REPORT

On contract research for

SAVANNAH ENVIRONMENTAL

SOIL INFORMATION FOR PROPOSED RHEBOKSFONTEIN WIND ENERGY FACILITY, NEAR DARLING, WESTERN CAPE

Section 2: SOIL PROFILES

By

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DECLARATION

I hereby declare that I am qualified to compile this report as a registered Natural Scientist, that I am independent of any of the parties involved and that I have compiled an impartial report, based solely on all the information available.

D G Paterson
October 2010

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1. TERMS OF REFERENCE

The ARC-Institute for Soil, Climate and Water (ARC-ISCW) was originally contracted by Savannah Environmental to undertake a desk-top soil investigation north of Cape Town, in Western Cape Province (Paterson, 2010). The purpose of the investigation was to contribute to the Environmental Impact assessment (EIA) process for a proposed wind energy facility. The objectives of the study were;

- To obtain all existing soil information and to produce a soil map of the specified area as well as

- To assess broad agricultural potential.

Despite the fact that the proposed wind turbines for the project would occupy a very small ground footprint, and that for most purposes, virtually all agricultural activities can continue in the immediate vicinity of such turbines, concern was raised by the Department of Agriculture: Western Cape as to the prevailing soil conditions and associated agricultural potential.

Consequently, a request was made to visit the site and obtain first-hand information concerning the soils occurring at certain of the turbine sites.

2. SITE CHARACTERISTICS

Location

The study area lies to the west of the town of Darling on parts of the farms Slangkop 552, Platklip 551, Slangkop 1199, Bonteberg 571, Rheboksfontein 5678, Doornfontein 574 and Nieuweplaats 567.

The area lies to the west of the R27 road, between 33^{o} 18" and 33^{o} 24' S and between 18^{o} 15' and 18^{o} 20' E. The position of the site is shown in the map in the Appendix.

All the other site characteristics were given in the original report (Paterson, 2010).

3. METHODOLOGY

The site was visited during September 2010 and a selection was made of all turbine sites occurring within the land type mapping units that were previously identified as containing soils of dominantly high potential. These points were located using a GPS and are shown by the **solid** white circles on the map (Appendix 1).

At each site, the soil was investigated using a hand-held soil auger to a maximum depth of 1 200 mm (or shallower, if a restricting layer was found). Information noted at each point included:

- Soil form and family; diagnostic horizons with clay content; effective depth and depth-limiting material; land use.

The soils were classified using the South African Soil Classification System (Soil Classification Working Group, 1991).

4. SOILS

The soils vary significantly, and the following soils were identified:

Cf1100 – Cartref form ("grey" E horizon, soft saprolite)
Cf2200 – Cartref form ("yellow" E horizon, hard saprolite)
Dr2000 – Dresden form (bleached A horizon on ferricrete)
Es1200 – Estcourt form ("grey" E horizon, non-black prismacutanic)
Fw1110 – Fernwood form ("grey" E horizon, no lamellae)
Gs2111 – Glenrosa form (bleached A horizon, soft saprolite, dry, no lime)
Gs2121 - Glenrosa form (bleached A horizon, soft saprolite, wet, no lime)
Hu2200 – Hutton form (moderately leached, luvic)
Kd1000 – Kroonstad form ("grey" E horizon)
Ms1100 – Mispah form (non-bleached A horizon, no lime, on rock)
Ms2100 – Mispah form (bleached A horizon, no lime, on rock)

Oa1110 – Oakleaf form (non-bleached A horizon, non-red, non-luvic)

Oa1210 – Oakleaf form (non-bleached A horizon, red, non-luvic)
Oa2120– Oakleaf form (bleached A horizon, non-red, non-luvic)
Oa2220– Oakleaf form (bleached A horizon, red, luvic)
Sw2121 – Swartland form (bleached A horizon, non-red, no lime)
Vf1120 – Vilafontes form (“grey” E, non-red, luvic)
Wa1000 - Wasbank form (“grey” E on ferricrete)

Due to the location of the observation sites, mainly on crests and upper midslopes, the average soil depth of soils varies between 100 - 800 mm onto underlying material that can differ from relict hard plinthite (weathering phases can varies from weak to strong weathering), and pre weathered granite.

