CHAPTER NINE: SOIL SUITABILITY ASSESSMENT

9.1 INTRODUCTION

This Chapter of the report 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 Risk Assessment process, in order to determine the suitability of the soils on the site for the commercial production of citrus; and to inform the project layout by identifying areas most suitable for cultivation.

9.2 SPECIALIST TERMS OF REFERENCE

The terms of reference (ToR) for the Reconnaissance Soil Survey are stated below:

- Undertake a soil survey of the farm (~1200ha) to determine the inherent properties, mainly physical and morphological, of the soils based on observations made in ~100 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.

9.3 CONSULTATION

On 31 March 2015, we were approached by Mr. Frikkie Olivier (hereafter referred to as Project Applicant) of the Sundays River Citrus Company, to give a quotation to do a Reconnaissance Soil Survey of Farm 653, an area (totaling about 1200ha) lying slightly inland on the southern side of the Sundays River between Kirkwood and Addo. After approval, the survey took place during May 2015. The request for the soil information was also given by Marisa Jacoby (BSc Hons), Environmental Assessment Practitioner, Public Process Consultants, Adcockvale, Port Elizabeth, to be utilized in an Environmental Risk Assessment being undertaken on the property.

The project applicant indicated that Ikamva Lethu Farms (Pty) Ltd has purchased Farm 653, for the purpose of establishing at ~586ha of citrus under irrigation. Farm 653 is zoned for Agriculture. The extent of the proposed agricultural development will be dependent on a number of biophysical factors including topography, vegetation, ecology and soil suitability. Environmental Authorisation in terms of the NEMA EIA Regulations, 2014 (as amended), published in GN R326, 327, 325 and 324, promulgated under Chapter Five of the National Environmental Management Act (Act 107 of 1998) ("NEMAA"), and published in Government Gazette 40772 on the 7 April 2017, will be required to be obtained prior to commencement of any activities on site.

Since the applicant has decided to proceed with the proposed agricultural development, this report, though initially prepared as part of the Environmental Risk Assessment, is being incorporated into the Environmental Impact Assessment Report, in support of the application for Environmental Authorisation.

The applicant does not require a detailed analysis of the total production area of the farm. The only requirement is the determination whether the soils in the surveyed section are generally suitable for the production of the intended crops (i.e. citrus). If necessary, the applicant 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.
- Securing the site (e.g. erecting appropriate fencing);
- Establishment of internal unpaved service roads and a new access points;
- Installation of irrigation pipelines (~8km) from the canal, across the Sundays River to Farm 653;
- Construction of three new irrigation dams and expansion of an existing dam;
- Installation of internal water reticulation and irrigation infrastructure;
- Planting of orchards and windbreaks (if required); and
- Renovation of existing structures to be utilised for administrative purposes;
- Installation of new supporting infrastructure (e.g. water reticulation, conservancy tanks).

Once the necessary infrastructure has been established, the lands will be used for the production of citrus.

9.4 FIELD SOIL SURVEY AND THE RECONNAISSACE SOIL MAP

Due to the nature (entire farm is undeveloped) and size of Farm 653, a detailed soil survey at this stage was considered unnecessary. It was, therefore, decided that a reconnaissance soil survey would be sufficient to identify the agricultural suitability of the soils for citrus.

In consultation with the applicant, a total of ~84 soil pit positions (where possible and in accessible areas) were marked on a Google Earth map of the surveyed section (see **Annexure 3: Figures 9.1 – 9.2)**.

During the reconnaissance soil survey, soil pits were mechanically excavated at the identified positions to a depth of approximately 1 200mm, or down to any restricting subsoil limitation. The latitude and longitude of the excavated soil profile pits were determined by GPS 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 2210 is family number 2210 of the Augrabies soil form. The soil forms and families described during the soil survey are listed in **Table 9.1** below.

Table 9.1: Soil forms and families listed alphabetically, according to soil form abbreviation symbol.

Abbreviation	Soil form and vertical sequence of diagnostic horizons and/ or materials

Ad **ADDO FORM**

Orthic A	
Neocarbonate B	
Soft carbonate horizon	

SOIL FAMILIES

1000¬A horizon not bleached
- 1100¬Non-red B horizon
  - 1110¬Non-luvic B1 horizon
    - 1111¬No signs of wetness in carbonate horizon
    - 1112¬Signs of wetness in carbonate horizon
  - 1120¬Luvic B1 horizon
    - 1121¬No signs of wetness in carbonate horizon1000 A horizon not bleached
- 1200 Red B horizon
  - 1210 Non-luvic B1 horizon
    - 1211 No signs of wetness in carbonate horizon

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 horizon1000 A horizon not bleached
  - 1120¬Luvic B1 horizon
- 1200 Red B horizon
  - 1210¬Non-luvic B1 horizon

Br **BRANDVLEI FORM**

Orthic A
Soft carbonate horizon

SOIL FAMILIES

1000 No signs of wetness in carbonate horizon

Cg **COEGA FORM**

Orthic A
Hardpan carbonate horizon

SOIL FAMILIES

1000 Non-calcareous A horizon
2000 Calcareous A horizon

Es **ESTCOURT FORM**

Orthic A
E horizon
Prismacutanic B horizon

SOIL FAMILIES

2000Colour of E horizon “yellow” when moist
2100B horizon lacks continuous black cutans on vertical ped faces

Et **ETOSHA FORM**

Orthic A
Neocutanic B
Soft carbonate horizon

SOIL FAMILIES

1000A horizon not bleached
1100Non-red B horizon
1110Non-luvic B1 horizon
1111No signs of wetness in carbonate horizon

Gm **GAMOEP FORM**

Orthic A
Neocutanic B
Hardpan carbonate horizon

SOIL FAMILIES

1000A horizon not bleached
1100Non-red B horizon
1110Non-luvic B1 horizon
1120- Luvic B1 horizon
1200- Red B horizon
1210- Non-luvic B1 horizon
1220-Luvic B1 horizon

Kn **KNERSVLAKLTE FORM**

Orthic A
Dorbank

SOIL FAMILIES

1000Non-calcareous A horizon

Oa **OAKLEAF FORM**

Orthic A
Neocutanic B
Unspecified material

SOIL FAMILIES

1000A horizon not bleached
1100Non-red B horizon
1110Non-luvic B1 horizon
1120Luvic B1 horizon
1200Red B horizon
1210Non-luvic B1 horizon
1220-Luvic B1 horizon

Ou **OUDTSHOORN FORM**

Orthic A
Neocutanic B
Dorbank

SOIL FAMILIES

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

Pr **PRIESKA FORM**

Orthic A
Neocarbonate B
Hardpan carbonate horizon

SOIL FAMILIES

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

Py **PLOOYSBURG FORM**

Orthic A
Red Apedal B
Hardpan Carbonate Horizon

SOIL FAMILIES

1000Non-luvic B1 horizon

Tr **TRAWAL FORM**

Orthic A
Neocarbonate B
Dorbank

SOIL FAMILIES

1000 A horizon not bleached
1100Non-red B horizon
1110Non-luvic B1 horizon
1200 Red B horizon
1210Non-luvic B1 horizon

Va **VALSRIVIER FORM**

Orthic A
Pedocutanic B
Unconsolidated material without signs of wetness

SOIL FAMILIES

1000A horizon not bleached
1100B horizon not red
1110Subangular/fine angular B horizon
1112Calcareous B or upper C horizon
1120Medium/coarse angular B horizon
1121 Non-calcareous B and upper C horizon
1122Calcareous 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** to this Chapter 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 9.2** below**,** 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 9.2: Brief description of soil types (and one land unit) on Farm 653, Kirkwood.

