Total area surveyed	179.99
Not surveyed	44.30
Total area farm	223.45

Based on the average suitability rating (see **Table 4**) most of the soil types (Ad 1, Ad 2, Ag 1, Ag 2, Pr 1, Va 1 and Va 2) can be conditionally recommended for irrigated crop production that may include watermelon, cabbage and perennial citrus, while the Oakleaf (Oa 1; 1.38 ha) soil type has a higher suitability and can be recommended for annual and perennial crops. Due to the more severe soil limitations soil types Br 1and Km 1 (total area 72.73 ha) can only be marginally recommended while Br 2 and Va 3 (total area 7.52 ha) cannot be recommended for these crops. Refer to **Annexure 3: Table 2** for soil suitability map for citrus.

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** the most important limitations are listed per soil type.

Table 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 1	Low-Mod	Low-Mod	Mod		
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+	
Ag 2	Low-Mod	Low-Mod	Mod		
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*					
Br 1	Low-Mod	Mod	Sev		
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	
Oakleaf soil form: *Soils with an orthic A horizon on a neocutanic B horizon on unspecified material*					
Oa 1	Low				
Prieska soil form: *Soils with an orthic A on a neocarbonate B horizon on a hardpan carbonate horizon*					
Pr 1	Low	Low-Mod	Mod-Sev		Sev ≈50
Valsrivier soil form: *Soils with an orthic A- on a pedocutanic B horizon on unconsolidated material without signs of wetness*					
Va 1	Low-Mod			Mod 10-20	
Va 2	Low-Mod			Mod 10-20	
Va 3	Low-Mod			Mod ≈10	

In the following paragraphs the individual limitations will be discussed.

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.

5.2 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.

5.3 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.

5.4 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 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.

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 6** the recommended physical soil amelioration measures for deep rooted crops are listed per soil type.

Table 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 horizon*				
Ad 1				Recom DE
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
Ag 2				Recom DE
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*				
Br 1		Essen		Recom DE
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
Oakleaf soil form: *Soils with an orthic A horizon on a neocutanic B horizon on unspecified material*				
Oa 1			Essen DE	Recom DE
Prieska soil form: *Soils with an orthic A on a neocarbonate B horizon on a hardpan carbonate horizon*				
Pr 1		Essen		Essen DE
Valsrivier soil form: *Soils with an orthic A- on a pedocutanic B horizon on unconsolidated material without signs of wetness*				
Va 1		Essen		Recom DE
Va 2		Essen		Recom DE
Va 3		Essen		Recom DE

6 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.

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.

Provided that there is sufficient irrigation water available, approximately 100 ha conditionally recommended and recommended soil types could be deforested for the production of citrus, watermelons or cabbage. An additional 73 ha that is marginally recommended can also be developed provided that the specified amelioration measures are followed and high pH resistant citrus rootstocks are selected.

The specific area where the best and most appropriate area of suitable soils that occur adjacent to each other can be developed to suite the applicant's requirements is shown on **Annexure 3: Figure 3**. In **Table 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.