The relevant soil information was recorded in a spread sheet, shown in Table 1 below.

Table 1 Soils

Point	Soil Form	Hor.	Horizon depth (mm)	Clay % plus Texture (est)	Depth limiting mat.	Eff. Depth	Land use	Perennial Crops		Annual Crops
								Limiting Factors	Suitability	Suitability
1R	Kd1000	A	300	0-6 coSa			Wheat	6,2,1	M-L	M
		E	650	0-6 coSa		650				
		G	850	35+ cl	Gleycutanic					
		R	850+							
2R	Cf1100	A	250	0-6 coSa			Disturbed land (old land)	6,2,4	M-L	M
		E	600	0-6 coSa		600				
		B	700+		Lithocutanic/neocutanic					
3R	Dr2000	A	300	0-6 coSa		300	Disturbed land (old land)	1,6	L	L-M
		B			Hard plinthite					
4R	Cf2200	A	250	10-15 fi-meSa			Wheat	2,4	M-L	M-H
		E	600	10-15 fi-meSa		600				
		R	700+		Rock					
5R	Cf1100	A	300	0-6 coSa			Disturbed land (old land)	6,2	L-M	M
		E1	700	0-6 coSa						
		E2	1400	0-6 coSa		1400				
		Cso	1500+		Deep weathered granite					
6R	Hu2200	A	250	6-8 meSa			Disturbed land (old land)	6,4	M-H	M-H
		B	600	20-25 fiSa		600				
		C	800	25-30 fiSa	lithocutanic					
		R	800+		Granite					
7R	Cf1100	A	300	6-8 coSa			Wheat	6,2,4	M	M
		E	600	6-8 coSa		600				
		Blc	850	35+						
		R	850+		Granite					
8R	Oa1210	A	250	8-10 meSa			Wheat	1,4	M-L	H
		B	450	10-15 meSa		450				

		Cso	500+		Weathered granite					
9R	Oa1210	A	200	8-10 meSa			Wheat	1,4	M-L	H
		B	450	10-15 meSa		450				
		R	500+							
10R	Cf1100	A	250	0-6 coSa			Disturbed land (old land)	6,2,4	M	M
		E	600	0-6 coSa		600				
		Blc	700	20-25 meSa						
		R	700+							
11R	Gs2111	A	300	6-8 coSa		300	Disturbed land (old land)	1,6	L	M-H
		Blc	600	25-30 fiSa						
		R	800+		Granite					
12R	Cf1100	A	250	0-6 coSa			Disturbed land (old land)	6,2	M	M
		E1	600	0-6 coSa						
		E2	900	0-6 coSa		900				
		B	1000	20-25 fiSa						
		R	1000+		Granite					
18R	Cf1100	A	200	0-6 coSa			Disturbed land (old land)	6,2,4	M	M
		E1	400	0-6 coSa						
		E2	600	0-6 coSa		600				
		B	800	10-15 coSa	lithocutanic/saprolitic					
		R	800+		Granite					
19R	Oa2220	A	250	10-15 fi-meSa			Vines	5,3	M-H	H
		B	500	30+ fiSa		500				
		C1	900	20-25 fiSa						
		C2	1100	20-25 fiSa						
		C3	1200+	30+ fiSa						
20R	Ms1100	A	300	6-8 me-coSa		300	Disturbed land (old land)	1	L	M-L
		R	300+		Granite					
22R	Oa2120	A	250	15-20 meSa			Vines	5,3	M-H	H
		B1	900	20+						
		B3	1100	20+		1100				
		R/stones?	1100+							