Explanation of superscripts

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

SOIL TYPES

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**	**Ad 3**
Soil family	Ad 1111	Ad 1111	Ad 1112
Family criteria:			
Bleaching of A horizon	Non-bleached	Non-bleached	Non-bleached
Colour of B horizon	Non-red (yellowish)	Non- red	Non- red
Clay increase from A to B	Non-luvic	Non-luvic	Non-luvic
Signs of wetness in carbonate horizon	Absent	Absent	Present
Additional features:			
Free lime in topsoil	Non-calcareous	Non-calcareous	Non-calcareous
Clay content topsoil	5 – 12 %	10 - 15 %	5 – 12 %
Depth to soft carbonate horizon	50 - 70 cm	30 – 40 cm	50 – 60 cm
Depth to and nature of material below soft carbonate horizon	Not reached	Not reached	Not reached
Coarse fragments in B horizon	Non-gravelly	Non-gravelly	Non-gravely
Effective depth (cm):	50 - 70[1)]; 75+[2)]	30 - 40[1)]; 75+[2)]	50 cm[1)] 75+[2)]

Soil type symbol:	**Ad 4**	**Ad 5**
Soil family	Ad 1121	Ad 1211
Family criteria:		
Bleaching of A horizon	Non-bleached	Non-bleached
Colour of B horizon	Yellowish	Red
Clay increase from A to B	Luvic	Non-luvic
Signs of wetness in carbonate horizon	Absent	Absent
Additional features:		
Free lime in topsoil	Non-calcareous	Non-calcareous
Clay content topsoil	8 – 15 %	10 - 15 %
Depth to soft carbonate horizon	50 - 70 cm	70 – 90 cm
Depth to and nature of material below soft carbonate horizon	Not reached	Not reached
Coarse fragments in B horizon	Non-gravelly	Non-gravelly
Effective depth (cm):	50 - 70[1)]; 75+[2)]	70 - 90[1)]; 75+[2)]

Augrabies form soils: *Soils with an orthic A- on a neocarbonate B horizon, on unspecified material without signs of wetness.*

Soil type symbol:	Ag 1	Ag 2
Soil family	Ag 1110 & 1120	Ag 1210
Family criteria: Bleaching of A horizon Colour of B horizon Clay increase from A to B	 Non-bleached Non-red Non-luvic & luvic	 Non-bleached Red Non-luvic
Additional features: Free lime in topsoil Clay content topsoil Coarse fragments in B horizon Depth to and type of unspecified material	 Non-calcareous 8 - 14 % Non-gravelly Not reached	 Non-calcareous 10 – 18 % Non-gravelly 70 - 100 cm; Locally stratified alluvium
Effective depth (cm):	≈90[1)]; 120+[2)]	80[1)]; 75+[2)]

Brandvlei form soils: *Soils with an orthic A- on a soft carbonate horizon.*

Soil type symbol:	Br 1
Soil family	Br 1000
Family criteria: Signs of wetness in carbonate horizon	 Absent
Additional features: Clay content topsoil Depth to soft carbonate horizon Depth to and nature of material below soft carbonate horizon Coarse fragments in B horizon	 5 – 12, rare 15 - 25 % 20 – 30 cm ≈60 cm; Hard carbonate horizon Non-gravelly but gravelly on surface and topsoil
Effective depth (cm):	20 - 30[1)]; 55+[2)]

Coega form soils: *Soils with an orthic A- on a hardpan carbonate horizon.*

Soil type symbol:	Cg 1	Cg 2
Soil family	Cg 1000	Cg 2000
Family criteria: Free lime in A horizon	 Present	 Present
Additional features: Clay content topsoil Depth to hardpan carbonate horizon Coarse fragments in A horizon	 5 – 15 % ≈30 cm Gravelly	 5 – 10 % ≈20 cm Gravelly
Effective depth (cm):	≈20[1)]; 55+[2)]	≈20[1)]; 55+[2]

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

Map unit symbol:	Es 1
Soil family:	Es 2100
Family criteria: Colour of E horizon in moist state Dark cutans on ped faces	 Yellow Absent
Additional features: Clay content A horizon Depth to prismacutanic horizon Coarse fragments in the A horizon and/or stratified alluvium	 10 - 15 % 50 cm Gravelly
Effective depth (cm):	50[1)]; 50+[1)];

Etosha form soils: *Soils with an orthic A- on a neocutanic B horizon, on a soft carbonate horizon.*

Soil type symbol:	Et 1
Soil family	Et 1111
Family criteria:	
Bleaching of A horizon	Non-bleached
Colour of B horizon	Non-red (yellowish)
Clay increase from A to B	Non-luvic
Additional features:	
Free lime in topsoil	Non-calcareous
Clay content topsoil	5 - 10 %
Coarse fragments in B horizon	None
Depth to soft carbonate horizon	120 cm
Material below soft carbonate horizon	Not reached
Effective depth (cm):	≈110[1)]; 75+[2)]

Gamoep form soils: *Soils with an orthic A- on a neocutanic B horizon, on a hardpan carbonate horizon.*

Soil type symbol:	Gm 1	Gm 2	Gm 3
Soil family	Gm 1110 + Gm 1120	Gm 1210+Gm1220	Gm 1220
Family criteria:			
Bleaching of A horizon	Non-bleached	Non-bleached	Non-bleached
Colour of B horizon	Non-red	Red	Red
Clay increase from A to B	Non-luvic	Non-luvic to luvic	Luvic
Additional features:			
Free lime in topsoil	Non-calcareous	Non-calcareous	Non-calcareous
Clay content topsoil	5 - 10 %	5 - 10 %	10 - 16 %
Coarse fragments in B horizon	None	None	None
Depth to hardpan carbonate horizon	50 - 60 cm	20 - 30 cm	50 - 60 cm
Effective depth (cm):	≈50[1)]; 75+[2)]	≈30[1)]; 75+[2)]	≈50[1)]; 75+[2)]

Knersvlakte form soils: *Soils with an orthic A on dorbank.*

Soil type symbol:	Kn
Soil family	Kn 1000
Family criteria:	
Free lime in A horizon	Absent
Additional features:	
Clay content topsoil	≈10 %
Depth to dorbank	≈40 cm
Coarse fragments in A horizon	Non-gravelly
Effective depth (cm):	≈40[1)]; 75+[2)]

Oakleaf form soils: *Soils with an orthic A- on a neocutanic B horizon, on unspecified material without signs of wetness.*

Soil type symbol:	Oa 1	Oa 2
Soil family	Oa 1110	Oa 1210
Family criteria:		
Bleaching of A horizon	Non-bleached	Non-bleached
Colour of B horizon	Yellow-brown	Red
Clay increase from A to B	Non-luvic	Non-luvic
Additional features:		
Clay content topsoil	6 - 10 %	6 - 15%
Coarse fragments in B horizon	Non-gravelly	Non-gravelly
Depth to and type of unspecified material	≈70 cm neocarbonate type material	≈100 cm neocutanic type material
Effective depth (cm):	≈130[1)]; 75+[2)]	≈130[1)]; 75+[2)]

Oudtshoorn form soils: *Soils with an orthic A- on a neocutanic B horizon, on dorbank.*

Soil type symbol:	**Ou 1**
Soil family	Ou 1210 & 1220
Family criteria: Bleaching of A horizon Colour of B horizon Clay increase from A to B	 Non-bleached Red Non-luvic, rare transitional to luvic
Additional features: Clay content topsoil Depth to dorbank Coarse fragments in B horizon	 10-15 % ≈60 cm Non-gravelly
Effective depth (cm):	≈60[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 1210
Family criteria: Bleaching of A horizon Colour of B horizon Clay increase from A to B	 Non-bleached Red Non-luvic
Additional features: Free lime in topsoil Clay content topsoil Depth to hardpan carbonate horizon Coarse fragments in B horizon	 Non-calcareous ≈15 % ≈40 cm Generally non-gravelly
Effective depth (cm):	≈40[1)]; 75+[2)]

Plooysburg form soils: *Soils with an orthic A- on a red apedal B horizon, on a hardpan carbonate horizon.*

Soil type symbol:	**Py 1**
Soil family:	Py 1000
Family criteria: Clay increase from A to B	 Non-luvic
Additional features: Clay content topsoil Coarse fragments in topsoil and B horizon Depth to and hardness of hardpan carbonate horizon	 5 - 10 % Gravelly ≈40 cm; very hard
Effective depth (cm):	≈40[1)]; ≈60[2)] depending on effectiveness of loosening

Trawal form soils: *Soils with an orthic A- on a neocarbonate B horizon, on dorbank.*

Soil type symbol:	**Tr 1**	**Tr 2**
Soil family	Tr 1110	Tr 1210
Family criteria: Bleaching of A horizon Colour of B horizon Clay increase from A to B	 Non-bleached Non-red Non-luvic	 Non-bleached Red Non-luvic
Additional features: Clay content topsoil Depth to dorbank Coarse fragments in B horizon	 5 – 10 % ≈40 cm Non-gravelly	 10 – 15 % 80 – 120 cm Non-gravelly
Effective depth (cm):	≈40[1)]; 75+[2)]	≈100[1)]; 75+[2]

Tukulu form soils: *Soils with an orthic A- on a neocutanic B horizon, on unspecified material with signs of wetness.*

