Hydrological characteristics and properties of soils in Southern Africa 1: Runoff response

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Abstract

Soil is a prime regulator of a catchment's response, for it is the soil which absorbs, retains, redistributes and releases rain falling on it. The binomial system of soil classification with 41 soil forms divided into 501 soil series is first outlined and then used as the basis for dividing the 501 soil series into seven soil groupings in terms of hydrological response for application in the now widely used SCS method for estimating runoff volume and peak discharge. Furthermore, since lateral flow of soil water is now being recognized as an important mechanism in runoff production, a simple categorization of the interflow potential of Southern African soil series is also given.

Introduction

In hydrological assessment, be it in terms of flood peaks, flood volumes or water yield, a vital role is played by the processes occurring in or on the soil. Indeed, it is the capacity of soil to absorb, retain and release/redistribute, water that is a prime regulator of the response of a catchment, and the soil is the medium in/through which the other hydrological processes can operate.

Soils data are often used in hydrological computations by "lumping" the characteristics of many soils found within a catchment to derive an average areal parameter. A catchment is not, however, a "lumped" system in regard to soils, and pronounced differences in magnitude and sequence of hydrological processes may be observed within a catchment. Spatially homogeneous soil units with respect to hydrological response are thus critical in determining overall magnitudes of a variety of hydrological processes taking place at any given time.

In the light of this background the three aims of this first of two papers on hydrological characteristics of Southern African soils are now described.

Aims

Any meaningful hydrological categorization of the over 500 soil series now recognized in Southern Africa has to be undertaken within the framework of the existing and now established and accepted "binomial system of soil classification" as presented by MacVicar *et al.* (1977). The concepts embodied in this classification are therefore outlined at the outset. It is imperative, however, that hydrological modellers and engineering consultants designing structures on small rural catchments in Southern Africa acquaint themselves and become conversant with the detailed classification by MacVicar *et al.* (1977) and with current changes to the classification.

Secondly, with the recognition of the SCS model for generating design runoff volumes and peak discharges (United States Department of Agriculture – Soil Conservation Service, 1972; Schulze and Arnold, 1979) as an accepted hydrological design tool by many public institutions and engineering consultants, the Southern African classification of over 500 soil series in terms of hydrological response by the SCS method is described and tabulated.

Hydrologically the lateral movement of soil water (interflow) is being recognized as an important mechanism in runoff production. A simple categorization of the interflow potential of Southern African soil series is therefore also given.

Hydrological classifications of soils – notes of caution

A few notes of caution regarding hydrological classifications of soils need to be sounded before technical details of the two papers are presented:

- This is a first attempt at classifying soil series in Southern Africa on a hydrological basis. While care has been taken to set out clearly the premises and assumptions on which the various classifications have been undertaken, field experience may prove the need for re-classification in future.
- Categories, groups and values are given in these papers at the level of the soil series. However, tabulated values of the so-called soil moisture "constants", viz. wilting point and field capacity, have been *derived*; the SCS soil grouping and the interflow potential categories, on the other hand, have been *deduced*. It must be stressed that all groupings should be viewed generalizations and that all values derived are ballpark figures, to be treated as first values when used in hydrological decision-making.
- Following on the above, it must be emphasised that the generalized information given in the two papers does not replace the need for fieldwork, particularly since it is well-known that much variation in terms of hydrological response exists within any given soil series in Southern Africa.
- Soils classifications, like many other classifications, are dynamic in nature, changing as more experience is gained or as laboratory analyses become available. The "binomial system of soil classification" for Southern Africa is known to be under revision at the present time (MacVicar, 1984) and it will, in all probability, be superseded in the next five years. However, being the classification that users of soils information in Southern Africa regard as the "official" one at present (and it will remain such for the ensuing few years) this "binomial system" has been retained as the one for which all soil series groupings are presented in this report.

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The binomial system of soil classification for Southern Africa

Soil, as the medium in which hydrological processes occur, has a heterogeneous character by virtue of its horizonation, which controls rates of moisture movement both vertically and laterally. Horizons formed under given genetic conditions tend to be reproduced over and over again, with their organization and re-organization resulting in generalized *master horizons* (MacVicar *et al.*, 1977). This concept is illustrated in Figure 1.

The specific properties of master horizons led to the recognition in the Southern African binomial system of soil classification (MacVicar *et al.*, 1977) of *diagnostic horizons* (Figure 2). In the diagnostic horizon concept a grouping of pedological features is recognized. For example, organic carbon content, colour, structure, thickness or expansive properties distinguish the five diagnostic topsoil horizons. On the other hand, eluviation, gleying, colour variegations, concretions, redistribution of clay materials, differential weathering, podzolization or lack of development are used to categorize the 15 subsoil diagnostic horizons recognized in Southern Africa (MacVicar *et al.*, 1977).

The grouping of specific kinds and sequences of diagnostic horizons has resulted in the concept of the *soil form* of which 41 have been described to date. These soil forms have been further subdivided into 501 *soil series* (MacVicar *et al.*, 1977). Criteria used to distinguish series within forms include soil texture (clay content, sand grading); base status in terms of leaching; calcareousness; soil reaction (pH); surface physical properties; colour of the B horizon; consistence of the B horizon; surface wetness; and topography.

At series level no depth limits of the various horizons are set. Depth of horizons, or the slope or topographic position of the series and other local properties, which are most important to hydrological response, cannot be generalized but must be determined *in situ* and added as a further descriptor of the soil series, namely, the *soil phase*. Figure 3 illustrates the above concepts.