Table 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**

7 REFERENCES

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Annexure 1

Table 1

Coordinates of soil profiles - Miskruierveld - Addo

Pit number	Coordinates					
	South			East		
	°	'	"	°	'	"
1	-33	26	40.3	25	40	44.3
2	-33	26	43.0	25	40	37.7
3	-33	26	47.7	25	40	26.4
4	-33	26	57.0	25	40	29.7
5	-33	27	5.8	25	40	20.6
6	-33	27	8.7	25	40	17.7
7	-33	27	5.9	25	40	30.2
8	-33	26	50.3	25	40	34.4
9	-33	27	4.3	25	40	36.6
10	-33	26	54.5	25	40	51.1
11	-33	26	59.3	25	40	45.1
12	-33	27	2.0	25	40	49.6
13	-33	27	10.1	25	40	38.5
14	-33	27	19.4	25	40	39.3
15	-33	27	26.4	25	40	39.4
16	-33	27	32.2	25	40	40.4
17	-33	27	36.8	25	40	41.0
18	-33	27	38.3	25	40	35.4
19	-33	27	30.1	25	40	30.5
20	-33	27	25.4	25	40	27.7
21	-33	27	19.5	25	40	24.4
22	-33	27	16.8	25	40	30.1
23	-33	27	23.6	25	40	40.0
24	-33	27	25.0	25	40	48.0
25	-33	27	21.7	25	40	50.2
26	-33	27	17.1	25	40	52.3
27	-33	27	18.4	25	40	53.2
28	-33	27	21.6	25	40	59.2
29	-33	27	33.1	25	40	50.6
30	-33	27	30.2	25	40	57.4
31	-33	27	25.9	25	41	6.7
32	-33	27	19.2	25	41	3.4
33	-33	27	17.3	25	41	2.5
34	-33	27	15.0	25	41	1.8
35	-33	27	13.5	25	41	5.4
36	-33	27	10.5	25	41	11.5
37	-33	27	7.1	25	41	20.5
38	-33	27	19.2	25	41	23.4
39	-33	27	2.9	25	41	18.2
40	-33	27	6.6	25	41	9.1

Annexure 1
Table 2

Map units and soil types with complete list of profiles and soil codes - Farm Miskruierveld, Addo

Map unit	Pit #	Depth codes	Form & Family	Subsoil limitations/properties				Topsoil properties		Transi-tional form	Suita-bility rating
				Upper	Middle	Lower	Coarse fragments	Sand grade	Clay class		
Addo soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on a soft carbonate horizon*											
Ad 1	1	2 6	Ad 1121	nc	sk/vp			fi	3		4.5-5.0
Ad 1	26	1 4	Ad 1121	nc/vp	sk			fi	4		3.5-4.0
Ad 2	15	2 5	Ad 1221	nc	sk/nc+vr			fi	3/4		4.0
Ad 2	35	2 5	Ad 1221	nc	sk/hk1			fi	3/4		4.0
Ad 2	36	2 5	Ad 1221	ne/nc	nc			fi	3	Et	4.5-5.0
Ad 2	40	2 5	Ad 11/221	nc	sk			fi	4		4.0
Augrabies soil form: *Soils with an orthic A horizon on a neocarbonate B horizon on unspecified material*											
Ag 1	16	2 6	Ag 1220	nc/ne	nc/vr+ca			fi	4		4.5
Ag 1	18	2 6	Ag 1220	nc/ne	vr/nc/db+ca			fi	3/4		4.5-5.0
Ag 1	19	2 5	Ag 121/20	nc	vr/nc			fi	3/4		4.5-5.0
Ag 1	27	2	Ag 1/2220	nc/vr				fi	3/4	Weak Va	5.5
Ag 1	30	1 6	Ag 1/2220	nc/vr	so/sw			fi	3/4	Red Va	4.5
Ag 1	31	2 7	Ag 1/2220	ne/nc	nc/vr			fi	3/4		4.5-5.0
Ag 1	32	2 7	Ag 1/2220	ne/nc	nc/vr			fi	3/4		4.5-5.0
Ag 1	33	2 7	Ag 1/2220	ne/nc	nc/vr			fi	3/4		4.5-5.0
Ag 1	38	2 6	Ag 1220	nc/ne/vr	nc/vr			fi	4		4.5-5.0
Ag 2	7	2 7	Ag 2220	nc/ne	ne/vr			fi	3		5.0-5.5
Ag 2	25	2	Ag 2220	nc				fi	3/4		4.5
Brandvlei soil form: *Soils with an orthic A on a soft carbonate horizon on unspecified material*											
Br 1	3	1 1	Br 1000	sk			2k	fi	3		3.5
Br 1	10	3	Br 1000	sk				fi	3/4		3.5-4.0
Br 1	11	2	Br 1000	sk				fi	2		3.5-4.0
Br 1	13	2	Br 1000	sk				fi	3/4		3.0-3.5
Br 1	14	2	Br 1000	sk				fi	3/4		3.0-3.5
Br 1	22	2	Br 1000	sk				fi	3		3.5
Br 1	23	2	Br 1000	sk				fi	3/4		3.5
Br 1	24	2	Br 1000	sk				fi	3/4		3.0
Br 1	28	3	Br 1000	sk				fi	3/4		3.5
Br 1	34	3	Br 1000	sk				fi	4		3.0-3.5
Br 2	12	2	Br 2000	sk				fi	2		2.5-3.0
Br 2	39	1	Br 2000	sk/gl				fi	3/4		2.5-3.0
Klapmuts soil form: *Soils with an orthic A horizon on an E horizon on a pedocutanic B horizon*											
Km 1	37	3 4 6	Km 1120	gs	vp	gc+ca		fi	2/3		3.5-4.0
Oakleaf soil form: *Soils with an orthic A horizon on a neocutanic B horizon on unspecified material*											
Oa 1	4	3	Oa 1120	ne	ne/vp			fi	3		6.0
Prieska soil form: *Soils with an orthic A on a neocarbonate B horizon on a hardpan carbonate horizon*											
Pr 1	20	2 5	Pr 121/20	ne/nc	hk2			fi	3		4.5
Pr 1	21	1 3	Pr 121/20	ne/nc	hk2			fi	3		4.0
Valsrivier soil form: *Soils with an orthic A- on a pedocutanic B horizon on unconsolidated material without signs of wetness*											
Va 1	5	2 6	Va 1222	vr/ne	vr+ca			fi	3	Ag	4.5-5.0
Va 1	6	2 6	Va 1222	vr	vr+ca			fi	3		4.5-5.0
Va 1	9	1 5	Va 1/2212	vr	vr+ca			fi	4	Weak Ag	4.5-5.0
Va 1	17	1 5	Va 1212	vr/ne	ve/ne+ca			fi	4		4.5
Va 2	2	1 6	Va 2222	vr	vr+ca			fi	3		4.0
Va 2	29	2 6	Va 2222	vr/ne	vr+ca			fi	3/4		4.5
Va 3	8	1 3	Va 1122	vp	vp+ca			fi	4		3.0