Soil type symbol:	Tu 1
Soil family	Tu 2110
Family criteria: Bleaching of A horizon Colour of B horizon Clay increase from A to B	 Bleached Non-red (yellow and gray) Non-luvic
Additional features: Clay content topsoil Coarse fragments in B horizon Depth to and type of unspecified material	 5 - 10 % Non-gravelly 60+ cm; commonly prismacutanic to pedocutanic type material (weak signs of wetness) on hard carbonate in deepest part
Effective depth (cm):	60+[1)]; 75+[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	Va 3
Soil family:	Va 1112	Va 1121	Va 1122
Family criteria: Bleaching of A horizon Colour of B horizon Structure of B horizon Presence of free lime in B or upper C horizon	 Non-bleached Non-red Subangular blocky Calcareous	 Non-bleached Non-red Medium angular blocky Non-calcareous	 Non-bleached Non-red Medium angular blocky Calcareous
Additional features: Clay content topsoil Depth to B horizon Coarse fragments in topsoil Depth to and nature of unconsolidated material	 5 - 10 % ≈10 cm Non-gravelly ≈50 cm; neocarbonate to soft carbonate material	 ≈15 % 50 cm Non-gravelly Neocarbonate, reddish coloured	 15 – 20% 40 cm Non-gravelly ≈110 cm; reddish blocky structured material with $CaSO_4$ concentrations
Effective depth (cm):	≈50[1)]; 75+[2)] depending on effectiveness of loosening	10[1)]; 75+[2)] depending on effectiveness of loosening	40[1)]; 75+[2)] depending on effectiveness of loosening

LAND UNIT

S	Denotes areas where slopes are generallly more than 15%, in some parts even exceeding 25%, and where conditions hindered accessibility during the survey

In **Annexure 1: Table 2,** the soil types are listed alphanumerically 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 in **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 9.2** (see **Annexure 3: Figures 9.1 – 9.2**). Most of the map units are characterised by a single soil type symbol (e.g. Ag 1) or land unit (e.g. S) or as a complex of two or three soil types (e.g. S + Ag 1 + Va 1). A complex map unit was used for those areas where the soil pattern appeared to be varying over

shorter distances so that such differences, without losing their detail, would be best described in this way on the soil map. 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. In **Table 9.3** below the area in hectares of the soil types as presented in **Annexure 3: Figures 9.1 – 9.2** are listed together with average field rating.

Table 9.3: Area (in ha) of individual soil types and average field rating for citrus.

Soil type symbol	Area per soil type (ha)	Average field rating	Recommendation
Ad 1	38.96	4.57	Conditionally Recommended (CR)
Ad 2	15.81	3.50	Marginally Recommended (MR)
Ad 3	6.12	5.00	Conditionally Recommended (CR)
Ad 4	14.83	4.58	Conditionally Recommended (CR)
Ad 5	10.60	4.63	Marginally Recommended (MR)
Ag 1	8.63	5.95	Recommended (RE)
Ag 1 + Va 1	399.77	5.19	Recommended (RE)
Ag 2	48.25	5.17	Recommended (RE)
Cg 1	8.64	2.92	Not Recommended (NR)
Cg 2	195.64	2.67	Not Recommended (NR)
Cg 2 + Va 1	2.18	3.21	Marginally Recommended (MR)
Es 1	2.77	3.25	Marginally Recommended (MR)
Et 1	4.04	6.50	Highly Recommended (HR)
Et 1 + Ad 2	6.50	4.47	Marginally Recommended (MR)
Gm 1	10.85	4.00	Marginally Recommended (MR)
Gm 2	1.15	3.75	Marginally Recommended (MR)
Gm 3	4.40	4.50	Conditionally Recommended (CR)
Kn 1	2.40	4,25	Conditionally Recommended (CR)
Oa 1	12.42	5.63	Recommended (RE)
Oa 2	6.55	6.75	Highly Recommended (HR)
Ou 1	23.93	5.42	Recommended (RE)
Pr 1	16.95	4.42	Conditionally Recommended (CR)
Py 1	18.36	4.42	Conditionally Recommended (CR)
S	134.43	2.00	Not Recommended (NR)
S + Ag 1	18.90	3.58	Marginally Recommended (MR)
S + Ag 1 + Va 1	18.78	3.59	Marginally Recommended (MR)
S + Br 1	14.30	2.40	Not Recommended (NR)
S + Cg 2	39.97	2.27	Not Recommended (NR)
Tr 1	1.50	4.00	Marginally Recommended (MR)
Tr 2	2.76	5.13	Recommended (RE)
Tu 1	6.30	5.00	Conditionally Recommended (CR)
Va 1	9.04	4.04	Conditionally Recommended (CR)
Va 2	5.84	4.50	Conditionally Recommended (CR)
Va 3	1.63	3.75	Marginally Recommended (MR)
Vf + Oa 2	30.85	6.50	Highly Recommended (HR)
Streambed	16.08		Not Applicable
Dam	1.85		Not Applicable
Total (ha)	1161.98		

From **Table 9.3,** it is evident that the dominant soil types are Ag 1 + Va 1 (~35% in total) while Cg 2 are subdominant (~17% each). The S land unit alone also covers about 12% of the farm but much more when associated with other map units (e.g. S + Cg 2). Other soil types are rare and occupy each less than 6% of the total area.

9.5 SUITABILITY OF SOIL TYPES FOR CROP PRODUCTION

The most common limitations of the soils types on the surveyed section of Farm 653 are variable clay content in topsoil, coarse fragments, wetness (rare), alkalinity due to free lime at various depths through the profile (very common), dense subsoil clay layers and subsoil hardpans (common).

During the field soil survey, the individual soil pits were evaluated by the soil surveyor in terms of its general suitability for citrus production. The suitability rating ranges from 1 to 10, with 1 the lowest and 10 equal to the highest or best suitability. 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 9.4**.

Table 9.4: 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	

In **Table 9.5,** the percentage and ha of soil per suitability class for citrus after amelioration of physical limitations are listed.

Table 9.5: Suitability and ha of Farm 653 for citrus after amelioration of physical limitations.

Suitability Class	Suitability rating/ recommendation for citrus	Percentage of suitability class	Hectare
≤3	Not recommended (NR)	34.35	392.97
>3 - ≤4	Marginally recommended (MR)	6.43	73.57
>4 - ≤5	Conditionally recommended (CR)	12.26	140.27
>5 - ≤6	Recommended (RE)	43.33	495.76
>6	Highly recommended (HR)	3.62	41.44
	Total	99.99	1144.01

Table 9.5 above, indicates that ~400ha (34%) out of a total of ~1145ha potentially arable land is *not recommended for the growing of citrus* due to one or more limitations. Alternatively, ~745ha (65%) can be *recommended for citrus production* (Marginally to Highly Recommended classes). Here, the Recommended class (Suitability between 5 and 6) dominate. This is a promising situation, as the land that is seen as suitable falls in the higher suitability category within the general recommended classes.

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 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 9.3** above. The average general suitability rating for soil types was calculated from the individual profile ratings.
The limitations in most soil types, however, are low enough that it can be successfully ameliorated for citrus production. Slope gradients of *>25 % are not suitable for the commercial production of*

citrus. In **Annexure 3, Figure 9.5,** a map showing areas with slopes >25% for the whole farm is given. Most of these steep areas occupy relatively small portions of the farm and have been included in the S map unit. Depending on the row direction and potential land surface modifications (e.g. terracing), a 15% to 25% slope gradient class might be used for citrus production, but special measures should be applied to control water erosion.

In **Annexure 3: Figures 9.3 – 9.4,** the suitability of the soil types for the production of citrus is displayed.

9.6 SOIL LIMITATIONS

All the profiles investigated during the field survey have one or more soil physical, morphological and/ or chemical property(ies) that will negatively affect root development, plant growth and production potential. In **Table 9.2** above, the most important limitations are listed per soil type. The individual limitations are discussed in the following paragraphs.

9.6.1 Dense subsoil clay layers (pans)

Dense subsoil clay layers are a moderate to severe depth limitation in the Estcourt and Valsrivier soil forms where it qualifies as a prismacutanic or pedocutanic B horizon.

In the Estcourt and Valsrivier soil types, the abrupt to clear transition between the topsoil and the clay rich B horizon with significantly higher clay content, stronger structure and higher consistence, may result in the accumulation of free water in the overlying, slightly lighter textured topsoil 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 topsoil in the dry state. A bleached topsoil horizon tends to set hard and crust in the dry state.

In addition to the physical limitation of the clay pan on root development, the clay itself is usually 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.

9.6.2 High clay content in topsoil

High clay content was not seen as an important property to take note of on this farm. Most profiles had clay contents of below 15%.