28R	Cf1100	A	300	3-6 me-coSa			Disturbed land (old land)	6,2,4	M	M
		E	700	0-6 coSa		700				
		Blc/so	900	20 fi-meSa						
		R	900+		Granite					
31R	Cf1100	A	350	0-6 coSa			Disturbed land (old land)	6,2,4	M	M
		E	700	0-6 coSa		700				
		Blc/so	900							
		R	900+		Granite					
32R	Kd1000	A	300	0-6 coSa			Disturbed land (old land)	2,6	M-L	M
		E	1000	0-6 coSa		1000				
		G	1100+	20-25 me - coSa						
33R	Kd1000	Aob	250	0-6 coSa			Grass (vleiland area)	2,6	M-L	M
		A	600	0-6 coSa						
		E	1200	0-6 coSa		1200				
		G	1500+	6 coSa						
36R	Cf1100	A	200	6-10 meSa			Disturbed land (old land)	2,1	M-L	M
		E	450	6-10 me- coSa		450				
		Blc/ne/pr?	700	35+						
		Cso	1100		Weathered granite					
		R	1200+							
40R	Kd1000	A	300	0-6 coSa			Disturbed land (old land)	2,6	M-L	M
		E	800	0-6 coSa		800				
		G	1000	6-8 fi - meSa						
		E	1200+	0-6 coSa						
47R	Vf1120	A	300	10-15 fi-meSa			Disturbed land (old land)	2	M	M-H
		E1	600	8-10 fi-meSa						
		E2	700	8-10 me-coSa		700				
		Bne/pr?	900+	35+						
50R	Wa1000	A	250	0-6 coSa			Disturbed land (old land)	2,6,1	L-M	M
		E	500	0-6 coSa		500				
		Bhp	500+							
51R	Kd1000	A	300	6+ me-coSa			Vines	2,6	M-L	M

		E1	600	3-6 coSa						
		E2	900	3-6 coSa		900				
		G	1100+	35+						
60R	Kd1000	A	300	0-6 meSa			Vines	2,6,1	L-M	M
		E	500	0-6 coSa		500				
		G	600+	40+ fiSa						
61R	Ms1100	A	300	10-15 fi-meSa			Oats	1	L	L-M
		R	300+		Granite	300				
62R	Gs2121	A	300	15 coSa			Oats	1,3	L	M-H
		Blc/so	900+	10-15 coSa						
63R	Sw2121	A	350	8-10 me-coSa			Oats	1,3	L-M	H
		B	600	30+ fiSa		350				
		Cso	700+	35+						
66R	Es1200	A	300	0-6 me-coSa			Oats	1,2	L-M	M
		E	400	0-6 coSa		300				
		Bpr	400+	35+						
67R	Fw1110	A	350	0-6 me-coSa			Oats	6,2	M-L	M
		E1	1000	0-6 coSa						
		E2	1500	0-6 coSa		1500				
69R	Oa1110	A	300	6-8 me-coSa			Oats - side of land	6	M-H	M-H
		B	800	10-15 meSa						
		B3	900	6-8 me-coSa		900				
		R	900+		Granite					
70R	Oa2120	A	250	10-15 fi-meSa			Oats	3,5	M-H	H
		B	500	20+ fiSa		500				
		Chp	500+							
71R	Cf2200	A	300	8-10 meSa			Oats - side of land	2,4	M	M
		E	500	6-8 me-coSa		500				
		R/stone?			Granite					
74R	Ms2100	A	300	10-15 meSa			Oats - side of land	1	L	L-M
		R	300+		Granite	300				
75R	Cf1100	A	350	6-8 me-coSa			Oats	6,2	M	M

		E	900	0-6 coSa						
		Blc	1000+	20+ coSa	Weathered granite					
76R	Sw2121	A	350	8-10 coSa			Oats harvested	1,3	L-M	H
		B	450	20+ fiSa		350				
		Clc	500	25+ fiSa						
		R	600+							

5. AGRICULTURAL POTENTIAL

Soil suitability

The suitability of a soil for successful crop production is dependant on the physical, morphological and chemical limitations that occur in that soil.

The suitability of the area, according to climate, for the cultivation of perennial crops such as dryland wine grapes and olives, is medium to high for the Darling area (Department of Agriculture, 1989a).

The annual crops included winter small grains, such as wheat and oats.

For annual winter small grain, the suitability rating according to climate is high for the Darling area (Department of Agriculture, 1989ba). The variation in the suitability rating of different soil types was fairly small. The reason for this small variation is the relatively shallow effective soil depth required by these crops for optimum production under winter rainfall conditions e.g. 30 – 35 cm for small grains. Only in localised small upland depressions and areas with sandy soils or where “heuweltjie” soils with calcrete/dorbank at <300 mm depth occurs, were the ratings low.