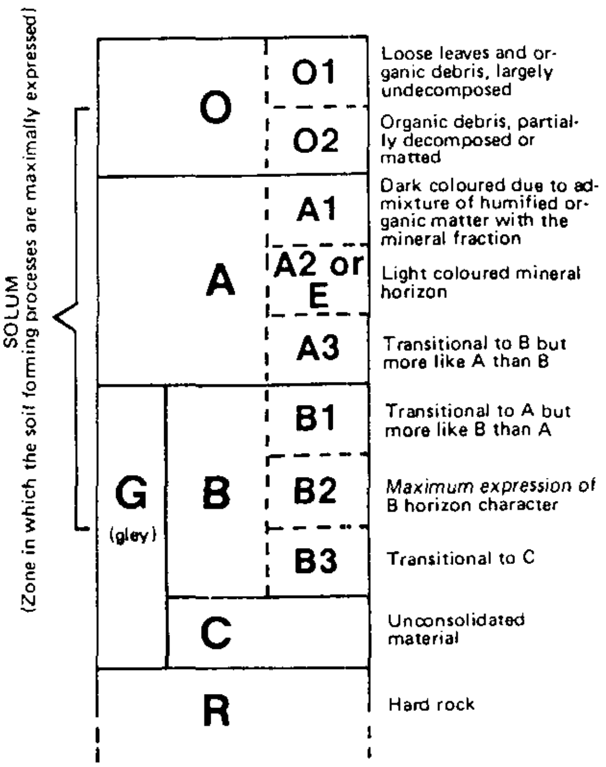

Figure 1
Arrangement of master horizons (MacVicar et al., *1977)*

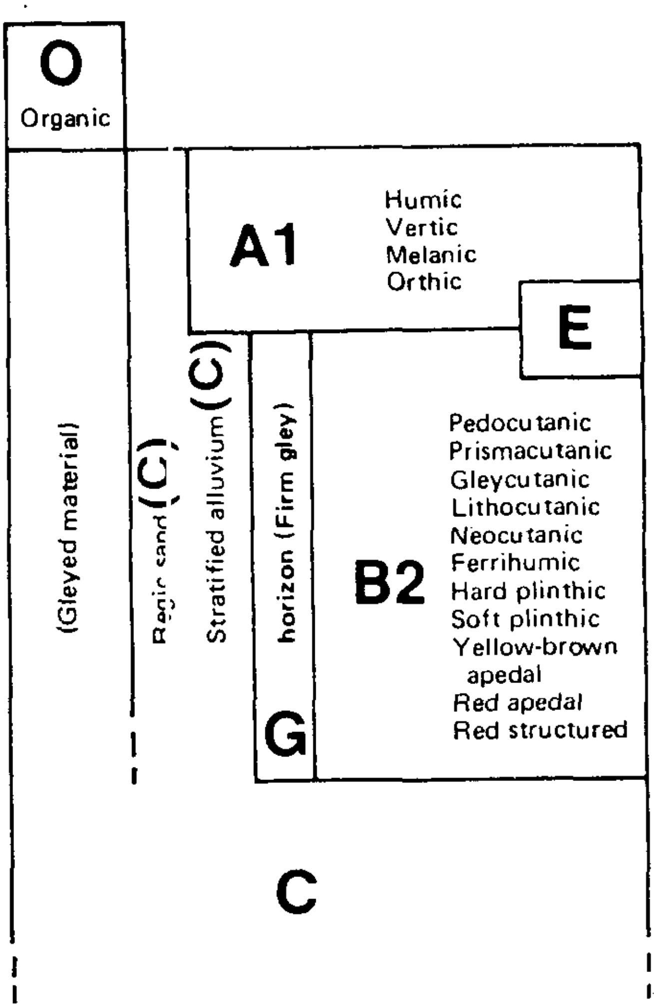

Figure 2
Diagnostic horizons (MacVicar et al., *1977)*

Hydrologically, the division of soils into diagnostic horizons, with their attendant properties and subdivisions, is important. This is so because they constitute the vital heterogeneous soil stores within, between and along which important hydrological processes can take place (arrows in Figure 3).

Hydrological response grouping of Southern African soils for the SCS model

Background

A hydrological response grouping of Southern African soil series for the SCS model was first undertaken in 1979. The guidelines and criteria for the classification were formulated together with colleagues who had wide pedological, engineering or agronomic experience and who were drawn from the University of Natal, the Department of Agriculture at Cedara, the Soil and Irrigation Research Institute and the Hydrological Research Institute, both in Pretoria.

The parameter which provides the basis for a hydrological response classification of soils in Southern Africa was formulated as a "typical amount of infiltration for the soil at likely moisture content to the point of maximum runoff rate". This premise is somewhat different in concept to the one described by the SCS in

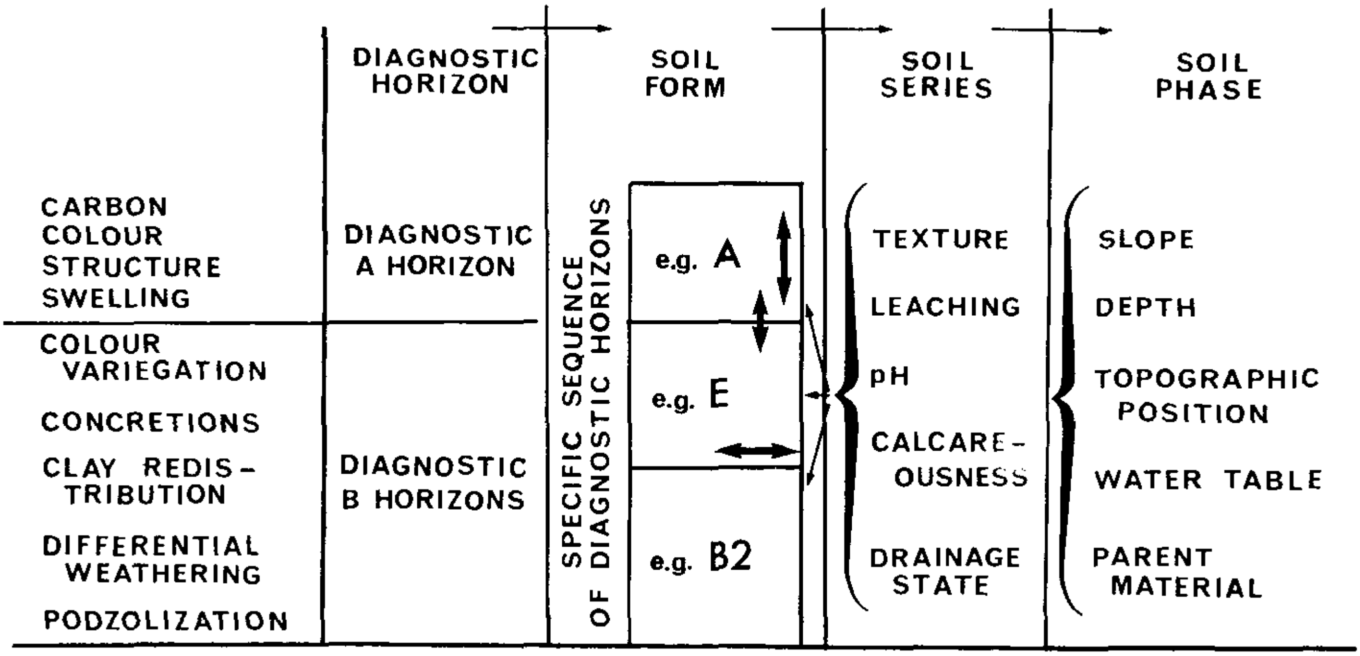

Figure 3
Hierarchical classification of soils in Southern Africa (Schulze, 1984)

the National Engineering Handbook (USDA-SCS, 1972) in which the "minimum rate of infiltration for a thoroughly wetted bare soil assuming maximum swelling" forms the basis of soils grouping. The reason for altering the concept of classification is that a comparison of the actual physical properties of soil series in the USA and their hydrological grouping showed that many series have been classed intuitively according to "typical" or "likely" moisture characteristics in the field.

Basic hydrological grouping

As in the SCS literature (USDA-SCS, 1972), four basic hydrological soil groups have been recognized. Hydrologically, the limiting properties in a soil profile may be

- its infiltration rate at the surface (i.e. the rate at which water enters the soil at the surface, which is controlled by surface conditions);
- its permeability (i.e. the rate at which water is transmitted through soil, which is controlled by the porosity and capillary distribution of the various individual horizons making up a soil profile); and
- its water storage capacity (which is dependent primarily on the soil texture and its depth).