9.6.3 Wetness

Wetness was observed only in a small area of the farm and mapped as the Estcourt soil type. This type of wetness may occur seasonally in the subsoil, immediately above the prismacutanic B horizon.

9.6.4 High alkalinity

Free lime in the subsoil associated with neocarbonate B horizons (e.g. in the Ag and Ad soil types) or deep subsoil horizons that qualify as soft carbonate or hardpan carbonate horizons (e.g. Br 1 soil type) 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 plowing) cultivation. High pH sensitive crops might experience these nutritional problems especially if the topsoil is also calcareous.

9.6.5 Coarse fragments in top- and/ or subsoil

Soil types Cg 1, Cg 2 and Py 1 contain coarse material that qualifies as gravel or stones in the top- and/ or upper subsoil.

The main limitation of coarse fragments is that an increase in the volume-content of coarse fragments decreases the fine soil (<2mm) fraction and consequently the water holding capacity. The nutrient retention capacity is similarly influenced.

Dry, gravelly soils, therefore, require less water to reach field water capacity but require more regular and lighter irrigation than similarly textured, non-gravelly/ stony soils. Fertilizer programs should also be adjusted.

9.6.6 Cemented subsoil hardpans

The Cg 1, Cg 2, Kn 1, Gm 1 Ou 1, Pr 1, Py 1 and all Tr soil types are characterised by a hardpan carbonate or dorbank as a diagnostic subsoil horizon below the A or B horizon.

Silica is the primary cementing agent in the dorbank (db) layers and calcium carbonate in the hardpan carbonate (hk) horizon.

These **db** and **hk** hardpans vary in hardness from slightly hard to very hard. These pans are large to platy and are a moderate to severe limitation for root penetration and are relatively slowly permeable to water.

In the Vredendal area, soils with dorbank horizons are successfully developed for wine grape production under irrigation. The success rate largely depends on the effectiveness of loosening the dorbank through ripping. The deeper the depth of loosening the better the growth and production of the wine grapes. This is also applicable to hardpan carbonate horizons. Because soils with dorbank and hardpan carbonate horizons tend to be inherently saline, irrigation may lead to salinisation of lower lying soils. To restrict the possible salinisation it is recommended that cut-off drains are installed on the transition between the dorbank and/ or hardpan carbonate soils and the lower lying soils. In general, the suitability for crop production of properly ripped shallow dorbank soils should be higher than that of shallow hardpan carbonate soils because of the absence of free lime in the dorbank soils.

9.6.7 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 investigated, these limitations are limited to small, restricted areas on these soil types.

9.7 AMELIORATION MEASURES

The following amelioration measures could be used to improve the soils for deep rooted crops such as citrus:

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

9.8 RECOMMENDATIONS

According to the soil survey, most of the soil types (65% of the surveyed area) are suitable (marginally recommended and higher) for citrus production (refer to **Table 9.5**), provided that the recommended physical amelioration measures are applied. The *marginally recommended* soil types should only be used after a more detailed survey has been done. Such a survey should indicate where the better suitable soils occur and should also take slope into consideration.

Provided that there is sufficient irrigation water available, a total of ~675ha (Highly Recommended, Recommended and Conditionally Recommended classes) can be cleared for the production of citrus, provided that the recommended amelioration measures are applied and that the required erosion control measures are followed. An additional ~75ha was rated Marginally Recommended. As mentioned above, marginally recommended soils are subject to a more detailed survey in order to determine suitable areas for citrus cultivation, whilst taking slope into consideration. The remainder (~400ha) of the total area of ~1162ha was rated Not Suitable and included areas occupied by dams or watercourses.

9.9 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.

9.10 ACKNOWLEDGEMENT

We thank the operators of the two mechanical diggers, who assisted in speeding up the survey.

9.11 ANNEXURE 1

Table 1: Coordinates of soil pits on Farm 653.

Profile number		Area	Soil type symbol	Coordinates					
Field number	New number			South			East		
				°	'		°		'
B 1	53	Farm 653	**Ag 1 + Va 1**	-33,53722			25,57472		
B 2	54	Farm 653	**Ag 1 + Va 1**	-33,53806			25,57806		
B 3	55	Farm 653	**Ag 1 + Va 1**	-33,53861			25,58222		
B 4	56	Farm 653	**Ag 1 + Va 1**	-33,53861			25,58556		
B 5	57	Farm 653	**Ad 1**	-33,53917			25,59083		
B 6	58	Farm 653	**Ag 1 + Va 1**	-33,54111			25,59056		
B 7	59	Farm 653	**Et 1**	-33,54361			25,58750		
B 8	60	Farm 653	**Tu 1**	-33,54917			25,58389		
B 9	61	Farm 653	**Cg 2 + Va 1**	-33,55444			25,58639		
B10	62	Farm 653	**Cg 2 + Va 1**	-33,55389			25,58528		
B11	63	Farm 653	**Ag 1 + Va 1**	-33,55361			25,58417		
B12	64	Farm 653	**Es 1**	-33,55389			25,58083		
B13	65	Farm 653	**Cg 2**	-33,55083			25,57750		
B14	66	Farm 653	**Cg 2**	-33,55278			25,57389		
B15	67	Farm 653	**Cg 2**	-33,55505			25,57370		
B16	68	Farm 653	**Ag 1 + Va 1**	-33,55971			25,57467		
B17	69	Farm 653	**Cg 1**	-33,55909			25,57266		
B18	70	Farm 653	**Cg 2**	-33,54950			25,57342		
B19	71	Farm 653	**S + Ag 1 + Va 1**	-33,54790			25,57048		
B20	72	Farm 653	**Ad 1**	-33,54570			25,57219		
B21	73	Farm 653	**Ad 1**	-33,54293			25,57324		
B22	74	Farm 653	**Tr 1**	-33,54162			25,57543		
B23	75	Farm 653	**Cg 2**	-33,54234			25,58003		
B24	76	Farm 653	**Ad 4**	-33,54290			25,58293		
B25	77	Farm 653	**Cg 2**	-33,53794			25,57209		
B26	78	Farm 653	**Ag 1 + Va 1**	-33,54068			25,57128		
B27	79	Farm 653	**S +Ag 1**	-33,54215			25,57067		
B28	80	Farm 653	**Ag 1 + Va 1**	-33,54311			25,57021		
B29	81	Farm 653	**Ag 1 + Va 1**	-33,54348			25,57081		
B30	82	Farm 653	**Ag 1 + Va 1**	-33,54661			25,56838		
B31	83	Farm 653	**Ag 1 + Va 1**	-33,54542			25,56649		
B32	84	Farm 653	**Vf 1 + Oa 2**	-33,54463			25,56397		
B33	85	Farm 653	**Cg 2**	-33,55224			25,57218		
B34	86	Farm 653	**Ag 1 + Va 1**	-33,55598			25,56928		
B35	87	Farm 653	**Ad 3 + Ag 1**	-33,55916			25,56844		
B36	88	Farm 653	**Ag 1 + Va 1**	-33,55909			25,56617		
B37	89	Farm 653	**Ag 1 + Va 1**	-33,55889			25,56391		
B38	90	Farm 653	**Va 1**	-33,55775			25,55911		
B39	91	Farm 653	**Ag 1**	-33,55448			25,55885		
B40	92	Farm 653	**Va 2**	-33,55108			25,55759		
B41	93	Farm 653	**Oa 2**	-33,54950			25,55758		
F	1	Farm 653	**S + Br 1**	-33,529569			25,58933		
F	2	Farm 653	**Ad 5**	-33,527236			25,58806		
F	3	Farm 653	**Gm 3**	-33,524261			25,58622		
F	4	Farm 653	**Cg 2**	-33,524126			25,58793		
F	5	Farm 653	**Cg 1**	-33,524846			25,59026		
F	6	Farm 653	**Cg 2**	-33,523126			25,58458		
F	7	Farm 653	**Cg 2**	-33,524164			25,58365		
F	8	Farm 653	**Pr 1**	-33,525108			25,58229		
F	9	Farm 653	**Cg 2**	-33,524492			25,58124		
F	10	Farm 653	**Pr 1**	-33,523473			25,58113		
F	11	Farm 653	**Gm 1**	-33,522419			25,58007		
F	12	Farm 653	**Ad 1**	-33,522695			25,57889		