Annexure 2

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	2.1
Soil form	2.2
Soil family	2.3
Subsoil limitations or properties	2.4
Below the line	
Coarse fragments in the topsoil horizon and outcrops	3.1
Texture of topsoil horizon and underlying E or apedal B1	3.2
Soil water conditions	3.3

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. Depth symbols for subsoil limitations or properties (arranged from shallow to deep) are written between the depth symbols for diagnostic horizon transitions and the form symbol.

2.2 Soil Form

Soil forms and abbreviations used in the soil code are explained by the Soil Classification Working Group (1991). For example Ag is the abbreviation for a Augrabies 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 1120 is the four-digit symbol for the Giyani 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 1120.

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 Klapmuts 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:

- **Hardpans; irreversibly cemented**

  This is soil material cemented by one or more compounds to such an extent that it does not soften in water.

  db - Dorbank: cemented by silica. Calcium carbonate and iron oxide are permissible as secondary cementing agents. It meets the requirements of a diagnostic dorbank horizon.

  hk - Calcrete: cemented by calcium and/or magnesium carbonate. It meets the requirements of a hardpan carbonate horizon.

  The degree of cementation is distinguished in terms of the intensity and continuity of cementation:

  1 - **Hard**: Numerous vertical fracture planes, or vesicular; moderate degree of cementation; more than 25% of the layer is accessible and penetrable to roots; sufficient fracture planes for free drainage through the pan under normal conditions.

  2 - **Very hard**: Platy and/or massive with occasional vertical fracture planes; moderate to high degree of cementation; predominantly impenetrable to roots; locally (<25% over a horizontal section) soft enough for root penetration; sporadic accumulation of free water on the pan.