The four basic hydrological soil groups recognised by the SCS (USDA-SCS, 1972) are the following:

Soil Group A. *Low runoff potential.* Infiltration rate is high and permeability is rapid in this group. Overall drainage is excessive to well-drained.

Soil Group B. *Moderately low runoff potential.* The soils of this group are characterized by moderate infiltration rates, effective depth and drainage. Permeability is slightly restricted.

Soil Group C. *Moderately high runoff potential.* Infiltration rate is slow or deteriorates rapidly in this group. Permeability is restricted. Soil depth tends to be shallow.

Soil Group D. *High runoff potential.* Soils in this group are characterized by very slow infiltration rates and severely restricted permeability. Very shallow soils and expansive soils (those of high shrink-swell potential) are included in this group.

With the wide spectrum of properties found in Southern African soils, it was felt that a four-fold grouping of soils was too coarse for the SCS model, and three intermediate soil groups have therefore been used in the classification of soil forms and series. These groups are A/B, B/C and C/D, thus giving seven soil groups in all.

Classification procedure

Each soil form, according to its overall diagnostic properties (MacVicar *et al.*, 1977) was placed initially in one of the seven groups. The series within each soil form were then graded up or down from the general soil group assigned to the form, according to their specific physical or chemical properties.

The following properties were considered to be relevant:

Texture (t): Soils with A-horizon clay content exceeding 35%

were downgraded one group; where clay content was less than 6% and coarse sand made up at least 6% of the soil fraction, soil series were upgraded one group.

Leaching (l): Dystrophic (highly leached) soils were upgraded one group while eutrophic soils were downgraded one group.

Water Table (w): Series with a high water table typically present were downgraded one group.

Crusting (c): Soil forms which typically displayed a crusted surface, but where crusting was absent at series level, were upgraded one group, and vice-versa. Soils exhibiting a hardening of the B-horizon (for example, a ferrihumic B-horizon) were downgraded one group. There may be exceptions to these general rules, for example, Cass (1984) considers crusting in the Arcadia soil series not to be a hydrological barrier.

At the present stage a degree of uncertainty still exists as to the overall effects of soil colouration and calcareousness on infiltration and permeability rates. Doubts have also been expressed as to whether an up- and downgrading due to degree of leaching is warranted. The regrading procedure has nevertheless been kept, pending detailed investigation. Future research and experience will also determine whether/to what degree expansive soils should be downgraded (Cass, 1984).

Because of the variable nature of soil properties within a specific series, some further guidelines for adjustment in the field are given:

Soil depth: Where typically deep soils are in the shallow phase (generally less than 0,5 m), they should be downgraded one group.

Surface sealing: Where surface sealing is evident *in loco*, soils should be downgraded one group.

Topographic position: Generally series in bottomlands may be downgraded and series formed on uplands upgraded one group.

Parent material: Identical series derived from different parent materials may require re-grouping (e.g. series derived from Table Mountain sandstones would be upgraded relative to the same series derived from Dwyka tillites).

The hydrological soil groupings for the 501 soil series given in MacVicar *et al.* (1977) are listed in Table 1. In assessing the hydrological response of a catchment the information on soil groups is used in conjunction with different agricultural and non-agricultural land use and treatment classes, which are detailed in the SCS manual for Southern Africa (Schulze and Arnold, 1979).

Potential for interflow

With the advent of research into distributed hydrological models in Southern Africa, a grouping of soil forms and series into their potential for interflow becomes necessary. The potential for interflow is not just a simple matter of association with soil form and series however, because the process is dependent largely on slope, on topographic position inducing a convergence of soil water, as well as on soil depth, and in addition also on the degree of transmissivity which can take place through an impeding layer and which can be highly variable.

A threefold grouping into the potential for interflow, namely interflow unlikely, some/low interflow potential, and high interflow potential has nevertheless been attempted.

The following criteria were used as initial 'rules of thumb' to demarcate soils with a 'low interflow potential', namely the presence of

- a soft plinthic horizon (for example, with Avalon, Bainsvlei, Tambankulu and Westleigh forms) particularly in shallow phases of series, which then become prone to waterlogging;
- a pedocutanic horizon (for example, with the Valsrivier form);
- a lithocutanic horizon (Glenrosa, Mayo and Nomanci forms under certain field conditions);
- a ferrihumic horizon (Houwhoek and Lamotte forms), although many variants of the ferrihumic horizon with little or much sesquioxide hardening may exist and testing *in situ* becomes imperative;
- gleycutanic (Pinedene) and neocutanic (Oakleaf) horizons, although some doubt exists as to whether interflow would actually be enhanced by the presence of these horizons in the two forms named; and
- gradual transitions between horizons typical of certain series of the Constantia, Shepstone and Vilafontes forms.

Soils with a 'high interflow potential' are characterized by

- hard plinthic B-horizons (for example, Glencoe and Wasbank forms);
- A-horizons overlying hard/unconsolidated rock directly (Milkwood and Mispah forms);
- lithocutanic horizons under certain field conditions (Glenrosa, Mayo and Nomanci forms); and
- abrupt textural transitions down a soil profile (for example, Estcourt and Sterkspruit forms with prismacutanic B-horizons, Kroonstad with a gleycutanic and certain series of the Shepstone, Constantia and Vilafontes forms).

Using the above 'rules of thumb' as an initial guide, the 501 soil series were distinguished by their interflow potential in Table 1. Based on a field knowledge of individual forms and series, appropriate changes were then made. For example, all Estcourt and Vilafontes series were classified as having a 'high' interflow potential, the first seven Glencoe series were changed from the 'unlikely' to the 'some' interflow group, all Longlands series were reassigned to 'high', all Mayo and Milkwood to 'some' and all Oakleaf and Shepstone series to 'unlikely' interflow potential.

It should be noted that in regard to interflow potential, that *in situ* examination of soil conditions is crucial. Furthermore, it may be seen in Table 1 that not all series of a given soil form respond identically in terms of interflow potential, as series may differ according to the degree of abruptness of clay content changes down a soil profile.

Aspects of the runoff responses of Southern African soils having been discussed in terms of the soil grouping used for the SCS model as well as in regard to the interflow potential of soils, the second paper on hydrological characteristics of soils focusses on water retention properties of soils.