F	13	Farm 653	**Gm 1**	-33,521798			25,57742		
F	14	Farm 653	**Py 1**	-33,521855			25,57566		
F	15	Farm 653	**Py 1**	-33,520302			25,57410		
F	16	Farm 653	**Cg 2**	-33,51941			25,57252		
F	17	Farm 653	**Oa 2 + Va 3**	-33,519524			25,57104		
F	18	Farm 653	**Oa 2 + Va 3**	-33,520792			25,57064		
F	19	Farm 653	**Ag 2**	-33,522219			25,56952		
F	20	Farm 653	**S + Cg 2**	-33,522224			25,57091		
F	21	Farm 653	**Py 1**	-33,523113			25,57382		
F	22	Farm 653	**Py 1**	-33,524354			25,57626		
F	23	Farm 653	**Gm 2**	-33,522247			25,57554		
F	24	Farm 653	**Tr 2**	-33,521513			25,56885		
F	25	Farm 653	**Tr 2**	-33,52044			25,56786		
F	26	Farm 653	**Ad 1**	-33,519499			25,56649		
F	27	Farm 653	**Ad 2**	-33,519471			25,56485		
F	28	Farm 653	**Cg 2**	-33,519974			25,56244		
F	29	Farm 653	**Cg 2**	-33,521371			25,56168		
F	30	Farm 653	**Cg 2**	-33,525464			25,56044		
F	31	Farm 653	**Ou 1**	-33,528025			25,55983		
F	32	Farm 653	**Oa 1**	-33,529715			25,55967		
F	33	Farm 653	**Ou 1**	-33,531454			25,56099		
F	34	Farm 653	**Ag 1**	-33,532756			25,56336		
F	35	Farm 653	**Gm 3**	-33,533364			25,56497		
F	36	Farm 653	**Cg 2**	-33,532884			25,56630		
F	37	Farm 653	**Ad 2**	-33,532663			25,56771		
F	38	Farm 653	**Pr 1**	-33,532309			25,56934		
F	39	Farm 653	**Ad 1**	-33,530504			25,56793		
F	40	Farm 653	**Ad 1**	-33,526608			25,56485		
F	41	Farm 653	**Ag 2**	-33,529216			25,56892		
F	42	Farm 653	**Ou 1**	-33,529897			25,57351		
F	43	Farm 653	**Ad 4**	-33,527742			25,57597		
F	44	Farm 653	**Kn 1**	-33,530276			25,57619		
F	45	Farm 653	**Cg 1**	-33,528085			25,58133		
F	46	Farm 653	**Ag 2**	-33,527693			25,58375		
F	47	Farm 653	**Ag 2**	-33,530304			25,58591		
F	48	Farm 653	**Ag 2**	-33,531844			25,58152		
F	49	Farm 653	**Ag 2**	-33,532194			25,57617		
F	50	Farm 653	**Ad 5**	-33,533759			25,572		
F	51	Farm 653	**Oa 1**	-33,533352			25,580		
F	52	Farm 653	**Oa 2**	-33,535039			25,578		

Table 2: Soil types with described soil profiles and codes, on Farm 653.

Soil type symbol	Profile number	Depth codes	Form & Family	Subsoil limitations/properties				Topsoil			Wetness class	Changes	Transi-tional form	Suitability rating
				Upper	Middle	Lower	Coarse fragments	Coarse fragments	Sand grade	Clay class				
Addo form soils: *Soils with an orthic A- on a neocarbonate B horizon on a soft carbonate horizon*														
Ad 1	12	1 5	Ad 1111	nc(ye/br)	hk1/db2	sk			fi	4			Va	4
Ad 1	26	2,85714	Ad 1111	nc(ye)	sk				fi	3/4				4.5-5
Ad 1	39	2 7	Ad 1111	nc(yebr)	sk				fi	3/4				4.5-5
Ad 1	40	2 4 6 7	Ad 1111	ne/nc(yebr)	nc(ye)	sk	hk1/2		fi	3/4				4.5-5
Ad 1	57	2 6	Ad 1111	nc	5k			2k+1g	fi	2				5
Ad 1	72	2 5	Ad 1111	nc	sk				fi	2				4.5-5
Ad 1	73	2 7	Ad 1111	nc	sk				fi	2				6
Ad 2	27	2 3	Ad 1111	nc(ye)	sk			2g	fi	3/4			Pr	4
Ad 2	37	1 3	Ad 1111	nc(dkbr)	sk			2g+1k	fi	3/4				3
Ad 3	87	2 5	Ad 1112	nc	sk				fi	2				5
Ad 4	43	2 6	Ad 1121	nc(yebr)	sk/hk1				fi	3/4			Va kolle	4-4.5
Ad 4	76	2 6	Ad 1121	nc	sk				fi	2				5,5
Ad 5	2	2 7	Ad 1211	nc(re)	sk				fi	4				4.5-5
Ad 5	50	2 7	Ad 1211	nc(reye)	sk/nc				fi	3				5
Augrabies form soils: *Soils with an orthic A- on a neocarbonate B horizon on unspecified material*														
Ag 1	53	2	Ag 1110	nc					fi	2				6
Ag 1	55	2 6	Ag 1110	nc	vp				fi	2				5
Ag 1	56	2 7	Ag 1110	nc	vp+5l				fi	2				6
Ag 1	58	2 7	Ag 1110	nc	vp+5h				fi	2				6
Ag 1	63	2 7	Ag 1110	nc	nc/vp				fi	2				5.5-6
Ag 1	68	2 7	Ag 1110	nc/ne	hk				fi	2			Tu	7
Ag 1	78	2 6	Ag 1110	nc/ne	nc				fi	2			Tu	6.5-7
Ag 1	79	2 6	Ag 1110	nc	nc/vp/db				fi	3				5,5
Ag 1	80	2 2	Ag 1110	nc			1g+1h	1g+1h	fi	2				5
Ag 1	81	2	Ag 1110	nc					fi	2				6
Ag 1	82	2 7	Ag 1110	nc	2h2g				fi	2				6
Ag 1	83	2 7	Ag 1110	nc	ne/ye				fi	2				6,5
Ag 1	89	2 6	Ag 111/20	nc	nc+db				fi	2				6
Ag 1	91	2	Ag 1110	nc					fi	2				6
Ag 2	19	2 7	Ag 1210	ne	nc				fi	4			Oa/Ag	6
Ag 2	41	2 0	Ag 1210	nc(re/ye)	sk				fi	3			diep Ad	4.5
Ag 2	46	1 5	Ag 1210	nc(rebr)	U1+ca				fi	3			Ou	4.5-5
Ag 2	47	2 7	Ag 1210	ne/nc(veye)	nc/db1				fi	3				5-5.6

Ag 2	48	2 7	Ag 1210	ne/nc(dkbr)	nc/db1				fi	3				5-5.5
Ag 2	49	2 6	Ag 1210	nc(reye)	nc/db1				fi	3				5-5.5
Brandvlei form soils: *Soils with an orthic A- on a soft carbonate horizon*														
Br 1	1	3	Br 1000	sk				2g	fi	4				3
Br 1	20	3 6	Br 1000	sk	hk1			2g	fi	2				2.5
Br 1	28	2 6	Br 1000	sk	hk2			2f+1g	fi	2			Cg in dele	2.5
Br 1	66	2 6	Br 1000	sk	hk				fi	2			Cg	3,5
Br 1	77	2 5	Br 1000	sk	hk				fi	2			Pr	3,5
Br 1	85	2 8	Br 1000	sk	hk				fi	2				3
Coega form soils: *Soils with an orthic A- on a hardpan carbonate horizon*														
Cg 1	5	1 5	Cg 1000	hk2	hk3			2g	fi	1/2				2.5-3
Cg 1	45	2	Cg 1000	hk3				2f+3g+1k	fi	4				2.5
Cg 1	69	3	Cg 1000	hk				3g4h	fi	2			vlak Py	3,5
Cg 2	4	1	Cg 2000	hk1+sk					fi	1				2.5
Cg 2	6	1	Cg 2000	hk1+sk				2f+2g	fi	1			Br	2.5-3
Cg 2	7	1	Cg 2000	hk1+sk				2f+2g	fi	1			Br	2.5-3
Cg 2	9	2	Cg 2000	hk1/2					fi	2				2.5-3
Cg 2	16	2 6	Cg 2000	hk1/2	hk2			2f	fi	2			Br	2.5
Cg 2	29	2 5	Cg 2000	hk1	hk2				fi	2			Br in kolle	2.5
Cg 2	30	2,5	Cg 2000	hk1	hk2				fi	2			Br in kolle	2.5
Cg 2	36	2	Cg 2000	hk2/3				2f+2g	fi	2				2.5
Cg 2	62	2	Cg 2000	hk					fi	2				2.5-3
Cg 2	65	2	Cg 2000	hk					fi	2				2,5
Cg 2	67	1/2	Cg 2000	hk				2g	fi	2				3
Cg 2	70	2	Cg 2000	hk				2g	fi	2				3
Cg 2	75	1	Cg 2000	hk					fi	2				2.5-3
Estcourt form soils: *Soils with an orthic A on an E horizon on a Prismacutanic B horizon*														
Es 1	64	2 5	Es 2100	pr	ne				fi	3		Vf		3-3.5
Etosha form soils: *Soils with an orthic A on a neocutanic B on a soft carbonate horizon*														
Et 1	59	2 6 8	Et 1111	ne(yebr)	nc	sk			fi	2				6,5
Gamoep form soils: *Soils with an orthic A on a neocutanic B on a hardpan carbonate horizon*														
Gm 1	11	2 4	Gm 11/210	ne(re/ye)	hk1/db1				fi	2/3			Va	4
Gm 1	13	1 5 7	Gm 1120	ne/vp(dk/br)	hk2/db1	hk2/3			fi	3			Gm/Va	4
Gm 2	23	1 2	Gm 121/20	ne(re)	hk2/3				fi	3/4				3.5-4
Gm 3	3	2 5	Gm 1220	nc(re)+2k	hk1	hk2/3			fi	3			Py	4.5-5
Gm 3	35	2 6 2	Gm 1220	ne(re)	hk2	2f+2g+2k			fi	3/4				4.5-5
Knersvlakte form soils: *Soils with an orthic A- on dorbank*														