  3 - **Extremely hard**: Massive and/or continuously platy with no fracture planes in which root development can occur; under normal conditions impermeable to water; regular accumulation of free water on the pan.

  Example: A hardpan cemented primarily by iron with vertical cracks approximately 10 mm to 15 mm apart is coded by the symbol **hp2**.

- **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.

  ne - Non-calcareous unconsolidated material with signs of soil formation, e.g. aggregation, clay illuviation and/or disappearance of original stratification. It largely meets the requirements of a neocutanic B horizon. Its colour must not qualify for diagnostic red or yellow-brown apedal, although red and yellow-brown variants occur.

  sk - Calcareous material which largely meets the requirements of a soft carbonate horizon.

- **Unconsolidated material with signs of wetness; predominantly gleyed**

  gc - Gleyed clay, usually with a firm or firmer consistency; it is firmer than the overlying horizon. If the structure is prismatic or columnar, it is usually weakly developed; moderate to strong blocks are permitted. It largely meets the requirements of a G horizon.

  gl - Gleyed loam, usually with a consistency not firmer than firm; it is usually not firmer than the overlying horizon. If the structure is prismatic or columnar, it is usually weakly developed; moderate to strong blocks are not permitted. It largely meets the requirements of a G horizon.

  gs - Gleyed, coarse textured material, usually friable, non-sticky and non-plastic. It largely meets the requirements of a sandy E horizon.

- **Diagnostic and non-diagnostic material with signs of weathering residual rock**

  Material in various stages of weathering and alteration that ranges from hard rock to completely homogenized soil that has cutanic character expressed as tongues or prominent colour variegation resulting from residual soil formation and illuviation occurs in many soils. It may occur in soils as diagnostic (e.g. lithocutanic B horizon, saprolite, hard rock) or non-diagnostic horizons or materials. Such materials should always be coded when it occur as a non-diagnostic horizon of material in a soil. At times it may be essential to code it as a diagnostic horizon or material.

  Depending on the degree of weathering two kinds of weathering rock are recognized, viz:

  Saprolite (or lithocutanic B) is a horizon of weathering rock with general organization in respect of colour, structure or consistence that is clearly related to the underlying parent rock. With depth it grades into relatively unweathered rock and eventually fresh rock. It does not qualify as a diagnostic soft or hardpan carbonate horizon, dorbank or hard rock.

  Hard rock is, in contrast with saprolite, a continuous hard layer of rock, that even in the wet state, cannot be cut with a spade. The most important examples are igneous, metamorphic and indurated sedimentary rock and silcrete. It is a material that does not qualify as a hard plinthic B horizon, as a hardpan carbonate horizon or as a dorbank.

  The following variants are recognized in terms of degree of weathering and wetness:

so - It conforms to the requirements of saprolite (or lithocutanic B horizon). More than 70 % of the volume of such a horizon or material consists of rock, fresh or partially weathered, with at least a hard consistence in the dry, moist and wet state. No signs of wetness is present.

sw - Material as defined for so, except that it contains signs of wetness.

- **Predominantly gravelly, stony, or bouldery diagnostic and non-diagnostic horizons or materials**

Coarse fragments (> 2 mm) can occur in varying quantities either in a part of or throughout a horizon or layer. Such coarse material can seriously affect root development, water infiltration and water holding capacity and must be indicated in the soil code in terms of **size** and **quantity** (volume percentage).

The predominant size classes and symbols for coarse fragments used in the code are as follows:

Class name	Size	Symbol
Fine gravel	2 - 25 mm	f
Coarse gravel	25 – 75 mm	g
Stones	75 - 250 mm	k
Boulders	> 250 mm	r

The volume percent of coarse fragment classes is qualified by the following numerals:

Volume %	Symbol	Volume %	Symbol
0-10	1	30-40	4
10-20	2	40-50	5
20-30	3	50-60	6

If more than one size class and/or type of coarse material occur in a horizon, it must be indicated in the code (e.g. **3f + 2g**). If the coarse fragments are poorly sorted and range in size from fine gravel to stones, a forward slash is used to separate the size class limit symbols (e.g. **4f/g**).