TABLE 1
HYDROLOGICAL CLASSIFICATIONS OF SOIL FORMS AND SERIES FOUND IN SOUTHERN AFRICA

Legend

A – low runoff potential	Cl – clay
B – moderately low potential	S – sand
C – moderately high potential	Lm – loam
D – high runoff potential	O – no/low interflow potential
c – crusting	X – some interflow potential
l – leaching	XX – high interflow potential
t – texture	
w – water table	

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
ARCADIA	Ar 40	Arcadia	C/D		2e	Cl	O
	Ar 11	Bloukrans	C/D		2e	Cl	O
	Ar 21	Clerkness	C/D		2e	Cl	O
	Ar 41	Eenzaam	C/D		2e	Cl	O
	Ar 20	Gelykvlakte	C/D		2e	Cl	O
	Ar 10	Mngazi	C/D		2e	Cl	O
	Ar 32	Nagana	C/D		2e	Cl	O
	Ar 12	Noukloof	C/D		2e	Cl	O
	Ar 31	Rooidraai	C/D		2e	Cl	O
	Ar 30	Rydalvale	C/D		2e	Cl	O
	Ar 42	Wanstead	C/D		2e	Cl	O
	Ar 22	Zwaarkrygen	C/D		2e	Cl	O
AVALON	Av 13	Ashton	A/B	+l	1b	SLm	X
	Av 26	Avalon	B		1c	SClLm	X
	Av 12	Banchory	A	+l/+t	1a	S	X
	Av 27	Bergville	B/C	−t	1d	SCl	X
	Av 37	Bezuidenhout	C	−t/−l	1d	SCl	X
	Av 33	Bleeksand	B/C	−l	1b	SLm	X
	Av 34	Heidelberg	B/C	−l	1b	SLm	X
	Av 20	Hobeni	A/B	+t	1a	LmS	X
	Av 14	Kanhym	A/B	+l	1b	SLm	X
	Av 24	Leksand	B		1b	SLm	X
	Av 10	Mastaba	A	+l/+t	1a	LmS	X
	Av 32	Middelpos	B	+t/−l	1a	S	X
	Av 31	Mooiveld	B	+t/−l	1a	LmS	X
	Av 25	Newcastle	A/B	+t	1b	SLm	X
	Av 17	Normandien	B	+l/−t	1d	SCl	X
	Av 22	Rossdale	A/B	+t	1a	S	X
	Av 16	Ruston	B	+l	1c	SClLm	X
	Av 36	Soetmelk	B/C	−l	1c	SClLm	X
	Av 21	Uithoek	A/B	+t	1a	LmS	X
	Av 30	Viljoenskroon	B	+t/−l	1a	LmS	X
	Av 23	Villiers	B		1b	SLm	X
	Av 11	Welverdiend	A	+l/+t	1a	LmS	X
	Av 35	Windmeul	B	+t/−l	1b	SLm	X
	Av 15	Wolweberg	A	+l/+t	1b	SLm	X
BAINSVLEI	Bv 23	Ashkelon	A/B		1b	SLm	X
	Bv 36	Bainsvlei	B	−l	1c	SClLm	X
	Bv 12	Camelot	A	+t	1a	S	X
	Bv 20	Chelsea	A	+t	1a	LmS	X
	Bv 30	Delwery	A/B	+t/−l	1a	LmS	X
	Bv 13	Dunkeld	A/B		1b	SLm	X
	Bv 16	Elysium	A/B		1c	SClLm	X
	Bv 10	Hlatini	A	+t	1a	LmS	X
	Bv 34	Kareekuil	B	−l	1b	SLm	X
	Bv 31	Kingston	A/B	+t/−l	1a	LmS	X
	Bv 26	Lonetree	A/B		1c	SClLm	X
	Bv 25	Maanhaar	A	+t	1b	SLm	X
	Bv 11	Makong	A	+t	1a	LmS	X
	Bv 27	Metz	B	−t	1d	SCl	X
	Bv 22	Oosterbeek	A	+t	1a	S	X
	Bv 37	Ottosdal	B/C	−t/−l	1d	SCl	X
	Bv 24	Redhill	A/B		1b	SLm	X
	Bv 32	Trekboer	A/B	+t/−l	1a	S	X
	Bv 15	Tygerkloof	A	+t	1b	SLm	X
	Bv 33	Vermaas	B	−l	1b	SLm	X
	Bv 21	Vungama	A	+t	1a	LmS	X
	Bv 35	Wedgewood	A/B	+t/−l	1b	SLm	X
	Bv 17	Wilgenhof	B	−t	1d	SCl	X
	Bv 14	Wykeham	A/B		1b	SLm	X
BONHEIM	Bo 41	Bonheim	C/D	−t	1a	LmS	O
	Bo 20	Bushman	C		2c	SClLm	O

TABLE 1 (continued)

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
BONHEIM (contd)	Bo 30	Dumasi	C		2c	SClLm	O
	Bo 31	Glengazi	C/D	−t	2d	SCl	O
	Bo 10	Kiora	C		2c	SClLm	O
	Bo 21	Rasheni	C/D	−t	2d	SCl	O
	Bo 11	Stanger	C/D	−t	2d	SCl	O
	Bo 40	Weenen	C		2c	SClLm	O
CARTREF	Cf 10	Amabele	B/C	+t	5a	LmS	O
	Cf 12	Arrochar	C		5c	SClLm	O
	Cf 13	Byrne	C/D	−t	5d	SCl	O
	Cf 21	Cartref	C		5b	SLm	O
	Cf 22	Cranbrook	C		5c	SClLm	O
	Cf 30	Grovedale	B/C	+t	5a	S	O
	Cf 31	Kusasa	B/C	+t	5b	SLm	O
	Cf 32	Noodhulp	C		5c	SClLm	O
	Cf 11	Rutherglen	C		5b	SLm	O
	Cf 20	Waterridge	B/C	+t	5a	LmS	O
CHAMPAGNE	Ch 11	Champagne	D		2c	SLm	O
	Ch 21	Ivanhoe	D		2e	SClLm	O
	Ch 10	Mposa	D		2c	SLm	O
	Ch 20	Stratford	D		2e	SClLm	O
CLOVELLY	Cv 33	Annandale	B	−l	1b	SLm	O
	Cv 18	Balgowan	B	−t	1e	Cl	O
	Cv 40	Bleskop	A	+t	1a	LmS	O
	Cv 36	Blinkklip	B	−l	1c	SClLm	O
	Cv 17	Clovelly	B	−t	1d	SCl	O
	Cv 28	Clydebank	B	−t	1e	Cl	O
	Cv 35	Denhere	A/B	+t/−l	1b	SLm	O
	Cv 46	Dudfield	A/B		1c	SClLm	O
	Cv 11	Geelhout	A	+t	1a	LmS	O
	Cv 25	Gutu	A	+t	1b	SLm	O
	Cv 47	Klippan	B	−t	1d	SCl	O
	Cv 38	Klipputs	B/C	−t/−l	1e	Cl	O
	Cv 10	Lismore	A	+t	1a	LmS	O
	Cv 12	Lundini	A	+t	1a	S	O
	Cv 34	Makuya	B	−l	1b	SLm	O
	Cv 14	Mossdale	A/B		1b	SLm	O
	Cv 48	Nelspan	B	−t	1e	Cl	O
	Cv 27	Newport	B	−t	1d	SCl	O
	Cv 16	Oatsdale	A/B		1c	SClLm	O
	Cv 23	Ofazi	A/B		1b	SLm	O
	Cv 41	Oranje	A	−t	1a	LmS	O
	Cv 32	Paleisheuwel	A/B	+t/−l	1a	S	O
	Cv 31	Sandspruit	A/B	+t/−l	1a	LmS	O
	Cv 22	Sebakwe	A	+t/−l	1a	S	O
	Cv 45	Skipskop	A	+t	1b	SLm	O
	Cv 21	Sonnenblom	A	+t	1a	LmS	O
	Cv 26	Southwold	A/B		1c	SClLm	O
	Cv 15	Soweto	A	+t	1b	SLm	O
	Cv 24	Springfield	A/B		1b	SLm	O
	Cv 30	Sunbury	A/B	+t/−l	1a	LmS	O
	Cv 37	Summerhill	B/C	−t/−l	1d	SCl	O
	Cv 42	Thornhill	A	+t	1a	S	O
	Cv 44	Torquay	A/B		1b	SLm	O
	Cv 20	Tweefontein	A	+t	1a	LmS	O
	Cv 43	Vaalbank	A/B		1b	SLm	O
	Cv 13	Vidal	A/B		1b	ClLm	O
CONSTANTIA	Ct 25	Cintsa	B		3e	SLm/SClLm	XX
	Ct 12	Constantia	B		3a	LmS	X
	Ct 23	Dwesa	B		3e	SLm/SClLm	XX
	Ct 22	Fencote	B		3b	S/SClLm	XX
	Ct 13	Harkerville	B		2b	SLm	O
	Ct 24	Kromhoek	B		3e	SCl/SClLm	XX
	Ct 14	Noetzie	B		2b	SLm	O
	Ct 20	Palmyra	B		3b	LmS/SClLm	XX
	Ct 10	Strombolis	B		3a	LmS	X
	Ct 11	Tokai	B		3a	S	X
	Ct 21	Vlakfontein	B		3b	LmS/SClLm	XX
	Ct 15	Wynberg	B		2b	SLm	O
DUNDEE	Du 10	Dundee	B/C		2c	SLm	O
ESTCOURT	Es 20	Assegaai	D		3c	LmS/SClLm	XX
	Es 11	Auckland	D		3b	LmS/SLm	XX
	Es 22	Avontuur	D		3c	S/SClLm	XX