Limitations

The following limitations were taken into account during the field evaluation phase.

Limitation	Description	Symbol
Effective depth	This term refers to the depth to which plant roots will penetrate without any significant restrictions	1
Wetness	This refers to the presence of free water for shorter or longer periods at varying depths in a soil profile	2
Surface hard setting	Bleached topsoil, which is hard to very hard in the dry state. Possible loss of iron and clay	3
Weathering rock	Rock in different stages of weathering, from well weathered to unweathered, is present in many soils as a diagnostic or non-diagnostic horizon or material.	4
Hard plinthic horizons	Hardpan cemented primarily by iron in various degrees of cementation	5
Low clay content in top- and upper subsoils	Rapid loss of soil moisture during drier periods	6

These numerical symbols were only used as an identification number for each of the limitations and bear no value. However, the limitations are noted in a sequence of dominance. All the limitations noted per observation, are not always severe but should be mentioned (see Table 1).

Suitability classes

H – high few limitations which can be eliminated or prevented with standard soil preparation and fertilising practices

M – medium the elimination of one or more limitations is possible with the correct amelioration practices so that successful cultivation can take place

L – low severe limitations that prevent cultivation or need above-average management skills. Amelioration costs can be high

In summary, only eight of the 37 turbine sites investigated had an effective soil depth of 900 mm or more, while seven sites had shallow soils on rock. However, as previously stated, disturbance to an soils with a significant agricultural potential will be limited to the immediate area of the infrastructure, which would occupy a very small proportion of the landscape and not be limiting to dryland agriculture in the wider context in any way.

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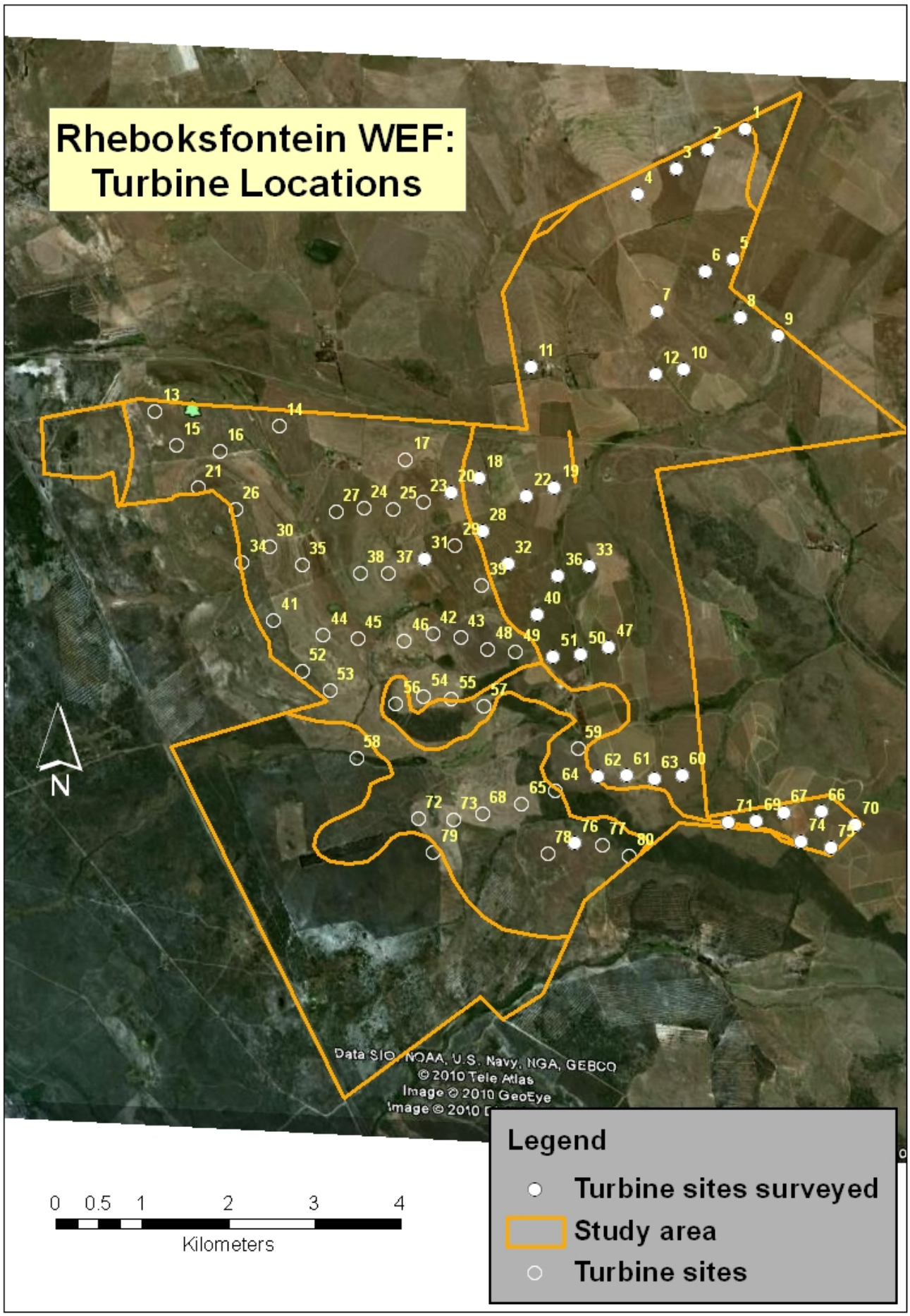
Soil Classification Working Group, 1991. Soil classification. A taxonomic system for South Africa. ARC-Institute for Soil, Climate and Water, Pretoria.