- **Additional properties in diagnostic and non-diagnostic horizons or materials**

  In some diagnostic as well as non-diagnostic horizons or materials, properties occur that are important for soil use, but that cannot be inferred from the definition of such horizons or materials. The following additional properties are recognized in the Western Cape Province.

  ca - The presence of free lime; either powdery or concretionary.

3 Classes and symbols for properties below the line

3.1 Coarse fragments in topsoil horizon

The presence of coarse fragments (>2 mm) in the topsoil horizon or rock outcrops has an important effect on several physical (e.g. water holding capacity) and chemical (e.g. exchangeable cation content) properties, as well as on tillage and landuse.

The size and quantity of coarse fragments in the topsoil horizon (or plough layer) are indicated with the same symbols as those used to describe such materials as **Subsoil limitations or properties**.

3.2 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:

1 Sand grade	2 Symbol
3 coarse	4 co
5 medium	6 me
7 fine	8 fi

Clay content	Symbol
0 - 5	1
5 – 10	2
10 – 15	3
15 – 20	4
20 – 35	5

Examples:

- A topsoil with 13 % clay and fine sand grade is coded by the symbol **fi 3**.
- In cases where the clay content is on or near the boundary between two classes, e.g. 11 %, it should be coded as **fi 2/3**.

3.3 Soil water conditions

A wetness classification was developed based on the number of days and depth of saturation with water. Profile morphology is used to determine the depth of water saturation and the maximum height of signs of hydromorphy is used as depth limit. Climate, locality, aspect, vegetation and water conditions during the survey as well as profile morphology are used to evaluate the duration of water saturation. The expected number of days of

saturation during the rainy season in "wet" years is used to determine duration. It is essential for free water to occur in the profile continuously for at least seven (7) days. However, the total number of days with free water need not be continuous.

Diagram for the determination of wetness classes

Depth range of upper boundary of free water surface (mm)	Wetness symbol			
0 - 300	6	7	8	9
300- 700	3	6	7	8
700 – 1 200	2	3	4	5
> 1 500	1			

0 30 90 180 365

Cumulative number of days with free water

Note: The numeral 1 is not used in the code.

Example: A soil with a wetness class symbol of 6 implies that the upper boundary of the free water surface can either be 0 – 300 mm with a maximum cumulative number of 30 days with free water, or a free surface depth of 300 – 700 mm with a cumulative duration of 30 – 90 days with free water.

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:

Estcourt form soil with a “grey” and non-black cutans in the B. The A/B transition is at 200 mm, E/B at 500 mm, soft saprolite with weakly developed signs of wetness at 750 mm and hard rock with strong signs of wetness at 1 000 mm. The topsoil contains 15 % fine and 25 % coarse gravel, 10 – 15 % clay, has a fine to medium sand grade and forms a crust on drying. The E horizon contains 35 % coarse gravel and 35 % stones and sets very hard when dry. The upper boundary of free water is 200 mm and the cumulative number of days with free water is between 90 and 180. The code for this soil may be written in one of the following ways

Field code 1 2 5 6/7 8 2 2 Es1100 pr lo/lw Rw yp 2f+3g
4g+4k fi/me3 7 cr

Field code 2 2 5 6/7 8 Es1100 gl+yp+2f+3g pr lo/lw Rw
4g+4k fi/me3 7 cr

Word/Excel format 1 2 5 6/7 8 2 2 Es1100 pr lo/lw Rw yp 2f+3g
followed in same line by a double forward slash and then
4g+4k fi/me3 7 cr

Word/Excel format 2 2 5 6/7 8 Es1100 gl+yp+2f+3g pr lo/lw Rw
followed in same line by a double forward slash and then
4g+4k fi/me3 7 cr

Note: In both examples 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.