TABLE 1 (continued)

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
ESTCOURT	Es 35	Balfour	D		3e	LmS/SClLm	XX
(contd)	Es 40	Beerlaagte	D		3c	LmS/SClLm	XX
	Es 37	Buffelsdrif	D		3k	SCl/Cl	XX
	Es 42	Darling	D		3c	S/SClLm	XX
	Es 13	Dohne	D		3e	SLm/SClLm	XX
	Es 31	Elim	D		3b	LmS/SLm	XX
	Es 33	Enkeldoorn	D		3e	SLm/SClLm	XX
	Es 36	Estcourt	D		3h	SClLm/SCl	XX
	Es 14	Grasslands	D		3e	SLm/SClLm	XX
	Es 41	Heights	D		3c	LmS/SClLm	XX
	Es 10	Houdenbeck	D		3b	LmS/SLm	XX
	Es 21	Langkloof	D		3c	LmS/SClLm	XX
	Es 30	Mozi	D		3b	LmS/SLm	XX
	Es 12	Potela	D		3b	S/SLm	XX
	Es 16	Rosemead	D		3h	SClLm/SCl	XX
	Es 32	Soldaatskraal	D		3b	S/SLm	XX
	Es 34	Uitvlugt	D		3e	SLm/SClLm	XX
	Es 15	Vredenhoek	D		3e	LmS/SClLm	XX
	Es 17	Zintwala	D		3k	SCl/Cl	XX
FERN-WOOD	Fw 40	Brinley	C	−w	1b	SLm	XX
	Fw 11	Fernwood	A		1b	SLm	O
	Fw 21	Langebaan	A		1b	SLm	O
	Fw 42	Mambone	C	−w	1b	SLm	XX
	Fw 10	Maputa	A		1b	SLm	O
	Fw 20	Motopi	A		1b	SLm	O
	Fw 22	Saldanha	A		1b	SLm	O
	Fw 12	Sandveld	A		1b	SLm	O
	Fw 30	Shasha	B	−w	1b	SLm	XX
	Fw 41	Soetvlei	C	−w	1b	SLm	XX
	Fw 32	Trafalgar	B	−w	1b	SLm	XX
	Fw 31	Warrington	B	−w	1b	SLm	XX
GLENCOE	Gc 16	Appam	B		1c	SClLm	X
	Gc 33	Beatrix	B/C	−l	1b	SLm	X
	Gc 20	Boskuil	A/B	+t	1a	LmS	X
	Gc 15	Delmas	A/B	+t	1b	SLm	X
	Gc 10	Driepan	A/B	+t	1a	LmS	X
	Gc 24	Dunbar	B		1b	SLm	X
	Gc 26	Glencoe	B		1c	SClLm	X
	Gc 37	Graspan	C	−t/−l	1d	SCl	XX
	Gc 11	Hartog	A/B	+t	1a	LmS	XX
	Gc 13	Klipstapel	B		1b	SLm	XX
	Gc 32	Kwezana	B	+t/−l	1a	S	XX
	Gc 34	Leeudoorn	B/C	−l	1b	SLm	XX
	Gc 36	Leslie	B/C	−l	1c	SClLm	XX
	Gc 27	Ontevrede	B/C	−t	1d	SCl	XX
	Gc 21	Penhoek	A/B	+t	1a	LmS	XX
	Gc 31	Ribblesdale	B	+t/−l	1a	LmS	XX
	Gc 17	Shotton	B/C	−t	1d	SCl	XX
	Gc 23	Strathrae	B		1b	SLm	XX
	Gc 22	Talana	A/B	+t	1a	S	XX
	Gc 12	Tranendal	A/B	+t	1a	S	XX
	Gc 35	Uitskot	B	+t/−l	1b	SLm	XX
	Gc 30	Vlakpan	B	+t/−l	1a	LmS	XX
	Gc 14	Weltevrede	B		1b	SLm	XX
	Gc 25	Wesselsnek	A/B	+t	1b	SLm	XX
GLENROSA	Gs 28	Achterdam	B/C		5c	SClLm	X
	Gs 27	Dothole	B/C		5c	SClLm	X
	Gs 24	Dunvegan	B/C		5b	SLm	X
	Gs 15	Glenrosa	B	+t	5b	SLm	X
	Gs 13	Kanonkop	B/C		5b	SLm	X
	Gs 22	Knapdaar	B	+t	5a	S	X
	Gs 26	Lekfontein	B/C		5c	SClLm	X
	Gs 25	Lomondo	B	+t	5b	SLm	X
	Gs 21	Majeng	B	+t	5a	LmS	X
	Gs 20	Malgas	B	+t	5a	LmS	X
	Gs 10	Martindale	B	+t	5a	LmS	X
	Gs 11	Oribi	B	+t	5a	LmS	X
	Gs 12	Paardeberg	B	+t	5a	S	X
	Gs 14	Platt	B/C		5b	SLm	X
	Gs 29	Ponda	C	−t	5d	SCl	X
	Gs 18	Robmore	B/C		5c	SClLm	X
	Gs 19	Saintfaiths	C	−t	5d	SCl	X
	Gs 23	Southfield	B/C		5b	SLm	X
	Gs 17	Trevanian	B/C		5c	SClLm	X
	Gs 16	Williamson	B/C		5c	SClLm	X