Kn 1	44	1 4 6	Kn 1000	db1(re)	nc/db1	hk1/2			fi	3		Ag/Ou op sk/hk	Ag/Ou op sk/hk	4-4.5
Oakleaf form soils: *Soils with an orthic A- on a neocutanic B horizon on unconsolidated material without signs of wetness*														
Oa 1	32	2 6	Oa 1110	ne/ye	nc				fi	2				5.5-6
Oa 1	51	2 6	Oa 1110	ne/ye	nc/db1(lu)				fi	2			Ag	5.5
Oa 2	17	2	Oa 1210	ne(re)					fi	4/5				6.5
Oa 2	52	3 7	Oa 121/20	ne/re	nc/ye				fi	1/2				6-6.5
Oa 2	93	2 7 2	Oa 1210	ne/nc	nc	2g2h		1g1h	fi	2			Ag	7,5
Oudtshoorn form soils: *Soils with an orthic A- on a neocutanic B horizon on dorbank*														
Ou 1	31	2 6 7	Ou 1210	ne(re/br)+2g	db1	nc			fi	3			Ag/Oa	5
Ou 1	33	2 7	Ou 121/20	ne(re)	ne(re)/db1				fi	3				6.5-7
Prieska form soils: *Soils with an orthic A on a neocarbonate B horizon on a hardpan carbonate horizon*														
Pr 1	8	2,5	Pr 1210	ne(re)	hk2				fi	4				4.5
Pr 1	10	2 4	Pr 1210	nc(re)	hk2				fi	4				4-4.5
Pr 1	38	2 5	Pr 1210	nc(re)	hk2				fi	3				4.5
Plooysburg form soils: *Soils with an orthic A on a red apedal B horizon on a hardpan carbonate horizon*														
Py 1	14	1 3 5	Py 1000	re/ne	hk1	hk2		2f+2g	fi	3			Gm	3.5-4
Py 1	15	1 4 5	Py 1000	re/ne	hk2/3				fi	3			Gm	4
Py 1	21	1 6 1	Py 1000	re	hk2	2f+3g		2f+3g	fi	2				4.5
Py 1	22	1 3/ 4 1	Py 1000	re	hk2	2f+3g+1k		2f+3g+1k	f1	2				4
Trawal form soils: *Soils with an orthic A horizon on a neocarbonate B horizon on dorbank*														
Tr 1	74	1 4	Tr 1110	nc	db				fi	2				4
Tr 2	24	2 7	Tr 1210	nc(re)	db1				fi	3				5
Tr 2	25	2 9	Tr 1210	nc(re)	db1/nc				fi	3			Ag	5-5.5
Tukulu form soils: *Soils with an orthic A- on a neocutanic B horizon on unconsolidated material with signs of wetness*														
Tu 1	60	2 6 8	Tu 2110	ne	pr/vp	hk			fi	2			Vf	5
Valsrivier form soils: *Soils with an orthic A horizon on a pedocutanic B horizon on unconsolidated material without signs of wetness*														
Va 1	54	1/2 4 7	Va 1112	vp	nc	hk			fi	2			Et	5
Va 1	61	2 6	Va 1112	vp	sk				fi	2				3,5
Va 1	71	2/3 6 8	Va 1112	vp	nc	hk			fi	2			Km	3.5-4
Va 1	86	2 5	Va 1112	vp	nc				fi	2				4
Va 1	88	2 5	Va 1112	vp	nc				fi	2				4
Va 1	90	3	Va 1112	vp					fi	3			Ag vlak	4
Va 2	92	2 5	Va 1121	vp	nc(re)				fi	2/3				4,5
Va 3	18	1 4 8	Va 1122	vp(dk)+2g	vp(ye/bv)	vp(ye/br+CaSO4)		2g	fi	4				3.5-4

9.12 ANNEXURE 2

Structure of soil codes 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 Above the line	For description refer to section
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 - 300mm 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: Refer to *Soil Classification Working Group (1991*)

2.3 Soil family: Refer to *Soil Classification Working Group (1991)*

2.4 Subsoil limitations and properties

- Hardpans; irreversibly cemented
  db - Dorbank
  hg - Petro-gypsic horizon
  hk - Hardpan calcrete

Degree of cementation:
1 - **Hard**: Numerous vertical fracture planes or vesicular
2 - **Very hard**: Platy and/or massive with occasional vertical fracture planes
3 - **Extremely hard**: Massive/continuously platy with no fracture planes
Example: **hk2**

- Moderate to strongly structured, unconsolidated material without signs of wetness
  vp - Blocky clay; non-gleyed with non-uniform non-red colour
  vr - Blocky clay; non-gleyed soil material with uniform red colour

- Weaker than moderately structured, unconsolidated material without signs of wetness
  nc - Calcareous unconsolidated material
  ne - Non-calcareous unconsolidated material
  re - Red, non-calcareous apedal material
  sk - Soft carbonate horizon
  ye - Brown/yellow-brown, non-calcareous apedal material
  Note: Dominant colour is coded by one of the following colour abbreviation symbols: **dkbr** = dark brown; **dkre** = dark red; **gr** = grey; **re** = red; **rebr** = reddish brown; **reye** = reddish yellow; **ye** = yellow; **yebr** = yellowish brown
  The combined symbol **ne/yere** (horizon/material symbol linked to the colour symbol with forward slash) refers to a yellowish red neocutanic horizon/material.

- Unconsolidated material with signs of wetness; predominantly gleyed
  gc - Gleyed clay
  gl - Gleyed loam

- Diagnostic and non-diagnostic material with signs of weathering residual rock
  lo - Saprolite/lithocutanic B horizon with less than 70 % rock, fresh or partially weathered, with hard consistence; no signs of wetness
  lw - As lo, with signs of wetness
  so - As lo with more than 70 % rock, fresh or partially weathered, with hard consistence; no signs of wetness present
  sw - As so, with signs of wetness
  Ro - Hard rock; no signs of wetness
  Rw - As Ro, with signs of wetness

- Textural stratification in diagnostic and non-diagnostic unconsolidated material

Description	Symbol
Textural stratification non-prominent or absent	
Predominantly sandy	U5

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

Class name	Size	Symbol
Fine gravel	2 - 25 mm	F
Coarse gravel	25 – 75 mm	G
Stones	75 - 250 mm	K

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

Examples: **5k – s**; **3f + 2g**;. **4f/g**).