ANNEXURE 3

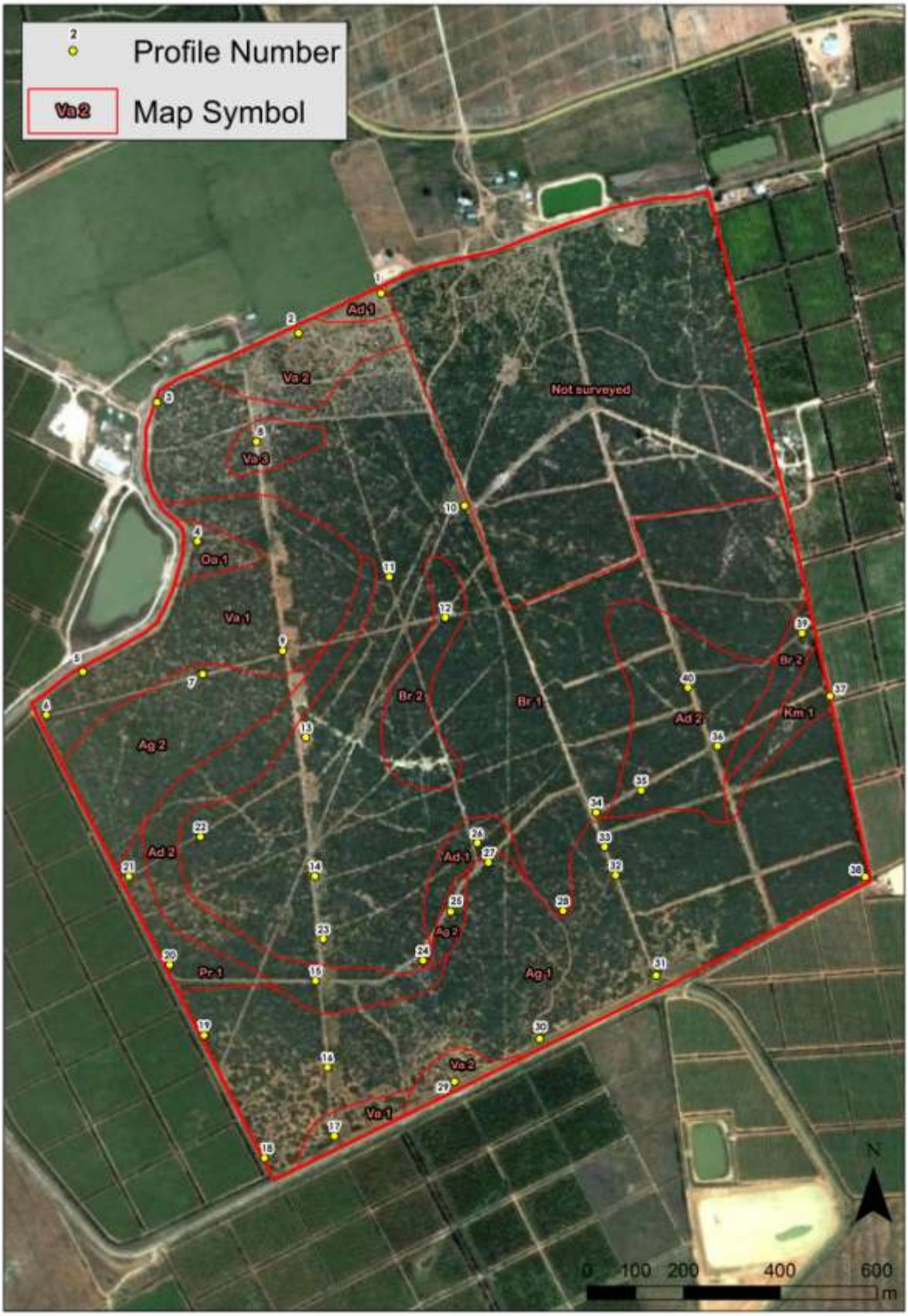

Figure 1 Reconnaissance soil map of Miskruier Farm, Addo