APPENDIX

MAP OF LAND TYPES


Rheboksfontein WEF:
Turbine Locations
N
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Tele Atlas
Image © 2010 GeoEye
0 0.5 1 2 3 4
Kilometers
Legend
Turbine sites surveyed
Study area
Turbine sites

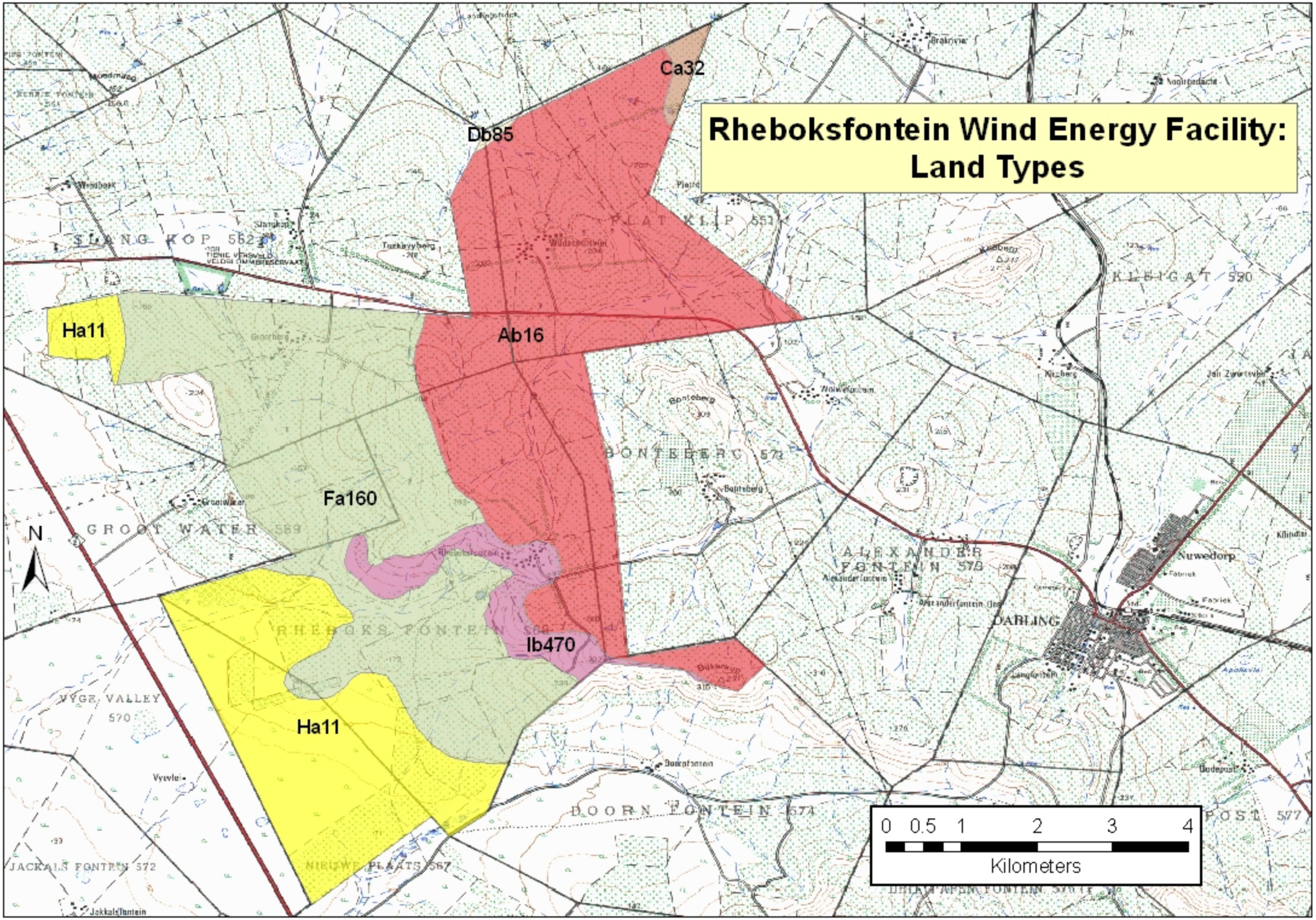
APPENDIX 2:

SOIL FORM DEFINITIONS

Soil Form	Abbr.	Topsoil	Subsoil 1	Subsoil 2	General Description	Notes
1. ORGANIC SOILS (Wetland Peat)						
Champagne	**Ch**	Organic	Gleyed material	-	Always wet	Cooler areas, often high-lying
2. HUMIC SOILS (Humus-rich topsoil)						
Kranskop	**Kp**	Humic	Yellow-brown apedal	Red apedal	Deep, structureless soil	Higher rainfall areas
Magwa	**Ma**	Humic	Yellow-brown apedal	-	Deep, structureless soil	Higher rainfall areas
Inanda	**Ia**	Humic	Red apedal	-	Deep, structureless soil	Higher rainfall areas
Lusiki	**Lu**	Humic	Pedocutanic	-	Deep, structured subsoil	Higher rainfall areas
Sweetwater	**Sw**	Humic	Neocutanic	-	Deep, structureless soil	Higher rainfall areas
Nomanci	**No**	Humic	Lithocutanic	(Usually rock)	Shallow, but often deeply weathered	Higher rainfall areas
3. VERTIC SOILS (Swelling clays)						
Arcadia	**Ar**	Vertic	-	-	Black turf soil, high clay content	On basic rocks; can be shallow
Rensburg	**Rg**	Vertic	Gleyed horizon	-	High clay content, often wet	On basic rocks
4. MELANIC SOILS (Dark, non-swelling clays)						
Willowbrook	**Wo**	Melanic	Gleyed horizon	-	High clay content, often wet	
Bonheim	**Bo**	Melanic	Pedocutanic	-	High clay contant	On basic rocks
Steendal	**Sn**	Melanic	Soft Carbonate	-	Often shallow	On basic rocks, dry
Immerpan	**Im**	Melanic	Hard Carbonate	-	Usually shallow	On basic rocks, dry
Mayo	**My**	Melanic	Lithocutanic	(Usually hard rock)	Dark, blocky topsoil	On basic rocks
Milkwood	**Mw**	Melanic	Rock	-	Dark, blocky topsoil	On basic rocks
Inhoek	**Ik**	Melanic	Alluvium/unspecified	-	Usually deep	
5. SILICIC SOILS (Silica enriched)						
Garies	**Gr**	Orthic	Red apedal	Dorbank	Structureless, variable depth	Occurs in driest areas
Oudtshoorn	**Ou**	Orthic	Neocutanic	Dorbank	Structureless, variable depth	Occurs in driest areas
Trawal	**Tr**	Orthic	Neocarbonate	Dorbank	Structureless, variable depth	Occurs in driest areas
Knersvlakte	**Kn**	Orthic	Dorbank	-	Structureless, usually shallow	Occurs in driest areas
6. CALCIC SOILS (Carbonate/gypsum enriched)						
Molopo	**Mp**	Orthic	Yellow-brown apedal	Soft carbonate	Structureless, variable depth	Occurs in dry areas
Askham	**Ak**	Orthic	Yellow-brown apedal	Hardpan carbonate	Structureless, variable depth	Occurs in dry areas
Kimberley	**Ky**	Orthic	Red apedal	Soft carbonate	Structureless, variable depth	Occurs in dry areas
Plooysburg	**Py**	Orthic	Red apedal	Hardpan carbonate	Structureless, variable depth	Occurs in dry areas
Etosha	**Et**	Orthic	Neocutanic	Soft carbonate	Structureless, variable depth	Occurs in dry areas
Gamoep	**Gm**	Orthic	Neocutanic	Hardpan carbonate	Structureless, variable depth	Occurs in dry areas