- Additional properties in diagnostic and non-diagnostic horizons or materials
  yp - Subsurface hardsetting

3 Classes and symbols for properties below the line

3.1 Coarse fragments in topsoil horizon

3.1.1 Coarse fragments: Refer to Subsoil limitations or properties

3.2 Texture of topsoil horizon

Sand grade			Symbol
coarse			Co
medium			Me
fine			Fi

Clay content	Symbol
0 - 5	1
5 – 10	2
10 – 15	3
15 – 20	4
20 – 35	5
35 – 55	6
> 55	7

3.3 Soil water conditions

Diagram for the determination of wetness classes

Depth range of upper boundary of free water (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

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 1:

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

Example 2:

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/me 3 7 cr

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

9.13 ANNEXURE 3

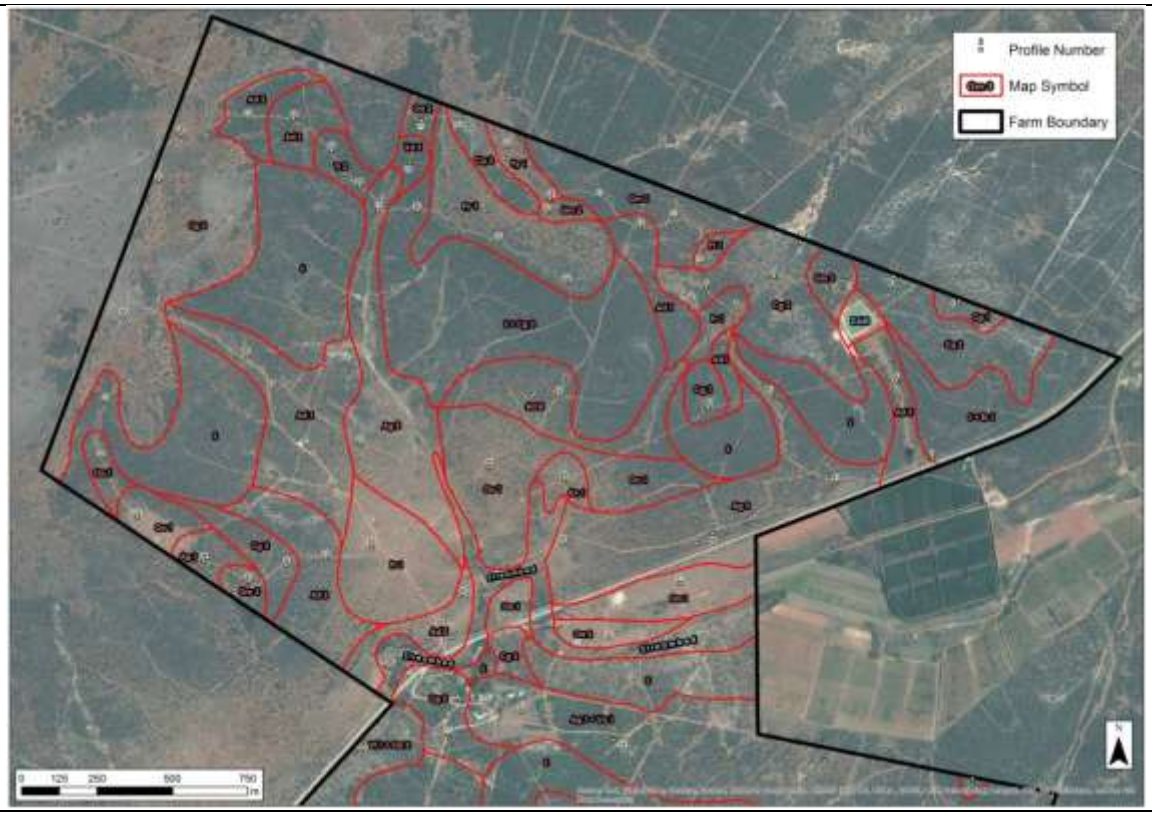

Figure 9.1: Reconnaissance soil map of Farm 653 with soil type symbols and boundaries, and positions of the soil pits (North).

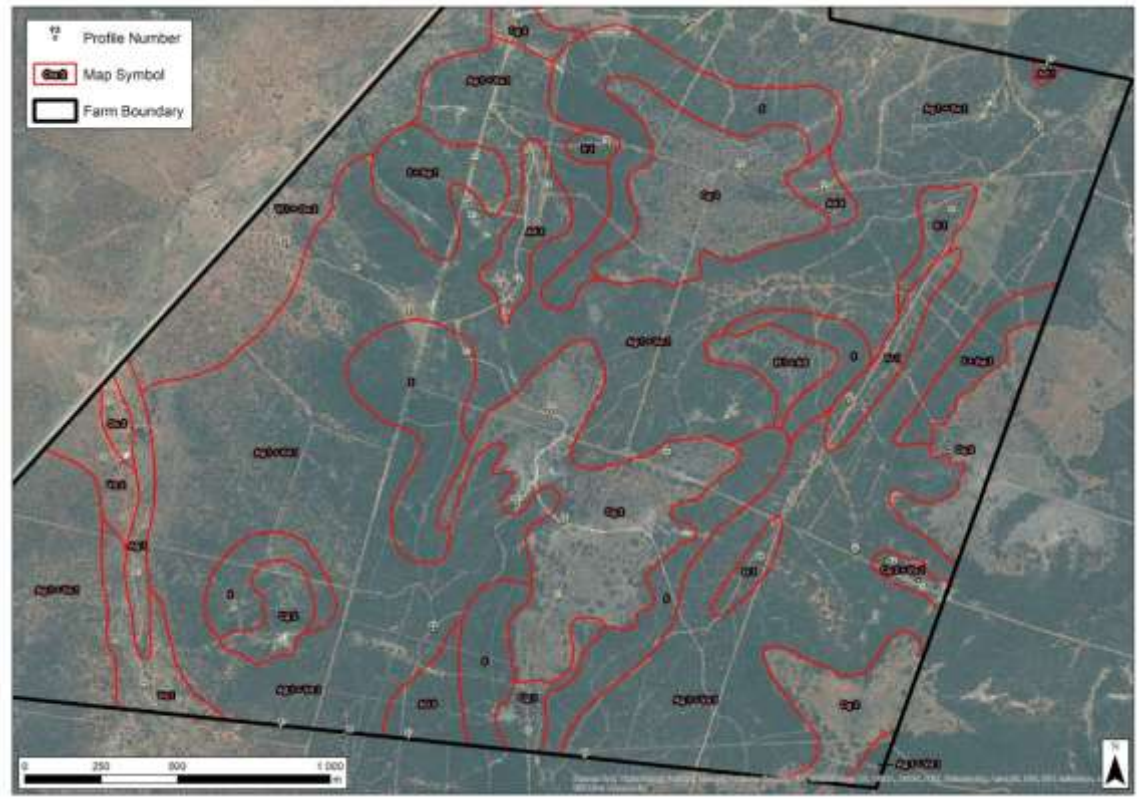

Figure 9.2: Reconnaissance soil map of Farm 653 with soil type symbols and boundaries, and positions of the soil pits (South).

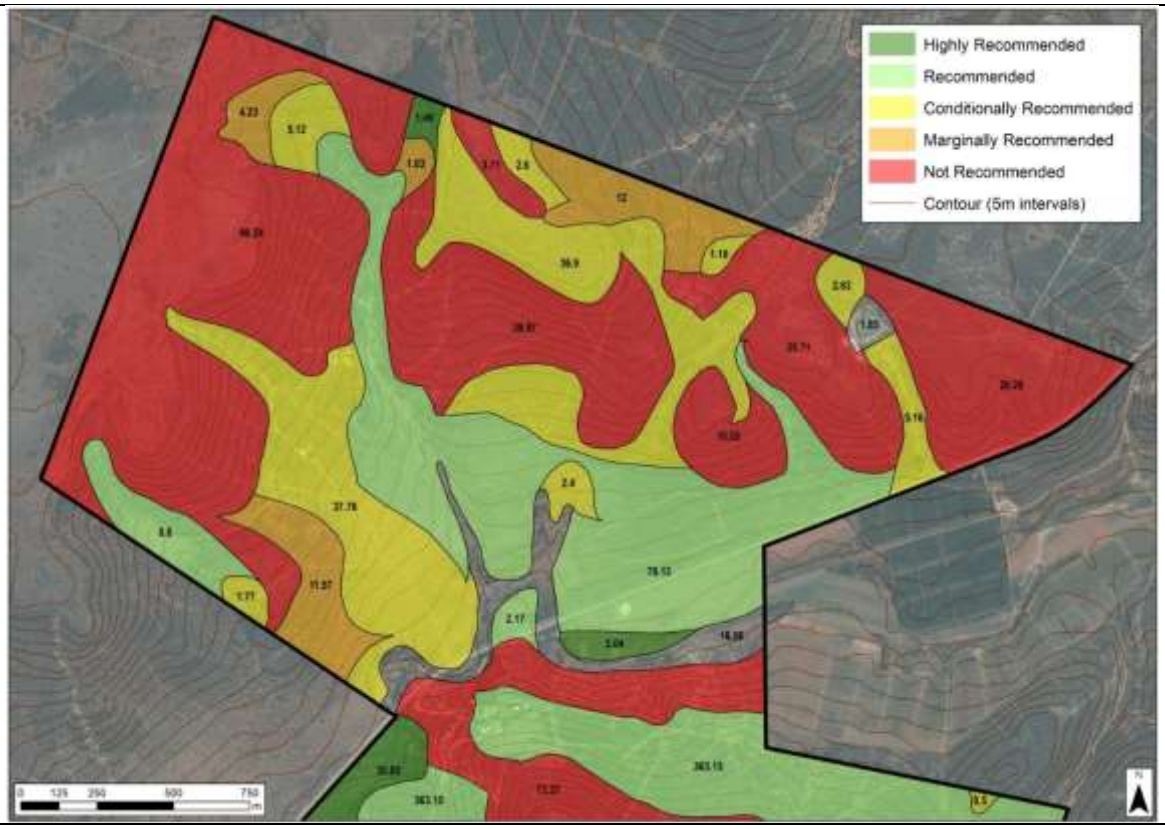

Figure 9.3: Recommendation for the production of citrus under irrigation on Farm 653 (North).