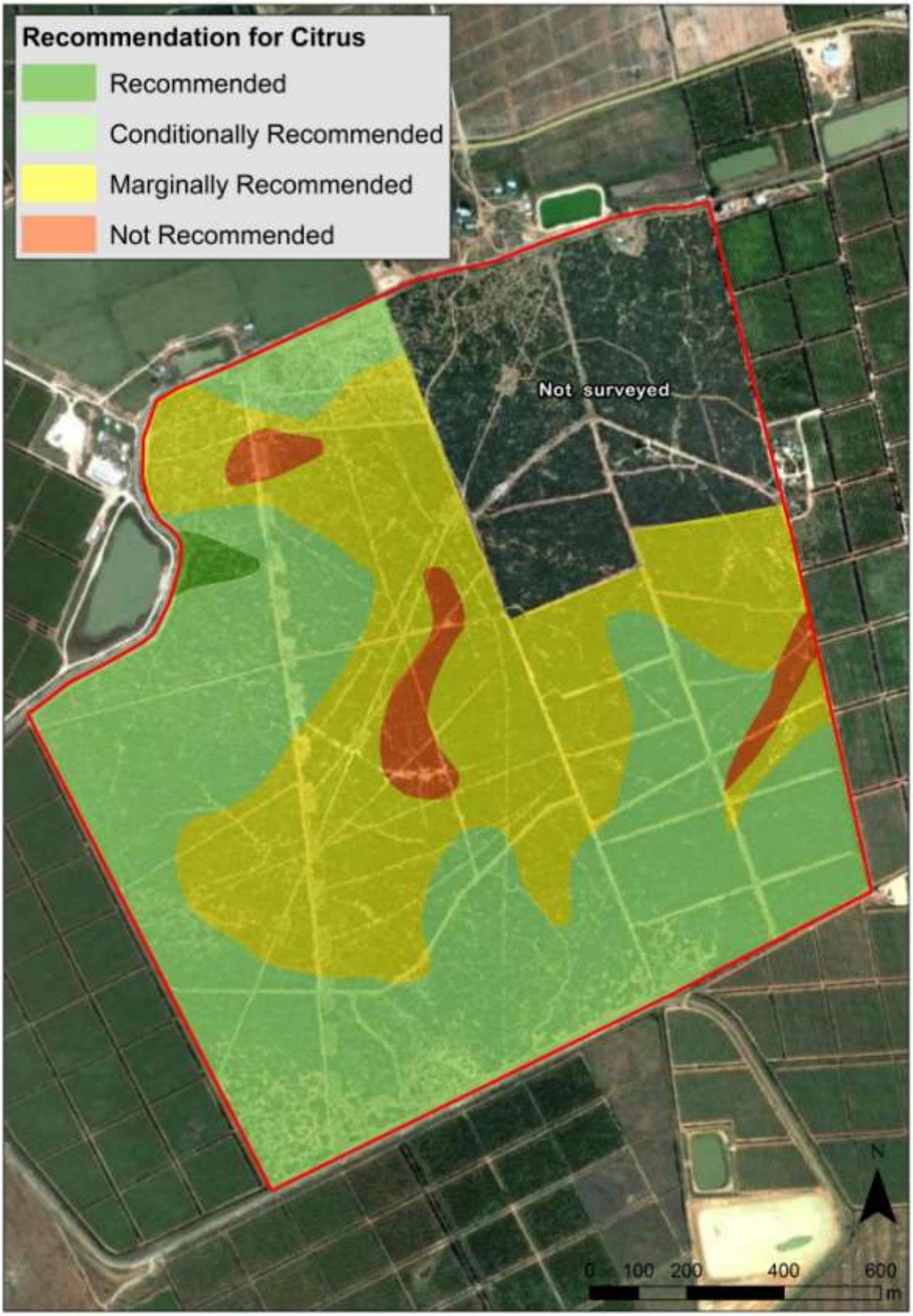

Figure 2 Soil suitability map for citrus, Miskruier Farm, Addo