Addo	**Ad**	Orthic	Neocarbonate	Soft carbonate	Structureless, variable depth	Occurs in dry areas
Prieska	**Pr**	Orthic	Neocarbonate	Hardpan carbonate	Structureless, variable depth	Occurs in dry areas
Brandvlei	**Br**	Orthic	Soft carbonate	-	Structureless, usually shallow	Occurs in dry areas
Coega	**Cg**	Orthic	Hardpan carbonate	-	Structureless, usually shallow	Occurs in dry areas
7. DUPLEX SOILS (Sandy topsoil on structured clay)						
Estcourt	**Es**	Orthic	E Horizon	Prismacutanic	Sandy over structured, blocky subsoil	Very erodible if exposed
Klapmuts	**Km**	Orthic	E Horizon	Pedocutanic	Sandy over structured, blocky subsoil	Very erodible if exposed
Sterkspruit	**Ss**	Orthic	Prismacutanic	-	Sandy over structured, blocky subsoil	Very erodible if exposed
Sepane	**Se**	Orthic	Pedocutanic	Uncons., wet	Variable depth, structured soil	Often in lower positions
Valsrivier	**Va**	Orthic	Pedocutanic		Deep, structured clayey soil	Often on basic parent material
Swartland	**Sw**	Orthic	Pedocutanic	Saprolite	Variable depth, structured soil	Often on basic parent material
8. PODZOLS						
Tsitsikamma	**Ts**	Orthic	E Horizon	Podzol/Placic Pan	Often sandy, may be wet	Occurs in Southern & Western Cape
Lamotte	**Lt**	Orthic	E Horizon	Podzol	Deep, usually sandy	Occurs in Southern & Western Cape
Concordia	**Cc**	Orthic	E Horizon	Podzol/Unconsol.	Deep, usually sandy	Occurs in Southern & Western Cape
Houwhoek	**Hh**	Orthic	E Horizon	Podzol/Saprolite	Shallow, usually sandy	Occurs in Southern & Western Cape
Jonkersberg	**Jb**	Orthic	Podzol/Placic Pan	-	May be wet beneath	Occurs in Southern & Western Cape
Witfontein	**Wf**	Orthic	Podzol	Uncons., wet	Often sandy, wet beneath	Occurs in Southern & Western Cape
Pinegrove	**Pg**	Orthic	Podzol	Uncons., dry	Often sandy, depth will vary	Occurs in Southern & Western Cape
Groenkop	**Gk**	Orthic	Podzol	Saprolite	Often shallow	Occurs in Southern & Western Cape
9. PLINTHIC SOILS (Mottled, iron-rich subsoils)						
Longlands	**Lo**	Orthic	E Horizon	Soft plinthic	Often sandy and infertile	Depth to plinthic can vary
Westleigh	**We**	Orthic	Soft plinthic	(Usually gleyed)	Shallow soil on plinthic	Often close to wetlands
Avalon	**Av**	Orthic	Yellow-brown apedal	Soft plinthic	Moderately deep, structureless soil	Important maize soil in drier areas
Lichtenburg	**Li**	Orthic	Red apedal	Hard plinthic	Moderately deep, structureless soil	Important maize soil in drier areas
Bainsvlei	**Bv**	Orthic	Red apedal	Soft plinthic	Moderately deep, structureless soil	Important maize soil in drier areas
Wasbank	**Wa**	Orthic	E Horizon	Hard plinthic	Often sandy and infertile	Restricting if hard plinthic is shallow
Glencoe	**Gc**	Orthic	Yellow-brown apedal	Hard plinthic	Moderately deep, structureless soil	Restricting if hard plinthic is shallow
Dresden	**Dr**	Orthic	Hard plinthic	-	Shallow soil	Plinthite often outcrops at surface
10. OXIDIC SOILS (Iron-enriched)						
Pinedene	**Pn**	Orthic	Yellow-brown apedal	Gleycutanic	Moderately deep, structureless soil	Restricting if gleycutanic is shallow