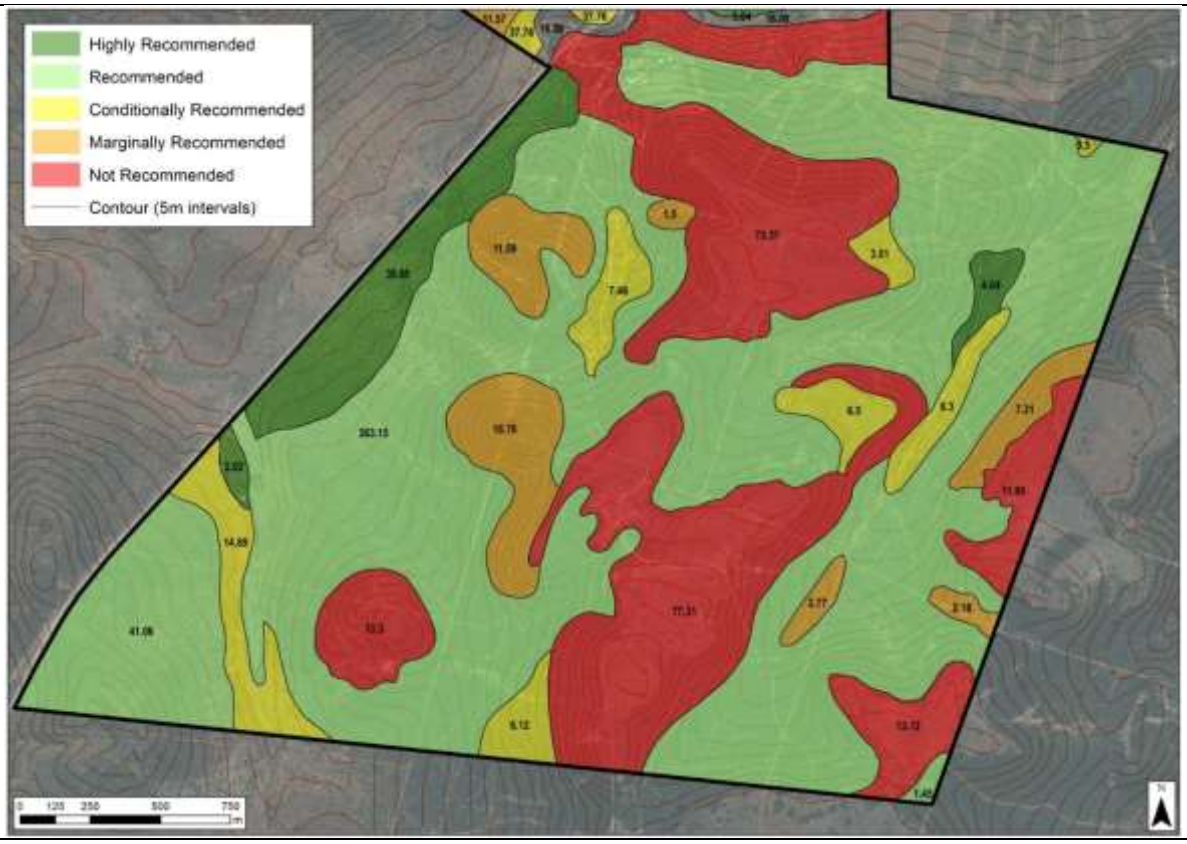

Figure 9.4: Recommendation for the production of citrus under irrigation on Farm 653 (South).

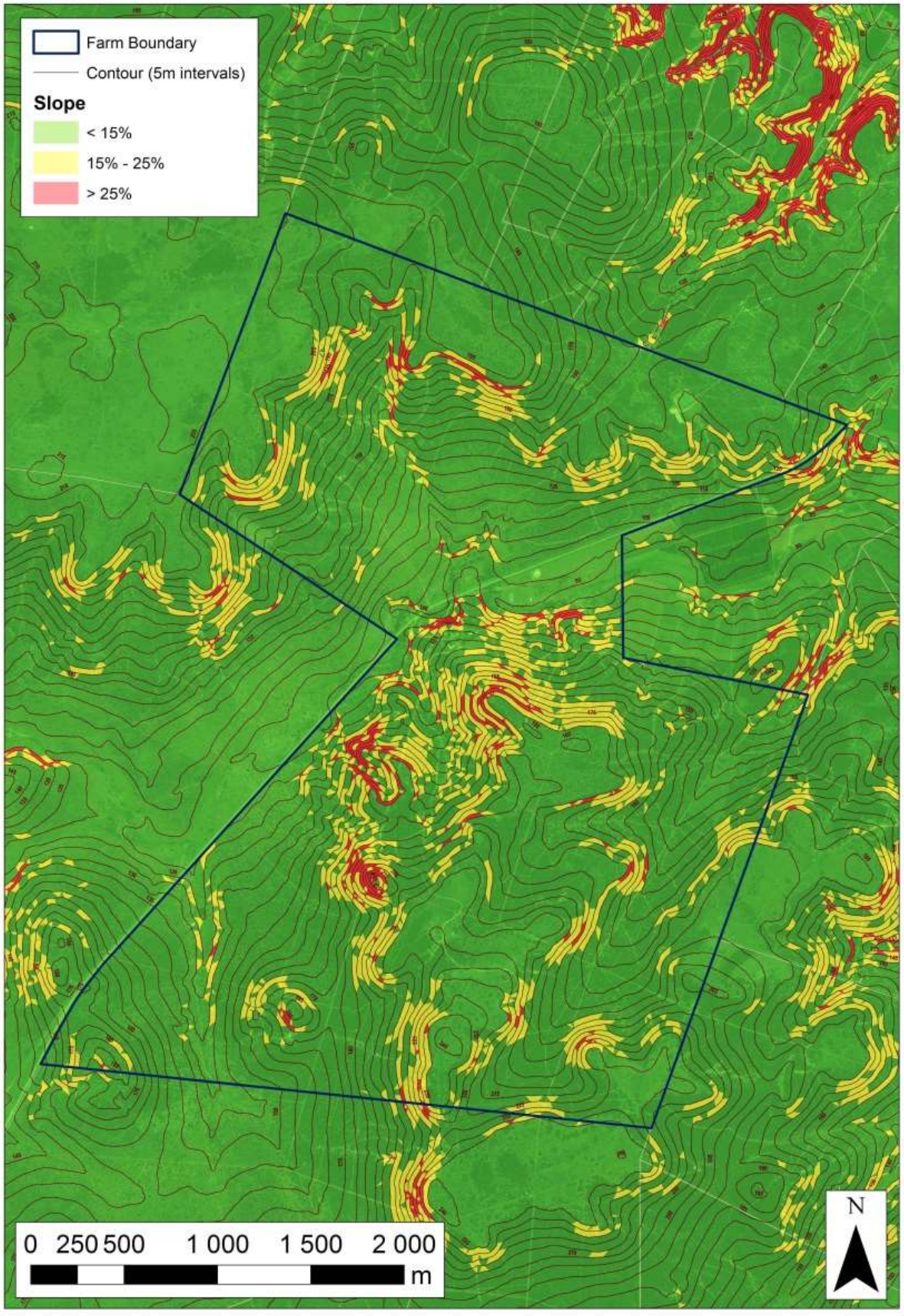

Figure 9.5: Map of the whole farm showing slope classes with areas in red indicating slopes of 25% or more.