TABLE 1 (continued)

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
GRIFFIN	Gf 10	Burnside	A		1b	SLm	O
	Gf 11	Cleveland	A		1c	SClLm	O
	Gf 32	Cradock	B	−t/−l	1d	SCl	O
	Gf 20	Erfdeel	A		1b	SLm	O
	Gf 13	Farmhill	A/B	−t	1e	Cl	O
	Gf 12	Griffin	A/B	−t	1d	SCl	O
	Gf 22	Ixopo	A/B	−t	1d	SCl	O
	Gf 30	Runnymeade	A/B	−l	1b	SLm	O
	Gf 33	Slagkraal	B	−t/−l	1e	Cl	O
	Gf 21	Umzimkulu	A		1c	SClLm	O
	Gf 31	Welgemoed	A/B	−l	1c	SClLm	O
	Gf 23	Zwagershoek	A/B	−t	1e	Cl	O
HOUW-HOEK	Hh 20	Albertinia	C		2a	LmS	X
	Hh 10	Elgin	C		2a	LmS	X
	Hh 21	Garcia	C		2b	SLm	XX
	Hh 31	Gouna	B/C	+t	2b	SLm	XX
	Hh 30	Houwhoek	B/C	+t	2a	S	X
	Hh 11	Stormsrivier	C		2b	SLm	XX
HUTTON	Hu 10	Alloway	A		1a	LmS	O
	Hu 11	Arnot	A		1a	LmS	O
	Hu 18	Balmoral	A/B	−t	1e	Cl	O
	Hu 25	Bontberg	A		1b	SLm	O
	Hu 22	Chester	A		1a	S	O
	Hu 24	Clansthal	B		1b	SLm	O
	Hu 27	Doveton	A/B	−t	1d	SCl	O
	Hu 17	Farningham	A/B	−t	1d	SCl	O
	Hu 31	Gaudam	A	−l/+t	1a	LmS	O
	Hu 47	Hardap	A/B	−t	1d	SCl	O
	Hu 16	Hutton	A		1c	SClLm	O
	Hu 21	Joubertina	A		1a	LmS	O
	Hu 15	Kyalami	A		1b	SLm	O
	Hu 23	Lichtenburg	A		1b	SLm	O
	Hu 40	Lowlands	A		1a	LmS	O
	Hu 43	Maitengwe	A		1b	SLm	O
	Hu 37	Makatini	B	−t/−l	1d	SCl	O
	Hu 44	Malonga	A		1b	SLm	O
	Hu 33	Mangano	A/B	−l	1b	SLm	O
	Hu 38	Marikana	B	−t/−l	1e	Cl	O
	Hu 14	Middelburg	A		1b	SLm	O
	Hu 48	Minhoop	A/B	−t	1e	Cl	O
	Hu 32	Moriah	A	−l/+t	1a	S	O
	Hu 26	Msinga	A		1c	SClLm	O
	Hu 41	Nyala	A		1a	LmS	O
	Hu 35	Portsmouth	A	−l/+t	1b	SLm	O
	Hu 42	Quaggafontein	A		1a	S	O
	Hu 30	Roodepoort	A	−l/+t	1a	LmS	O
	Hu 46	Shigalo	A		1c	SClLm	O
	Hu 36	Shorrocks	A/B	−l	1c	SClLm	O
	Hu 12	Stonelaw	A		1a	S	O
	Hu 45	Vergenoeg	A		1b	SLm	O
	Hu 28	Vimy	A/B	−t	1e	Cl	O
	Hu 13	Wakefield	A		1b	SLm	O
	Hu 20	Whithorn	A		1a	LmS	O
	Hu 34	Zwartfontein	A/B	−l	1b	ClLm	O
INANDA	Ia 10	Fountainhill	A		1c	SClLm	O
	Ia 11	Inanda	A		1d	SCl	O
	Ia 12	Sprinz	A		1e	Cl	O
INHOEK	Ik 11	Coniston	C/D	−t	2d	SCl	O
	Ik 10	Cromley	C		2c	SClLm	O
	Ik 21	Drydale	C/D	−t	2d	SCl	O
	Ik 20	Inhoek	C		2c	SClLm	O
KAT-SPRUIT	Ka 10	Katspruit	C/D		1d	SCl	O
	Ka 20	Killarney	C/D		1d	SCl	O
KRANS-KOP	Kp 10	Kipipiri	A		1c	SClLm	O
	Kp 11	Kranskop	A		1d	SCl	O
	Kp 12	Umbumbulu	A		1e	Cl	O
KROON-STAD	Kd 17	Avoca	C/D		3h	SClLm/SCl	XX
	Kd 16	Bluebank	C/D		3h	SClLm/SCl	XX
	Kd 22	Katarra	C/D		3c	S/SClLm	XX
	Kd 20	Koppies	C/D		3c	LmS/SClLm	XX
	Kd 13	Kroonstad	C/D		3e	SLm/SClLm	XX

TABLE 1 (continued)