Griffin	**Gf**	Orthic	Yellow-brown apedal	Red apedal	Often deep, structureless soil	Variation in texture and base status
Clovelly	**Cv**	Orthic	Yellow-brown apedal	-	Often deep, structureless soil	Variation in texture and base status
Bloemdal	**Bd**	Orthic	Red apedal	Unspecified, wet	Structureless soil, wetness beneath	May occur in lower positions
Hutton	**Hu**	Orthic	Red apedal	-	Often deep, structureless soil	Variation in texture and base status
Shortlands	**Sd**	Orthic	Red structured	-	Often deep, structured soil	Usually on basic parent material
Constantia	**Ct**	Orthic	E Horizon	Yellow-brown apedal	Deep, sandy soil	Common in W Cape flats
11. GLEYIC SOILS(Wet, mottled subsoils)						
Kroonstad	**Kd**	Orthic	E Horizon	Gleycutanic	Sandy over blocky subsoil	Very erodible if exposed
Katspruit	**Ka**	Orthic	Gleyed horizon	-	Usually clayey, always wet	Low-lying positions (wetland soil)
12. CUMULIC SOILS (Young deposits)						
Tukulu	**Tu**	Orthic	Neocutanic	Unspecified, wet	Usually deep, often alluvial	Often in lower positions
Oakleaf	**Oa**	Orthic	Neocutanic	-	Usually deep, often alluvial	Variety of colours and textures
Montagu	**Mu**	Orthic	Neocarbonate	Unspecified, wet	Usually deep, often alluvial	Often in lower positions
Augrabies	**Ag**	Orthic	Neocarbonate	-	Usually deep, often alluvial	Variety of colours and textures
Namib	**Nb**	Orthic	Regic sand	-	Sometimes calcareous	Often coastal dunes
Vilafontes	**Vf**	Orthic	E Horizon	Neocutanic	Deep soil, often sandy	
Kinkelbos	**Kk**	Orthic	E Horizon	Neocarbonate	Deep soil, often sandy	
Fernwood	**Fw**	Orthic	E Horizon	-	Deep, sandy soil	
Dundee	**Du**	Orthic	Stratified alluvium	-	Deep, alluvial soil	Usually on floodplains
13. LITHIC SOILS (Shallow and/or rocky)						
Glenrosa	**Gs**	Orthic	Lithocutanic	(Usually hard rock)	May be deeply weathered	May be very shallow
Mispah	**Ms**	Orthic	Hard rock	-	Shallow, non-arable	* Or calcrete, ferricrete, etc
Cartref	**Cf**	Orthic	E Horizon	Lithocutanic	Usually shallow, often stony	May be very shallow
14. ANTHROPIC SOILS (Man-affected)						
Witbank	**Wb**	Orthic	Man-made deposit	-	Very variable	Often very disturbed


Rheboksfontein Wind Energy Facility:
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Ca32
Db85
Ab16
Ha11
Fa160
Ib470
Ha11
N
0 0.5 1 2 3 4
Kilometers
SLANG KOP 562
PLAT KLIP 551
KLEIGAT 520
BONTEBERG 573
GROOT WATER 569
ALEXANDER FONTEIN 578
RHEBOKS FONTEIN
VYGE VALLEY 570
DOORN FONTEIN 574
JACKALS FONTEIN 572
NIEUWE PLAATS 567
POST 577
DABLING
Nuwedorp