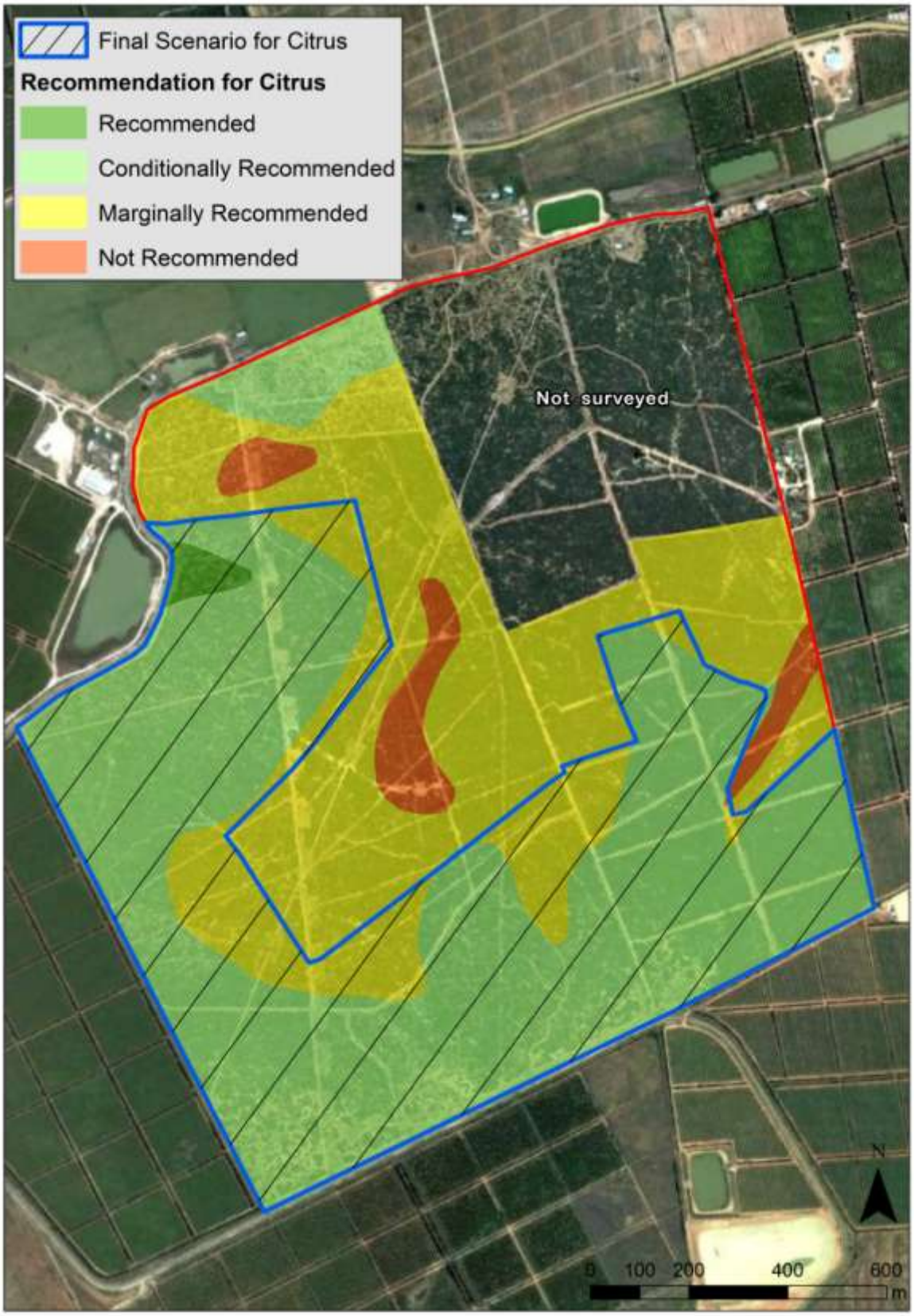

Figure 3 Map showing suggested area to be deforested for the planting of citrus