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
KROON-STAD (contd)	Kd 14	Mkambati	C/D		3e	SLm/SClLm	XX
	Kd 10	Rocklands	C/D		3b	LmS/SLm	XX
	Kd 15	Slangkop	C/D		3e	LmS/SClLm	XX
	Kd 12	Swellengift	C	+t	3b	S/SLm	XX
	Kd 18	Uitspan	C/D		3h	SClLm/SCl	XX
	Kd 21	Umtentweni	C/D		3c	LmS/SClLm	XX
	Kd 11	Velddrif	C/D		3b	LmS/SLm	XX
	Kd 19	Volksrust	D	−t	3k	SCl/Cl	XX
LAMOTTE	Lt 10	Alsace	A/B		2a	LmS	X
	Lt 21	Burgundy	B	+c	2a	LmS	XX
	Lt 14	Chamond	A/B		2b	SLm	X
	Lt 22	Franschhoek	B	+c	2a	LmS	XX
	Lt 25	Hooghalen	B	+c	2b	SLm	XX
	Lt 12	Lamotte	A/B		2a	LmS	X
	Lt 11	Laparis	A/B		2a	LmS	X
	Lt 15	Lillesand	A/B		2b	SLm	X
	Lt 20	Lorraine	B	+c	2a	LmS	XX
	Lt 24	Ringwood	B	+c	2b	SLm	XX
	Lt 23	Tillberga	B	+c	2b	SLm	XX
	Lt 13	Vevey	A/B		2b	SLm	X
LONG-LANDS	Lo 22	Albany	C/D	−t	1c	SClLm	XX
	Lo 32	Chitsa	C/D	−t	1c	SClLm	XX
	Lo 21	Longlands	C		1b	SLm	XX
	Lo 10	Orkney	C		1a	LmS	XX
	Lo 30	Tayside	C		1a	S	XX
	Lo 31	Vaalsand	C		1b	SLm	XX
	Lo 20	Vasi	C		1a	LmS	XX
	Lo 11	Waaisand	C		1b	SLm	XX
	Lo 12	Waldene	C/D	−t	1c	SClLm	XX
	Lo 13	Winterton	C	−t	1d	SCl	XX
MAGWA	Ma 12	Frazer	A/B		1e	Cl	O
	Ma 11	Magwa	A/B		1d	SCl	O
	Ma 10	Milford	A	+t	1c	SClLm	O
MAYO	My 10	Mayo	C		5c	SClLm	O/X
	My 11	Msinsini	C/D	−t	5d	SCl	O/X
	My 21	Pafuri	C/D	−t	5d	SCl	O/X
	My 20	Tshipise	C		5c	SCl	O/X
MILK-WOOD	Mw 10	Dansland	C		2c	SClLm	O/X
	Mw 21	Graythorne	C/D	−t	2d	SCl	O/X
	Mw 11	Milkwood	C/D	−t	2d	SCl	O/X
	Mw 20	Sunday	C		2c	SClLm	O/X
MISPAH	Ms 21	Hillside	C		2c	SClLm	XX
	Ms 22	Kalkbank	C		2c	SClLm	XX
	Ms 11	Klipfontein	C		2c	SClLm	XX
	Ms 12	Loskop	C		2c	SClLm	XX
	Ms 23	Misgund	C		2c	SClLm	XX
	Ms 10	Mispah	C		2c	SClLm	XX
	Ms 20	Muden	C		2c	SClLm	XX
	Ms 13	Plettenberg	C		2c	SClLm	XX
	Ms 14	Winchester	C		2c	SClLm	XX
	Ms 24	Vredendal	C		2c	SClLm	XX
NOMANCI	No 11	Lusiki	B		5d	SCl	O
	No 10	Nomanci	B		5c	SClLm	O
OAKLEAF	Oa 43	Allantridge	B		1b	SLm	O
	Oa 45	Calueque	A/B	+t	1b	SLm	O
	Oa 21	Doornlaagte	A/B	+t	1a	LmS	O
	Oa 25	Hazelwood	A/B	+t	1b	SLm	O
	Oa 17	Highflats	B/C	−t	1d	SCl	O
	Oa 22	Holpan	A/B	+t	1a	S	O
	Oa 36	Jozini	B		1c	SClLm	O
	Oa 23	Kirkton	B		1b	SLm	O
	Oa 13	Klipplaat	B		1b	SLm	O
	Oa 37	Koedoesvlei	B/C	−t	1d	SCl	O
	Oa 16	Leeufontein	B		1c	SClLm	O
	Oa 26	Letaba	B		1c	SClLm	O
	Oa 34	Levubu	B		1b	SLm	O
	Oa 46	Limpopo	B		1c	SClLm	O
	Oa 41	Lovedale	A/B	+t	1a	LmS	O
	Oa 11	Madwaleni	A/B	+t	1a	LmS	O
	Oa 24	Magersfontein	B		1b	SLm	O

TABLE 1 (continued)

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
OAKLEAF (contd)	Oa 27	Makulek	B/C	−t	1d	SCl	O
	Oa 12	Mbanyana	A/B	+t	1d	S	O
	Oa 47	Mutale	B/C	−t	1d	SCl	O
	Oa 42	Naulila	A/B	+t	1a	S	O
	Oa 30	Oakleaf	A/B	+t	1a	LmS	O
	Oa 44	Okavango	B		1b	SLm	O
	Oa 31	Oshikango	A/B	+t	1a	LmS	O
	Oa 15	Pollock	A/B	+t	1b	SLm	O
	Oa 14	Rockford	B		1b	SLm	O
	Oa 32	Sezela	A/B	+t	1a	S	O
	Oa 10	Smaldeel	A/B	+t	1a	LmS	O
	Oa 33	Vaalrivier	B		1b	SLm	O
	Oa 35	Venda	A/B	+t	1b	SLm	O
	Oa 40	Voorspoed	A/B	+t	1a	LmS	O
	Oa 20	Warrenton	A/B	+t	1a	LmS	O
PINEDENE	Pn 27	Airlie	B/C	−t	1d	SCl	X
	Pn 12	Bethlehem	A	+t/+1	1a	S	X
	Pn 25	Chatsworth	A/B	+t	1b	SLm	X
	Pn 15	Eykendal	A	+t/+1	1b	SLm	X
	Pn 10	Fortuin	A	+t/+1	1a	LmS	X
	Pn 13	Graymead	A/B	+1	1b	SLm	X
	Pn 22	Hermanus	A/B	+t	1a	S	X
	Pn 17	Kilburn	B	−t/+1	1d	SCl	X
	Pn 32	Kleinrivier	B	+t/+1	1a	S	X
	Pn 36	Klerksdorp	B/C	−1	1c	SClLm	X
	Pn 34	Nagtwagt	B/C	−1	1b	SLm	X
	Pn 33	Oewer	B/C	−1	1b	SLm	X
	Pn 16	Ouwerf	A/B	+1	1c	SClLm	X
	Pn 30	Papiesvlei	B	+t/−1	1a	LmS	X
	Pn 14	Pinedene	A/B	+1	1b	SLm	X
	Pn 11	Radyn	A	+t/+1	1a	LmS	X
	Pn 20	Rotterdam	A/B	+t	1a	LmS	X
	Pn 31	Stormsvlei	B	+t/−1	1a	LmS	X
	Pn 26	Suurbraak	B		1c	SClLm	X
	Pn 24	Tulbagh	B		1b	SLm	X
	Pn 23	Vyeboom	B		1b	SLm	X
	Pn 21	Wemmershoek	A/B	+t	1a	LmS	X
	Pn 37	Witpoort	C	−t/−1	1d	SCl	X
	Pn 35	Yzerspruit	B	+t/−1	1b	SLm	X
RENS-BURG	Rg 10	Phoenix	D		2e	Cl	X
	Rg 20	Rensburg	D		2e	Cl	X
SHEP-STONE	Sp 12	Addington	A		3a	LmS	O
	Sp 11	Bitou	A		3a	LmS	O
	Sp 13	Gouritz	A		2b	SLm	O
	Sp 15	Inhaminga	A		2b	SLm	O
	Sp 22	Kunjane	A		3c	LmS/SClLm	O
	Sp 23	Pencarrow	A		3e	SLm/SClLm	O
	Sp 24	Portobello	A		3e	SLm/SClLm	O
	Sp 25	Pumula	A		3e	SLm/SClLm	O
	Sp 14	Robberg	A		2b	SLm	O
	Sp 21	Shepstone	A		3c	LmS/SClLm	O
	Sp 20	Southbroom	A		3c	LmS/SClLm	O
	Sp 10	Tergniet	A		3a	LmS	O
SHORT-LANDS	Sd 11	Argent	B		1d	SCl	O
	Sd 10	Bokuil	A/B	+t	1c	SClLm	O
	Sd 30	Ferry	B		1c	SClLm	O
	Sd 21	Glendale	B/C	−1	1d	SCl	O
	Sd 20	Kinross	B	−1/+t	1c	SClLm	O
	Sd 12	Richmond	B/C	−t	1e	Cl	O
	Sd 22	Shortlands	C	−1/−t	1e	Cl	O
	Sd 31	Sunvalley	B/C	−1	1d	SCl	O
	Sd 32	Tugela	C	−1/−t	1e	Cl	O
STERK-SPRUIT	Ss 27	Antioch	D		3k	SCl	X
	Ss 13	Bakklysdrift	D		3e	SLm	X
	Ss 15	Dehoek	D		3e	LmS	X
	Ss 10	Diepkloof	D		3b	LmS	X
	Ss 17	Driebaden	D		3k	SCl	X
	Ss 21	Graafwater	D		3b	LmS	X
	Ss 25	Grootfontein	D		3e	LmS	X
	Ss 20	Halseton	D		3b	LmS	X
	Ss 24	Hartbees	D		3e	SLm	X
	Ss 12	Ruacana	D		3b	S	X
	Ss 22	Silwana	D		3b	S	X

TABLE 1 (continued)

Soil form	Code	Soil series	SCS grouping	SCS adjustment factor	Clay distribution model	Typical textural class	Interflow potential
STERK-SPRUIT (contd)	Ss 23	Stanford	D		3e	SLm	X
	Ss 26	Sterkspruit	D		3h	SClLm	X
	Ss 16	Swaerskloof	D		3h	SClLm	X
	Ss 11	Tina	D		3b	LmS	X
	Ss 14	Toleni	D		3e	SLm	X
SWART-LAND	Sw 12	Breidbach	D	−t	1e	Cl	X
	Sw 21	Broekspruit	C/D		1d	SCl	X
	Sw 32	Hogsback	D	−t	1e	Cl	X
	Sw 40	Malakata	C/D		1c	SCl	X
	Sw 41	Nyoka	C/D		1d	SCl	X
	Sw 42	Omdraai	D	−t	1e	Cl	X
	Sw 22	Prospect	D	−t	1e	Cl	X
	Sw 10	Reveillie	C/D		1c	SClLm	X
	Sw 30	Rosehill	C/D		1c	SClLm	X
	Sw 11	Skilderkrans	C/D		1d	SCl	X
	Sw 31	Swartland	C/D		1d	SCl	X
	Sw 20	Uitsicht	C/D		1c	SClLm	X
TAMBAN-KULU	Tk 10	Fenfield	C		2c	SClLm	X
	Tk 20	Loshoek	C		2c	SClLm	X
	Tk 21	Masala	C/D	−t	2d	SCl	X
	Tk 11	Tambankulu	C/D	−t	2d	SCl	X
VALS-RIVIER	Va 31	Arniston	C/D		1d	SCl	X
	Va 32	Chalumna	C	−t	1e	Cl	X
	Va 21	Craven	C/D		1d	SCl	O
	Va 30	Herschel	C/D		1c	SClLm	X
	Va 12	Lilydale	D	−t	1e	Cl	O
	Va 41	Lindley	C/D		1d	SCl	X
	Va 22	Marienthal	C	−t	1e	Cl	O
	Va 42	Sheppardvale	D	−t	1e	Cl	X
	Va 10	Sunnyside	C/D		1c	SClLm	O
	Va 40	Valsrivier	C/D		1c	SClLm	X
	Va 11	Waterval	C/D		1d	SCl	O
	Va 20	Zuiderzee	C/D		1c	SClLm	O
VILA-FONTES	Vf 45	Blombosch	B/A		3e	SLm/SClLm	XX
	Vf 23	Blythdale	B/A		3e	SLm/SClLm	XX
	Vf 31	Brenton	B/A		3a	LmS	XX
	Vf 24	Chantilly	B/A		3e	CLm/SClLm	XX
	Vf 44	Dassenhoek	B/A		3e	SLm/SClLm	XX
	Vf 21	Fairbreeze	B/A		3c	LmS/SCLm	XX
	Vf 43	Geelbek	B/A		3e	SLm/SClLm	XX
	Vf 11	Hudley	B/A		3a	LmS	XX
	Vf 22	Klaarwater	B/A		3c	LmS/SClLm	XX
	Vf 34	Knysna	B/A		2b	SLm	XX
	Vf 40	Kransduinen	B/A		3c	LmS/SClLm	XX
	Vf 20	Matigulu	B/A		3c	LmS/SClLm	XX
	Vf 41	Mazeppa	B/A		3c	LmS/SClLm	XX
	Vf 35	Meulvlei	B/A		2b	SLm	XX
	Vf 10	Moreland	B/A		3a	LmS	XX
	Vf 14	Moyeni	B/A		2b	SLm	XX
	Vf 25	Nhamacala	B/A		3e	SLm/SClLm	XX
	Vf 33	Rheebok	B/A		2b	SLm	XX
	Vf 30	Sedgefield	B/A		3a	LmS	XX
	Vf 32	Swinton	B/A		3a	LmS	XX
	Vf 13	Tinley	B/A		2b	SLm	XX
	Vf 42	Vallance	B/A		3c	LmS/SClLm	XX
	Vf 15	Vilafontes	B/A		2b	SLm	XX
	Vf 12	Zeekoe	B/A		3a	LmS	XX
WASBANK	Wa 12	Burford	C		2c	SClLm	XX
	Wa 13	Endicott	C/D	−t	2d	SCl	XX
	Wa 30	Hamman	B/C	+t	2a	S	XX
	Wa 10	Hoopstad	B/C	+t	2a	LmS	XX
	Wa 11	Kromvlei	C		2b	SLm	XX
	Wa 20	Rondevlei	B/C	+t	2a	LmS	XX
	Wa 31	Sandvlei	B/C	+t	2b	SClLm	XX
	Wa 22	Warrick	C		2c	SClLm	XX
	Wa 21	Wasbank	C		2b	SLm	XX
	Wa 32	Winterveld	C		2c	SClLm	XX
WEST-LEIGH	We 10	Chinde	B/C	+t	1a	LmS	X
	We 32	Davel	C		1c	SClLm	X
	We 22	Devon	C		1c	SClLm	X
	We 20	Kosi	B/C	+t	1a	LmS	X
	We 30	Langkuil	B/C	+t	1a	S	X
WEST-LEIGH (contd)	We 3	Paddock	B/C	+t	1b	SLm	X
	We 1	Rietvlei	C		1c	SClLm	X
	We 1	Sibasa	D	−t	1d	SCl	X
	We 1	Westleigh	C		1b	SLm	X
	We 2	Witsand	C		1b	SLm	X
WILLOW-BROOK	Wo 2	Chinyika	D		2d	SCl	O
	Wo 10	Emfuleni	D		2c	SClLm	O
	Wo 20	Sarasdale	D		2c	SClLm	O
	Wo 1	Willowbrook	D		2d	SCl	O

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